4. Baseline Conditions in Area Potentially Affected by Project ("Project Area")

4.1 Designation of project area perimeters

4.1.1 Direct Influence Area (DIA)

In accordance with the terms of reference for the accomplishment of Environmental Management Measures aimed at establishing and managing commercial forestry projects mentioned in Resolution No. 500.41-15-1753 dated December 3, 2015, the direct influence area is defined as "*Territory where agricultural or forestry projects are being developed or will be developed, usually defined by a polygon within which environmental impacts are generated*" ([1])

According to the above definition, the direct influence area of the Project is made up by all the premises in which *FFC* exercises this activity and within which forestry activities take place. Such an area measures 19,167.6 Ha in the properties where the Orinoquía Forestry Project will be developed, and 2,089.5 Ha in the premise where the forestry services are provided, yielding a total area of 20,800.3 Ha.

Table 4.1: Areas of the properties corresponding to the Orinoquía Forestry Project

Name of the Premise	Usage Area (Ha)
El Triunfo	693.46
Paraíso (PC)	899.9
Cuernavaca	556.32
El Barajuste	906.91
El Comienzo	702.19
La Cordobeza	989.81
Garza Morena	1,024.8
Las Victorias	274.96
La Pista	516.6
La Fe	511.45
La Fortaleza	488.99
San Cristóbal	632.5
Paraíso (PR)	875.93
Paraíso (II)	1,081.39
Paraíso (I)	1,036.23
Los palmares	971.63
Hato Nuevo	2,006.3
Toro I FMS	1,632.7
La Josa	879.96
Llano Lindo	761.79
Malvinas	11.8
Tierradentro	1,931.64
Tierradentro 5	146.77
Tierradentro 2	220.79
Tierradentro El Paraiso	1,045.47

Source: (Valoración Economica Ambiental , 2017) based on information from Forestal de la Orinoquía.

[1] Terms of Reference for Environmental Management Measures aiming at establishing and managing commercial forestry projects mentioned in Resolution 500.41-15-1753 dated December 3, 2015- Glossary page 33.

4.1.2 Indirect Influence Area (IIA)

In accordance with the terms of reference for the accomplishment of Environmental Management Measures aimed at establishing and managing commercial forestry projects mentioned in Resolution No. 500.41-15-1753 dated December 3, 2015, the indirect influence area is defined as "*Territory corresponding to the set of areas different from the places where the projects in which environmental impacts occur, or may occur, either concurrently and/or subsequent to the time in which the action resulting in the environmental impact takes place*"([2]).

According to the above, the following areas were considered as places where impacts from the Orinoquía Forestry Project may be perceived and which are not found within the DIA. Such areas are:

- Conservation and preservation areas of forests and relict woodland, areas destined to protect production, regulation and stabilization of the regional hydric cycle and protection areas for fragile environments, as defined in Resolution No 500.41-15-1753 dated December 3, 2015. Definitions:

  Conservation and preservation areas of forests and relict Woodland: *"areas with primary forests and/or relicts of important forests for representative ecological connectivity in the landscape and all those that fulfill the function of maintaining biodiversity and the ecological balance, since they contribute climate and hydric regulation, preservation of the soil and cleaning of the air; and practically they contribute the only biological corridors or forest areas of the region that help preserve both, fauna and native flora for they constitute the habitat of threatened and endangered species"([3]*)

  Areas destined to protect production, regulation and stabilization of the local, regional and national hydric cycle: "*areas of river sources, underground bodies of water" ([4])*

  Protection areas for fragile environments: "*areas with strategic ecosystems associated with high ground-water level of the soils or to hydric dynamics, as a result of biocenosis" ([5])*

In accordance with the above, we present the following areas in Table 4.2.

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[2] Terms of Reference for Environmental Management Measures aiming at establishing and managing commercial forestry projects mentioned in Resolution No. 500.41-15-1753 dated December 3, 2015, Glossary page 33.

[3] Terms of Reference to Establish and Manage Commercial Forestry Projects mentioned in Resolution No. 500.41-15-1753 dated December 3, 2015, Glossary page 9.

[4] Terms of Reference to Establish and Manage Commercial Forestry Projects mentioned in Resolution No. 500.41-15-1753 dated December 3, 2015, Glossary page 9.

Table 4.2: Indirect Influence Areas (areas with use restriction).

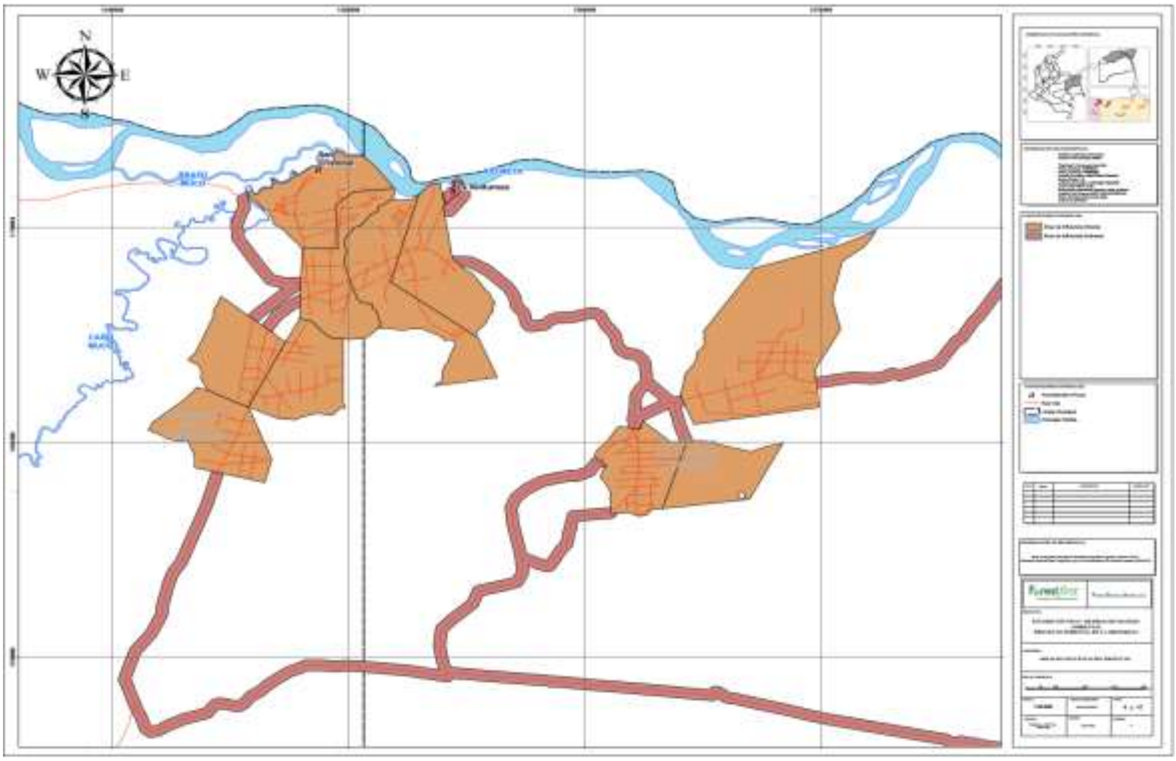
Property Name	Areas with Use Restrictions (Ha)	Exclusion Area (Ha)
El Triunfo	267.44	162.3
Paraíso (PC)	192.05	16.17
Cuernavaca	282.85	124.52
El Barajuste	225.48	85.09
El Comienzo	322.09	114.03
La Cordobeza	215.58	49.63
Garza Morena	208.14	60.75
Las Victorias	126.62	33.89
La Pista	508.4	0
La Fe	267.44	220.1
La Fortaleza	248.33	155.78
San Cristóbal	296.52	365.01
Paraíso (PR)	216.64	51.72
Paraíso (II)	497.27	185.63
Paraíso (I)	286.78	101.2
Los palmares	223.7	98.7
Hato Nuevo	715.09	193.39
Toro I FMS	336.2	122.04
La Josa	148.83	46.96
Llano Lindo	245.81	67.63
Malvinas	83.63	15.28
Tierradentro	266.09	35.97
Tierradentro 5	55.52	8.82
Tierradentro 2	63.14	10.61
Tierradentro El Paraiso	360.7	77.13

Source: (Valoración Economica Ambiental , 2017) based on information from FFC

- Areas adjacent to the roads that communicate the properties amongst them and with the main access ways of the Project. It was determined how the IIA framed this within a 250 meter distance from each side of the road.
- Areas corresponding to the inspection points nearby the project, which in the case of the Orinoquía Forestry Project deal with the inspection points La Venturosa, closely located to the San Cristóbal, Palmares, Paraíso II and Paraíso I properties. The second inspection point is near El Aceitico, close to the Malvinas and Toro I properties. And lastly, the inspection point Puerto Murillo, close to the Malvinas and Hato Nuevo properties.

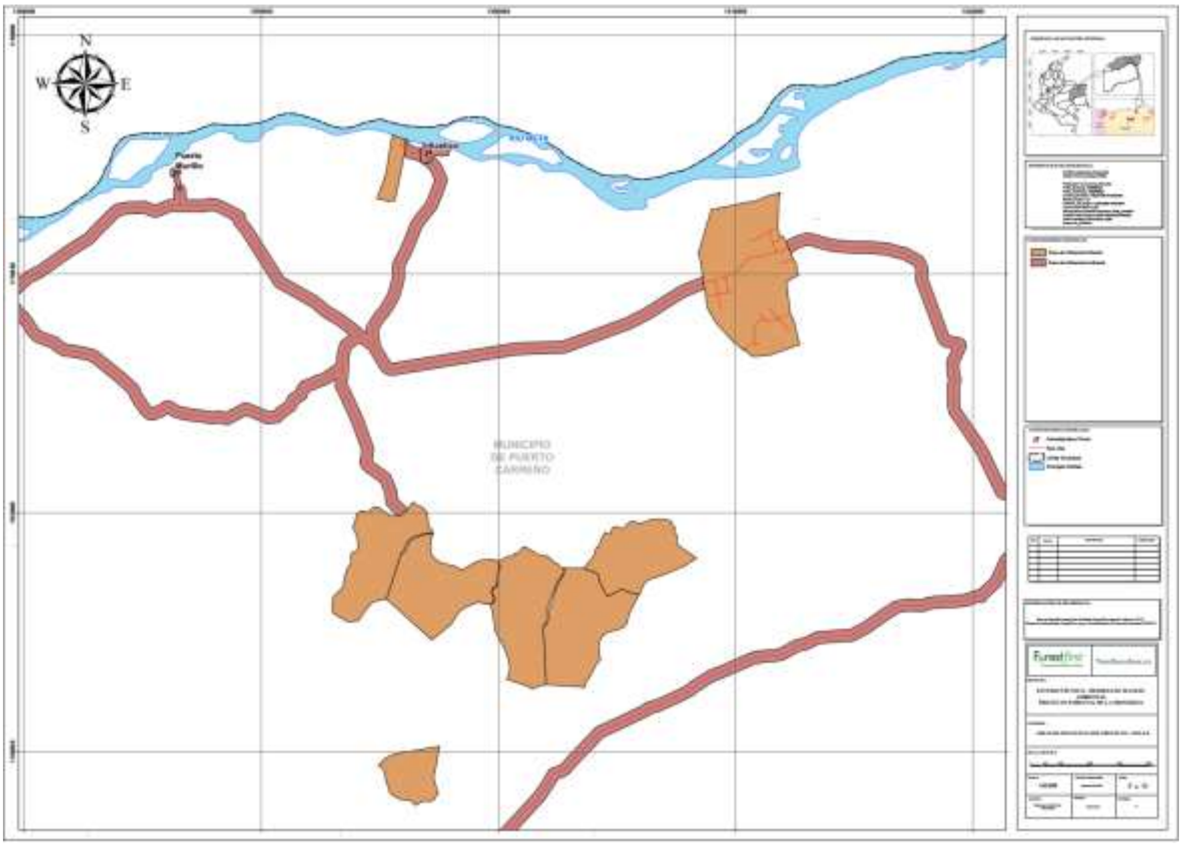
Herein below we present the figures with identification and demarcation of direct and indirect influence areas:

Figure 4.1: Area A having Direct and Indirect Influence.



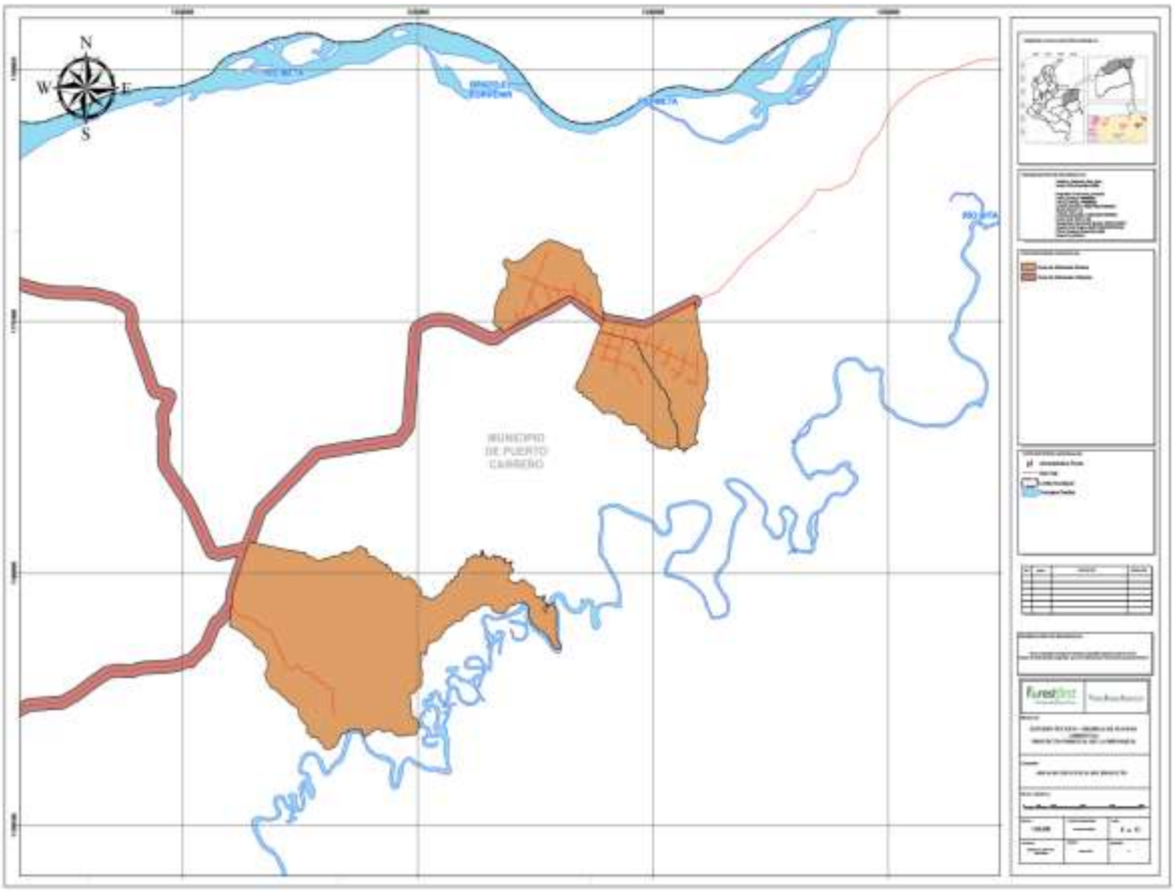
Source: Prepared by (Valoración Economica Ambiental , 2017)

Figure 4.2: Area B having Direct and Indirect Influence.



Source: Prepared by (Valoración Economica Ambiental , 2017)

Figure 4.3: Area C having Direct and Indirect Influence.



Source: Prepared by (Valoración Economica Ambiental , 2017)

4.2 Physical geography (climate, geology, topography)

4.2.1 Geology

From the physical point of view, Geology analyzes, rebuilds and interprets permanent evolution of lands, providing information on the characteristics, properties, capability of the land to support anthropogenic activities (human activities) and indicate the most adequate way of utilizing the subsoil, as well as the occurrence of instability processes, caused either by structural and tectonic characteristics, or by seismic activity, lithological nature or anthropogenic conditions. The methodology for the geological characterization of the area of interest for the *FFC* Environmental Measures Management Project, where lithology conditions are included, was developed through the following activities, abiding by what was established in the terms of reference and according to the general Methodology for presentation of Environmental Impact Surveys.

The area containing *Forestal de la Orinoquia'*s properties is found within the NW South American Amazonic Craton geological framework, which has not been thoroughly studied in Colombia and may be framed within two main streams that try to explain the evolution of the most ancient Colombian rocks: The first one, the Fixed Stream, proposed by authors such as Radelli 1967; Irving 1971, Álvarez 1983, among other, who postulate that the W boundary of the Precambrian crust would be located in the W flank of the Cordillera Central, and the second, the Movable Stream, explained within the plates tectonic concept, which is evidenced by authors such as Martin, (1972); Cordani et al. (1979,1988); Bley de Brito & Cordani, (1991); Teixeira et al. (1989); Tassinari et al. (1996) and Tassinari & Macambira, (1999), among other.

4.2.1.1 Revision of the Geological Information

This information includes both, the Direct Influence Area (DIA), and the Indirect Influence Area (IIA), since it is considered both, primary and secondary information. Within this analysis, technical, scientific and general geological and structural data were identified and validated, such as the Municipal Land Management Schemes (EOT, for its initials in Spanish) mainly of the Puerto Carreño municipality, specific surveys of the area conducted by Servicio Geológico Colombiano, academic papers prepared by universities, environmental authorities and other entities.

Table 4.3: Bibliographic References Consulted by the Geological Component.

REFERENCES	DATE
Land Management Scheme (EOT, for its initials in Spanish) of the Primavera Municipality	2000
EXPLANATORY MEMORY OF DRAWINGS 162, 162 BIS, 182 AND 182 BIS OF PUERTO CARREÑO, VICHADA	2009
GEOLOGICAL CARTOGRAPHY AND GEOCHEMICAL SAMPLING OF DRAWINGS 159, 160, 161, 179, 180 AND 181 OF PUERTO CARREÑO, VICHADA	2012
Technical Supporting Document – LAND MANAGEMENT SCHEME - Puerto Carreño, Vichada.	2012
General Soils Study and Land Zoning at the Vichada Department	2014

Source: (Valoración Economica Ambiental , 2017)

4.2.1.2 Field Exploration

A field exploration was carried out within the geological and structural analysis. The following properties were visited for the characterization of the baseline studies:

Table 4.4: Forestal de la Orinoquia's Properties.

Property	Area
San Cristóbal	1,294.0
Los Palmares	1,294.0
La Cordobeza	1,255
La Garza Morena	1,293.7
El Paraíso I	1,424.2
El Paraíso II	1,764.3
Hato Nuevo	2,914.8
El Paraíso (PR)	1,144.3
El Paraíso (PC)	1,108.1
La Pista	1,025.0
La fe	999.0
El triunfo	1,123.2
El Comienzo	1,138.3
El Barajuste	1,217.5
La Fortaleza	893.1
La Victoria	435.5
La Josa	805.9
Llano Lindo	859.6
Cuernavaca	963.7

Property	Area
Las Malvinas	110.7
Tierradentro - Titulado	2,233.7
TAD El Paraíso - Titulado	1,483.4
Tierradentro 2 - Titulado	294.5
Tierradentro 5 - Titulado	211.2
Total	**27,287**

Source: *Forestal de la Orinoquia*

Table 4.5: Property to which Forestry Services are Offered

Property Name	Total Area (Ha)
Toro I FMS	2,089.50
Total	**2,089.50**

Source: (Valoración Economica Ambiental , 2017) based on information from *Forestal de la Orinoquía*.

Visits to the premises were conducted on September 10 through 18, 2017 where geological conditions were observed in relation to lithological units, recent deposits and current conditions of the materials in outcrop, such as the metheorization degree and profile and local fracturing; likewise, the structural component was visualized together with the tectonic conditions of the area of interest, including topographic and landscape, conditions of the exposed rocks regarding fractures, folds, foliations, and diaclases, among other. This land exploration also validated data compiled in the previous bibliographic compilation stage.

4.2.1.3 Analysis of Remote Sensors

This activity includes analysis of aerial photographs owned by *Forestal de la Orinoquía*. The aerial photographs were interpreted with the aid of stereoscopic vision permitting the extraction of data related to lithological units; also, important structural features were interpreted, such as benches, causes aligned to certain streams, slope changes, among other, which are shown associated to regional structures, erosive processes, and digression of courses in the main streams, among other features.

Table 4.6: List of Aerial Photographs of the Area

Characteristics of the Images	Sensor	Date of the satellite image
Worldview-2 images, Pan Sharpened Mode	WV02	10/01/2017
	WV02	10/01/2017
	WV02	23/03/2015
	WV02	23/03/2015
	WV02	10/01/2017
	WV02	17/01/2013
	WV02	17/01/2013
	WV02	25/01/2013
	WV02	25/01/2013
	WV02	17/01/2013
	WV02	17/01/2013
	WV02	17/01/2013
	WV02	17/01/2013
	WV02	17/01/2013

Source: Table prepared by (Valoración Economica Ambiental , 2017) PROCALCULO's data

4.2.1.4 Geographical Information Systems and Preparation of the Thematic Cartography

With the aid of the geographical information systems and working with digital level data, the data cleaning, digitization and integration of the cartographic and geological information was carried out. This activity was started in the first characterization phases of the area and it prolongs until its final stage. It is updated with field data and information from different analysis and it finally gives way to the geological map of the area of interest, containing lithological and structural-type information based on the data provided by *Forestal de la Orinoquia*'s Environmental Management Project, prepared at a 1:50.000 scale.

4.2.1.5 Seismicity

The seismicity studies are focused on identification and validation of possible seismic events that affect *Forestal de la Orinoquía*'s area of interest. Herein below we are mentioning the activities developed, following the typical methodology for these types of surveys:

- ***Revision of the Seismological Information***

In order to obtain knowledge of the lands' seismic conditions, previous works related to seismicity conditions present in the area of interest were identified, validated and analyzed; the starting point of such studies corresponds to information generated and updated by Servicio Geológico Colombiano SGC. In addition to the secondary information analyzed for the geological characterization, the Atlas of Colombian Seismic Threats (2010) wherein the above mentioned Colombian Geological Service records different seismic activities of the national territory was used as main reference.

- ***Characterization of seismic sources and of nearby neotectonic activity.***

The seismicity analyses took into account the neo-tectonic activity conditions for the area of interest based on the Colombian Active Faults Map, 1999, to then estimate seismic activity rates. In addition, the characterization of the seismic sources of the area of interest was reviewed according to the neo-tectonic observations that had been observed and identified, taking into account the benches and streams' straight courses.

- ***Field Exploration***

With the neo-tectonics vision, the neo-tectonic conditions of the lands were visualized in the field; this is related to regional environmental guidelines, benches and defined local structures, such as shear zones, intense fracturing, sand ponds, etc., identified as of the revision of the information.

- ***Preparation of the Report***

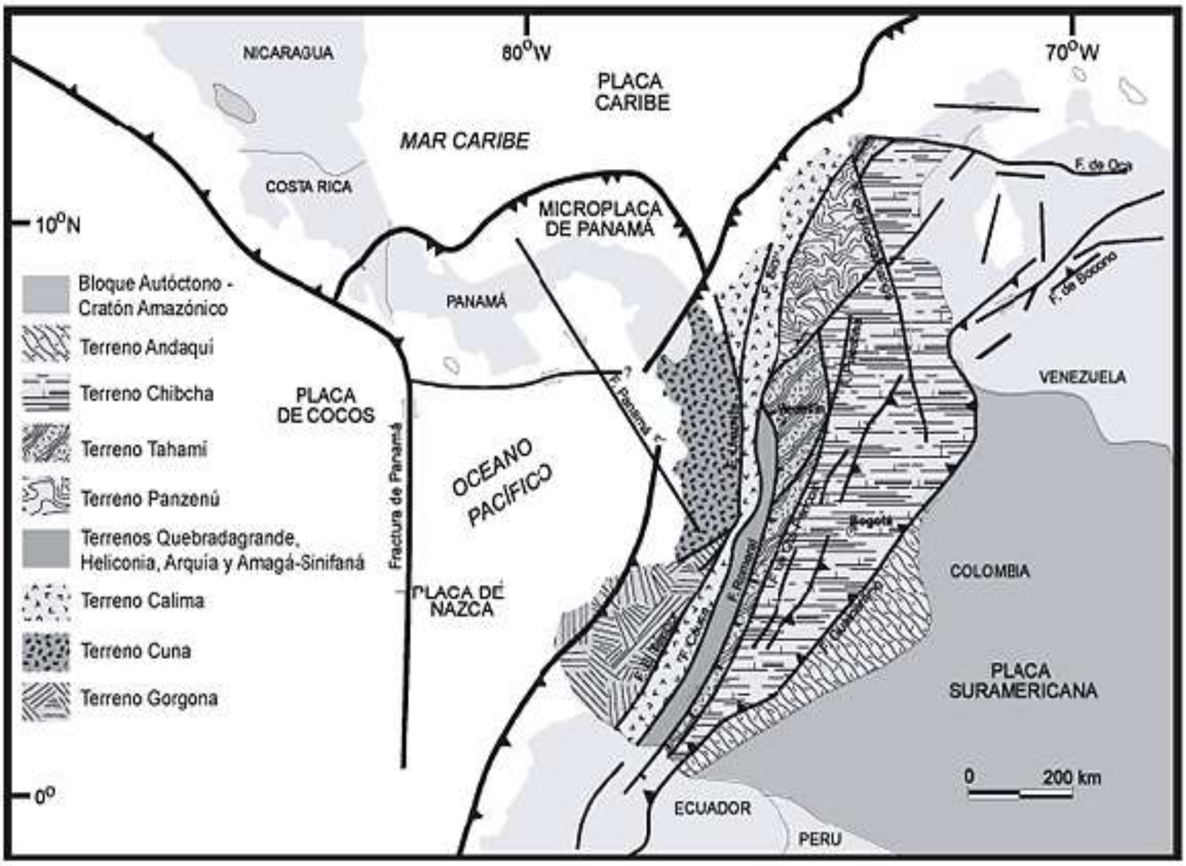
With the integration of the preceding data and under specialized analyses that include the estimate of seismic threat rates and the preparation of the map, the seismicity report of the area, including the maximum accelerations of the land (PGA) and the identification of the most relevant seismic sources as per the regional faults map of the area was prepared.

4.2.1.6 Geology of the Indirect Influence Area (IIA)

Ancient and recent outcrops located in premises belonging to *FFC* were established at the Indirect Influence Areas (IIA); the Geology of the Vichada Department corresponds to rocks of the Precambrian and Tertiary ages.

The Planes for the Department of Vichada according to IGAC, and those used in this survey are: 160, 161, 162, 180, 181, 182, at 1:100.000 scale for the most Eastern sector of the Oriental Planes Basin, located towards the north of the South American Platform and it represents one of the greatest cratonic bodies of the world; according to the Colombian Lands Map (INGEOMINAS, 1983)[6] shown in Figure 2, the area is defined as the Meta, Vichada, Guaviare Land, mentioning first an accumulation of pelitic and samitic sediments of the beginning of the Proterozoic age, which are subject to metamorphosis during the Trans-Amazonic metamorphic period(~1780m.a).

Figure 4.4: Colombian Lands Map.



Source: Geology of the southern part of Sabanalarga Batholith. Implications for terrain theory in the West of Colombia.

[6] Colombian Lands Map, Taken from Geology of the Southern Part of Sabanalarga Batholith. Implications for Terraine Theory in the West of Colombia.

4.2.1.6.1 Regional Geology

- **PRECAMBRIAN PERIOD**

Outcrops of very ancient ages were established in drawing 181 at the geographical sector called Cerro el Carajo, nearby the Bita River, town La Esmeralda, Puerto Carreño Municipality – Department of Vichada.

According to Tasinarii and Macambira (1999)[7], the Amazonic Craton is divided into 6 Chrono-tctonic provinces, namely: Central Amazónica (CA), over 2500M.a; Maroni-Itacaiúnas (MI), 2200-1950M.a; Ventuari-Tapajós (VT), 1950-1800M.a; Río Negro-Juruena (RNJ), 1800-1550M.a, which is separated in Santos et. al. (2000) at Río Negro (RNP), 1860-1520M.a and Rondonia-Juruena, 1760-1470M.a; Rondoniense- San Ignacio (RO), 1500-1300M.a and Sunsas (SS), 1250-1000M.a.

It is important to make reference to the granitic rocks located at the east of the survey area in the Venezuelan border, towards the western edge of the Orinoco River, rocks which belong to the Guyana Shield, and which together with the Brazil Central Shield or Guaporé, constitute the Amazonic Craton. The Bouger anomaly studies at the Colombian northwestern extreme suggest that the sialic platform of the Precambrian age rapidly thins out towards the West, and probably before reaching the Pacific Coast.

The stratigraphic sequence includes Precambrian ancient rocks, which are represented by the Mitú Migmatitic Complex and the Parguaza Granite.

  - **Mitú Migmatitic Complex**

Unit made up by igneous and high degree metaphoric rocks with different complex structural ratios; it lithologically comprises quartz-feldspar, amphibolites, migmatites, quartzites, quartz neises and granites with alaskite to monzonite variations. It is intruded by granitic bodies called granitoids, and by seams or dikes of quartz-feldspar composition. The protolith probably stems from sediment and it is of basic quartz-feldspar igneous nature. (Gálvis et al.1979). The Complex is the western prolongation of the Guyana Shield and it constitutes the crystalline basement of the Colombia's Eastern region. It is found in the surface in the southeastern part of the Vichada Department, outcropping in irregular patches, where the sediment layer is absent, or was eliminated by erosion. Presence of ancient sedimentary sand units was also observed at the field, lying on the ancient basement, but such units are not reported in the official geological cartography. Outcrops of quartz and ferruginous sandstones were observed at the Casuarito homestead and at La Esmeralda site. In Casuarito, the outcrop consists of siliceous quartz sandstone that forms tabular layers covering the Shield's rocks. At La Esmeralda site, in the unpaved road that leads from Puerto Carreño to Caño Tigre, ferruginous sandstone was observed forming residual hills with an approximate height of 40 meters, covering the Shield's rocks.

Age and Correlation: Regarding age, the geo-chronological data of the Mitú Complex according to de Priem (1978) and Priem et al. (1982) indicate three age groups, namely: 1.780 M.a. which would correspond to the cooling of the Mitú Complex at the end of the Transmazonic Orogenia; 1.575-1.450 M.a., with an age possibly related to Parguaza-type Rapakivi granites, and 1.200-1.100 M.a. which was interpreted as corresponding to the Nickriense tectonic-metamorphic episode occurred in Surinam.

[7] Geological setting of the Mitu complex and perspective of mineral occurrences of niobium and tantalum in the Colombian territory.

- **Parguaza Granite (MPgp)**

The Parguaza Granite (Petzal, et. al., 1974 in Cristancho, 1989), is of "Rapakivi"-type (literally rotten rock) term originally used by Urdan Hjarne (1694 on Volbort, 1962); some authors have used the term to describe petrographic characteristics, mainly from volcanic igneous rocks and intrusive granitic rocks with high content of potassium rich feldspar such as granodiorites, monzogranites and their varieties (Pinto and González, 1989).

In Colombia the Parguaza granite outcrops along the western Bank of the Orinoco River and forms part of the rocks that make up the Guyana Shield (Department of Vichada). The outcropping rocks are seen as isolated domes with abrupt slopes and heights oscillating between 5-200m, so called as "Inselbergs" hill isles. Their distribution and size is irregular; they are seen outcropping in the Banks of the Orinoco River and they refer to the hills called Bita, Bandera, Santa Helena, Guarípa, Hormiga, Bachaco, Casuarito, Murciélago, Ángela, and San Roque, amongst other.

Age: Up to the moment there are no dates of the Parguaza Granite in Colombia. The assigned age 1531±39M.a (Gaudette et. al.,1978) is derived from samples obtained in the Ayacucho area (Venezuela), and it would correspond to the Parguenze Event (1400-1600M.a) (Table 3).

Correlation:
The Parguaza Granite located around Puerto Carreño (Colombia) may be correlated with the Granitoides of the same name which outcrops between Puerto Ayacucho and Puerto Páez (Venezuela), with the Anorogenic Pluto of Río Branco (Brasil), as well as with the Mucuajai Granite, Surucucus Granite and the Biotitic Granite of the Vaupés river.

- **PALEOZOIC PERIOD**

  - **Araracuara Formation (MPtev)**

It corresponds to a succession of sedimentary rocks or of coastal marine shallow waters origin, deposited during the Paleozoic age, possibly in the Ordovicic period, mostly comprised of sandstones with presence of conglomeratic lenses. It presents two members: a lower one called Guácharos, made up by an oligoictic basal conglomerate of angular and rounded hyaline quartz in green clay matrix discordantly overlying on the Mitú Migmatitic Complex. The conglomerate harrows upward leading to conglomeratic quartz sandstone and coarse-grained brittle sandstones with wave marks and abundant biological activity fossil prints inter-bedded with finely laminated green and not too compact micaceus claystones with a thickness of up to 20 meters. The upper part of the member is a medium to fine greyish or white sandstone, sometimes glauconitic and not very compact.

The upper member called Angostura is made up of white to white-yellowish very compact coarse packets of quartz sandstones, with presence of abundant crossed stratification in its lower portion. The upper contact is discordant with the sedimentary units of the Tertiary.

The Araracuara formation rocks generally contain quartz having very low mineral variety and have low potential for contributing elements to the soil; such rocks have a high content of siliceous cement which provides the strata with high weathering resistance and very low porosity and permeability. The formation is shaped in structural plateaus with slightly dissected flat surfaces that have vertical and steep edges and scarce vegetal cover at the top; drainage presents a strong structural control. In the Vichada Department the formation appears in small outcrops within a sector nearby the Iteviare hamlet on the Guaviare River at the border with the Guainía Department.

- **CRETACEOUS PERIOD**

    - **Amazonic Upper Tertiary**

Informal name used to refer to sedimentary units deposited in a continental environment, after occurrence of the Cretaceous sea regression, as a consequence of the final raising of mountain ranges during the Andean Orogenia. Most of the sequences are constituted by ferruginous conglomerates at their base and by a succession of red, yellow and whitish claystones interspersed with lignite lenses and slightly consolidated sandstones with a matrix that varies between iron and clay content. (Galvis et al., 1979).

In the Department of Vichada, the unit outcrops in the south of Vichada River, showing low consolidation sandy tabular formations (Flórez, 2003), where the slight incision of the elementary drainage network favors the formation of large flat- to-corrugated interfluvios, which are characterized by not too much dissection and almost flat topography.

- **CENOZOIC PERIOD**

Within the Indirect Influence Area of the survey, this geological unit is the broadest one, occupying approximately 70% of the area; such unit has not been studied in detail, but has been referenced as Tertiary by several authors such as Navas (1991), Galvis (1998) et al., without differentiation. According to what has been observed, it corresponds to typical peneplain geoforms affected by a dendritic and sub-dendritic drainage network. Based on the fieldwork and on the photo-geological data, two geological units could be established within the surveyed area[8].

- **Paleogene – Neogene**

Within this period of time, a non-differentiated sedimentary unit was defined, which is characterized herein below.

- **Non-differentiated Tertiary (Tsd)**

These are peneplain non-differentiated sediments of continental origin and their outcrops are not very evident in the area, which makes it difficult to raise stratigraphic columns; however, some outcrops were found in the banks of the Bita River.

❖ Lithology

First Segment
According to the information compiled during the field phase, at the upstream right bank of the Bita River 1.177.675N and 1.044.028E, an 11 meters thick stratigraphic column was raised where the following data described from base to top was obtained. The First Segment is represented by a 1 meter thick mudstone layer, followed by a local yellowish clay-stone layer (0,9m thick), with reddish tones due to the presence of iron oxide, with curved crossed internal stratification, representing a total thickness of 1,9m[9].

Second Segment
Towards the base there is an intercalation of fine-to-medium increasing grain sandstones, with moderate selection ferruginous cement having sub-rounded grain, flat parallel stratification, with tabular grayish to

[8] Explanatory Memory of drawings 162, 162 bis, 182 and 182 bis Puerto Carreño, Vichada-
[9] Explanatory memory of drawings 162, 162 bis, 182 and 182 bis Puerto Carreño, Vichada-

yellowish-brown clay-stones. Its thickness is 1,65m. Towards the top there is a very fine Brown yellowish sandstone layer with sub-rounded grain and mud matrix, with a thickness of 1,70m.

Third Segment
It corresponds to mudstones with motted ochre-yellowish tones in tabular layers, net contacts, with a thickness of 2,7m. Such thickness is followed by a layer of medium grain sub-angular sandstones with moderate selection, 0,5m thick, Towards the south sector of the area, at the streams Dagua 1.045.607E, 1.128.358N and at the banks of the Orinoco Rriver 1.055.518E, 1.139.562N, punctual conglomerate lenses were found within a fine sand matrix, with 0,5 to 3cm diameter lithic and milky quartz clasts with sub-angular and sub-rounded shape and poor selection within ferruginous sandy, ochre-to-brown clay-stones. Greyish conglomerated sandstones were identified on the Dagua stream with presence of iron oxide; their clasts are sub-rounded and poorly selected within a sand-mud matrix having a minor percentage of ferruginous cement.

Figure 4.5: Rocky Unit at the Left Bank of the Bita River

Source: (Valoración Economica Ambiental , 2017)

Figure 4.6: Rocky Unit at the Left Bank of the Bita River

Source: (Valoración Economica Ambiental , 2017)

- **Quaternary**

The quaternary deposits of the area are composed of unknown thickness non-consolidated lutum sediments that cover deposits which have been formed through an intense weathering process of Precambrian and Tertiary rocks, known as lateritic soils which originate in stable landscapes that have been deposited through two means: surface rivers and creeks; and wind-generated. Two recent geological units within the survey area were classified as follows:

- **Ferruginous Crusts (Qcf)**

It corresponds to peneplain corrugated sediments which are nearby the dendritic and sub-dendritic drainages network and in some sectors, they are found in the low parts of the Inselberg (ancient granitic bodies).

The weather conditions of the surveyed area are characterized by long winters and long summers, situation which directly influences the weathering and leaching of pre-existing rocks rich in mafic minerals and feldspars, thus leading to the deposition of ferruginous crests with high content of iron oxide, limonite, hematite and goethite type. The ferruginous crusts are associated with low zones of granite bedrock and with dissection areas of main and secondary surface drainage (rivers and streams). This unit corresponds to very hard welded masses with high concentration of iron, granular porous texture with characteristic ochre to reddish shades and in some sectors, it is found with kidney-shaped texture.

According to what was observed in the field, the ferruginous crusts present textural variations and different compositions, depending on the places where they crop out. The ferruginous crusts are mainly located in the rivers Bita and Meta and at the Juriepe stream in the northern sector of the surveyed area and they are comprised of fine-to-medium sandstones with sub-rounded, moderate selection lithic milky quartz showing kidney or botroydal shape with 0,2cm thick siltstone and hematite strips. The thickness oscillates between 0.6 and 1,30m. Their exposure is more evident in the secondary tributaries of the Bita and Meta rivers and in the Murciélago and Dagua streams.

The Murciélago and Dagua streams sector at the southern part of the surveyed area evidences a textural change showing ferruginous crusts made up of sandy mudstones with clayey matrix and ferruginous cement with sub-angular, moderate selection lithic milky and hyaline quartz also with presence of iron oxide and manganese. Their geoforms are smoother than those observed in the northern part of the surveyed area. Thicknesses do not exceed 90cm[10].

Ferruginous crusts found at the lower parts of the granite bedrock, mainly in the sectors called: Las Hormigas, - northeast of the area under study; Puerto Carreño- urban center; Cerro Angelita, Cerro Piragua, Cerro Casuarito, and Guarípa, exhibit smooth elongated geoforms not over 1,50 meters high, mainly consisting of poor selection, medium grain, angular and sub-angular ochre-to-reddish sandstones with lithic milky quartz and micas, with compact silt-clay ferruginous cement matrix and limonite and hematite strips.

Figure 4.7: Altered Ferruginous Crust at the Bita River

Source: (Valoración Economica Ambiental , 2017)

- **Recent Deposits (Qp)**

These recent deposits cover a large segment of the area under study. They correspond to a non-consolidated unit made up of mud-sand sediments with undetermined thickness and age, with colors that vary from light gray to brown yellowish in several facies fluvial continental environments forming vast savannahs with none or slight dissection which cover tertiary deposits and pre-cambrian rocks located east of the area. Such sediments are mostly covered by “saeta”-type pastures and scarce bushes vegetation. In certain sectors the deposits are covered by sands brought by the wind.

[10] Explanatory Memory of drawings 162, 162 bis, 182 and 182 bis Puerto Carreño, Vichada

Figure 4.8: Photograph of Yellow Sand Flat Lands, with non-consolidated sediments.

Source: (Valoración Economica Ambiental , 2017)

- **Alluvial Deposits**

During field observations and image analyses two types of alluvial deposits were identified: flood plains and riverbed alluvial deposits.

Flood plains (Qll)

This corresponds to areas subject to constant flooding, especially in the winter. Nearby Orinoco in the Bita River there are fine material sediments deposited in the valleys of the Orinoco and Meta rivers as well as in the higher part of the Negro creek and at the source of the Murciélago and Amarillo creeks, and at the mouth of the Piragua, Pañuelo and Guarípa streams.

This unit hosts non-consolidated sediments with sand texture variations from fine- to-greyish clayey sands having high quartz content and low levels of feldspar and mafic minerals rich in organic material. For this reason they give way to soils that favor abundant development of bush-type topsoil that hosts minor species.

The flood plain's deposits are in contact with Tertiary sediments in the Meta River valley, leaving areas with a maximum 5Km extension, evident at the Palito sector, and with a minimum 1Km extension in Hacienda La Esmeralda. The flood plains are swampy, which makes access difficult.

Figure 4.9: Meta River Flood Plain

Source: (Valoración Economica Ambiental , 2017)

- **Riverbed Alluvial Deposits (Qac)**

These correspond to non-consolidated sediments deposited in the beds of the Meta, Orinoco, Dagua and Bita rivers, forming sandbanks located in active beds (islands), riverbanks and local terraces. The existing material varies according to the dynamics and to the material contribution, there being diverse textures and compositions.

Upstream, in the highest part of the Bita River, there are sandbanks in active beds, stabilized by tree-type native vegetation. At the Nimajay sector in the Banks of the Bita river siliceous sandbanks were found made up of very fine grain, good selection, rounded sands with low silt content.

The Meta River contains sandbanks within the active bed (islands) made up of greyish very fine sands with contribution of clay material and high concentration of iron oxides. In the upper part there are subsistence crops like cotton, yucca and maize. There are complex banks in the mouth of the Juriepe creek at the Meta River.

Deposits Brought by Wind (Qe)

Deposits brought by wind found in the Survey area are predominant in the Murciélago and Dagua creeks. They present parabolic forms of lesser size containing fine yellowish, good-to-moderate selection sands with sub-rounded grain and thicknesses of up to 40cm; notwithstanding, towards the Hormiga sector there are accumulations of very small thickness, covering the recent deposits that form the peneplain. Development of these deposits brought by wind in the area under study is not very evident and notorious as those observed in Venezuela towards the western sector of Vichada and in the Meta, Casanare and Arauca Departments.

The geographical and meteorological considerations of the Eastern Plains (Llanos Orientales) provide fundamental characteristics for developing deposits brought by wind. According to Khobzi (1976 en CIAF, 1981), in the Orinoquía case, the topography of the Guyana mountain range represents an obstacle for wind action, fact which restricts such modality to not beyond its foothills. Currents show an anti-cyclonic nature trajectory to the east, becoming cyclonic as of the Venezuelan western plains until Vichada in Colombia.

Goosen (1971 in CIAF, 1981) and Tricar (1974 a, b, c in CIAF, 1981) establish que that sedimentation at the plains where the rivers burst their banks have been mostly contemporaneous to the dunes and concurrently they have been an important source of their component material; the authors indicate that the dunes are more ancient than the Holocene alluvial deposits.

4.2.1.7 Geology of the Direct Influence Area (DIA)

The Direct Influence Area is defined as the area where direct or primary environmental impacts affect physical, biotic, socio-economic and cultural aspects at the sites that are intervened with any type of construction and operation, taking into account the following environmental criteria:

- Areas that are going to be intervened by building activities.
- Areas defined for the permanent camp and temporary facilities, as well as existing ways to be used as access for *Forest First* premises.
- Socio-economic and cultural characteristics or conditions of the communities settled in the area which may be positively or negatively affected.
- Especially the premises that will be used as right of way.
- Direct impacts generated by operating activities to be accomplished.

LOCAL GEOLOGY

Within the influence area of *Forestal de la Orinoquía*'s premises, there are rock and soil units, and exposed deposits with ages between the Precambrian, the Cretacic, the Paleozoic – Neogene and Quaternary periods.

Table 4.7: Geological Units (DIA)

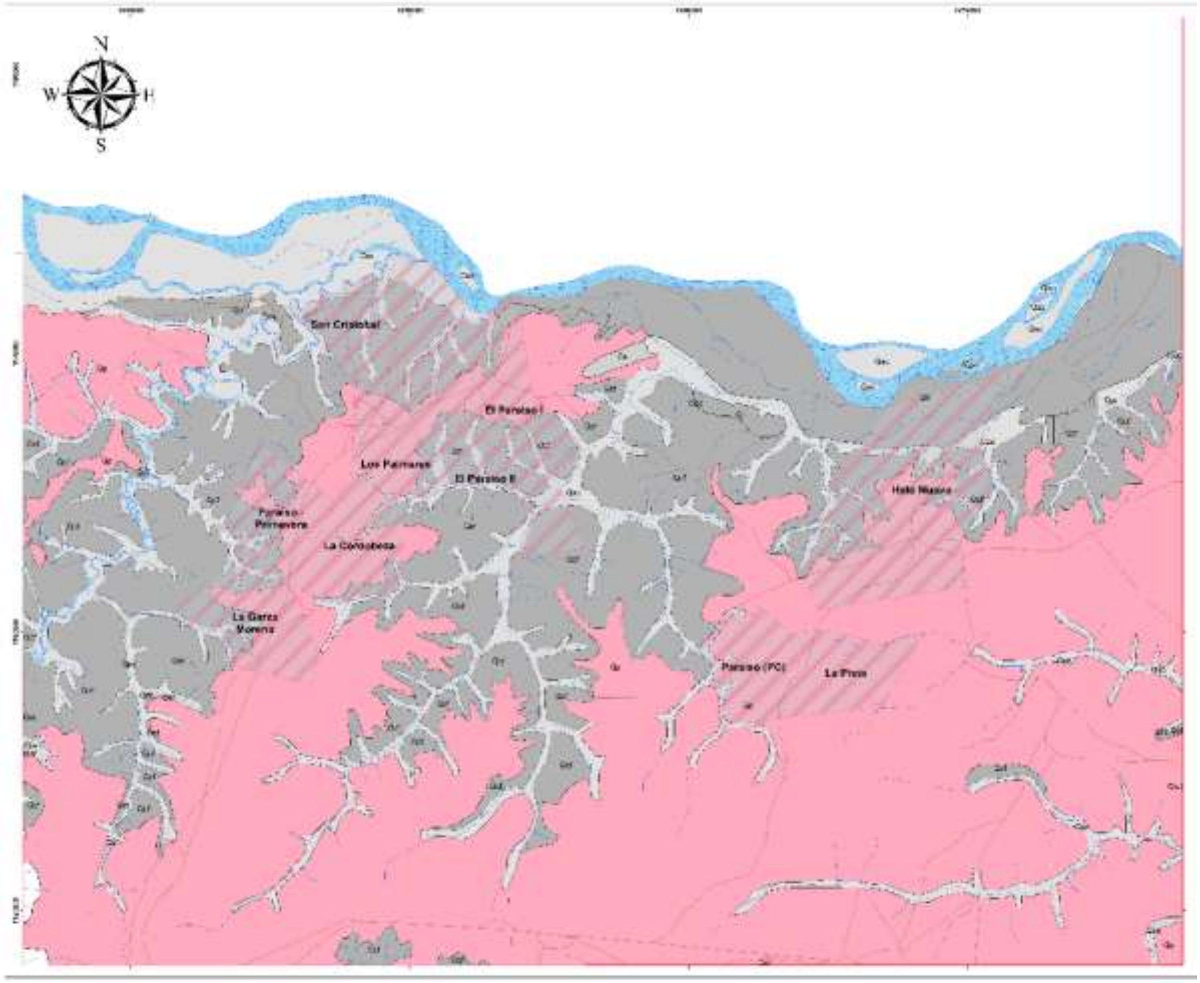
Premises	Geological Units
Cuernavaca	Qp, Qcf
El barajuste	Qp, Qcf, Qac
El Comienzo	Qp, Qcf, Qac
El Paraíso I	Qp, Qcf, Qac, Qll
El Paraíso II	Qp, Qcf, Qac
El Toro	Qp, Qcf, Qac
El Triunfo	Qcf,Qac
Hato Nuevo	Qp, Qcf, Qac, Qll
La Cordobeza	Qp, Qcf, Qac
La Fe	Qcf, Qac
La Fortaleza	Qcf, Qac
La Garza Morena	Qp, Qcf, Qac
La josa	Qp, Qcf, Qac
La Pista	Qp
La Victoria	Qp, Qcf, Qac
Las Malvinas	Qp, Qcf, Qll
Llano Lindo	Qp, Qcf, Qac
Los Palmares	Qp, Qcf, Qac
Paraíso – Primavera	Qp, Qcf, Qac

Premises	Geological Units
San Cristóbal	Qca, Qcf
Tierradentro	Qp, Qcf, Qac

Source: (Valoración Economica Ambiental , 2017)

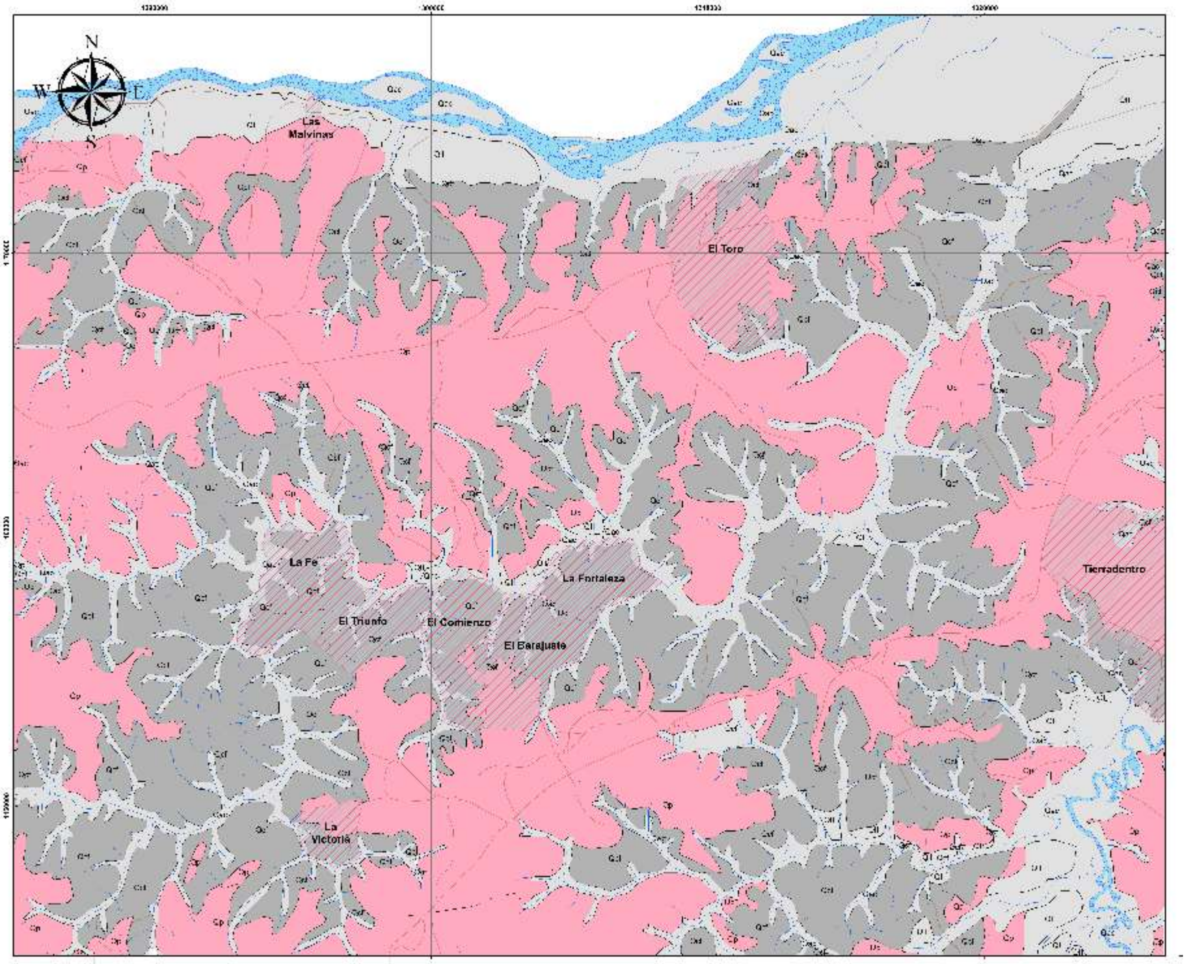
Units present at *Forestal de la Orinoquia*´s premises belong to the Quaternary Period.

Figure 4.10: Geological Map of Area A



Source: (Valoración Economica Ambiental , 2017)

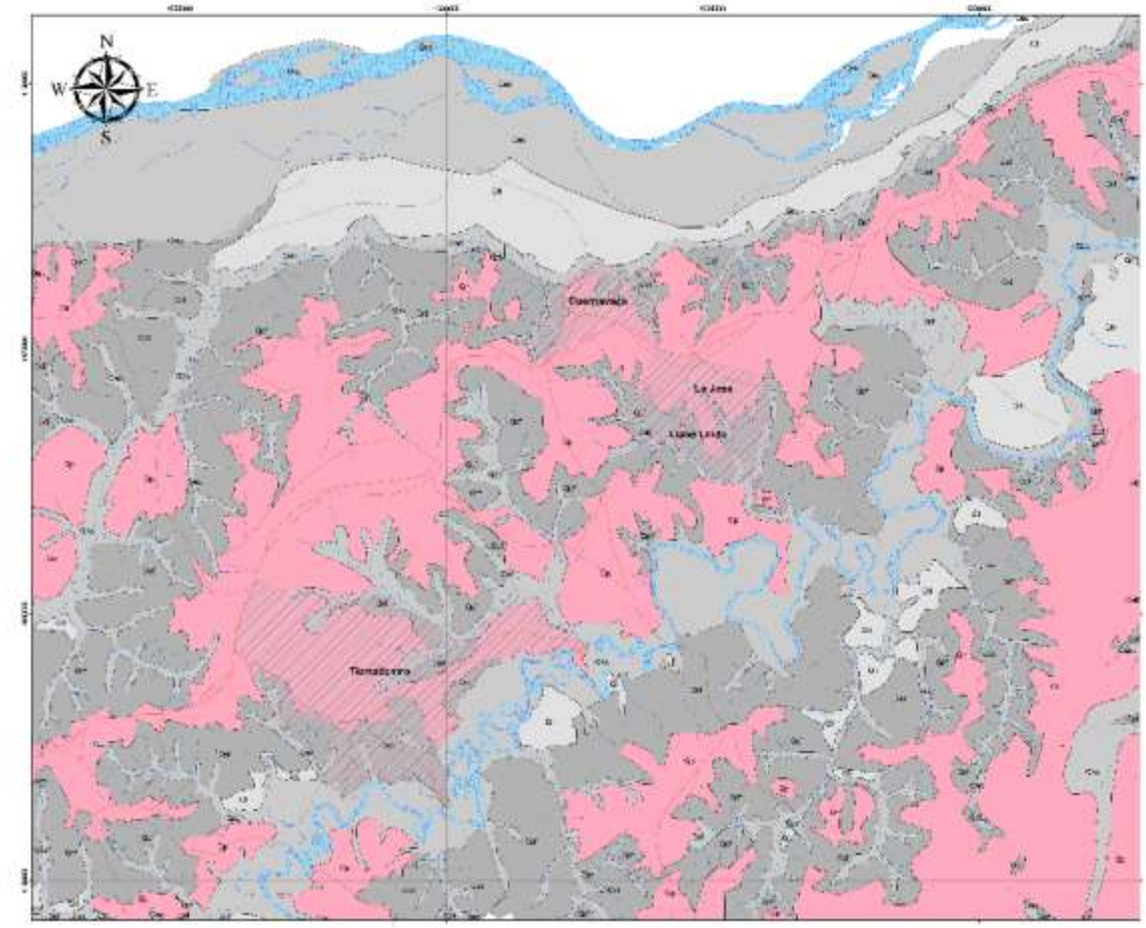
Figure 4.11: Geological Map of Area B.



Source: (Valoración Economica Ambiental , 2017)

Figure 4.12: Geological Map of Area C

Map of Area C



Source: (Valoración Economica Ambiental , 2017)

- **Ferruginous Crusts (Qcf)**

This unit is present in most of the premises and corresponds to corrugated peneplain sediments found near the dendritic-to-sub-dendritic drainages network, and in some sectors in the lower parts of the Inselberg (ancient granite bodies).

The weather conditions of the surveyed area are characterized by long winters and long summers, situation which directly influences the weathering and leaching of pre-existing rocks rich in mafic minerals and feldspars, thus leading to the deposition of ferruginous crests with high content of iron oxide, limonite, hematite and goethite type. The ferruginous crusts are associated with low zones of granite bedrock and with dissection areas of main and secondary surface drainage (rivers and streams). This unit corresponds to very hard welded masses with high concentration of iron, granular porous texture with characteristic ochre to reddish shades and in some sectors, it is found with kidney-shaped texture.

According to what was observed in the field, the ferruginous crusts present textural variations and different compositions, depending on the places where they crop out. The ferruginous crusts are mainly located in the rivers Bita and Meta and at the Juriepe stream in the northern sector of the surveyed area and they are comprised of fine-to-medium sandstones with sub-rounded, moderate selection lithic milky quartz showing kidney or botroydal shape with 0,2cm thick siltstone and hematite strips. Their thickness oscillates between 0.6 and 1,30m.

Figure 4.13: San Cristóbal Premise, Geological Units Qca, Qcf

Source: (Valoración Economica Ambiental , 2017)

Figure 4.14: El Paraíso I Premise, Geological Units Qp, Qcf

Source: (Valoración Economica Ambiental , 2017)

- **Recent Deposits (Qp):**

These recent deposits cover a large segment of the premises visited in the field. They correspond to a non-consolidated unit made up of mud-sand sediments with undetermined thickness and age, with colors that vary from light gray to brown yellowish in several facies fluvial continental environments forming vast savannahs with none or slight dissection which cover tertiary deposits and pre-Cambrian rocks located east of the area. Such sediments are mostly covered by “saeta”-type pastures and scarce bushes vegetation. In certain sectors the deposits are covered by sands brought by the wind.

Figure 4.15: Cuernavaca Premise, Geological Units Qp, Qcf

Source: (Valoración Economica Ambiental , 2017)

Alluvial Deposits:

❖ During field observations and image analyses two types of alluvial deposits were identified: flood plains and riverbed alluvial deposits.

- **Flood Plains' Deposits (Qll)**

This unit is found in 5 premises located nearby the Meta River and it corresponds to areas subject to constant flooding, especially in the winter. At the Bita River there are fine material sediments deposited in the valleys of the Orinoco and Meta rivers as well as in areas subject to constant flooding, mainly in the winter.

This unit hosts non-consolidated sediments with sand texture variations from fine- to-greyish clayey sands having high quartz content and low levels of feldspar and mafic minerals rich in organic material. For this reason they give way to soils that favor abundant development of bush-type topsoil that hosts minor species.

Figure 4.16: Malvinas Premise, Geological Units (QII)

Source: (Valoración Economica Ambiental , 2017)

- **Riverbed Alluvial Deposits (Qac)**

This variety is present in most of *Forestal de la Orinoquía's* premises and they correspond to non-consolidated sediments deposited in the beds of the Meta, Orinoco, Dagua and Bita rivers, forming sandbanks located in active beds (islands), riverbanks and local terraces. The existing material varies according to the dynamics and to the contribution of material, there being diverse textures and compositions.

In the sector of the Tierradentro premise on the Bita River silica sandbanks made up of very fine grain, good selection, rounded sand with low silt content are found.

The Meta River contains sandbanks within the active bed (islands) made up of greyish very fine sands with contribution of clay material and high concentration of iron oxides in the upper part.[11]

[11] Geological cartography and geochemical sampling of drawings 159, 160, 161, 179, 180 and 181 Puerto Carreño, Vichada

Figure 4.17: Prmise Cuernavaca, Geological Units QII

Source: (Valoración Economica Ambiental , 2017)

- ***STRUCURAL GEOLOGY (AII)***

REGIONAL STRUCTURAL GEOLOGY

The premises are located in the Llanos Orientales Basin in the East part of Colombia, bordering with the Barinas Basin at the northern part of Venezuela. The Serranía de La Macarena and the Arco del Vaupés to the South; and the Guaicáramo's fault system to the West and the Guyana Shield to the East. 1993).

The study of the *Forestal de la Orinoquia's* area is specifically developed in drawings 160, 161, 162, 180, 181 and 182 in the Department of Vichada.

LOCAL STRUCTURAL GEOLOGY (DIA)

At Forestal de la Orinoquia's premises there are no complex structural features; no material outcrops are evidenced that may require a deep analysis or supplementary studies; structural geology deals with the whole and the conditions of the land are referred to in the regional geology for the analysis of the Baseline.

❖ **Guidelines**

For the analysis of this Baseline study the previous bibliographic review is taken into account and the straight or nearly straight traits of topographic alignments that are visible in images of remote sensors, such as satellite images, aerial photographs or topographic maps are defined as guidelines. (Marshak & Mitra, 1988). Based on the information and analysis of satellite images, radar and topographic maps, linear features were identified showing varied predominant directions[12] From: * NW-SE * NE-SW, some E-W bound.

The above is related to the geomorphology of the land, taking as reference the array of first and second order drainages present in the area.

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[12] GEOLOGICAL CARTOGRAPHY AND GEOCHEMICAL SAMPLING OF DRAWINGS AS 159, 160, 161, 179, 180 Y 181 PUERTO CARREÑO, VICHADA

4.2.1.8 Geological Evolution

❖ **PRECAMBRIAN**

The surveyed area framed by drawings 160, 161, 162, 180 and 181 at a scale of 1:100.000 is located in the most Eastern sector of los Llanos Orientales Basin, region which makes part of the Amazonic Craton located towards the north of the South American Platform and represents one of the most cathodic bodies of the world.

According to the Colombian Lands Map (INGEOMINAS, 1983), the area has been defined as Terrain Meta, Vichada, Guaviare, mentioning first an accumulation of pelitic and samitic sediments of the beginning of the Proterozoic period which suffer metamorphosis during the Trans-Amazonic metamorphic phase (~1780m.a). The studies accomplished by Tassinary & Macambira (1999), propose a geotetonic evolution and summarized the geo-chronological control of the Amazonic Craton in 6 chronotectonic provinces based on the determination of ages derived from granite-bearing rocks and their metamorphic derivatives, as follows:

- Central Amazónica (CA): 2200 at 1950 M.a.
- Ventuari – Tapajos (VT): 1950 at 1800 M.a.
- Río Negro – Jurena (RNJ): 1800 at 1550 M.a, in turn divided into RíoNegro (RNP) – 1860 at 1520 M.a. and Rondonia – Jurena – 1760 at 1470 M.a.
- Rodiniense – San Ignacio (Ro): 1500 at 1300 M.a.
- Sunsás (SS): 1250 at 1000 M.a.

The Amazonic Craton comprises an area of 4400 million Km2. According to (Cordani et. al., 2009), its formation started approximately 3100 m.a when the Carajas-Imataca province was developed (3,1G.a-2,53G.a). According to Santos et. al (2000), it is associated with the Aroan tecto-metamorphic event. Tassinari et. al (1996), stated that this craton was formed during the Arqueano period when the micro-continents agglutination occurred, forming paleoproterozoic orogenic belts. According to several authors the most ancient exposed rocks in the Colombian Amazon region make part of the Rio Negro Province (Santos et al., 2006) of the Guyana Shield and correspond to an old continental magmatic arc due to a subduction of the ocean crust under the western bank of the province (Rogers & Santos, 2002; Zhao et al., 2004). The isotopic dating of these rocks have given a dispersion of ages between 1.8 G.a. y 1.55 G.a. Such subduction phase originated a plutonism which is evidenced in the Rio Negro Province due to occurrence of the Parguense magmatic event with the most recent ages of 1.52 G.a. (Priem et al., 1982; Kroonenberg, 1982; Toussaint, 1993), giving rise to rapakivi granitic intrusive bodies of the Gaudette & Olszewski of the Parguaza Intrusive Suite (1985). The Parguaza Intrusive Suite in Colombia and Venezuela may be correlated with Granitoids of the Içana y Uaupés Intrusive Suites and with the Gabroic Complex of Tapuruquara in Brasil.

According to Gaudette (1978 in González and Pinto, 1989), the precambrian rocks exposed in the western edge of the Guyana Shield present a Rb/Sr age of 1550 M.a and a U/Pb of 1545 ± 20 M.a. (medium Proterozoic) Gaudette (1978 in Buenaventura and Rosas, 1988) at Venezuelan territory, which locates them within the Rio Negro and Sunsás Province. Such plutonic event is represented in the Orinoco River strip both, in the Colombian side and in Venezuela. The Parguaza granite batholith presents an absolute age between 1590m.a and 1545m.a, through the U/Pb method, which evidences that it occurred during the Parguazensis event (1,8Ga – 1,5Ga). Such body is the most ancient one near to the area, and it was formed as of bimodal magmas due to partial fusion of the continental crust (intraplates). It is an anorogenic granite of the Mesoproterozoic age, intruded through very deep faults due to the formation of a rifting during the rupture of the Atlantida paleocontinent, exhibiting tension-type nature. It is worthwhile pointing out that granites have been found and have been interpreted as magmatic arc type in environments having an approximate age of 1800 m.a; hence, it may be estimated that there was a change of a compressional environment during the accretion of provinces to a tensional environment during the separation of the Atlantica supercontinent (Columbia). It could be said that the Parguaza Batholith is associated with the Suapure-Malaca Rift, contained in Toussaint's work, 1993.

In the case of the Meta-sandstones of Cerro El Carajo (Pεm?) defined by González and Pinto (1989), they are correlationable according to Petzal et. al (1974 in McCandless (1961 in Stratigraphic Lexicon of Venezuela,) the type section of which is found in Galeras de Cinaruco (Apure State) and it extends to Cinaruco in the right bank of the Orinoco River until the Villacoa River (Bolivar State), comprising locally ferruginous and partly sericitic compact quartzites with minor proportion of intra-formational conglomerates of sericitic shales which transitionally pass to the upper part of the conglomerates wherein they interstratified forming a phyllites matrix, sometimes hematitic-sericitic. These amply folded rocks result from low grade metamorphosis and clastic deformation with only partial recrystallization or quartz sand and compact quartzite conglomerates with crossed stratification and extensive varied proportions of locally ferruginous sericitic cement. McCandless (1965 in Stratigraphic Lexicon of Venezuela) mentioned lenticular concentrations of iron oxides.

Notwithstanding, according to what was observed in the field and to the lithological characteristics of the exposed rocks, such unit may by correlated with the Mataui formation described by A. R. Reid, 1974, belonging to the Roraima group defined as follows: "essentially consisting of fine grain ortho-quartzites, either white, beige or pink. The sand grains range from sub-rounded to sub-angular. The sandstones are presented as 1 meter thick strata and may be laterally traced for about 500 to 600 meters. Crossed stratification is common 250 meters above the base, while in the bottom the unit is absent. The top of the unit presents scarce silicification, which makes the sandstones very brittle. In general, the sandstones of of the lower part of the Mataui Formation are well selected, whereas at the top they are rather poorly selected; these present abundant sedimentary structures, such as crossed stratification, parallel lamination and curling".

- **Evolution of the Roraima Group**

According to several authors and to what INGEOMINAS (2006) has stated in the document "Potential of Mineral Resources at the Colombian East Region", the settling of the sediments that conform the protolith of successions corresponding to the Roraima Subgroup and to the "like Roraima" formations (i.e. the Tunuí Group) are within the same context (Brito, 2002; Santos et al., 2003). The cortical extension provokes the thinning of the continental crust, generating rifting due to lystric faults (Costa & Hasui, 1992; Stern, 2002; Ernst & Buchan, 2003). The final result is the cortical thinning and the formation of settling basins that will the filled by igneous material in or about the surface (Bosworth, 1987; Costa & Hasui, 1992), to which doleritic dikes, sills, tobas and/or sills, tuffs and/or basaltic, trachitic, riolitic flows and associated pyroclastites are associated. (Hess,1989). Since the Roraima Supergroup strata represent deposition events occurred in the Guyana Shield (Santos et al., 2003), it may be concluded that the extension affected the entire Guyana Shield. (Brito, 2002).

- **CRETACIC PERIOD**

Throughout the Cretacic period, the Colombian East was affected by distentioning tectonic phenomena and by a subsidence that allowed depositing epicontinental marine sedimentation within a rather calm environment. (Etayo- Serna et al., 1976; GEOTEC, 1993). As of Fabre's work (1984), the geodynamic evolution of Colombian East is divided into two large periods, A distension period during which important movements were produced due to normal type faults which limited horsts y grabens, and during which sedimentation was marked by rapid longitudinal and transverse facies and thicknesses changes; and then, as of Albiano, a slow cooling period of the lithosphere began without faults movement, allowing regional thermal subsidence that affected the set of the Andean East and the most western part of los Llanos Orientales.

- **PALEOGENE – NEOGENE PERIOD**

In the Paleogene-Neogene period, the beds of the Meta and Orinoco Rivers were different from what they are today (Hoorn et. al., 1995). For the Late Oligocene, the drainages coming from the Central Mountain Range and from the Amazonic Craton formed a Paleo-Orinoco the bed of which was more to the West than what it is at present, and its mouth was in the Maracaibo Gulf. This leads to think that there could have been a slight westward tilting in the worked area. The current course was acquired between the end of the Mioce ne and the Holocene, after the rising of the East Mountain Range in Colombia and Los Andes in Venezuela.

- **QUATERNARY**

Most of the area is associated with Young sediments defined as units of the quaternary period and described as irregular layers of ferruginous crusts and sandstones with iron content. These ferruginous crusts are considered as the mark of an ancient fluctuating level of the water table, possibly as a lagoon environment, deposited by shallow currents and sub-aerial exposure, which caused the formation of ferruginous crusts en their surface starting with iron in suspension that were precipitated and cemented.

The cover of recent deposits is due to fluctuations of the main drainages level in the area, such as those resulting from the Meta and Bita rivers and the Muco creek, the Chiquichaque stream, and the Juriepe stream, all of which extend the edges of their beds at flooding times and deposit sediments in the flooded plains, likewise leaving bars of deposits in low-tide areas.

4.2.2 Geomorphology

Geomorphology is centered in geoforms of the land derived from the interaction of factors that wear erosional surfaces, or accumulate sediments to form new landscapes, as well as the morphodynamic process surveys that also model the landscape. The methodology for the characterization of the environmental baseline of interest for *FFC* includes, in geomorphological terms, the definition of geomorphological units derived from the inherent conditions of the premises related to geoforms, morphogenesis, morphography, morphodynamics and morfostructures. Within the geomorphologic analysis process, the properties were visited from September 10 to September 18, 2017. We accomplished inspection of the land and reviewed the geomorphological data. The main source of information for the geomorphologic surveys corresponds to the general guidelines established by the Colombian Geological Service. Previous surveys are also included, such as technical and scientific reports, and we also accomplished a revision of the data existing in different entities (IGAC, INGEOMINAS, UNAL, etc..). As fundamental grounds in search of primary information, we adopted the parameter of image coverage given by different remote sensors that exist at the IGAC images Bank, such as Radarsat-1, Landsat and SPOT. Such images were processed using the ArcGIS program, implementing the band combination method in false color; images were overlapped through synergism (radar and landsat images) with the purpose of delimiting and describing different expressions of the landscape, types of relief and morphogenetic environments.

The Vichada Department, and particularly the drawings used for this survey, mostly deal with the Bita River basin, which in turn includes the Meta River basin in the North, and the Tomo River basin in the South. In the East it borders with the Eastern part of the Orinoco River. Several types of landscapes were identified in accordance with the predominant characteristics, which are pointed out both, for their morphological contrast, and for their extension. Herein below we are identifying the most standing out landscapes: 1) The Plateau or alluvial plain flooded by the Meta and Bita Rivers. On these strips there are different active riverbeds or courses that in whole form a twisted pattern for the Meta River and in some sections a meandering pattern for the Bita River. The strip that comprises alluvions associated with active beds of large rivers, such as the Orinoco, Meta and Bita Rivers 2) The vast plateau or alluvial plain that receives floods from main sources, such as the Orinoco, Meta and Bita Rivers, which generally presents low and flat relief, almost always floodable; 3) The Orinoquia's high plateau, (well drained), that presents different dissection stages which vary from very dissected, slightly dissected and non-dissected; 4) The relicts of the Guyana Shield which are represented by a series of isolated hills that protrude over the high plateau, mostly known as inselbergs o isle hills that form part of the peneplain landscape which is better developed on both banks of the Orinoco River but more developed towards Venezuelan territory.

4.2.2.1 Analysis of the Processes Evolution

MORPHODYNAMIC (MULTITEMPORARITY)

Within the survey for *Forestal de la Orinoquia*, we conducted an analysis of the evolution of morphodynamic or instability processes, allowing to know their dynamics and to provide tools for its future management in accordance with the requirements and needs of the company at the time of accomplishing any activity for the benefit of the project and of the environment where it is developed.

The morphogenetic units defined as of the geomorphological analysis are the lowest element in the geo-relief classification hierarchy. Such units have homogeneous characteristics both regarding form, and the morphogenesis and morphodynamics that affect them. Starting with the differentiation of these units, the morphodynamic processes occurring inside each of them are identified as passive or active forms that are differentiated according to the presence or absence of relevant morphodynamic processes. This exercise is initiated with interpretation of photographic images of several years, according to availability, and then, such images are represented in a map where they are overlapped to be able to identify the evolution of their features.

The activities to be conducted for this analysis are described below:

- Acquisition of available aerial photographs of the area under study, at an adequate or existing scale, based on consultations with the Instituto Agustín Codazzi (IGAC); the Cadastre Bureau of the Vichada Department; and the competent Regional Autonomous Corporation of the area (Corporinoquia), and *Forestal de la Orinoquia's own pictures*.
- Findings lead to selection of the aerial photographs to be used in multitemporal analyses, taking into account that to analyze the direct influence area, a scale of 1:50.000 is required, therefore looking for airlines that fly as close as possible and are able to provide the mentioned scale.
- Interpretation of aerial photographs of different times, making emphasis in cartography of morphodynamic processes and describing their characteristics. The processes to be taken into account are: sliding scar, active sliding, concentrated erosion (furrows and gullies), puddle formation, overgrazing, river banks scouring.
- Generation of morphodynamic processes maps overlapping different periods in order to visualize the progress or regression (given the case) of the morphodynamic processes throughout time.
- Overlapping the morphodynamic processes map with cartographic information of the sites intervened by the anthropic activity, especially by illegal mining exploitations.
- Based on the above, identify the influence of anthropic activities in the development, evolution or increase of the morphodynamic processes, making emphasis on the following activities: mining exploitation, construction of roads, earth fills, urban adaptations, among other interventions. This must be carried out thinking on the morphodynamic processes proficiency and the variability inherent to the natural regime that prevails in the sector.
- Prepare cartography on the morphodynamic processes map of the areas that have degraded or where the processes have accentuated due to unplanned anthropic intervention.
- Preparation of a report showing all the results informed as of this analysis including the other geomorphologic variables.

Record the land slopes after accomplishing the respective Land Digital Model. According to the cartographic base, this input is fundamental to define the Macro items and the geomorphological units, or the landscape. The used slope ranges correspond to those quoted within a range of 0 to 3 %.

4.2.2.2 Evaluation of sliding threat or mass movements.

The threat caused by mass movements is defined as the probability of fault, or by movement or sliding of the soils and rocks that are more superficial in the Project's area of influence.

Methodology used in this survey for probability estimates is based on the reliability theory, characterizing the variables that control speed, magnitude and extension of this natural phenomenon. The final product is a map containing diverse probability ranges due to failure of the surface materials.

The following variables are considered as input or entry data for the methodology: geology, geomorphology, erosion processes, land slope, direction of flow of surface currents, soil thicknesses, geotechnical parameters of the different weathering horizons, soil's humidity content, and seismic solicitations.

A. Procedure

- To evaluate the geology of the Survey area: demarcation of the rock types, geological structures, weathering profiles.
- To estimate basic geotechnical parameters: cohesion, friction angle, unit weight, embankment inclination angle and thickness of the analyzed soil.
- To estimate seismic considerations that involve the acceleration corresponding to the zone's design seism or to the type of project that is going to be built.
- To separate homogeneous areas considering the whole inputs stated in the preceding steps.

4.2.2.3 Revision of the geomorphologic data

The main information source for the geomorphologic surveys corresponds to the general guidelines established by the Colombian Geological Service. (*Servicio Geologico Colombiano)*. Previous studies are also includes, such as technical and scientific reports, thesis, graduation papers, articles among other, the surveys delivered by FFC are listed and as main information.

4.2.2.4 Field Inspection

Geomorphologically speaking, an inspection of the area of interest was accomplished in order to determine the conditions of the landscape, including erosion processes present in the land. The geomorphological conditions are related to the identification of superficial formations, weathering profiles and erosive processes, so as to define the colluvial deposits or residual soils that include unstable areas associated with active or potential mass-removal movements, or areas affected by intense lamination or concentrated erosion processes, furrows and gullies, or erosion that may affect stability.

Analysis of Remote Sensors.

The stereographic analyses carried out for the aerial photographs quoted in the analyses of morphodynamic processes evolution, and in the orthophotos (2005, 2011) are included in this activity. This activity results in the

4.2.2.5 Analysis of Remote Sensors

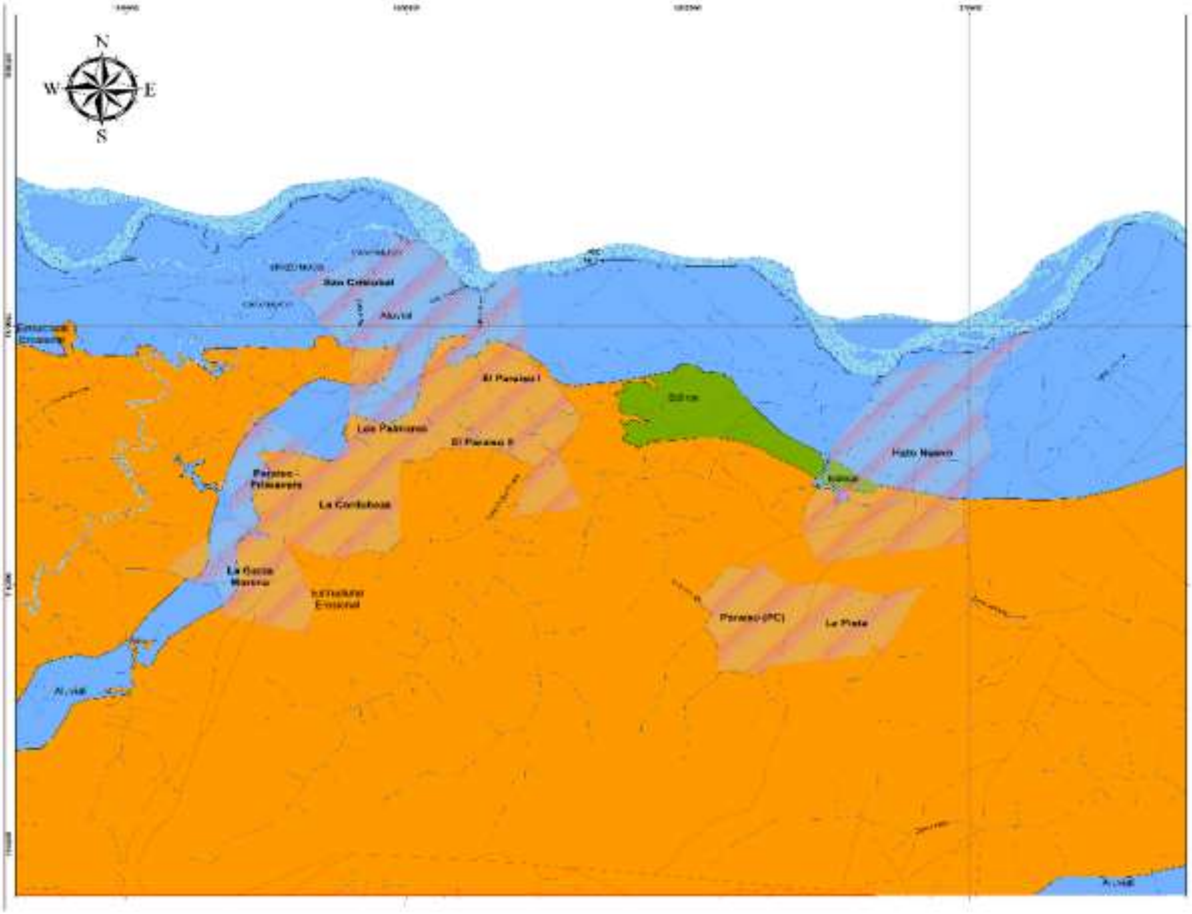
In this activity we include the analysis conducted for the aerial photographs mentioned in the morphodynamic processes evolution analysis and the orthophotos. The photomorphological cartography and the detailed mapping of the morphodynamic processes is derived from this activity.

4.2.2.6 Geographica Information Systems and Preparation of the Thematic Cartography

The preliminary cartographic and geomorphological data are cleaned-up, digitalized and integrated based on the geographic information systems (SIG, for its initials in Spanish).

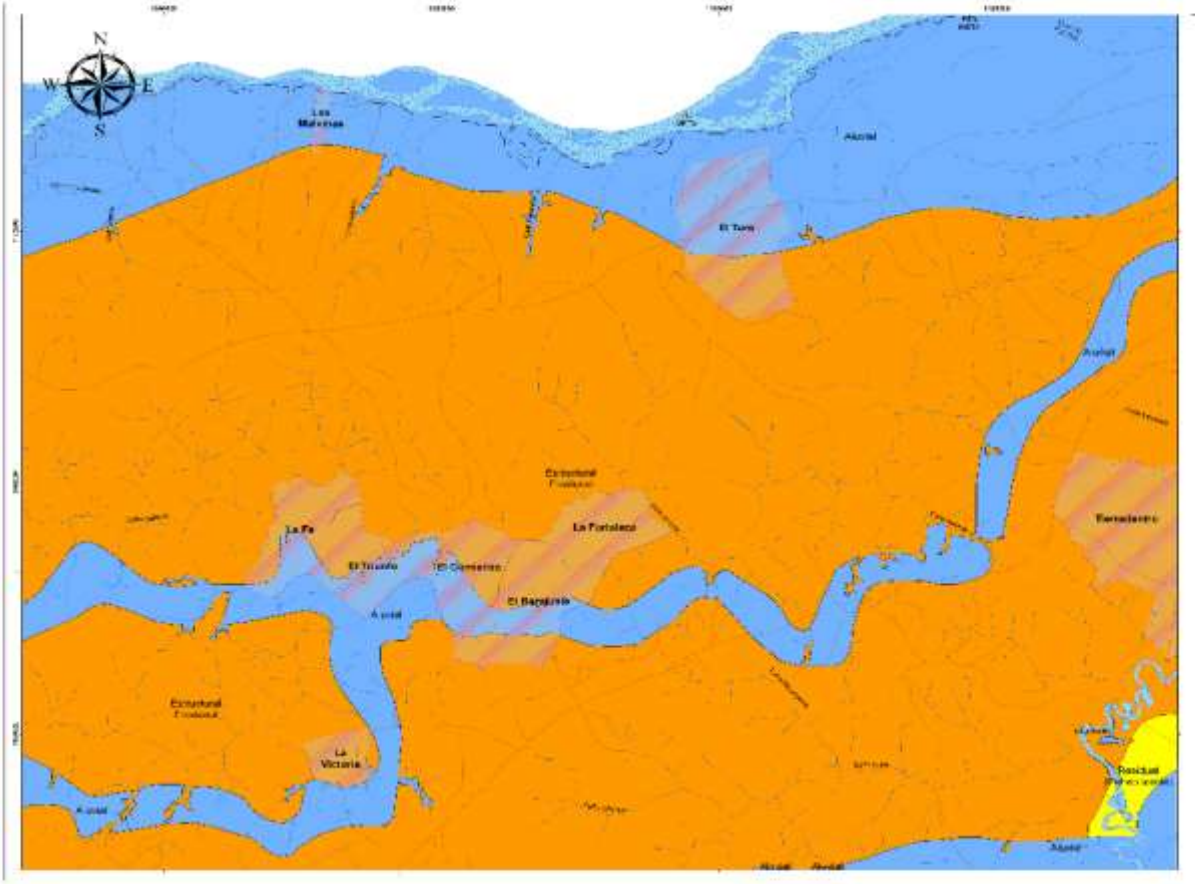
In addition, the map of land slopes is obtained in this activity after running the respective Terrain's Digital Model. According to the cartographic base, this input is fundamental to define both, the Macro, and the geomorphological units or the landscape. The embankment ranges used correspond to 0 to 3 %, where this values are synthesised, and the respective geomorphological unit to which they belong is shown.

Figure 4.18: Zone A Geomorphology



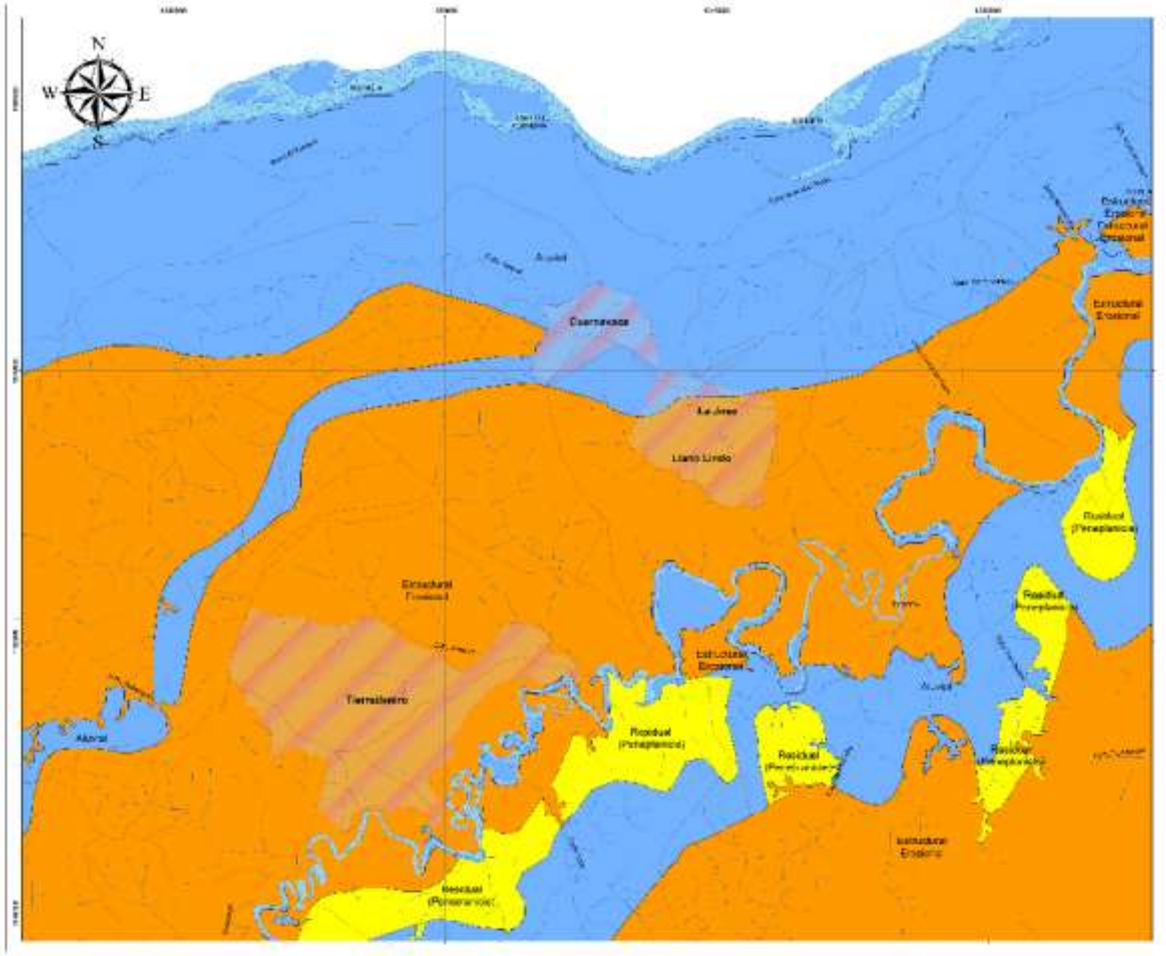
Source: (Valoración Economica Ambiental , 2017)

Figure 4.19: Zone B Geomorphology



Source: (Valoración Economica Ambiental , 2017)

Figure 4.20: Zone C Geomorphology



Source: (Valoración Economica Ambiental , 2017)

4.2.2.7 Morphogenetic Environments – Geomorphology (DIA)

During the process of interpretation of the remote sensor images LANDSAT and Radar, the different morphogenetic environments existing in the surveyed area could be identified and defined, either they are of exogenous or endogenous origin in the Survey area, including even the anthropic origin environments.

The area is influenced by geological and geomorphological processes associated with the origin and evolution of a vast low and plain area located between the Guyana Shield and the eastern flank of the Eastern mountain range, including the areas of the Orinoco, Meta and Bita river basins, where processes of different nature related with climate change occurred during the Pleistocene-Holocene period have taken place and are evidenced with the presence of sand banks brought by wind, ancient and sub-recent alluvial deposits and, above all, the presence of thick iron crusts located in the highlands.

There are also certain relicts of isolated hills developed on pericratonic granite-bearing rocks belonging to the Parguaza Rapakivi granite that extensively crop out in Venezuelan territory and continue towards Colombian territory on the left bank of the Orinoco River where it is expressed in isolated hills known as Inselbergs or island hills.
Within the main inspected environments in the survey area we identified those of Fluvial, Wind and Flooding origin.

4.2.2.8 Geomorphological Units of Fluvial and Colluvial-alluvial Origin[13]

On the Landsat- ETM and radarsat-1 images we may distinguish and differentiate several geomorphological units according to the presented contrasts, as per their origin. One of the most representative units of the region corresponds to the plateau or vast alluvial plain associated with the Meta and Bita Rivers. Small valleys located on the highlands are common and they are visible on such images, showing the presence of riparian forests along narrow and continuous small valleys.

- ***<u>Current Plateau or Alluvial Plain Associated with the Meta River</u>***

It includes more recent areas made up of alluvial sediments with less evolved soils and characteristics more associated with the dynamics of the branches associated with currents. This flooding alluvial plain which within the landscape of the general area generates the greatest density of sources and creeks also corresponds to the most floodable areas of the plateau. Locally it possesses accumulations brought by wind or dunes totally or partially buried by the most recent alluvial sediments.

[13] GEOLOGIC CARTOGRAPHY AND GEOCHEMICAL SAMPLING OF DRAWINGS 159, 160, 161, 179, 180 AND 181 PUERTO CARREÑO, VICHADA

Figure 4.21: San Cristóbal Premise, Alluvial Plain or Plateau Associated with the Meta River

Source: (Valoración Economica Ambiental, 2017)

- ***<u>Alluvial Plain or Plateau Associated with the Bita River</u>***

This unit corresponds to a variable amplitude alluvial plain according to the high, medium or low position of the basin; therein we see several interlinked or joined, continuous and stable sources. This plateau contrasts well with the environment occupied by the highlands. There is a clear differentiation between the geomorphological forms caused by alluvial deposition and their close relation to vegetation. Hence, in the photographs we note conspicuous riparian vegetation associated with dikes and aquifers or ground-water supplies of the rivers and their tributaries.

The flooding of these areas seems to be circumscribed to shallows and marshes resulting from rainwater and creeks that introduce water in winter, which does not find enough outlets to permanent courses; and occasionally flooding comes from areas of undulated topography riversides adjacent to main courses that overflow and cause flooding. The outcropping sediments are located in the Bita River Banks and are mainly made up of non-consolidated fine sand to slimy and clayey materials.

Figure 4.22: La Josa Plateau or Current Alluvial Plain Associated to the Meta River.

Source: (Valoración Economica Ambiental , 2017)

- ***NARROW VALLEYS OF ALLUVIAL-COLLUVIAL ORIGIN***

On the highlands area both, of the very dissected one, and of the less dissected, we may well appreciate the small and narrow valleys resulting from past dissection processes that are currently covered by long sections of riparian forests that have established there and still remain in such places.

- ***ALLUVIAL TERRACES***

This unit is associated with the two Banks of the Meta River, as a result of the erosion and sedimentation dynamics of the river. This unit is developed as being produced by the river sculpting processes within its own sediments.

- ***SANDBANKS WITHOUT VEGETAL COVERAGE***

Within the influence area of the Meta and Bita Rivers' active beds, there is a series of quartz-bearing sandbanks that have been deposited by the waters of such rivers during the rainy season. Such deposits have a pale or white shade in satellite images which contrasts with the blue color water and the red color vegetation associated with the alluvial plateau and the riparian forests that drain over the plain.

- ***WIND-ORIGIN GEOMORPHOLOGICAL UNITS***

The identified wind-origin units are located in the high plateau and are presented forming parabolic dunes several kilometers long and dozens of meters wide. There, we also find wind-origin deposits forming different thickness sand mantles that cover areas of the dissected and non-dissected high plateau, smoothing the surface, and are distinguished on images, since they appear with a pink color similar to the one of the parabolic dunes and the alluvions developed in the Meta and Bita active beds.

- ***PARABOLIC DUNES***

This unit corresponds to a series of sand deposits transported by wind and accumulated over the non-dissected plateau. The source of such deposits corresponds to alluvial sediments transported from the river beds and carried by the wind towards adjacent areas.

- ***DISPERSE SAND MANTLES TRANSPORTED BY WIND***

This unit has been discordantly deposited on different surfaces of the plateau, forming irregular pink spots which contrast with adjacent units located on non-dissected areas of the plateau.

- ***DENUDATIONAL ORIGIN GEOMORPHOLOGICAL UNITS***

The denudational origin units are developed on the Plateau corresponding to a relatively flat surface which has tectonically risen above the level of the current alluvial plain and which was subsequently affected by dissection processes in different degree, which in turn generate hilly undulated surfaces with a drainage development that varies between dense dendritic to sub-dendritic patterns. According to the field exploration, it corresponds to masses with high, soldered, competent concentrations of iron with granular porous texture and ochre to reddish tones. In certain sectors such deposits are kidney-shaped.

According to what was observed in the field and to what has been stated by several authors, such crusts are formed through leaching processes and through strong climate changes that occur in the area (long periods of summer and long periods of rain). The units within the area are located along the Bita River and the streams Juriepe, Juriepito, Caño Muco, Caño del Avión, Caño del Almorzadero, and their secondary and tertiary tributaries, and have lesser presence in the Meta river. It is worthwhile pointing out that this unit has been minimally affected by erosion and it is comprised of reddish, brown-to-ochre ferruginous crust horizons, mostly solid and others are nodular, gravel-type.

Figure 4.23: El Barajuste Premise, Current Alluvial Plateau associated with the Meta River

Source: (Valoración Economica Ambiental , 2017)

Differentiated geomorphological units on the plateau area may be classified in the following categories:

- **Iron Crusts and Layers**

Iron deposits having variable thickness layers according to their degree of alteration and position over the plateau. Such deposits are presented on the image that has been treated with a dark green algorithm.

- **Iron Crusts and Layers**

Iron deposits in partially altered and dissected layers of flat-to-undulated dissected relief. On the image treated with the algorithm they appear with a light green color.

- **Iron Crusts and Layers**

Very altered deposits represented by disperse iron gravel on the land surface. They present a Green -yellowish color on the image treated with the algorithm.

- **Very Dissected Plateau (DAmd)**

It corresponds to a series of areas characterized by presenting a dense dendritic pattern with short sections having the appearance of tree branches. In addition, a dissection patter is presented with different intensity degrees. In certain cases iron crusts are found in the sheer front of the dissection.

- **Flat-concave Dissected Plateau**

As opposed to the above, it is characterized by a more spaced and less dense drainage pattern developed on flat-concave surfaces which in certain cases may present lesser depressions which in the region are those called marshes.

- **Non-dissected Flat Plateau**

This unit of the non-dissected plateau presents a homogeneous flat surface that clearly contrasts with the dissected areas, allowing to separate it on the multispectral satellite images. In certain cases alluvial deposits are often found, together with wind-blown sands covering the iron crusts. Sporadically there are small wetlands.

- **Inselbergs or Island Hills**

This corresponds to a series of rocky outcrops that appear both, in Venezuelan and Colombian territory, belonging to the ancient Guyana Shield, which is made up of igneous rocks represented by the Parguaza granite that crops out on both Banks or the Orinoco River, especially around Puerto Carreño and on the left bank of the Orinoco River where they form a series of hills and slopes partially covered by quaternary deposits of fluvial and wing origin.

The premises area present different land characteristics that allow separating three geomorphological units: Hill islands (Inselbergs), Peneplaines forming Savannahs and Hills, and Systems of Alluvial Landscapes which were determined as of the field observations and the photo-geological analysis.

4.2.3 Soils

Based on the Terms of Reference for the characterization of the baseline for *Forestal de la Orinoquía*, the Methodology to submit Environmental Impact Surveys (MAVDT, 2010) and the Colombian Technical Standards for soil sampling (NTC 4113-1, NTC 4113-2, NTC 4113-3, NTC 4113-4 and ISO 10381-5) were followed to define the characteristics, borders and methodology for the soil study of the area of interest.

The soil survey objectives are: to determine the general quality of the soil regarding its natural and usage basic components; and to prepare soil maps for the area of interest. This sampling also provides legal back-up information for activities that affect this resource and require a baseline (NTC4113-1, 2007).

In this sense, the soil survey accomplished used as reference the Vichada Department Soils document prepared by the Instituto Geográfico Agustín Codazzi (IGAC), in 2014; according to the origin and evolution of the soils in the area, the soils are relatively young and have slightly evolved, so they could be designated as Entisols (young soils without development of horizons, generally fertile, with the exception of sandstones) and mainly Inceptisols (young soils with development of horizons and variable fertility).

4.2.3.1 Regional Cartographic Units (IIA)

The methodology was divided into two stages[14]:

[14] Geologial Cartography Geologica and Geochemical Sampling of Drawings 159, 160, 161, 179, 180 and 181 Puerto Carreño, Vichada

- The consultation of secondary sources, especially the "Soils General Survey and Zoning of Land in the Vichada Department" accomplished by the Instituto Geográfico Agustín Codazzi–IGAC- year 2014 (scala 1:100.000), as well as different land planning instruments of the Puerto Carreño and Primavera municipalities.
- Soil surveying in the areas under study (DIA), where physical characteristics were determined (depth, texture, structure, apparent density, infiltration, hydric features), as well as chemical characteristics (organic material, pH, nutrients, minerals) and biological characteristics (soil breathing), establishing correlation between results of the different sampled areas.

In accordance with IGAC (2010) the general objective of the soil surveys is to prepare an inventory and classification of the soil in order to know its distribution pattern and the land's capacity of use, to therefore be able to determine areas that may support the formulation of management policies and sustainable use of the resource, as well as the planning of agricultural, farming, forestry and environmental development.
For this survey, a detailed soil observation was defined for the DIA and a semi-detailed one for the IIA, which allowed to obtain data for biophysical zoning and allowed to cross this information with the one contained in the municipal land planning regulations.

- Association

The Association is a cartographic unit made up by several dominant soils (60% or more) and one or more inclusions of dissimilar soils, which added up should not represent more than 25%; it is a grouping of two, three or more different soils (each one belonging to a different taxonomic unit) but geographically related, in such a way that they may be separated in a more detailed survey.

- Consociation

Mapping cartographic unit comprised of a homogeneous population of soils, i.e. dominated by a single class of soils, with permissible inclusions of different soils which may not occupy more than 10%.

The dominant soil class occupies from 50 to 75% of the surface and it is the one that gives the name to the cartographic unit. Inclusions of similar soils within the same cartographic unit make the most important interpretations not be significantly affected.

- Complex

Cartographic unit containing two or more classes of soils, generally dissimilar, which are so intertwined that it is impossible to separate them even in a more detailed cartography, despite they present a space organization (distribution pattern) that fits in a certain logic.

For complete delimitation of a cartographic unit, the soil phases are also defined; they are a subdivision of a cartographic unit based on physical properties that were not considered in the taxonomic classification and define the use and management of the soils, and specially determine their potential use and are identified taking into account criteria concerning slope, erosion and flooding (either occasional or frequent), content of stones and/or rocks and depth.

Herein below we are describing the criteria of phases:

- Slope

Certain cartographic units present a small margin variation in the slopes; therefore it is convenient to subdivide the boundaries in accordance with the use and management needs of the respective soil. The gradient or inclination of the slope which is most observed in the premises is zero to three, with code unit A.

- Degree of Soil Erosion

One of the phenomena to take into account in soil mapping is erosion due to the effects it produces on the potential use of the soil and on the management practices required for maintaining it in production, or for recovering it. Differences in the degree of erosion found at the premises of the survey are slight-to-moderate, with 1 and 2 values.

- Flooding

It is used to indicate the occurrence of the event as such. It also applies to soils that, although artificially drained and protected by jarillones, at damp periods of strong and frequent rainfall, are affected by the "capillary rise" phenomenon which increases groundwater level up to the surface where flooding takes place. In most of the quoted premises there are soil units prone to be flooded due to their morphology. These units are represented by the letter i.

- Stone content in the surface

It indicates the presence of abundant fragments of different sizes of stones in the surface. On the name of the cartographic unit letter p is placed.

- Rock content

Where lying rocks cover 10% of the area, the rocky soil phase is identified with number 8.

- Depth

It is identified with letter s. It determines the depth until which the roots may explore the soil without physical or chemical obstacles. Soils are determined as shallow whenever their depth is under 50 centimeters, and as moderately deep whenever their depth is between 50 and 100 cm and they are considered deep whenever their depth exceeds 100 cm.

For a better understanding of the units present in the survey, it is assumed that the taxonomic components of the cartographic units take into account the subgroup as categorical level, wherein the following characteristics of the soils are considered: slope, source material, effective depth and its limitations, natural drainage, morphology, physical, chemical and mineral characteristics and the main parameters that determine its taxonomic classification. In addition, the general use and management restrictions are included in each of the soil classes.

Taking into account that the formation of the soil is the result of interaction factors such as: weather, relief, lithology, living beings and time, the results of such factors in the surveyed area established soils associated with: a) alluvial plateaus, made up by dykes and riversides, nappa overflow and terraces. b) concave and dissected peneplain, and marshes soils. c) Inselberg.

a) Soils Associated with Alluvial Plateaus[15]

Alluvial deposit areas with amplitudes that vary from 1 – 15 Km. having flat dissected relief suffer flooding in winter times. They are located along the Meta and Bita rivers and their respective attributes.

- Soils of Dykes and Riversides: areas subject to frequent floods, soils with coarse-to-fine textures, low-to-medium fertility.
- Nappa Overflow Soils: They are located at the rivers' nappa overflow and they are moderately-to-poorly drained and they have moderately coarse to fine textures. Such deposits are found in the surroundings of the Juriepe stream.
- Terraces Soils: These correspond to terraces located at the banks of the Meta River. They have flat relief made up by fine-to-medium textures of ancient alluvial sediments in advanced alteration conditions. Natural pastures.

b) Soils associated with peneplain

- Flat Peneplain Soils: They are located in the North part of the Meta River, and are made up by ancient alluvial material and they have flat relief with undulated micro-relieves.
- Concave Peneplain Soils: They correspond to vast shallows; the parental material is made up of alluvial deposits covered by a wind related thin layer. Such deposits are in an advanced alteration condition and hav medium textures.
- Dissected Peneplain Soils: They are complex surfaces with undulated-to strongly broken terrain, but with sectors of flat surfaces. Their characteristics depend on where they are located within the landscape. Such soils are evidenced in the surroundings of Curazao and nearby the Bita River.

c) Soils Associated with Inselber

The formation of these soils originate in meta-sedimentary rocks exposed in Cerro el Carajo; they appear in the lower part and are mainly made up by lateritic soils with abundant content of hyaline-to-milky quartz, with few development and located in sectors of the Inselberg.

4.2.3.2 Local Cartographic Units (DIA)

Following the field activities stated by *Forest First* and reckoning with available cartography, a field exploration was accomplished. Boundaries of the cartographic units were corroborated and soils' uniformity was verified with borehole and observations were made from September 10 to 18, 2017; and samples of 5 premises were collected for their respective analysis and development of results.

This field information also provided elements for the demarcation of the landscape proposed by Villota (1997)[16] using landscape, relief, weather and lithology units. This factor constituted the base for the final separation of the cartographic units and for the distribution of test pits inside the units.

Before taking samples in every site, the place was prepared acquiring verbal permits form the owners, verifying the security of the site and availability of materials. The tools and equipment used for the sampling consisted of

[15] GEOLOGICAL CARTOGRAPHY AND GEOCHEMICAL SAMPLING OF DRAWINGS 159, 160, 161, 179, 180 AND 181 PUERTO CARREÑO, VICHADA

[16] Villota, H. A new approach to the physiographic classification of the land. In: Magazine CIAF Vol. 15. No. 1 page 83-117. Santa Fe de Bogotá. 1997.

a drill, a rust-resisting trowel, shovels for manual excavation and taking of samples (NTC 4113-2). The field personnel included a Geologist, a field assistant and a worker to open the track.

Abiding by the previously established technical conditions, a protocol was followed for each sampling site. Then, large dimension test pits were opened to provide safe and professional conditions (a depth of at least 1,5 to 2 meters, and the width and length were usually of 1m x 1m, depending on th type and cohesion of the soil). The side of the test pit head was exposed to the sunlight. The extracted material was placed in the adjacent area, preventing it from falling into the bottom of the test pit, as well as to prevent crossed contamination. Furthermore, national regulations concerning safety established in standard NTC 4113-3 were complied with. After preparation of the test pit, the walls were carefully cleaned removing the material extracted from the soil in such a way that the horizon structures could be clearly seen, preventing standing on the pit shoulder.

Disturbed samplings of every horizon of interest were taken in every profile, from bottom to top, with a weight of approximately 1 Kg each, taking care of not mixing them.

Each sample taken for the different lab analysis was clearly and unequivocally marked with a label containing all the required information. This was done using adhesive labels taking precautions not to affect the sample since this may cause loss of data.

The receptacles used were White polyethylene bags which were protected and sealed in such a way that the samples would not deteriorate or loss any part of their content during transportation.
Upon arrival to their destination, the integrity and usefulness of the samples was verified in order to prevent errors due to confusion of the bags.

Laboratory analytic methods correspond to those established by the IGAC16 for soil analysis:

- pH: Water (1:1)
- Granulometry: Percentageof Sand, Clay and Silt (texture analysis): textural): Bouyoucos
- Porcentage of organic material (M.O)
- Calcium (Ca)
- Magnese (Mg)
- Potasium(K)
- Sodium (Na)
- Phosphorus (P)
- Borum (B)
- Iron (Fe)
- Maganese (Mn)
- Cupper (Cu)
- Zinc (Zn)
- Sulfur (S)
- Aluminium Content (Al)
- Electric Conductivity

These parameters were determined in the soils laboratory of Universidad Industrial de Santander, through analytic methods such as:

- Electrometric
- Colorimetric
- Atomic Adsorption

- Turbidimetric
- Extraction

<u>SOILS OF FORESTAL DE LA ORINOQUIA'S PREMISES (DIA)</u>

Table 4.8: Soils of Forestal de la Orinoquia's Premises (DIA)

PREMISES	SOILS
Cuernavaca	AVlai, AVBc1
El barajuste	AVlai, AVBc1
El Comienzo	AVlai, AVBc1
El Paraíso I	AVBc1, AVlai, SVAa, AVBd2
El Paraíso II	AVBc1, AVlai, SVAa, AVBd2
El Toro	AVlai, AVBc1
El Triunfo	AVlai, AVBc1
Hato Nuevo	AVlai, AVBc1
La Cordobeza	AVBc1, AVlai, SVAa, AVBd2
La Fe	AVlai, AVBc1
La Fortaleza	AVlai, AVBc1
La Garza Morena	AVBc1, AVlai, SVAa, AVBd2
La josa	AVHai, AVLai
La Pista	AVBc1, AVGae
La Victoria	AVlai, AVBc1
Las Malvinas	AVBc1, VVAai
Llano Lindo	AVHai, AVlai
Los Palmares	AVBc1, AVlai, SVAa, AVBd2
Paraíso (PC)	AVBc1, AVla1, AVBd2, AVGae
Paraíso – Primavera	AVBc1, AVlai, SVAa, AVBd2
San Cristóbal	AVBc1, AVlai, SVAa, AVBd2
Tierradentro	AVBc1, AVlai AVBd2

Source: (Valoración Economica Ambiental , 2017)

Table 4.9: Soils of Forestal de la Orinoquia's Premises (DIA)

PREMISES	SOILS
Cuernavaca	AVlai, AVBc1
El barajuste	AVlai, AVBc1
El Comienzo	AVlai, AVBc1
El Paraíso I	AVBc1, AVlai, SVAa, AVBd2
El Paraíso II	AVBc1, AVlai, SVAa, AVBd2
El Toro	AVlai, AVBc1
El Triunfo	AVlai, AVBc1
Hato Nuevo	AVlai, AVBc1
La Cordobeza	AVBc1, AVlai, SVAa, AVBd2
La Fe	AVlai, AVBc1

PREMISES	SOILS
La Fortaleza	AVIai, AVBc1
La Garza Morena	AVBc1, AVIai, SVAa, AVBd2
La josa	AVHai, AVLai
La Pista	AVBc1, AVGae
La Victoria	AVIai, AVBc1
Las Malvinas	AVBc1, VVAai
Llano Lindo	AVHai, AVIai
Los Palmares	AVBc1, AVIai, SVAa, AVBd2
Paraíso (PC)	AVBc1, AVIa1, AVBd2, AVGae
Paraíso – Primavera	AVBc1, AVIai, SVAa, AVBd2
San Cristóbal	AVBc1, AVIai, SVAa, AVBd2
Tierradentro	AVBc1, AVIai AVBd2

Source: (Valoración Economica Ambiental , 2017)

Table 4.10: Soils (DIA)

Soil Unit	Weather	Land-Scape	Type of Relief	Parental Material or Sediments	Soils Characteristics	Taxonomic Units			Cartographic Units		
						Taxonomic Classification	Modal Profile	%	Class	Symbol	Phases
AVBc1	Warm - Humid	Alluvial Valley	Flat - Flooding	Mixed Sediments resulting from the highlands.	Superficial, limited by water table and moderately deep, fine, moderately coarse and coarse textures, poorly and imperfectly drained, frequent flooding and forming of ponds, high aluminum saturation, very strong acid reaction, very low and low natural fertility.	Fluvaquentic Endoaquepts Oxyaquic Humudepts Typic Udipsamments Oxyaquic Udorthents	PV-08 VM-28 VC-25 VM-17	40 25 25 10	Association	VVB	ai
AVBd2		Highlands (Plateau)	Hills	Alterites of tertiary sedimentary rocks and clayey sand sediments with presence of petroferric gravel layers of different thicknesses and locally	Deep and very superficial, limited by high content of petroferric gravel and coarse to moderately coarse texture horizons, good and moderately excessive drainage; high, and very high aluminum	Plinthic Kandiustults Typic Kandiustults Typic Haplustox Petroferric Haplustox	VC-23 VC-26 VC-77 VC-80 VC-83 VC-22 VC-33 CT-05 LV-02 VC-36 VC-75	35 35 20 10	Complex	AVB	b b1 c1 c2 d2 d3

Soil Unit	Weather	Land-Scape	Type of Relief	Parental Material or Sediments	Soils Characteristics	Taxonomic Units			Cartographic Units		
						Taxonomic Classification	Modal Profile	%	Class	Symbol	Phases
				petroferric Armor	saturation, very strongly acid reaction and very low natural fertility						
AVlai			Small valleys	Clayey and Sandy Alluvial-colluvial Sediments coming from materials of the plateau.	Superficial and moderately deep, limited by water table, moderately coarse textures, poorly and imperfectly drained, with prolonged flooding in winter; high and very high aluminum saturation; moderate strong, very strong and extremely acid reaction and low and very low fertility.	Oxyaquic Udifluvents Aquic Udorthents Plinthic Haplaquox	GU-13 CT-08 LV-09 VC-78	GU-13 CT-08 LV-09 VC-78	Complejo	AVI	ai

Soil Unit	Weather	Land-Scape	Type of Relief	Parental Material or Sediments	Soils Characteristics	Taxonomic Units			Cartographic Units		
						Taxonomic Classification	Modal Profile	%	Class	Symbol	Phases
AVGaz			Depressions	Clay and silt deposits with variable content of organic matter.	Very superficial and superficial, limited by water table, and moderately deep limited by petroferric gravel, moderately fine textures; well, imperfect and poorly drained, with long and very long frequent formation of ponds; very high aluminum saturation, strongly acid reaction and very low natural fertility.	Typic Humaquepts Typic Haplaquox Oxyaquic Haplustox Oxyaquic Humustepts Fluventic Dystrustepts	VC-17 NA-08 VC-86 VC-67 VC-05 VC-14 NA-09	35 30 20 10 5	Complejo	AVG	az ay
AVHa			Depressions	Deposits of mixed materials an organic matter.	Superficial, limited by water table, moderately fine textures, poorly drained; short to very long flooding, occasional and long formation of ponds; high aluminum saturation; strongly	Typic Humaquepts Fluvaquentic Humaquepts Plinthic Kandiaquults	VC-29 VC-10 NA-07 VC-76	70 20 10	Consociation	AVH	ai

Soil Unit	Weather	Land-Scape	Type of Relief	Parental Material or Sediments	Soils Characteristics	Taxonomic Units			Cartographic Units		
						Taxonomic Classification	Modal Profile	%	Class	Symbol	Phases
					acid reaction and low natural fertility						
SVAa			Peneplains	Deposits of Disaggregation materials originating in the Guyana Shield; mainly concave plain relief sands.	Moderatelydeep, coarse textures, imperfectly drained; moderate aluminum saturations, strongly acid, low natural fertility	Oxyaquic Udipsamments	VC-68	95	Consociation	SVB	az
VVAai		Alluvial Valley	Flat – Flooding	Mixed Sediments coming from the highland (plateau)	Superficial, limited by water table and moderately deep, fine, moderately coarse, and coarse textures, poor and imperfectly drained, frequent flooding or forming of ponds, high aluminum saturation, very strong acid reaction, very low	Fluvaquentic Endoaquepts Oxyaquic Humudepts Typic Udipsamments Oxyaquic Udorthents	PV-08 VM-28 VC-25 VM-17	40 25 25 10	Asociación	VVB	ai

Soil Unit	Weather	Land-Scape	Type of Relief	Parental Material or Sediments	Soils Characteristics	Taxonomic Units			Cartographic Units		
						Taxonomic Classification	Modal Profile	%	Class	Symbol	Phases
					and low natural fertility						

Source: (Valoración Economica Ambiental , 2017)

In accordance with what was written above, a total of 5 samples were collected and an equal number of test pits were made to characterize and correlate the existing information with the data compiled in the field.

Table 4.11: Test Pits and Samples - Forestal de la Orinoquia's Properties

Premise	Samples' Code	Area
San Cristobal	17 – 0859	1294
Malvinas	17 – 0860	110,7
Hato Nuevo	17 – 0861	2914,8
El Barajuste	17 – 0862	1217,5
Garza Morena	17 – 0863	1293,7

Source: (Valoración Economica Ambiental , 2017)

Table 4.12: Results of the Lab Analyses

Soil Analyses Results																				
Code - M	**PH**	**% C**	**P (ppm)**	**Ca**	**Mg**	**Na**	**K**	**Al**	**Sand %**	**Silt %**	**Clay %**	**Texture**	**B**	**Fe**	**Mn**	**Cu**	**Zn**	**S**	**CIC**	**CE**
17 – 0859	5,7	0,2	4,85	0,6	0,12	0,08	0,01	N/A	24	64	12	F-Silty	0,08	52	0	0,29	0,04	1,68	4	0,03
17 – 0860	5,4	0,3	3,98	0,5	0,12	0,08	0,06	0,8	36	44	20	Clear	0,06	11,3	1,3	0,8	0,15	1	3,8	0,03
17 – 0861	4,7	0,3	6,3	0,5	0,11	0,07	0,01	1,2	50	34	16	Clear	0,08	19	0,6	0,28	0,14	2,4	5,8	0,03
17 – 0862	5,7	0,5	8,47	0,5	0,11	0,07	0,02	N/A	34	6	20	Clear	0,09	5,4	0,1	0,38	0,17	6,01	6	0,02
17 – 0863	0,5	0,3	3,26	0,5	0,12	0,1	0,03	0,6	36	52	12	F-Silty	0,06	28,8	0,2	0,37	0,09	1,68	5,4	0,03

Source: (Valoración Economica Ambiental , 2017)

The results of the samples that were used for the description of the soils and their correlation with previous surveys are presented.

For the calculation of the fertility index, the cationic exchange capacity data are required, together with the percentage of organic carbon, total bases, reaction, salinity and alkalinity. (IGAC, 2007)[17]

[17] For the calculation of the fertility index, cationic exchange capacity date are required, together with the percentage of organic carbon, total bases, reaction, salinity and alkalinity (IGAC, 2007)1

- **San Cristóbal Premise: (AVA)**

Figure 4.24: Soil of San Cristóbal Premise

Source: (Valoración Economica Ambiental , 2017)

This type of soil corresponds to the life area of the tropical rainforest (bs-T). Soils have been developed as of very weathered fine deposits with low content of sand and silt; they are deep and well drained.

The association[18] is integrated by the soils Xanthic Haplustox (40%), Typic Kandiustults (20%), Oxyaquic Humustepts (20%) and there are inclusions of the following soils Plinthic Kandiustults (5%), Fluvaquentic Humaquepts (5%), Typic Ustifluvents (5%) and Typic Acrustox (5%).

In small quantities there are other similar soils: Oxic Dystrudepts (VC-28, VC-01), Acrustoxic Kantiustults (CT-03) and Inceptic Haplustox (VC-08).

The unit has two phases:

- AVAa: flat phase, slope 0-3%.
- AVAa1: plat phase, slope 0-3%, slightly eroded.

18 General Survey of Soils and Zoning of Land in the Department of Vichada

The lab analyses indicate that the soils have a medium real density, low bulk density and total low porosity.

These soils are of high pedogenetic evolution, characterized by having an ocric epipedon and a kandic endopedon, Ustic moisture regime and very low cationic exchange capacity, aspects which allowed classifying them as Typic Kandiustults.

The restrictions these soils present for their use and Management are related to low natural fertility, lack of phosphorous, low total bases, high saturation of aluminum and susceptibility to hydric erosion.

- **Malvinas Premise: (AVB)**

Figure 4.25: Soil of the Malvinas Premise

Source: (Valoración Economica Ambiental , 2017)

It has slight to strongly undulated relief and has the characteristic vegetation of life in a dry tropical forest. (bs-T).

Soils have been developed as of alterites of sedimentary rocks and as of clayey-sandy tertiary sediments; they are deep and well drained. There is erosion in a slight to severe extent.

The complex is made up by soils Plinthic Kandiustults (35%), Typic Kandiustults (35%) and Typic Haplustox (20%); there are inclusions of soils Petroferric Haplustox (10%). In small quantities a similar soil Plinthic Haplustox (VC-35) is found

- AVBc1: moderately undulated, slopes 7-12%, lightly eroded.

These soils are mainly located in the top of the plateau hills; were brought about from clayey-sandy tertiary sediments, with presence of petroferric gravel layers of different thicknesses and local petroferric plates. They are very superficial soils limited by iron concretions, well drained, with moderately fine textures.

The profile of this soil type has a few organic material. Such soils are mainly located in the hills of the plain; they have originated as of clayey-sandy tertiary sediments, with presence of petroferric gravel layers of different thicknesses and local petroferric plates. They are very superficial soils limited by iron concretions, well drained, with moderately fine textures.

These soils are highly evolved and they are characterized by having ochric epipedon, kandic endopedon, very low saturation of bases, Ustic moisture regime and medium cationic exchange capacity. Therefore, they were classified as Plinthic Kandiustults.

- **Hato Nuevo Premise: (AVB)**

Figure 4.26: Soil of the Hato Nuevo Premise

Source: (Valoración Economica Ambiental , 2017)

Soils have been developed as of sedimentary rock alterites and of clayey-sand tertiary sediments; they are deep and well drained; mild to severe erosion is present.
The complex comprises Plinthic Kandiustults (35%), Typic Kandiustults (35%) and Typic Haplustox (20%) soils; and there are inclusions of Petroferric Haplustox (10%) soils.

In small quantities there is the Plinthic Haplustox (VC-35) similar soil.

- AVBb1: Slightly undulated, Slope 3-7%, mild erosion.

These soils are mainly located in the hills of the plain; they have originated from clayey-sandy tertiary sediments; they are excessively drained deep soils with moderately coarse textures.

Morphologically they present profiles with a horizons sequence A-Bw-Bto. Horizon A, 16 cm thick is dark brown, clear sand texture and without structure (loose). Horizon Bw is of a strong brown color, clear sand texture and without structure (loose). Horizon Bto is of strong brown color, clear sand structure and structure in fine and medium angular blocks with weak development.

These soils are of high pedogenetic evolution and are characterized by having ochric epipedon, kandic endopedon, low bases saturation, Ustic moisture regime and very low cationic exchange capacity, characteristics which allowed classifying them as Typic Kandiustults.

The use and Management restrictions presented by these soils are related to low natural fertility, very low total bases, poor phosphorus content, low retention of moisture and susceptibility to hydric erosion.

- **El Barajuste Premise: (AVI)**

Figure 4.27: Soil of El Barajuste Premise

Source: (Valoración Economica Ambiental , 2017)

This unit is defined by the course of the streams that drain the plain; the soils were originated as of clayey and sandy alluvial-colluvial sediments coming from materials of the plain; it has flat relief and slopes under 3%.

The Complex is made up by the following soils: Fluvaquentic Humaquepts (30%) – Oxyaquic Udifluvents (30%) - Aquic Udorthents (30%) and 10% of Plinthic Haplaquox soil inclusions.

The unit has the phase shown below:

- AVHai: Flat phase, floodable, 0-3% slopes.

These soils are mainly located in the top of the Peneplain convexities having slopes under 7%; and they have originated as of Sandy deposits; they are deep, well drained and with moderately coarse textures.

Garza Morena Premise: (AVB)

Figure 4.28: Garza Morena's Soil

Source: (Valoración Economica Ambiental , 2017)

The soils have developed as of sedimentary rock alterites and as of clayey-sandy tertiary sediments; they are well drained and deep. Mild to severe erosion is present.

The Complex is made up of the following soils: Plinthic Kandiustults (35%), Typic Kandiustults (35%) and Typic Haplustox (20%); there are inclusions of Petroferric Haplustox soils.(10%).

In small quantities the similar soil Plinthic Haplustox is present.

- AVBd2: strongly undulated with moderately eroded 12-25% slopes.

These soils are located in the upper part of the hillside; they have originated from fine sediments of the Tertiary; they are deep, well drained and with moderately fine textures.

These soils are of high pedogenetic evolution and have ochric epipedon, oxyc endopedon, very low bases saturation, Ustic moisture regime and low capacity of cationic exchange. Such characteristics allowed classifying them as Typic Haplustox.

The use and management restrictions presented by these soils are related to low natural fertility, low bases saturation, low total bases, poor phosphorus content, high aluminum saturation and susceptibility of suffering hydric erosion.

4.2.4 Current Use of the Soil

In order to determine the current use of the soil, the basic information was taken from the land cover map prepared based in nomenclature CLC Colombia (Corine Land Cover, 2010), scale 1:25.000, orthophoto designed (2011) and the map used at present prepared in the Soils and Zoning General Survey of Land within the Department of Vichada accomplished by the IGAC in 2014. This information was complemented with the field exploration.

- Slope: 0 – 3%
- Erosion: Moderate to Severe
- Effective Depth: Superficial (25 to 50 centimeters)
- Natural Drainage: Well drained.

Based on the above indicators, highly homogeneous land delineations are obtained, the quality of which shall be compared with the requirements of the specific uses selected.

Table 4.13: Class Distribution by capacity of use in the Department of Vichada, sampling in premises.

Classes and Subclasses	Symbols of the soil cartographic units	Main characteristics of the capacity units	Main use restrictions	Recommended Uses	Management Practicesrácticas de manejo
4sc	AVAa, AVAa1	Flat relief, with well drained soils; deep and moderately deep; medium and moderately fine textures; very strong and extremely strong acids.	High and very high aluminum saturation; poor distribution of rainfall, with deficit during more than four months; low and very low fertility.	Land adequate for certain transitory crops resistant to high aluminum saturation (maize, soy beans) and for semi-permanent and permanent crops (yucca, sugar cane, plantain, cashew nuts, oil palm and rubber trees) or agrosilvopastoral systems (trees in grazing land) with improved pastures (braquiaria, carimagua chopin).	Implementation of intensive management practices regarding application of corrections, organic material and balanced fertilization according to crop requirements. Irrigation systems to provide water in the moisture deficit months.
6p	AVBc1	Moderately corrugated topography. The soils have sound and moderately excessive drainage; deep and superficial (limited by gravel on surface and depth, by sectors), moderately thin and thick textures; very strong and extremely acid reaction.	Moderate susceptibility to erosion, low humidity retention, by sectors; high aluminum saturation; presence of gravel in surface and within the profile; very low fertility.	Agrosilvopastoral systems. Livestock with introduction of pastures; proper land plot rotation practices avoiding herding excess.	Strip crop is recommended. This practice helps mitigating erosive processes. Maintain the native forest or foster its reestablishment in case it has been logged; incorporate organic material and fertilize in order to improve crop development.
6sc	AVBb1	Plain and slightly inclined topography with sound and moderately excessive drainage; deep and superficial soils (limited by the presence of gravel	High and slight susceptibility to degradation; low retention of humidity; low capacity of cationic	Development of agroforestry, silvopastoral and agrosilvopastoral (with a restricted range of crops). Extensive cattle breeding with introduction of pastures and	Deliver essential management practices such as periodical incorporation of amendments (limes), organic material and fertilizers, and implementation of irrigation systems. The use of

Classes and Subclasses	Symbols of the soil cartographic units	Main characteristics of the capacity units	Main use restrictions	Recommended Uses	Management Practicesrácticas de manejo
		upon surface and within the profile) by sectors; moderately thin and moderately thick textures; moderate, strong and very strong acid reaction.	exchange; gravel within the profile and on the surface; high and very high aluminum saturation and very low fertility.	proper land plots rotation practices, thus avoiding an excess in cattle grazing. Arboreal forage species.	species tolerant to high aluminum contents. Introduction of improved species, legumes and maintain the current vegetation. Establishing arboreal and forage species tolerant to humidity stress.
8h	AVHai	Plain and plain-concave topography with superficial and moderately deep soils; poorly and faultily drained; thin, moderately thin and thick textures; strong to very strong acid reaction.	Fragility of the ecosystem upon hydric rounds (important for the protection of waters, soils and biological diversity).	The productive capacity of this unit does not allow the implementation of agriculture due to severe humidity limitations; alternatively, its use is geared towards preserving native species.	Upon logged sectors, allow natural regeneration of species enabling land rest and fostering reforestation with native species, by establishing tree nurseries.
7pe	AVBd2	Strongly corrugated topography; the soils are well drained, with moderately thin and moderately thick textures; deep, moderately deep in small superficial sector; very strong and extremely acid.	Strong slopes; moderate and high susceptibility to erosion; limited root depth in sectors; low retention of humidity and high aluminum saturation.	Reforestation aimed at protecting banks and zones with higher slopes and erosion. In more favorable areas, cultivate species that are resistant to high aluminum saturations and climate conditions, keeping the equilibrium and sustainability of the region.	Deliver some essential management practices, as periodical application of amendments (limes) and fertilizers. Maintain the existing vegetation.

Source: General Study of Soils and Land Zoning, Department of Vichada.

Class 5 Lands: These lands are suitable for few transitory crops that upon cultivation require intensive, costly and high environmental impact management, in case proper technologies are not available; therefore, and in many occasions, it is best to use these lands with permanent vegetation: either improved pastures with intensive or semi-intensive livestock systems, or permanent crops. There are also successful experiences with agroforestry and agrosilvopastoral systems.

The Class 4 limiting factors are related to the toxicity of aluminum which affects the growth on most short cycle commercial crops.

The AVAa and AVAa1 soil cartographic units are part of the high plains landscape 4sc subclass. The soil has the same limitations and the same intensity, therefore sharing the same domain of recommendation in which it is possible to submit proposals addressing similar uses and equivalent management practices.

In relation to the chemical limitations, these soils have very little organic matter with very low contents of organic carbon. The above is expressed upon the superficial area of the soil by means of light colors and a very feeble structure; thus, these are very vulnerable soils to deterioration and erosion upon inadequate management.

Class 6sc Lands: This agrological unit is comprised by the AVBb1 cartographic units, which are part of the peneplains, hills and sand hills landscape (peneplain topography), which in turn is part of the high plain landscape. These lands are suitable for permanent herbaceous or shrubby type vegetation, but unsuitable for crops or intensive crops systems. The main limitations are determined by the slight root depth of the soil, which is limited by the high content of petroferric gravel, appearing within the first 50 centimeters and upon the soil surface, and high aluminum saturations exceeding values of 80%. Additionally, these lands have a low nutrient retention capacity, very low fertility, and moisture deficit during a large part of the year.

The sand fields are plain topography lands, unaffected by erosive processes. The soils have sandy textures and quartz minerology with a very low, or null, availability of nutrients and very low moisture retention. The above, together with moisture deficits during part of the year, limits severely the root development for most crops, and yields only potential for herbaceous or shrubby vegetation which may be adapted to these conditions.

Class 6p Lands: These lands are suitable for permanent vegetation and may be used for grazing or forestry, silvopastoral or agroforestry systems with moderate restrictions due to: i) steep slopes; ii) ongoing processes or susceptibility to erosion; and iii) soil limitations, which may act either individually or combined upon determining capacity subclasses.

The AVBc1, AVEc1 y LUBc1 soil cartographic units of the low hills and high plains landscapes are part of this subclass. The slope and erosion conditions restrict their use for forestry systems with a moderate exploitation. These are lands with a moderate steep topography reaching 7-12% dominant slopes, slight erosion, and very superficial soils with high content of petroferric gravel, both in the upper part of the soil as in the surface or thick-textured soils; as well as very high aluminum saturations, and very low fertility.

The development of forestry and agroforestry systems demands an extensive or semi-intensive use of these lands in order to avoid exhaustion of the vegetation, and enable its spontaneous renovation. The intensive agricultural developments may produce irreversible ecological impact.

Most of these lands are covered by a variety of vegetation which includes stubbles, forests and natural pastures upon small sectors in which extensive livestock systems are being developed. This subclass lands reach 1´000.303 hectares in extension, reaching a 10 % of the total area of the department.

7pe Class Lands: This subclass is comprised of the AVBd2 cartographic units, namely peneplain, low hills and high plain landscapes. The slope, soil and erosion conditions of these lands create very strong restrictions for their agricultural use; forestry, under production protection schemes, is the most convenient use in these lands. The protection of slopes and most eroded sectors is recommended, and develop production at the hilltops.

These are moderately corrugated lands with a gravel layer and in some cases petroferric shields, which limits root depth; the erosion is moderated, but there is great susceptibility toward such process. Most of these lands are covered by natural vegetation.

This subclass lands cover a 1,788,116 hectare extension, representing 17.87 % of the total area of the department.
8h Class Lands: This unit is comprised of AVHai soil cartographic units, namely, narrow valleys with their respective gallery forests, which are part of the high plain, low hills and peneplain landscapes. These lands are affected by excess humidity which remains saturating the soil for so long periods that their use is not feasible for resource exploitation projects; therefore, these lands should act as conservation areas.

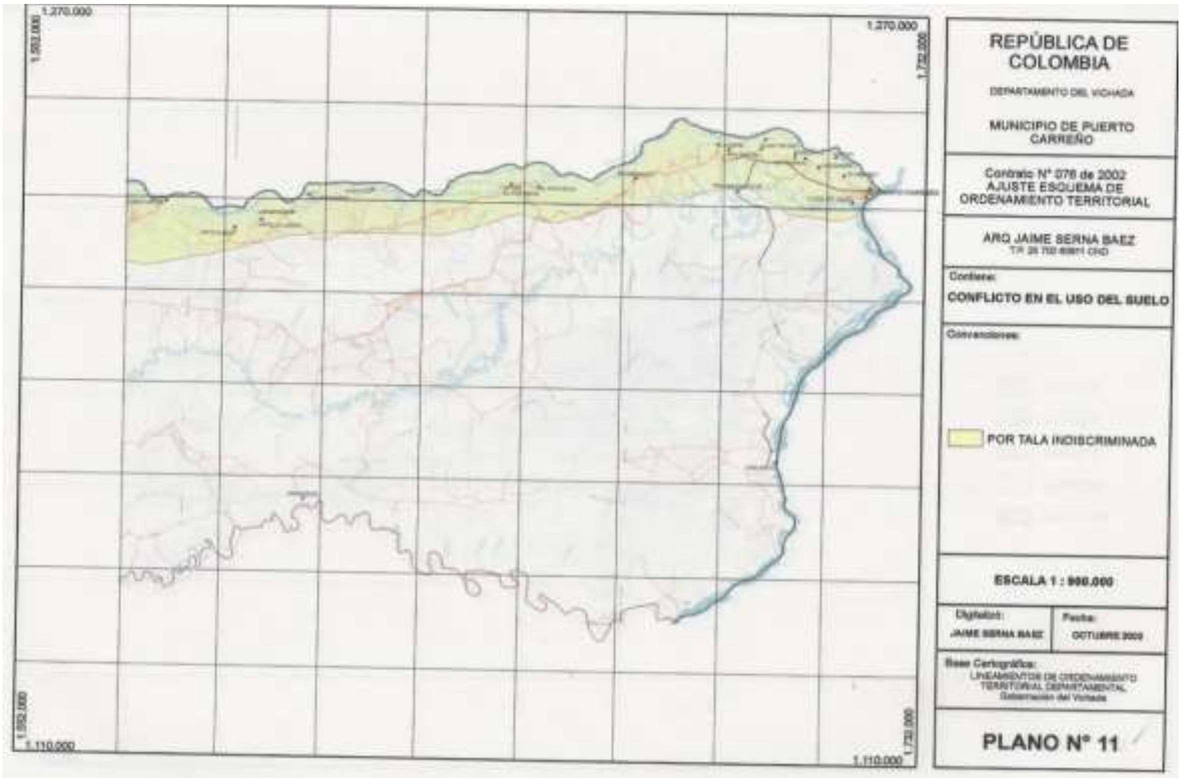
4.2.5 Conflicts upon the Use of Soil

The Orinoquia Forestry Project is located within the jurisdiction of the municipalities of Puerto Carreño and La Primavera. According to the Territorial Management Plan (EOT) information (La Primavera EOT-2000 and Puerto Carreño EOT 2003 -2012), the following conflicts have been identified.

- ***Puerto Carreño***

The indiscriminate logging has been outlined by the EOT as a use conflict in the department as indicated in the soil use conflict plane attached to such EOT.

Figure 4.29: Puerto Carreño EOT Map – Conflict upon the Use of Soil



Source: Puerto Carreño EOT-2000

- ***La Primavera***

The main conflicts established are outlined as follows: the need for combustible material geared towards cooking (firewood); preparing the terrain to establish subsistence crops; and the establishment of small brick industries which accelerate the destruction of plant material. On the other hand, due to culture and tradition, summer burns are performed without due control and breach of regulations which prohibits such practice; additionally, there is massive use of the following palms: Real, Cucurita, Moriche, Majaguillo, Saladillo, Flor Morado, and Laureal. This use is mainly for construction and extraction of their corresponding by-products. The lack of planning in the use of these palms may lead to the destruction of the habitat of different organisms, including evidently humankind. However, according to the EOT and based on the research performed, it may be concluded that the current conflicts upon use in the zone are too low or inexistent to say the least.

4.2.6 Hydrology

According to the 2014 IDEAM National Water Study (*Estudio Nacional del agua 2014*), a large portion of the river flows that are part of the Orinoco hydrographical area are originated upon the Eastern Cordillera, in the departments of Boyacá, Meta and Cundinamarca; then the stream travels through the oriental plains via large river flows such as the Meta, Guaviare, Inírida, Arauca, Vichada, Guayabero and Upía rivers. The area hydrological regime is considered as unimodal, with maximum river flows between June and August, while the minimum flows are present between January and March. The monthly annual maximum, median and minimum river flows average recorded at the hydrological stations of *Aceitico* and *Patevacal*, located near and within the area of the project, are outlined below.

Table 4.14: Monthly-annual river flows mean values (m3/seg) – *Aceitico* Station

VALUE	E	F	M	A	MY	JN	JL	A	S	O	N	D	ANNUAL VALUE
Annual Mean Flows	1310	1034	1059	2295	5242	8140	10136	8887	7006	6249	5208	2832	4949,83
Maximum Flows Annual Mean	1854	1431	1627	3900	7033	9948	11710	10359	8170	7521	6653	4413	6218,07
Minimum Flows Annual Mean	999,5	809,9	783,1	1139	3527	6471	8410	7498	5762	5169	3817	1771	3846,39

Source: IDEAM

Figure 4.30: Graph: Monthly-Annual Mean Value – E. Aceitico

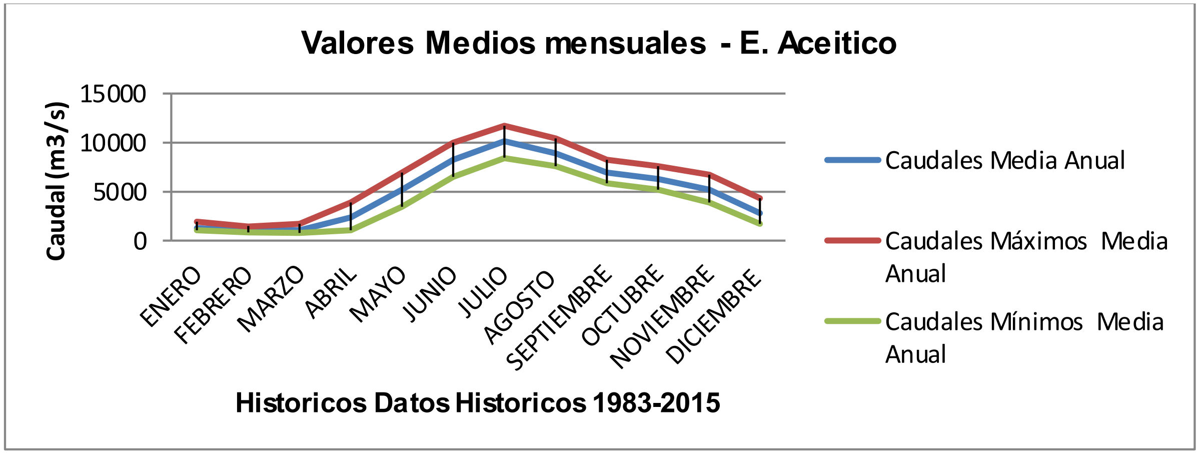
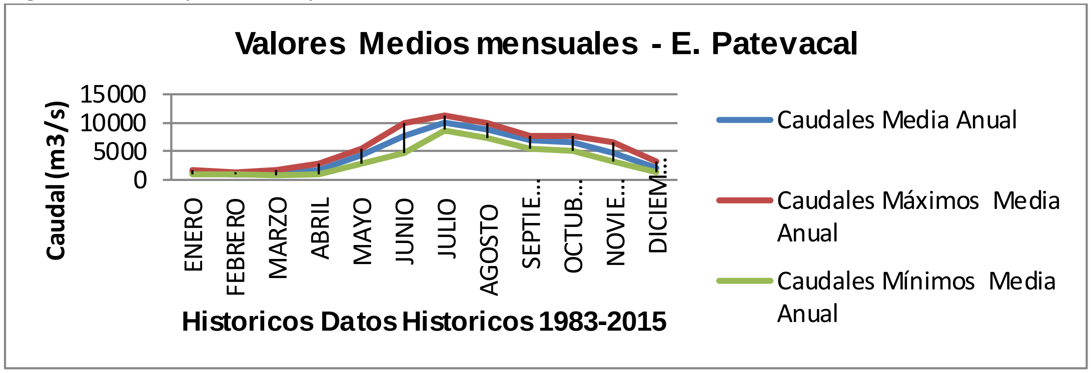


Table 4.15: Monthly-annual river flows mean values (m3/seg) – Patevacal Station

VALUE	E	F	M	A	MY	JN	JL	A	S	O	N	D	VR ANUAL
River Flows Annual Mean	1398	938,4	1107	1620	4222	7540	10027	8837	6907	6431	4548	2135	4642,41
Maximum River Flows Annual Mean	1801	1316	1837	2775	5448	9951	11285	9897	7820	7637	6585	3327	5806,56
Minimum River Flows Annual Mean	1089	834	818,1	879,5	2758	4866	8645	7272	5636	5104	3214	1487	3550,02

Source: IDEAM

Figure 4.31: Graph: Monthly Annual Mean Values – E. Patevacal



As outlined in Table 4.14 and Table 4.15, the river flows annual mean values (m^3/s) recorded 4949,83 (m^3/s) at *Aceitico* station, and recorded 4642,41(m^3/s) at *Patevacal* station; the maximum annual flows reached between 6218,07 and 5806,56 (m^3/s), and annual minimum flows reached between 3846,39 and 3550,02 (m^3/s), accordingly.

4.2.6.1 Mainstreams (Lotic Systems) and Lentic Systems Characterization

1. Inventory of lentic and lotic systems within the project area

The lentic bodies of water are either natural or artificial water bodies with vertical or horizontal water movement, yet never artificial bodies as reservoirs; most of them are natural, and may contain salt or fresh water . Taking into consideration this definition, the inventory of lentic systems performed within the area of the project found a total of 161 single drains and 4 double drains, all of them located within the project land plots.

On the other hand, the lotic water bodies, with unidirectional flow waterways which run from one terrain with higher altitude towards another with lower altitude. Considering this definition, 33 lotic water bodies were identified within the land plots of the project.

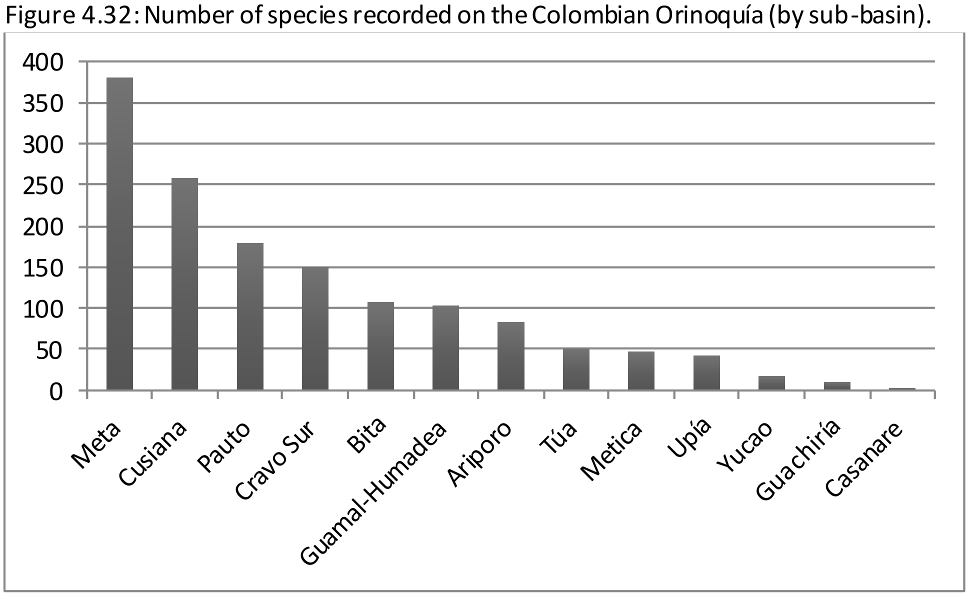
Subsequently, a characterization of these systems was delivered within the land plots of the project.

2. Characterization of the lotic and lentic systems within the project area

- **Secondary information**

A total of 577 species were recorded in the hydro-geographical zone of the Colombian Orinoquia and the Meta river basin; these records are grouped by the main sub-basins where the ichthyologic inventories were carried out. The sub-basin with larger number of records reported was the Meta river basin gathering a total of 380 species, followed by the Cusiana river basin with 258 records, and the Pauto river basin reaching 150 records; the other basins gathered records from 3 to 103 species (See Figure 4.32).

Figure 4.32: Number of species recorded on the Colombian Orinoquía (by sub-basin).

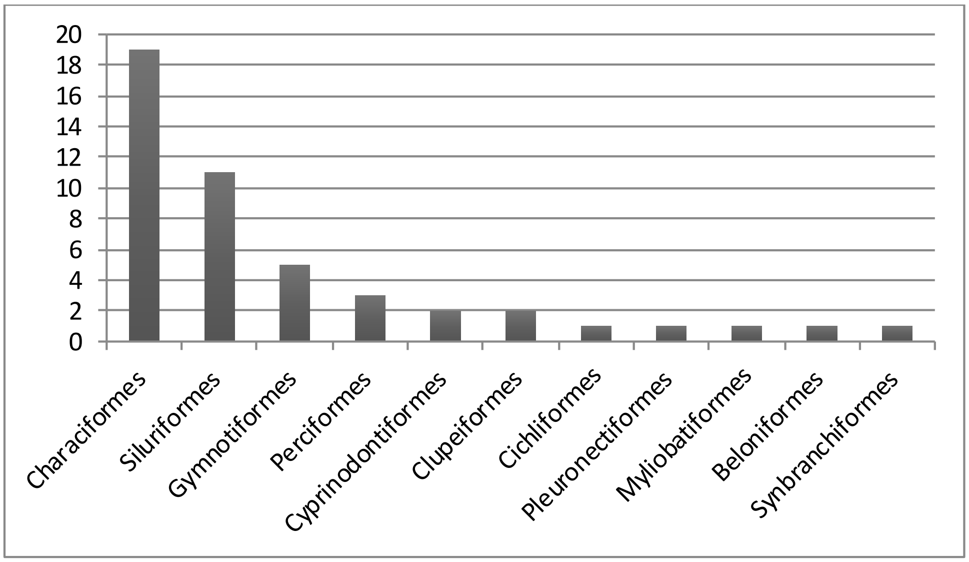


Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Species Composition

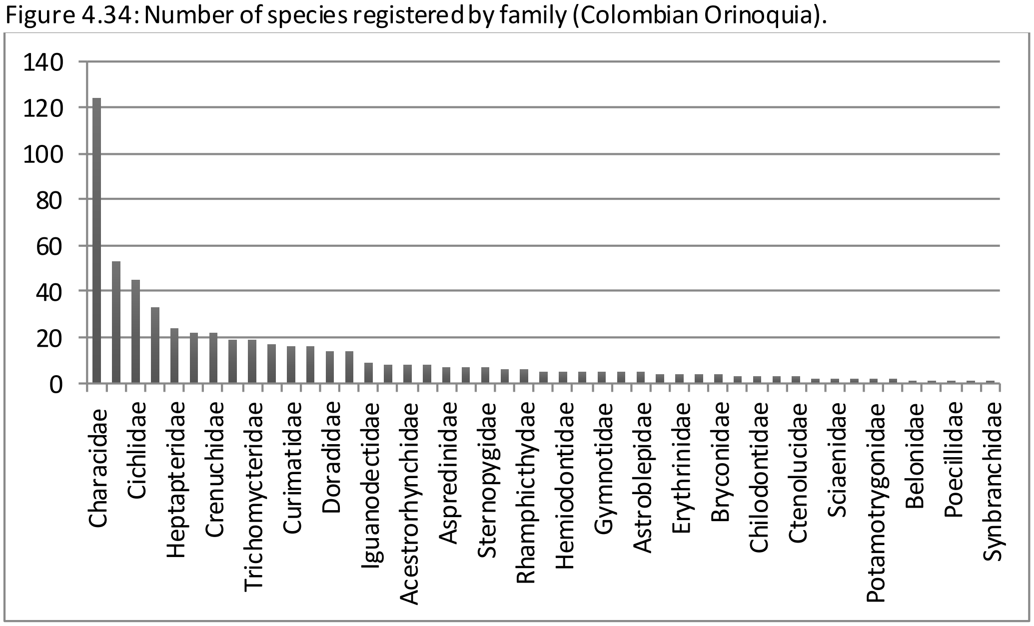
A total of 577 specimens were collected distributed among 47 families and 11 orders. The Characiformes had the largest representation gathering 19 families and 261 species, followed by Siluriformes with 11 families and 204 species, and Gymnotiformes with 5 families and 42 species. The rest of the orders covered between 1 and 3 families (see Figure 4.33). On the other hand, the Characidae family had the largest representation gathering 124 species (21%); followed by Loricariidae with 53 species (10%), and Cichlidae with 45 species (8%). The other families covered a range between 1 and 33 species (see Figure 4.34).

Figure 4.33: Number of families registered by order (Colombian Orinoquia).



Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.34: Number of species registered by family (Colombian Orinoquia).



Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

- **METHODOLOGY**

Field Phase: Diurnal and nocturnal collections were carried out upon each sampling point, covering a 100 meter distance in average; the sampling points were selected by the following criteria: a) access to the site; b) effectiveness of the fishing gear used; and c) inclusion of the largest number of aquatic environments. A total of 5 fishing gears were used in order to collect the specimens, cover the different water column levels and the different fish sizes.

Trawl Net (Figure 4.35): A trawl net with ballast chain (5m in length and 2m width) was used in order to carry out 10 random samplings. The trawls were delivered in three different systems, all of which running against the water flow; the first was performed using the net in a transversal manner toward the course of the spout, and moving both extremes of the net in opposite direction to the flow; the second left an extreme against the shore, and moved the other extreme toward the shore; and the third left the net at the bottom, and then stir the preceding rocks in the course of the flow in order to collect the fishes that were adhered to the rocks and to the bottom; in all cases, the ballast chain was affixed to the bottom of the river and/or the spout in order to ensure that the fishes were trapped, and that the opposite extreme was always above the water level.

Hook Fishing (Figure 4.36): Different hooks -with different sizes- were used to fish during a two hour period as a means to cover the riverside zone and the main water bodies flow; this fishing gear targets larger size specimens (<15 cm), and with specific eating habits, such as omnivores and carnivores.

Fishing-throwing net (Figure 4.37): A fishing-throwing net (2.5m in diameter and a 3cm eye net) was used to carry out 10 random throwing's in the riverside zone of the water bodies; this fishing gear covers all the water column and targets larger size specimens (>15cm) specifically bottom-dwelling species.

Aquarium Fish Net: A square aquarium fish net (15 cm and 1mm net eye) (Figure 4.38) was used to manually collect individuals upon nocturnal circuits at the riverside of the bodies of water; this fishing gear is very selective as it harnesses the circadian rhythm of species to ease the capture of specimens.

Agallera net: This is a 10m length by 1.5 m width net with a 10 cm net eye. This net is placed on one of the Bita river riverside (Figure 4.39) and is fixed by riparian vegetation during a 6 hour period (from 5:00 pm to 11:00pm). This fishing gear is passive and has preference for species that explore the river in a longitudinal manner.

The specimens collected were deposited in Ziploc type plastic bags (Figure 4.40) and a photographic record was then taken (in the event that staining was an important taxonomic character). Subsequently, the collected specimens were sedated with clove essence, sacrificed with formalin at 10%, and packed in a plastic bin for transportation.

Table 4.16: Fishing gear used in the study area

Fishing Gear	Dimensions	Observations
Trawl Net	5 m de largo x 2 m de alto	Ojo de malla de 2 mm
Fishing-throwing net	2.5 meters in diameter	3.0 cm net eye
Hooks	From ½´ up to 2	Artificial baits
Aquarium Fish Net	15 cm	
Agallera net	10 m length x 2.5 m height	10.0 cm net eye

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.35: Collection of botanic samples during floristic inventory.

Source (MURCIA, 2017)

Figure 4.36: Hook Fishing (Locality: Hato Nuevo)

Source (MURCIA, 2017)

Figure 4.37: Aquarium Fish Net (Locality: *Tierradentro*)

Source (MURCIA, 2017)

Figure 4.38: Placing the *Agallera* Net (Locality: Tierradentro)

Source (MURCIA, 2017)

Figure 4.39: Fishing-throwing net (Locality: *Base mono*).

Source (MURCIA, 2017)

Figure 4.40: Handling of specimens using the Ziploc type bags (Locality: *Tierradentro*).

Source (MURCIA, 2017)

Description of sampled environments: The environment characterization was performed during each fishing session and in each locality (Figure 4.41). Accordingly, the characterization considered the vegetation cover at the riversides of the bodies of water (arboreal, shrubby or pasture) as per estimated height, as well as the percentage of riparian vegetation cover of the body of water (from 0-100%); type of water (clear waters, white waters and black waters, in line with German Galvis et al. 2007 description), and type of body of water: lentic (closed environments with nonexistent mobility in the water) or lotic (environments with some mobility in the water) in light of the flow speed. Each of these variables were measured and described in situ using specialized instruments (meter, laminated graph paper, and lightweight floating object).

A visual estimation was carried out in order to characterize the type of substrate and its categories (mud, sand, gravel and boulders). Measurements of particles with laminated graph paper were made as a means to determine the category; magnitudes were arranged as follows:

- Mud: particles under 0.75mm.
- Sand: particles between 0.76 and 2 mm.
- Gravel: particles between 2 and 300 mm
- Boulders: particles between 300 and over 1800mm

Additionally, the superficial speed of the flow was recorded using a lightweight floating object, calculating the time taken for the journey at a determined distance.

Figure 4.41: Location of sampled points in the study area

Source: Satellite image available coming from the remote sensor Digitalglobe. Google Earth.

Table 4.17: List of sampled points at the study area with geographical location.

Locality	Sampling Point	X	Y	Altitude m.a.s.l
Base Mono	BM-01	915917,7724	1160773,328	91
Cuerna Vaca	CV-01	1004302,821	1170971,983	60
Hato Nuevo	HN-01	938417,1583	1165988,159	72
Hato Nuevo	HN-02	936308,1339	1165512,981	78
Hato Nuevo	HN-03	937020,3595	1166145,981	68
San Cristóbal	SC-01	915201,951	1171471,189	69

Locality	Sampling Point	X	Y	Altitude m.a.s.l
San Cristóbal	SC-02	915721,6063	1172126,041	69
San Cristóbal	SC-04	918381,3448	1171494,679	63
San Cristóbal	SC-05	917573,3638	1172434,332	65
Tierra Adentro	TA-01	994755,9153	1152850,279	75
Tierra Adentro	TA-02	997524,442	1151865,271	58
Tierra Adentro	TA-03	999537,4322	1157274,125	59
Tierra Adentro	TA-04	997597,9404	1151676,657	58
Tierra Adentro	TA-05	998074,1867	1156394,684	57

Source: (*Universidad Distrital Francisco José De Caldas*, 2017). Colombia East East Magna Plane Coordinates.

Phase of laboratory and taxonomic determination

This phase was carried out at the *Pontificia Universidad Javeriana* Bogotá-PUJ ichthyology laboratory. The biological material collected was washed with abundant water during several days to withdraw the excess of formalin and then deposit such material in glass jars with 70% ethanol. Subsequently, the morphological species were separated by lots for best effectiveness upon performing the 47 identifications (see Figure 4.42).

The taxonomic determination of species was carried out using a stereoscope and taxonomic keys cited as follows: Armburuster[19], Carlos A. Lasso, Antonio Machado-Alilson[20], Gèry[21], Gárcia-Azate et al[22]., Jardim de Queiroz et al[23]. Vol I, II and III, and specialized books: German Galvis et al[24]: *Peces De La Orinoquía Colombiana Con Énfasis En Especies De Interés Ornamental*, Ramírez-Gil[25] (2012) *Ictiofauna del Río Orotoy*, among others. Finally, the status of the species was corroborated with the University of California fish digital catalogue, and the PUJ fish databases in Colombia.

Figure 4.42: Morphological type of species at the PUJ ichthyology laboratory

[19] (Armbruster, 1996)
[20] (Lasso & Machado, 2000)
[21] (Gery, 1977)
[22] (García, Román, & Prada, 2010)
[23] (Jardim de Queiroz, 2013)
[24] (Galvis, 2007)
[25] [25] (Ramírez Gil, 2011)

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.43: Separation of species (*Serrasalmidae* family)

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.44: Lots of Collected Species

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

- **FIELD PHASE RESULTS**

Description of the study area

The five localities under study are part of the hydro-geographical zone of the Colombian Orinoquía and the basins of the Meta and Bita rivers, which are direct tributaries of the Orinoco river. Both of these basins are mainly differentiated by their source; the river Meta basin has an Andean origin while the river Bita basin is originated at the high plain of the department of Vichada; this condition grants them different physical-chemical characteristics. For example, the type of water: the river Meta basin is characterized for its white waters with a high grade of suspended sediments, and a 55 µS conductivity. While, according to Galvis[26], the Bita river waters flow from clear to black, without suspended sediments, with a 9.08 µS conductivity, and few nutrients.

Description of the environments under study

Five types of bodies of water were registered in the zone under study: a) Rivers with a 40m+ riverbe d width; b) meanders; c) spout associated to a *morichal*; d) navigation channel associated to a gallery forest; and e) a flooded savannah. The physical characteristics are described below:

- **River with a 40m+ riverbed width:** Lotic type body of water as the flow recorded an approximate speed of 0.8m/s; it has white waters due to the amount of suspended sediments, and substrate comprised of mud and sand; additionally, there is an arboreal type riparian vegetation on both riversides comprised mainly by trees over 8m tall covering approximately a 10% of the body of water.
- **Meanders:** Closed lentic type body of water without flow (0m/s speed); its waters are black due to the elevated concentration of tannins emanating from plant material in decomposition which are present in its substrate. It has shrubby type riparian vegetation with some great stand mature trees bordering the body of water covering approximately 15% of its area.

[26] (Galvis, 2007)

- **Spout associated to a morichal:** Lotic type body of water as the flow recorded an approximate speed of 03.m/s; its waters are clear with few sediments suspended, indicating a lack of nutrients; additionally, the substrates were very variable including plant material in decomposition, mud and sand. The shrubby type riparian vegetation on both riversides has very variable abundance of moriche palms (Mauritia flexuosa) which covers, in most cases, 100% of the body of water.
- **Spout associated to a gallery forest:** Lotic type body of water as the flow recorded an approximate speed of a 0.2 m/s; its waters are white due to the concentration of suspended sediments; there are substrates comprised of mud, sand and fallen trunks in some zones. There is arboreal type riparian vegetation on both riversides forming gallery forests with trees over 8 meters tall covering mostly 100% of the body of water.
- **Flooded Savannah:** Acts as a floodplain for rivers with 40m+ riverbed width; these zones are temporary, and are formed during the rainy season when the rivers reach their highest water levels. This environment has a low flow, recording an approximate speed of 0.1m/s; waters with an inclination toward clear waters, and a substrate based on immersed pastures coupled with silts. In relation to the riparian vegetation, there is pasture type vegetation in the most remote margin of the main channel of the river, and arboreal type vegetation in the nearest margin of the main channel; the arboreal vegetation is comprised of good stand trees over 8 meters tall, covering approximately 5% of the environment.

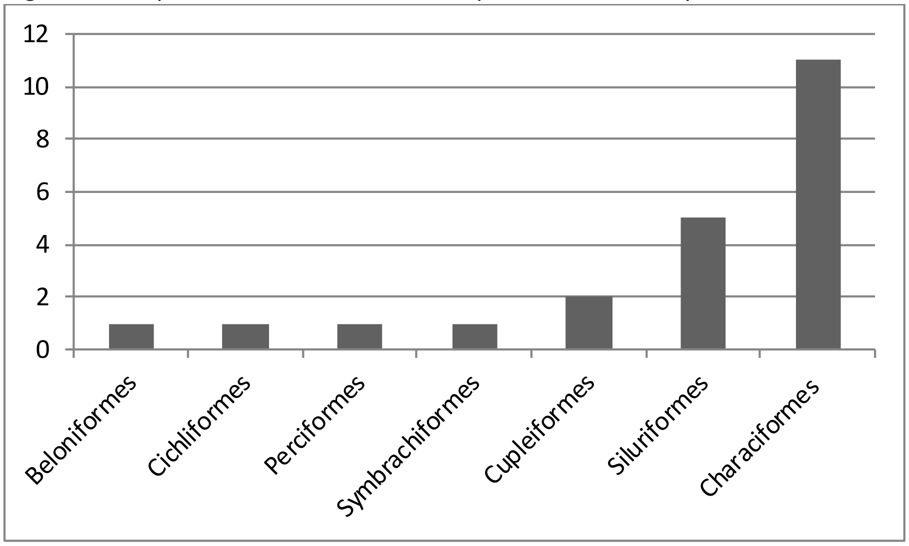
Composition and structure of the ichthyofaunal community.

A total of 668 specimens distributed among 81 species, 22 families, and 7 orders (Table 4.18) were collected in the study area. The *Characiformes* order had the largest representation gathering 7 families, representing 50% of the ichthyofaunal community, followed by *Siluriformes* with 5 families (27.7%), and *Clupeiformes* reaching 2 families (9%). The other orders, namely, *Beloniformes*, *Cichliformes*, *Perciformes* and Symbrachiformes were represented by 1 family (4,54% each one) (see Figure 4.45). The *Characiformes* and *Siluriformes* orders dominance follow the pattern of richness at an order level outlined by Maldonado-Ocampo in 2001 for the ichthyofaunal upon the zone of influence of the Meta and Orinoco rivers in Puerto Carreño, and with the 2008 Maldonado Ocampo description of the national ichthyofaunal.

On the other hand, the *Characidae* was the family with the largest representation with 29 species (35.8%), followed by *Cichlidae* reaching 9 species (11.11%), *Serrasalmidae* with 6 species (7,4%), and *Lebiasinidae* gathering 5 species. The other 18 families provided between 1, 2, 3 and 4 species accruing 39.5% of the records (see Figure 4.46). The pattern found on the species distribution, in relation to the families recorded, is as expected, considering that the *Characidae* family is the most diverse and encompasses the greatest number of genders in the Orinoquia (Taphorn 2003).

The study found, in relation to the estimated diversity for each locality, that out of the five localities, only Cuernavaca showed low diversity, as there was a marked dominance in the species; the other localities have higher diversity values. However, the species accumulation curve warns us of a possible sub-sampling as the curve fails to reach the asymptote. This result is the one expected, since, in order to achieve a more complete representation of the ichthyofaunal community that is present in this zone, it is necessary to carry out sampling exercises throughout the hydrological cycle; and, in this case, there is only information for the rainy season.

Figure 4.45: Specific richness of fish orders present in the study area in relation to the number of families.



Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Table 4.18: List of species found in the study area.

Order	Family	Specie
Beloniformes	Belonidae	*Belonion dibranchodon*
Characiformes	Acestrorhynchidae	*Acestrorhynchus microlepis*
		Acestrorhynchus sp.
	Anostomidae	*Leporellus vittatus*
		Leporinus brunneus
		Leporinus yophorus
	Characidae	*Agoniates halecinus*
		Astyanax integer cf.
		Astyanax siapae
		Brycon falcatus
		Brycon whitei
		Bryconops alburnoides
		Bryconops giacopinii
		Chalceus macrolepidotus
		Gymnocorymbus bondi

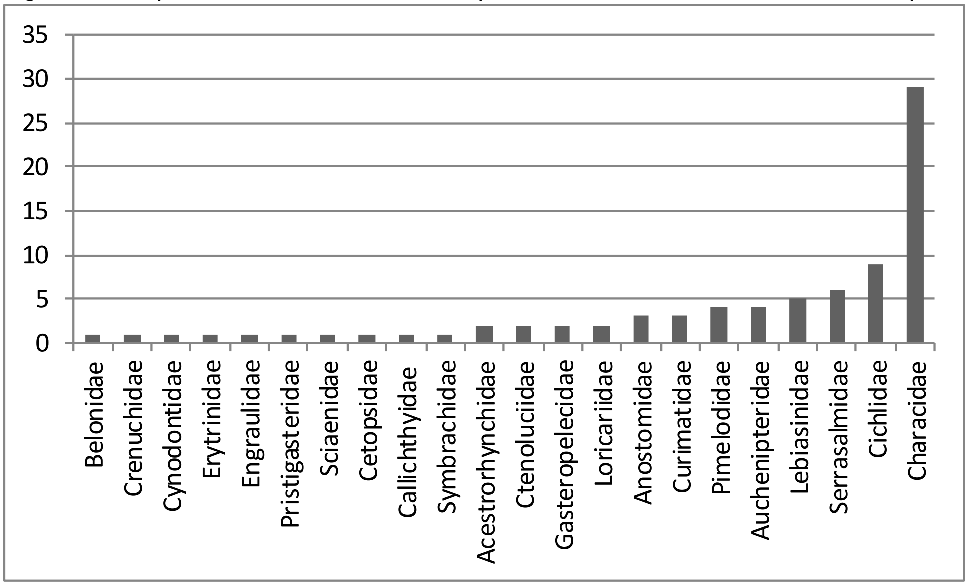
Order	Family	Specie
		Hemigrammus barrigonae
		Hemigrammus micropterus
		Hemigrammus newboldi
		Hemigrammus rhodostomus
		Hyphessobrycon aff. acaciae
		Hyphessobrycon diancistrus
		Hyphessobrycon mavro
		Hyphessobrycon sp.
		Knodus breviceps cf.
		Moenkhausia copei
		Moenkhausia lepidura
		Moenkhausia mikia cf.
		Moenkhausia oligolepis
		Poptella compressa
		Poptella longipinnis
		Tetragonopterus argenteus
		Tetragonopterus chalceus
		Thayeria obliqua
	Characidae	*Triportheus venezuelensis*
		Ctenobrycon oliverai
	Crenuchidae	*Poecilocharax weitzmani*
	Ctenoluciidae	*Boulengerella cuvieri*
		Boulengerella lateristriga
	Curimatidae	*Curimatopsis sp.*
		Cyphocharax festivus
		Cyphocharax spilurus
	Cynodontidae	*Hydrolycus armatus*
	Erytrinidae	*hoplerythrinus unitaeniatus*
	Gasteropelecidae	*Carnegiella strigata*
		Thoracocharax stellatus

Order	Family	Specie
	Lebiasinidae	*Copella arnoldi*
		Copella eigenmanni
		Nannostomus eques
		Nannostomus unifasciatus
		Pyrrhulina lugubris
	Serrasalmidae	*Pristobrycon striolatus*
		Pygocentrus cariba
		Pygocentrus sp.
		Serrasalmus elongatus
		Serrasalmus manueli
		Serrasalmus rhombeus
Cichliformes	Cichlidae	*Aequidens tetramerus*
		Apistogramma hongsloi
		Biotodoma wavrini
		Caquetaia myersi cf.
		Crenicichla lenticulata
		Dicrossus filamentosus
		Heros severus
		Mesonauta egregius
		Satanoperca mapiritensis
Cupleiformes	Engraulidae	*Anchoviella jamesi*
	Pristigasteridae	*Pellona flavipinnis*
Perciformes	Sciaenidae	*Plagioscion squamosissimus*
Siluriformes	Pimelodidae	*Calophysus macropterus*
		Pimelodus blochii
		Pimelodus ornatus
		Pinirampus pirinampu
	Loricariidae	*Rineloricaria eigenmanni*
		Hypostomus plecostomoides
	Cetopsidae	*Cetopsis orinoco*
	Callichthyidae	*Callichthys callichthys*
	Auchenipteridae	*Ageneiosus inermis*
		Tatia sp.
		Tetranematichthys quadrifilis
		Trachelyopterus galeatus

Order	Family	Specie
Symbrachiformes	Symbrachidae	*Symbrachus marmoratus*

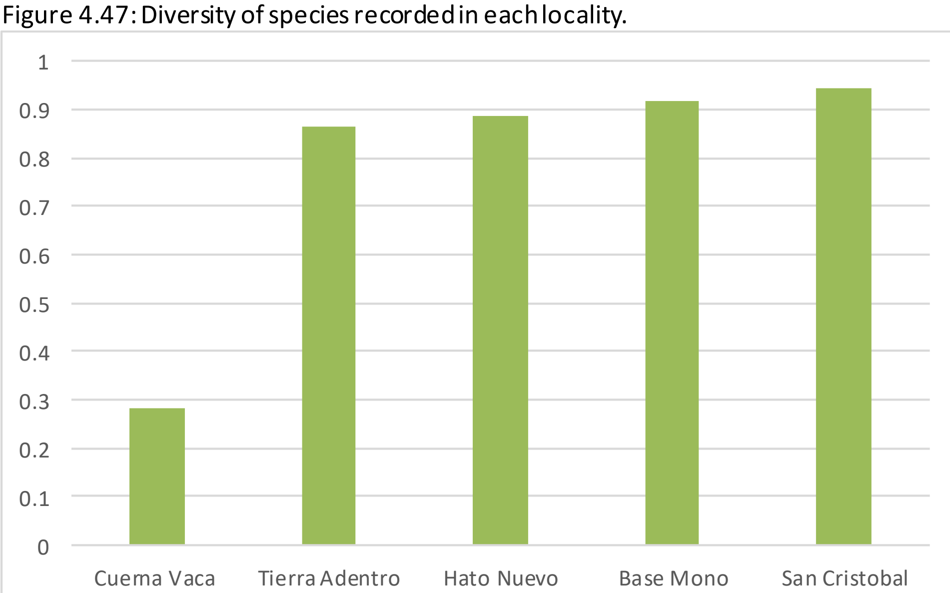
Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.46: Specific richness for each family of fishes in relation to the number of species found.



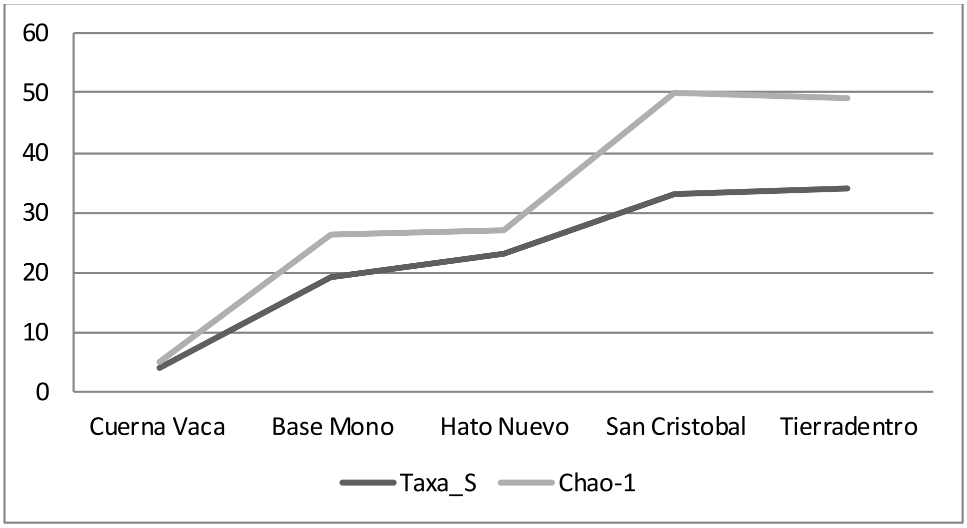
Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.47: Diversity of species recorded in each locality.



Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.48: Curve of accumulation of species recorded upon the study area



Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Ichthyofaunal composition and structure for each locality

- Locality I: San Cristóbal.

This locality is directly influenced by the Meta river. Four (4) environments were sampled in this locality: a) Gallery forest spout; b) Muco river; c) Muco river meander; and d) *Morichal* spout (Table 4.19). As the rainy season was finalizing, and due to an increase on the levels of water at the Muco river, a direct tributary to the Meta river, a connection was found between the Muco river and the locality meanders (see Figure 4.49 and Figure 4.50).

Table 4.19: Geographical location of sampled environments: Locality I.

Cód.	X	Y	Body of Water
SC-01	915201,950961	1171471,18924	Gallery Forest Spout
SC-02	915721,606326	1172126,0411	Muco River
SC-04	918381,344771	1171494,67899	Morichal Spout
SC-05	917573,363797	1172434,3315	Muco river meander

Source: (*Universidad Distrital Francisco José De Caldas*, 2017). Colombia East East Magna Plains Coordinates.

Table 4.20: Physical characteristics of sampled environments: Locality I.

Cód.	Coverage	Type of Substrate	Type of Water	Body of Water
SC-01	100%	Organic Material in Decomposition and silts	Clear waters	Lotic
SC-02	20%	Silts and sand	White waters	Lotic
SC-04	100%	Organic material in decomposition	Clear waters	Lotic
SC-05	20%	Organic material in decomposition	White waters	Lentic

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.49: Hook fishing at the Muco river (SC-02).

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.50: Hook fishing at the Muco river meander (SC-05).

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

A total of 92 specimens distributed among 39 species, 15 families, and 4 orders (Table 4.21) were collected. The *Characiformes* and *Siluriformes* orders had the largest representation with 6 families each one, followed by Cicliformes and Clupeiformes with one family each. On the other hand, Characidae was the dominant family covering 36.36% of the collected species, followed by Lebiasinidae, Pimelodidae and Serrasalmidae with 9% of the species collected. The other families provided 1 or 2 recorded species.

Table 4.21: List of species found in the study area: Locality I

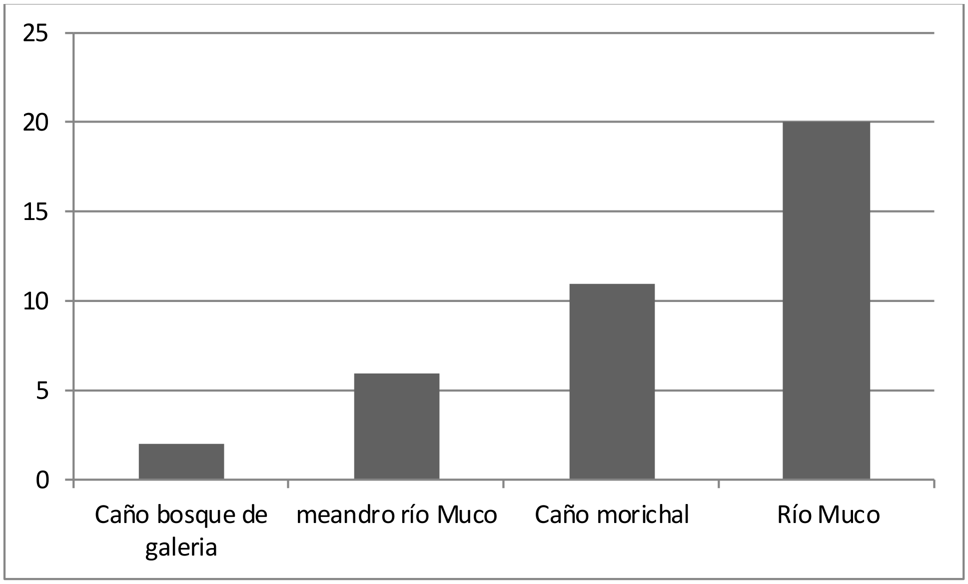
Order	Family	Specie	Abundance
Characiformes	Anostomidae	*Leporellus vittatus*	1
		Leporinus yophorus	1
	Characidae	*Bryconops alburnoides*	2

Order	Family	Specie	Abundance
		Bryconops giacopinii	1
		Ctenobrycon oliverai	1
		Hemigrammus newboldi	4
		Hyphessobrycon mavro	11
		Knodus breviceps cf.	3
		Moenkhausia copei	6
		Moenkhausia lepidura gr.	19
		Moenkhausia oligolepis	1
		Poptella compressa	3
		Tetragonopterus argenteus	1
		Tetragonopterus chalceus	3
	Ctenoluciidae	*Boulengerella cuvieri*	2
	Gasteropelecidae	*Thoracocharax stellatus*	2
	Lebiasinidae	*Copella eigenmanni*	5
		Nannostomus eques	1
		Pyrrhulina lugubris	1
	Serrasalmidae	*Serrasalmus rhombeus*	2
		Pygocentrus cariba	1
		Pygocentrus sp.	1
		Aequidens tetramerus	3
		Caquetaia myersi cf.	1
Cichliformes	Cichlidae	*Aequidens tetramerus*	1
	Cichlidae	*Caquetaia myersi cf.*	1
Cupleiformes	Engraulidae	*Anchoviella jamesi*	1
Siluriformes	Loricariidae	*Hypostomus plecostomoides*	2
		Rineloricaria eigenmanni	2
	Auchenipteridae	*Tatia sp.*	1
	Cetopsidae	*Cetopsis orinoco*	2
	Pimelodidae	*Calophysus macropterus*	1
		Pinirampus pirinampu	2
	Callichthyidae	*Callichthys callichthys*	2
	Pimelodidae	*Pimelodus blochii*	1

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Out of the environments sampled, the Muco river was the point that contributed with the largest collection of species (20 species), followed by the *morichal* spout (11 species) (see Figure 4.51); this results from the fact that the most effective fishing gear was the nocturnal collection using manual *jama* from a canoe at the Muco riverside.

Figure 4.51: Specific richness of species in each sampled environment: Locality of San Cristobal.



Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

- Locality II: Base Mono.

This locality is part of the Meta river basin, a hydro-geographical zone of the Orinoquia. The sampled environment was the *morichal* spout, tributary to the *Chiquichaque* river, which flows directly into to the Meta river (Table 4.22 and Table 4.23).

Table 4.22: Geographic location of sampled environments: Locality II.

Code	X	Y	Body of Water
BM-01	915917,772391	1160773,32813	Morichal Spout

Source: (*Universidad Distrital Francisco José De Caldas*, 2017). East East Magna Colombia Plane Coordinates.

Table 4.23: Physical characteristics of the sampled environments: Locality II.

Code	Coverage	Type of Substrate	Type of Water	Body of Water
BM-01	90%	Organic Material	Clear Waters	Lotic

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

A total of 47 specimens were collected at this point distributed among 19 species, 9 families, and 3 orders (Table 4.24). The *Characiformes* order was the largest representation with 3 families; the *Siluriformes* and *Cichliformes* orders gathered only one family each.

On the other hand, the *Characidae* was the dominant family covering 36.84% of the species collected; the families *Lebiasinidae* y *Cichlidae* provided each one 15% of the species recorded. The other six families provided one specie accordingly.

Table 4.24: List of species found at locality II.

Order	Family	Specie	# Specimens
Characiformes	Acestrorhynchidae	*Acestrorhynchus sp.*	1
	Characidae	*Bryconops giacopinii*	4
		Hemigrammus newboldi	1
		Hyphessobrycon mavro	4
		Hyphessobrycon sp.	2
		Moenkhausia copei	4
		Moenkhausia mikia cf.	7
		moenkhausia oligolepis	2
	Crenuchidae	*Poecilocharax weitzmani*	1
	Curimatidae	*Cyphocharax spilurus*	1
	Erytrinidae	*hoplerythrinus unitaeniatus*	1
	Gasteropelecidae	*Carnegiella strigata*	5
	Lebiasinidae	*Copella arnoldi*	1
		Nannostomus eques	6
		Pyrrhulina lugubris	2
Cichliformes	Cichlidae	*Aequidens tetramerus*	1
		Mesonauta egregius	1
		Satanoperca mapiritensis	1
Siluriformes	Auchenipteridae	*Tetranematichthys cf quadrifilis*	2

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

- Locality III: Hato Nuevo.

Hato Nuevo, as well as San Cristóbal (locality I), is directly influenced by the Meta river as it is part of its floodplain. Three types of environments were sampled at this locality (Figure 4.52, Figure 4.53 and Figure 4.54): a) Gallery Forest Spout; b) Gallery Forest Spout + *morichal;* and, c) Meta river meanders (Table 4.25 y Table 4.26)

Table 4.25: Geographical location of sampled environments: Locality III.

Cód.	Latitude	Longitude	Body of Water
HN-01	938417,158322	1165988,15884	Gallery Forest Spout
HN-02	936308,133895	1165512,98055	Gallery Forest Spout + *morichal*
HN-03	937020,359487	1166145,98094	Meta river meander

Source: (*Universidad Distrital Francisco José De Caldas*, 2017). East East Colombia Magna Plane Coordinates.

Table 4.26: Physical characteristics of sampled environments: Locality III.

Cód.	Coverage	Type of Substrate	Type of Water	Body of Water
Cód.	100%	Organic material in decomposition	White Waters	Lotic
HN-01	80%	Organic Material in Decomposition + silts	Clear Waters	Lotic
HN-02	20%	Organic Material in Decomposition	Black Waters	Lentic

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.52: Gallery Forest Spout (HN-01).

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.53: Gallery Forest Spout + *morichal* (HN-02).

Figure 4.54: Meta river meander (HN-03).

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.55: Hook fishing at the Meta river meander. HN-03.

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

A total of 113 specimens were collected distributed among 23 species, 6 families, and 3 orders (Table 4.27). The Characiformes order has the largest representation gathering 5 families, while the Cichliformes and Siluriformes orders provided only one family each. On the other hand, Characidae was the dominant family covering 52% of the collected species; Serrasalmidae and Cichlidae delivered 17 and 13% of the records accordingly. The other families, Erythrinidae, Lebiasinidae and Auchenipteridae were represented by one specie each, namely, 4.34% each. Finally, the abundance of species found in this point was very similar; out of the 11 species recorded, 7 had 1 specimen, and the other 4, 2 specimens.

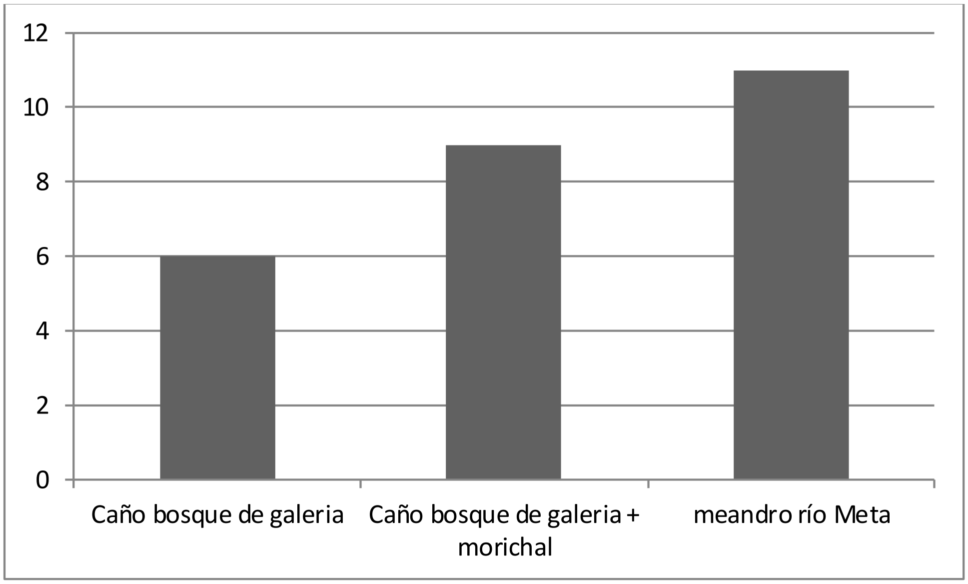
Table 4.27: List of species found at the study area: locality III.

Order	Family	Specie	# specimens
Characiformes	Characidae	*Astyanax integer cf.*	3
		Astyanax siapae	23
		Brycon falcatus	3
		Brycon whitei	1
		Bryconops giacopinii	1
		Gymnocorymbus bondi	6
		Hyphessobrycon mavro	21
		Moenkhausia lepidura	5
		Moenkhausia oligolepis	1
		Poptella longipinnis	16
		Tetragonopterus argenteus	1
	Characidae	*Tetragonopterus chalceus*	2
		Triportheus venezuelensis	5
	Erytrinidae	*Hoplerythrinus unitaeniatus*	2
	Lebiasinidae	*Copella arnoldi*	11
	Serrasalmidae	*Pristobrycon striolatus*	2
		Pygocentrus cariba	1
		Serrasalmus elongatus	1
		Serrasalmus rhombeus	1
Cichliformes	Cichlidae	*Aequidens tetramerus*	1
		Apistogramma hongsloi	2
		Crenicichla lenticulata	2
Siluriformes	Auchenipteridae	*Trachelyopterus galeatus*	2

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Out of the sampled environments, the point "Meta river meander" delivered the largest value regarding its specific richness, as the net trawling and hook fishing sessions were more effective in comparison to the other environments (see Figure 4.56).

Figure 4.56: Specific richness of species in each sampled environment: Hato Nuevo Locality.



Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

- Locality IV: Tierra Adentro.

This locality is located at the margin of the Bita river, an important tributary of the Orinoco river, a hydro-geographical zone of the Orinoquía. Two types of environments were sampled at 4 sampling points (Figure 4.57, Figure 4.58, Figure 4.59): a) Bita river wharf sector; b) Bita river *Morichal* tourist center; c) flooded savannah I; and d) flooded Savannah II (Table 4.28 y Table 4.29).

Table 4.28: Geographic location of sampled environments: locality IV.

Code	X	Y	Body of Water
TA-01	994755,915263	1152850,27874	Bita River
TA-03	999537,432221	1157274,12526	Bita River
TA-04	997597,940357	1151676,65675	Flooded Savannah Bita River
TA-05	998074,186695	1156394,68448	Flooded Savannah Bita River II

Source: (*Universidad Distrital Francisco José De Caldas*, 2017). East East Colombia Magna Plane Coordinates

Table 4.29: Physical characteristics of sampled environments: locality IV.

Coverage	Type of Substrate	Type of Water	Body of Water
20%	Silts and clays	Black Waters	Lotic
20%	Silts and Clays	Black Waters	Lotic
10%	Clays and underwater vegetation	Clear Waters	Lotic
10%	Clays and underwater Vegetation	Clear Waters	Lotic

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.57: Bita River (TA-03).

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.58: Flooded Savannah - Bita River (TA-04).

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.59: Hook fishing sessions supported by local fishermen (TA-03).

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

A total of 349 specimens were collected distributed among 34 species, 15 families, and 6 orders (Table 4.30). The Characiformes was the order with the largest representation reaching 8 families, followed by the Clupeiformes and Siluriformes orders with 2 families, while the Beloniformes, Cichliformes y Perciformes orders provided only one family each.

The study found, in relation to the richness by number of species at a family level, that the Characidae family gathered the largest number of species reaching 38.23% of the records; the families Curimatidae and Cichlidae gathered a 11.76 and 14.7% accordingly; additionally, the other families gathered one or two species, equivalent to 2.94 and 5.88% of participation within the community. On the other hand, this locality gathered the most abundant specie: *Hyphessobrycon diancistrus* reaching a total of 88 specimens; followed by *Hemigrammus micropterus* with 55 specimens.

Table 4.30: List of species found at the study area: locality IV.

Order	Family	Specie	# Specimens
Beloniformes	Belonidae	*Belonion dibranchodon*	5
Characiformes	Acestrorhynchidae	*Acestrorhynchus microlepis*	2
	Anostomidae	*Leporinus brunneus*	1
	Characidae	*Agoniates halecinus*	2
		Brycon falcatus	1
		Bryconops giacopinii	7
		Chalceus macrolepidotus	2
		Hemigrammus barrigonae	5
		Hemigrammus micropterus	55

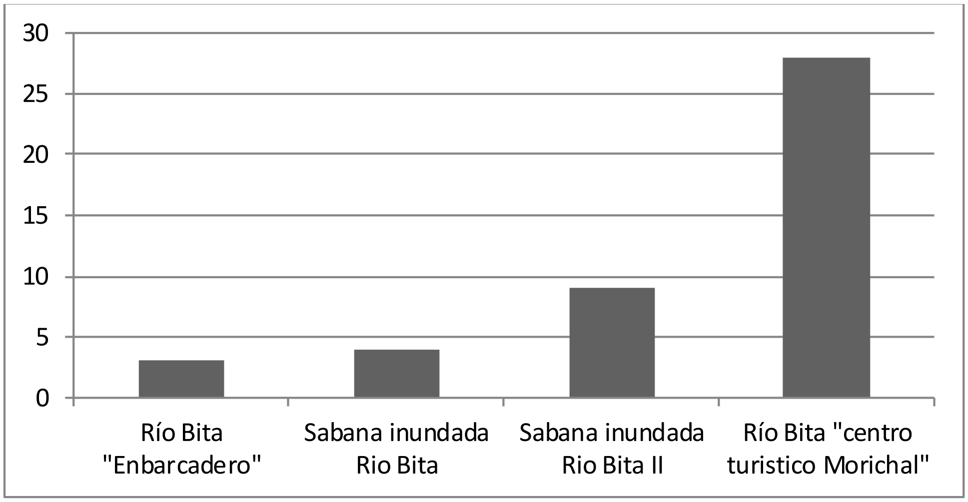
Order	Family	Specie	# Specimens
		Hemigrammus rhodostomus	11
Characiformes	Characidae	*Hyphessobrycon aff. acaciae*	12
		Hyphessobrycon diancistrus	88
		Hyphessobrycon sp.	1
		Moenkhausia copei	51
		Moenkhausia lepidura gr.	1
		Thayeria obliqua	2
	Ctenoluciidae	*Boulengerella lateristriga*	1
	Curimatidae	*Curimatopsis sp.*	1
		Cyphocharax spilurus	5
		Cyphocharax festivus	28
	Cynodontidae	*Hydrolycus armatus*	1
	Lebiasinidae	*Nannostomus unifasciatus*	2
	Serrasalmidae	*Serrasalmus manueli*	2
Cichliformes	Cichlidae	*Aequidens tetramerus*	1
		Biotodoma wavrini	1
		Dicrossus filamentosus	1
		Heros severus	1
		Mesonauta egregius	3
Cupleiformes	Engraulidae	*Anchoviella jamesi*	47
	Pristigasteridae	*Pellona flavipinnis*	5
Perciformes	Sciaenidae	*Plagioscion squamosissimus*	1
Siluriformes	Pimelodidae	*Pimelodus blochii*	1
		Pimelodus ornatus	1
	Auchenipteridae	*Ageneiosus inermis*	1

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Although the sites sampled were very similar at a physical level, there was a marked difference between them (Figure 4.60).

The above can be credited mainly to the fishing gear used, which was more effective at the Bita river *Morichal* touristic center sampling point; this point delivered the best sampling conditions, which allowed to gather a large number of species; additionally, it was the only place in which it was possible to collect species using the *agallera* net, which enabled the collection of good stand species such as *Pellona flavipinnis* and *Agoniates halecinus*.

Figure 4.60: Specific richness of species at each sampled environment (Locality: Tierra Adentro).



Source: (Universidad Distrital Francisco José De Caldas, 2017)

- Locality V: Cuerna Vaca.

This locality is part of the zone of influence of the Meta river, a hydro-geographical zone of the Orinoquia. A reduced body of water was sampled at this point. This environment is part of a gallery forest gathering abundant *moriche* palms (Table 4.31 and Table 4.32) and (Figure 4.61 and Figure 4.62).

Table 4.31: Geographical Position of sampled environment: Locality V.

Code	X	Y	Body of Water
CV-01	1004302,82135	1170971,98276	Morichal Spout

Source: (*Universidad Distrital Francisco José De Caldas*, 2017). East East Colombia Magna Plane Coordinates.

Table 4.32: Physical characteristics of the sampled environment: Locality V.

Code	Coverage	Type of Substrate	Type of Water	Body of Water
CV-01	100%	Organic Material in Decomposition	Clear Waters	Lotic

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.61: CV-01 Sampling Point

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.62: Trawl at sample point CV-

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

A total of 67 specimens distributed among to 2 orders, 3 families and 4 species were collected. The *Characiformes* was the order with the largest representation gathering 2 families, while *Symbrachiformes* presented the only registered family for the order.

Regarding the richness presented at a family level by number of species, *Characidae* was found to be the largest representation gathering 50% of the records, while the families Lebiasinidae and Symbrachidae recorded one only one specie reaching 25% of the records accordingly. The *Copella eigenmani* species delivered a very strong dominance reaching 83.58% of the specimens collected (Table 4.33).

Table 4.33: List of the species found in the study area (Locality V).

Order	Family	Specie	# Specimens
Characiformes	Characidae	*Hemigrammus barrigonae*	9
Characiformes	Characidae	*Hyphessobrycon mavro*	1
Characiformes	Lebiasinidae	*Copella eigenmanni*	56
Symbrachiformes	Symbrachidae	*Symbrachus marmoratus*	1

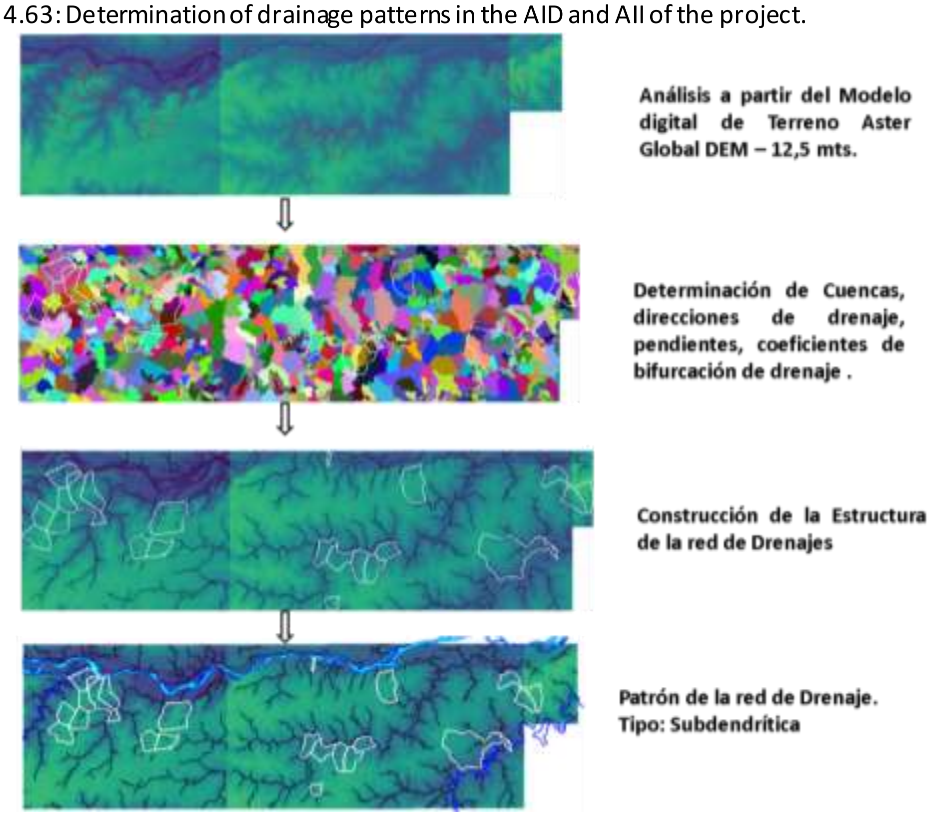
Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

4.2.6.2 Drainage patterns

In order to determine the drainage patterns in the area of direct and indirect influence of the project, the study proceeded to use three Aster Global DEM images from the United States Geological Survey (USGS) digital terrain model (12.5 meter pixels from the Alos Palsar satellite). These images were corrected and processed to properly determine the drainage patterns.

This determination was performed using the GRASS GIS 7.0.2 software which processed and eliminated the DEM invalid and empty values. Subsequently, the process determined the possible basins in the study area, using a 20,000 threshold upon the r.watershed command, and thus determining the drainage directions, basins, accumulation indexes, topographic indexes, and drainages.

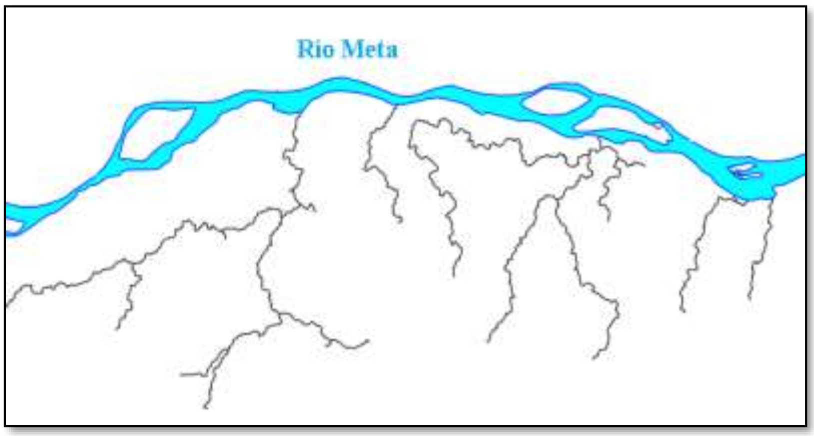
Figure 4.63: Determination of drainage patterns in the AID and AII of the project.



Source: Prepared by (*Valoración Económica Ambiental* SAS, 2017), using information from the (United States Geological Survey - USGS, 2017)

According to Figure 4.63, the drainage distribution and order at the project area of influence corresponds to a *Subdendritic* type pattern.
The above is considered as a modification of the dendritic drainage pattern, in which the tributaries of the main rivers (Río Meta and Río Bita) get together upon acute angles as shown in Figure 4.64.

Figure 4.64: Subdendritic drainage pattern



Source: Prepared by (*Valoración Económica Ambiental* SAS, 2017), using information from the (United States Geological Survey - USGS, 2017)

The area whereby the tributaries drain is possibly covered with relatively resistant sediments, which offer a stronger control than the area where the main course runs (these are meanders). In this case, there is a well-defined major tributary, with a greater flow quantity, where a series of small tributaries arrive, showing that there is an intense accumulation area, and that there is also a low structural or topographic control, fostering the overflow in some areas due to the development of the plain area (Farfan, 2008).

4.2.6.3 Polluting sources

As shown in the characterization of the lentic and lotic systems, there is no activity in these bodies of water. On the other hand, according to the analysis of the socioeconomic environment and the inspections to the area of influence, there is neither a sewage system nor a prior discharged waters treatment. Septic tanks located in each home are the systems used by local dwellers.

No sources of contamination are foreseen with the development of the project, as the camps where activities will be carried out, and where the personnel will work on the operational part. The project will install treatment systems for the domestic wastewater, and then these waters will be disposed at infiltration fields once the water has been correctly treated.

The project contemplates the installation of five treatment systems distributed in the following camps: *Mono Base, San Cristóbal*, *Las Malvinas*, *Tierradentro* and *Paraíso Pc*. These systems will treat the waters for daily domestic use of the project staff.

4.2.6.4 Water use

The use of water for the project will come from surface and underground water sources as outlined in Table 4.34.

Table 4.34: Water use specifications for the Orinoquia Forestry Project

Camp	Land Plot	Hydric Resource	Activity and type of use
San Cristóbal	San Cristóbal	Surface water – Caño Muco	Project main field activities: camp, irrigation and fertirrigation for nursery; fertilizations and herbicide application; firebreaks, controlled burning and firefighting.
Base Mono	La Cordobeza	Underground water	Forest Ranger (Fire Fighting), firewalls, controlled burning and firefighting.
Paraíso PC	Paraíso PC (Puerto Carreño)	Underground water	Camp, fertilization and herbicide application (Firefighting) firebreaks, controlled burning and firefighting.
Malvinas	Malvinas	Underground water	Forest Ranger (This site is planned for the future location of a cargo terminal). (Firefighting) firebreaks, controlled burning and firefighting.
Tierradentro	Tierradentro 6	Surface water – Rio Bita	Campsite, fertilization and herbicide application. (Firefighting) firebreaks, controlled burning and firefighting.
Toro I	Toro I	Underground water	Campsite; this land plot provides forestry services. (Firefighting) firebreaks, controlled burning and firefighting.

Source: (*Valoración Económica Ambiental*, 2017)

Table 4.35: Physicochemical characterization and specifications of the water resource

Nº Lab Sample CIMA	Campsite Nº	Sample Description	Type of sampling	Source	Sample Date
22887	PM01	Capturing Point Tierra Adentro	Snapshot	Surface water	2017-09-18
22888	PM02	Base Malvinas Raw Water	Snapshot	Underground water	2017-09-18
22889	PM04	Base San Cristobal Raw Water	Snapshot	Surface water	2017-09-18
22890	PM06	Base Mono	Snapshot	Underground water	2017-09-18
22891	PM07	Base Paraiso PC	Snapshot	Underground water	2017-09-18
22892	PM08	Base Toro	Snapshot	Underground water	2017-09-18

Source: Corporación Integral del Medio Ambiente CIMA 2017

Figure 4.65: Physicochemical characterization of water resources 1 – Laboratory Report

LABORATORIO DE AGUAS Y SUELOS
REPORTE DE RESULTADOS A-2541

BOGOTÁ D. C., 2017-10-13

INFORMACIÓN DEL CLIENTE		INFORMACIÓN DEL MUESTREO	
Nombre del Cliente	Corporacion Integral del Medio Ambiente	Fecha de recepción de muestras	2017-09-23
		Fecha de inicio de Análisis	2017-09-23
NIT	900.241.439-8	Fecha de finalización de Análisis	2017-10-13
		Proyecto	698
Dirección	carrera 35a #1c-29	Plan de muestreo CIMA	698
		Muestreo realizado por	Cima/Julian Jimenez
Contacto	José Rodriguez	Localización (Departamento/Ciudad)	N.R./N.R.
		Sitio de muestreo	vichada- puerto Carreño
Télefono	3000697	Versión de reporte de resultados	1
Correo electrónico	directortecnico@cimambiente.com	No de Anexos	2

RESULTADOS

VARIABLE	TIPO	UNIDADES	22687	22688	22689
ALCALINIDAD POR CO3	N.A.C.	mg $CaCO_3$/L	<5.0	<5.0	<5.0
ALCALINIDAD POR HCO3	N.A.C.	mg $CaCO_3$/L	<5.0	7.0	<5.0
ALCALINIDAD TOTAL	N.A.C.	mg $CaCO_3$/L	<5	7	<5
CLORUROS	A.C.	mg Cl^-/L	<5	<5	<5
COLIFORMES TOTALES UFC	A.S.X.	UFC/100 mL	150	400	190.0
COLOR REAL	A.S.X.	UPC	35	5	37
ESCHERICHIA COLI UFC	A.S.X.	UFC/100 mL	10.0	0.0	0.0
NITRITOS	A.C.	mgNO_2^--N /L	<0.003	<0.003	<0.003
ORTOFOSFATOS	A.S.X.	mg/L	<0.05	<0.05	0.06
RECUENTO DE HETERÓTROFOS (MESÓFILOS)	A.C.	NMP/100mL	15500	33600	52100
SULFATOS	A.C.	mg SO_4^{2-} / L	3	8	5
TURBIEDAD	A.C.	NTU	4.6	1.0	7.9

Figure 4.66: Physicochemical characterization of water resources 2 – Laboratory Report

LABORATORIO DE AGUAS Y SUELOS
REPORTE DE RESULTADOS A-2541

BOGOTÁ D. C., 2017-10-13

INFORMACIÓN DEL CLIENTE		INFORMACIÓN DEL MUESTREO	
Nombre del Cliente	Corporacion Integral del Medio Ambiente	Fecha de recepción de muestras	2017-09-23
		Fecha de inicio de Análisis	2017-09-23
NIT	900.241.439-8	Fecha de finalización de Análisis	2017-10-13
		Proyecto	698
Dirección	carrera 35a #1c-29	Plan de muestreo CIMA	698
		Muestreo realizado por	Cima/Julian Jimenez
Contacto	José Rodriguez	Localización (Departamento/Ciudad)	N.R./N.R.
		Sitio de muestreo	vichada- puerto Carreño
Télefono	3000697	Versión de reporte de resultados	1
Correo electrónico	directortecnico@cimambiente.com	No de Anexos	2

VARIABLE	TIPO	UNIDADES	22890	22891	22892
ALCALINIDAD POR CO3	N.A.C.	mg $CaCO_3$/L	<5.0	<5.0	<5.0
ALCALINIDAD POR HCO3	N.A.C.	mg $CaCO_3$/L	<5.0	<5.0	<5.0
ALCALINIDAD TOTAL	N.A.C.	mg $CaCO_3$/L	<5	<5	<5
CLORUROS	A.C.	mg Cl^-/L	<5	<5	<5
COLIFORMES TOTALES UFC	A.S.X.	UFC/100 mL	1400	450	6900
COLOR REAL	A.S.X.	UPC	46	8	32
ESCHERICHIA COLI UFC	A.S.X.	UFC/100 mL	0.0	0.0	0.0
NITRITOS	A.C.	mgNO_2^--N /L	<0.003	<0.003	<0.003
ORTOFOSFATOS	A.S.X.	mg/L	0.06	0.06	<0.05
RECUENTO DE HETERÓTROFOS (MESÓFILOS)	A.C.	NMP/100mL	111900	29200	131700
SULFATOS	A.C.	mg SO_4^{2-} / L	4	5	8
TURBIEDAD	A.C.	NTU	50.0	40.0	35.0

Source: *Corporación Integral del Medio Ambiente* - CIMA 2017

In general and according to the characterizations results, these waters fulfill the Resolution 2115/2007 provisions, indicating good quality waters, which after collection thereof, will be treated and used for human consumption upon all bases, and for other uses established in Table 4.34.

The results indicate that total alkalinity, chlorides, color, nitrates, orthophosphates, and sulfates parameters fulfill Resolution 2115/2007 provisions. The other parameters will be subject of analysis and subsequent treatment in order to meet the drinking water standards.

The water collection and distribution system is included in the technical documents needed required for the application of the respective water concession permits.

4.2.6.5 Conflicts of use

There is no information available in the *Puerto Carreño* EOT in relation to the conflicts upon use. However, the IDEAM, through the planning and land use SIG-OT geographical information systems project, developed a dry year municipal shortage index map. Accordingly, the department of Vichada is located in the non-significant index, according to the demand / supply in the zone, showing that the information, at a departmental level, has no problems and / or shortages during the dry months of the year.

On the other hand, the IDEAM developed a second vulnerability map for water availability per municipality during dry year, registering the department of Vichada as a median category, namely, moderately fragile for vulnerable conditions, which indicates that this could generate some conflict in the future for the availability of resource use.

4.2.6.6 Well inventory

The study identifies some underground water wells within the area of direct and indirect influence of the project. These wells are used for domestic water, and for the water supply of La Venturosa, Aceitico and Puerto Murillo inspections. The East East Magna Colombia system flat coordinates are outlined below.

Table 4.36: Project wells inventory.

N° Well	Plane Coordinates	
	X	Y
1	922270,722	1171079,32
2	918900,016	1163097,89
3	954283,409	1173374,82
4	954052,046	1172379,38
5	954367,399	1172250,73
6	953794,803	1168955,9
7	964930,068	1174284,51
8	965362,376	1173306,46
9	965261,67	1172494,31
10	931586,069	1161422,87
11	962007,502	1166620,96
12	962492,817	1166293,5

Source: (*Valoración Económica Ambiental SAS*, 2017)

4.2.7 Atmosphere

The study area climatological performance was carried out by means of a historical series analysis for each variable, for the case of precipitation during the period between 1968 and 2016 for the *Aceitico* station, and between 1983 and 2016 for the *Patevacal* station; and the Puerto Carreño Airport station involved an analysis for such variables for the period between 1968 and 2016. Additionally, the temperature, solar brightness, and relative humidity variables were analyzed for the period between 1972 and 2016 as recorded by the Puerto Carreño Airport station. Finally, a wind speed variable analysis included information during the period between 1974 and 2016 as recorded at the Puerto Carreño Airport station. Due to the lack of meteorological stations near the study area with complete information, as required, the study used the information from the Puerto Carreño Airport station and, in some variables, the hydrological stations near the Aceitico and Patevacal study area, wherewith the analysis of the meteorological performance of the area was performed.

4.2.7.1 Climate

For the analysis of this component, the statistical data of the Puerto Carreño Airport meteorological station was analyzed. This airport is located at latitude 0610 N, longitude 6729 W, with a 50 m.a.s.l. inclination. However, for the precipitation variable, data was collected from: the Patevacal station located at latitude 0610 N and longitude 6907 W with a 76 m.a.s.l elevation, and from the Aceitico station located at latitude 0610 N and longitude 6823 W with a 67 m.a.s.l. inclination.

The statistical data of the variable are described below:

- Precipitation
- Temperature
- Solar brightness
- Relative Humidity
- Wind speed and direction
- Evaporation

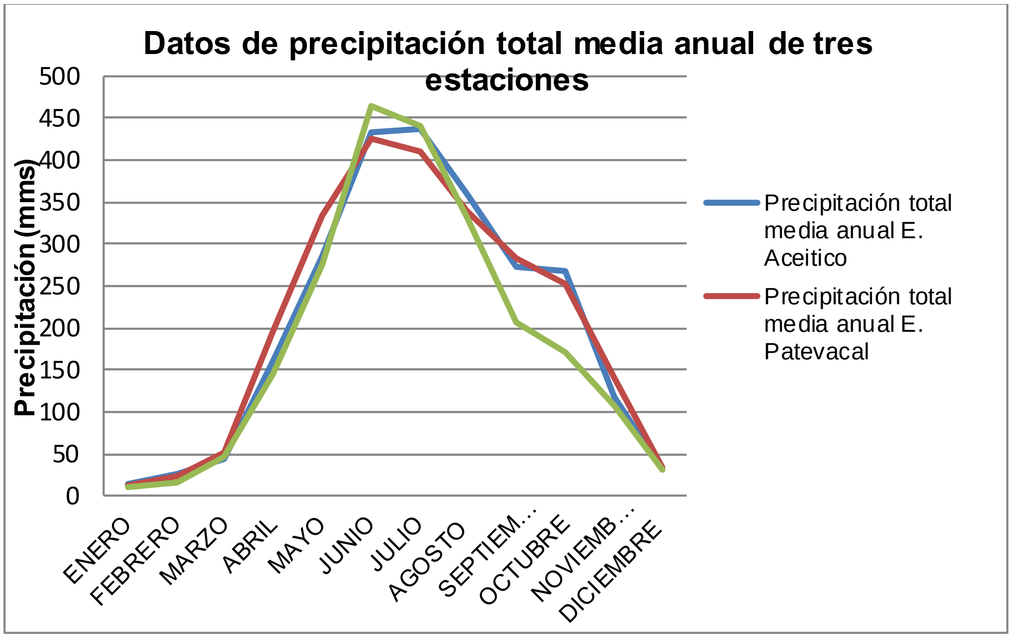
PRECIPITATION

Based on the stations data previously described in Table 4.37, Table 4.38 and Table 4.39, the average annual total values reported reached 2447.8 mm for the Aceitico station, 2503.6 mm for the Patevacal station, and 2242.6 mm for the Puerto Carreño Airport station. Therefore, the average for the project area reaches 2398 mms, framing the regional rain regime within the unimodal type, with a rainy season from April to November, and the dry season from December to March.

The lowest values of monthly total precipitation corresponded to the month of January with values between 10.1 mm for the Puerto Carreño Airport station, 12.1 mm for the Patevacal station, and 13.8 mm for the Aceitico station. The highest averages were recorded in June (434.4 mm) and July (437.3 mm) for the Aceitico station, in June (425.7 mm) and July (410.7 mm) for the Patevacal station, and in June (464.6 mm) and July (441.9 mm) for the Puerto Carreño Airport station. For the period between March and June, the records showed a significant decrease during the months of May and June with respect to the Airport historical data series, during the first wet season (April and May).

The figure representing the precipitation graph for each station analyzed for this variable is outlined below. The individual data per each station is presented in the following tables.

Figure 4.67: Graph of the mean annual total precipitation values (mms) for the three stations analyzed.



Source: IDEAM

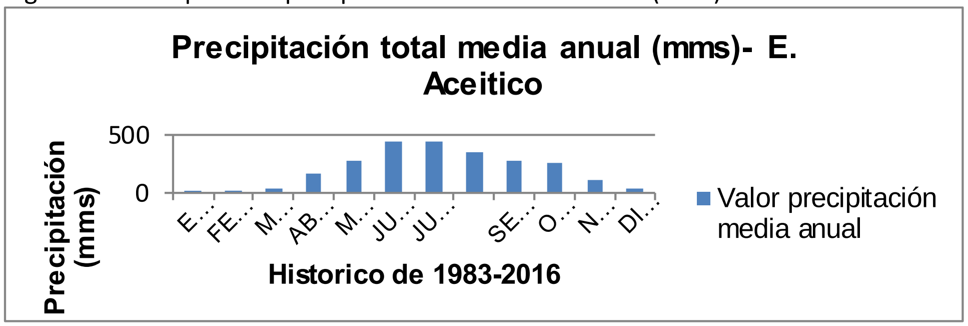
Data and graphical representation of the stations analyzed for the project area climatology analysis.

Table 4.37: Total precipitation annual mean data (mms) – Aceitico Station

VALUE	E	F	M	A	MY	JN	JL	A	S	O	N	D	ANNUAL VALUE
Total Precipitation Annual Mean	13,8	25,4	42,5	161,2	285,4	434,4	437,3	358,8	273,9	267,5	117,6	29,9	2447,8

Source: IDEAM

Figure 4.68: Graph: Total precipitation annual mean values (mms) – Aceitico Station



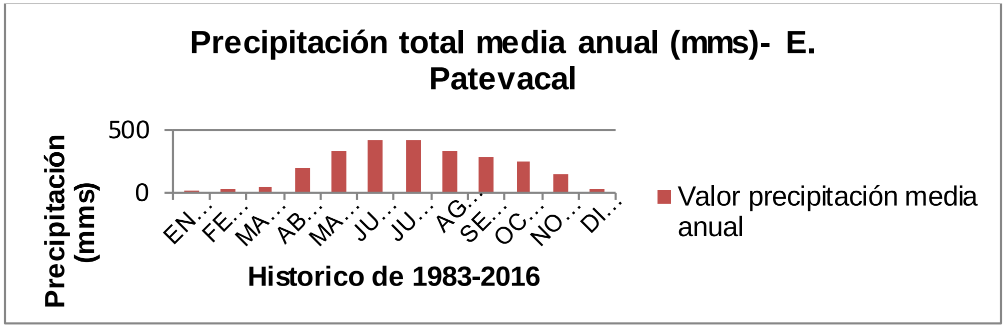
Source: IDEAM

Table 4.38: Total precipitation annual mean data (mms) – Patevacal Station

VALUE	E	F	M	A	MY	JN	JL	A	S	O	N	D	VR ANUAL
Total Precipitation Annual Mean	12,1	23,9	50,9	195,7	334,2	425,7	410,7	339,3	284	253,4	139,2	34,4	2503,6

Source: IDEAM

Figure 4.69: Graph: Total precipitation annual mean values (mms) – Patevacal Station



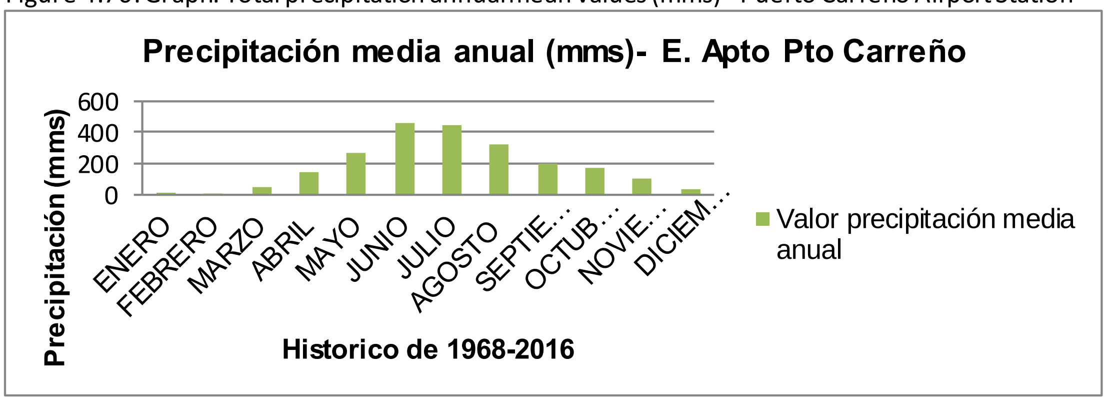
Source: IDEAM

Table 4.39: Total precipitation annual mean data (mms) - Puerto Carreño Airport Station

VALUE	E	F	M	A	MY	JN	JL	A	S	O	N	D	ANNUAL VALUE
Total Precipitation Annual Mean	10,1	15,2	45	144,9	274,7	464,6	441,9	330,2	206,7	171,3	106,6	31,4	2242,6

Source: IDEAM

Figure 4.70: Graph: Total precipitation annual mean values (mms) - Puerto Carreño Airport Station



Source: IDEAM

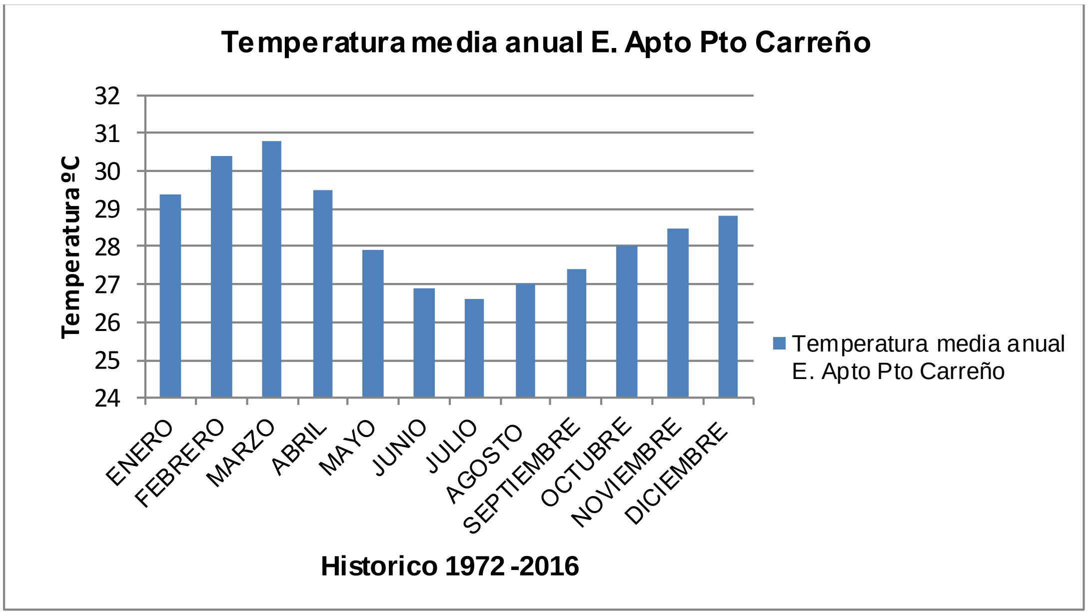
- **AVERAGE TEMPERATURE**

As shown in Table 4.40, the area recorded a 28.4 ºC average annual temperature, with variations throughout the year reaching values between 26.9 and 27 ºC during the months of June and July respectively. This information was gathered using the historical series of the Puerto Carreño Airport station, and taking into account the similar orographic conditions that the station presents within the study area.

Table 4.40: Average annual temperature (ºC) - Puerto Carreño Airport

VALUE	E	F	M	A	MY	JN	JL	A	S	O	N	D	ANNUAL VALUE
Temperature Annual Mean	29,4	30,4	30,8	29,5	27,9	26,9	26,6	27	27,4	28	28,5	28,8	28,4

Figure 4.71: Graph of the average annual temperature values (ºC) Puerto Carreño Airport



Source: IDEAM

- **SOLAR BRIGHTNESS**

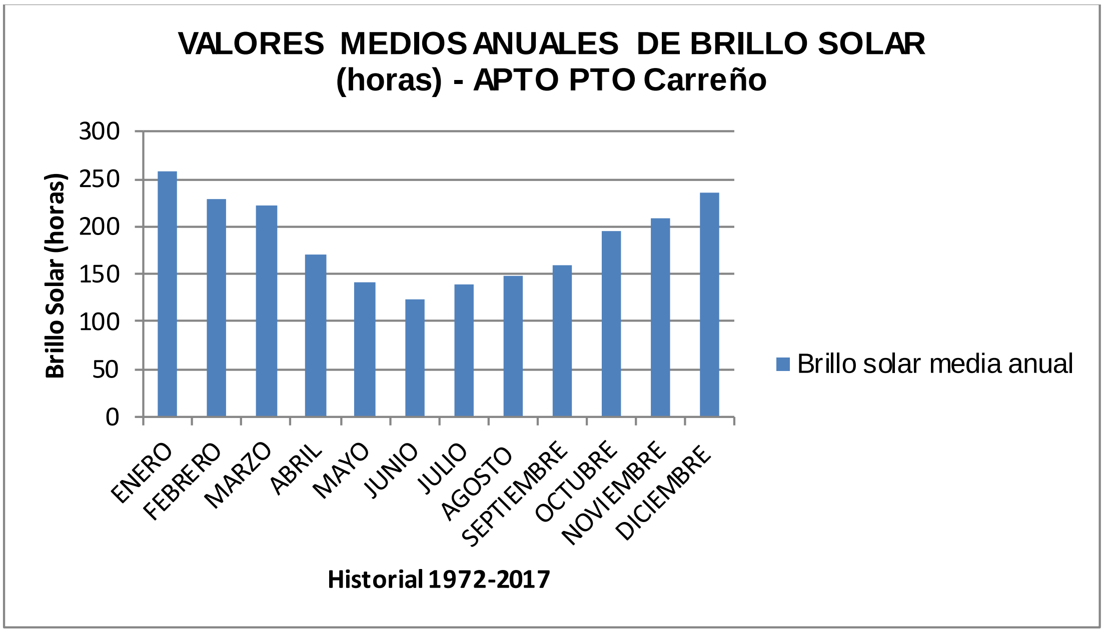
According to the historical series of the Puerto Carreño Airport station, the area reaches an average annual solar brightness of 2227.2 hours, as shown in Table 4.41; and an annual variation of 123.6 hours of solar brightness in June.

Table 4.41: Average annual solar brightness data (ºC) Puerto Carreño Airport

VALUE	J	F	M	A	MY	JN	JL	A	S	O	N	D	ANNUAL VALUE
Solar brightness Annual Mean	257,5	228,2	222,7	170,3	141,6	123,6	138,3	147,2	159,2	194,8	207,5	236,2	2227,2

Source: IDEAM

Figure 4.72: Graph of annual average solar brightness values (ºC) Puerto Carreño Airport



Source: IDEAM

- **RELATIVE HUMIDITY**

This parameter presents a unimodal regime as shown in Figure 4.73, with a peak during the months of June and July (79%), and the lowest values during the months of February (56%) and March (57%). This variation is mainly due to an increase in temperature, causing a decrease in relative humidity. This is because increasing the temperature increases the maximum amount of water vapor that the mass of air can contain, while the actual water vapor content of such air mass remains constant. In other words, the degree of air saturation decreases because upon increasing the temperature, there is a greater capacity to contain water vapor. ([27])

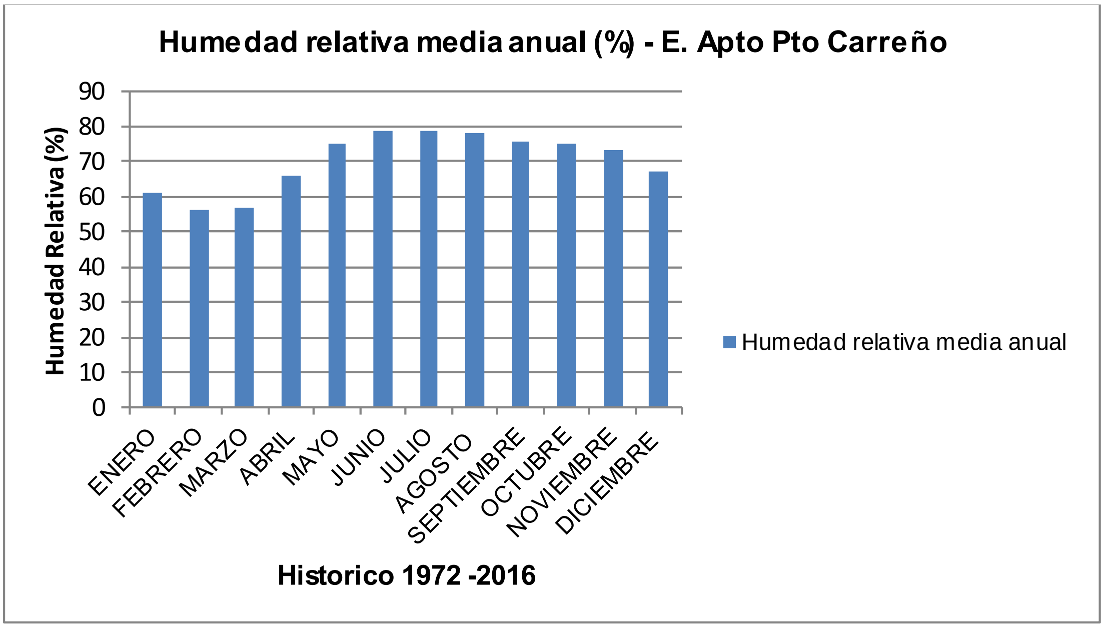
Table 4.42: Annual Relative Humidity Data (ºC) Puerto Carreño Airport

VALOR	J	F	M	A	MY	JN	JL	A	S	O	N	D	VR ANUAL
Relative Humidity Annual Mean	61	56	57	66	75	79	79	78	76	75	73	67	70

Source: IDEAM

[27] Meteoares. (2012). *¿Qué es la HUMEDAD RELATIVA?, ¿cómo varía con la temperatura del aire?* Obtenido de http://meteoares.blogspot.com/2010/09/que-es-la-humedad-relativa-como-varia.html

Figure 4.73: Graph of the mean annual Relative Humidity values (ºC) Apto Pto Carreño



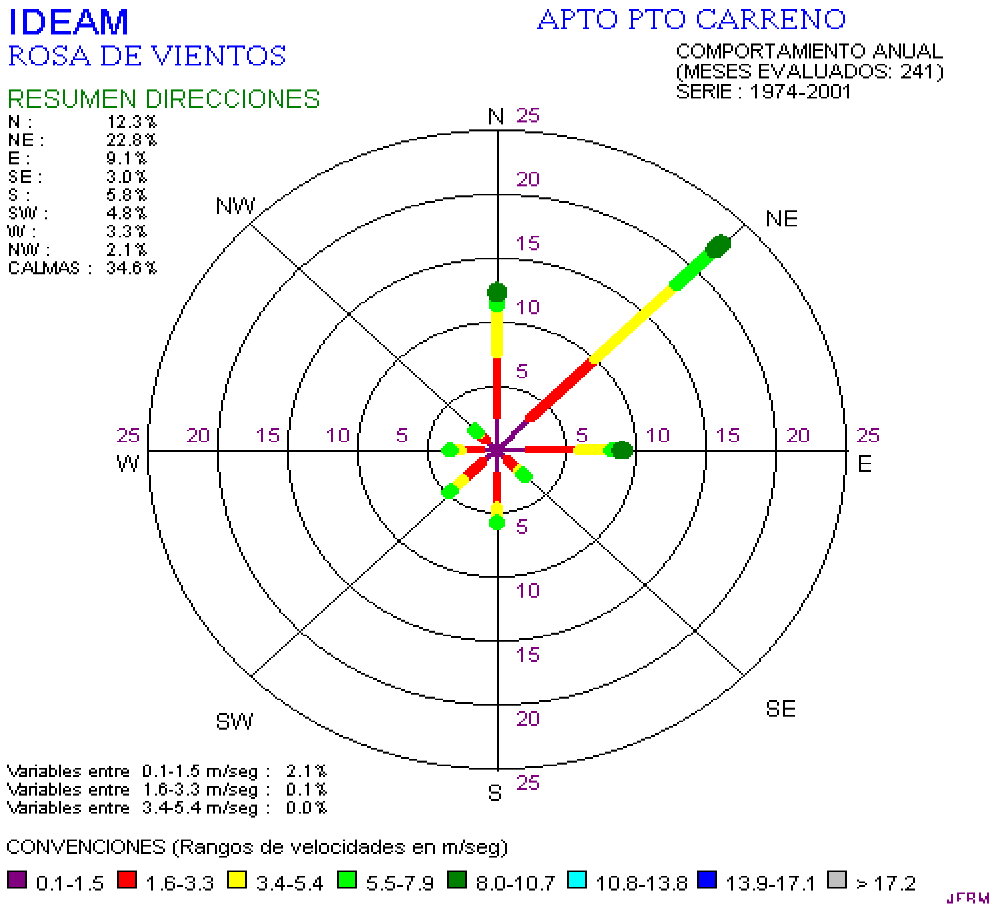
Source: IDEAM

- **WIND SPEED AND WIND DIRECTION – PUERTO CARREÑO WIND ROSE**

For the analysis of this parameter, the Puerto Carreño Airport wind rose was used as shown in Figure 4.74. The trade winds bring along drizzles from the month of April, as once the influence of this wind begins, the rains (October and November) ceases and are replaced by drizzles.

The study observed, regarding the analysis of the annual wind performance by means of the wind rose, that each year there is a component of the northeast direction with a 22.8% of predominance, followed by the north and east with a 12.3 and 9.1 % accordingly; followed by a 5.8% of the south direction, while the other directions perform between 4.8 and 2.1%; the calms reach a total of 33.8% in the area. The direction of the winds is related to humidity and rainfall. The range between 0.1 to 1.5 m / s is in general the most representative speed.

Figure 4.74: Puerto Carreño Airport Wind Rose



Source: IDEAM

- **EVAPORATION**

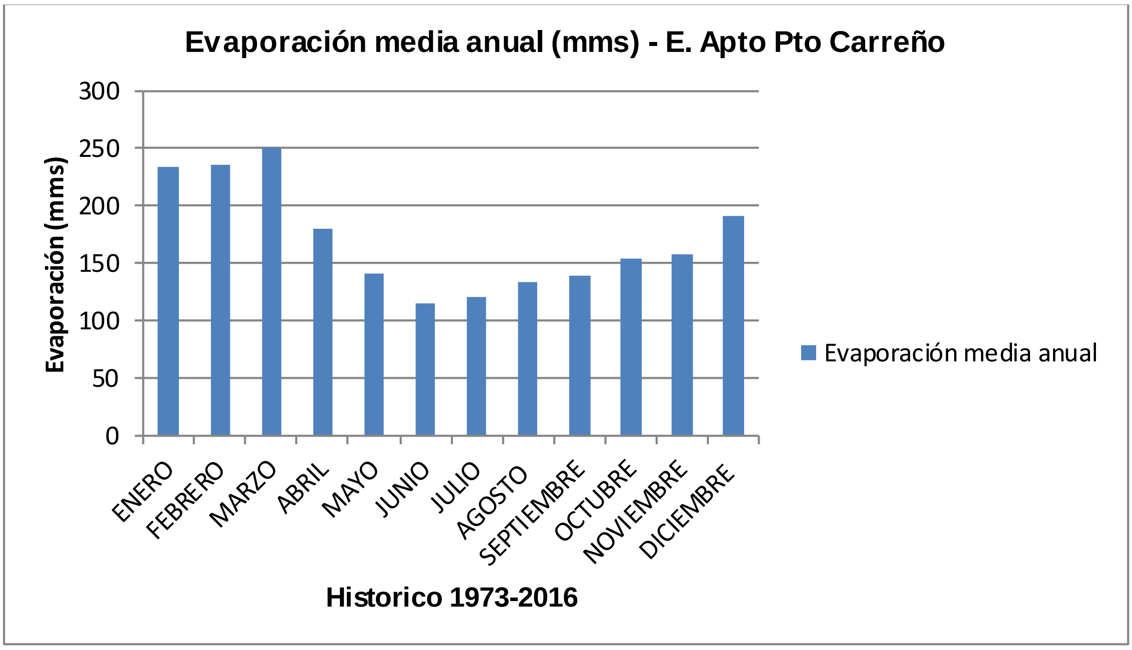
There is a 2054.8 (mms) annual mean evaporation as shown in Table 4.43, which variates throughout the year, reaching a 114, 8 (mms) value of evaporation during June. This information was based on the historical series of the Puerto Carreño Airport station.

Table 4.43: Annual Average Evaporation Data (mms) Puerto Carreño Airport

VALUE	J	F	M	A	MY	JN	JL	A	S	O	N	D	ANNUAL VALUE
Evaporation Annual Mean	234	236,8	250,8	180,2	140,8	114,8	120,8	133,2	138,8	154,2	158,4	192,2	2054,8

Source: IDEAM

Figure 4.75: Graph of annual mean evaporation values (mms) Puerto Carreño Airport



Source: IDEAM

4.3 Biological environment

4.3.1 Flora

4.3.1.1 Secondary information

The information below shows the review results of secondary information regarding the flora component within the department of Vichada, with an emphasis on the municipality of Puerto Carreño. The Colombian National Herbarium (COL), the Forest Herbarium "Gilberto Emilio Mahecha Vega" at the *Universidad Francisco José de Caldas* (UDBC), the Colombian Amazonian Herbarium of the SINCHI Institute (COAH), and the Catalog of Colombian plants and lichens of the Institute of Natural Sciences of the National University of Colombia were the sources of information for this analysis. In relation to the flora of the department of Vichada, the study consulted the article *"Avance del conocimiento de la flora del Andén Orinoqués en el Departamento de Vichada"* written by Francisco Castro and the compilation of flora from the Orinoco from *El Tuparro* National Natural Park developed by Darío Fajardo.

The information on the number of records was organized in Figures, according to the databases of each institution or source. In addition, the richness by family and by gender reported for the department and the municipality.

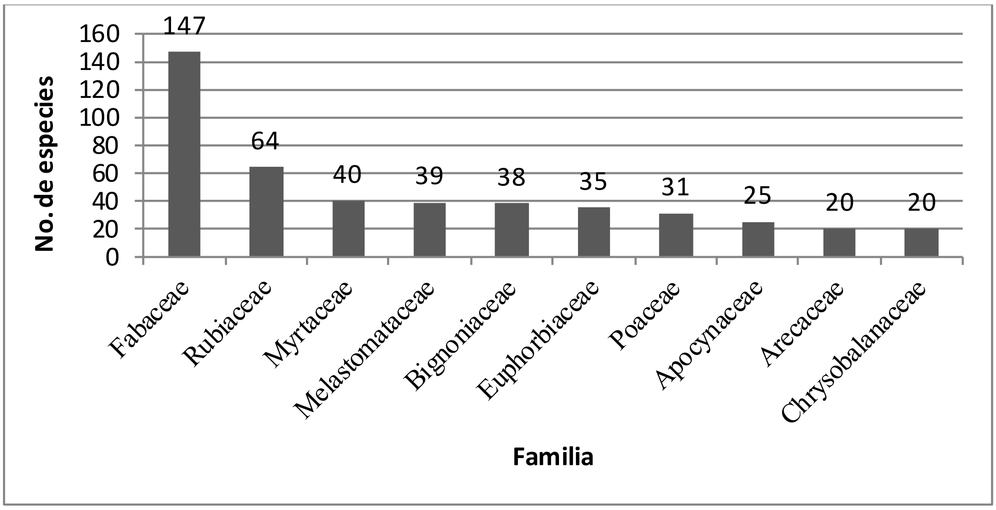
- ***<u>COMPOSITION OF SPECIES.</u>***

Avance del conocimiento de la flora del Andén Orinoqués en el Departamento de Vichada.

This article presents a general study of the flora of the Orinoquía in the department of Vichada. A total of 19 ecosystems and 10 species of plants were identified, grouped into 129 families and 473 genres

The Figure 4.76 shows the most representative families for the area studied. The *Fabaceae* had the largest number of species reaching 147, followed by *Rubiaceae* with 64, *Myrtaceae* with 40, *Melastomataceae* with 39, and *Bignoniaceae* with 35 species.

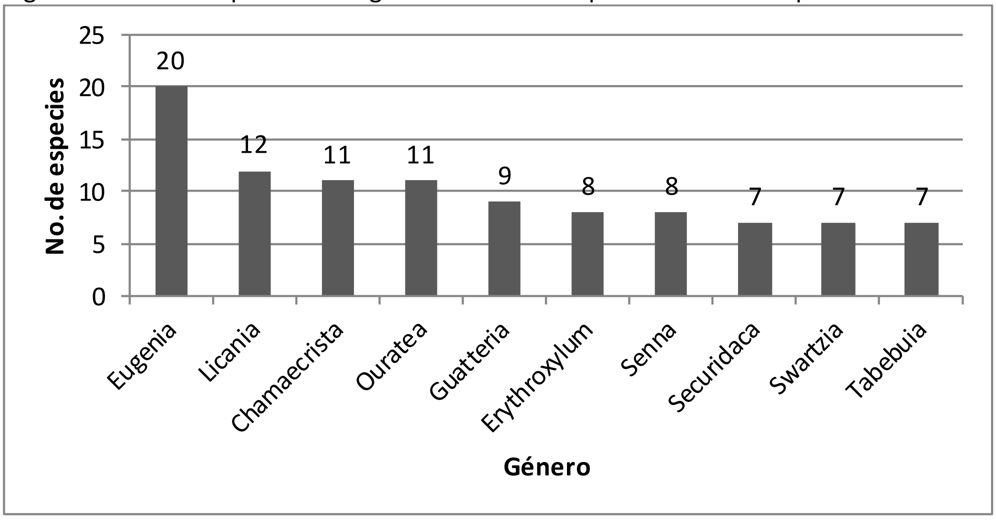
Figure 4.76: Most representative families at the Orinoquía Platform in the department of Vichada.



Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

The most representative genres were: *Eugenia* with 20 species, *Licania* with 12 species, *Chamaecrista* and *Ouratea* with 11 species each, *Guatteria* reaching 9 species, and Erythroxylum, and Senna with 8 species each (See Figure 4.77).

Figure 4.77: Most representative genres in the Orinoqués River in the department of Vichada.

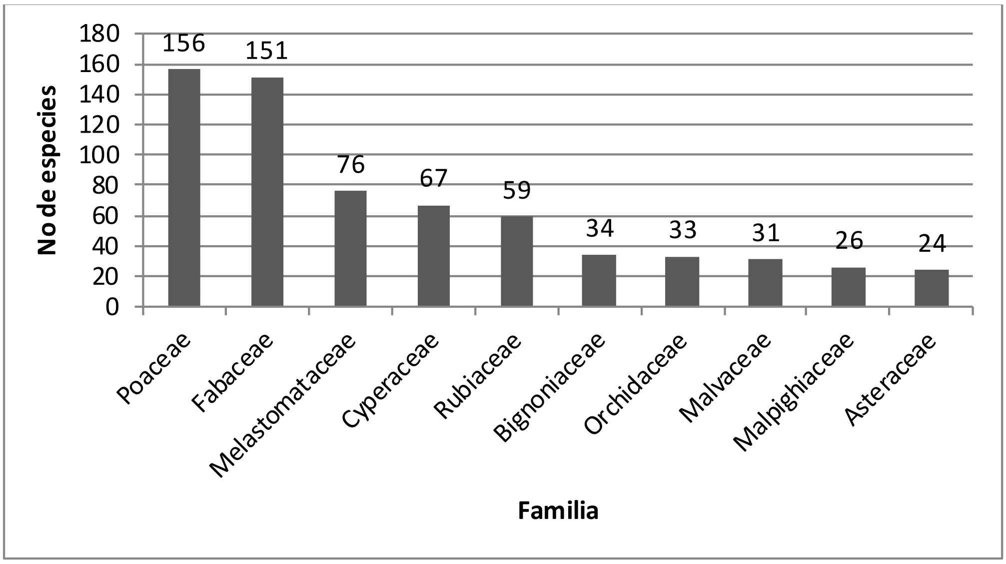


Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Catalog of plants and lichens of Colombia

This catalog reports a total of 1166 species, grouped in 501 genus, and 115 families. The most representative families are: *Poaceae* with 156 species, *Fabaceae* with 151 species, *Melastomataceae* with 76 species, *Cyperaceae* with 67 species, and Rubiaceae with 59 species (see Figure 4.78).

Figure 4.78: Most representative families in the department of Vichada.



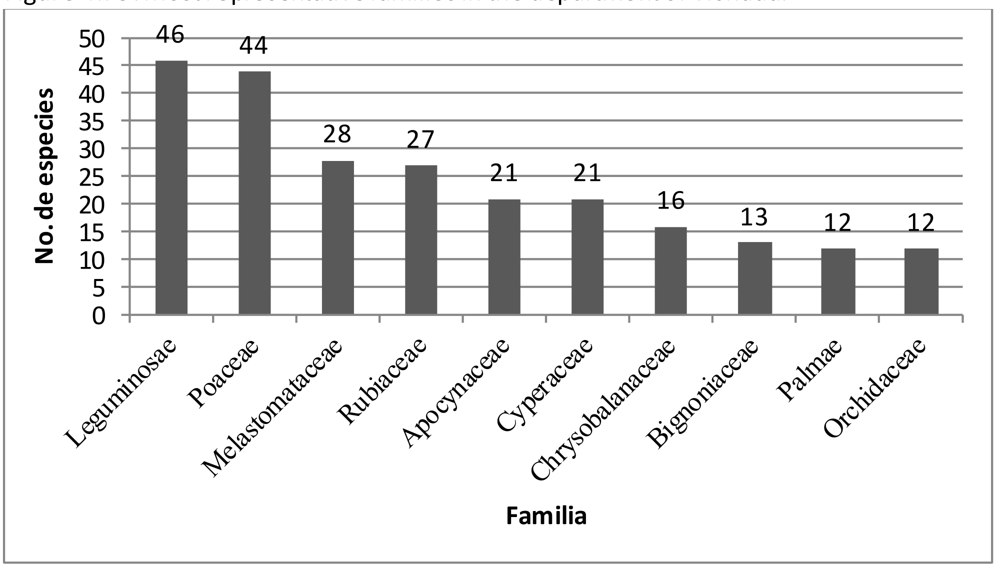
Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Compilation of *Orinoquense* flora - *El Tuparro* National Natural Park

The study estimated 535 higher plant species for the park area, which correspond to 111 families and 344 genres. This figure represents 25% of the species distributed in the Colombian *Orinoquía*; this may be considered as high, and provides an idea of the floristic richness of the area.

The most representative families for the park area are: Leguminosae with 46 species; Poaceae with 44 species; Melastomataceae with 28 species; Rubiaceae with 27 species, and Apocynaceaea and Cyperaceae with 21 species (see Figure 4.79).

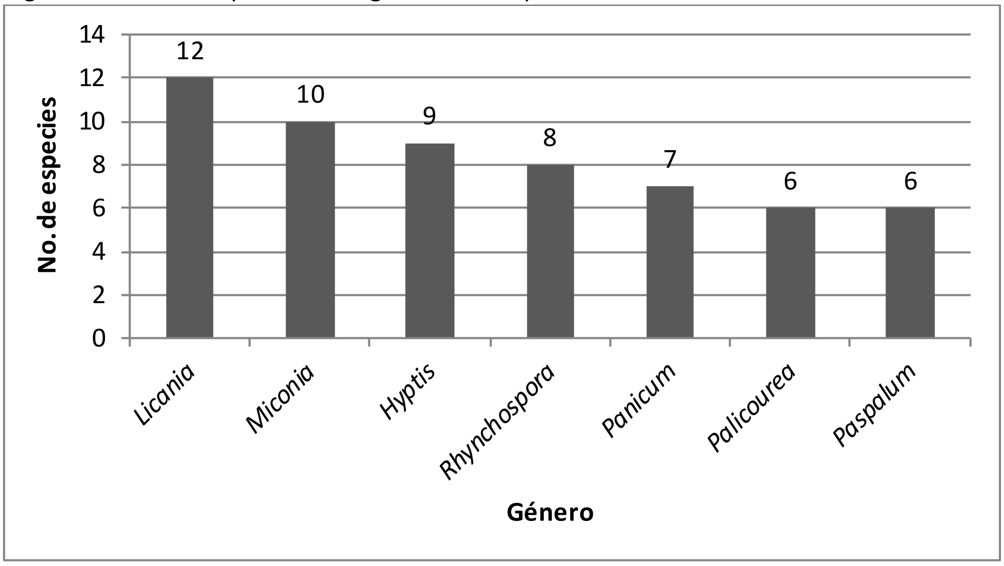
Figure 4.79: Most representative families in the department of Vichada.



Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

The most representative genres for *El Tuparro* Park were: *Eugenia* with 20 species; *Licania* with 12 species; *Miconia* reaching 10 species; *Hyptis* with 9 species, and *Rhynchospora* with 8 species, and Panicum reching 7 species (see Figure 4.80).

Figure 4.80: Most representative genres at *El Tuparro* Park.

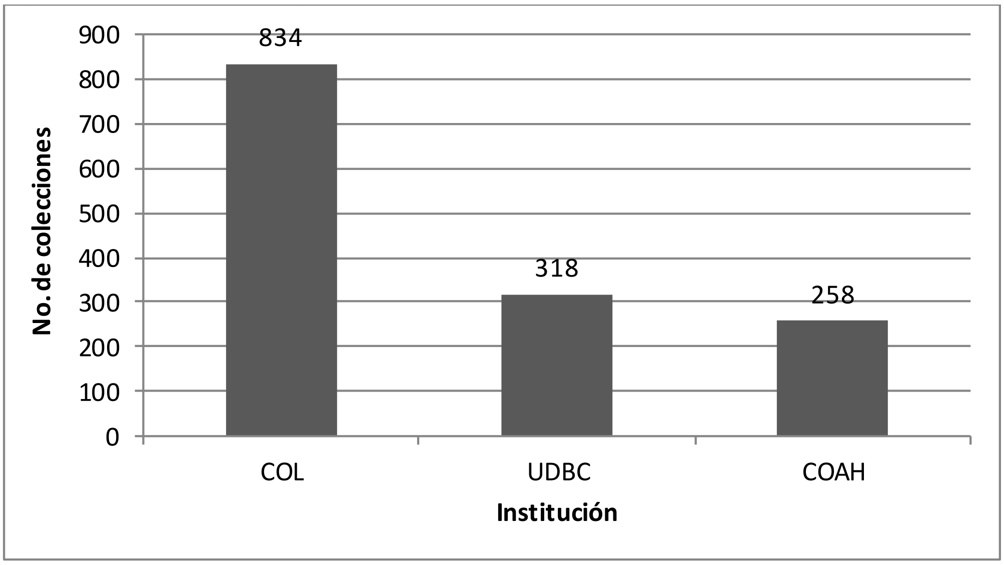


Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Herbal consultation

The aforementioned herbaria were consulted, gathering a total of 1410 botanical collections for the municipality of Puerto Carreño. The Colombian National Herbarium[28] (COL) gathers the largest amount reaching 834 collections (59.1%), followed by the Forest Herbarium "Gilberto Emilio Mahecha Vega"[29] of the Universidad Distrital Francisco José de Caldas (UDBC) gathering 318 collections (22.6%) and the SINCHI Institute Colombian Amazonian Herbarium[30] (COAH) with 258 (18.6%), as shown in Figure 4.81**.**

Figure 4.81: Number of vegetation collections by Institutions (municipality of Puerto Carreño).

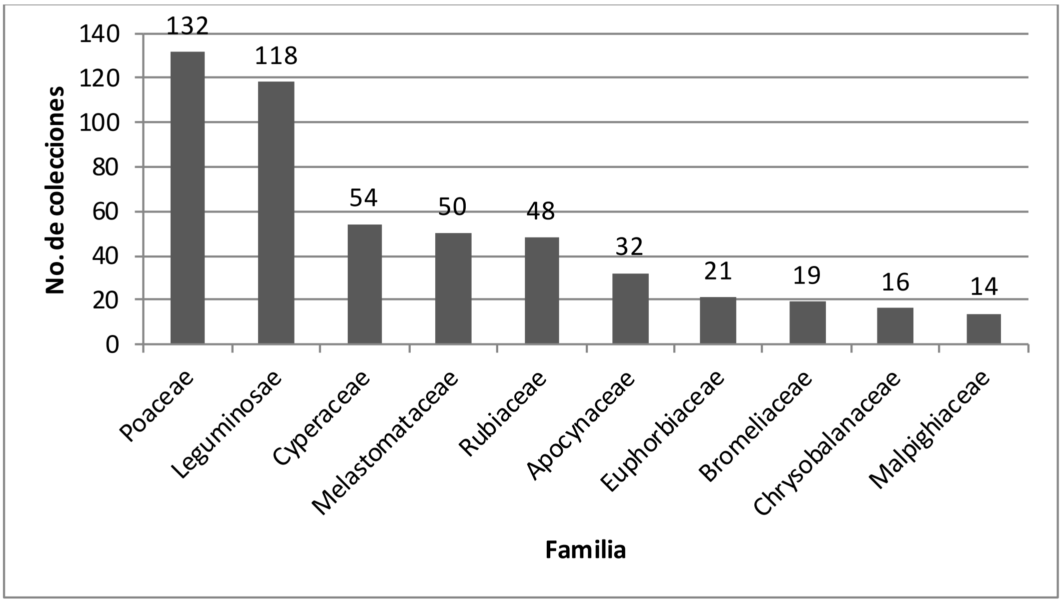


Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

[28] (Colombian National Herbarium, COL)
[29] (Forest Herbarium District University, UDBC)
[30] (Colombian Amazonian Herbarium, COAH)

The records of the Colombian National Herbarium[31] (COL) include the following the most representative families regarding the number of collections: *Poaceae* with 132; *Leguminosae* reaching 118; *Cyperaceae* with 54; *Melastomataceae* gathering 50; *Rubiaceae* with 48, and Apocynaceae with 32 collections (see Figure 4.82).

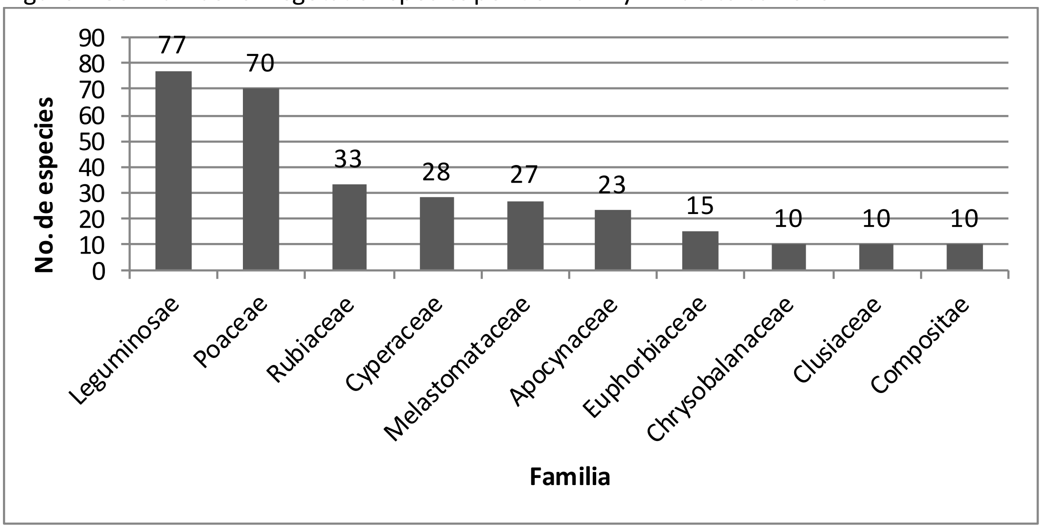
Figure 4.82: Number of vegetation collections by COL family in Puerto Carreño.



Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

The most representative families, in terms of number of species, for COL were: *Leguminosae* with 77; Poaceae gathering 70; Rubiaceae with 33; Cyperaceae with 27; Melastomataceae reaching 50, and Apocynaceae gathering 23 species (see Figure 4.83).

Figure 4.83: Number of vegetation species per COL family in Puerto Carreño



Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

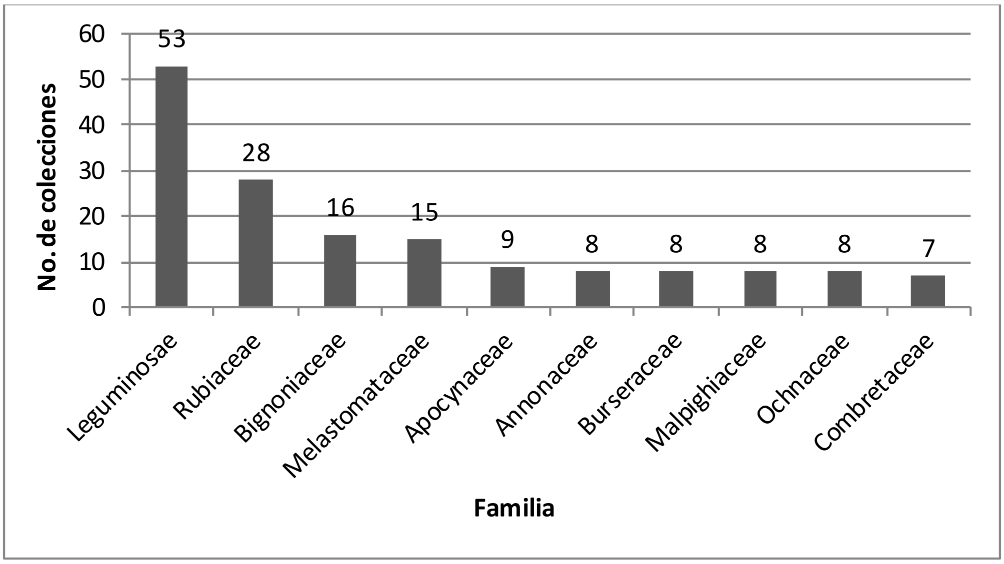
The records of the "Gilberto Emilio Mahecha Vega"[32] at the Universidad Distrital Francisco José de Caldas (UDBC) outline the most representative families regarding the number of collections: *Leguminosae* with 53; *Rubiaceae*

[31] (Colombian National Herbarium, COL)

[32] (Forest Herbarium Universisdad Francisco José de Caldas, UDBC)

reaching 28; *Bignoniaceae* gathering 16; *Melastomataceae* with 15 and *Apocynaceae* with 8 collections (see Figure 4.84).

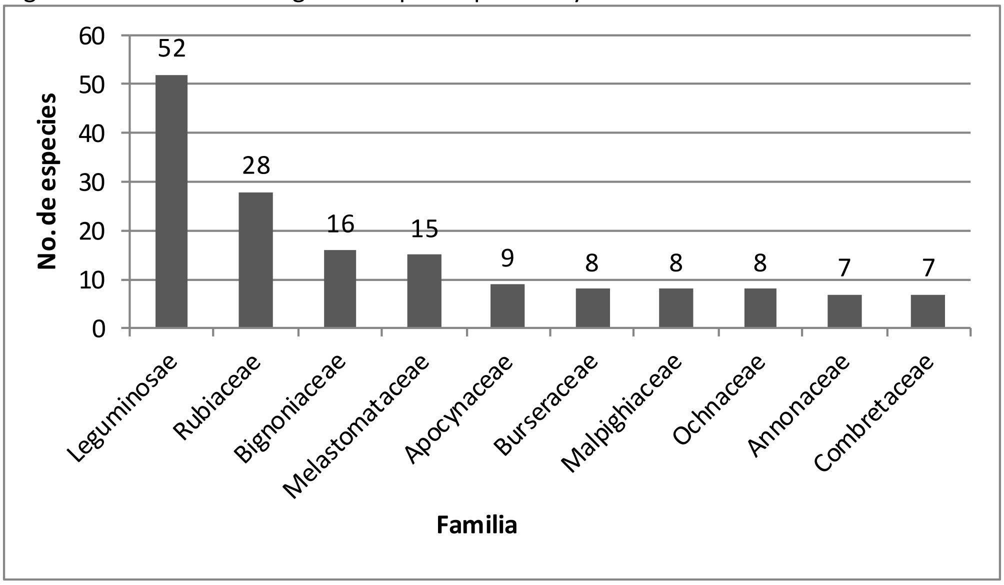
Figure 4.84: Number of vegetation collections per family of the *Universidad Distrital Francisco José de Caldas* in Puerto Carreño.



Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

The most representative families in terms of number of species for the UDBC were: *Leguminosae* with 52; Rubiaceae reaching 28; Bignoniaceae with 16; Melastomataceae gathering 15, and Apocynaceae reaching 8 collections (see Figure 4.85).

Figure 4.85: Number of vegetation species per family at the UDBC in Puerto Carreño.



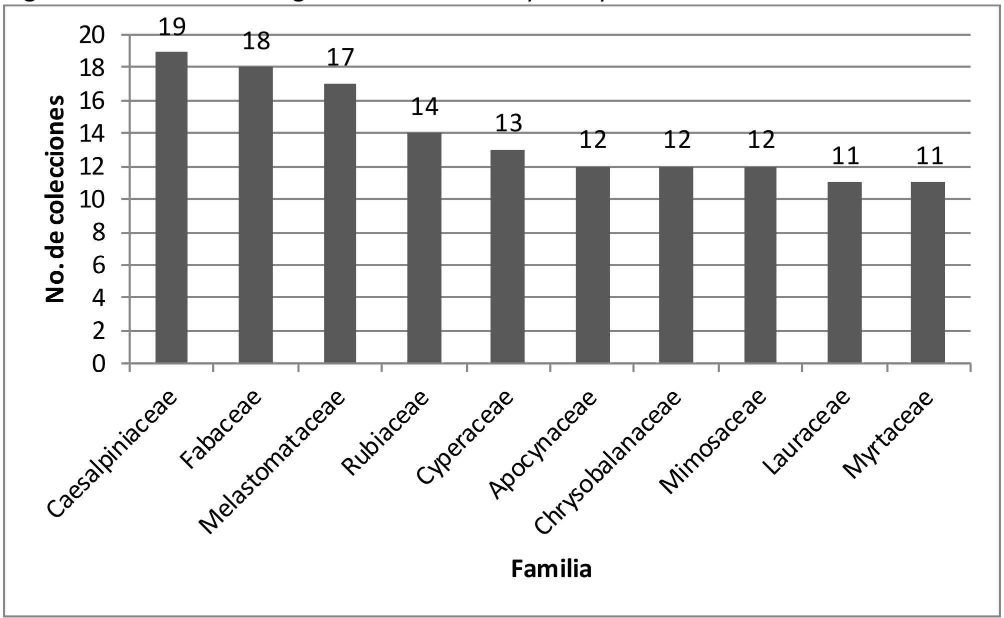
Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

The Colombian Amazonian Herbarium[33] (COAH) records show the most representative families regarding the number of collections: *Caesalpiniaceae* with 19; *Fabaceae* with 18; *Melastomataceae* gathering 17; *Rubiaceae*

[33] (Colombian Amazonian Herbarium, COAH)

reaching 14; *Cyperaceae* with 13, and *Apocynaceae*, *Chrysobalanaceae* and *Mimosaceae* with 12 collections each (see Figure 4.86).

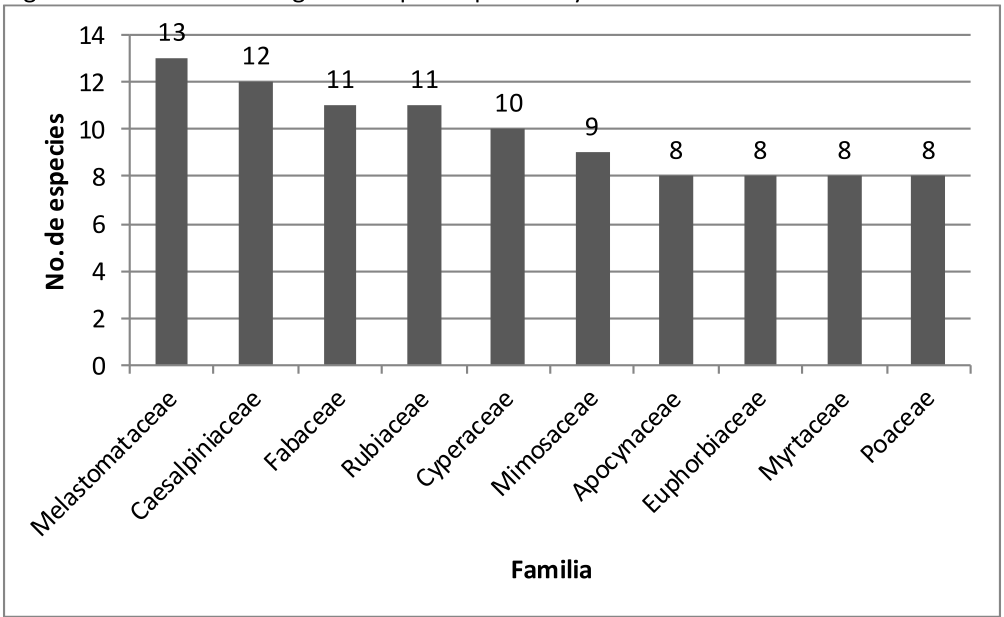
Figure 4.86: Number of vegetation collections by family of the COAH in Puerto Carreño.



Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

The most representative families in terms of number of species for the COAH[34] were: Melastomataceae with 13; Caesalpiniaceae with 12; Fabaceae and Rubiaceae with 11 each, and Cyperaceae with 10 species (see Figure 4.87).

Figure 4.87: Number of vegetation species per family of the COAH in Puerto Carreño.



Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

[34] (Colombian Amazonian Herbarium, COAH)

4.3.1.2 Methodology

The landscape analysis was based on the consultation of geomorphology secondary information in the municipality of Puerto Carreño, and the landscape units field verification which combined land coverings with geomorphological units, and a photographic record was taken for such purpose. Accordingly, a visibility, quality, and landscape fragility qualitative basic analysis was carried out, as well as the description of the project in the landscape component, including the landscape interest sites.

A set of technical activities was carried out in order to characterize the wild flora in the area of influence. These activities allow determining the composition, structure and general condition of the natural vegetation present in the territory where the commercial reforestation project is located. For such purpose, three phases were carried out: firstly, consisting on the collection of secondary information; secondly, the field information gathering phase, and thirdly, the information processing phase and document preparation. Each of these phases is described below.

- ***FIELD PHASE.***

The flora component field phase was focused on the wild flora characterization represented in the natural plant coverings.

A forest inventory was performed in order to characterize the wild flora, which, according to the Ministry of Environment, is defined as the method used to gather the floristic information of the natural forests, thus obtaining qualitative and quantitative information, in accordance with the established objectives. The above refers not only to the individual assessment of trees, their volume and size, but also other elements that characterize the forest such as composition, structure and function, which are important for decision making. In order to deliver this characterization, the information was collected by means of sampling plots for each type of natural vegetation cover. The above involved the measurement of arboreal individuals, which was carried out in three size categories: *Fustales*, *Latizales* and *Brinzales*. The dimensions of these categories are described in Table 4.44.

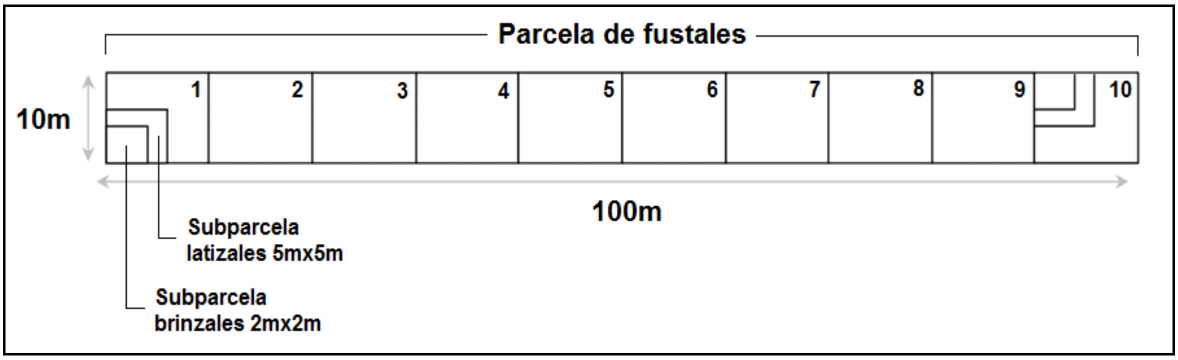
Table 4.44: Criteria in order to differentiate the three categories: fustales, latizales and brinzales.

Category	Classification Criteria
Brinzales	Total height greater than 30 cm; diameter under 2.5 cm
Latizales	Diameter greater than or equal to 2.5 cm and less than 10 cm.
Fustales	Diameter greater than or equal to 10 cm

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

The size and shape of the plots depends on the type of vegetation cover to be inventoried. A 1,000 square meters rectangular plots were used (0.1 hectares) for the forest gallery and *morichales,* which are the arboreal type natural vegetation present in the area. The size and shape of the plots for these covers are shown below.

Figure 4.88: Sample plots shape and size (for forests).



Upon the plots described, the coordinates were recorded with the help of Garmin Map62sc® GPS equipment. The information gathered, from the initial and final points are distributed as follows:

Upon 10 x 10 meters subplots, a complete *fustales* inventory was carried out; in order to evaluate the natural regeneration, 5 x 5 meters subplots were taken for the *latizales* category, and 2 x 2 meters for *brinzales,* upon the initial and final *fustales* subplots.

The information of the arboreal individuals was recorded within these plots using three determined size categories (*Fustales*, *Latizales* and *Brinzales*). Accordingly, the circumference was measured at the breast height (CAP); additionally, the total and commercial height was estimated (Figure 120).

Figure 4.89: Measurement of attributes (inventoried individuals).

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

The attribute measurements were performed made by a Forest Engineer using a Tablet and a digital form (in order to obtain information compatible with Microsoft Excel® databases). Some of the generalities of the area were recorded in such platforms including the location at municipal and local level, altitude, cover unit, date, and starting and ending coordinates of plots (See Figure 121).

Figure 4.90: Forest inventory digital form used to register the taxa sampling by plot upon polygons of the Orinoquia Forestry (Vichada).

		FORMULARIO DE INVENTARIO FORESTAL FUSTALES					Hoja No	
Proyecto		Coord Inicio (EW-NS)				Altura (a.s.n.m)	Inicial	
Municipio	Puerto Carreño	Coord Fin (EW-NS)					Final	
Vereda	Venturosa	Cobertura	Bosque de Galería			Parcela		
Fecha	27/07/2017					Diligencia	Mario Jiménez	

No	Sub parcela	NOMBRE COMÚN	ESPECIE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	HC	HT	Observaciones	No. Foto
1	A	Gualanday	*Jacaranda obtusifolia*	38					5	9		
2	A	Madroño	*Garcinia madruno*	41					6	9.5		
3	A	Nn1	*Eschweilera parvifolia*	175					12	18	Fotos	572-574
4	A	Nn2	*Parinari pachyphylla*	32					5	10		
5	B	Choapo	*Socratea exorrhiza*	32					5	9		
6	B	Escobo rojo	*Licania subarachnophylla*	72					9	16		
7	B	Anime	*Protium heptaphyllum*	56					7	14		
8	B	Saladillo rojo	*Caraipa llanorum*	67					9	17		
9	C	Manaco	*Euterpe precatoria*	32					12	19		
10	C	Aceite	*Copaifera pubiflora*	266					8	22		
11	C	Saladillo rojo	*Caraipa llanorum*	58					6	17		
12	C	Nn3	*Eschweilera parvifolia*	57					6	13		
13	D	Manaco	*Euterpe precatoria*	34					15	19		
14	D	Saladillo rojo	*Caraipa llanorum*	48					12	16		

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

The study also marked the individuals with paint (using a consecutive number per plot, for the *fustales* category, and using a visible mark for the *latizales* category). Additionally, the respective points were taken by plot in order to define its location using GPS equipment (Figure 122 and Figure 123).

Figure 4.91: Marking of individuals sampled during inventory

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

Figure 4.92: Registration of location points with a GPS navigator

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

The identification of arboreal species was carried out in accordance with the APG III classification system, taking into account the expertise of the specialist in charge of such forest inventory. This inventory analyzed the main taxonomic characteristics of the individuals inventoried. This exercise was also supported by field guides (in order to obtain common names). In cases where the identification was not possible in the field, the collection of the botanical sample performed (See Figure 124) in order to achieve its identification with the support of specialized professionals, and through dichotomous keys and herbaria consultation.

Figure 4.93: Collection of botanical samples during the development of the floristic inventory.

Source: (*Universidad Distrital Francisco José De Caldas*, 2017)

- ***INFORMATION PROCESSING PHASE***

Once obtained the information of the plots, entered in the field forms and the final determination of species, we proceeded to elaborate the database for each coverage, under the platform Microsoft Excel© and the respective calculations were made, in this way we proceeded to the analysis of composition, structure and diversity of each coverage inventoried. This information articulates with the established parameters by the terms of reference and by the technical Guides for the ordering and the sustainable management of natural forests of the Ministry of Environment1 today Ministry of Environment and Sustainable Development, implemented for environmental studies in Colombia.

The parameters determined for the characterization of the vegetable coverages are described below:

Statistical analysis

To give statistical validity and representativeness to the forest inventory, the statistical analysis of the information collected in the field was made, through the use of the variable total volume, determining a sampling error no greater than 15% and a probability level of 95. The statistical parameters used are shown in Table 4.45.

Table 4.45: Statistical Parameters used.

PARAMETER	EQUATIONS
Average volume	$\overline{\mathrm{X}} = \frac{\sum x}{n}$
Standard deviation st	$SX = \sqrt{\frac{\sum \mathrm{X}^2 - (\sum \mathrm{X})^2 / n}{N-1}}$
Variation coefficient	$CV = \frac{SX}{\mathrm{X}} \times 100\%$
Standard error	$\mathrm{EX} = \frac{S}{\sqrt{n}}$
Sampling error with probability 95%	$\mathrm{E}m_{0.05} = \mathrm{EX}\% \times t$
Sampling error	$\mathrm{E}m\% = \mathrm{EX} \ / \bar{X} \times 100$

Floristic composition

The analysis of the floristic composition is made through the elaboration of databases for each type of vegetable coverage inventoried, where the list of species is made with its taxonomic classification listing information on family, gender, common name and scientific name of each species and including the author of each one of these.

Horizontal structure

The analysis of the horizontal structure consists of determining quantitatively the behaviour of the individuals on the ground surface and it is analyzed from the frequency, basal area or dominance, abundance and the importance value index. It is complemented with the degree of aggregation of the species.

Absolute abundance

It is the number of trees by species accounted for in the inventory.

Relative abundance

It indicates the percentage of participation of each species, referred to the number of total trees found. It is expressed as a percentage and is defined as the relationship between the number of trees of each species and the total number of individuals found in the sampling.

$$\mathbf{AR} = \left(\frac{\mathbf{Aa}}{\mathbf{At}}\right) * \mathbf{100}$$

Aa = number of individuals by species in the sampled area
At = total number of individuals in the sampled area

Absolute frequency

It is the presence-absence of a given species in a plot. It is calculated as the percentage ratio corresponding to the number of plots in which a species occurs, between the total number of plots.

$$\mathbf{Fa} = \frac{\mathbf{U}}{\mathbf{T}} * \mathbf{100}$$

U = number of sampling units in which a species occurs
T = total number of sampling units.

Relative frequency

It is the percentage of the absolute frequency of a species in relation to the sum of the absolute frequencies of the species present.

$$\mathbf{FR} = \frac{\mathbf{Fa}}{\mathbf{Ft}} * \mathbf{100}$$

Fa = Absolute frequency
Ft = Sum of the absolute frequencies

According to the absolute frequency, to perform the frequency histogram, the species are grouped in the following classes:

I	Fa=1-20	Very rare.
II	Fa=20,1-40	Infrequent.
III	Fa=40,1-60	Frequent.
IV	Fa=60,1-80	Quite frequent.
V	Fa=80,1-100	Very frequent.

Absolute dominance

Also called the degree of coverage of the species, which is the expression of the space occupied by them. It is defined as the sum of the horizontal projections of the trees on the ground. Due to the complex vertical structure of the tropical forests, on occasions its determination becomes impossible, for this reason, the basal areas are used as substitutes for the true dominance values. This process is justified due to the high linear correlation between the cup diameter and the stem diameter for a particular species.

$$\mathbf{DA} = \mathbf{\Sigma}[\left(\frac{\boldsymbol{\pi}}{\mathbf{4}}\right) * \mathbf{DAP^2}\ ]$$

π = 3.141593
DAP = Diameter at chest height.

Relative dominance

It is calculated as the proportion of a species in the total evaluated area, expressed as a percentage.

$$\mathbf{DR} = \left(\frac{\mathbf{DA}}{\mathbf{At}}\right) * \mathbf{100}$$

DA = Absolute dominance of each species
At = Total basal area in the sampled area.

Importance value index (IVI)

This index is given by the sum of the parameters expressed in percentage of the abundance, frequency and relative dominance and is used to perform descriptive and quantitative studies of the structures of the types of forests. The maximum value of the IVI is 300 and is reached in strata presenting a single species. This index also allows to deduce aspects such as dynamism, dominance and representativeness of the species.

$$\mathbf{I.V.I} = \mathbf{AR} + \mathbf{FR} + \mathbf{DR}$$

Degree of aggregation

The degree of aggregation is a variable that indicates the extent to which the individuals that make up a certain coverage tend to group; its value always moves in three ranges. The interpretation of the degree of aggregation is made taking into account that if its value is less than one (1) the species is dispersed in the coverage. If, on the contrary, values greater than or equal to two (2) are obtained, it reflects a grouped distribution, whereas values between one (1) and two (2) indicate a tendency to group the species. These parameters can be summarized as follows:

GA ≥ a 1 y < 2, indicates a tendency to group.
GA ≥ a 2, indicates that the species has a grouped distribution.
GA< a 1, indicates that the species is dispersed.

It determines the spatial distribution of the species, being the mathematical expression of the observed density with respect to the expected density.

Ga = Do / De

Where:
Do = Observed density: Total number of trees per species / Total number of plots sampled.
De = Expected density: -Ln (1-F/100)
F = Absolute frequency
Ln = Natural or Neperian logarithm (e base).

Vertical structure

The vertical structure is analyzed according to the height, differentiating strata, according to qualitative or quantitative profiles in relation to the total height and height at the base of the cup (also called commercial height). To analyze the vertical structure, the arboreal strata are defined: higher (Es), medium (Em) and lower (Ei), depending on the maximum and minimum height or with preset ranges.

Ogwa Diagram

This is a quantitative method of describing the vegetation, used to detect the presence of strata, tailoring a graph with the total heights in the ordinates and the heights to the base of the cup on the abscissa; the appearance of swarms of more or less isolated points indicates the virtual void of the cups at intermediate levels, suggesting a number of differential strata in the profile of the forest; when a single elongated cloud of points and with a positive slope is generated, no strata can be differentiated, since there is continuity of points from the understory to the canopy.

Vegetation profile

The vegetation profile comprises a qualitative method of evaluating the vertical structure, to illustrate structural aspects of the forest such as: height, coverage, form of cups, strata and vertical spacing. During the field work in the capture of information, a "type" sampling unit is made for the forest in which it is registered for trees, besides the information already mentioned, the location of the trees with respect to the plot axis and the form and size of the cups, in order to establish their position in the plot space. With this, we proceed to locate them in a Cartesian plane and a schematic design of each species is made to provide a synthesized example of its shaft, foliage, color and type of cup. With these inputs and using the information originating of the forest inventory, specifically the DAP, the commercial height and the total height of each individual, they are located in the horizontal and vertical plane and, in this way, the vegetable profile is created. For a better understanding of the way the trees are distributed on the plot, is used the location of each individual and an orthogonal view of the "type" sampling unit is made.

Sociological position

It indicates the importance value of the species for the different strata that make up the forest; it can be said then that a certain species has a place assured in the floristic structure and composition when it is present in all the strata.
It is contemplated to divide the sampled population in three strata for which it is necessary to calculate the difference between the extreme values of the height variable, that is to say the value of the individual with greatest height minus the value of the individual with lesser height. A phytosociological value is assigned to each sub-stratum, dividing the number of individuals in each sub-stratum by the number of individuals of all species.

$$\mathbf{VF} = \frac{\mathbf{n}}{\mathbf{N}}$$

VF = Phytosociological Value
n = Number of individuals of the sub-stratum
N = Total number of individuals of all species

To calculate the absolute value of the sociological position of a species, its phytosociological values in each sub-stratum are added, effecting the product of the phytosociological value of the considered stratum times the number of individuals of the species in that same stratum.

$$\mathbf{PSa} = \mathbf{VF(i)} * \mathbf{n(i)} + \mathbf{VF(m)} * \mathbf{n(m)} + \mathbf{VF(s)} * \mathbf{n(s)}$$

PSa = Absolute Sociological Position of the species
VF = Phytosociological value of the sub-stratum
n = N° of Individuals of each species

i = lower
m = medium
s = higher

The sociological position of each species is expressed as a percentage over the total sum of the absolute values:

$$\mathbf{PS\% = PSa/\Sigma PSa}$$

Basal area and volume calculation

Basal area

It is defined as the surface of a cross section of the stem or trunk of the individual at a certain height from the ground; it is expressed in cm2 or m2.

$$\mathbf{AB = \frac{\pi}{4} \times (DAP)^2}$$

Volume

This parameter is the most important result of the forest inventory, as an indicator of the potential or production capacity of the vegetable coverage analyzed; the volume obtained refers to trees standing and is calculated on the basis of the DAP, the height and the form factor. In a forest inventory, it can be expressed as volume per area unit and total volume of the inventoried area in the form of total and commercial volume; the most used method is the application of the conventional volume equation:

$$V = \frac{3.1416 * d^2}{4} * h * f$$

Where:
V = Tree volume
d = Diameter at chest height squared
h = Height of the shaft
f = Form factor

According to Posada (1989) and the FAO (1974), the form factor to be used for hardwood species of the tropics, according to the tests carried out is 0.7.

Distribution by class intervals

In a general way, an altimetric distribution is the result of grouping the trees of a forest within certain categories, according to the maximum and minimum values of each parameter and with the number of individuals, the class intervals or categories are established in the following way:

$$\mathbf{C = (X\,max - X\,min)/M}$$
$$\mathbf{M = 1 + 3.3\ (Log10\ (n))}$$

n: total number of individuals of the group
M: number of intervals

For the diameter classes, a distribution by class is made and the shafts are classified in different ranges with a class amplitude of 10 cm.

Floristic diversity

Biological diversity refers to the variety and abundance of species, their genetic composition and the communities, ecosystems and landscapes in which they occur; it also refers to the ecological structures, functions and processes at all these levels. The richness is defined as the number of taxa that typify a locality, region or plot. The information on the number of species present is used to determine the richness, through the application of the mix ratio (CM) and the species richness indexes of Margalef[35] and Menhinick[36]; Shannon's structural index of diversity and Simpson's equity index are also estimated.

Mix ratio

It measures the mix intensity in natural forests. To this end the number of species found is divided by the total number of trees, obtaining a figure that represents the average of individuals of each species within the association.

$$\mathbf{CM} = \left(\frac{\mathbf{Ns}}{\mathbf{Na}}\right) * \mathbf{100}$$

Ns= Number of species
Na= Number of trees

CM = 1, is the highest value of this ratio, which means that each new individual is a new species for the inventory, but in turn determines the homogeneity or heterogeneity of the forest. By exchanging the numerator with the denominator, it is possible to interpret how many individuals it is necessary to inventory to find a new species in the inventory.

Margalef Index

This index transforms the number of species per sample to a proportion at which species are added by sample expansion. It assumes that there is a functional relationship between the number of species and the total number of individuals S=k√N where k is constant. If this does not hold, then the index varies with the sample size in an unknown way. Using S–1, instead of S, gives DMg = 0 when there is only one species.

$$\mathbf{DMg = S - 1/\ln N}$$

S = number of species
N = total number of individuals

Values lower than 2.0 are related to low diversity zones (generally the result of anthropogenic effects) and values higher than 5.0 are considered as indicative of high biodiversity.

[35] (Margalef, 1995)
[36] (Menhinick, 1964)

Shannon-Wiener Index

To measure the richness or variety of species, the Shannon index is used, a mathematical expression that relates the number of species to the number of individuals in a given community. This index also assumes that all species are represented in the sample and is also a measure of the diversity or richness in species of a given population; in this case, the maximum value is equal to LN(S), where S is the total number of individuals. The Shannon diversity index allows to calculate the sum of probabilities of the species and the homogeneity of the distribution for a number of species.

$$\mathbf{H} = \sum (\mathbf{pi\ x\ ln\ pi})$$

pi = Abundance of each one of the species (ni/N).
ni= Number of individuals sampled for the species i.
N = Total number of individuals sampled.
ln = Neperian logarithm.

This index allows to calculate the sum of probabilities of the species and the homogeneity of the distribution for a number of species. It is usually found to fall between 1.5 and 3.5 and only rarely exceeds 4.5.

Simpson Index

It shows the probability that two individuals taken at random from a sample are of the same species. It is strongly influenced by the importance of the most dominant species.

$$\lambda = \Sigma p_i{}^2$$

pi= proportional abundance of species i, that is, the number of individuals of species i divided by the total number of individuals of the sample.

The Simpson index measures the degree of concentration and varies between 0 and 1; when the diversity is low it tends to 1. For the interpretation of this index, the numerical values are expressed in reciprocal form (1 / λ), in this way they are directly proportional to the diversity.

Natural regeneration

For the analysis of the natural regeneration of the forest, the variables and methodologies previously described for the characterization of trees in the aspect of horizontal structure were used, that is, floristic composition, abundance and frequency calculation, with the respective relative analysis (%) of these variables.

Endangered, banned, endemic and trade restricted species

In order to determine the vascular flora species of interest for the area of study, either because they are in critical danger or threatened, the Red Books of Colombian plants, the Red List of the International Union for the Conservation of Nature and the Resolution 0192 of 2015 of the Ministry of Environment and Sustainable Development, by which the listing of endangered wild species of the Colombian biological diversity found in the national territory is established, were reviewed. Those species over which may exist some kind of restriction for their commercialization and those that have some kind of national or regional ban, were determined, from the review of the Annexes CITES and the resolutions issued by the former INDERENA, the Ministry of Environment and Sustainable Development and by Corporinoquia, about banned species. Additionally, endemics of the area were searched for, through available taxonomic revision for each one of the groups found, mainly of Colombian Flora, Neotropic Flora, in articles, specialized pages and virtual herbaria.

4.3.1.3 Results of the sampling phase

- ***<u>FLORISTIC AND STRUCTURAL ANALYSIS OF THE NATURAL VEGETABLE COVERAGES.</u>***

The wild flora in the area of study is conditioned by historic natural processes like periodic fires and localized edaphic and hydric characteristics, but also by the action of man specially in the last century with developments of colonization and agricultural activities, which together have relegated the vegetation to small relicts associated with water bodies.

Two natural plant coverings of arboreal size (Forests) were determined for the area, according to the classification of the hierarchical type methodology CORINE Land Cover adapted for Colombia (IDEAM 2010), corresponding to Forest of Gallery and Palmares (Morichales). These coverings are found associated with water bodies like rivers, spouts, lagoons and abandoned meanders of the rivers (madreviejas), and intermingle in elongated forms in a matrix of natural grasslands composed of grass and some shrubs in a dispersed form.

Despite being in reduced areas and with constant alteration, these forests represent an important genetic reservoir of the regional flora and provide an innumerable amount of ecosystem services, such as refuge and wildlife habitat, hydric regulation, erosion control, among many others.

The forest inventory was made on the coverages of Gallery Forest and Morichal in a total of 28 sampling units (plots), in the five sectors determined for that end. The location of the plots in the area is shown in Figure 4.94.

Figure 4.94: Location of the flora sampling units.

Source: Available satellite images coming from the remote sensor Digitalglobe. Google Earth.

Next, the characterization of each of the aforementioned natural plant coverings is described, with the information obtained in the forest inventory.

- **Gallery Forest.**

The information necessary for the characterization of the gallery forests in the area of influence of the project was taken through the field survey of 21 sampling units of 0.1 hectares each, in the five sampling zones determined, for a total sampled area of 2.1 hectares; These sampling plots were georeferenced in the geographic coordinates system WGS84 both at the initial and final points, as shown in Table 4.46.

Table 4.46: Location data of the parcels surveyed in gallery forest.

CODE	START POINT		FINAL POINT	
	X	Y	X	Y
Bg1	917713,827515	1168850,5071	917753,929123	1168942,61525
Bg2	916497,840332	1172237,68773	916599,308226	1172237,54461
Bg3	916850,94563	1172183,28076	916906,186681	1172266,1506
Bg4	917434,043404	1172163,331	917333,632108	1172153,56662
Bg5	915884,801603	1160859,44276	915882,007215	1160761,23706
Bg6	915527,985252	1160553,03735	915591,648765	1160476,19412
Bg7	916457,070236	1161252,1471	916442,343555	1161153,54022
Bg8	937497,507667	1165990,9575	937573,516354	1166056,85243
Bg9	936759,676847	1165927,2222	936666,493984	1165893,5289
Bg10	936356,848242	1165921,88706	936455,256312	1165930,61738
Bg11	936285,845607	1165731,11709	936215,271263	1165802,93006
Bg12	936802,648399	1166096,81307	936863,451039	1166019,27262
Bg13	994600,423331	1154303,88903	994575,811642	1154208,66393
Bg14	996356,489589	1154242,32144	996362,635062	1154144,02205

Bg15	994686,474936	1153609,64456	994591,13866	1153643,44319
Bg16	996164,81548	1154417,42832	996218,074862	1154503,43665
Bg17	995826,916162	1154469,67203	995910,564581	1154417,4449
Bg18	1001940,97626	1169647,57939	1001913,3014	1169742,80613
Bg19	1001796,46122	1169856,4612	1001728,81728	1169930,18387
Bg20	1001587,37887	1170126,77898	1001532,03368	1170206,64586
Bg21	1001292,21706	1170089,90953	1001276,84596	1169991,60967

Source: (Universidad Distrital Francisco José De Caldas, 2017). Flat coordinates Magna Colombia Este Este

For the gallery forest coverage, a relative sampling error lower than 15% was achieved, and with a probability of 95%. Table 4.47 shows the different statisticians calculated for this coverage from the variable total volume, with which a sampling error for this coverage in the inventory of 10,9% was determined.

Table 4.47: Statisticians for the gallery forest.

STATISTICIAN	VALUE
Sum	497,47
Average	23,69
Standard deviation	6,86
Variation coefficient (%)	21,97
Relative error required (%)	15
Sample size (n)	21
Student t variable degrees of freedom (n – 1), probability 95%	1,72
Standard error	1,50
Absolute error	2,58
Relative error%	**10,90**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Floristic composition

In the analysis of the floristic composition for the trees of the gallery forest, 944 individuals were found distributed in 42 families, 88 genders and 109 species. At a specific level the families Leguminosae with 16 species, Chrysobalanaceae with 6 species and Lauraceae y Moraceae with 5 species each one stand out; at a genders level *Licania* with 4 species, followed by *Protium* and *Virola* with 3 species each one stand out, as shown in Table 4.48.

Table 4.48: Floristic Composition of trees in gallery forest.

FAMILY	GENDER	SPECIES	COMMON NAME	ABUN.
Anacardiaceae	*Astronium*	*Astronium graveolens* Jacq.	Abejón	1
	Tapirira	*Tapirira guianensis* Aubl.	Guarupayo	26
Annonaceae	*Guatteria*	*Guatteria metensis* R.E.Fr.	Majagüillo blanco	1
		Guatteria schomburgkiana Mart.	Majagüillo negro	52
	Xylopia	*Xylopia aromatica* (Lam.) Mart.	Malagueto	10
		Xylopia emarginata Mart.	Majagüillo	1

FAMILY	GENDER	SPECIES	COMMON NAME	ABUN.
Apocynaceae	*Aspidosperma*	*Aspidosperma desmanthum* Benth. ex Müll.Arg.	Costillo	1
		Aspidosperma excelsum Benth.	Costillo blanco	2
	Himatanthus	*Himatanthus articulatus* (Vahl) Woodson	Platanote	25
	Parahancornia	*Parahancornia oblonga* (Benth. ex Müll.Arg.) Monach.	Pendare	10
Araliaceae	*Dendropanax*	*Dendropanax arboreus* (L.) Decne. & Planch.	Mantequillo	5
	Schefflera	*Schefflera morototoni* (Aubl.) Maguire, Steyerm. & Frodin	Tortolito	11
Arecaceae	*Attalea*	*Attalea maripa* (Aubl.) Mart.	Cucurita	7
	Euterpe	*Euterpe precatoria* Mart.	Manaco	83
	Mauritia	*Mauritia flexuosa* L.f.	Moriche	22
	Oenocarpus	*Oenocarpus bacaba* Mart.	Maporilla	5
	Socratea	*Socratea exorrhiza* (Mart.) H.Wendl.	Choapo	9
Bignoniaceae	*Jacaranda*	*Jacaranda copaia* (Aubl.) D.Don	Pavito	7
		Jacaranda obtusifolia Bonpl.	Gualanday	7
Bixaceae	*Cochlospermum*	*Cochlospermum orinocense* (Kunth) Steud.	Bototo	4
		Cochlospermum vitifolium (Willd.) Spreng.	Bototo	1
Boraginaceae	*Cordia*	*Cordia sericicalyx* A.DC.	Palo de agua	3
Burseraceae	*Protium*	*Protium glabrescens* Swart	Anime	24
		Protium heptaphyllum (Aubl.) Marchand	Anime	65
		Protium llanorum Cuatrec.	Anime	1
	Tetragastris	*Tetragastris panamensis* (Engl.) Kuntze	Caraño blanco	9
Calophyllaceae	*Caraipa*	*Caraipa llanorum* Cuatrec.	Saladillo rojo	93
	Mahurea	*Mahurea exstipulata* Benth.	Caucho amarillo	4
Chrysobalanaceae	*Hirtella*	*Hirtella elongata* Mart. & Zucc.	Garrapato	11
	Licania	*Licania hypoleuca* Benth.	Escobo blanco	1
		Licania leucosepala Griseb.	Aceituno	14
		Licania parvifructa Fanshawe & Maguire	Escobo colorado	4
		Licania subarachnophylla Cuatrec.	Escobo	1
	Parinari	*Parinari pachyphylla* Rusby	Escobo	13
Clusiaceae	*Calophyllum*	*Calophyllum brasiliense* Cambess.	Cachicamo	28
	Garcinia	*Garcinia madruno* (Kunth) Hammel	Madroño	2
	Symphonia	*Symphonia globulifera* L.f.	Breo	9
Connaraceae	*Connarus*	*Connarus lambertii* (DC.) Britton	Sangrito	4
Dichapetalaceae	*Stephanopodium*	*Stephanopodium* sp.	Naranjo	1
Dilleniaceae	*Curatella*	*Curatella americana* L.	Chaparro	1
Ebenaceae	*Diospyros*	*Diospyros sericea* A.DC.	Carbonero	22

FAMILY	GENDER	SPECIES	COMMON NAME	ABUN.
Erythroxylaceae	*Erythroxylum*	*Erythroxylum macrophyllum* Cav.	Ajicito	2
Euphorbiaceae	*Alchornea*	*Alchornea discolor* Poepp.	Algodoncillo	4
		Alchornea triplinervia (Spreng.) Müll.Arg.	Carnegallina	2
	Mabea	*Mabea trianae* Pax	Canilla de venado	11
Humiriaceae	*Sacoglottis*	*Sacoglottis guianensis* Benth.	Fierrito	29
Hypericaceae	*Vismia*	*Vismia baccifera* (L.) Planch. & Triana	Lacre blanco	4
		Vismia macrophylla Kunth	Punta de lanza	4
Lacistemataceae	*Lacistema*	*Lacistema aggregatum* (P.J.Bergius) Rusby	Laurel rosado	1
Lamiaceae	*Vitex*	*Vitex orinocensis* Kunth	Guarataro	2
Lauraceae	*Aniba*	*Aniba panurensis* (Meisn.) Mez	Yema de huevo	5
	Licaria	*Licaria canella* (Meisn.) Kosterm.	Amarillo	1
	Nectandra	*Nectandra cuspidata* Nees & Mart.	Laurel sabanero	2
	Ocotea	*Ocotea bofo* Kunth	Laurel	14
		Ocotea longifolia Kunth	Laurel matatigre	4

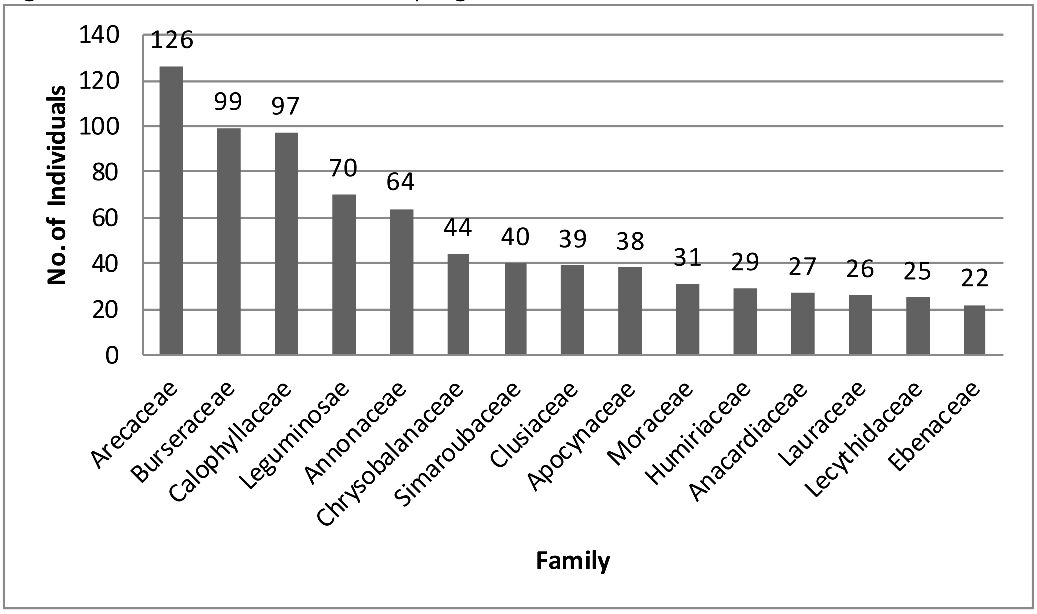
		Ocotea longifolia Kunth	Laurel matatigre	4
Lecythidaceae	*Eschweilera*	*Eschweilera parvifolia* Mart. ex DC.	Coco de mono	12
		Eschweilera tenuifolia (O.Berg) Miers	Copo	13
Leguminosae	*Albizia*	*Albizia lebbeck* (L.) Benth.	Menudito	11
	Andira	*Andira surinamensis* (Bondt) Pulle	Arenoso	3
	Campsiandra	*Campsiandra comosa* Benth.	Chigo	4
	Copaifera	*Copaifera pubiflora* Benth.	Aceite	7
	Crudia	*Crudia oblonga* Benth.	Cascarillo	3
	Dipteryx	*Dipteryx punctata* (S.F.Blake) Amshoff	Sarrapio	8
	Enterolobium	*Enterolobium schomburgkii* (Benth.) Benth.	Dormidero	1
	Heterostemon	*Heterostemon conjugatus* Benth.	Guamita	1
	Hydrochorea	*Hydrochorea corymbosa* (Rich.) Barneby & J.W.Grimes	Dormilón	5
	Hymenaea	*Hymenaea courbaril* L.	Algarrobo	2
	Inga	*Inga cylindrica* (Vell.) Mart.	Guamo	5
	Lonchocarpus	*Lonchocarpus floribundus* Benth.	Matarratón	2
	Sclerolobium	*Sclerolobium melanocarpum* Ducke	Pategarza	14
	Senna	*Senna silvestris* (Vell.) H.S.Irwin & Barneby	Alcaparillo	1
	Swartzia	*Swartzia leptopetala* Benth.	Sangretoro	2
	Zygia	*Zygia inaequalis* (Willd.) Pittier	Cimbrapotro	1
Linaceae	*Hebepetalum*	*Hebepetalum* sp.	Colorado	5
Melastomataceae	*Bellucia*	*Bellucia grossularioides* (L.) Triana	Níspero	4

Moraceae	*Brosimum*	*Brosimum lactescens* (S.Moore) C.C.Berg	Guáimaro	25
	Ficus	*Ficus americana* Aubl.	Matapalo	1
		Ficus mathewsii (Miq.) Miq.	Matapalo	2
	Maquira	*Maquira coriacea* (H.Karst.) C.C.Berg	Lechero	2
	Perebea	*Perebea xanthochyma* H.Karst.	Cauchillo	1
Myristicaceae	*Virola*	*Virola carinata* (Spruce ex Benth.) Warb.	Carnevaca blanco	3
		Virola elongata (Benth.) Warb.	Carnevaca	8
		Virola parvifolia Ducke	Carnevaca	3
Myrtaceae	*Myrcia*	*Myrcia paivae* O.Berg	Arrayán	1
		Myrcia subsessilis O.Berg	Arrayán	14
	Myrciaria	*Myrciaria floribunda* (H.West ex Willd.) O.Berg	Guayabo montañero	1
Ochnaceae	*Ouratea*	*Ouratea castaneifolia* (DC.) Engl.	Lengua de yataro	1
		Ouratea polyantha (Triana & Planch.) Engl.	Coralito	1
	Quiina	*Quiina macrophylla* Tul.	Guayacán	1
Peraceae	*Pera*	*Pera arborea* Mutis	Pategallina	3
Phyllanthaceae	*Phyllanthus*	*Phyllanthus attenuatus* Miq.	Totumito	3
	Richeria	*Richeria grandis* Vahl	Alcafeto	3
Picramniaceae	*Picramnia*	*Picramnia magnifolia* J.F.Macbr.	Quemacarate	1
Polygonaceae	*Coccoloba*	*Coccoloba mollis* Casar.	Uvero	4
	Ruprechtia	*Ruprechtia costata* Meisn.	Rascarrabio	1
Proteaceae	*Euplassa*	*Euplassa saxicola* (R.E.Schult.) Steyerm.	Yolombó	7
Rubiaceae	*Amaioua*	*Amaioua guianensis* Aubl.	Macanillo	4
	Elaeagia	*Elaeagia maguirei* Standl.	Marfil	1
	Genipa	*Genipa americana* L.	Caruto	1
Sapindaceae	*Cupania*	*Cupania scrobiculata* Rich.	Partemachete	1
	Matayba	*Matayba adenanthera* Radlk.	Patepajuil	7
		Matayba scrobiculata Radlk.	Patepajuil	4
	Vouarana	*Vouarana guianensis* Aubl.	Partemachete	1
Sapotaceae	*Micropholis*	*Micropholis guyanensis* (A.DC.) Pierre	Caimillo	1
	Pouteria	*Pouteria guianensis* Aubl.	Caimo	3
Simaroubaceae	*Simarouba*	*Simarouba amara* Aubl.	Simaruba	40
Strelitziaceae	*Phenakospermum*	*Phenakospermum guyannense* (A.Rich.) Endl. ex Miq.	Tarriago	3
Vochysiaceae	*Vochysia*	*Vochysia ferruginea* Mart.	Botagajo	1
		Vochysia lehmannii Hieron.	Saladillo blanco	2
General total				**944**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

In the analysis of absolute abundance per family in the gallery forest, the most representative are: Arecaceae, Burseraceae, Calophyllaceae, Leguminosae and Annonaceae with values between 126 and 64 individuals, which is equivalent to relative values of between 13.3 and 6.8 of abundance; the other families show values lower than 5% for this parameter (see Figure 4.95).

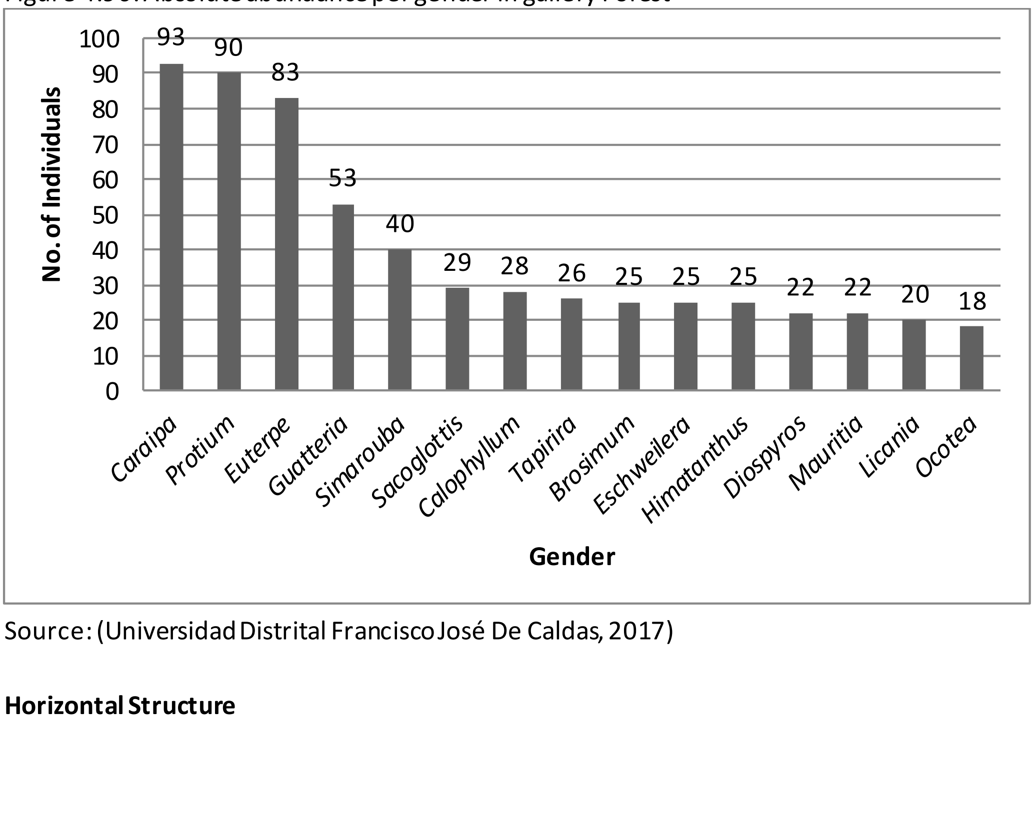
Figure 4.95: Location of the flora sampling units.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

As for the abundance of individuals per gender (see Figure 127), *Caraipa*, *Protium* and *Euterpe*, appear as the most representative reporting absolute abundances of 93, 90 and 83 individuals respectively (between 9.9 and 8.8% of the total each one), appear with significative values as well: *Guatteria* with 53 individuals (5.6%) and *Simarouba*, with 40 individuals (4.2%), the other genders report less than 30 individuals (3% of the total abundance).

Figure 4.96: Absolute abundance per gender in gallery Forest



Source: (Universidad Distrital Francisco José De Caldas, 2017)

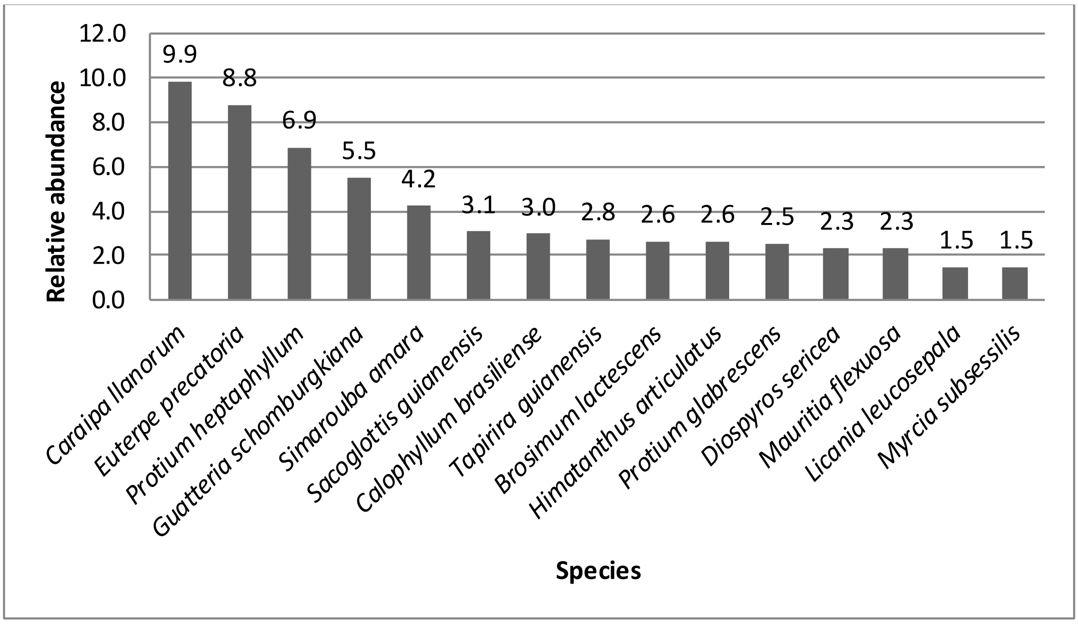
Horizontal Structure

For the characterization of the horizontal structure was used, the importance value index, which allows to determine the ecological weight of the species in the coverage under analysis and which is composed of the sum of the parameters of relative abundance, frequency and dominance; likewise the frequency histogram was built for the graphic representation of the proportion in which the species are distributed spatially and the degree of aggregation was determined.

Relative abundance

In the analysis of this parameter for the gallery forest, stand out the species: *Caraipa llanorum* (Saladillo rojo) with 9.9% (93 individuals), followed by *Euterpe precatoria* (Manaco) with 8.8% (83 individuals), *Protium heptaphyllum* (Anime) with 6.9% (65 individuals), *Guatteria schomburgkiana* (Majagüillo negro) with 5.5% (52 individuals) and *Simarouba amara* (Simaruba) with 4.2% (40 individuals); the other species report values lower than 4% of relative abundance (see Figure 128). This parameter allows to infer that the gallery forest tends to be heterogeneous in composition, in the absence of such marked abundances of one or several species.

Figure 4.97: Relative abundance in gallery Forest.

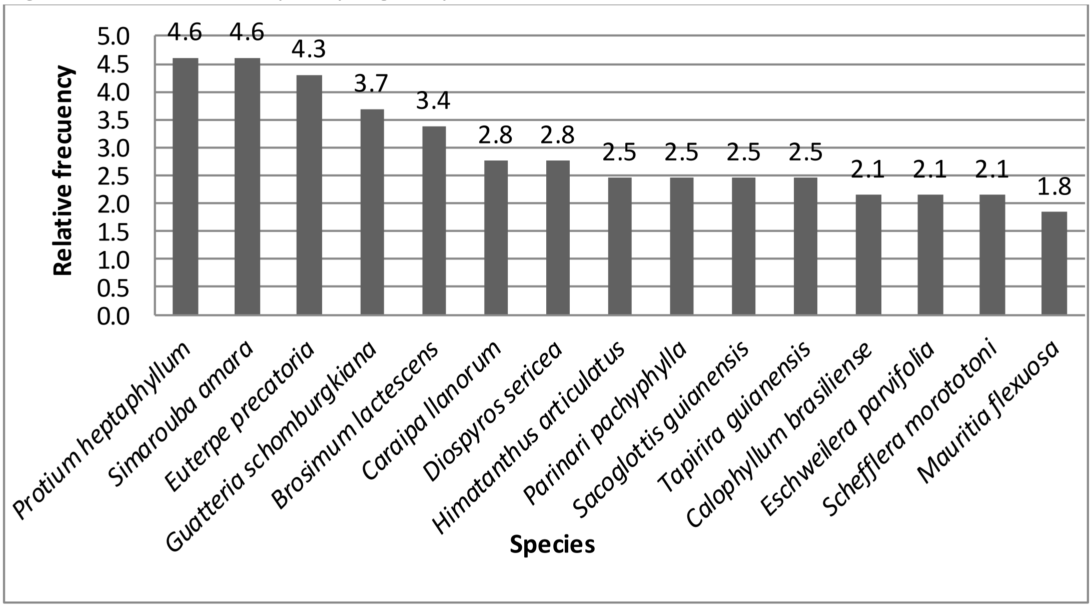


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Relative frequency

Just like for relative abundance, the parameter relative frequency shows a tendency of this coverage to be heterogeneous regarding the appearance of the species in the sampling units, nonetheless the most representative species in this parameter are: *Protium heptaphyllum* (Anime) and *Simarouba amara* (Simaruba) with 4.6% when reporting in 15 of the 21 surveyed plots, followed by *Euterpe precatoria* (Manaco) with 4.3% (report in 14 plots), *Guatteria schomburgkiana* (Majagüillo negro) with 3.7% (report in 12 plots) y *Brosimum lactescens* (Guáimaro) with 3,4% (report in 11 plots) the other species report less than 3% of the relative frequency (see Figure 4.98).

Figure 4.98: Relative frequency in gallery Forest.

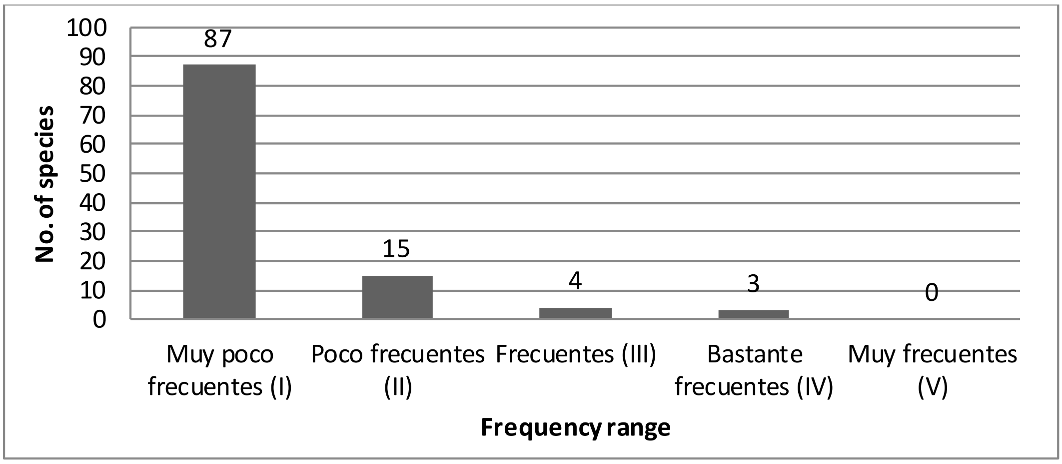


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Frequency histogram

The frequency histogram for the gallery forest, shows that the majority of the species fall in the category very rare, represented with 79.8% (87 species), followed by the category infrequent with13.8% (15 species), then the category frequent with 3.7% (four species) and last quite frequent with only 2.8% (three species). This confirms what was mentioned regarding the condition of heterogeneity of the coverage in terms of frequency of species and is a typical condition of this type of coverages (see Figure 4.99).

Figure 4.99: Frequency histogram for gallery Forest.

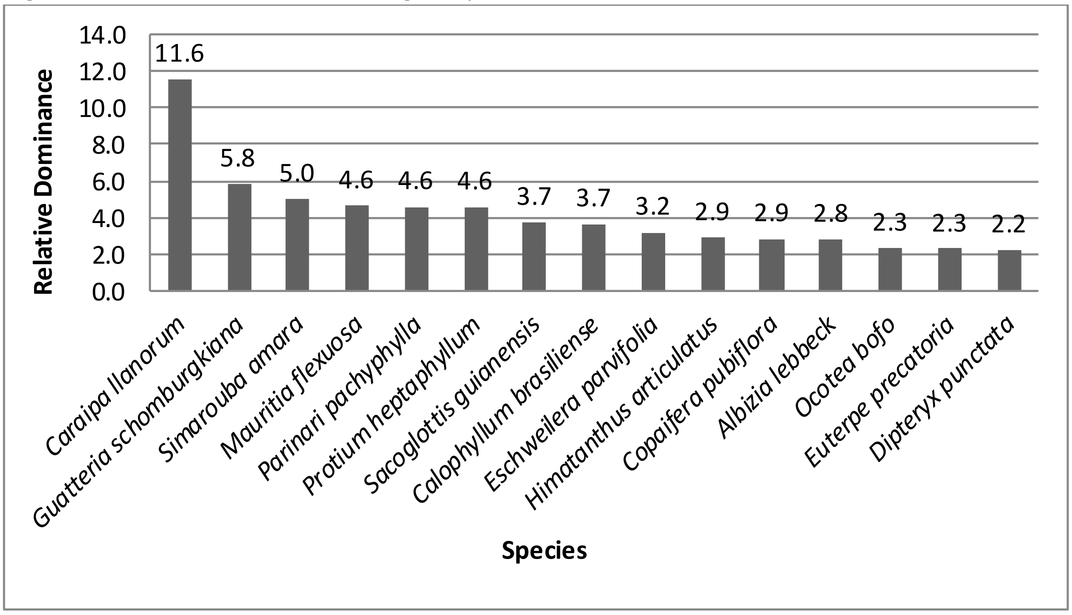


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Relative dominance

In the analysis of this parameter for the gallery forest, a species with a certain dominance is noticeable and corresponds to the species *Caraipa llanorum* (Saladillo rojo) with 11.6% of this parameter, while the other species show a uniform distribution of this parameter in the forest composition, with values lower than 6% (see Figure 4.100). This can be attributed to the abundance of the species and to the bearing of the trees in the coverage.

Figure 4.100: Relative dominance in gallery Forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Importance value index (IVI)

In Table 4.49 the values of abundance, dominance, frequency and importance value index are shown, for each one of the species found in the category of tree size in the gallery forest.

Table 4.49: Importance value index in gallery forest.

SPECIES	COMMON NAME	ABUND.	FREC.	DOM.	ABUN. %	FREC. %	DOM.%	IVI	IVI %
Albizia lebbeck	Menudito	11	4,8	1,1	1,2	0,3	2,8	4,3	1,4
Alchornea discolor	Algodoncillo	4	9,5	0,1	0,4	0,6	0,4	1,4	0,5
Alchornea triplinervia	Carnegallina	2	9,5	0,0	0,2	0,6	0,1	0,9	0,3
Amaioua guianensis	Macanillo	4	14,3	0,0	0,4	0,9	0,1	1,4	0,5
Andira surinamensis	Arenoso	3	14,3	0,2	0,3	0,9	0,4	1,7	0,6
Aniba panurensis	Yema de huevo	5	23,8	0,1	0,5	1,5	0,3	2,3	0,8
Aspidosperma desmanthum	Costillo	1	4,8	0,1	0,1	0,3	0,3	0,7	0,2
Aspidosperma excelsum	Costillo blanco	2	9,5	0,1	0,2	0,6	0,3	1,1	0,4
Astronium graveolens	Abejón	1	4,8	0,0	0,1	0,3	0,0	0,5	0,2
Attalea maripa	Cucurita	7	14,3	0,4	0,7	0,9	0,9	2,6	0,9
Bellucia grossularioides	Níspero	4	14,3	0,1	0,4	0,9	0,3	1,6	0,5
Brosimum lactescens	Guáimaro	25	52,4	0,7	2,6	3,4	1,9	7,9	2,6
Calophyllum brasiliense	Cachicamo	28	33,3	1,5	3,0	2,1	3,7	8,8	2,9
Campsiandra comosa	Chigo	4	9,5	0,4	0,4	0,6	1,0	2,0	0,7
Caraipa llanorum	Saladillo rojo	93	42,9	4,6	9,9	2,8	11,6	24,2	8,1
Coccoloba mollis	Uvero	4	9,5	0,2	0,4	0,6	0,5	1,5	0,5
Cochlospermum orinocense	Bototo	4	4,8	0,4	0,4	0,3	1,0	1,7	0,6
Cochlospermum vitifolium	Bototo	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Connarus lambertii	Sangrito	4	4,8	0,1	0,4	0,3	0,2	1,0	0,3
Copaifera pubiflora	Aceite	7	23,8	1,1	0,7	1,5	2,9	5,1	1,7
Cordia sericicalyx	Palo de agua	3	4,8	0,1	0,3	0,3	0,2	0,8	0,3
Crudia oblonga	Cascarillo	3	4,8	0,1	0,3	0,3	0,3	0,9	0,3
Cupania scrobiculata	Partemachete	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Curatella americana	Chaparro	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1

SPECIES	COMMON NAME	ABUND.	FREC.	DOM.	ABUN. %	FREC. %	DOM.%	IVI	IVI %
Dendropanax arboreus	Mantequillo	5	9,5	0,1	0,5	0,6	0,3	1,4	0,5
Diospyros sericea	Carbonero	22	42,9	0,5	2,3	2,8	1,3	6,3	2,1
Dipteryx punctata	Sarrapio	8	9,5	0,9	0,8	0,6	2,2	3,7	1,2
Elaeagia maguirei	Marfil	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Enterolobium schomburgkii	Dormidero	1	4,8	0,1	0,1	0,3	0,1	0,6	0,2
Erythroxylum macrophyllum	Ajicito	2	4,8	0,0	0,2	0,3	0,0	0,6	0,2
Eschweilera parvifolia	Coco de mono	12	33,3	1,3	1,3	2,1	3,2	6,6	2,2
Eschweilera tenuifolia	Copo	13	9,5	0,5	1,4	0,6	1,2	3,2	1,1
Euplassa saxicola	Yolombó	7	19,0	0,3	0,7	1,2	0,8	2,7	0,9
Euterpe precatoria	Manaco	83	66,7	0,9	8,8	4,3	2,3	15,4	5,1
Ficus americana	Matapalo	1	4,8	0,1	0,1	0,3	0,2	0,7	0,2
Ficus mathewsii	Matapalo	2	4,8	0,1	0,2	0,3	0,1	0,6	0,2
Garcinia madruno	Madroño	2	9,5	0,0	0,2	0,6	0,1	0,9	0,3
Genipa americana	Caruto	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Guatteria metensis	Majagüillo blanco	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Guatteria schomburgkiana	Majagüillo negro	52	57,1	2,3	5,5	3,7	5,8	15,0	5,0
Hebepetalum sp.	Colorado	5	14,3	0,4	0,5	0,9	1,0	2,5	0,8
Heterostemon conjugatus	Guamita	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Himatanthus articulatus	Platanote	25	38,1	1,2	2,6	2,5	2,9	8,0	2,7
Hirtella elongata	Garrapato	11	23,8	0,4	1,2	1,5	1,0	3,7	1,2
Hydrochorea corymbosa	Dormilón	5	14,3	0,8	0,5	0,9	2,0	3,4	1,1
Hymenaea courbaril	Algarrobo	2	4,8	0,1	0,2	0,3	0,3	0,8	0,3
Inga cylindrica	Guamo	5	19,0	0,5	0,5	1,2	1,3	3,0	1,0
Jacaranda copaia	Pavito	7	4,8	0,3	0,7	0,3	0,8	1,9	0,6
Jacaranda obtusifolia	Gualanday	7	19,0	0,3	0,7	1,2	0,7	2,7	0,9
Lacistema aggregatum	Laurel rosado	1	4,8	0,0	0,1	0,3	0,0	0,5	0,2
Licania hypoleuca	Escobo blanco	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Licania leucosepala	Aceituno	14	23,8	0,4	1,5	1,5	1,0	4,0	1,3
Licania parvifructa	Escobo colorado	4	14,3	0,1	0,4	0,9	0,2	1,5	0,5
Licania subarachnophylla	Escobo	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2

SPECIES	COMMON NAME	ABUND.	FREC.	DOM.	ABUN. %	FREC. %	DOM.%	IVI	IVI %
Licaria canella	Amarillo	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Lonchocarpus floribundus	Matarratón	2	9,5	0,1	0,2	0,6	0,1	1,0	0,3
Mabea trianae	Canilla de venado	11	23,8	0,1	1,2	1,5	0,4	3,1	1,0
Mahurea exstipulata	Caucho amarillo	4	9,5	0,1	0,4	0,6	0,3	1,3	0,4
Maquira coriacea	Lechero	2	9,5	0,1	0,2	0,6	0,2	1,0	0,3
Matayba adenanthera	Patepajuil	7	9,5	0,1	0,7	0,6	0,3	1,6	0,5
Matayba scrobiculata	Patepajuil	4	9,5	0,1	0,4	0,6	0,3	1,3	0,4
Mauritia flexuosa	Moriche	22	28,6	1,9	2,3	1,8	4,6	8,8	2,9
Micropholis guyanensis	Caimillo	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Myrcia paivae	Arrayán	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Myrcia subsessilis	Arrayán	14	23,8	0,3	1,5	1,5	0,7	3,7	1,2
Myrciaria floribunda	Guayabo montañero	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Nectandra cuspidata	Laurel sabanero	2	4,8	0,0	0,2	0,3	0,1	0,6	0,2
Ocotea bofo	Laurel	14	14,3	0,9	1,5	0,9	2,3	4,7	1,6
Ocotea longifolia	Laurel matatigre	4	4,8	0,0	0,4	0,3	0,1	0,8	0,3
Oenocarpus bacaba	Maporilla	5	4,8	0,1	0,5	0,3	0,2	1,0	0,3
Ouratea castaneifolia	Lengua de yataro	1	4,8	0,1	0,1	0,3	0,1	0,5	0,2
Ouratea polyantha	Coralito	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Parahancornia oblonga	Pendare	10	19,0	0,6	1,1	1,2	1,5	3,8	1,3
Parinari pachyphylla	Escobo	13	38,1	1,8	1,4	2,5	4,6	8,4	2,8
Pera arborea	Pategallina	3	9,5	0,1	0,3	0,6	0,2	1,2	0,4
Perebea xanthochyma	Cauchillo	1	4,8	0,1	0,1	0,3	0,2	0,6	0,2
Phenakospermum guyannense	Tarriago	3	9,5	0,0	0,3	0,6	0,1	1,0	0,3
Phyllanthus attenuatus	Totumito	3	9,5	0,2	0,3	0,6	0,5	1,4	0,5
Picramnia magnifolia	Quemacarate	1	4,8	0,0	0,1	0,3	0,0	0,5	0,2
Pouteria guianensis	Caimo	3	9,5	0,2	0,3	0,6	0,5	1,4	0,5
Protium glabrescens	Anime	24	23,8	0,6	2,5	1,5	1,6	5,6	1,9
Protium heptaphyllum	Anime	65	71,4	1,8	6,9	4,6	4,6	16,1	5,4

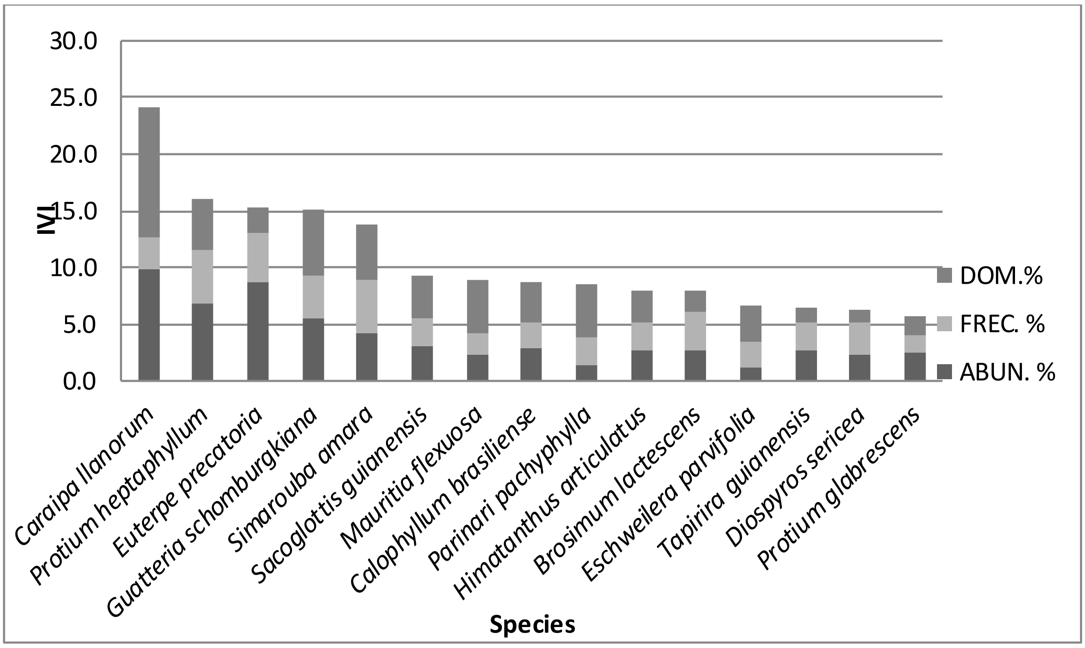
SPECIES	COMMON NAME	ABUND.	FREC.	DOM.	ABUN. %	FREC. %	DOM.%	IVI	IVI %
Protium llanorum	Anime	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Quiina macrophylla	Guayacán	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Richeria grandis	Alcafeto	3	4,8	0,1	0,3	0,3	0,2	0,8	0,3
Ruprechtia costata	Rascarrabio	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Sacoglottis guianensis	Fierrito	29	38,1	1,5	3,1	2,5	3,7	9,3	3,1
Schefflera morototoni	Tortolito	11	33,3	0,5	1,2	2,1	1,3	4,6	1,5
Sclerolobium melanocarpum	Pategarza	14	4,8	0,3	1,5	0,3	0,8	2,6	0,9
Senna silvestris	Alcaparillo	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Simarouba amara	Simaruba	40	71,4	2,0	4,2	4,6	5,0	13,9	4,6
Socratea exorrhiza	Choapo	9	9,5	0,1	1,0	0,6	0,2	1,8	0,6
Stephanopodium sp.	Naranjo	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Swartzia leptopetala	Sangretoro	2	4,8	0,1	0,2	0,3	0,2	0,7	0,2
Symphonia globulifera	Breo	9	19,0	0,3	1,0	1,2	0,7	2,9	1,0
Tapirira guianensis	Guarupayo	26	38,1	0,5	2,8	2,5	1,2	6,4	2,1
Tetragastris panamensis	Caraño blanco	9	9,5	0,4	1,0	0,6	0,9	2,5	0,8
Virola carinata	Carnevaca blanco	3	9,5	0,1	0,3	0,6	0,1	1,1	0,4
Virola elongata	Carnevaca	8	14,3	0,6	0,8	0,9	1,4	3,2	1,1
Virola parvifolia	Carnevaca	3	9,5	0,1	0,3	0,6	0,2	1,1	0,4
Vismia baccifera	Lacre blanco	4	9,5	0,0	0,4	0,6	0,1	1,2	0,4
Vismia macrophylla	Punta de lanza	4	9,5	0,0	0,4	0,6	0,1	1,1	0,4
Vitex orinocensis	Guarataro	2	4,8	0,1	0,2	0,3	0,4	0,9	0,3
Vochysia ferruginea	Botagajo	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Vochysia lehmannii	Saladillo blanco	2	4,8	0,1	0,2	0,3	0,3	0,8	0,3
Vouarana guianensis	Partemachete	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Xylopia aromatica	Malagueto	10	19,0	0,3	1,1	1,2	0,7	3,0	1,0
Xylopia emarginata	Majagüillo	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Zygia inaequalis	Cimbrapotro	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
General total		**944**	**1552,4**	**39,9**	**100,0**	**100,0**	**100,0**	**300,0**	**100,0**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

The analysis of the importance value index for this coverage, shows the species: *Caraipa llanorum* (Saladillo rojo) as the most representative or the one with the highest ecological weight, with a net value of 24.2 (over 300), corresponding to a percentage of 8.1%; other species with significant values are: *Protium heptaphyllum* (Anime), *Euterpe precatoria* (Manaco), *Guatteria schomburgkiana* (Majagüillo negro) and *Simarouba amara*

(Simaruba) with net values between 16,1 and 13,9 corresponding to percentages between 5.4% and 4.6%, being evidently the ones that showed the highest values in each one of the parameters that compose the index; the other species report values at 4% of the total determined for this parameter (see Figure 4.101). As was shown individually in each parameter, the gallery forest tends to be heterogeneous, despite showing certain importance of one or several species.

Figure 4.101: Importance value index in gallery forest.

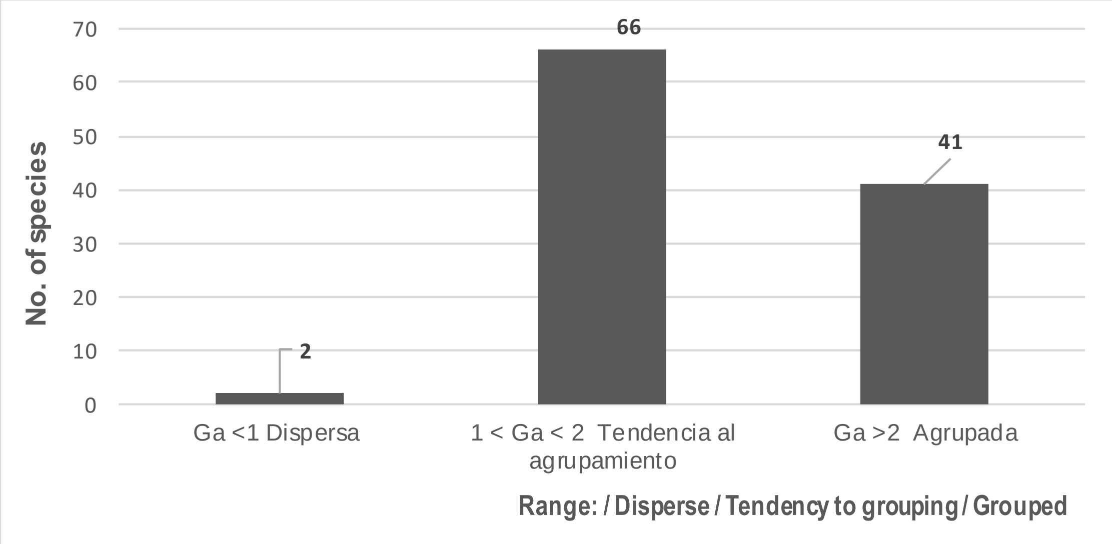


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Degree of aggregation

In the analysis of the degree of aggregation of the species in gallery forest, it was determined that 66 species, equivalent to 60.6% of the total, have a distribution with a tendency to grouping, while 41 species (37.6%) are grouped and the remaining 2 species are disperse (see Figure 4.102); in this analysis are includes species that not necessarily are abundant and frequent but that do tend to group in a few plots. This parameter shows in general terms that the gallery forest despite being heterogeneous as to species distribution in space, these are grouped or tend to group, this can be related with the type of dispersion of the species and the adaptation to extreme humidity conditions with long periods of flood which is a constant characteristic in these forests.

Figure 4.102: Degree of aggregation in gallery forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Vertical structure

For the analysis of the vertical structure of the gallery forest the sociological position was determined and the Ogawa diagram and the vegetation profile were built.

Sociological position

In order to define the sociological position of the gallery forest three strata were determined, dividing the difference of the maximum and minimum values reported in the trees inventory corresponding to 32 and 6 meters respectively, which allowed to establish a range of 8.7 meters in height for each stratum.

In the vertical stratification of this coverage, carried out for the analysis of sociological position, it is observed that 55.3% of the sampled individuals (522), are grouped in the middle stratus with heights between 14.7 meters and less than or equal to 23.3 meters, while 41.5% (392 individuals) are in the lower stratum with heights between 6 and 14.7 meters and only 3,2% (30 individuals) are in the higher stratum with heights higher than 23.3 meters and less than or equal to 32 meters (see Table 4.50). This suggests that it is a coverage conformed predominantly by individuals of medium-low bearing with some emergent trees.

Table 4.50: Vertical stratification in gallery forest.

STRATUM	HEIGHT RANGE (m)	NUMBER OF INDIVIDUALS	% INDIVIDUALS
Lower stratum	6 - 14,7	392	41,5
Middle stratum	> 14,7 - 23,3	522	55,3
Higher stratum	> 23,3 - 32	30	3,2
TOTAL		**944**	**100,0**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

With the strata defined, the phytosociological value was determined for each one and the absolute and relative sociological position was obtained for each species as shown in Table 4.51.

Table 4.51: Sociological position in gallery forest.

SPECIES	COMMON NAME	CT 1	CT 2	CT 3	Total	Lower stratum	Middle stratum	Higher stratum	Psa	Ps%
Albizia lebbeck	Menudito	1	10		11	0,4	5,5	0,0	5,9	1,3
Alchornea discolor	Algodoncillo	2	2		4	0,8	1,1	0,0	1,9	0,4
Alchornea triplinervia	Carnegallina	2			2	0,8	0,0	0,0	0,8	0,2
Amaioua guianensis	Macanillo	4			4	1,7	0,0	0,0	1,7	0,4
Andira surinamensis	Arenoso	1	2		3	0,4	1,1	0,0	1,5	0,3
Aniba panurensis	Yema de huevo	4	1		5	1,7	0,6	0,0	2,2	0,5
Aspidosperma desmanthum	Costillo		1		1	0,0	0,6	0,0	0,6	0,1
Aspidosperma excelsum	Costillo blanco		2		2	0,0	1,1	0,0	1,1	0,2
Astronium graveolens	Abejón	1			1	0,4	0,0	0,0	0,4	0,1
Attalea maripa	Cucurita		7		7	0,0	3,9	0,0	3,9	0,9
Bellucia grossularioides	Níspero		3	1	4	0,0	1,7	0,0	1,7	0,4
Brosimum lactescens	Guáimaro	14	11		25	5,8	6,1	0,0	11,9	2,6
Calophyllum brasiliense	Cachicamo	6	22		28	2,5	12,2	0,0	14,7	3,2
Campsiandra comosa	Chigo	3	1		4	1,2	0,6	0,0	1,8	0,4
Caraipa llanorum	Saladillo rojo	38	54	1	93	15,8	29,9	0,0	45,7	10,1
Coccoloba mollis	Uvero	1	2	1	4	0,4	1,1	0,0	1,6	0,3
Cochlospermum orinocense	Bototo		3	1	4	0,0	1,7	0,0	1,7	0,4
Cochlospermum vitifolium	Bototo	1			1	0,4	0,0	0,0	0,4	0,1
Connarus lambertii	Sangrito	4			4	1,7	0,0	0,0	1,7	0,4
Copaifera pubiflora	Aceite		7		7	0,0	3,9	0,0	3,9	0,9
Cordia sericicalyx	Palo de agua	1	2		3	0,4	1,1	0,0	1,5	0,3
Crudia oblonga	Cascarillo	2	1		3	0,8	0,6	0,0	1,4	0,3
Cupania scrobiculata	Partemachete	1			1	0,4	0,0	0,0	0,4	0,1
Curatella americana	Chaparro	1			1	0,4	0,0	0,0	0,4	0,1
Dendropanax arboreus	Mantequillo	3	2		5	1,2	1,1	0,0	2,4	0,5
Diospyros sericea	Carbonero	8	13	1	22	3,3	7,2	0,0	10,5	2,3
Dipteryx punctata	Sarrapio	2	4	2	8	0,8	2,2	0,1	3,1	0,7
Elaeagia maguirei	Marfil		1		1	0,0	0,6	0,0	0,6	0,1
Enterolobium schomburgkii	Dormidero			1	1	0,0	0,0	0,0	0,0	0,0
Erythroxylum macrophyllum	Ajicito	2			2	0,8	0,0	0,0	0,8	0,2
Eschweilera parvifolia	Coco de mono	2	9	1	12	0,8	5,0	0,0	5,8	1,3
Eschweilera tenuifolia	Copo	7	6		13	2,9	3,3	0,0	6,2	1,4
Euplassa saxicola	Yolombó	3	3	1	7	1,2	1,7	0,0	2,9	0,6
Euterpe precatoria	Manaco	12	70	1	83	5,0	38,7	0,0	43,7	9,7
Ficus americana	Matapalo		1		1	0,0	0,6	0,0	0,6	0,1
Ficus mathewsii	Matapalo	1	1		2	0,4	0,6	0,0	1,0	0,2
Garcinia madruno	Madroño	2			2	0,8	0,0	0,0	0,8	0,2
Genipa americana	Caruto		1		1	0,0	0,6	0,0	0,6	0,1

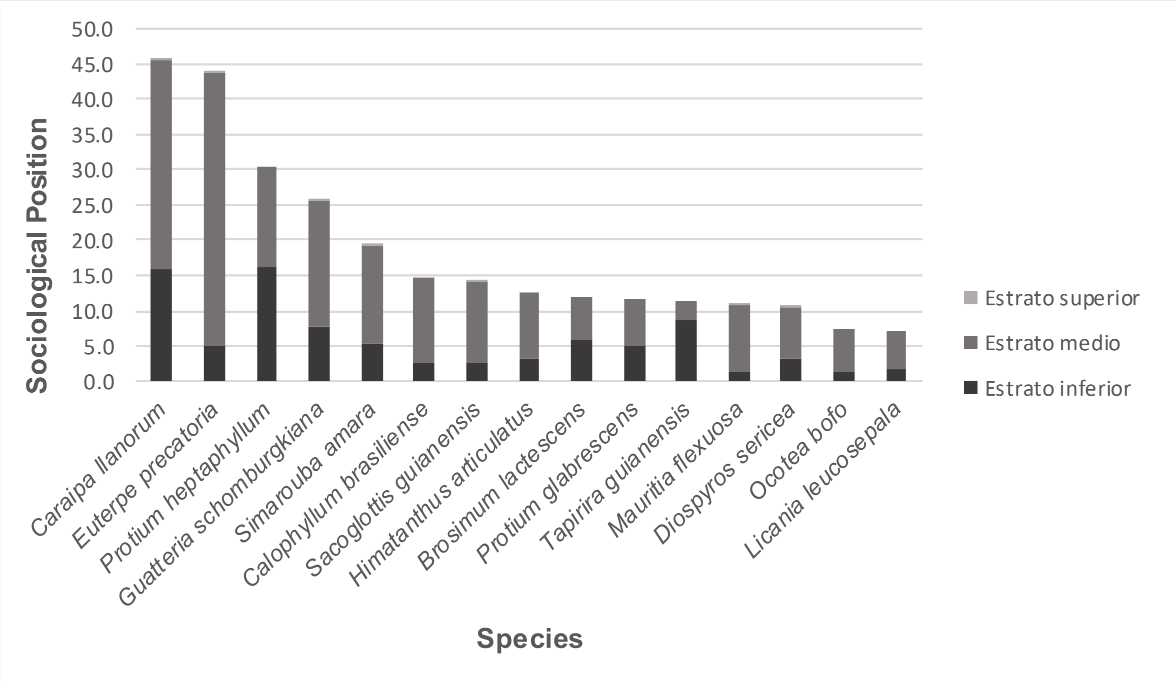
SPECIES	COMMON NAME	CT 1	CT 2	CT 3	Total	Lower stratum	Middle stratum	Higher stratum	Psa	Ps%
Guatteria metensis	Majagüillo blanco	1			1	0,4	0,0	0,0	0,4	0,1
Guatteria schomburgkiana	Majagüillo negro	19	32	1	52	7,9	17,7	0,0	25,6	5,7
Hebepetalum sp.	Colorado	2	3		5	0,8	1,7	0,0	2,5	0,6
Heterostemon conjugatus	Guamita		1		1	0,0	0,6	0,0	0,6	0,1
Himatanthus articulatus	Platanote	8	17		25	3,3	9,4	0,0	12,7	2,8
Hirtella elongata	Garrapato	10	1		11	4,2	0,6	0,0	4,7	1,0
Hydrochorea corymbosa	Dormilón	1	4		5	0,4	2,2	0,0	2,6	0,6
Hymenaea courbaril	Algarrobo		2		2	0,0	1,1	0,0	1,1	0,2
Inga cylindrica	Guamo		5		5	0,0	2,8	0,0	2,8	0,6
Jacaranda copaia	Pavito		3	4	7	0,0	1,7	0,1	1,8	0,4
Jacaranda obtusifolia	Gualanday	5	1	1	7	2,1	0,6	0,0	2,7	0,6
Lacistema aggregatum	Laurel rosado	1			1	0,4	0,0	0,0	0,4	0,1
Licania hypoleuca	Escobo blanco		1		1	0,0	0,6	0,0	0,6	0,1
Licania leucosepala	Aceituno	4	10		14	1,7	5,5	0,0	7,2	1,6
Licania parvifructa	Escobo colorado	2	2		4	0,8	1,1	0,0	1,9	0,4
Licania subarachnophylla	Escobo		1		1	0,0	0,6	0,0	0,6	0,1
Licaria canella	Amarillo	1			1	0,4	0,0	0,0	0,4	0,1
Lonchocarpus floribundus	Matarratón		2		2	0,0	1,1	0,0	1,1	0,2
Mabea trianae	Canilla de venado	11			11	4,6	0,0	0,0	4,6	1,0
Mahurea exstipulata	Caucho amarillo	2	2		4	0,8	1,1	0,0	1,9	0,4
Maquira coriacea	Lechero	1	1		2	0,4	0,6	0,0	1,0	0,2
Matayba adenanthera	Patepajuil	7			7	2,9	0,0	0,0	2,9	0,6
Matayba scrobiculata	Patepajuil	2	2		4	0,8	1,1	0,0	1,9	0,4
Mauritia flexuosa	Moriche	3	17	2	22	1,2	9,4	0,1	10,7	2,4
Micropholis guyanensis	Caimillo		1		1	0,0	0,6	0,0	0,6	0,1
Myrcia paivae	Arrayán	1			1	0,4	0,0	0,0	0,4	0,1
Myrcia subsessilis	Arrayán	14			14	5,8	0,0	0,0	5,8	1,3
Myrciaria floribunda	Guayabo montañero	1			1	0,4	0,0	0,0	0,4	0,1
Nectandra cuspidata	Laurel sabanero	1	1		2	0,4	0,6	0,0	1,0	0,2
Ocotea bofo	Laurel	3	11		14	1,2	6,1	0,0	7,3	1,6
Ocotea longifolia	Laurel matatigre	4			4	1,7	0,0	0,0	1,7	0,4
Oenocarpus bacaba	Maporilla	4	1		5	1,7	0,6	0,0	2,2	0,5
Ouratea castaneifolia	Lengua de yataro		1		1	0,0	0,6	0,0	0,6	0,1
Ouratea polyantha	Coralito	1			1	0,4	0,0	0,0	0,4	0,1
Parahancornia oblonga	Pendare	2	8		10	0,8	4,4	0,0	5,3	1,2

SPECIES	COMMON NAME	CT 1	CT 2	CT 3	Total	Lower stratum	Middle stratum	Higher stratum	Psa	Ps%
Parinari pachyphylla	Escobo	3	9	1	13	1,2	5,0	0,0	6,3	1,4
Pera arborea	Pategallina		3		3	0,0	1,7	0,0	1,7	0,4
Perebea xanthochyma	Cauchillo		1		1	0,0	0,6	0,0	0,6	0,1
Phenakospermum guyannense	Tarriago	3			3	1,2	0,0	0,0	1,2	0,3
Phyllanthus attenuatus	Totumito	1	2		3	0,4	1,1	0,0	1,5	0,3
Picramnia magnifolia	Quemacarate	1			1	0,4	0,0	0,0	0,4	0,1
Pouteria guianensis	Caimo	1	1	1	3	0,4	0,6	0,0	1,0	0,2
Protium glabrescens	Anime	12	12		24	5,0	6,6	0,0	11,6	2,6
Protium heptaphyllum	Anime	39	26		65	16,2	14,4	0,0	30,6	6,8
Protium llanorum	Anime		1		1	0,0	0,6	0,0	0,6	0,1
Quiina macrophylla	Guayacán	1			1	0,4	0,0	0,0	0,4	0,1
Richeria grandis	Alcafeto	2	1		3	0,8	0,6	0,0	1,4	0,3
Ruprechtia costata	Rascarrabio		1		1	0,0	0,6	0,0	0,6	0,1
Sacoglottis guianensis	Fierrito	6	21	2	29	2,5	11,6	0,1	14,2	3,1
Schefflera morototoni	Tortolito	5	6		11	2,1	3,3	0,0	5,4	1,2
Sclerolobium melanocarpum	Pategarza	8	6		14	3,3	3,3	0,0	6,6	1,5
Senna silvestris	Alcaparillo	1			1	0,4	0,0	0,0	0,4	0,1
Simarouba amara	Simaruba	13	25	2	40	5,4	13,8	0,1	19,3	4,3
Socratea exorrhiza	Choapo	5	4		9	2,1	2,2	0,0	4,3	0,9
Stephanopodium sp.	Naranjo	1			1	0,4	0,0	0,0	0,4	0,1
Swartzia leptopetala	Sangretoro	1	1		2	0,4	0,6	0,0	1,0	0,2
Symphonia globulifera	Breo	4	4	1	9	1,7	2,2	0,0	3,9	0,9
Tapirira guianensis	Guarupayo	21	5		26	8,7	2,8	0,0	11,5	2,5
Tetragastris panamensis	Caraño blanco	4	5		9	1,7	2,8	0,0	4,4	1,0
Virola carinata	Carnevaca blanco	2	1		3	0,8	0,6	0,0	1,4	0,3
Virola elongata	Carnevaca		4	4	8	0,0	2,2	0,1	2,3	0,5
Virola parvifolia	Carnevaca		3		3	0,0	1,7	0,0	1,7	0,4
Vismia baccifera	Lacre blanco	4			4	1,7	0,0	0,0	1,7	0,4
Vismia baccifera	Lacre blanco	4			4	1,7	0,0	0,0	1,7	0,4
Vismia macrophylla	Punta de lanza	4			4	1,7	0,0	0,0	1,7	0,4
Vitex orinocensis	Guarataro	1	1		2	0,4	0,6	0,0	1,0	0,2
Vochysia ferruginea	Botagajo		1		1	0,0	0,6	0,0	0,6	0,1
Vochysia lehmannii	Saladillo blanco	1	1		2	0,4	0,6	0,0	1,0	0,2
Vouarana guianensis	Partemachete	1			1	0,4	0,0	0,0	0,4	0,1
Xylopia aromatica	Malagueto	6	4		10	2,5	2,2	0,0	4,7	1,0
Xylopia emarginata	Majagüillo		1		1	0,0	0,6	0,0	0,6	0,1
Zygia inaequalis	Cimbrapotro	1			1	0,4	0,0	0,0	0,4	0,1
General total		**392**	**522**	**30**	**944**				**452,4**	**100,0**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

The analysis of the absolute sociological position (Figure 4.103), shows for the gallery forest the species: *Caraipa llanorum* (Saladillo rojo), *Euterpe precatoria* (Manaco), *Protium heptaphyllum* (Anime), *Guatteria schomburgkiana* (Majagüillo negro) and *Simarouba amara* (Simaruba) as the most representative, or those that appear in all the strata of the forest and assure their place in the vertical structure, with net values between 45.7 and 19.3 equivalent to relative values between 10.1 and 4.3%. The other species show values lower than 4% of this relative parameter. In general terms a uniform distribution of the sociological position is observed, which suggests the tendency to heterogeneity of this coverage at the level of vertical structure.

Figure 4.103: Sociological position in gallery forest.

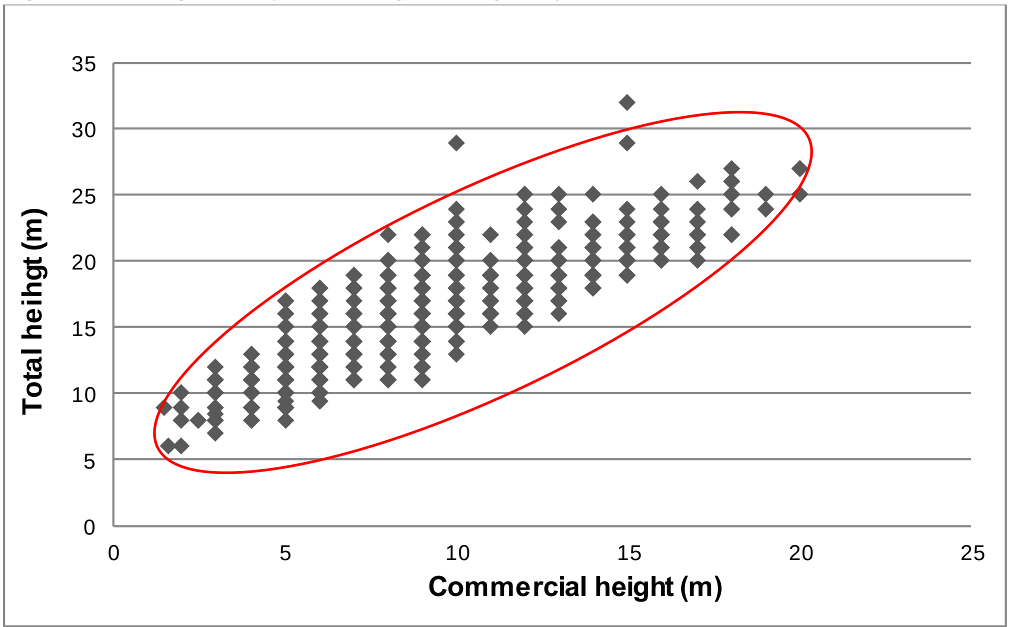


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Ogawa Stratification

In the cups dispersion analysis applying the Ogawa technique, which combines total and commercial heights,(see Figure 4.104), it is observed the presence of individuals in all the canopy, in a continuous that makes it difficult to differentiate strata, nonetheless certain grouping of individuals is observed in a big stratum with total heights between 7 and 22 meters and commercial between 3 and 17 meters.

Figure 4.104: Ogawa Dispersion diagram for gallery forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Vegetation profile

For the construction of the vegetation structural profile of the gallery forest, the graphic representation of the individuals of the 23 species found in the selected type plot was made (Bg16), with some of the characteristics registered of their architecture. In Table 4.52 the graphic representation of each one of these species is shown.

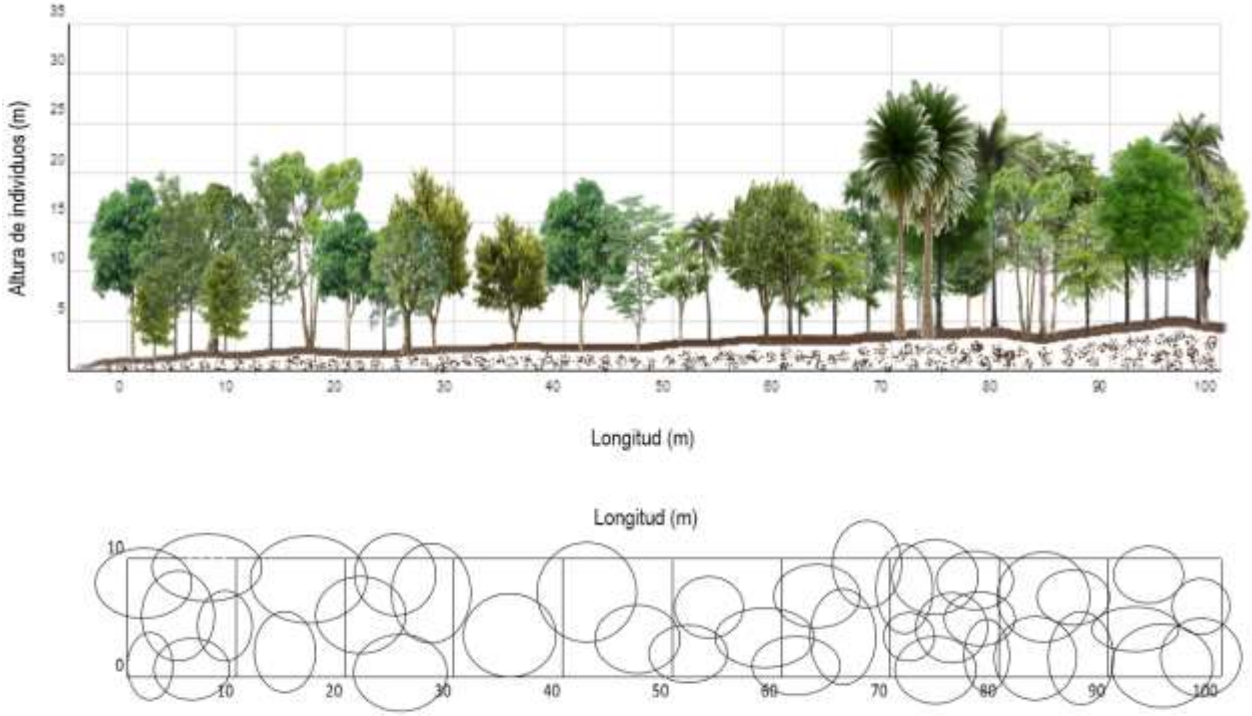
Table 4.52: Graphic representation of species in gallery forest.

VIEW	SPECIES	COMMON NAME	VIEW	SPECIES	COMMON NAME
	*Aniba panurensis*	Yema de huevo		*Parahancornia oblonga*	Pendare
	*Brosimum lactescens*	Guáimaro		*Pera arborea*	Pategallina
	*Calophyllum brasiliense*	Cachicamo		*Protium glabrescens*	Anime
	*Diospyros sericea*	Carbonero		*Simarouba amara*	Simaruba
	*Euplassa saxicola*	Yolombó		*Socratea exorrhiza*	Choapo
	*Euterpe precatoria*	Manaco		*Symphonia globulifera*	Breo
	*Ficus mathewsii*	Matapalo		*Tapirira guianensis*	Guarupayo
	*Guatteria schomburgkiana*	Majagüillo negro		*Virola carinata*	Carnevaca blanco
	*Hebepetalum sp.*	Colorado		*Virola parvifolia*	Carnevaca
	*Mauritia flexuosa*	Moriche		*Vochysia ferruginea*	Botagajo
	*Myrcia subsessilis*	Arrayán		*Xylopia aromatica*	Malagueto
	*Ouratea polyantha*	Coralito			

Source: (Universidad Distrital Francisco José De Caldas, 2017)

The vegetation structural profile for the gallery forest, shows that in the vertical visual structure the cups structural continuity is observed, making it difficult to differentiate strata, as well as the presence of a few emergent individuals; while for the horizontal structure a good proportion of coverage on the ground is observed, leaving few uncovered areas and hindering the entry of light for the continuity of the canopy; this situation is typical of the forest analyzed and evinces as well a Good degree of conservation of this natural covering (see Figure 4.105).

Figure 4.105: Structural vegetable profile for gallery forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Altimetric Distribution by class intervals

For the distribution of the individuals of tree size category in the class intervals for heights, in the gallery forest were determined 11 intervals with a class amplitude of 2.36 meters. The altimetric classes with their range, quantity and proportion of individuals are shown for this coverage.

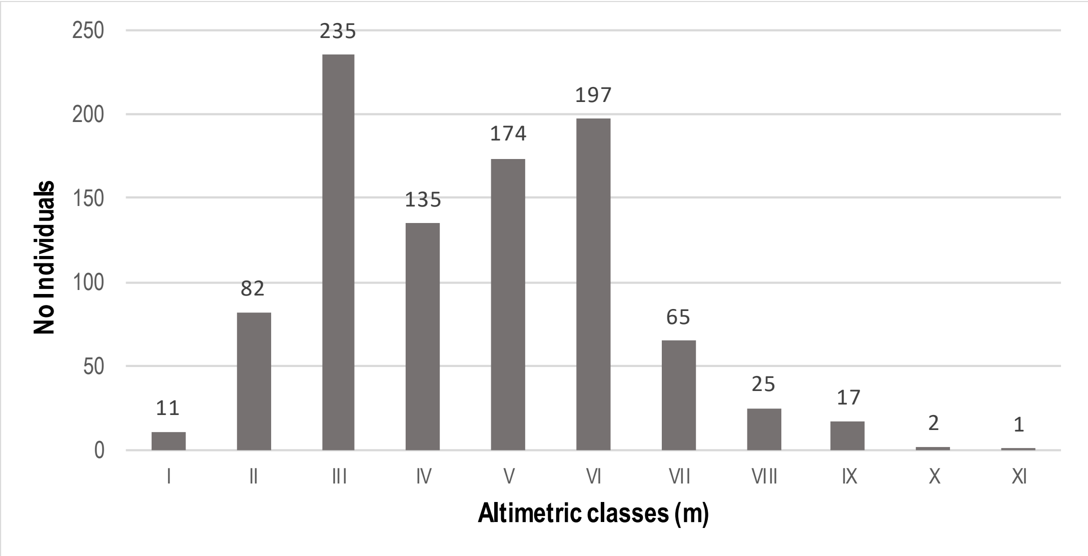
Table 4.53: Altimetric distribution in gallery forest.

Altimetric class	Range (m)	No. of Individuals	% Individuals
I	6 - 8,36	11	1,2
II	8,37 - 10,74	82	8,7
III	10,75 - 13,11	235	24,9
IV	13,12 - 15,248	135	14,3
V	15,49 - 17,86	174	18,4
VI	17,87 - 20,23	197	20,9
VII	20,24 - 22,61	65	6,9
VIII	22,62 - 24,98	25	2,6
IX	24,49 - 27,35	17	1,8
X	27,36 - 29,73	2	0,2
XI	29,74 - 32,10	1	0,1
General total		**944**	**100,0**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

In Figure 4.106 the distribution of individuals in the class intervals is shown, denoting a grouping in the intermediate classes, with III being the highest value with 235 individuals (24.9% of the total individuals), followed by VI with 197 individuals (20.9%) and class V with 174 individuals (18.4%) and class IV with 135 individuals (14.3%). This is a typical behaviour of a natural coverage with continuous development processes, with a good offer of individuals of middle-low bearing, this being congruent with the vertical structure analysis.

Figure 4.106: Altimetric distribution in gallery forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Diameter distribution

For the distribution of individuals in the diameter class intervals, for the gallery forest 8 intervals a fixed class amplitude of 10 centimeters were determined. Table 4.54 shows the diameter classes with their range and proportion of individuals.

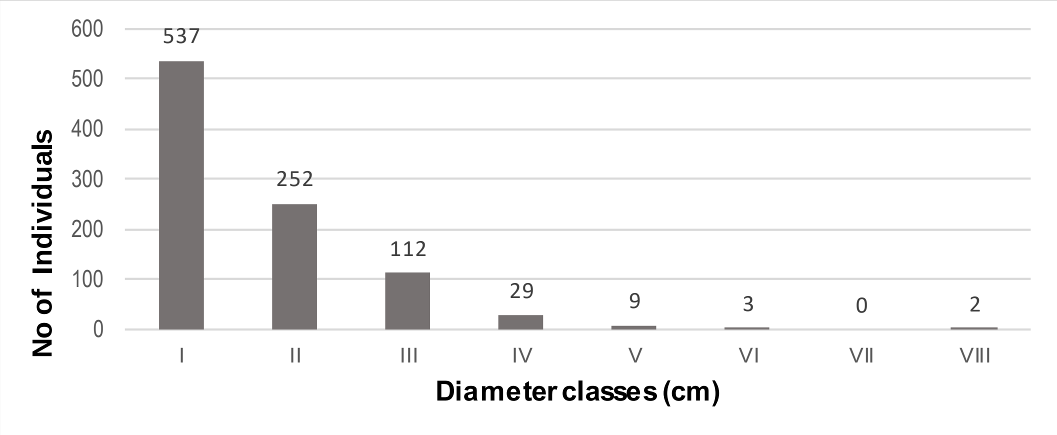
Table 4.54: Diameter distribution in gallery forest.

Diameter classes	Range (cm)	No. Individuals	% Individuals
I	10,01 - 20	537	56,9
II	20,01 - 30	252	26,7
III	30,01 - 40	112	11,9
IV	40,01 - 50	29	3,1
V	50,01 - 60	9	1,0
VI	60,01 - 70	3	0,3
VII	70,01 - 80	0	0,0
VIII	80,01 - 90	2	0,2
General total		**944**	**100**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Figure 4.107 shows the distribution of individuals in the diameter classes of the gallery forest, showing a normal behaviour, with 56.9% of the individuals in the first class (537 individuals) and 26.7% (252 individuals) in the second, showing a curve in the shape of a jack in which there are many individuals in the first classes and with regular decrease as class is increased, characteristic of developing natural forests, with active processes of natural regeneration and with a good offer of small trees to replace the dying ones.

Figure 4.107: Diameter distribution in gallery forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Basal area and volume by species

Table 4.55 shows the volume reported in the inventory for each of the species found in the gallery forest in tree size category, in the analyzed area corresponding to 2.1 hectares and with its respective value and proportion per hectare.

Table 4.55: Basal area and volume by species in gallery forest.

SPECIES	COMMON NAME	BASAL AREA (m^2)	COM VOL (m^3)	TOT VOL (m^3)	TOT VOL /ha (m^3)
Albizia lebbeck	Menudito	1,1	6,3	14,0	6,7
Alchornea discolor	Algodoncillo	0,1	0,7	1,7	0,8
Alchornea triplinervia	Carnegallina	0,0	0,2	0,3	0,1
Amaioua guianensis	Macanillo	0,0	0,1	0,2	0,1
Andira surinamensis	Arenoso	0,2	0,9	2,0	1,0
Aniba panurensis	Yema de huevo	0,1	0,4	0,9	0,4
Aspidosperma desmanthum	Costillo	0,1	1,2	1,5	0,7
Aspidosperma excelsum	Costillo blanco	0,1	0,9	1,5	0,7
Astronium graveolens	Abejón	0,0	0,0	0,1	0,0
Attalea maripa	Cucurita	0,4	1,8	4,5	2,1
Bellucia grossularioides	Níspero	0,1	0,8	1,8	0,9
Brosimum lactescens	Guáimaro	0,7	3,7	7,4	3,5
Calophyllum brasiliense	Cachicamo	1,5	10,9	19,5	9,3
Campsiandra comosa	Chigo	0,4	2,1	4,4	2,1
Caraipa llanorum	Saladillo rojo	4,6	28,8	53,5	25,5
Coccoloba mollis	Uvero	0,2	1,2	2,2	1,0
Cochlospermum orinocense	Bototo	0,4	3,6	5,8	2,8
Cochlospermum vitifolium	Bototo	0,0	0,0	0,1	0,0
Connarus lambertii	Sangrito	0,1	0,3	0,7	0,3
Copaifera pubiflora	Aceite	1,1	7,5	17,2	8,2
Cordia sericicalyx	Palo de agua	0,1	0,4	0,7	0,3

SPECIES	COMMON NAME	BASAL AREA (m^2)	COM VOL (m^3)	TOT VOL (m^3)	TOT VOL /ha (m^3)
Crudia oblonga	Cascarillo	0,1	0,4	1,1	0,5
Cupania scrobiculata	Partemachete	0,0	0,0	0,1	0,0
Curatella americana	Chaparro	0,0	0,0	0,1	0,0
Dendropanax arboreus	Mantequillo	0,1	0,5	1,0	0,5
Diospyros sericea	Carbonero	0,5	4,3	6,5	3,1
Dipteryx punctata	Sarrapio	0,9	7,5	13,5	6,4
Elaeagia maguirei	Marfil	0,0	0,3	0,5	0,3
Enterolobium schomburgkii	Dormidero	0,1	0,8	1,1	0,5
Erythroxylum macrophyllum	Ajicito	0,0	0,1	0,2	0,1
Eschweilera parvifolia	Coco de mono	1,3	11,3	17,1	8,1
Eschweilera tenuifolia	Copo	0,5	2,7	5,1	2,4
Euplassa saxicola	Yolombó	0,3	2,5	4,3	2,0
Euterpe precatoria	Manaco	0,9	7,9	11,1	5,3
Ficus americana	Matapalo	0,1	0,9	1,3	0,6
Ficus mathewsii	Matapalo	0,1	0,2	0,6	0,3
Garcinia madruno	Madroño	0,0	0,1	0,2	0,1
Genipa americana	Caruto	0,0	0,2	0,3	0,2
Guatteria metensis	Majagüillo blanco	0,0	0,0	0,1	0,0
Guatteria schomburgkiana	Majagüillo negro	2,3	17,1	28,3	13,5
Hebepetalum sp.	Colorado	0,4	2,8	5,5	2,6
Heterostemon conjugatus	Guamita	0,0	0,1	0,2	0,1
Himatanthus articulatus	Platanote	1,2	8,3	14,4	6,9
Hirtella elongata	Garrapato	0,4	1,5	3,5	1,7
Hydrochorea corymbosa	Dormilón	0,8	4,7	9,3	4,4
Hymenaea courbaril	Algarrobo	0,1	1,3	2,0	1,0
Inga cylindrica	Guamo	0,5	4,0	6,8	3,3
Jacaranda copaia	Pavito	0,3	4,1	5,7	2,7
Jacaranda obtusifolia	Gualanday	0,3	2,2	4,1	1,9
Lacistema aggregatum	Laurel rosado	0,0	0,1	0,1	0,1
Licania hypoleuca	Escobo blanco	0,0	0,1	0,3	0,2
Licania leucosepala	Aceituno	0,4	2,3	4,5	2,2
Licania parvifructa	Escobo colorado	0,1	0,3	0,7	0,3
Licania subarachnophylla	Escobo	0,0	0,3	0,5	0,2
Licaria canella	Amarillo	0,0	0,1	0,2	0,1
Lonchocarpus floribundus	Matarratón	0,1	0,4	0,7	0,3
Mabea trianae	Canilla de venado	0,1	0,4	1,0	0,5
Mahurea exstipulata	Caucho amarillo	0,1	0,4	1,3	0,6
Maquira coriacea	Lechero	0,1	0,5	0,7	0,3
Matayba adenanthera	Patepajuil	0,1	0,3	0,7	0,4
Matayba scrobiculata	Patepajuil	0,1	0,8	1,2	0,6
Mauritia flexuosa	Moriche	1,9	16,5	24,5	11,7
Micropholis guyanensis	Caimillo	0,0	0,2	0,4	0,2
Myrcia paivae	Arrayán	0,0	0,0	0,1	0,0
Myrcia subsessilis	Arrayán	0,3	1,0	2,2	1,0

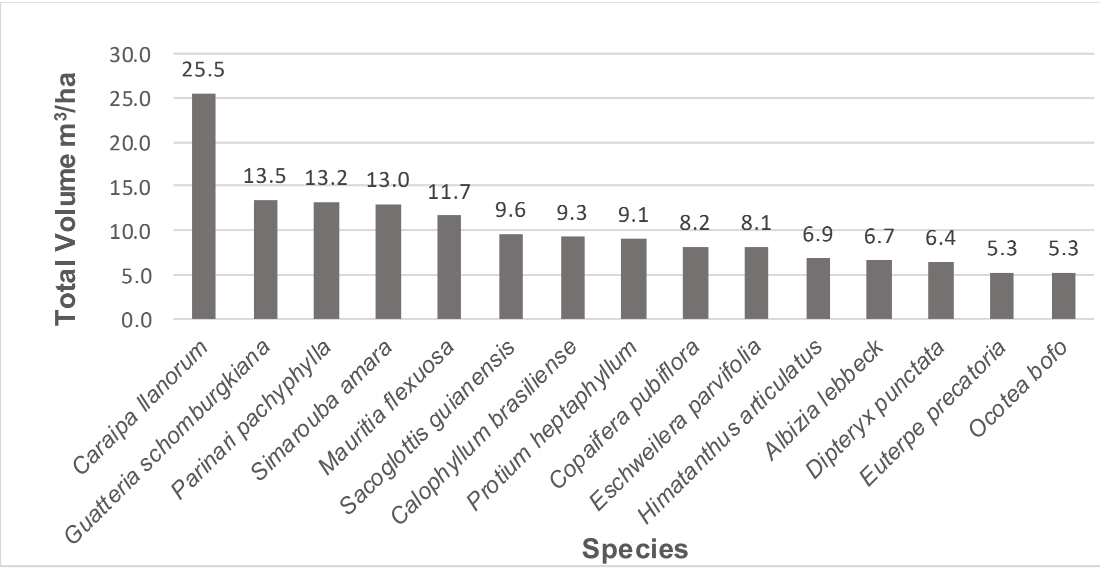
SPECIES	COMMON NAME	BASAL AREA (m^2)	COM VOL (m^3)	TOT VOL (m^3)	TOT VOL /ha (m^3)
Myrciaria floribunda	Guayabo montañero	0,0	0,0	0,1	0,0
Myrciaria floribunda	Guayabo montañero	0,0	0,0	0,1	0,0
Nectandra cuspidata	Laurel sabanero	0,0	0,2	0,3	0,2
Ocotea bofo	Laurel	0,9	5,4	11,1	5,3
Ocotea longifolia	Laurel matatigre	0,0	0,2	0,3	0,2
Oenocarpus bacaba	Maporilla	0,1	0,4	0,6	0,3
Ouratea castaneifolia	Lengua de yataro	0,1	0,4	0,6	0,3
Ouratea polyantha	Coralito	0,0	0,0	0,1	0,0
Parahancornia oblonga	Pendare	0,6	5,3	8,6	4,1
Parinari pachyphylla	Escobo	1,8	14,1	27,8	13,2
Pera arborea	Pategallina	0,1	0,7	1,1	0,5
Perebea xanthochyma	Cauchillo	0,1	0,7	1,0	0,5
Phenakospermum guyannense	Tarriago	0,0	0,1	0,2	0,1
Phyllanthus attenuatus	Totumito	0,2	1,4	2,3	1,1
Picramnia magnifolia	Quemacarate	0,0	0,1	0,2	0,1
Pouteria guianensis	Caimo	0,2	1,6	2,8	1,3
Protium glabrescens	Anime	0,6	3,8	6,9	3,3
Protium heptaphyllum	Anime	1,8	10,6	19,0	9,1
Protium llanorum	Anime	0,0	0,3	0,4	0,2
Quiina macrophylla	Guayacán	0,0	0,1	0,1	0,1
Richeria grandis	Alcafeto	0,1	0,5	0,8	0,4
Ruprechtia costata	Rascarrabio	0,0	0,1	0,3	0,1
Sacoglottis guianensis	Fierrito	1,5	11,3	20,2	9,6
Schefflera morototoni	Tortolito	0,5	3,5	6,7	3,2
Sclerolobium melanocarpum	Pategarza	0,3	1,5	3,6	1,7
Senna silvestris	Alcaparillo	0,0	0,0	0,1	0,0
Simarouba amara	Simaruba	2,0	16,8	27,3	13,0
Socratea exorrhiza	Choapo	0,1	0,6	0,9	0,4
Stephanopodium sp.	Naranjo	0,0	0,0	0,1	0,0
Swartzia leptopetala	Sangretoro	0,1	0,5	0,9	0,4
Symphonia globulifera	Breo	0,3	3,0	4,3	2,0
Tapirira guianensis	Guarupayo	0,5	2,4	4,6	2,2
Tetragastris panamensis	Caraño blanco	0,4	2,2	3,8	1,8
Virola carinata	Carnevaca blanco	0,1	0,4	0,6	0,3
Virola elongata	Carnevaca	0,6	6,0	9,0	4,3
Virola parvifolia	Carnevaca	0,1	0,6	0,8	0,4
Vismia baccifera	Lacre blanco	0,0	0,2	0,4	0,2
Vismia macrophylla	Punta de lanza	0,0	0,2	0,3	0,2
Vitex orinocensis	Guarataro	0,1	0,6	1,4	0,7
Vochysia ferruginea	Botagajo	0,0	0,1	0,2	0,1
Vochysia lehmannii	Saladillo blanco	0,1	0,5	1,0	0,5

Vouarana guianensis	Partemachete	0,0	0,1	0,2	0,1
Xylopia aromatica	Malagueto	0,3	2,0	3,0	1,4
Xylopia emarginata	Majagüillo	0,0	0,1	0,3	0,1
Zygia inaequalis	Cimbrapotro	0,0	0,0	0,0	0,0
Total general		**39,9**	**280,2**	**497,5**	**236,9**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

According to the volume analysis (see Figure 4.108), the species reporting the highest total volume per hectare for the gallery forest, is *Caraipa llanorum* (Saladillo rojo), with 25,5 cubic meters equivalent to 10,8% of the total, other representative species are: *Guatteria schomburgkiana* (Majagüillo negro), *Parinari pachyphylla* (escobo), *Simarouba amara* (Simaruba) and *Mauritia flexuosa* (Moriche).

Figure 4.108: Basal area and volumen by species in gallery forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Floristic diversity

Table 4.56 shows the results obtained for the mix ratio and the richness and diversity indexes for the trees of the gallery forest, taking into account that 944 individuals and 109 species were reported in an analyzed area of 2.1 hectares.

Table 4.56: Richness and diversity indexes for trees of the gallery forest.

No. Species	**No. Individuals**	**RICHNESS**			**DIVERSITY**	
		Margalef	**Cm**		**Shannon**	**Simpson**
109	944	15,77	0,12	1:9	3,88	0,036

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Margalef Index

This index estimates the richness of a community based on the numeric distribution of individuals of the different species, depending on the number of individuals in the sample analyzed. It is assumed that values lower than two determine a low diversity and when they are higher than five, they indicate a high floristic diversity. For trees of this coverage, a value of 15.77 was determined which represents a very high richness and a quite heterogeneous forest in species composition.

Mix ratio

This parameter measures the mix intensity of the species in the sampled area, for trees in the gallery forest showed a value of 0.12 which is equivalent to a relationship 1:9, that is, it is assumed that each species is represented by 9 individuals on the average or that every 9 individuals a different species is reported; if the number of individuals (sample size) is taken into account, this value suggests a high species heterogeneity in this coverage.

Shannon-Wiener Index

This index allows calculating the sum of probabilities of the species and the homogeneity of the distribution for a given number of species, taking into account that the maximum possible value to obtain is the natural logarithm of the number of individuals (944), corresponding to a value of 6.95, which would indicate that all species are equally abundant. For trees of the gallery forest a value of 3.88 was determined, a datum representing a medium value with tendency to the estimate, determining that the species found in this coverage tend to be equally abundant indicating a medium-high heterogeneity and floristic diversity.

Simpson Index

The Simpson index refers to the probability that two individuals of a community taken at random, belong to the same species, measures the degree of concentration an varies between 0 and 1; when the diversity is low tends to 1. For trees in the gallery forest, a value of 0.036 was determined which indicates a very low probability that two individuals taken at random be of the same species; this means that there exists a high specific heterogeneity, that is a high floristic diversity in this coverage.

Natural regeneration gallery Forest

Within the sub-plots of the sampling units made for the characterization of the gallery forest, a total of 586 individuals of natural regeneration were recorded, corresponding to 234 pole stands (in an area of 1050 $m^{2)}$ and 352 saplings (in an area of 168 m^2).

Floristic composition of the natural regeneration

The 586 reported individuals for the natural regeneration of the gallery forest, are grouped in 37 families, 70 genders and 82 species. At a specific level stands out the family: Leguminosae with 8 species, followed by Areaceae and Chrysobalanaceae with 5 species each one and Euphorbiaceae, Myrtaceae y Rubiaceae with 4 species each one; at a gender level stands out *Licania* with 3 species. Table 4.57 shows the floristic composition of the natural regeneration, as well as the number of individuals found by species for each one of the size categories.

Table 4.57: Floristic composition of the natural regeneration in gallery forest.

FAMILY	GENDER	SPECIES	COMMON NAME	Pole stand	Sap ling	To tal
Anacardiaceae	*Astronium*	*Astronium graveolens* Jacq.	Abejón	1		1
	Tapirira	*Tapirira guianensis* Aubl.	Guarupayo	2		2
Annonaceae	*Guatteria*	*Guatteria schomburgkiana* Mart.	Majagüillo negro	2	12	14
	Xylopia	*Xylopia aromatica* (Lam.) Mart.	Malagueto	1		1
Apocynaceae	*Himatanthus*	*Himatanthus articulatus* (Vahl) Woodson	Platanote	1	5	6
	Malouetia	*Malouetia virescens* Spruce ex Müll.Arg.	Palo de boya	3	4	7
	Parahancornia	*Parahancornia oblonga* (Benth. ex Müll.Arg.) Monach.	Pendare		4	4
	Tabernaemontana	*Tabernaemontana siphilitica* (L.f.) Leeuwenb.	Sanango		6	6
Araliaceae	*Dendropanax*	*Dendropanax arboreus* (L.) Decne. & Planch.	Mantequillo	1	2	3
Arecaceae	*Astrocaryum*	*Astrocaryum aculeatum* G.Mey.	Cubarro	3	9	12
	Euterpe	*Euterpe precatoria* Mart.	Manaco	26	19	45
	Mauritia	*Mauritia flexuosa* L.f.	Moriche		3	3
	Oenocarpus	*Oenocarpus bacaba* Mart.	Maporilla	1		1
	Socratea	*Socratea exorrhiza* (Mart.) H.Wendl.	Choapo	1		1
Bignoniaceae	*Jacaranda*	*Jacaranda copaia* (Aubl.) D.Don	Pavito		5	5
Burseraceae	*Protium*	*Protium glabrescens* Swart	Anime	2	13	15
		Protium heptaphyllum (Aubl.) Marchand	Anime	2	33	35
	Tetragastris	*Tetragastris panamensis* (Engl.) Kuntze	Caraño blanco		7	7
Calophyllaceae	*Caraipa*	*Caraipa llanorum* Cuatrec.	Saladillo rojo	2	4	6
Chrysobalanaceae	*Hirtella*	*Hirtella elongata* Mart. & Zucc.	Garrapato	4	3	7
		Hirtella racemosa Lam.	Huesito	4	3	7
	Licania	*Licania hypoleuca* Benth.	Escobo blanco		2	2
		Licania leucosepala Griseb.	Aceituno	1	1	2
		Licania parvifructa Fanshawe & Maguire	Escobo colorado		2	2
	Parinari	*Parinari pachyphylla* Rusby	Escobo	4	7	11
Clusiaceae	*Calophyllum*	*Calophyllum brasiliense* Cambess.	Cachicamo		12	12
	Garcinia	*Garcinia madruno* (Kunth) Hammel	Madroño		2	2
	Symphonia	*Symphonia globulifera* L.f.	Breo		3	3
Connaraceae	*Connarus lambertii (DC.)*	*Connarus lambertii* (DC.) Britton	Sangrito	2		2
Ebenaceae	*Diospyros*	*Diospyros sericea* A.DC.	Carbonero	2	7	9
Euphorbiaceae	*Alchornea*	*Alchornea triplinervia* (Spreng.) Müll.Arg.	Carnegallina	1		1
	Mabea	*Mabea nitida* Spruce ex Benth.	Lechero blanco	1		1

FAMILY	GENDER	SPECIES	COMMON NAME	Pole stand	Sap ling	To tal
		Mabea trianae Pax	Canilla de venado	15	11	26
	Sapium	*Sapium glandulosum* (L.) Morong	Lechero	1		1
Hypericaceae	*Vismia*	*Vismia baccifera* (L.) Planch. & Triana	Lacre blanco	1	1	2
		Vismia macrophylla Kunth	Punta de lanza	1	4	5
Lauraceae	*Aniba*	*Aniba panurensis* (Meisn.) Mez	Yema de huevo	4	3	7
	Ocotea	*Ocotea bofo* Kunth	Laurel	1		1
		Ocotea longifolia Kunth	Laurel matatigre	2	21	23
Lecythidaceae	*Eschweilera*	*Eschweilera parvifolia* Mart. ex DC.	Coco de mono	4	1	5
		Eschweilera tenuifolia (O.Berg) Miers	Copo	1	3	4
Leguminosae	*Copaifera*	*Copaifera pubiflora* Benth.	Aceite		1	1
	Dipteryx	*Dipteryx punctata* (S.F.Blake) Amshoff	Sarrapio		6	6
	Enterolobium	*Enterolobium schomburgkii* (Benth.) Benth.	Dormidero		1	1
	Lonchocarpus	*Lonchocarpus floribundus* Benth.	Matarratón	1		1
	Macrolobium	*Macrolobium multijugum* (DC.) Benth.	Dormilón	1	1	2
	Sclerolobium	*Sclerolobium melanocarpum* Ducke	Pategarza	5	3	8
	Senna	*Senna silvestris* (Vell.) H.S.Irwin & Barneby	Alcaparillo	1		1
	Zygia	*Zygia inaequalis* (Willd.) Pittier	Cimbrapotro	3		3
Linaceae	*Hebepetalum*	*Hebepetalum* sp.	Colorado		2	2
Malpighiaceae	*Byrsonima*	*Byrsonima japurensis* A.Juss.	Coropo	1		1
Melastomataceae	*Henriettea*	*Henriettea goudotiana* (Naudin) Penneys, F.A. Michelangeli, Judd & Almeda	Tuno	3	9	12
	Miconia	*Miconia trinervia* (Sw.) D. Don ex Loudon	Tuno sabanero	2	2	4
Meliaceae	*Guarea*	*Guarea glabra* Vahl	Trompillo blanco	1	3	4
Moraceae	*Brosimum*	*Brosimum lactescens* (S.Moore) C.C.Berg	Guáimaro	7	7	14
Myristicaceae	*Virola*	*Virola carinata* (Spruce ex Benth.) Warb.	Carnevaca blanco		3	3
		Virola parvifolia Ducke	Carnevaca		6	6
Myrtaceae	*Eugenia*	*Eugenia biflora* (L.) DC.	Guayabito sabanero	1	3	4
	Myrcia	*Myrcia paivae* O.Berg	Arrayán	4	21	25
		Myrcia subsessilis O.Berg	Arrayán	5	13	18
	Myrciaria	*Myrciaria floribunda* (H.West ex Willd.) O.Berg	Guayabo montañero	2		2
Ochnaceae	*Ouratea*	*Ouratea castaneifolia* (DC.) Engl.	Lengua de yataro	1		1
	Quiina	*Quiina macrophylla* Tul.	Guayacán	1	4	5

FAMILY	GENDER	SPECIES	COMMON NAME	Pole stand	Sap ling	To tal
Peraceae	*Pera*	*Pera arborea* Mutis	Pategallina	2	3	5
Phyllanthaceae	*Phyllanthus*	*Phyllanthus attenuatus* Miq.	Totumito	3		3
Polygonaceae	*Coccoloba*	*Coccoloba mollis* Casar.	Uvero	2		2
Proteaceae	*Euplassa*	*Euplassa saxicola* (R.E.Schult.) Steyerm.	Yolombó	1	1	2
Rubiaceae	*Amaioua*	*Amaioua guianensis* Aubl.	Macanillo	5	10	15
	Cordiera	*Cordiera myrciifolia* (K.Schum.) Perss. & Delprete	Macano	5	5	10
	Elaeagia	*Elaeagia maguirei* Standl.	Marfil	1		1
	Rudgea	*Rudgea crassiloba* (Benth.) B.L.Rob.	Cafetillo	5	3	8
Sapindaceae	*Cupania*	*Cupania scrobiculata* Rich.	Partemachete	1		1
	Matayba	*Matayba adenanthera* Radlk.	Patepajuil	4	3	7
		Matayba scrobiculata Radlk.	Patepajuil	3		3
Sapotaceae	*Micropholis*	*Micropholis guyanensis* (A.DC.) Pierre	Caimillo	2		2
	Pouteria	*Pouteria guianensis* Aubl.	Caimo	1	2	3
Simaroubaceae	*Simarouba*	*Simarouba amara* Aubl.	Simaruba	4	3	7
Siparunaceae	*Siparuna*	*Siparuna guianensis* Aubl.	Romadizo	18	4	22
Strelitziaceae	*Phenakospermum*	*Phenakospermum guyannense* (A.Rich.) Endl. ex Miq.	Tarriago	37	12	49
Urticaceae	*Cecropia*	*Cecropia peltata* L.	Guarumo	3	1	4
Vochysiaceae	*Vochysia*	*Vochysia ferruginea* Mart.	Botagajo	1		1
		Vochysia lehmannii Hieron.	Saladillo blanco		8	8
Total general				**234**	**352**	**586**

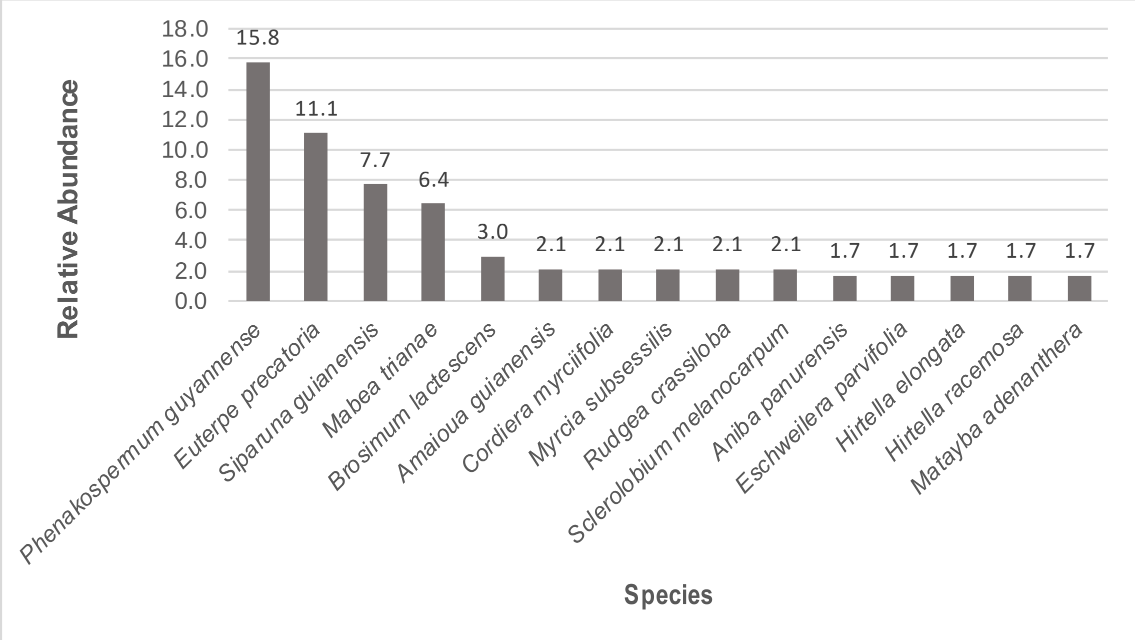
Source: (Universidad Distrital Francisco José De Caldas, 2017)

Relative abundance of natural regeneration

Pole stands

In the analysis of the relative abundance for the pole stands of the gallery forest, the following species stand out: *Phenakospermum guyannense* (Tarriago) with 15.8% of the parameter with 37 individuals, followed by *Euterpe precatoria* (Manaco) with 11.1% (26 individuals), *Siparuna guianensis* (Romadizo) with 7.7% (18 individuals) and *Mabea trianae* (Canilla de venado) with 6.4% (15 individuals); the other species show values less than or equal to 3% of relative abundance (see Figure 4.109). For this parameter for pole stands, like for the trees a structure with a tendency to be heterogeneous is shown.

Figure 4.109: Relative abundance of pole stands in gallery forest.

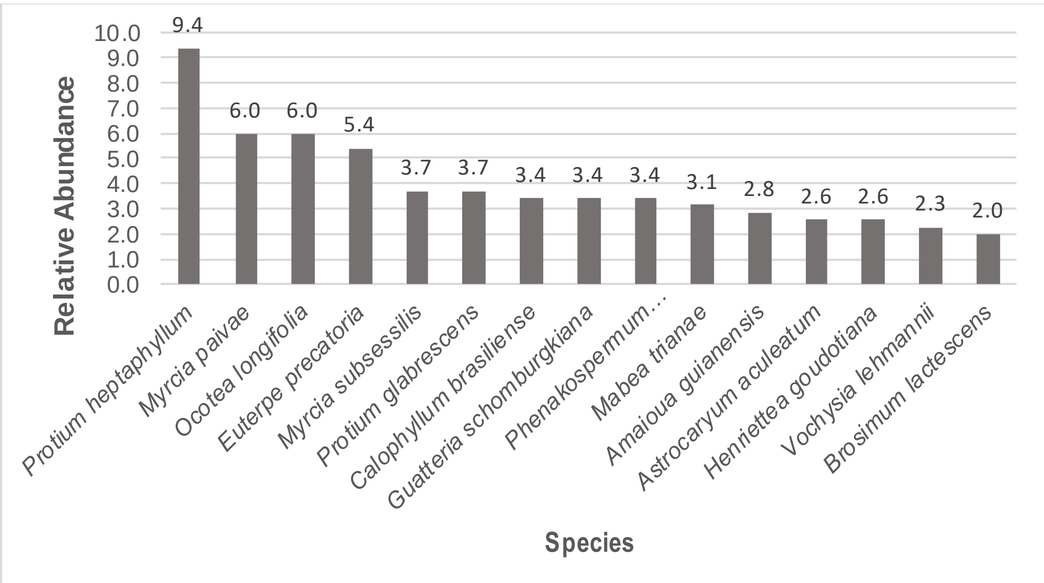


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Saplings

As for relative abundance for Saplings in gallery forest, the species: *Protium heptaphyllum* (Anime) with 9.4% (33 individuals) stands out, followed by *Myrcia paivae* (Arrayán) and *Ocotea longifolia* (Laurel matatigre) with 6% (21 individuals) each one and *Euterpe precatoria* (Manaco) with 5.4% (19 individuals); the other species show values less than 4% (see Figure 4.110). In this size category the structural tendency to heterogeneity in the forest also holds.

Figure 4.110: Relative abundance of saplings in gallery forest.



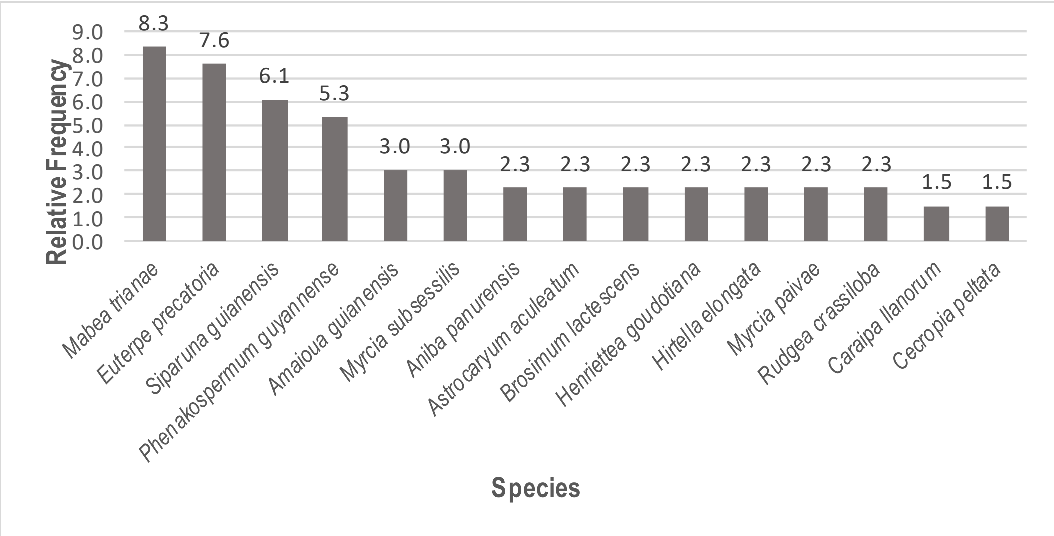
Source: (Universidad Distrital Francisco José De Caldas, 2017)

Relative frequency of the natural regeneration

Pole stands

The most representative species in this parameter for pole stands are: *Mabea trianae* (Canilla de venado) with 8.3% when appearing in 11 of the 21 plots surveyed, followed by *Euterpe precatoria* (Manaco) with 7.6% (report in 10 plots), *Siparuna guianensis* (Romadizo) with 6.1% (report en 8 plots) y *Phenakospermum guyannense* (Tarriago) with 5.3% (report in 7 plots); the other species report values lower than or equal to 3% when reporting in 4 or less plots (see Figure 4.111). According to this analysis, there are no species with very marked differences in relative frequency with respect to others, which determines a heterogeneous horizontal structure for pole stands in the dense forest.

Figure 4.111: Relative frequency of pole stands in gallery forest.

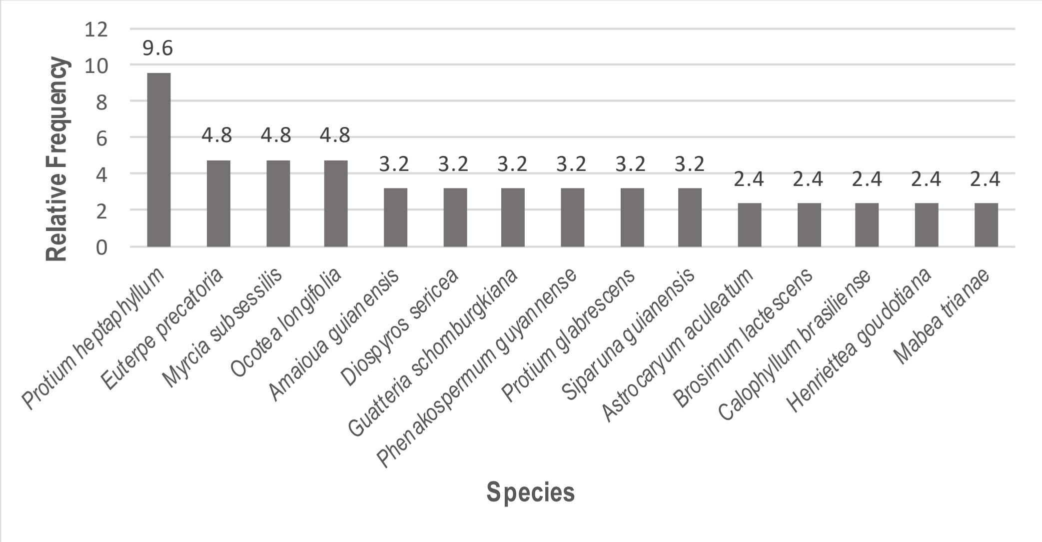


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Saplings

In the analysis of relative frequency for saplings of the gallery forest appears the species *Protium heptaphyllum* (Anime) with 9.6% (report in 12 of the 21 plots surveyed), followed by *Euterpe precatoria* (Manaco), *Myrcia paivae* (Arrayán) and *Ocotea longifolia* (Laurel matatigre) with 4.8% (report in 6 plots) each one; The other species report values lower than 4% when reporting in 4 or less plots (see Figure 4.112). The saplings of the gallery forest show the same tendency of all the coverage as for structural heterogeneity, however with a little more uniformity when showing a species with high frequency.

Figure 4.112: Relative frequency of saplings in gallery forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

- **Morichal.**

The information necessary for the characterization of the Morichales in the area of influence of the Project, was taken through the field survey of 7 sampling units of 0.1 hectares each one, in four sampling zones, for a total sampled area of 0.7 hectares; in Table 4.58 the geographic coordinates both in the start and final points of each plot are shown.

Table 4.58: Location data of the plots surveyed in Morichal.

CODE	START POINT		FINAL POINT	
	X	Y	X	Y
Mor1	918301,46	1171314	918209,163	1171277
Mor2	919826,18	1171026	918053,22	1171099
Mor3	915048,48	1160636	915042,335	1160642
Mor4	916398,95	1160908	916330,502	1160837
Mor5	937636,3	1166163	937706,318	1166233
Mor6	1001144,6	1169546	1001052,41	1169510
Mor7	1001052,4	1169310	1001095,45	1169399

Source: (Universidad Distrital Francisco José De Caldas, 2017). flat coordinates coordenadas Magna Colombia Este Este

For the Morichal covering, a relative sampling error lower than 15% with a probability of 95% was accomplished. In Table 4.59 the different statisticians calculated for this coverage from the variable total volume, with which a sampling error of 7.9% in the inventory for this coverage was determined.

Table 4.59: Statisticians for Morichal.

STATISTICIAN	VALUE
Sum	233,46
Average	33,35
Standard deviation	3,59
Variation coefficient (%)	10,76

STATISTICIAN	VALUE
Relative error required(%)	15
Sample size (n)	7
Student t Variable degrees of freedom (n – 1), probability 95%	1,94
Standard error	1,36
Absolute error	2,64
Relative error%	**7,90**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Floristic composition

In the analysis of the floristic composition for the trees of the Morichal, 375 individuals distributed in 22 families, 29 genders and 30 species were found. At a specific level the families Clusiaceae with 3 species and Annonaceae, Apocynaceae, Arecaceae, Calophyllaceae, Moraceae y Myristicaceae with 2 species each one stand out, the other families present one species each one; at gender level *Virola* with two species stands out, the other genders present one species each one, as shown in Table 4.60.

Table 4.60: Floristic composition of trees in Morichal.

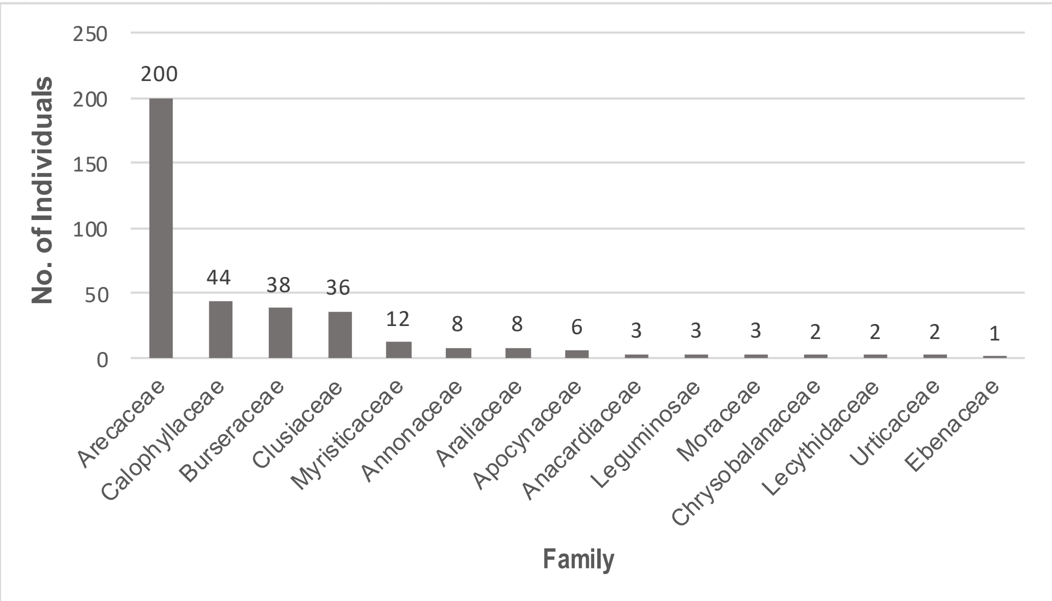
FAMILY	GENDER	SPECIES	COMMON NAME	ABUN.
Anacardiaceae	*Tapirira*	*Tapirira guianensis* Aubl.	Guarupayo	3
Annonaceae	*Guatteria*	*Guatteria schomburgkiana* Mart.	Majagüillo negro	7
	Xylopia	*Xylopia emarginata* Mart.	Majagüillo	1
Apocynaceae	*Malouetia*	*Malouetia virescens* Spruce ex Müll.Arg.	Palo de boya	2
	Parahancornia	*Parahancornia oblonga* (Benth. ex Müll.Arg.) Monach.	Pendare	4
Araliaceae	*Dendropanax*	*Dendropanax arboreus* (L.) Decne. & Planch.	Mantequillo	8
Arecaceae	*Euterpe*	*Euterpe precatoria* Mart.	Manaco	50
	Mauritia	*Mauritia flexuosa* L.f.	Moriche	150
Burseraceae	*Protium*	*Protium glabrescens* Swart	Anime	38
Calophyllaceae	*Caraipa*	*Caraipa llanorum* Cuatrec.	Saladillo rojo	29
	Mahurea	*Mahurea exstipulata* Benth.	Caucho amarillo	15
Chrysobalanaceae	*Hirtella*	*Hirtella elongata* Mart. & Zucc.	Garrapato	2
Clusiaceae	*Calophyllum*	*Calophyllum brasiliense* Cambess.	Cachicamo	32
	Garcinia	*Garcinia madruno* (Kunth) Hammel	Madroño	1
	Symphonia	*Symphonia globulifera* L.f.	Breo	3
Ebenaceae	*Diospyros*	*Diospyros sericea* A.DC.	Carbonero	1
Euphorbiaceae	*Alchornea*	*Alchornea discolor* Poepp.	Algodoncillo	1
Hypericaceae	*Vismia*	*Vismia macrophylla* Kunth	Punta de lanza	1
Lauraceae	*Endlicheria*	*Endlicheria verticillata* Mez	Amarillo	1
Lecythidaceae	*Eschweilera*	*Eschweilera parvifolia* Mart. ex DC.	Coco de mono	2

FAMILY	GENDER	SPECIES	COMMON NAME	ABUN.
Leguminosae	*Hydrochorea*	*Hydrochorea corymbosa* (Rich.) Barneby & J.W.Grimes	Dormilón	3
Malvaceae	*Pachira*	*Pachira sessilis* Benth.	Ceiba paquira	1
Moraceae	*Brosimum*	*Brosimum lactescens* (S.Moore) C.C.Berg	Guáimaro	1
	Maquira	*Maquira coriacea* (H.Karst.) C.C.Berg	Lechero	2
Myristicaceae	*Virola*	*Virola carinata* (Spruce ex Benth.) Warb.	Carnevaca blanco	6
		Virola parvifolia Ducke	Carnevaca	6
Myrtaceae	*Myrcia*	*Myrcia subsessilis* O.Berg	Arrayán	1
Ochnaceae	*Quiina*	*Quiina macrophylla* Tul.	Guayacán	1
Rubiaceae	*Duroia*	*Duroia micrantha* (Ladbr.) Zarucchi & J.H.Kirkbr.	Turmemico	1
Urticaceae	*Cecropia*	*Cecropia peltata* L.	Guarumo	2
Total general				**375**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

In the analysis of absolute abundance per family in Morichal, the most representative is Arecaceae with 200 individuals which is equivalent to 53.3% of the abundance; the other meaningful families are: Calophyllaceae, Burseraceae and Clusiaceae with 48, 38 y 36 individuals respectively, which is equivalent to relative values between 11.7 and 9.6% of the total (see Figure 4.113).

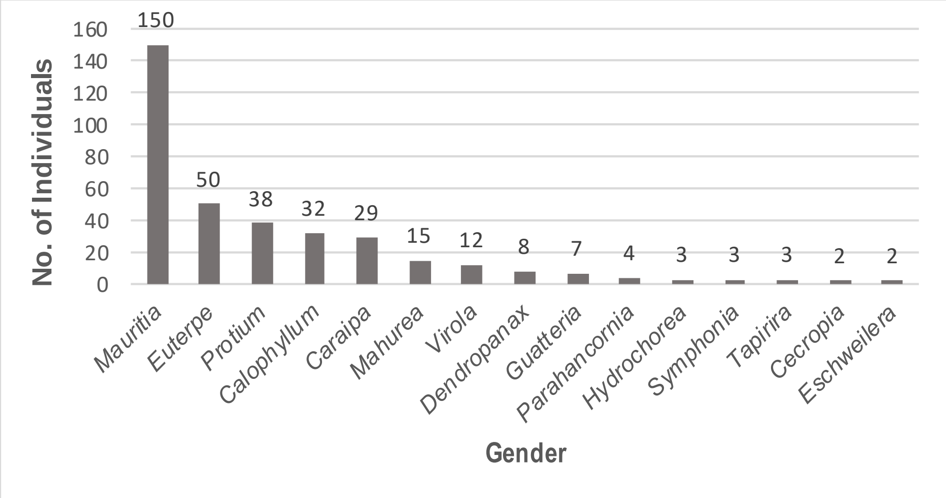
Figure 4.113: Absolute abundance per family in Morichal.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

As for the abundance of individuals by gender, *Mauritia* appears as the most representative reporting 150 individuals, which is equivalent to 40% of the abundance, other genders with a certain representation in abundance are: Euterpe, Protium, Calophyllum and Caraipa (see Figure 4.114).

Figure 4.114: Absolute abundance by gender in Morichal.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

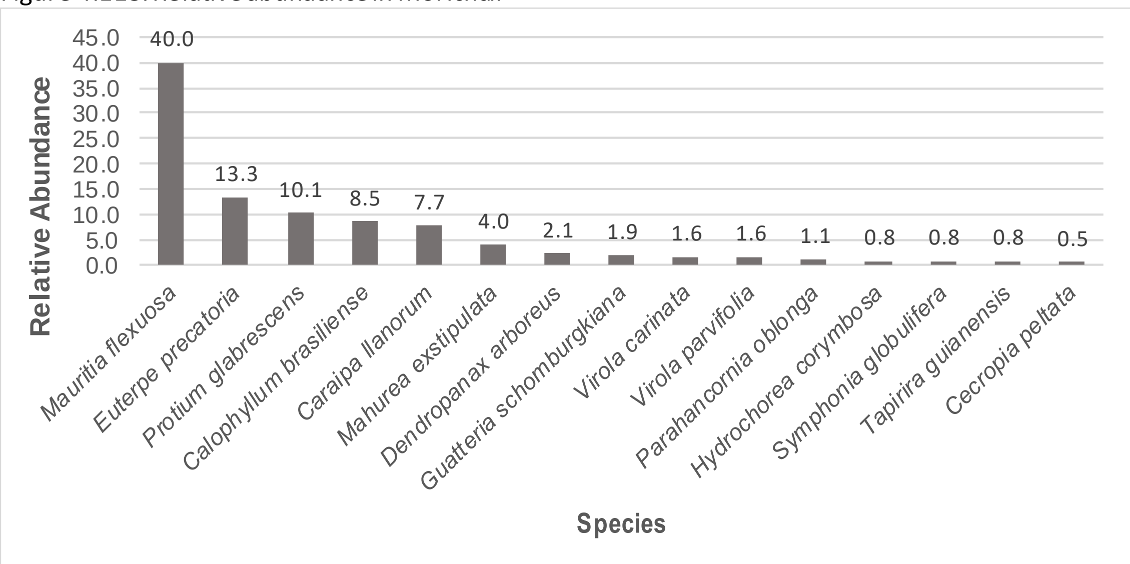
Horizontal Structure

For the characterization of the horizontal structure of the Morichal, the importance value index and the parameters: abundance, frequency and relative dominance were used, likewise the frequency histogram was built and the degree of aggregation was determined.

Relative abundance

In the analysis of this parameter for the Morichal, evidently the species: *Mauritia flexuosa* (Moriche) with 40.0% (150 individuals) stands out, followed in a lesser proporion by: *Euterpe precatoria* (Manaco) with 13.3% (50 individuals), *Protium glabrescens* (Anime) with 10.1% (38 individuals), *Calophyllum brasiliense* (Cachicamo) with 8.5% (32 individuals) and *Caraipa llanorum* (Saladillo rojo) with 7.7% (29 individuals); the other species report values lower than or equal to 4% of relative abundance (see Figure 4.115). This parameter allows inferring that the Morichal tends to be homogeneous in composition, to show such a marked abundance of a species.

Figure 4.115: Relative abundance in Morichal.

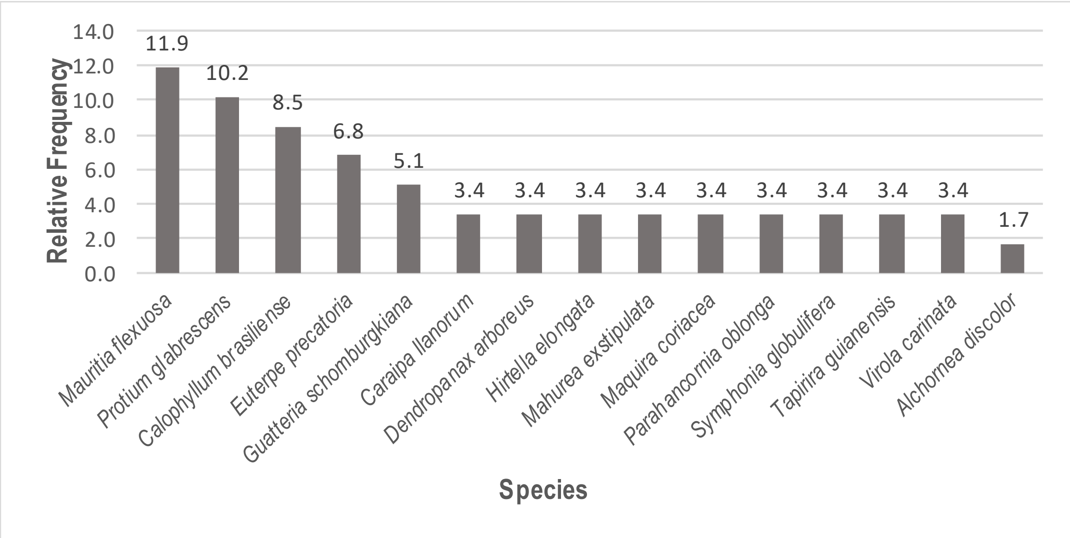


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Relative frequency

The most representative species in this parameter for the Morichal are: *Mauritia flexuosa* (Moriche), *Protium glabrescens* (Anime), *Calophyllum brasiliense* (Cachicamo), *Euterpe precatoria* (Manaco) and *Guatteria schomburgkiana* (Majagüillo negro) with values between 11.9 and 5.1% (report between 7 and 3 plots); the other species report less than 4% of the relative frequency when reporting in two or less plots (see Figure 4.116). For this parameter a tendency similar to the gallery forest is shown, but with a lesser proportion which determines to this coverage to be more homogeneous in regard to the appearance of the species in the sampling units.

Figure 4.116: Relative frequency in Morichal.

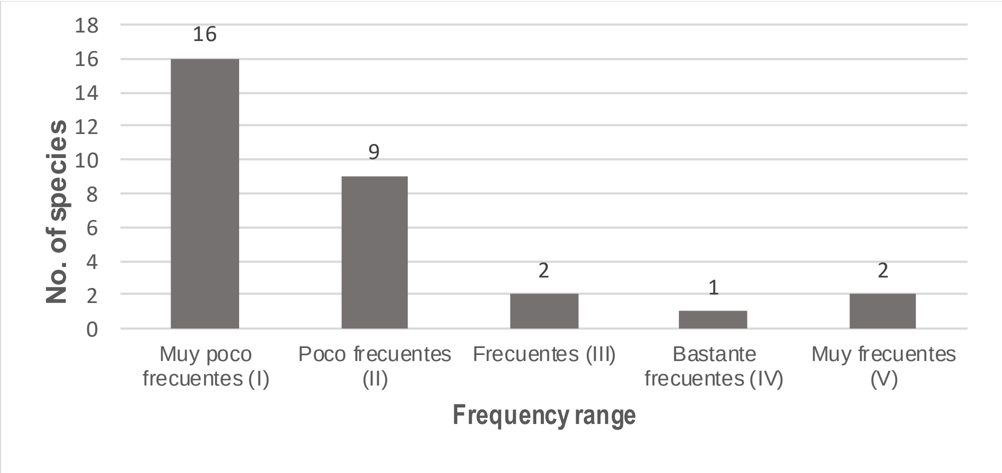


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Frequency histogram

The frequency histogram for the Morichal (Figure 4.117), shows that in a little more than half of the species are in the category very rare, represented with 53.3% (16 species), followed by category infrequent with 30% (9 species), then the category frequent and the category Very frequent with 6.7% (two species) each one and finally the category quite frequent with only 3.3% (one species). This behaviour shows for this parameter, the condition of homogeneity mentioned in terms of frequency of the species and is a typical condition of this type of coverings.

Figure 4.117: Frequency histogram for Morichal.

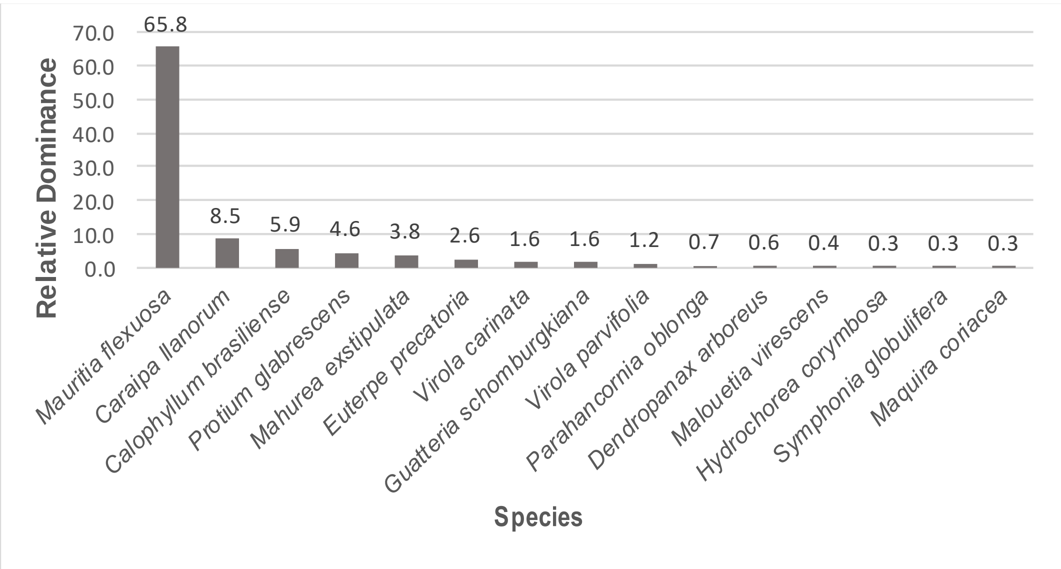


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Relative dominance

In the analysis of this parameter for the Morichal, it is appreciated a species with a marked dominance and corresponds to the species *Mauritia flexuosa* (Moriche) with 65.8% of relative dominance, other species with some significance are: *Caraipa llanorum* (Saladillo rojo), *Calophyllum brasiliense* (Cachicamo) and *Protium glabrescens* (Anime), with values between 8.5 and 4.6% respectively, while the other species show values less than 4% (see Figure 4.118). This is attributed to the abundance of the species and to the bearing of the individuals in the coverage.

Figure 4.118: Relative dominance in Morichal.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Importance value index (IVI)

In Table 4.61 the abundance, dominance, frequency and importance value index (IVI) values are shown, for each one of the species found in the category of tree size in the Morichal.

Table 4.61: Importance value index in Morichal.

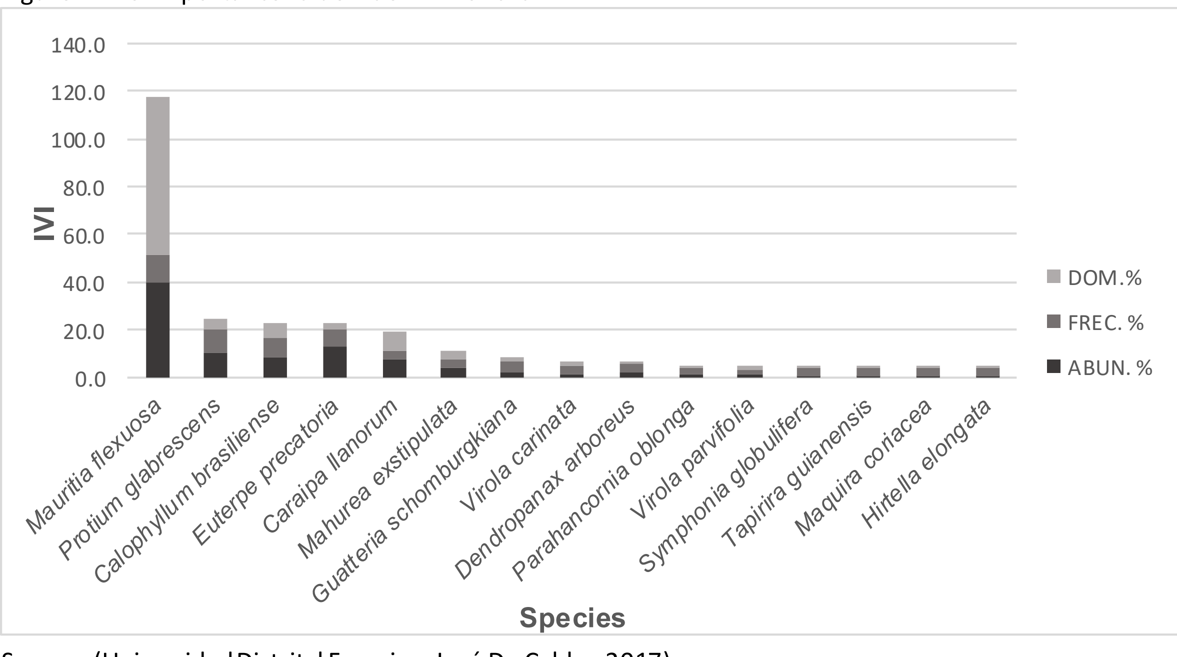
SPECIES	COMMON NAME	ABUND.	FREC.	DOM.	ABUN. %	FREC. %	DOM.%	IVI	IVI %
Alchornea discolor	Algodoncillo	1	14,3	0,0	0,3	1,7	0,1	2,1	0,7
Brosimum lactescens	Guáimaro	1	14,3	0,0	0,3	1,7	0,1	2,1	0,7
Calophyllum brasiliense	Cachicamo	32	71,4	1,2	8,5	8,5	5,9	22,9	7,6
Caraipa llanorum	Saladillo rojo	29	28,6	1,7	7,7	3,4	8,5	19,6	6,5
Cecropia peltata	Guarumo	2	14,3	0,0	0,5	1,7	0,2	2,4	0,8
Dendropanax arboreus	Mantequillo	8	28,6	0,1	2,1	3,4	0,6	6,1	2,0
Diospyros sericea	Carbonero	1	14,3	0,0	0,3	1,7	0,0	2,0	0,7
Duroia micrantha	Turmemico	1	14,3	0,0	0,3	1,7	0,1	2,0	0,7
Endlicheria verticillata	Amarillo	1	14,3	0,0	0,3	1,7	0,0	2,0	0,7
Eschweilera parvifolia	Coco de mono	2	14,3	0,0	0,5	1,7	0,2	2,4	0,8
Euterpe precatoria	Manaco	50	57,1	0,5	13,3	6,8	2,6	22,7	7,6
Garcinia madruno	Madroño	1	14,3	0,0	0,3	1,7	0,1	2,1	0,7
Guatteria schomburgkiana	Majagüillo negro	7	42,9	0,3	1,9	5,1	1,6	8,5	2,8
Hirtella elongata	Garrapato	2	28,6	0,0	0,5	3,4	0,2	4,2	1,4
Hydrochorea corymbosa	Dormilón	3	14,3	0,1	0,8	1,7	0,3	2,8	0,9
Mahurea exstipulata	Caucho amarillo	15	28,6	0,8	4,0	3,4	3,8	11,2	3,7
Malouetia virescens	Palo de boya	2	14,3	0,1	0,5	1,7	0,4	2,6	0,9
Maquira coriacea	Lechero	2	28,6	0,1	0,5	3,4	0,3	4,2	1,4
Mauritia flexuosa	Moriche	150	100,0	13,2	40,0	11,9	65,8	117,6	39,2
Myrcia subsessilis	Arrayán	1	14,3	0,0	0,3	1,7	0,0	2,0	0,7
Pachira sessilis	Ceiba paquira	1	14,3	0,0	0,3	1,7	0,1	2,0	0,7
Parahancornia oblonga	Pendare	4	28,6	0,1	1,1	3,4	0,7	5,2	1,7
Protium glabrescens	Anime	38	85,7	0,9	10,1	10,2	4,6	24,9	8,3
Quiina macrophylla	Guayacán	1	14,3	0,0	0,3	1,7	0,0	2,0	0,7

SPECIES	COMMON NAME	ABUND.	FREC.	DOM.	ABUN. %	FREC. %	DOM.%	IVI	IVI %
Symphonia globulifera	Breo	3	28,6	0,1	0,8	3,4	0,3	4,5	1,5
Tapirira guianensis	Guarupayo	3	28,6	0,0	0,8	3,4	0,2	4,4	1,5
Virola carinata	Carnevaca blanco	6	28,6	0,3	1,6	3,4	1,6	6,6	2,2
Virola parvifolia	Carnevaca	6	14,3	0,2	1,6	1,7	1,2	4,5	1,5
Vismia macrophylla	Punta de lanza	1	14,3	0,0	0,3	1,7	0,1	2,0	0,7
Xylopia emarginata	Majagüillo	1	14,3	0,0	0,3	1,7	0,1	2,1	0,7
Total general		**375**	**842,9**	**20,0**	**100,0**	**100,0**	**100,0**	**300,0**	**100,0**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

The analysis of the importance value index for this coverage, shows the species: *Mauritia flexuosa* (Moriche) as the most representative or the one with the highest ecological weight, with a net value of 117,6 (over 300), corresponding to a percentage of 39.2%; other species with significant values are: *Protium glabrescens* (Anime), *Calophyllum brasiliense* (Cachicamo), *Euterpe precatoria* (Manaco) and *Caraipa llanorum* (Saladillo rojo), with net values between 24.9 and 19.6 corresponding to percentages between 8.3% and 6.5%; the other species report values lower than 4% of the total determined for this parameter (see Figure 4.119). As shown individually in each parameter, the Morichal is quite homogeneous, by showing a high importance of a species.

Figure 4.119: Importance value index in Morichal.

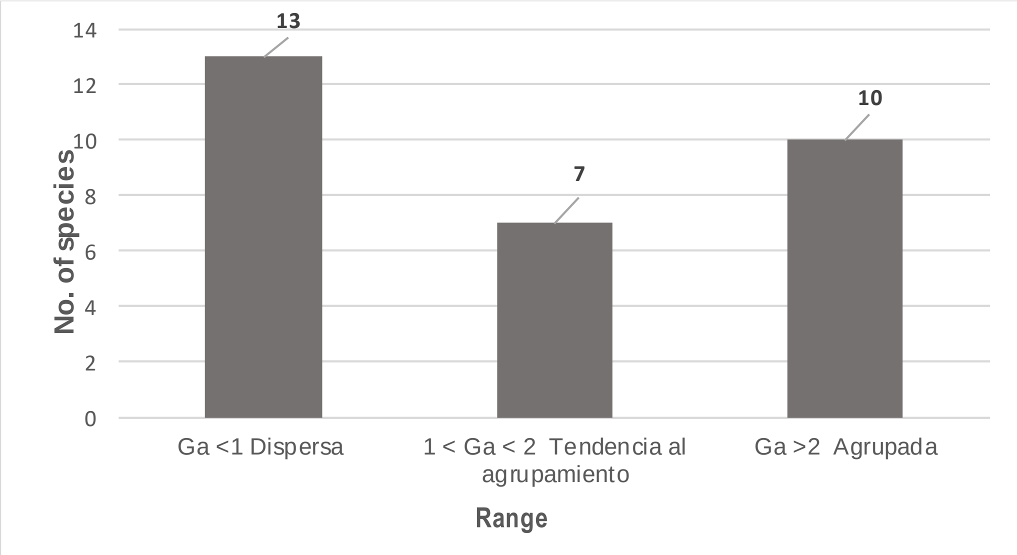


Source: (Universidad Distrital Francisco José De Caldas, 2017)

- Degree of aggregation

In the analysis of degree of aggregation of the species in Morichal, it was determined that 13 species, equivalent to 43.3% of the total, have a disperse distribution, while 10 species (33.3%) are grouped and the remaining 7 species have a tendency to grouping (see Figure 4.120); in this analysis are included species that are not necessarily abundant and frequent but that do tend to group in few plots. This parameter shows in general terms that the Morichal despite being homogeneous in terms of the distribution of species in space, for the dominance of a species, a significant portion of the species is disperse.

Figure 4.120: Degree of aggregation in Morichal.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Vertical structure

For the analysis of the vertical structure of the Morichal the sociological position was determined also and the Ogawa diagram and the vegetation profile were built.

Sociological position

In order to define the sociological position of the Morichal the three strata were determined, dividing the difference of the maximum and minimum values reported in the trees inventory corresponding to 32 and 7 meters respectively, which allowed to establish a range of 8.3 meters in height for each stratum.

In the vertical stratification of this coverage, carried out for the analysis of sociological position, it is observed that 51.2% of the sampled individuals (192), is grouped in the lower stratum with heights between 7 and 15.3 meters, while 39.7% (149 individuals) is in the middle stratum with heights greater than 15.3 meters and less than or equal to 23.7 meters and the remaining 3.2% (34 individuals) is in the higher stratum with heights greater than 23.7 meters and less than or equal to 32 meters (see Table 4.62). This suggests that the Morichal is formed predominantly by individuals of medium-low bearing with some emergent trees.

Table 4.62: Vertical stratification in Morichal.

STRATUM	HEIGHT RANGE (m)	NUMBER OF INDIVIDUALS	% INDIVIDUALS
Lower stratum	7 - 15,3	192	51,2
Middle stratum	> 15,3 - 23,7	149	39,7
Higher stratum	> 23,7 - 32	34	9,1
TOTAL		**375**	**100,0**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

With the strata defined, the phytosociological value was determined for each one and the absolute and relative sociological position value for each species was obtained as shown in Table 4.63.

Table 4.63: Sociological position in Morichal.

SPECIES	COMMON NAME	CT1	CT2	CT3	Total	Lower stratum	Middle stratum	Higher stratum	Psa	Ps%
Alchornea discolor	Algodoncillo		1		1	0,0	0,4	0,0	0,4	0,2
Brosimum lactescens	Guáimaro	1			1	0,5	0,0	0,0	0,5	0,3
Calophyllum brasiliense	Cachicamo	16	16		32	8,2	6,4	0,0	14,5	9,1
Caraipa llanorum	Saladillo rojo	23	6		29	11,8	2,4	0,0	14,2	8,8
Cecropia peltata	Guarumo	1	1		2	0,5	0,4	0,0	0,9	0,6
Dendropanax arboreus	Mantequillo	7	1		8	3,6	0,4	0,0	4,0	2,5
Diospyros sericea	Carbonero		1		1	0,0	0,4	0,0	0,4	0,2
Duroia micrantha	Turmemico		1		1	0,0	0,4	0,0	0,4	0,2
Endlicheria verticillata	Amarillo	1			1	0,5	0,0	0,0	0,5	0,3
Eschweilera parvifolia	Coco de mono	2			2	1,0	0,0	0,0	1,0	0,6
Euterpe precatoria	Manaco	10	38	2	50	5,1	15,1	0,2	20,4	12,7
Garcinia madruno	Madroño	1			1	0,5	0,0	0,0	0,5	0,3
Guatteria schomburgkiana	Majagüillo negro	2	5		7	1,0	2,0	0,0	3,0	1,9
Hirtella elongata	Garrapato	2			2	1,0	0,0	0,0	1,0	0,6
Hydrochorea corymbosa	Dormilón	3			3	1,5	0,0	0,0	1,5	1,0
Mahurea exstipulata	Caucho amarillo	14	1		15	7,2	0,4	0,0	7,6	4,7
Malouetia virescens	Palo de boya	1	1		2	0,5	0,4	0,0	0,9	0,6
Maquira coriacea	Lechero	2			2	1,0	0,0	0,0	1,0	0,6
Mauritia flexuosa	Moriche	61	59	30	150	31,2	23,4	2,7	57,4	35,7
Myrcia subsessilis	Arrayán	1			1	0,5	0,0	0,0	0,5	0,3
Pachira sessilis	Ceiba paquira	1			1	0,5	0,0	0,0	0,5	0,3
Parahancornia oblonga	Pendare	2	2		4	1,0	0,8	0,0	1,8	1,1
Protium glabrescens	Anime	31	7		38	15,9	2,8	0,0	18,7	11,6
Quiina macrophylla	Guayacán	1			1	0,5	0,0	0,0	0,5	0,3
Symphonia globulifera	Breo	2	1		3	1,0	0,4	0,0	1,4	0,9

SPECIES	COMMON NAME	CT1	CT2	CT3	Total	Lower stratum	Middle stratum	Higher stratum	Psa	Ps%
Tapirira guianensis	Guarupayo	3			3	1,5	0,0	0,0	1,5	1,0
Virola carinata	Carnevaca blanco	3	1	2	6	1,5	0,4	0,2	2,1	1,3
Virola parvifolia	Carnevaca	1	5		6	0,5	2,0	0,0	2,5	1,6
Vismia macrophylla	Punta de lanza		1		1	0,0	0,4	0,0	0,4	0,2
Xylopia emarginata	Majagüillo		1		1	0,0	0,4	0,0	0,4	0,2
Total general		**192**	**149**	**34**	**375**				**160,6**	**100,0**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

The analysis of the absolute sociological position (see Figure 4.120), shows for the Morichal the species: *Mauritia flexuosa* (Moriche) as the most representative, which appears in all the forest strata and assures its place in the vertical structure, with a net value of 57.4 equivalent to 35.7% of the total; other species with some significance are: *Euterpe precatoria* (Manaco), *Protium glabrescens* (Anime), *Calophyllum brasiliense* (Cachicamo) and *Caraipa llanorum* (Saladillo rojo), with net values between 20.4 and 14.2 equivalent to relative values between 12.7 and 8.8%. The other species show values lower than 5% of this relative parameter. In general terms the high representation of a species in the sociological position, suggests a tendency to homogeneity of this coverage in this parameter.

The identification of the species of the arboreal individuals, was carried out according to the Classification System APG III, taking into account the knowledge of the specialist in charge of the respective forest inventory, analyzing the main taxonomic characteristics of the individual to be inventoried, besides the help of the field guides (for obtaining common names); in cases where it was not possible the field identification, the collection of the botanic sample was carried out (see Figure 4.121), to accomplish its identification with the help of specialized professionals and through dichotomous keys and herbaria consultation.

Figure 4.121: Collection of botanical samples during the development of the floristic inventory.

Source: (Universidad Distrital Francisco José De Caldas, 2017)

- ***INFORMATION PROCESSING PHASE***

Once obtained the information of the plots, entered in the field forms and the final determination of species, we proceeded to elaborate the database for each coverage, under the platform Microsoft Excel© and the respective calculations were made, in this way we proceeded to the analysis of composition, structure and diversity of each coverage inventoried. This information articulates with the established parameters by the terms of reference and by the technical Guides for the ordering and the sustainable management of natural forests of the Ministry of Environment1 today Ministry of Environment and Sustainable Development, implemented for environmental studies in Colombia.

The parameters determined for the characterization of the vegetable coverages are described below:

Statistical analysis

To give statistical validity and representativeness to the forest inventory, the statistical analysis of the information collected in the field was made, through the use of the variable total volume, determining a sampling error no greater than 15% and a probability level of 95. The statistical parameters used are shown in Table 4.64.

Table 4.64: Statistical Parameters used.

PARAMETER	EQUATIONS
Average volume	$\overline{X} = \frac{\sum x}{n}$
Standard deviation st	$SX = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{N-1}}$
Variation coefficient	$CV = \frac{SX}{X} \times 100\%$
Standard error	$EX = \frac{S}{\sqrt{n}}$
Sampling error with probability 95%	$Em_{0.05} = EX\% \times t$
Sampling error	$Em\% = EX \ / \bar{X} \times 100$

Floristic composition

The analysis of the floristic composition is made through the elaboration of databases for each type of vegetable coverage inventoried, where the list of species is made with its taxonomic classification listing information on family, gender, common name and scientific name of each species and including the author of each one of these.

Horizontal structure

The analysis of the horizontal structure consists of determining quantitatively the behaviour of the individuals on the ground surface and it is analyzed from the frequency, basal area or dominance, abundance and the importance value index. It is complemented with the degree of aggregation of the species.

Absolute abundance

It is the number of trees by species accounted for in the inventory.

Relative abundance

It indicates the percentage of participation of each species, referred to the number of total trees found. It is expressed as a percentage and is defined as the relationship between the number of trees of each species and the total number of individuals found in the sampling.

$$\mathbf{AR} = \left(\frac{\mathbf{Aa}}{\mathbf{At}}\right) * \mathbf{100}$$

Aa = number of individuals by species in the sampled area
At = total number of individuals in the sampled area

Absolute frequency

It is the presence-absence of a given species in a plot. It is calculated as the percentage ratio corresponding to the number of plots in which a species occurs, between the total number of plots.

$$\mathbf{Fa} = \frac{\mathbf{U}}{\mathbf{T}} * \mathbf{100}$$

U = number of sampling units in which a species occurs
T = total number of sampling units.

Relative frequency

It is the percentage of the absolute frequency of a species in relation to the sum of the absolute frequencies of the species present.

$$\mathbf{FR} = \frac{\mathbf{Fa}}{\mathbf{Ft}} * \mathbf{100}$$

Fa = Absolute frequency
Ft = Sum of the absolute frequencies

According to the absolute frequency, to perform the frequency histogram, the species are grouped in the following classes:

I	Fa=1-20Very rare.	
II	Fa=20,1-40	Infrequent.
III	Fa=40,1-60	Frequent.
IV	Fa=60,1-80	Quite frequent.
V	Fa=80,1-100	Very frequent.

Absolute dominance

Also called the degree of coverage of the species, which is the expression of the space occupied by them. It is defined as the sum of the horizontal projections of the trees on the ground. Due to the complex vertical structure of the tropical forests, on occasions its determination becomes impossible, for this reason, the basal areas are used as substitutes for the true dominance values. This process is justified due to the high linear correlation between the cup diameter and the stem diameter for a particular species.

$$\mathbf{DA} = \mathbf{\Sigma}[\left(\frac{\boldsymbol{\pi}}{\mathbf{4}}\right) * \mathbf{DAP^2}\ ]$$

π = 3.141593
DAP = Diameter at chest height.

Relative dominance

It is calculated as the proportion of a species in the total evaluated area, expressed as a percentage.

$$\mathbf{DR} = \left(\frac{\mathbf{DA}}{\mathbf{At}}\right) * \mathbf{100}$$

DA = Absolute dominance of each species
At = Total basal area in the sampled area.

Importance value index (IVI)

This index is given by the sum of the parameters expressed in percentage of the abundance, frequency and relative dominance and is used to perform descriptive and quantitative studies of the structures of the types of forests. The maximum value of the IVI is 300 and is reached in strata presenting a single species. This index also allows to deduce aspects such as dynamism, dominance and representativeness of the species.

$$\mathbf{I.V.I} = \mathbf{AR} + \mathbf{FR} + \mathbf{DR}$$

Degree of aggregation

The degree of aggregation is a variable that indicates the extent to which the individuals that make up a certain coverage tend to group; its value always moves in three ranges. The interpretation of the degree of aggregation is made taking into account that if its value is less than one (1) the species is dispersed in the coverage. If, on the contrary, values greater than or equal to two (2) are obtained, it reflects a grouped distribution, whereas values between one (1) and two (2) indicate a tendency to group the species. These parameters can be summarized as follows:

GA ≥ a 1 y < 2, indicates a tendency to group.
GA ≥ a 2, indicates that the species has a grouped distribution.
GA< a 1, indicates that the species is dispersed.

It determines the spatial distribution of the species, being the mathematical expression of the observed density with respect to the expected density.

Ga = Do / De

Where:
Do = Observed density: Total number of trees per species / Total number of plots sampled.
De = Expected density: -Ln (1-F/100)
F = Absolute frequency
Ln = Natural or Neperian logarithm (e base).

Vertical structure

The vertical structure is analyzed according to the height, differentiating strata, according to qualitative or quantitative profiles in relation to the total height and height at the base of the cup (also called commercial height). To analyze the vertical structure, the arboreal strata are defined: higher (Es), medium (Em) and lower (Ei), depending on the maximum and minimum height or with preset ranges.

Ogwa Diagram

This is a quantitative method of describing the vegetation, used to detect the presence of strata, tailoring a graph with the total heights in the ordinates and the heights to the base of the cup on the abscissa; the appearance of swarms of more or less isolated points indicates the virtual void of the cups at intermediate levels, suggesting a number of differential strata in the profile of the forest; when a single elongated cloud of points and with a positive slope is generated, no strata can be differentiated, since there is continuity of points from the understory to the canopy.

Vegetation profile

The vegetation profile comprises a qualitative method of evaluating the vertical structure, to illustrate structural aspects of the forest such as: height, coverage, form of cups, strata and vertical spacing. During the field work in the capture of information, a “type” sampling unit is made for the forest in which it is registered for trees, besides the information already mentioned, the location of the trees with respect to the plot axis and the form and size of the cups, in order to establish their position in the plot space. With this, we proceed to locate them in a Cartesian plane and a schematic design of each species is made to provide a synthesized example of its shaft, foliage, color and type of cup. With these inputs and using the information originating of the forest inventory, specifically the DAP, the commercial height and the total height of each individual, they are located in the horizontal and vertical plane and, in this way, the vegetable profile is created. For a better understanding of the way the trees are distributed on the plot, is used the location of each individual and an orthogonal view of the “type” sampling unit is made.

Sociological position

It indicates the importance value of the species for the different strata that make up the forest; it can be said then that a certain species has a place assured in the floristic structure and composition when it is present in all the strata.
It is contemplated to divide the sampled population in three strata for which it is necessary to calculate the difference between the extreme values of the height variable, that is to say the value of the individual with greatest height minus the value of the individual with lesser height. A phytosociological value is assigned to each sub-stratum, dividing the number of individuals in each sub-stratum by the number of individuals of all species.

$$\mathbf{VF} = \frac{\mathbf{n}}{\mathbf{N}}$$

VF = Phytosociological Value
n = Number of individuals of the sub-stratum
N = Total number of individuals of all species

To calculate the absolute value of the sociological position of a species, its phytosociological values in each sub-stratum are added, effecting the product of the phytosociological value of the considered stratum times the number of individuals of the species in that same stratum.

$$\mathbf{PSa = VF(i) * n(i) \ + \ VF(m) * n(m) + \ VF(s) * n(s)}$$

PSa = Absolute Sociological Position of the species
VF = Phytosociological value of the sub-stratum
n = N° of Individuals of each species
i = lower
m = medium
s = higher

The sociological position of each species is expressed as a percentage over the total sum of the absolute values:

$$\mathbf{PS\% = PSa/\Sigma PSa}$$

Basal area and volume calculation

Basal area

It is defined as the surface of a cross section of the stem or trunk of the individual at a certain height from the ground; it is expressed in cm2 or m2.

$$\mathbf{AB = \frac{\pi}{4} \times (DAP)^2}$$

Volume

This parameter is the most important result of the forest inventory, as an indicator of the potential or production capacity of the vegetable coverage analyzed; the volume obtained refers to trees standing and is calculated on the basis of the DAP, the height and the form factor. In a forest inventory, it can be expressed as volume per area unit and total volume of the inventoried area in the form of total and commercial volume; the most used method is the application of the conventional volume equation:

$$V = \frac{3.1416 * d^2}{4} * h * f$$

Where:
V = Tree volume
d = Diameter at chest height squared
h = Height of the shaft
f = Form factor

According to Posada (1989) and the FAO (1974), the form factor to be used for hardwood species of the tropics, according to the tests carried out is 0.7.

Distribution by class intervals

In a general way, an altimetric distribution is the result of grouping the trees of a forest within certain categories, according to the maximum and minimum values of each parameter and with the number of individuals, the class intervals or categories are established in the following way:

$$\mathbf{C = (X\,max - X\,min)/M}$$
$$\mathbf{M = 1 + 3.3\ (Log10\ (n))}$$

n: total number of individuals of the group
M: number of intervals

For the diameter classes, a distribution by class is made and the shafts are classified in different ranges with a class amplitude of 10 cm.

Floristic diversity

Biological diversity refers to the variety and abundance of species, their genetic composition and the communities, ecosystems and landscapes in which they occur; it also refers to the ecological structures, functions and processes at all these levels. The richness is defined as the number of taxa that typify a locality, region or plot. The information on the number of species present is used to determine the richness, through the application of the mix ratio (CM) and the species richness indexes of Margalef[37] and Menhinick[38]; Shannon's structural index of diversity and Simpson's equity index are also estimated.

Mix ratio

It measures the mix intensity in natural forests. To this end the number of species found is divided by the total number of trees, obtaining a figure that represents the average of individuals of each species within the association.

$$\mathbf{CM} = \left(\frac{\mathbf{Ns}}{\mathbf{Na}}\right) * \mathbf{100}$$

Ns= Number of species
Na= Number of trees

CM = 1, is the highest value of this ratio, which means that each new individual is a new species for the inventory, but in turn determines the homogeneity or heterogeneity of the forest. By exchanging the numerator with the denominator, it is possible to interpret how many individuals it is necessary to inventory to find a new species in the inventory.

Margalef Index

This index transforms the number of species per sample to a proportion at which species are added by sample expansion. It assumes that there is a functional relationship between the number of species and the total number of individuals S=k√N where k is constant. If this does not hold, then the index varies with the sample size in an unknown way. Using S–1, instead of S, gives DMg = 0 when there is only one species.

$$\mathbf{DMg = S - 1/\ln N}$$

S = number of species
N = total number of individuals

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[37] (Margalef, 1995)
[38] (Menhinick, 1964)

Values lower than 2.0 are related to low diversity zones (generally the result of anthropogenic effects) and values higher than 5.0 are considered as indicative of high biodiversity.

Shannon-Wiener Index

To measure the richness or variety of species, the Shannon index is used, a mathematical expression that relates the number of species to the number of individuals in a given community. This index also assumes that all species are represented in the sample and is also a measure of the diversity or richness in species of a given population; in this case, the maximum value is equal to LN(S), where S is the total number of individuals. The Shannon diversity index allows to calculate the sum of probabilities of the species and the homogeneity of the distribution for a number of species.

$$\mathbf{H} = \sum (\mathbf{pi\ x\ ln\ pi})$$

pi = Abundance of each one of the species (ni/N).
ni= Number of individuals sampled for the species i.
N = Total number of individuals sampled.
ln = Neperian logarithm.

This index allows to calculate the sum of probabilities of the species and the homogeneity of the distribution for a number of species. It is usually found to fall between 1.5 and 3.5 and only rarely exceeds 4.5.

Simpson Index

It shows the probability that two individuals taken at random from a sample are of the same species. It is strongly influenced by the importance of the most dominant species.

$$\lambda = \Sigma p_i^{\,2}$$

pi= proportional abundance of species i, that is, the number of individuals of species i divided by the total number of individuals of the sample.

The Simpson index measures the degree of concentration and varies between 0 and 1; when the diversity is low it tends to 1. For the interpretation of this index, the numerical values are expressed in reciprocal form (1 / λ), in this way they are directly proportional to the diversity.

Natural regeneration

For the analysis of the natural regeneration of the forest, the variables and methodologies previously described for the characterization of trees in the aspect of horizontal structure were used, that is, floristic composition, abundance and frequency calculation, with the respective relative analysis (%) of these variables.

Endangered, banned, endemic and trade restricted species

In order to determine the vascular flora species of interest for the area of study, either because they are in critical danger or threatened, the Red Books of Colombian plants, the Red List of the International Union for the Conservation of Nature and the Resolution 0192 of 2015 of the Ministry of Environment and Sustainable

Development, by which the listing of endangered wild species of the Colombian biological diversity found in the national territory is established, were reviewed. Those species over which may exist some kind of restriction for their commercialization and those that have some kind of national or regional ban, were determined, from the review of the Annexes CITES and the resolutions issued by the former INDERENA, the Ministry of Environment and Sustainable Development and by Corporinoquia, about banned species. Additionally, endemics of the area were searched for, through available taxonomic revision for each one of the groups found, mainly of Colombian Flora, Neotropic Flora, in articles, specialized pages and virtual herbaria.

4.3.1.4 Results of the sampling phase

- ***FLORISTIC AND STRUCTURAL ANALYSIS OF THE NATURAL VEGETABLE COVERAGES.***

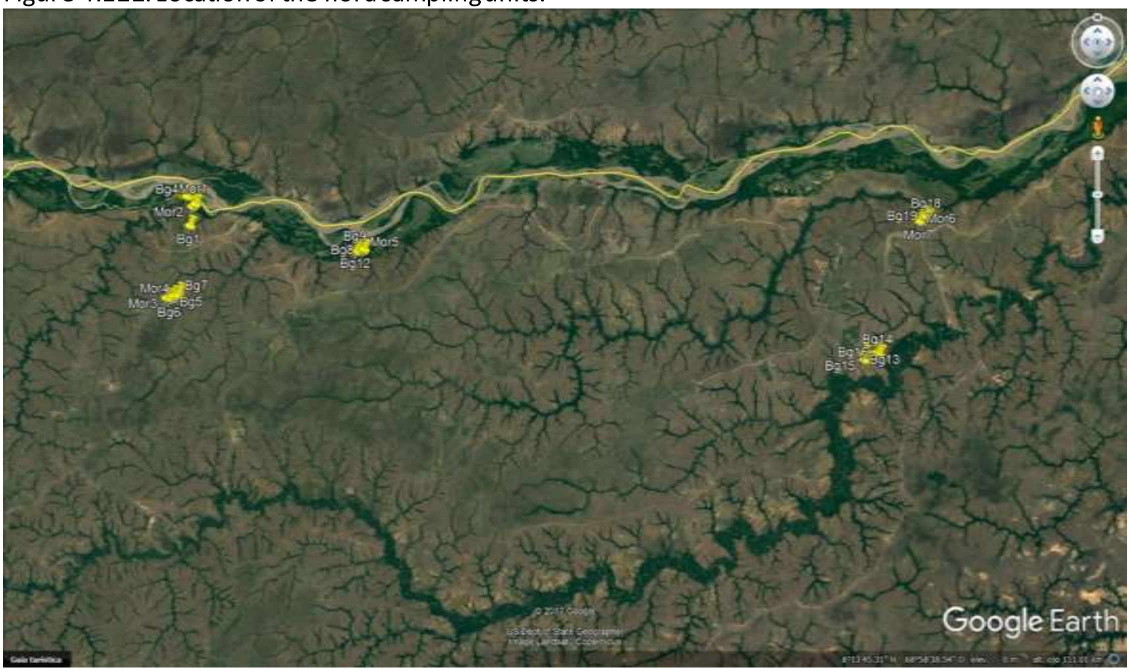
The wild flora in the area of study is conditioned by historic natural processes like periodic fires and localized edaphic and hydric characteristics, but also by the action of man specially in the last century with developments of colonization and agricultural activities, which together have relegated the vegetation to small relicts associated with water bodies.

Two natural plant coverings of arboreal size (Forests) were determined for the area, according to the classification of the hierarchical type methodology CORINE Land Cover adapted for Colombia (IDEAM 2010), corresponding to Forest of Gallery and Palmares (Morichales). These coverings are found associated with water bodies like rivers, spouts, lagoons and abandoned meanders of the rivers (madreviejas), and intermingle in elongated forms in a matrix of natural grasslands composed of grass and some shrubs in a dispersed form.

Despite being in reduced areas and with constant alteration, these forests represent an important genetic reservoir of the regional flora and provide an innumerable amount of ecosystem services, such as refuge and wildlife habitat, hydric regulation, erosion control, among many others.

The forest inventory was made on the coverages of Gallery Forest and Morichal in a total of 28 sampling units (plots), in the five sectors determined for that end. The location of the plots in the area is shown in Figure 4.122.

Figure 4.122: Location of the flora sampling units.



Source: Available satellite images coming from the remote sensor Digitalglobe. Google Earth.

Next, the characterization of each of the aforementioned natural plant coverings is described, with the information obtained in the forest inventory.

- **Gallery Forest.**

The information necessary for the characterization of the gallery forests in the area of influence of the project was taken through the field survey of 21 sampling units of 0.1 hectares each, in the five sampling zones determined, for a total sampled area of 2.1 hectares; These sampling plots were georeferenced in the geographic coordinates system WGS84 both at the initial and final points, as shown in Table 4.65.

Table 4.65: Location data of the parcels surveyed in gallery forest.

CODE	START POINT		FINAL POINT	
	X	Y	X	Y
Bg1	917713,827515	1168850,5071	917753,929123	1168942,61525
Bg2	916497,840332	1172237,68773	916599,308226	1172237,54461
Bg3	916850,94563	1172183,28076	916906,186681	1172266,1506
Bg4	917434,043404	1172163,331	917333,632108	1172153,56662
Bg5	915884,801603	1160859,44276	915882,007215	1160761,23706
Bg6	915527,985252	1160553,03735	915591,648765	1160476,19412
Bg7	916457,070236	1161252,1471	916442,343555	1161153,54022
Bg8	937497,507667	1165990,9575	937573,516354	1166056,85243
Bg9	936759,676847	1165927,2222	936666,493984	1165893,5289
Bg10	936356,848242	1165921,88706	936455,256312	1165930,61738
Bg11	936285,845607	1165731,11709	936215,271263	1165802,93006
Bg12	936802,648399	1166096,81307	936863,451039	1166019,27262
Bg13	994600,423331	1154303,88903	994575,811642	1154208,66393
Bg14	996356,489589	1154242,32144	996362,635062	1154144,02205
Bg15	994686,474936	1153609,64456	994591,13866	1153643,44319
Bg16	996164,81548	1154417,42832	996218,074862	1154503,43665
Bg17	995826,916162	1154469,67203	995910,564581	1154417,4449
Bg18	1001940,97626	1169647,57939	1001913,3014	1169742,80613
Bg19	1001796,46122	1169856,4612	1001728,81728	1169930,18387
Bg20	1001587,37887	1170126,77898	1001532,03368	1170206,64586
Bg21	1001292,21706	1170089,90953	1001276,84596	1169991,60967

Source: (Universidad Distrital Francisco José De Caldas, 2017). Flat coordinates Magna Colombia Este Este

For the gallery forest coverage, a relative sampling error lower than 15% was achieved, and with a probability of 95%. Table 4.66 shows the different statisticians calculated for this coverage from the variable total volume, with which a sampling error for this coverage in the inventory of 10,9% was determined.

Table 4.66: Statisticians for the gallery forest.

STATISTICIAN	VALUE
Sum	497,47
Average	23,69

STATISTICIAN	VALUE
Standard deviation	6,86
Variation coefficient (%)	21,97
Relative error required (%)	15
Sample size (n)	21
Student t variable degrees of freedom (n – 1), probability 95%	1,72
Standard error	1,50
Absolute error	2,58
Relative error%	**10,90**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Floristic composition

In the analysis of the floristic composition for the trees of the gallery forest, 944 individuals were found distributed in 42 families, 88 genders and 109 species. At a specific level the families Leguminosae with 16 species, Chrysobalanaceae with 6 species and Lauraceae y Moraceae with 5 species each one stand out; at a genders level *Licania* with 4 species, followed by *Protium* and *Virola* with 3 species each one stand out, as shown in Table 4.67.

Table 4.67: Floristic Composition of trees in gallery forest.

FAMILY	GENDER	SPECIES	COMMON NAME	ABUN.
Anacardiaceae	*Astronium*	*Astronium graveolens* Jacq.	Abejón	1
	Tapirira	*Tapirira guianensis* Aubl.	Guarupayo	26
Annonaceae	*Guatteria*	*Guatteria metensis* R.E.Fr.	Majagüillo blanco	1
		Guatteria schomburgkiana Mart.	Majagüillo negro	52
	Xylopia	*Xylopia aromatica* (Lam.) Mart.	Malagueto	10
		Xylopia emarginata Mart.	Majagüillo	1
Apocynaceae	*Aspidosperma*	*Aspidosperma desmanthum* Benth. ex Müll.Arg.	Costillo	1
		Aspidosperma excelsum Benth.	Costillo blanco	2
	Himatanthus	*Himatanthus articulatus* (Vahl) Woodson	Platanote	25
	Parahancornia	*Parahancornia oblonga* (Benth. ex Müll.Arg.) Monach.	Pendare	10
Araliaceae	*Dendropanax*	*Dendropanax arboreus* (L.) Decne. & Planch.	Mantequillo	5
	Schefflera	*Schefflera morototoni* (Aubl.) Maguire, Steyerm. & Frodin	Tortolito	11
Arecaceae	*Attalea*	*Attalea maripa* (Aubl.) Mart.	Cucurita	7
	Euterpe	*Euterpe precatoria* Mart.	Manaco	83
	Mauritia	*Mauritia flexuosa* L.f.	Moriche	22
	Oenocarpus	*Oenocarpus bacaba* Mart.	Maporilla	5
	Socratea	*Socratea exorrhiza* (Mart.) H.Wendl.	Choapo	9
Bignoniaceae	*Jacaranda*	*Jacaranda copaia* (Aubl.) D.Don	Pavito	7

FAMILY	GENDER	SPECIES	COMMON NAME	ABUN.
		Jacaranda obtusifolia Bonpl.	Gualanday	7
Bixaceae	*Cochlospermum*	*Cochlospermum orinocense* (Kunth) Steud.	Bototo	4
		Cochlospermum vitifolium (Willd.) Spreng.	Bototo	1
Boraginaceae	*Cordia*	*Cordia sericicalyx* A.DC.	Palo de agua	3
Burseraceae	*Protium*	*Protium glabrescens* Swart	Anime	24
		Protium heptaphyllum (Aubl.) Marchand	Anime	65
		Protium llanorum Cuatrec.	Anime	1
	Tetragastris	*Tetragastris panamensis* (Engl.) Kuntze	Caraño blanco	9
Calophyllaceae	*Caraipa*	*Caraipa llanorum* Cuatrec.	Saladillo rojo	93
	Mahurea	*Mahurea exstipulata* Benth.	Caucho amarillo	4
Chrysobalanaceae	*Hirtella*	*Hirtella elongata* Mart. & Zucc.	Garrapato	11
	Licania	*Licania hypoleuca* Benth.	Escobo blanco	1
		Licania leucosepala Griseb.	Aceituno	14
		Licania parvifructa Fanshawe & Maguire	Escobo colorado	4
		Licania subarachnophylla Cuatrec.	Escobo	1
	Parinari	*Parinari pachyphylla* Rusby	Escobo	13
Clusiaceae	*Calophyllum*	*Calophyllum brasiliense* Cambess.	Cachicamo	28
	Garcinia	*Garcinia madruno* (Kunth) Hammel	Madroño	2
	Symphonia	*Symphonia globulifera* L.f.	Breo	9
Connaraceae	*Connarus*	*Connarus lambertii* (DC.) Britton	Sangrito	4
Dichapetalaceae	*Stephanopodium*	*Stephanopodium* sp.	Naranjo	1
Dilleniaceae	*Curatella*	*Curatella americana* L.	Chaparro	1
Ebenaceae	*Diospyros*	*Diospyros sericea* A.DC.	Carbonero	22
Erythroxylaceae	*Erythroxylum*	*Erythroxylum macrophyllum* Cav.	Ajicito	2
Euphorbiaceae	*Alchornea*	*Alchornea discolor* Poepp.	Algodoncillo	4
		Alchornea triplinervia (Spreng.) Müll.Arg.	Carnegallina	2
	Mabea	*Mabea trianae* Pax	Canilla de venado	11
Humiriaceae	*Sacoglottis*	*Sacoglottis guianensis* Benth.	Fierrito	29
Hypericaceae	*Vismia*	*Vismia baccifera* (L.) Planch. & Triana	Lacre blanco	4
		Vismia macrophylla Kunth	Punta de lanza	4
Lacistemataceae	*Lacistema*	*Lacistema aggregatum* (P.J.Bergius) Rusby	Laurel rosado	1
Lamiaceae	*Vitex*	*Vitex orinocensis* Kunth	Guarataro	2
Lauraceae	*Aniba*	*Aniba panurensis* (Meisn.) Mez	Yema de huevo	5
	Licaria	*Licaria canella* (Meisn.) Kosterm.	Amarillo	1
	Nectandra	*Nectandra cuspidata* Nees & Mart.	Laurel sabanero	2

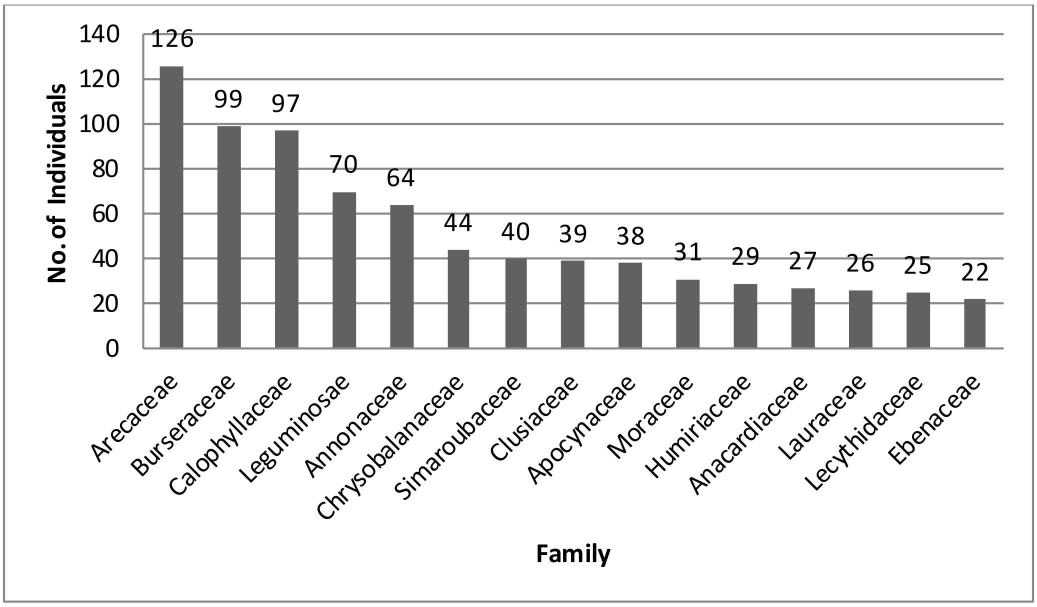
FAMILY	GENDER	SPECIES	COMMON NAME	ABUN.
	Ocotea	*Ocotea bofo* Kunth	Laurel	14
		Ocotea longifolia Kunth	Laurel matatigre	4
Lecythidaceae	*Eschweilera*	*Eschweilera parvifolia* Mart. ex DC.	Coco de mono	12
		Eschweilera tenuifolia (O.Berg) Miers	Copo	13
Leguminosae	*Albizia*	*Albizia lebbeck* (L.) Benth.	Menudito	11
	Andira	*Andira surinamensis* (Bondt) Pulle	Arenoso	3
	Campsiandra	*Campsiandra comosa* Benth.	Chigo	4
	Copaifera	*Copaifera pubiflora* Benth.	Aceite	7
	Crudia	*Crudia oblonga* Benth.	Cascarillo	3
	Dipteryx	*Dipteryx punctata* (S.F.Blake) Amshoff	Sarrapio	8
	Enterolobium	*Enterolobium schomburgkii* (Benth.) Benth.	Dormidero	1
	Heterostemon	*Heterostemon conjugatus* Benth.	Guamita	1
	Hydrochorea	*Hydrochorea corymbosa* (Rich.) Barneby & J.W.Grimes	Dormilón	5
	Hymenaea	*Hymenaea courbaril* L.	Algarrobo	2
	Inga	*Inga cylindrica* (Vell.) Mart.	Guamo	5
	Lonchocarpus	*Lonchocarpus floribundus* Benth.	Matarratón	2
	Sclerolobium	*Sclerolobium melanocarpum* Ducke	Pategarza	14
	Senna	*Senna silvestris* (Vell.) H.S.Irwin & Barneby	Alcaparillo	1
	Swartzia	*Swartzia leptopetala* Benth.	Sangretoro	2
	Zygia	*Zygia inaequalis* (Willd.) Pittier	Cimbrapotro	1
Linaceae	*Hebepetalum*	*Hebepetalum* sp.	Colorado	5
Melastomataceae	*Bellucia*	*Bellucia grossularioides* (L.) Triana	Níspero	4
Moraceae	*Brosimum*	*Brosimum lactescens* (S.Moore) C.C.Berg	Guáimaro	25
	Ficus	*Ficus americana* Aubl.	Matapalo	1
		Ficus mathewsii (Miq.) Miq.	Matapalo	2
	Maquira	*Maquira coriacea* (H.Karst.) C.C.Berg	Lechero	2
	Perebea	*Perebea xanthochyma* H.Karst.	Cauchillo	1
Myristicaceae	*Virola*	*Virola carinata* (Spruce ex Benth.) Warb.	Carnevaca blanco	3
		Virola elongata (Benth.) Warb.	Carnevaca	8
		Virola parvifolia Ducke	Carnevaca	3
Myrtaceae	*Myrcia*	*Myrcia paivae* O.Berg	Arrayán	1
		Myrcia subsessilis O.Berg	Arrayán	14
	Myrciaria	*Myrciaria floribunda* (H.West ex Willd.) O.Berg	Guayabo montañero	1
Ochnaceae	*Ouratea*	*Ouratea castaneifolia* (DC.) Engl.	Lengua de yataro	1
		Ouratea polyantha (Triana & Planch.) Engl.	Coralito	1
	Quiina	*Quiina macrophylla* Tul.	Guayacán	1
Peraceae	*Pera*	*Pera arborea* Mutis	Pategallina	3

FAMILY	GENDER	SPECIES	COMMON NAME	ABUN.
Phyllanthaceae	*Phyllanthus*	*Phyllanthus attenuatus* Miq.	Totumito	3
	Richeria	*Richeria grandis* Vahl	Alcafeto	3
Picramniaceae	*Picramnia*	*Picramnia magnifolia* J.F.Macbr.	Quemacarate	1
Polygonaceae	*Coccoloba*	*Coccoloba mollis* Casar.	Uvero	4
	Ruprechtia	*Ruprechtia costata* Meisn.	Rascarrabio	1
Proteaceae	*Euplassa*	*Euplassa saxicola* (R.E.Schult.) Steyerm.	Yolombó	7
Rubiaceae	*Amaioua*	*Amaioua guianensis* Aubl.	Macanillo	4
	Elaeagia	*Elaeagia maguirei* Standl.	Marfil	1
	Genipa	*Genipa americana* L.	Caruto	1
Sapindaceae	*Cupania*	*Cupania scrobiculata* Rich.	Partemachete	1
	Matayba	*Matayba adenanthera* Radlk.	Patepajuil	7
		Matayba scrobiculata Radlk.	Patepajuil	4
	Vouarana	*Vouarana guianensis* Aubl.	Partemachete	1
Sapotaceae	*Micropholis*	*Micropholis guyanensis* (A.DC.) Pierre	Caimillo	1
	Pouteria	*Pouteria guianensis* Aubl.	Caimo	3
Simaroubaceae	*Simarouba*	*Simarouba amara* Aubl.	Simaruba	40
Strelitziaceae	*Phenakospermum*	*Phenakospermum guyannense* (A.Rich.) Endl. ex Miq.	Tarriago	3
Vochysiaceae	*Vochysia*	*Vochysia ferruginea* Mart.	Botagajo	1
		Vochysia lehmannii Hieron.	Saladillo blanco	2
General total				**944**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

In the analysis of absolute abundance per family in the gallery forest, the most representative are: Arecaceae, Burseraceae, Calophyllaceae, Leguminosae and Annonaceae with values between 126 and 64 individuals, which is equivalent to relative values of between 13.3 and 6.8 of abundance; the other families show values lower than 5% for this parameter (see Figure 4.123).

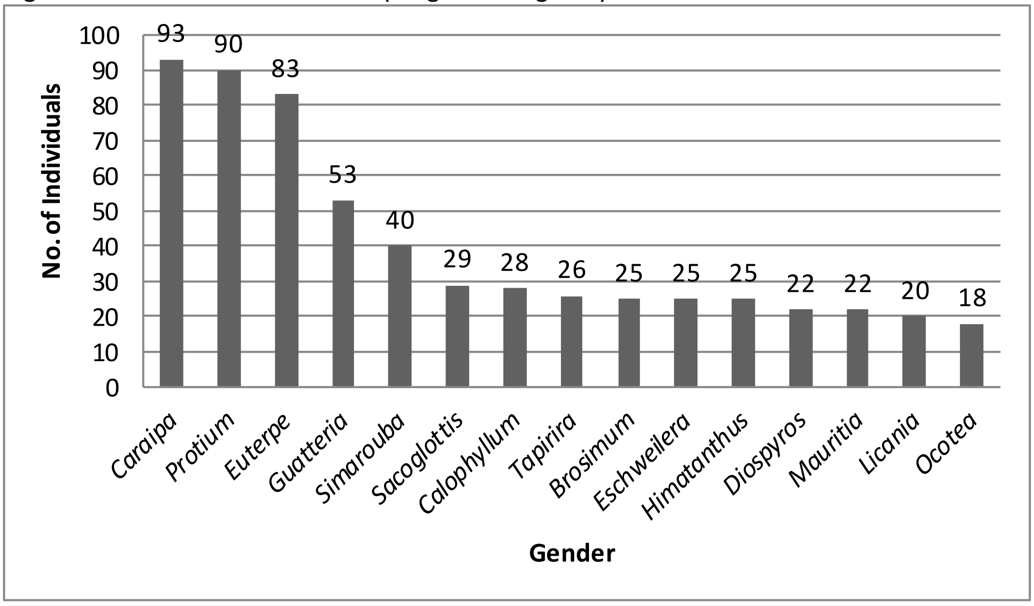
Figure 4.123: Location of the flora sampling units.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

As for the abundance of individuals per gender (see Figure 4.124), *Caraipa*, *Protium* and *Euterpe*, appear as the most representative reporting absolute abundances of 93, 90 and 83 individuals respectively (between 9.9 and 8.8% of the total each one), appear with significative values as well: *Guatteria* with 53 individuals (5.6%) and *Simarouba*, with 40 individuals (4.2%), the other genders report less than 30 individuals (3% of the total abundance).

Figure 4.124: Absolute abundance per gender in gallery Forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

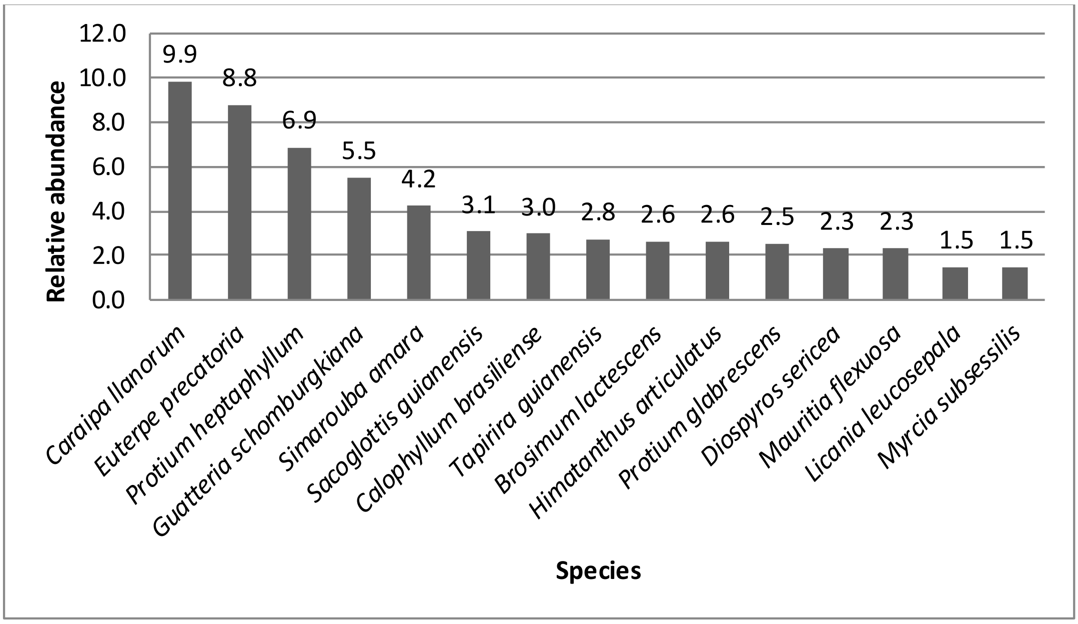
Horizontal Structure

For the characterization of the horizontal structure was used, the importance value index, which allows to determine the ecological weight of the species in the coverage under analysis and which is composed of the sum of the parameters of relative abundance, frequency and dominance; likewise the frequency histogram was built for the graphic representation of the proportion in which the species are distributed spatially and the degree of aggregation was determined.

Relative abundance

In the analysis of this parameter for the gallery forest, stand out the species: *Caraipa llanorum* (Saladillo rojo) with 9.9% (93 individuals), followed by *Euterpe precatoria* (Manaco) with 8.8% (83 individuals), *Protium heptaphyllum* (Anime) with 6.9% (65 individuals), *Guatteria schomburgkiana* (Majagüillo negro) with 5.5% (52 individuals) and *Simarouba amara* (Simaruba) with 4.2% (40 individuals); the other species report values lower than 4% of relative abundance (see Figure 4.125). This parameter allows to infer that the gallery forest tends to be heterogeneous in composition, in the absence of such marked abundances of one or several species.

Figure 4.125: Relative abundance in gallery Forest.

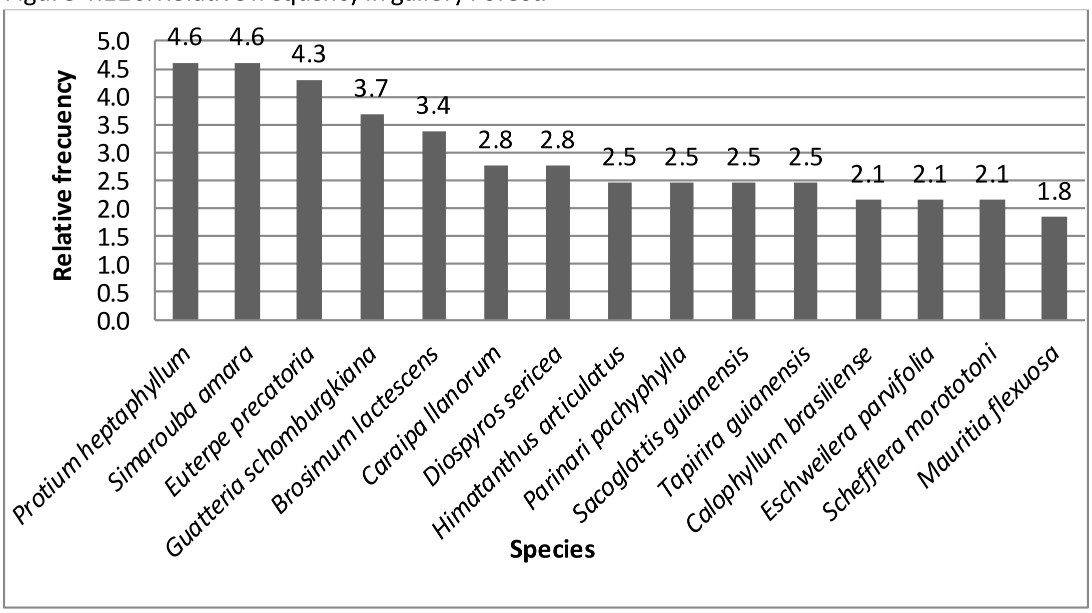


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Relative frequency

Just like for relative abundance, the parameter relative frequency shows a tendency of this coverage to be heterogeneous regarding the appearance of the species in the sampling units, nonetheless the most representative species in this parameter are: *Protium heptaphyllum* (Anime) and *Simarouba amara* (Simaruba) with 4.6% when reporting in 15 of the 21 surveyed plots, followed by *Euterpe precatoria* (Manaco) with 4.3% (report in 14 plots), *Guatteria schomburgkiana* (Majagüillo negro) with 3.7% (report in 12 plots) y *Brosimum lactescens* (Guáimaro) with 3,4% (report in 11 plots) the other species report less than 3% of the relative frequency (see Figure 4.126).

Figure 4.126: Relative frequency in gallery Forest.

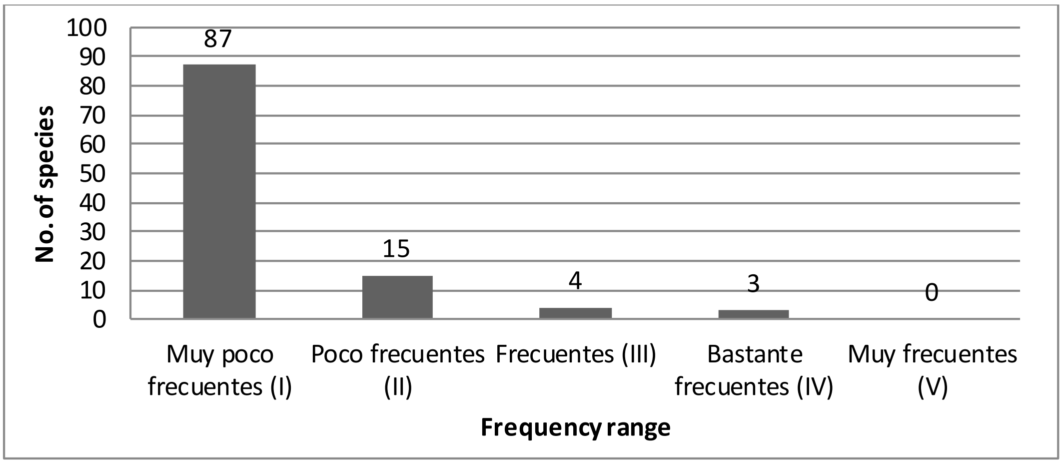


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Frequency histogram

The frequency histogram for the gallery forest, shows that the majority of the species fall in the category very rare, represented with 79.8% (87 species), followed by the category infrequent with13.8% (15 species), then the category frequent with 3.7% (four species) and last quite frequent with only 2.8% (three species). This confirms what was mentioned regarding the condition of heterogeneity of the coverage in terms of frequency of species and is a typical condition of this type of coverages (see Figure 4.127).

Figure 4.127: Frequency histogram for gallery Forest.

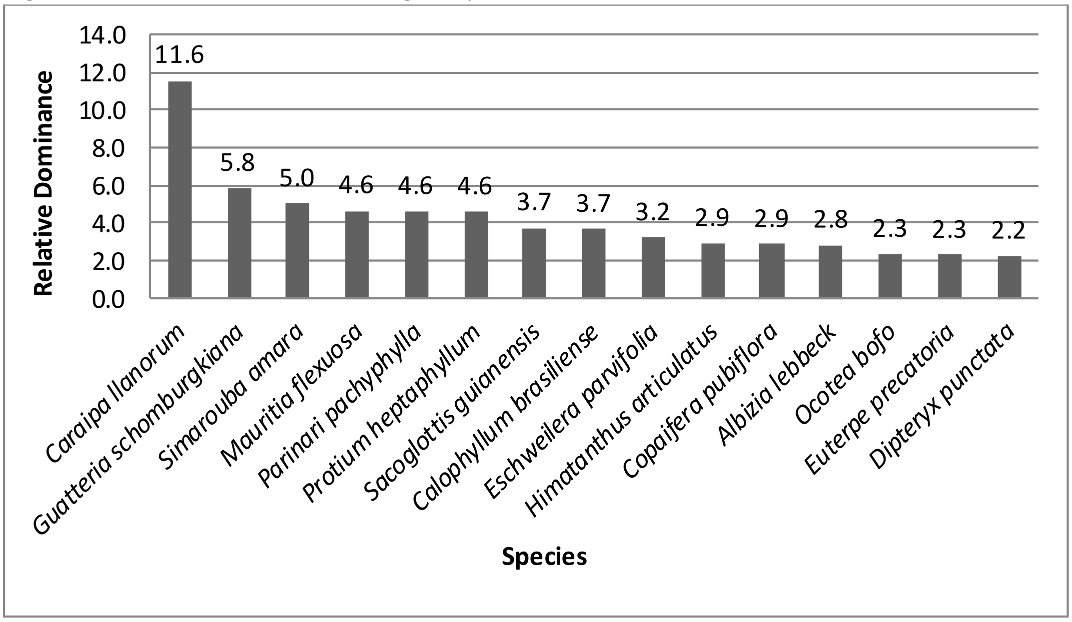


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Relative dominance

In the analysis of this parameter for the gallery forest, a species with a certain dominance is noticeable and corresponds to the species *Caraipa llanorum* (Saladillo rojo) with 11.6% of this parameter, while the other species show a uniform distribution of this parameter in the forest composition, with values lower than 6% (see Figure 4.128). This can be attributed to the abundance of the species and to the bearing of the trees in the coverage.

Figure 4.128: Relative dominance in gallery Forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Importance value index (IVI)

In Table 4.68 the values of abundance, dominance, frequency and importance value index are shown, for each one of the species found in the category of tree size in the gallery forest.

Table 4.68: Importance value index in gallery forest.

SPECIES	COMMON NAME	ABUND.	FREC.	DOM.	ABUN. %	FREC. %	DOM.%	IVI	IVI %
Albizia lebbeck	Menudito	11	4,8	1,1	1,2	0,3	2,8	4,3	1,4
Alchornea discolor	Algodoncillo	4	9,5	0,1	0,4	0,6	0,4	1,4	0,5
Alchornea triplinervia	Carnegallina	2	9,5	0,0	0,2	0,6	0,1	0,9	0,3
Amaioua guianensis	Macanillo	4	14,3	0,0	0,4	0,9	0,1	1,4	0,5
Andira surinamensis	Arenoso	3	14,3	0,2	0,3	0,9	0,4	1,7	0,6
Aniba panurensis	Yema de huevo	5	23,8	0,1	0,5	1,5	0,3	2,3	0,8
Aspidosperma desmanthum	Costillo	1	4,8	0,1	0,1	0,3	0,3	0,7	0,2
Aspidosperma excelsum	Costillo blanco	2	9,5	0,1	0,2	0,6	0,3	1,1	0,4
Astronium graveolens	Abejón	1	4,8	0,0	0,1	0,3	0,0	0,5	0,2
Attalea maripa	Cucurita	7	14,3	0,4	0,7	0,9	0,9	2,6	0,9
Bellucia grossularioides	Níspero	4	14,3	0,1	0,4	0,9	0,3	1,6	0,5
Brosimum lactescens	Guáimaro	25	52,4	0,7	2,6	3,4	1,9	7,9	2,6
Calophyllum brasiliense	Cachicamo	28	33,3	1,5	3,0	2,1	3,7	8,8	2,9
Campsiandra comosa	Chigo	4	9,5	0,4	0,4	0,6	1,0	2,0	0,7
Caraipa llanorum	Saladillo rojo	93	42,9	4,6	9,9	2,8	11,6	24,2	8,1
Coccoloba mollis	Uvero	4	9,5	0,2	0,4	0,6	0,5	1,5	0,5
Cochlospermum orinocense	Bototo	4	4,8	0,4	0,4	0,3	1,0	1,7	0,6
Cochlospermum vitifolium	Bototo	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Connarus lambertii	Sangrito	4	4,8	0,1	0,4	0,3	0,2	1,0	0,3
Copaifera pubiflora	Aceite	7	23,8	1,1	0,7	1,5	2,9	5,1	1,7
Cordia sericicalyx	Palo de agua	3	4,8	0,1	0,3	0,3	0,2	0,8	0,3
Crudia oblonga	Cascarillo	3	4,8	0,1	0,3	0,3	0,3	0,9	0,3
Cupania scrobiculata	Partemachete	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Curatella americana	Chaparro	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1

SPECIES	COMMON NAME	ABUND.	FREC.	DOM.	ABUN. %	FREC. %	DOM.%	IVI	IVI %
Dendropanax arboreus	Mantequillo	5	9,5	0,1	0,5	0,6	0,3	1,4	0,5
Diospyros sericea	Carbonero	22	42,9	0,5	2,3	2,8	1,3	6,3	2,1
Dipteryx punctata	Sarrapio	8	9,5	0,9	0,8	0,6	2,2	3,7	1,2
Elaeagia maguirei	Marfil	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Enterolobium schomburgkii	Dormidero	1	4,8	0,1	0,1	0,3	0,1	0,6	0,2
Erythroxylum macrophyllum	Ajicito	2	4,8	0,0	0,2	0,3	0,0	0,6	0,2
Eschweilera parvifolia	Coco de mono	12	33,3	1,3	1,3	2,1	3,2	6,6	2,2
Eschweilera tenuifolia	Copo	13	9,5	0,5	1,4	0,6	1,2	3,2	1,1
Euplassa saxicola	Yolombó	7	19,0	0,3	0,7	1,2	0,8	2,7	0,9
Euterpe precatoria	Manaco	83	66,7	0,9	8,8	4,3	2,3	15,4	5,1
Ficus americana	Matapalo	1	4,8	0,1	0,1	0,3	0,2	0,7	0,2
Ficus mathewsii	Matapalo	2	4,8	0,1	0,2	0,3	0,1	0,6	0,2
Garcinia madruno	Madroño	2	9,5	0,0	0,2	0,6	0,1	0,9	0,3
Genipa americana	Caruto	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Guatteria metensis	Majagüillo blanco	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Guatteria schomburgkiana	Majagüillo negro	52	57,1	2,3	5,5	3,7	5,8	15,0	5,0
Hebepetalum sp.	Colorado	5	14,3	0,4	0,5	0,9	1,0	2,5	0,8
Heterostemon conjugatus	Guamita	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Himatanthus articulatus	Platanote	25	38,1	1,2	2,6	2,5	2,9	8,0	2,7
Hirtella elongata	Garrapato	11	23,8	0,4	1,2	1,5	1,0	3,7	1,2
Hydrochorea corymbosa	Dormilón	5	14,3	0,8	0,5	0,9	2,0	3,4	1,1
Hymenaea courbaril	Algarrobo	2	4,8	0,1	0,2	0,3	0,3	0,8	0,3
Inga cylindrica	Guamo	5	19,0	0,5	0,5	1,2	1,3	3,0	1,0
Jacaranda copaia	Pavito	7	4,8	0,3	0,7	0,3	0,8	1,9	0,6
Jacaranda obtusifolia	Gualanday	7	19,0	0,3	0,7	1,2	0,7	2,7	0,9
Lacistema aggregatum	Laurel rosado	1	4,8	0,0	0,1	0,3	0,0	0,5	0,2
Licania hypoleuca	Escobo blanco	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Licania leucosepala	Aceituno	14	23,8	0,4	1,5	1,5	1,0	4,0	1,3
Licania parvifructa	Escobo colorado	4	14,3	0,1	0,4	0,9	0,2	1,5	0,5
Licania subarachnophylla	Escobo	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2

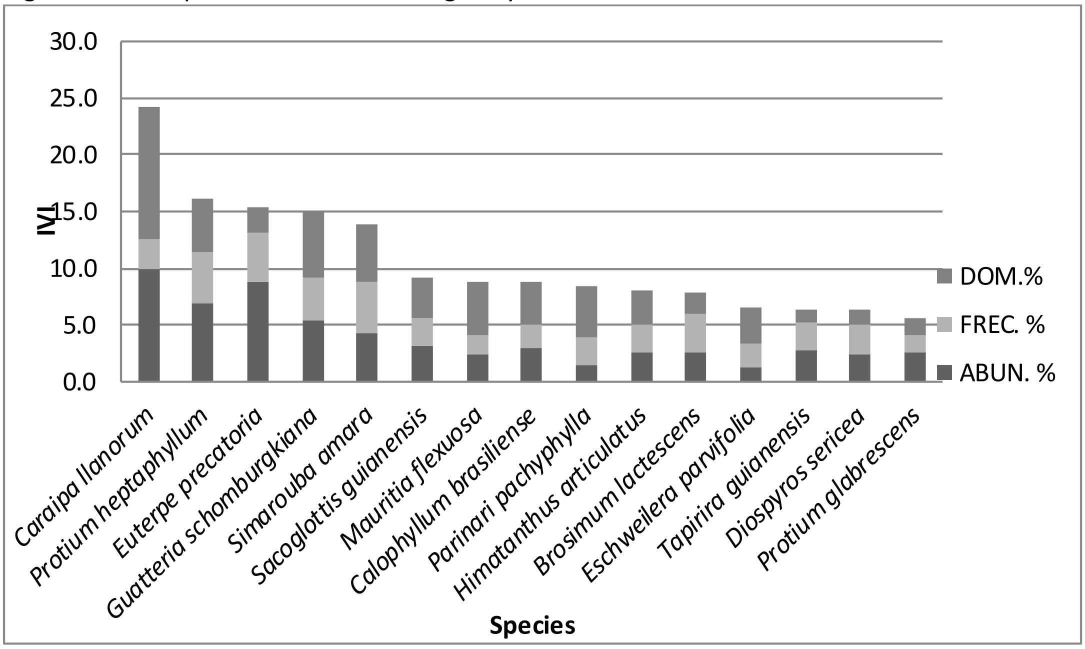
SPECIES	COMMON NAME	ABUND.	FREC.	DOM.	ABUN. %	FREC. %	DOM.%	IVI	IVI %
Licaria canella	Amarillo	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Lonchocarpus floribundus	Matarratón	2	9,5	0,1	0,2	0,6	0,1	1,0	0,3
Mabea trianae	Canilla de venado	11	23,8	0,1	1,2	1,5	0,4	3,1	1,0
Mahurea exstipulata	Caucho amarillo	4	9,5	0,1	0,4	0,6	0,3	1,3	0,4
Maquira coriacea	Lechero	2	9,5	0,1	0,2	0,6	0,2	1,0	0,3
Matayba adenanthera	Patepajuil	7	9,5	0,1	0,7	0,6	0,3	1,6	0,5
Matayba scrobiculata	Patepajuil	4	9,5	0,1	0,4	0,6	0,3	1,3	0,4
Mauritia flexuosa	Moriche	22	28,6	1,9	2,3	1,8	4,6	8,8	2,9
Micropholis guyanensis	Caimillo	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Myrcia paivae	Arrayán	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Myrcia subsessilis	Arrayán	14	23,8	0,3	1,5	1,5	0,7	3,7	1,2
Myrciaria floribunda	Guayabo montañero	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Nectandra cuspidata	Laurel sabanero	2	4,8	0,0	0,2	0,3	0,1	0,6	0,2
Ocotea bofo	Laurel	14	14,3	0,9	1,5	0,9	2,3	4,7	1,6
Ocotea longifolia	Laurel matatigre	4	4,8	0,0	0,4	0,3	0,1	0,8	0,3
Oenocarpus bacaba	Maporilla	5	4,8	0,1	0,5	0,3	0,2	1,0	0,3
Ouratea castaneifolia	Lengua de yataro	1	4,8	0,1	0,1	0,3	0,1	0,5	0,2
Ouratea polyantha	Coralito	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Parahancornia oblonga	Pendare	10	19,0	0,6	1,1	1,2	1,5	3,8	1,3
Parinari pachyphylla	Escobo	13	38,1	1,8	1,4	2,5	4,6	8,4	2,8
Pera arborea	Pategallina	3	9,5	0,1	0,3	0,6	0,2	1,2	0,4
Perebea xanthochyma	Cauchillo	1	4,8	0,1	0,1	0,3	0,2	0,6	0,2
Phenakospermum guyannense	Tarriago	3	9,5	0,0	0,3	0,6	0,1	1,0	0,3
Phyllanthus attenuatus	Totumito	3	9,5	0,2	0,3	0,6	0,5	1,4	0,5
Picramnia magnifolia	Quemacarate	1	4,8	0,0	0,1	0,3	0,0	0,5	0,2
Pouteria guianensis	Caimo	3	9,5	0,2	0,3	0,6	0,5	1,4	0,5
Protium glabrescens	Anime	24	23,8	0,6	2,5	1,5	1,6	5,6	1,9
Protium heptaphyllum	Anime	65	71,4	1,8	6,9	4,6	4,6	16,1	5,4

SPECIES	COMMON NAME	ABUND.	FREC.	DOM.	ABUN. %	FREC. %	DOM.%	IVI	IVI %
Protium llanorum	Anime	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Quiina macrophylla	Guayacán	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Richeria grandis	Alcafeto	3	4,8	0,1	0,3	0,3	0,2	0,8	0,3
Ruprechtia costata	Rascarrabio	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Sacoglottis guianensis	Fierrito	29	38,1	1,5	3,1	2,5	3,7	9,3	3,1
Schefflera morototoni	Tortolito	11	33,3	0,5	1,2	2,1	1,3	4,6	1,5
Sclerolobium melanocarpum	Pategarza	14	4,8	0,3	1,5	0,3	0,8	2,6	0,9
Senna silvestris	Alcaparillo	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Simarouba amara	Simaruba	40	71,4	2,0	4,2	4,6	5,0	13,9	4,6
Socratea exorrhiza	Choapo	9	9,5	0,1	1,0	0,6	0,2	1,8	0,6
Stephanopodium sp.	Naranjo	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
Swartzia leptopetala	Sangretoro	2	4,8	0,1	0,2	0,3	0,2	0,7	0,2
Symphonia globulifera	Breo	9	19,0	0,3	1,0	1,2	0,7	2,9	1,0
Tapirira guianensis	Guarupayo	26	38,1	0,5	2,8	2,5	1,2	6,4	2,1
Tetragastris panamensis	Caraño blanco	9	9,5	0,4	1,0	0,6	0,9	2,5	0,8
Virola carinata	Carnevaca blanco	3	9,5	0,1	0,3	0,6	0,1	1,1	0,4
Virola elongata	Carnevaca	8	14,3	0,6	0,8	0,9	1,4	3,2	1,1
Virola parvifolia	Carnevaca	3	9,5	0,1	0,3	0,6	0,2	1,1	0,4
Vismia baccifera	Lacre blanco	4	9,5	0,0	0,4	0,6	0,1	1,2	0,4
Vismia macrophylla	Punta de lanza	4	9,5	0,0	0,4	0,6	0,1	1,1	0,4
Vitex orinocensis	Guarataro	2	4,8	0,1	0,2	0,3	0,4	0,9	0,3
Vochysia ferruginea	Botagajo	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Vochysia lehmannii	Saladillo blanco	2	4,8	0,1	0,2	0,3	0,3	0,8	0,3
Vouarana guianensis	Partemachete	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Xylopia aromatica	Malagueto	10	19,0	0,3	1,1	1,2	0,7	3,0	1,0
Xylopia emarginata	Majagüillo	1	4,8	0,0	0,1	0,3	0,1	0,5	0,2
Zygia inaequalis	Cimbrapotro	1	4,8	0,0	0,1	0,3	0,0	0,4	0,1
General total		**944**	**1552,4**	**39,9**	**100,0**	**100,0**	**100,0**	**300,0**	**100,0**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

The analysis of the importance value index for this coverage, shows the species: *Caraipa llanorum* (Saladillo rojo) as the most representative or the one with the highest ecological weight, with a net value of 24.2 (over 300), corresponding to a percentage of 8.1%; other species with significant values are: *Protium heptaphyllum* (Anime), *Euterpe precatoria* (Manaco), *Guatteria schomburgkiana* (Majagüillo negro) and *Simarouba amara* (Simaruba) with net values between 16,1 and 13,9 corresponding to percentages between 5.4% and 4.6%, being evidently the ones that showed the highest values in each one of the parameters that compose the index; the other species report values at 4% of the total determined for this parameter (see Figure 4.129). As was shown individually in each parameter, the gallery forest tends to be heterogeneous, despite showing certain importance of one or several species.

Figure 4.129: Importance value index in gallery forest.

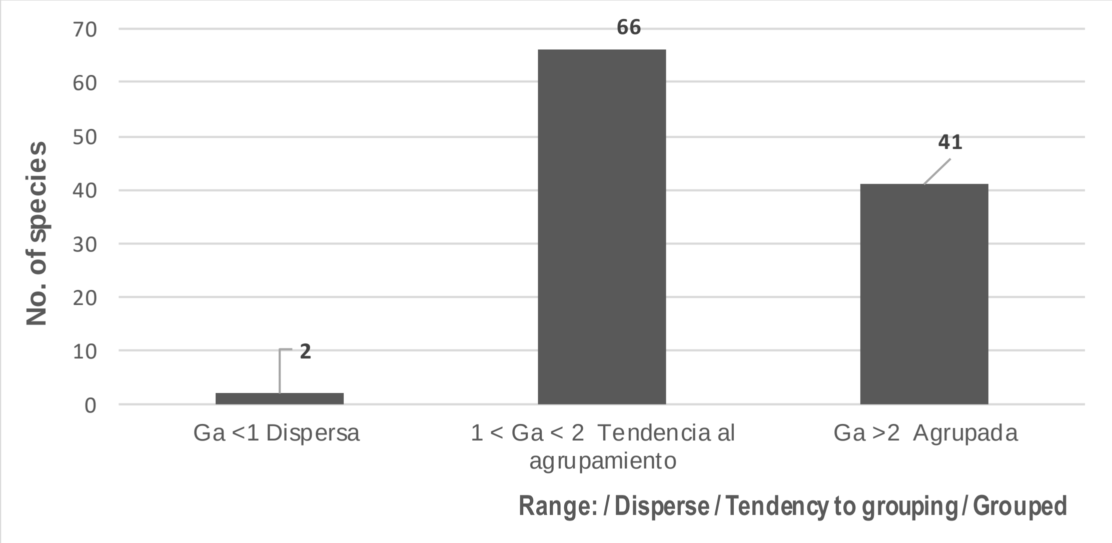


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Degree of aggregation

In the analysis of the degree of aggregation of the species in gallery forest, it was determined that 66 species, equivalent to 60.6% of the total, have a distribution with a tendency to grouping, while 41 species (37.6%) are grouped and the remaining 2 species are disperse (see Figure 4.130); in this analysis are includes species that not necessarily are abundant and frequent but that do tend to group in a few plots. This parameter shows in general terms that the gallery forest despite being heterogeneous as to species distribution in space, these are grouped or tend to group, this can be related with the type of dispersion of the species and the adaptation to extreme humidity conditions with long periods of flood which is a constant characteristic in these forests.

Figure 4.130: Degree of aggregation in gallery forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Vertical structure

For the analysis of the vertical structure of the gallery forest the sociological position was determined and the Ogawa diagram and the vegetation profile were built.

Sociological position

In order to define the sociological position of the gallery forest three strata were determined, dividing the difference of the maximum and minimum values reported in the trees inventory corresponding to 32 and 6 meters respectively, which allowed to establish a range of 8.7 meters in height for each stratum.

In the vertical stratification of this coverage, carried out for the analysis of sociological position, it is observed that 55.3% of the sampled individuals (522), are grouped in the middle stratus with heights between 14.7 meters and less than or equal to 23.3 meters, while 41.5% (392 individuals) are in the lower stratum with heights between 6 and 14.7 meters and only 3,2% (30 individuals) are in the higher stratum with heights higher than 23.3 meters and less than or equal to 32 meters (see Table 4.69). This suggests that it is a coverage conformed predominantly by individuals of medium-low bearing with some emergent trees.

Table 4.69: Vertical stratification in gallery forest.

STRATUM	HEIGHT RANGE (m)	NUMBER OF INDIVIDUALS	% INDIVIDUALS
Lower stratum	6 - 14,7	392	41,5
Middle stratum	> 14,7 - 23,3	522	55,3
Higher stratum	> 23,3 - 32	30	3,2
TOTAL		**944**	**100,0**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

With the strata defined, the phytosociological value was determined for each one and the absolute and relative sociological position was obtained for each species as shown in Table 4.70.

Table 4.70: Sociological position in gallery forest.

SPECIES	COMMON NAME	CT 1	CT 2	CT 3	Total	Lower stratum	Middle stratum	Higher stratum	Psa	Ps%
Albizia lebbeck	Menudito	1	10		11	0,4	5,5	0,0	5,9	1,3
Alchornea discolor	Algodoncillo	2	2		4	0,8	1,1	0,0	1,9	0,4
Alchornea triplinervia	Carnegallina	2			2	0,8	0,0	0,0	0,8	0,2
Amaioua guianensis	Macanillo	4			4	1,7	0,0	0,0	1,7	0,4
Andira surinamensis	Arenoso	1	2		3	0,4	1,1	0,0	1,5	0,3
Aniba panurensis	Yema de huevo	4	1		5	1,7	0,6	0,0	2,2	0,5
Aspidosperma desmanthum	Costillo		1		1	0,0	0,6	0,0	0,6	0,1
Aspidosperma excelsum	Costillo blanco		2		2	0,0	1,1	0,0	1,1	0,2
Astronium graveolens	Abejón	1			1	0,4	0,0	0,0	0,4	0,1
Attalea maripa	Cucurita		7		7	0,0	3,9	0,0	3,9	0,9
Bellucia grossularioides	Níspero		3	1	4	0,0	1,7	0,0	1,7	0,4
Brosimum lactescens	Guáimaro	14	11		25	5,8	6,1	0,0	11,9	2,6
Calophyllum brasiliense	Cachicamo	6	22		28	2,5	12,2	0,0	14,7	3,2
Campsiandra comosa	Chigo	3	1		4	1,2	0,6	0,0	1,8	0,4
Caraipa llanorum	Saladillo rojo	38	54	1	93	15,8	29,9	0,0	45,7	10,1
Coccoloba mollis	Uvero	1	2	1	4	0,4	1,1	0,0	1,6	0,3
Cochlospermum orinocense	Bototo		3	1	4	0,0	1,7	0,0	1,7	0,4
Cochlospermum vitifolium	Bototo	1			1	0,4	0,0	0,0	0,4	0,1
Connarus lambertii	Sangrito	4			4	1,7	0,0	0,0	1,7	0,4
Copaifera pubiflora	Aceite		7		7	0,0	3,9	0,0	3,9	0,9
Cordia sericicalyx	Palo de agua	1	2		3	0,4	1,1	0,0	1,5	0,3
Crudia oblonga	Cascarillo	2	1		3	0,8	0,6	0,0	1,4	0,3
Cupania scrobiculata	Partemachete	1			1	0,4	0,0	0,0	0,4	0,1
Curatella americana	Chaparro	1			1	0,4	0,0	0,0	0,4	0,1
Dendropanax arboreus	Mantequillo	3	2		5	1,2	1,1	0,0	2,4	0,5
Diospyros sericea	Carbonero	8	13	1	22	3,3	7,2	0,0	10,5	2,3
Dipteryx punctata	Sarrapio	2	4	2	8	0,8	2,2	0,1	3,1	0,7
Elaeagia maguirei	Marfil		1		1	0,0	0,6	0,0	0,6	0,1
Enterolobium schomburgkii	Dormidero			1	1	0,0	0,0	0,0	0,0	0,0
Erythroxylum macrophyllum	Ajicito	2			2	0,8	0,0	0,0	0,8	0,2
Eschweilera parvifolia	Coco de mono	2	9	1	12	0,8	5,0	0,0	5,8	1,3
Eschweilera tenuifolia	Copo	7	6		13	2,9	3,3	0,0	6,2	1,4
Euplassa saxicola	Yolombó	3	3	1	7	1,2	1,7	0,0	2,9	0,6
Euterpe precatoria	Manaco	12	70	1	83	5,0	38,7	0,0	43,7	9,7
Ficus americana	Matapalo		1		1	0,0	0,6	0,0	0,6	0,1
Ficus mathewsii	Matapalo	1	1		2	0,4	0,6	0,0	1,0	0,2
Garcinia madruno	Madroño	2			2	0,8	0,0	0,0	0,8	0,2
Genipa americana	Caruto		1		1	0,0	0,6	0,0	0,6	0,1

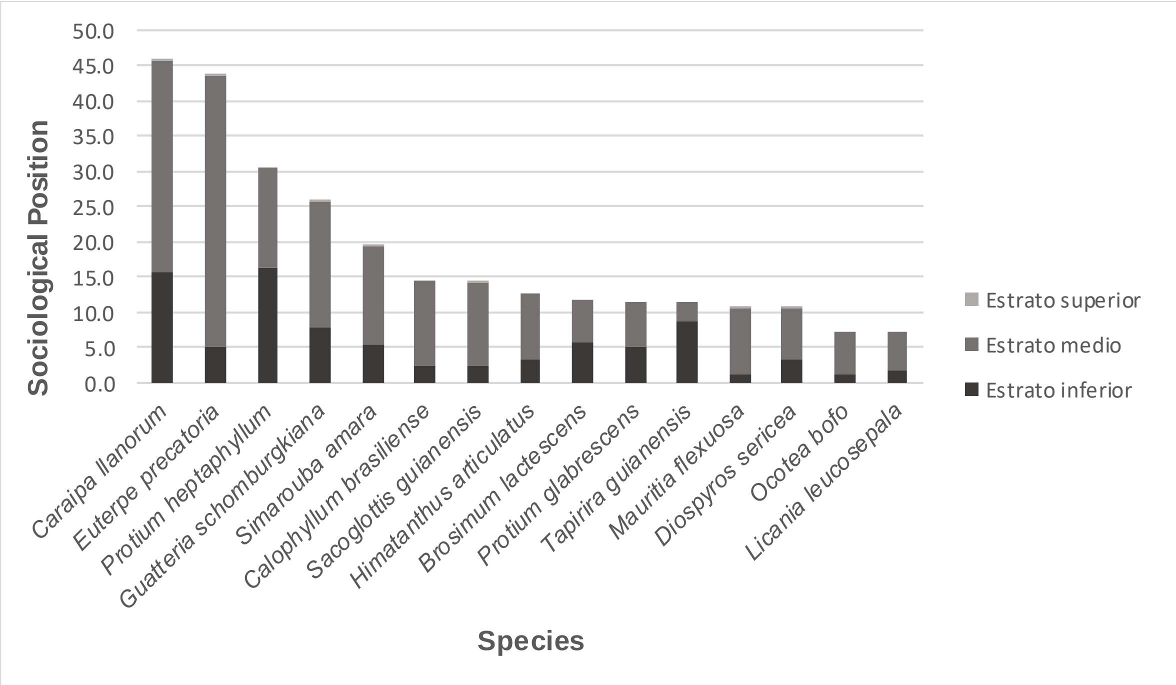
SPECIES	COMMON NAME	CT 1	CT 2	CT 3	Total	Lower stratum	Middle stratum	Higher stratum	Psa	Ps%
Guatteria metensis	Majagüillo blanco	1			1	0,4	0,0	0,0	0,4	0,1
Guatteria schomburgkiana	Majagüillo negro	19	32	1	52	7,9	17,7	0,0	25,6	5,7
Hebepetalum sp.	Colorado	2	3		5	0,8	1,7	0,0	2,5	0,6
Heterostemon conjugatus	Guamita		1		1	0,0	0,6	0,0	0,6	0,1
Himatanthus articulatus	Platanote	8	17		25	3,3	9,4	0,0	12,7	2,8
Hirtella elongata	Garrapato	10	1		11	4,2	0,6	0,0	4,7	1,0
Hydrochorea corymbosa	Dormilón	1	4		5	0,4	2,2	0,0	2,6	0,6
Hymenaea courbaril	Algarrobo		2		2	0,0	1,1	0,0	1,1	0,2
Inga cylindrica	Guamo		5		5	0,0	2,8	0,0	2,8	0,6
Jacaranda copaia	Pavito		3	4	7	0,0	1,7	0,1	1,8	0,4
Jacaranda obtusifolia	Gualanday	5	1	1	7	2,1	0,6	0,0	2,7	0,6
Lacistema aggregatum	Laurel rosado	1			1	0,4	0,0	0,0	0,4	0,1
Licania hypoleuca	Escobo blanco		1		1	0,0	0,6	0,0	0,6	0,1
Licania leucosepala	Aceituno	4	10		14	1,7	5,5	0,0	7,2	1,6
Licania parvifructa	Escobo colorado	2	2		4	0,8	1,1	0,0	1,9	0,4
Licania subarachnophylla	Escobo		1		1	0,0	0,6	0,0	0,6	0,1
Licaria canella	Amarillo	1			1	0,4	0,0	0,0	0,4	0,1
Lonchocarpus floribundus	Matarratón		2		2	0,0	1,1	0,0	1,1	0,2
Mabea trianae	Canilla de venado	11			11	4,6	0,0	0,0	4,6	1,0
Mahurea exstipulata	Caucho amarillo	2	2		4	0,8	1,1	0,0	1,9	0,4
Maquira coriacea	Lechero	1	1		2	0,4	0,6	0,0	1,0	0,2
Matayba adenanthera	Patepajuil	7			7	2,9	0,0	0,0	2,9	0,6
Matayba scrobiculata	Patepajuil	2	2		4	0,8	1,1	0,0	1,9	0,4
Mauritia flexuosa	Moriche	3	17	2	22	1,2	9,4	0,1	10,7	2,4
Micropholis guyanensis	Caimillo		1		1	0,0	0,6	0,0	0,6	0,1
Myrcia paivae	Arrayán	1			1	0,4	0,0	0,0	0,4	0,1
Myrcia subsessilis	Arrayán	14			14	5,8	0,0	0,0	5,8	1,3
Myrciaria floribunda	Guayabo montañero	1			1	0,4	0,0	0,0	0,4	0,1
Nectandra cuspidata	Laurel sabanero	1	1		2	0,4	0,6	0,0	1,0	0,2
Ocotea bofo	Laurel	3	11		14	1,2	6,1	0,0	7,3	1,6
Ocotea longifolia	Laurel matatigre	4			4	1,7	0,0	0,0	1,7	0,4
Oenocarpus bacaba	Maporilla	4	1		5	1,7	0,6	0,0	2,2	0,5
Ouratea castaneifolia	Lengua de yataro		1		1	0,0	0,6	0,0	0,6	0,1
Ouratea polyantha	Coralito	1			1	0,4	0,0	0,0	0,4	0,1
Parahancornia oblonga	Pendare	2	8		10	0,8	4,4	0,0	5,3	1,2

SPECIES	COMMON NAME	CT 1	CT 2	CT 3	Total	Lower stratum	Middle stratum	Higher stratum	Psa	Ps%
Parinari pachyphylla	Escobo	3	9	1	13	1,2	5,0	0,0	6,3	1,4
Pera arborea	Pategallina		3		3	0,0	1,7	0,0	1,7	0,4
Perebea xanthochyma	Cauchillo		1		1	0,0	0,6	0,0	0,6	0,1
Phenakospermum guyannense	Tarriago	3			3	1,2	0,0	0,0	1,2	0,3
Phyllanthus attenuatus	Totumito	1	2		3	0,4	1,1	0,0	1,5	0,3
Picramnia magnifolia	Quemacarate	1			1	0,4	0,0	0,0	0,4	0,1
Pouteria guianensis	Caimo	1	1	1	3	0,4	0,6	0,0	1,0	0,2
Protium glabrescens	Anime	12	12		24	5,0	6,6	0,0	11,6	2,6
Protium heptaphyllum	Anime	39	26		65	16,2	14,4	0,0	30,6	6,8
Protium llanorum	Anime		1		1	0,0	0,6	0,0	0,6	0,1
Quiina macrophylla	Guayacán	1			1	0,4	0,0	0,0	0,4	0,1
Richeria grandis	Alcafeto	2	1		3	0,8	0,6	0,0	1,4	0,3
Ruprechtia costata	Rascarrabio		1		1	0,0	0,6	0,0	0,6	0,1
Sacoglottis guianensis	Fierrito	6	21	2	29	2,5	11,6	0,1	14,2	3,1
Schefflera morototoni	Tortolito	5	6		11	2,1	3,3	0,0	5,4	1,2
Sclerolobium melanocarpum	Pategarza	8	6		14	3,3	3,3	0,0	6,6	1,5
Senna silvestris	Alcaparillo	1			1	0,4	0,0	0,0	0,4	0,1
Simarouba amara	Simaruba	13	25	2	40	5,4	13,8	0,1	19,3	4,3
Socratea exorrhiza	Choapo	5	4		9	2,1	2,2	0,0	4,3	0,9
Stephanopodium sp.	Naranjo	1			1	0,4	0,0	0,0	0,4	0,1
Swartzia leptopetala	Sangretoro	1	1		2	0,4	0,6	0,0	1,0	0,2
Symphonia globulifera	Breo	4	4	1	9	1,7	2,2	0,0	3,9	0,9
Tapirira guianensis	Guarupayo	21	5		26	8,7	2,8	0,0	11,5	2,5
Tetragastris panamensis	Caraño blanco	4	5		9	1,7	2,8	0,0	4,4	1,0
Virola carinata	Carnevaca blanco	2	1		3	0,8	0,6	0,0	1,4	0,3
Virola elongata	Carnevaca		4	4	8	0,0	2,2	0,1	2,3	0,5
Virola parvifolia	Carnevaca		3		3	0,0	1,7	0,0	1,7	0,4
Vismia baccifera	Lacre blanco	4			4	1,7	0,0	0,0	1,7	0,4
Vismia macrophylla	Punta de lanza	4			4	1,7	0,0	0,0	1,7	0,4
Vitex orinocensis	Guarataro	1	1		2	0,4	0,6	0,0	1,0	0,2
Vochysia ferruginea	Botagajo		1		1	0,0	0,6	0,0	0,6	0,1
Vochysia lehmannii	Saladillo blanco	1	1		2	0,4	0,6	0,0	1,0	0,2
Vouarana guianensis	Partemachete	1			1	0,4	0,0	0,0	0,4	0,1
Xylopia aromatica	Malagueto	6	4		10	2,5	2,2	0,0	4,7	1,0
Xylopia emarginata	Majagüillo		1		1	0,0	0,6	0,0	0,6	0,1
Zygia inaequalis	Cimbrapotro	1			1	0,4	0,0	0,0	0,4	0,1
General total		**392**	**522**	**30**	**944**				**452,4**	**100,0**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

The analysis of the absolute sociological position (Figure 4.131), shows for the gallery forest the species: *Caraipa llanorum* (Saladillo rojo), *Euterpe precatoria* (Manaco), *Protium heptaphyllum* (Anime), *Guatteria schomburgkiana* (Majagüillo negro) and *Simarouba amara* (Simaruba) as the most representative, or those that appear in all the strata of the forest and assure their place in the vertical structure, with net values between 45.7 and 19.3 equivalent to relative values between 10.1 and 4.3%. The other species show values lower than 4% of this relative parameter. In general terms a uniform distribution of the sociological position is observed, which suggests the tendency to heterogeneity of this coverage at the level of vertical structure.

Figure 4.131: Sociological position in gallery forest.

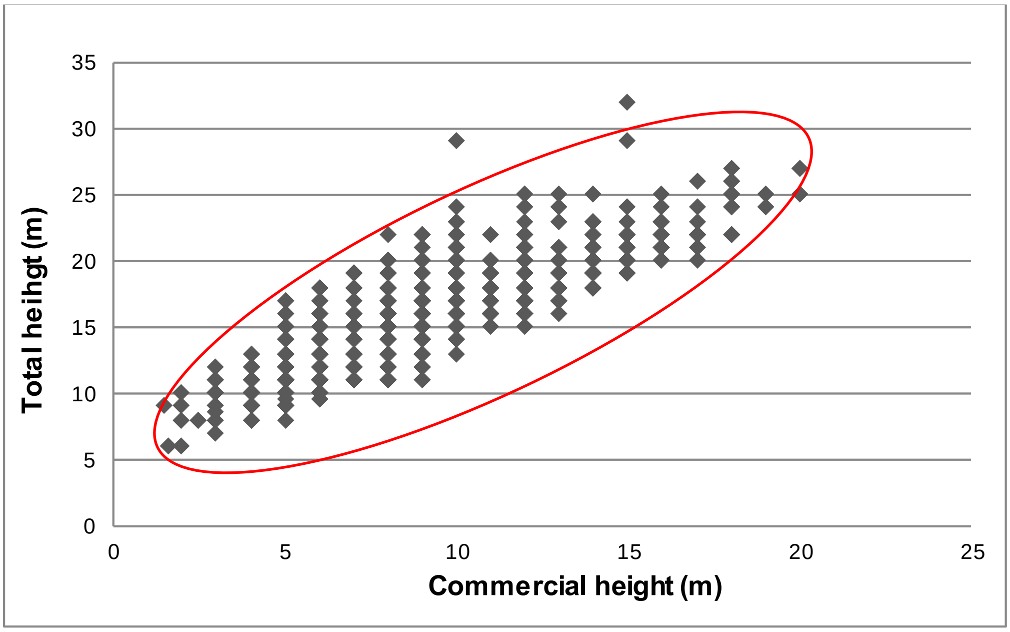


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Ogawa Stratification

In the cups dispersion analysis applying the Ogawa technique, which combines total and commercial heights,(see Figure 4.132), it is observed the presence of individuals in all the canopy, in a continuous that makes it difficult to differentiate strata, nonetheless certain grouping of individuals is observed in a big stratum with total heights between 7 and 22 meters and commercial between 3 and 17 meters.

Figure 4.132: Ogawa Dispersion diagram for gallery forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Vegetation profile

For the construction of the vegetation structural profile of the gallery forest, the graphic representation of the individuals of the 23 species found in the selected type plot was made (Bg16), with some of the characteristics registered of their architecture. In Table 4.71 the graphic representation of each one of these species is shown.

Table 4.71: Graphic representation of species in gallery forest.

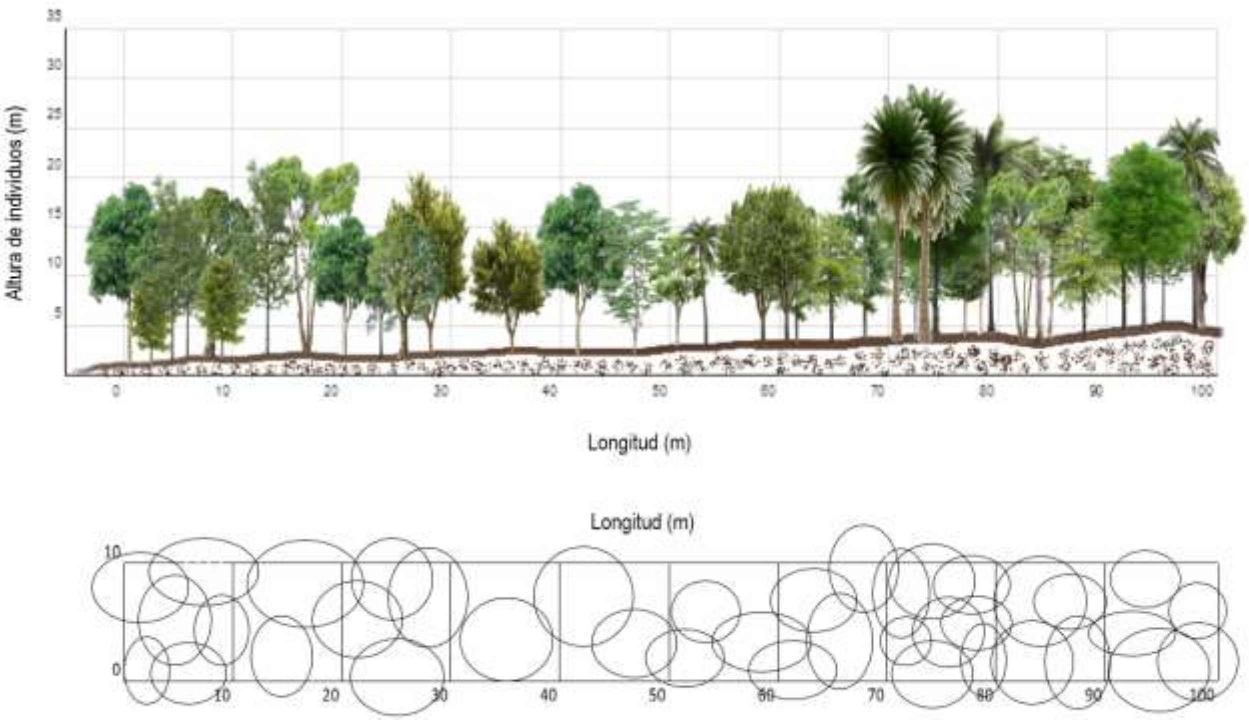
VIEW	SPECIES	COMMON NAME	VIEW	SPECIES	COMMON NAME
	*Aniba panurensis*	Yema de huevo		*Parahancornia oblonga*	Pendare
	*Brosimum lactescens*	Guáimaro		*Pera arborea*	Pategallina
	*Calophyllum brasiliense*	Cachicamo		*Protium glabrescens*	Anime
	*Diospyros sericea*	Carbonero		*Simarouba amara*	Simaruba
	*Euplassa saxicola*	Yolombó		*Socratea exorrhiza*	Choapo
	*Euterpe precatoria*	Manaco		*Symphonia globulifera*	Breo

	*Ficus mathewsii*	Matapalo		*Tapirira guianensis*	Guarupayo
	*Guatteria schomburgkiana*	Majagüillo negro		*Virola carinata*	Carnevaca blanco
	*Hebepetalum sp.*	Colorado		*Virola parvifolia*	Carnevaca
	*Mauritia flexuosa*	Moriche		*Vochysia ferruginea*	Botagajo
	*Myrcia subsessilis*	Arrayán		*Xylopia aromatica*	Malagueto
	*Ouratea polyantha*	Coralito			

Source: (Universidad Distrital Francisco José De Caldas, 2017)

The vegetation structural profile for the gallery forest, shows that in the vertical visual structure the cups structural continuity is observed, making it difficult to differentiate strata, as well as the presence of a few emergent individuals; while for the horizontal structure a good proportion of coverage on the ground is observed, leaving few uncovered areas and hindering the entry of light for the continuity of the canopy; this situation is typical of the forest analyzed and evinces as well a Good degree of conservation of this natural covering (see Figure 4.133).

Figure 4.133: Structural vegetable profile for gallery forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Altimetric Distribution by class intervals

For the distribution of the individuals of tree size category in the class intervals for heights, in the gallery forest were determined 11 intervals with a class amplitude of 2.36 meters. The altimetric classes with their range, quantity and proportion of individuals are shown for this coverage.

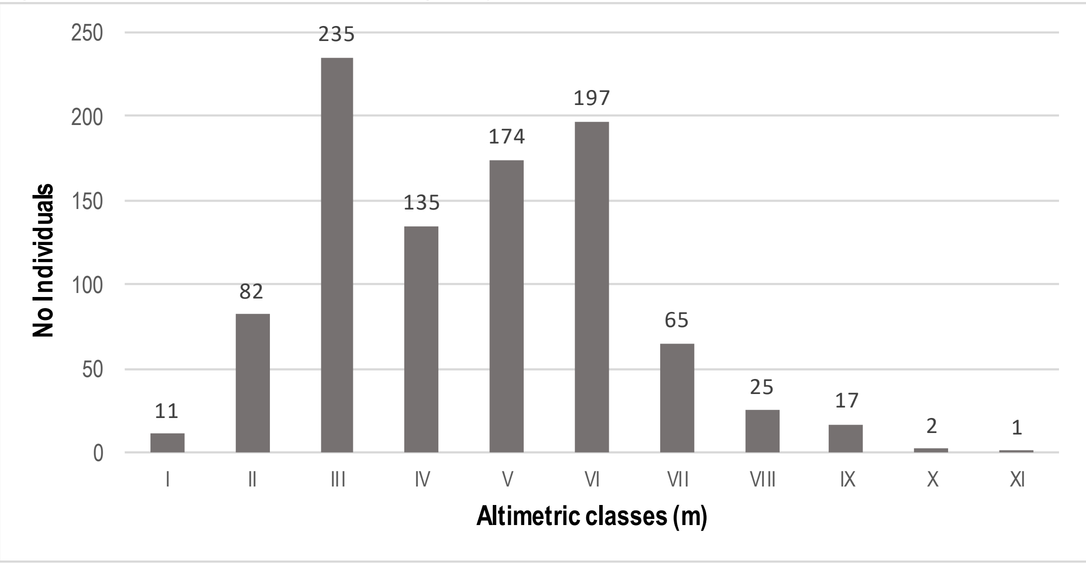
Table 4.72: Altimetric distribution in gallery forest.

Altimetric class	Range (m)	No. of Individuals	% Individuals
I	6 - 8,36	11	1,2
II	8,37 - 10,74	82	8,7
III	10,75 - 13,11	235	24,9
III	10,75 - 13,11	235	24,9
IV	13,12 - 15,248	135	14,3
V	15,49 - 17,86	174	18,4
VI	17,87 - 20,23	197	20,9
VII	20,24 - 22,61	65	6,9
VIII	22,62 - 24,98	25	2,6
IX	24,49 - 27,35	17	1,8
X	27,36 - 29,73	2	0,2
XI	29,74 - 32,10	1	0,1
General total		**944**	**100,0**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

In Figure 4.134 the distribution of individuals in the class intervals is shown, denoting a grouping in the intermediate classes, with III being the highest value with 235 individuals (24.9% of the total individuals), followed by VI with 197 individuals (20.9%) and class V with 174 individuals (18.4%) and class IV with 135 individuals (14.3%). This is a typical behaviour of a natural coverage with continuous development processes, with a good offer of individuals of middle-low bearing, this being congruent with the vertical structure analysis.

Figure 4.134: Altimetric distribution in gallery forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Diameter distribution

For the distribution of individuals in the diameter class intervals, for the gallery forest 8 intervals a fixed class amplitude of 10 centimeters were determined. Table 4.73 shows the diameter classes with their range and proportion of individuals.

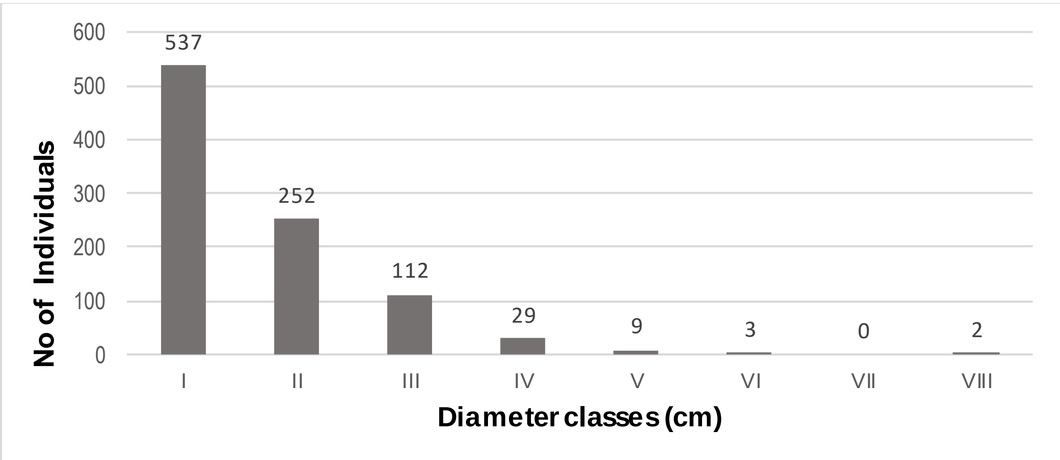
Table 4.73: Diameter distribution in gallery forest.

Diameter classes	Range (cm)	No. Individuals	% Individuals
I	10,01 - 20	537	56,9
II	20,01 - 30	252	26,7
III	30,01 - 40	112	11,9
IV	40,01 - 50	29	3,1
V	50,01 - 60	9	1,0
VI	60,01 - 70	3	0,3
VII	70,01 - 80	0	0,0
VIII	80,01 - 90	2	0,2
General total		**944**	**100**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Figure 4.135 shows the distribution of individuals in the diameter classes of the gallery forest, showing a normal behaviour, with 56.9% of the individuals in the first class (537 individuals) and 26.7% (2 52 individuals) in the second, showing a curve in the shape of a jack in which there are many individuals in the first classes and with regular decrease as class is increased, characteristic of developing natural forests, with active processes of natural regeneration and with a good offer of small trees to replace the dying ones.

Figure 4.135: Diameter distribution in gallery forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Basal area and volume by species

Table 4.74 shows the volume reported in the inventory for each of the species found in the gallery forest in tree size category, in the analyzed area corresponding to 2.1 hectares and with its respective value and proportion per hectare.

Table 4.74: Basal area and volume by species in gallery forest.

SPECIES	COMMON NAME	BASAL AREA (m^2)	COM VOL (m^3)	TOT VOL (m^3)	TOT VOL /ha (m^3)
Albizia lebbeck	Menudito	1,1	6,3	14,0	6,7
Alchornea discolor	Algodoncillo	0,1	0,7	1,7	0,8
Alchornea triplinervia	Carnegallina	0,0	0,2	0,3	0,1
Amaioua guianensis	Macanillo	0,0	0,1	0,2	0,1
Andira surinamensis	Arenoso	0,2	0,9	2,0	1,0
Aniba panurensis	Yema de huevo	0,1	0,4	0,9	0,4
Aspidosperma desmanthum	Costillo	0,1	1,2	1,5	0,7
Aspidosperma excelsum	Costillo blanco	0,1	0,9	1,5	0,7
Astronium graveolens	Abejón	0,0	0,0	0,1	0,0
Attalea maripa	Cucurita	0,4	1,8	4,5	2,1
Bellucia grossularioides	Níspero	0,1	0,8	1,8	0,9
Brosimum lactescens	Guáimaro	0,7	3,7	7,4	3,5
Calophyllum brasiliense	Cachicamo	1,5	10,9	19,5	9,3
Campsiandra comosa	Chigo	0,4	2,1	4,4	2,1
Caraipa llanorum	Saladillo rojo	4,6	28,8	53,5	25,5
Coccoloba mollis	Uvero	0,2	1,2	2,2	1,0
Cochlospermum orinocense	Bototo	0,4	3,6	5,8	2,8
Cochlospermum vitifolium	Bototo	0,0	0,0	0,1	0,0
Connarus lambertii	Sangrito	0,1	0,3	0,7	0,3
Copaifera pubiflora	Aceite	1,1	7,5	17,2	8,2
Cordia sericicalyx	Palo de agua	0,1	0,4	0,7	0,3
Crudia oblonga	Cascarillo	0,1	0,4	1,1	0,5
Cupania scrobiculata	Partemachete	0,0	0,0	0,1	0,0
Curatella americana	Chaparro	0,0	0,0	0,1	0,0
Dendropanax arboreus	Mantequillo	0,1	0,5	1,0	0,5
Diospyros sericea	Carbonero	0,5	4,3	6,5	3,1
Dipteryx punctata	Sarrapio	0,9	7,5	13,5	6,4
Elaeagia maguirei	Marfil	0,0	0,3	0,5	0,3
Enterolobium schomburgkii	Dormidero	0,1	0,8	1,1	0,5
Erythroxylum macrophyllum	Ajicito	0,0	0,1	0,2	0,1
Eschweilera parvifolia	Coco de mono	1,3	11,3	17,1	8,1
Eschweilera tenuifolia	Copo	0,5	2,7	5,1	2,4
Euplassa saxicola	Yolombó	0,3	2,5	4,3	2,0
Euterpe precatoria	Manaco	0,9	7,9	11,1	5,3
Ficus americana	Matapalo	0,1	0,9	1,3	0,6
Ficus mathewsii	Matapalo	0,1	0,2	0,6	0,3
Garcinia madruno	Madroño	0,0	0,1	0,2	0,1
Genipa americana	Caruto	0,0	0,2	0,3	0,2
Guatteria metensis	Majagüillo blanco	0,0	0,0	0,1	0,0
Guatteria schomburgkiana	Majagüillo negro	2,3	17,1	28,3	13,5
Hebepetalum sp.	Colorado	0,4	2,8	5,5	2,6
Heterostemon conjugatus	Guamita	0,0	0,1	0,2	0,1
Himatanthus articulatus	Platanote	1,2	8,3	14,4	6,9
Hirtella elongata	Garrapato	0,4	1,5	3,5	1,7

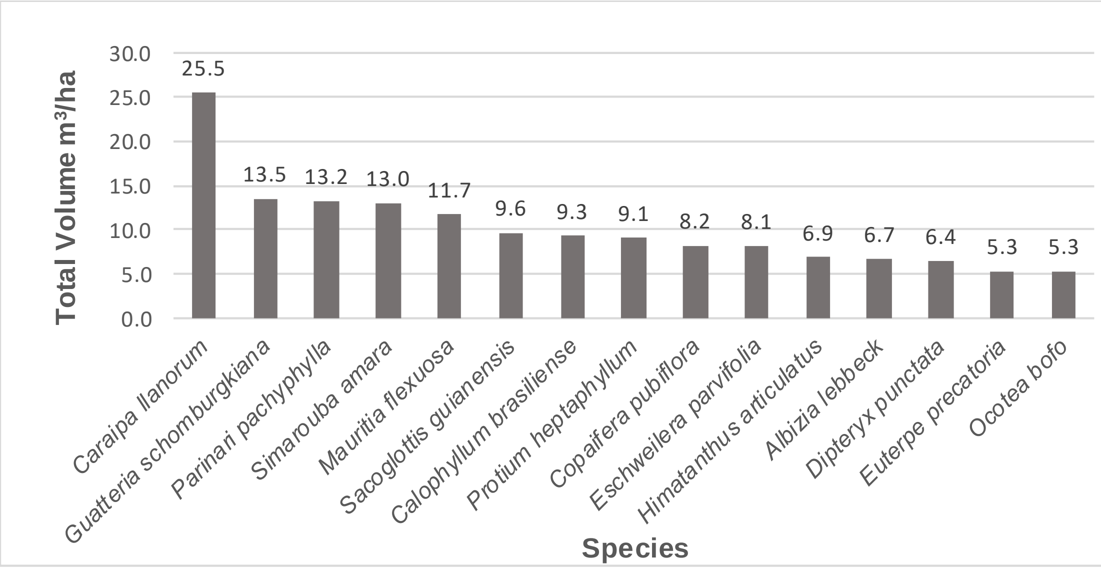
SPECIES	COMMON NAME	BASAL AREA (m^2)	COM VOL (m^3)	TOT VOL (m^3)	TOT VOL /ha (m^3)
Hydrochorea corymbosa	Dormilón	0,8	4,7	9,3	4,4
Hymenaea courbaril	Algarrobo	0,1	1,3	2,0	1,0
Inga cylindrica	Guamo	0,5	4,0	6,8	3,3
Jacaranda copaia	Pavito	0,3	4,1	5,7	2,7
Jacaranda obtusifolia	Gualanday	0,3	2,2	4,1	1,9
Lacistema aggregatum	Laurel rosado	0,0	0,1	0,1	0,1
Licania hypoleuca	Escobo blanco	0,0	0,1	0,3	0,2
Licania leucosepala	Aceituno	0,4	2,3	4,5	2,2
Licania parvifructa	Escobo colorado	0,1	0,3	0,7	0,3
Licania subarachnophylla	Escobo	0,0	0,3	0,5	0,2
Licaria canella	Amarillo	0,0	0,1	0,2	0,1
Lonchocarpus floribundus	Matarratón	0,1	0,4	0,7	0,3
Mabea trianae	Canilla de venado	0,1	0,4	1,0	0,5
Mahurea exstipulata	Caucho amarillo	0,1	0,4	1,3	0,6
Maquira coriacea	Lechero	0,1	0,5	0,7	0,3
Matayba adenanthera	Patepajuil	0,1	0,3	0,7	0,4
Matayba scrobiculata	Patepajuil	0,1	0,8	1,2	0,6
Mauritia flexuosa	Moriche	1,9	16,5	24,5	11,7
Micropholis guyanensis	Caimillo	0,0	0,2	0,4	0,2
Myrcia paivae	Arrayán	0,0	0,0	0,1	0,0
Myrcia subsessilis	Arrayán	0,3	1,0	2,2	1,0
Myrciaria floribunda	Guayabo montañero	0,0	0,0	0,1	0,0
Nectandra cuspidata	Laurel sabanero	0,0	0,2	0,3	0,2
Ocotea bofo	Laurel	0,9	5,4	11,1	5,3
Ocotea longifolia	Laurel matatigre	0,0	0,2	0,3	0,2
Oenocarpus bacaba	Maporilla	0,1	0,4	0,6	0,3
Ouratea castaneifolia	Lengua de yataro	0,1	0,4	0,6	0,3
Ouratea polyantha	Coralito	0,0	0,0	0,1	0,0
Parahancornia oblonga	Pendare	0,6	5,3	8,6	4,1
Parinari pachyphylla	Escobo	1,8	14,1	27,8	13,2
Pera arborea	Pategallina	0,1	0,7	1,1	0,5
Perebea xanthochyma	Cauchillo	0,1	0,7	1,0	0,5
Phenakospermum guyannense	Tarriago	0,0	0,1	0,2	0,1
Phyllanthus attenuatus	Totumito	0,2	1,4	2,3	1,1
Picramnia magnifolia	Quemacarate	0,0	0,1	0,2	0,1
Pouteria guianensis	Caimo	0,2	1,6	2,8	1,3
Protium glabrescens	Anime	0,6	3,8	6,9	3,3
Protium heptaphyllum	Anime	1,8	10,6	19,0	9,1
Protium llanorum	Anime	0,0	0,3	0,4	0,2
Quiina macrophylla	Guayacán	0,0	0,1	0,1	0,1
Richeria grandis	Alcafeto	0,1	0,5	0,8	0,4
Ruprechtia costata	Rascarrabio	0,0	0,1	0,3	0,1
Sacoglottis guianensis	Fierrito	1,5	11,3	20,2	9,6

SPECIES	COMMON NAME	BASAL AREA (m^2)	COM VOL (m^3)	TOT VOL (m^3)	TOT VOL /ha (m^3)
Schefflera morototoni	Tortolito	0,5	3,5	6,7	3,2
Sclerolobium melanocarpum	Pategarza	0,3	1,5	3,6	1,7
Senna silvestris	Alcaparillo	0,0	0,0	0,1	0,0
Simarouba amara	Simaruba	2,0	16,8	27,3	13,0
Socratea exorrhiza	Choapo	0,1	0,6	0,9	0,4
Stephanopodium sp.	Naranjo	0,0	0,0	0,1	0,0
Swartzia leptopetala	Sangretoro	0,1	0,5	0,9	0,4
Symphonia globulifera	Breo	0,3	3,0	4,3	2,0
Tapirira guianensis	Guarupayo	0,5	2,4	4,6	2,2
Tetragastris panamensis	Caraño blanco	0,4	2,2	3,8	1,8
Virola carinata	Carnevaca blanco	0,1	0,4	0,6	0,3
Virola elongata	Carnevaca	0,6	6,0	9,0	4,3
Virola parvifolia	Carnevaca	0,1	0,6	0,8	0,4
Vismia baccifera	Lacre blanco	0,0	0,2	0,4	0,2
Vismia macrophylla	Punta de lanza	0,0	0,2	0,3	0,2
Vitex orinocensis	Guarataro	0,1	0,6	1,4	0,7
Vochysia ferruginea	Botagajo	0,0	0,1	0,2	0,1
Vochysia lehmannii	Saladillo blanco	0,1	0,5	1,0	0,5
Vouarana guianensis	Partemachete	0,0	0,1	0,2	0,1
Xylopia aromatica	Malagueto	0,3	2,0	3,0	1,4
Xylopia emarginata	Majagüillo	0,0	0,1	0,3	0,1
Zygia inaequalis	Cimbrapotro	0,0	0,0	0,0	0,0
Total general		**39,9**	**280,2**	**497,5**	**236,9**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

According to the volume analysis (see Figure 4.136), the species reporting the highest total volume per hectare for the gallery forest, is *Caraipa llanorum* (Saladillo rojo), with 25,5 cubic meters equivalent to 10,8% of the total, other representative species are: *Guatteria schomburgkiana* (Majagüillo negro), *Parinari pachyphylla* (escobo), *Simarouba amara* (Simaruba) and *Mauritia flexuosa* (Moriche).

Figure 4.136: Basal area and volume by species in gallery forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Floristic diversity

Table 4.75 shows the results obtained for the mix ratio and the richness and diversity indexes for the trees of the gallery forest, taking into account that 944 individuals and 109 species were reported in an analyzed area of 2.1 hectares.

Table 4.75: Richness and diversity indexes for trees of the gallery forest.

No. Species	No. Individuals	RICHNESS			DIVERSITY	
		Margalef	Cm		Shannon	Simpson
109	944	15,77	0,12	1:9	3,88	0,036

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Margalef Index

This index estimates the richness of a community based on the numeric distribution of individuals of the different species, depending on the number of individuals in the sample analyzed. It is assumed that values lower than two determine a low diversity and when they are higher than five, they indicate a high floristic diversity. For trees of this coverage, a value of 15.77 was determined which represents a very high richness and a quite heterogeneous forest in species composition.

Mix ratio

This parameter measures the mix intensity of the species in the sampled area, for trees in the gallery forest showed a value of 0.12 which is equivalent to a relationship 1:9, that is, it is assumed that each species is represented by 9 individuals on the average or that every 9 individuals a different species is reported; if the number of individuals (sample size) is taken into account, this value suggests a high species heterogeneity in this coverage.

Shannon-Wiener Index

This index allows calculating the sum of probabilities of the species and the homogeneity of the distribution for a given number of species, taking into account that the maximum possible value to obtain is the natural logarithm of the number of individuals (944), corresponding to a value of 6.95, which would indicate that all species are equally abundant. For trees of the gallery forest a value of 3.88 was determined, a datum representing a medium value with tendency to the estimate, determining that the species found in this coverage tend to be equally abundant indicating a medium-high heterogeneity and floristic diversity.

Simpson Index

The Simpson index refers to the probability that two individuals of a community taken at random, belong to the same species, measures the degree of concentration an varies between 0 and 1; when the diversity is low tends to 1. For trees in the gallery forest, a value of 0.036 was determined which indicates a very low probability that two individuals taken at random be of the same species; this means that there exists a high specific heterogeneity, that is a high floristic diversity in this coverage.

Natural regeneration gallery Forest

Within the sub-plots of the sampling units made for the characterization of the gallery forest, a total of 586 individuals of natural regeneration were recorded, corresponding to 234 pole stands (in an area of 1050 m^2) and 352 saplings (in an area of 168 m^2).

Floristic composition of the natural regeneration

The 586 reported individuals for the natural regeneration of the gallery forest, are grouped in 37 families, 70 genders and 82 species. At a specific level stands out the family: Leguminosae with 8 species, followed by Areaceae and Chrysobalanaceae with 5 species each one and Euphorbiaceae, Myrtaceae y Rubiaceae with 4 species each one; at a gender level stands out *Licania* with 3 species. Table 4.76 shows the floristic composition of the natural regeneration, as well as the number of individuals found by species for each one of the size categories.

Table 4.76: Floristic composition of the natural regeneration in gallery forest.

FAMILY	GENDER	SPECIES	COMMON NAME	Pole stand	Sap ling	To tal
Anacardiaceae	*Astronium*	*Astronium graveolens* Jacq.	Abejón	1		1
	Tapirira	*Tapirira guianensis* Aubl.	Guarupayo	2		2
Annonaceae	*Guatteria*	*Guatteria schomburgkiana* Mart.	Majagüillo negro	2	12	14
	Xylopia	*Xylopia aromatica* (Lam.) Mart.	Malagueto	1		1
Apocynaceae	*Himatanthus*	*Himatanthus articulatus* (Vahl) Woodson	Platanote	1	5	6
	Malouetia	*Malouetia virescens* Spruce ex Müll.Arg.	Palo de boya	3	4	7
	Parahancornia	*Parahancornia oblonga* (Benth. ex Müll.Arg.) Monach.	Pendare		4	4

FAMILY	GENDER	SPECIES	COMMON NAME	Pole stand	Sap ling	To tal
	Tabernaemontana	*Tabernaemontana siphilitica* (L.f.) Leeuwenb.	Sanango		6	6
Araliaceae	*Dendropanax*	*Dendropanax arboreus* (L.) Decne. & Planch.	Mantequillo	1	2	3
Arecaceae	*Astrocaryum*	*Astrocaryum aculeatum* G.Mey.	Cubarro	3	9	12
	Euterpe	*Euterpe precatoria* Mart.	Manaco	26	19	45
	Mauritia	*Mauritia flexuosa* L.f.	Moriche		3	3
	Oenocarpus	*Oenocarpus bacaba* Mart.	Maporilla	1		1
	Socratea	*Socratea exorrhiza* (Mart.) H.Wendl.	Choapo	1		1
Bignoniaceae	*Jacaranda*	*Jacaranda copaia* (Aubl.) D.Don	Pavito		5	5
Burseraceae	*Protium*	*Protium glabrescens* Swart	Anime	2	13	15
		Protium heptaphyllum (Aubl.) Marchand	Anime	2	33	35
	Tetragastris	*Tetragastris panamensis* (Engl.) Kuntze	Caraño blanco		7	7
Calophyllaceae	*Caraipa*	*Caraipa llanorum* Cuatrec.	Saladillo rojo	2	4	6
Chrysobalanaceae	*Hirtella*	*Hirtella elongata* Mart. & Zucc.	Garrapato	4	3	7
		Hirtella racemosa Lam.	Huesito	4	3	7
	Licania	*Licania hypoleuca* Benth.	Escobo blanco		2	2
		Licania leucosepala Griseb.	Aceituno	1	1	2
		Licania parvifructa Fanshawe & Maguire	Escobo colorado		2	2
	Parinari	*Parinari pachyphylla* Rusby	Escobo	4	7	11
Clusiaceae	*Calophyllum*	*Calophyllum brasiliense* Cambess.	Cachicamo		12	12
	Garcinia	*Garcinia madruno* (Kunth) Hammel	Madroño		2	2
	Symphonia	*Symphonia globulifera* L.f.	Breo		3	3
Connaraceae	*Connarus lambertii (DC.)*	*Connarus lambertii* (DC.) Britton	Sangrito	2		2
Ebenaceae	*Diospyros*	*Diospyros sericea* A.DC.	Carbonero	2	7	9
Euphorbiaceae	*Alchornea*	*Alchornea triplinervia* (Spreng.) Müll.Arg.	Carnegallina	1		1
	Mabea	*Mabea nitida* Spruce ex Benth.	Lechero blanco	1		1
		Mabea trianae Pax	Canilla de venado	15	11	26
	Sapium	*Sapium glandulosum* (L.) Morong	Lechero	1		1
Hypericaceae	*Vismia*	*Vismia baccifera* (L.) Planch. & Triana	Lacre blanco	1	1	2
		Vismia macrophylla Kunth	Punta de lanza	1	4	5
Lauraceae	*Aniba*	*Aniba panurensis* (Meisn.) Mez	Yema de huevo	4	3	7
	Ocotea	*Ocotea bofo* Kunth	Laurel	1		1

FAMILY	GENDER	SPECIES	COMMON NAME	Pole stand	Sap ling	To tal
		Ocotea longifolia Kunth	Laurel matatigre	2	21	23
Lecythidaceae	*Eschweilera*	*Eschweilera parvifolia* Mart. ex DC.	Coco de mono	4	1	5
		Eschweilera tenuifolia (O.Berg) Miers	Copo	1	3	4
Leguminosae	*Copaifera*	*Copaifera pubiflora* Benth.	Aceite		1	1
	Dipteryx	*Dipteryx punctata* (S.F.Blake) Amshoff	Sarrapio		6	6
	Enterolobium	*Enterolobium schomburgkii* (Benth.) Benth.	Dormidero		1	1
	Lonchocarpus	*Lonchocarpus floribundus* Benth.	Matarratón	1		1
	Macrolobium	*Macrolobium multijugum* (DC.) Benth.	Dormilón	1	1	2
	Sclerolobium	*Sclerolobium melanocarpum* Ducke	Pategarza	5	3	8
	Senna	*Senna silvestris* (Vell.) H.S.Irwin & Barneby	Alcaparillo	1		1
	Zygia	*Zygia inaequalis* (Willd.) Pittier	Cimbrapotro	3		3
Linaceae	*Hebepetalum*	*Hebepetalum* sp.	Colorado		2	2
Malpighiaceae	*Byrsonima*	*Byrsonima japurensis* A.Juss.	Coropo	1		1
Melastomataceae	*Henriettea*	*Henriettea goudotiana* (Naudin) Penneys, F.A. Michelangeli, Judd & Almeda	Tuno	3	9	12
	Miconia	*Miconia trinervia* (Sw.) D. Don ex Loudon	Tuno sabanero	2	2	4
Meliaceae	*Guarea*	*Guarea glabra* Vahl	Trompillo blanco	1	3	4
Moraceae	*Brosimum*	*Brosimum lactescens* (S.Moore) C.C.Berg	Guáimaro	7	7	14
Myristicaceae	*Virola*	*Virola carinata* (Spruce ex Benth.) Warb.	Carnevaca blanco		3	3
		Virola parvifolia Ducke	Carnevaca		6	6
Myrtaceae	*Eugenia*	*Eugenia biflora* (L.) DC.	Guayabito sabanero	1	3	4
	Myrcia	*Myrcia paivae* O.Berg	Arrayán	4	21	25
		Myrcia subsessilis O.Berg	Arrayán	5	13	18
	Myrciaria	*Myrciaria floribunda* (H.West ex Willd.) O.Berg	Guayabo montañero	2		2
Ochnaceae	*Ouratea*	*Ouratea castaneifolia* (DC.) Engl.	Lengua de yataro	1		1
	Quiina	*Quiina macrophylla* Tul.	Guayacán	1	4	5
Peraceae	*Pera*	*Pera arborea* Mutis	Pategallina	2	3	5
Phyllanthaceae	*Phyllanthus*	*Phyllanthus attenuatus* Miq.	Totumito	3		3
Polygonaceae	*Coccoloba*	*Coccoloba mollis* Casar.	Uvero	2		2
Proteaceae	*Euplassa*	*Euplassa saxicola* (R.E.Schult.) Steyerm.	Yolombó	1	1	2
Rubiaceae	*Amaioua*	*Amaioua guianensis* Aubl.	Macanillo	5	10	15
	Cordiera	*Cordiera myrciifolia* (K.Schum.) Perss. & Delprete	Macano	5	5	10

FAMILY	GENDER	SPECIES	COMMON NAME	Pole stand	Sap ling	To tal
	Elaeagia	*Elaeagia maguirei* Standl.	Marfil	1		1
	Rudgea	*Rudgea crassiloba* (Benth.) B.L.Rob.	Cafetillo	5	3	8
Sapindaceae	*Cupania*	*Cupania scrobiculata* Rich.	Partemachete	1		1
	Matayba	*Matayba adenanthera* Radlk.	Patepajuil	4	3	7
		Matayba scrobiculata Radlk.	Patepajuil	3		3
Sapotaceae	*Micropholis*	*Micropholis guyanensis* (A.DC.) Pierre	Caimillo	2		2
	Pouteria	*Pouteria guianensis* Aubl.	Caimo	1	2	3
Simaroubaceae	*Simarouba*	*Simarouba amara* Aubl.	Simaruba	4	3	7
Siparunaceae	*Siparuna*	*Siparuna guianensis* Aubl.	Romadizo	18	4	22
Strelitziaceae	*Phenakospermum*	*Phenakospermum guyannense* (A.Rich.) Endl. ex Miq.	Tarriago	37	12	49
Urticaceae	*Cecropia*	*Cecropia peltata* L.	Guarumo	3	1	4
Vochysiaceae	*Vochysia*	*Vochysia ferruginea* Mart.	Botagajo	1		1
		Vochysia lehmannii Hieron.	Saladillo blanco		8	8
Total general				**234**	**352**	**586**

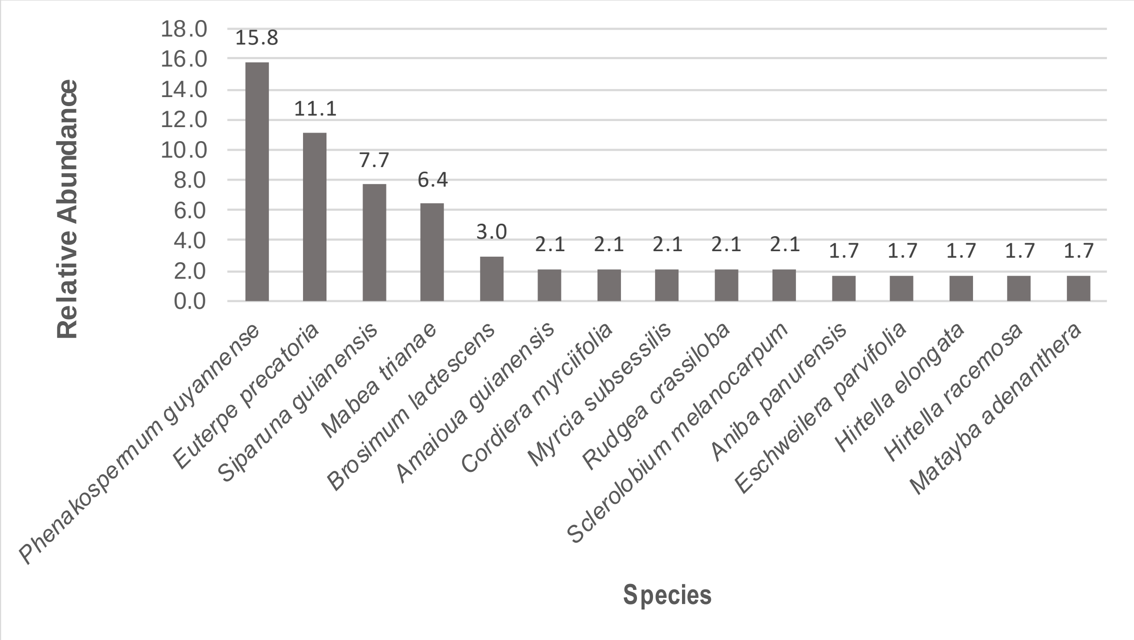
Source: (Universidad Distrital Francisco José De Caldas, 2017)

Relative abundance of natural regeneration

Pole stands

In the analysis of the relative abundance for the pole stands of the gallery forest, the following species stand out: *Phenakospermum guyannense* (Tarriago) with 15.8% of the parameter with 37 individuals, followed by *Euterpe precatoria* (Manaco) with 11.1% (26 individuals), *Siparuna guianensis* (Romadizo) with 7.7% (18 individuals) and *Mabea trianae* (Canilla de venado) with 6.4% (15 individuals); the other species show values less than or equal to 3% of relative abundance (see Figure 4.137). For this parameter for pole stands, like for the trees a structure with a tendency to be heterogeneous is shown.

Figure 4.137: Relative abundance of pole stands in gallery forest.

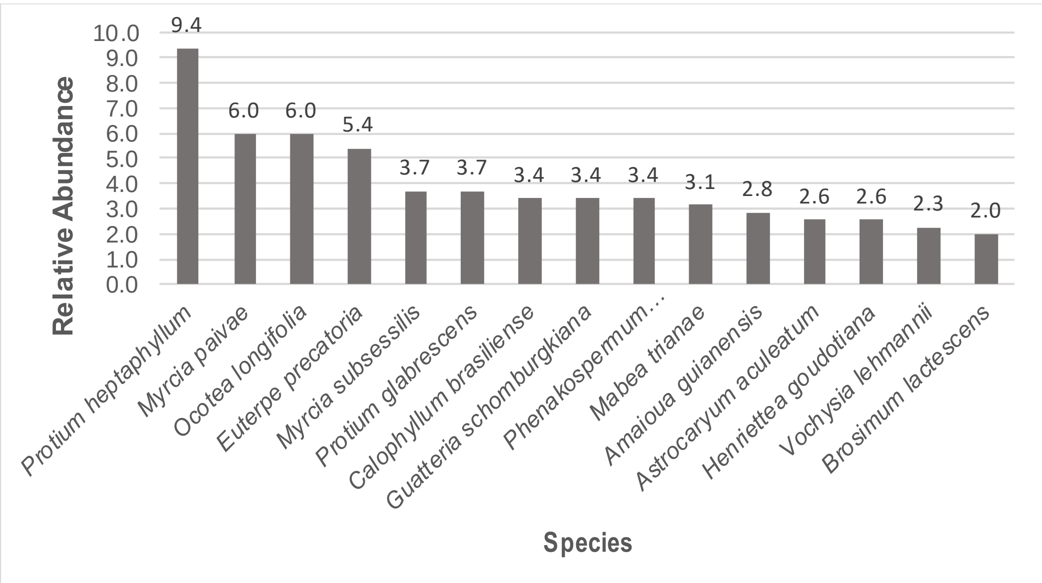


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Saplings

As for relative abundance for Saplings in gallery forest, the species: *Protium heptaphyllum* (Anime) with 9.4% (33 individuals) stands out, followed by *Myrcia paivae* (Arrayán) and *Ocotea longifolia* (Laurel matatigre) with 6% (21 individuals) each one and *Euterpe precatoria* (Manaco) with 5.4% (19 individuals); the other species show values less than 4% (see Figure 4.138). In this size category the structural tendency to heterogeneity in the forest also holds.

Figure 4.138: Relative abundance of saplings in gallery forest.



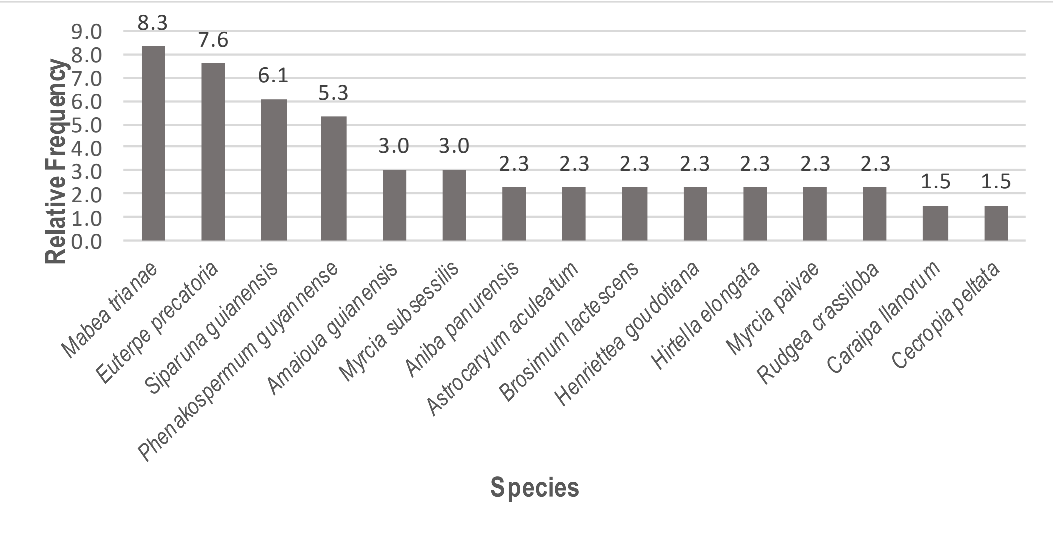
Source: (Universidad Distrital Francisco José De Caldas, 2017)

Relative frequency of the natural regeneration

Pole stands

The most representative species in this parameter for pole stands are: *Mabea trianae* (Canilla de venado) with 8.3% when appearing in 11 of the 21 plots surveyed, followed by *Euterpe precatoria* (Manaco) with 7.6% (report in 10 plots), *Siparuna guianensis* (Romadizo) with 6.1% (report en 8 plots) y *Phenakospermum guyannense* (Tarriago) with 5.3% (report in 7 plots); the other species report values lower than or equal to 3% when reporting in 4 or less plots (see Figure 4.139). According to this analysis, there are no species with very marked differences in relative frequency with respect to others, which determines a heterogeneous horizontal structure for pole stands in the dense forest.

Figure 4.139: Relative frequency of pole stands in gallery forest.

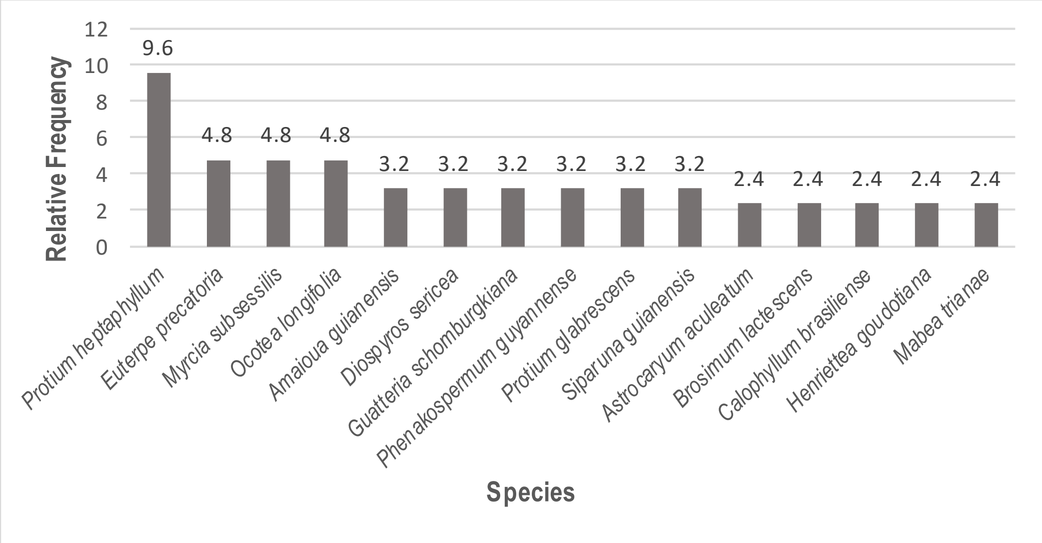


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Saplings

In the analysis of relative frequency for saplings of the gallery forest appears the species *Protium heptaphyllum* (Anime) with 9.6% (report in 12 of the 21 plots surveyed), followed by *Euterpe precatoria* (Manaco), *Myrcia paivae* (Arrayán) and *Ocotea longifolia* (Laurel matatigre) with 4.8% (report in 6 plots) each one; The other species report values lower than 4% when reporting in 4 or less plots (see Figure 4.140). The saplings of the gallery forest show the same tendency of all the coverage as for structural heterogeneity, however with a little more uniformity when showing a species with high frequency.

Figure 4.140: Relative frequency of saplings in gallery forest.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

- **Morichal**

The information necessary for the characterization of the Morichales in the area of influence of the Project, was taken through the field survey of 7 sampling units of 0.1 hectares each one, in four sampling zones, for a total sampled area of 0.7 hectares; in Table 4.77 the geographic coordinates both in the start and final points of each plot are shown.

Table 4.77: Location data of the plots surveyed in Morichal.

CODE	START POINT		FINAL POINT	
	X	Y	X	Y
Mor1	918301,46	1171314	918209,163	1171277
Mor2	919826,18	1171026	918053,22	1171099
Mor3	915048,48	1160636	915042,335	1160642
Mor4	916398,95	1160908	916330,502	1160837
Mor5	937636,3	1166163	937706,318	1166233
Mor6	1001144,6	1169546	1001052,41	1169510
Mor7	1001052,4	1169310	1001095,45	1169399

Source: (Universidad Distrital Francisco José De Caldas, 2017). flat coordinates coordenadas Magna Colombia Este Este

For the Morichal covering, a relative sampling error lower than 15% with a probability of 95% was accomplished. In Table 4.78 the different statisticians calculated for this coverage from the variable total volume, with which a sampling error of 7.9% in the inventory for this coverage was determined.

Table 4.78: Statisticians for Morichal.

STATISTICIAN	VALUE
Sum	233,46
Average	33,35
Standard deviation	3,59

STATISTICIAN	VALUE
Variation coefficient (%)	10,76
Relative error required (%)	15
Sample size (n)	7
Student t Variable degrees of freedom (n – 1), probability 95%	1,94
Standard error	1,36
Absolute error	2,64
Relative error%	**7,90**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Floristic composition

In the analysis of the floristic composition for the trees of the Morichal, 375 individuals distributed in 22 families, 29 genders and 30 species were found. At a specific level the families Clusiaceae with 3 species and Annonaceae, Apocynaceae, Arecaceae, Calophyllaceae, Moraceae y Myristicaceae with 2 species each one stand out, the other families present one species each one; at gender level *Virola* with two species stands out, the other genders present one species each one, as shown in Table 4.79.

Table 4.79: Floristic composition of trees in Morichal.

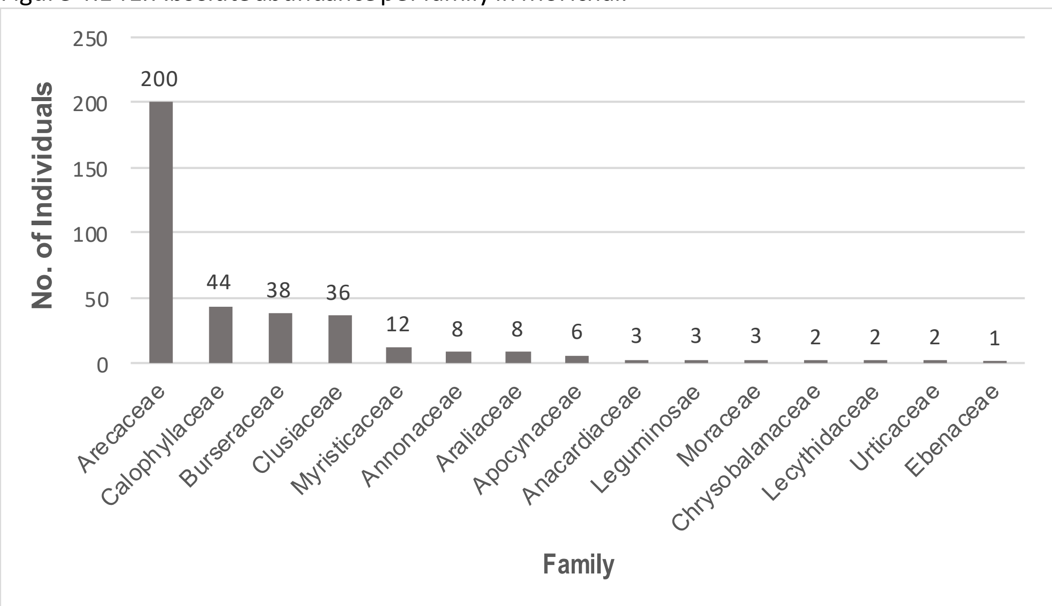
FAMILY	GENDER	SPECIES	COMMON NAME	ABUN.
Anacardiaceae	*Tapirira*	*Tapirira guianensis* Aubl.	Guarupayo	3
Annonaceae	*Guatteria*	*Guatteria schomburgkiana* Mart.	Majagüillo negro	7
	Xylopia	*Xylopia emarginata* Mart.	Majagüillo	1
Apocynaceae	*Malouetia*	*Malouetia virescens* Spruce ex Müll.Arg.	Palo de boya	2
	Parahancornia	*Parahancornia oblonga* (Benth. ex Müll.Arg.) Monach.	Pendare	4
Araliaceae	*Dendropanax*	*Dendropanax arboreus* (L.) Decne. & Planch.	Mantequillo	8
Arecaceae	*Euterpe*	*Euterpe precatoria* Mart.	Manaco	50
	Mauritia	*Mauritia flexuosa* L.f.	Moriche	150
Burseraceae	*Protium*	*Protium glabrescens* Swart	Anime	38
Calophyllaceae	*Caraipa*	*Caraipa llanorum* Cuatrec.	Saladillo rojo	29
	Mahurea	*Mahurea exstipulata* Benth.	Caucho amarillo	15
Chrysobalanaceae	*Hirtella*	*Hirtella elongata* Mart. & Zucc.	Garrapato	2
Clusiaceae	*Calophyllum*	*Calophyllum brasiliense* Cambess.	Cachicamo	32
	Garcinia	*Garcinia madruno* (Kunth) Hammel	Madroño	1
	Symphonia	*Symphonia globulifera* L.f.	Breo	3
Ebenaceae	*Diospyros*	*Diospyros sericea* A.DC.	Carbonero	1
Euphorbiaceae	*Alchornea*	*Alchornea discolor* Poepp.	Algodoncillo	1
Hypericaceae	*Vismia*	*Vismia macrophylla* Kunth	Punta de lanza	1
Lauraceae	*Endlicheria*	*Endlicheria verticillata* Mez	Amarillo	1

FAMILY	GENDER	SPECIES	COMMON NAME	ABUN.
Lecythidaceae	*Eschweilera*	*Eschweilera parvifolia* Mart. ex DC.	Coco de mono	2
Leguminosae	*Hydrochorea*	*Hydrochorea corymbosa* (Rich.) Barneby & J.W.Grimes	Dormilón	3
Malvaceae	*Pachira*	*Pachira sessilis* Benth.	Ceiba paquira	1
Moraceae	*Brosimum*	*Brosimum lactescens* (S.Moore) C.C.Berg	Guáimaro	1
	Maquira	*Maquira coriacea* (H.Karst.) C.C.Berg	Lechero	2
Myristicaceae	*Virola*	*Virola carinata* (Spruce ex Benth.) Warb.	Carnevaca blanco	6
		Virola parvifolia Ducke	Carnevaca	6
Myrtaceae	*Myrcia*	*Myrcia subsessilis* O.Berg	Arrayán	1
Ochnaceae	*Quiina*	*Quiina macrophylla* Tul.	Guayacán	1
Rubiaceae	*Duroia*	*Duroia micrantha* (Ladbr.) Zarucchi & J.H.Kirkbr.	Turmemico	1
Urticaceae	*Cecropia*	*Cecropia peltata* L.	Guarumo	2
Total general				**375**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

In the analysis of absolute abundance per family in Morichal, the most representative is Arecaceae with 200 individuals which is equivalent to 53.3% of the abundance; the other meaningful families are: Calophyllaceae, Burseraceae and Clusiaceae with 48, 38 y 36 individuals respectively, which is equivalent to relative values between 11.7 and 9.6% of the total (see Figure 4.141).

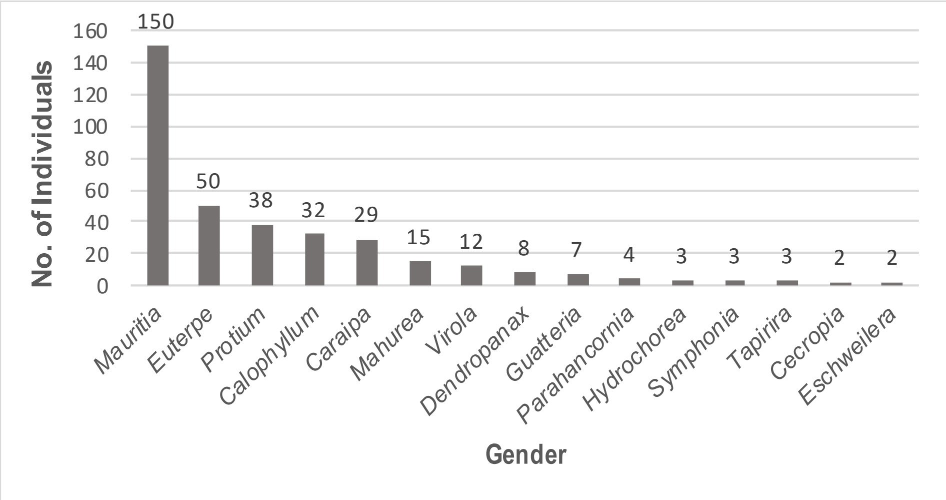
Figure 4.141: Absolute abundance per family in Morichal.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

As for the abundance of individuals by gender, *Mauritia* appears as the most representative reporting 150 individuals, which is equivalent to 40% of the abundance, other genders with a certain representation in abundance are: Euterpe, Protium, Calophyllum and Caraipa (see Figure 4.142).

Figure 4.142: Absolute abundance by gender in Morichal.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

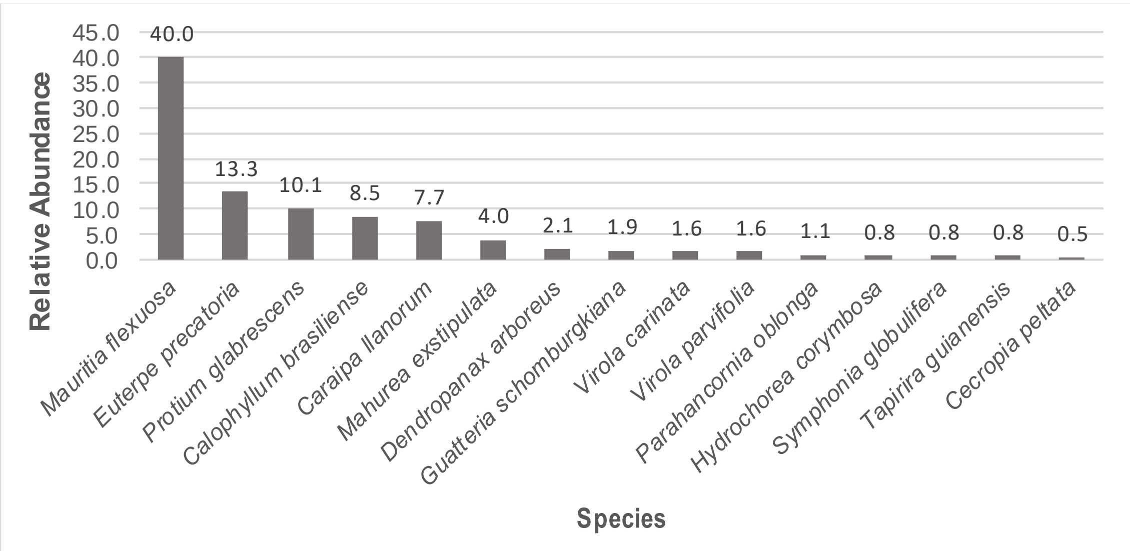
Horizontal Structure

For the characterization of the horizontal structure of the Morichal, the importance value index and the parameters: abundance, frequency and relative dominance were used, likewise the frequency histogram was built and the degree of aggregation was determined.

Relative abundance

In the analysis of this parameter for the Morichal, evidently the species: *Mauritia flexuosa* (Moriche) with 40.0% (150 individuals) stands out, followed in a lesser proportion by: *Euterpe precatoria* (Manaco) with 13.3% (50 individuals), *Protium glabrescens* (Anime) with 10.1% (38 individuals), *Calophyllum brasiliense* (Cachicamo) with 8.5% (32 individuals) and *Caraipa llanorum* (Saladillo rojo) with 7.7% (29 individuals); the other species report values lower than or equal to 4% of relative abundance (see Figure 4.143). This parameter allows inferring that the Morichal tends to be homogeneous in composition, to show such a marked abundance of a species.

Figure 4.143: Relative abundance in Morichal.

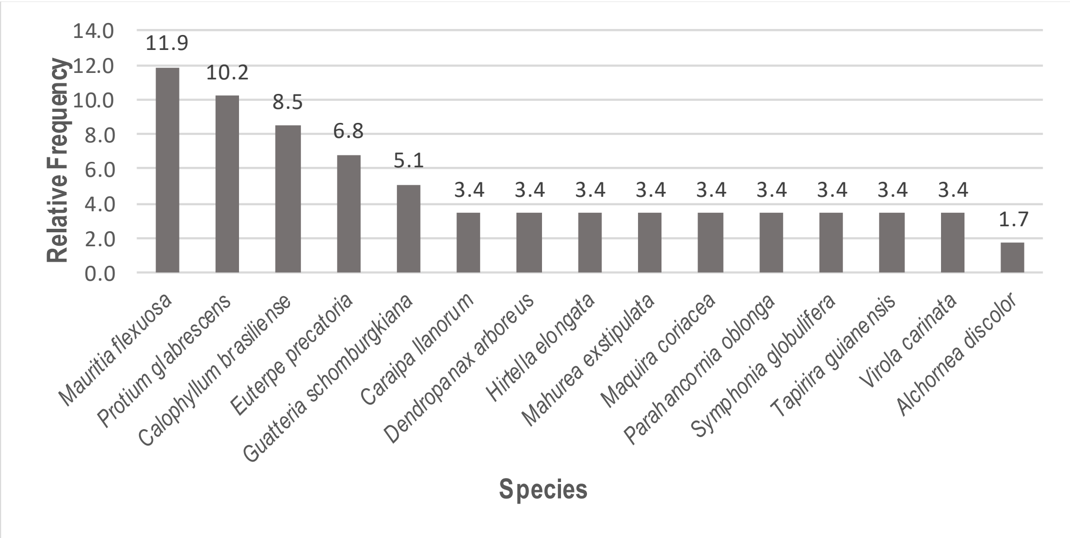


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Relative frequency

The most representative species in this parameter for the Morichal are: *Mauritia flexuosa* (Moriche), *Protium glabrescens* (Anime), *Calophyllum brasiliense* (Cachicamo), *Euterpe precatoria* (Manaco) and *Guatteria schomburgkiana* (Majagüillo negro) with values between 11.9 and 5.1% (report between 7 and 3 plots); the other species report less than 4% of the relative frequency when reporting in two or less plots (see Figure 4.144). For this parameter a tendency similar to the gallery forest is shown, but with a lesser proportion which determines to this coverage to be more homogeneous in regard to the appearance of the species in the sampling units.

Figure 4.144: Relative frequency in Morichal.

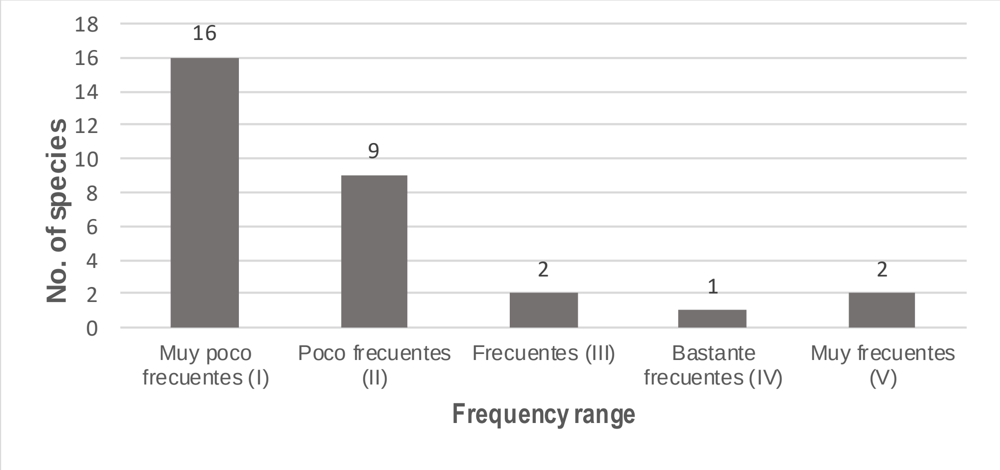


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Frequency histogram

The frequency histogram for the Morichal (Figure 4.145), shows that in a little more than half of the species are in the category very rare, represented with 53.3% (16 species), followed by category infrequent with 30% (9 species), then the category frequent and the category Very frequent with 6.7% (two species) each one and finally the category quite frequent with only 3.3% (one species). This behaviour shows for this parameter, the condition of homogeneity mentioned in terms of frequency of the species and is a typical condition of this type of coverings.

Figure 4.145: Frequency histogram for Morichal.

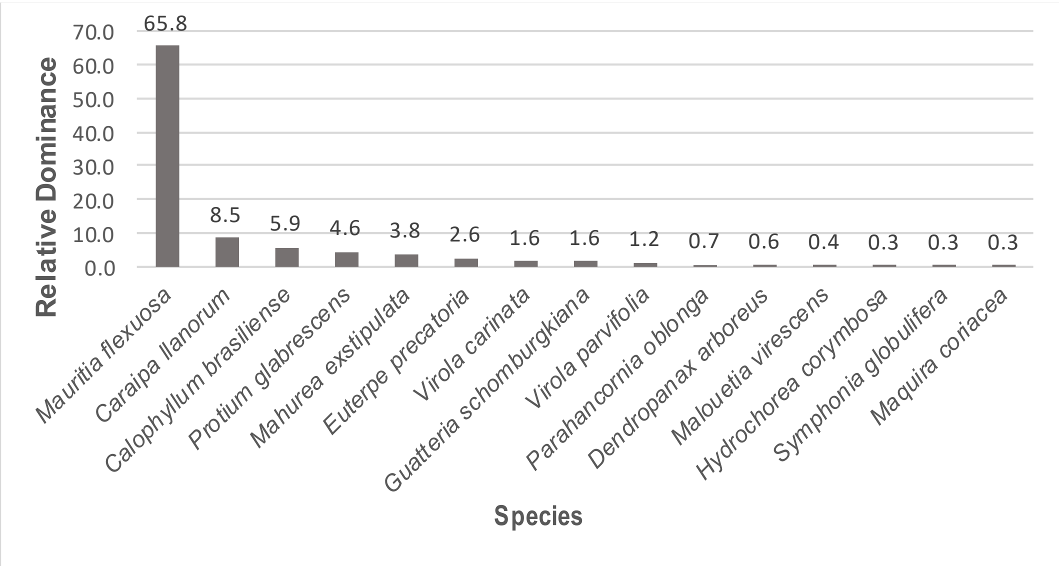


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Relative dominance

In the analysis of this parameter for the Morichal, it is appreciated a species with a marked dominance and corresponds to the species *Mauritia flexuosa* (Moriche) with 65.8% of relative dominance, other species with some significance are: *Caraipa llanorum* (Saladillo rojo), *Calophyllum brasiliense* (Cachicamo) and *Protium glabrescens* (Anime), with values between 8.5 and 4.6% respectively, while the other species show values less than 4% (see Figure 4.146). This is attributed to the abundance of the species and to the bearing of the individuals in the coverage.

Figure 4.146: Relative dominance in Morichal.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Importance value index (IVI)

In Table 4.80 the abundance, dominance, frequency and importance value index (IVI) values are shown, for each one of the species found in the category of tree size in the Morichal.

Table 4.80: Importance value index in Morichal.

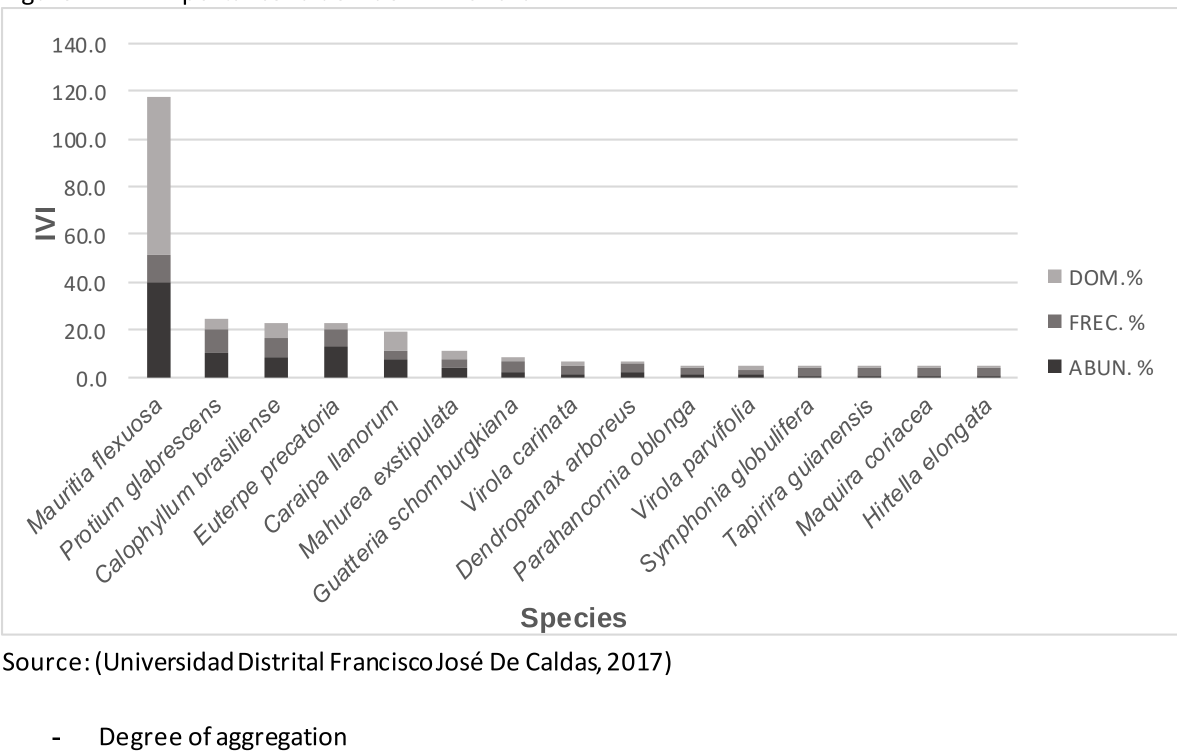
SPECIES	COMMON NAME	ABUND.	FREC.	DOM.	ABUN. %	FREC. %	DOM.%	IVI	IVI %
Alchornea discolor	Algodoncillo	1	14,3	0,0	0,3	1,7	0,1	2,1	0,7
Brosimum lactescens	Guáimaro	1	14,3	0,0	0,3	1,7	0,1	2,1	0,7
Calophyllum brasiliense	Cachicamo	32	71,4	1,2	8,5	8,5	5,9	22,9	7,6
Caraipa llanorum	Saladillo rojo	29	28,6	1,7	7,7	3,4	8,5	19,6	6,5
Cecropia peltata	Guarumo	2	14,3	0,0	0,5	1,7	0,2	2,4	0,8
Dendropanax arboreus	Mantequillo	8	28,6	0,1	2,1	3,4	0,6	6,1	2,0
Diospyros sericea	Carbonero	1	14,3	0,0	0,3	1,7	0,0	2,0	0,7
Duroia micrantha	Turmemico	1	14,3	0,0	0,3	1,7	0,1	2,0	0,7
Endlicheria verticillata	Amarillo	1	14,3	0,0	0,3	1,7	0,0	2,0	0,7
Eschweilera parvifolia	Coco de mono	2	14,3	0,0	0,5	1,7	0,2	2,4	0,8
Euterpe precatoria	Manaco	50	57,1	0,5	13,3	6,8	2,6	22,7	7,6
Garcinia madruno	Madroño	1	14,3	0,0	0,3	1,7	0,1	2,1	0,7
Guatteria schomburgkiana	Majagüillo negro	7	42,9	0,3	1,9	5,1	1,6	8,5	2,8
Hirtella elongata	Garrapato	2	28,6	0,0	0,5	3,4	0,2	4,2	1,4
Hydrochorea corymbosa	Dormilón	3	14,3	0,1	0,8	1,7	0,3	2,8	0,9
Mahurea exstipulata	Caucho amarillo	15	28,6	0,8	4,0	3,4	3,8	11,2	3,7
Malouetia virescens	Palo de boya	2	14,3	0,1	0,5	1,7	0,4	2,6	0,9
Maquira coriacea	Lechero	2	28,6	0,1	0,5	3,4	0,3	4,2	1,4
Mauritia flexuosa	Moriche	150	100,0	13,2	40,0	11,9	65,8	117,6	39,2
Myrcia subsessilis	Arrayán	1	14,3	0,0	0,3	1,7	0,0	2,0	0,7
Pachira sessilis	Ceiba paquira	1	14,3	0,0	0,3	1,7	0,1	2,0	0,7
Parahancornia oblonga	Pendare	4	28,6	0,1	1,1	3,4	0,7	5,2	1,7
Protium glabrescens	Anime	38	85,7	0,9	10,1	10,2	4,6	24,9	8,3
Quiina macrophylla	Guayacán	1	14,3	0,0	0,3	1,7	0,0	2,0	0,7

SPECIES	COMMON NAME	ABUND.	FREC.	DOM.	ABUN. %	FREC. %	DOM.%	IVI	IVI %
Symphonia globulifera	Breo	3	28,6	0,1	0,8	3,4	0,3	4,5	1,5
Tapirira guianensis	Guarupayo	3	28,6	0,0	0,8	3,4	0,2	4,4	1,5
Virola carinata	Carnevaca blanco	6	28,6	0,3	1,6	3,4	1,6	6,6	2,2
Virola parvifolia	Carnevaca	6	14,3	0,2	1,6	1,7	1,2	4,5	1,5
Vismia macrophylla	Punta de lanza	1	14,3	0,0	0,3	1,7	0,1	2,0	0,7
Xylopia emarginata	Majagüillo	1	14,3	0,0	0,3	1,7	0,1	2,1	0,7
Total general		**375**	**842,9**	**20,0**	**100,0**	**100,0**	**100,0**	**300,0**	**100,0**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

The analysis of the importance value index for this coverage, shows the species: *Mauritia flexuosa* (Moriche) as the most representative or the one with the highest ecological weight, with a net value of 117,6 (over 300), corresponding to a percentage of 39.2%; other species with significant values are: *Protium glabrescens* (Anime), *Calophyllum brasiliense* (Cachicamo), *Euterpe precatoria* (Manaco) and *Caraipa llanorum* (Saladillo rojo), with net values between 24.9 and 19.6 corresponding to percentages between 8.3% and 6.5%; the other species report values lower than 4% of the total determined for this parameter (see Figure 4.147). As shown individually in each parameter, the Morichal is quite homogeneous, by showing a high importance of a species.

Figure 4.147: Importance value index in Morichal.

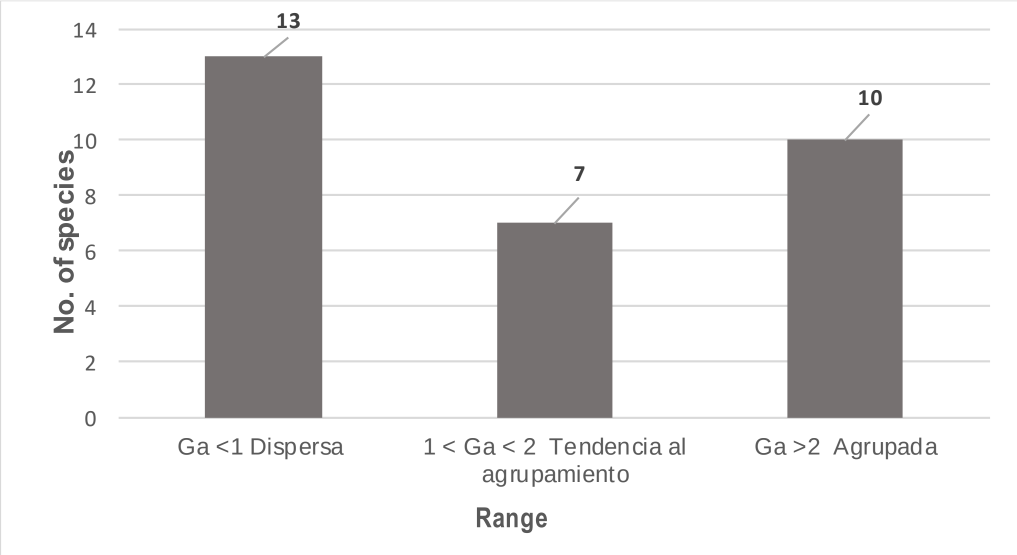


Source: (Universidad Distrital Francisco José De Caldas, 2017)

- Degree of aggregation

In the analysis of degree of aggregation of the species in Morichal, it was determined that 13 species, equivalent to 43.3% of the total, have a disperse distribution, while 10 species (33.3%) are grouped and the remaining 7 species have a tendency to grouping (see Figure 4.148); in this analysis are included species that are not necessarily abundant and frequent but that do tend to group in few plots. This parameter shows in general terms that the Morichal despite being homogeneous in terms of the distribution of species in space, for the dominance of a species, a significant portion of the species is disperse.

Figure 4.148: Degree of aggregation in Morichal.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Vertical structure

For the analysis of the vertical structure of the Morichal the sociological position was determined also and the Ogawa diagram and the vegetation profile were built.

Sociological position

In order to define the sociological position of the Morichal the three strata were determined, dividing the difference of the maximum and minimum values reported in the trees inventory corresponding to 32 and 7 meters respectively, which allowed to establish a range of 8.3 meters in height for each stratum.

In the vertical stratification of this coverage, carried out for the analysis of sociological position, it is observed that 51.2% of the sampled individuals (192), is grouped in the lower stratum with heights between 7 and 15.3 meters, while 39.7% (149 individuals) is in the middle stratum with heights greater than 15.3 meters and less than or equal to 23.7 meters and the remaining 3.2% (34 individuals) is in the higher stratum with heights greater than 23.7 meters and less than or equal to 32 meters (see Table 4.81). This suggests that the Morichal is formed predominantly by individuals of medium-low bearing with some emergent trees.

Table 4.81: Vertical stratification in Morichal.

STRATUM	HEIGHT RANGE (m)	NUMBER OF INDIVIDUALS	% INDIVIDUALS
Lower stratum	7 - 15,3	192	51,2
Middle stratum	> 15,3 - 23,7	149	39,7
Higher stratum	> 23,7 - 32	34	9,1
TOTAL		**375**	**100,0**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

With the strata defined, the phytosociological value was determined for each one and the absolute and relative sociological position value for each species was obtained as shown in Table 4.82.

Table 4.82: Sociological position in Morichal.

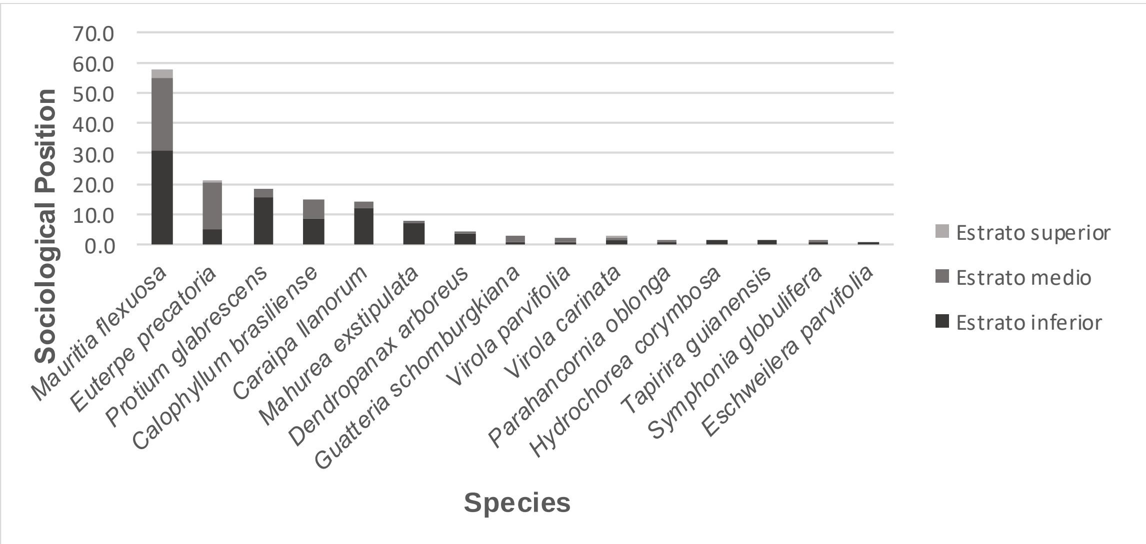
SPECIES	COMMON NAME	CT1	CT2	CT3	Total	Lower stratum	Middle stratum	Higher stratum	Psa	Ps%
Alchornea discolor	Algodoncillo		1		1	0,0	0,4	0,0	0,4	0,2
Brosimum lactescens	Guáimaro	1			1	0,5	0,0	0,0	0,5	0,3
Calophyllum brasiliense	Cachicamo	16	16		32	8,2	6,4	0,0	14,5	9,1
Caraipa llanorum	Saladillo rojo	23	6		29	11,8	2,4	0,0	14,2	8,8
Cecropia peltata	Guarumo	1	1		2	0,5	0,4	0,0	0,9	0,6
Dendropanax arboreus	Mantequillo	7	1		8	3,6	0,4	0,0	4,0	2,5
Diospyros sericea	Carbonero		1		1	0,0	0,4	0,0	0,4	0,2
Duroia micrantha	Turmemico		1		1	0,0	0,4	0,0	0,4	0,2
Endlicheria verticillata	Amarillo	1			1	0,5	0,0	0,0	0,5	0,3
Eschweilera parvifolia	Coco de mono	2			2	1,0	0,0	0,0	1,0	0,6
Euterpe precatoria	Manaco	10	38	2	50	5,1	15,1	0,2	20,4	12,7
Garcinia madruno	Madroño	1			1	0,5	0,0	0,0	0,5	0,3
Guatteria schomburgkiana	Majagüillo negro	2	5		7	1,0	2,0	0,0	3,0	1,9
Hirtella elongata	Garrapato	2			2	1,0	0,0	0,0	1,0	0,6
Hydrochorea corymbosa	Dormilón	3			3	1,5	0,0	0,0	1,5	1,0
Mahurea exstipulata	Caucho amarillo	14	1		15	7,2	0,4	0,0	7,6	4,7
Malouetia virescens	Palo de boya	1	1		2	0,5	0,4	0,0	0,9	0,6
Maquira coriacea	Lechero	2			2	1,0	0,0	0,0	1,0	0,6
Mauritia flexuosa	Moriche	61	59	30	150	31,2	23,4	2,7	57,4	35,7
Myrcia subsessilis	Arrayán	1			1	0,5	0,0	0,0	0,5	0,3
Pachira sessilis	Ceiba paquira	1			1	0,5	0,0	0,0	0,5	0,3
Parahancornia oblonga	Pendare	2	2		4	1,0	0,8	0,0	1,8	1,1
Protium glabrescens	Anime	31	7		38	15,9	2,8	0,0	18,7	11,6
Quiina macrophylla	Guayacán	1			1	0,5	0,0	0,0	0,5	0,3
Symphonia globulifera	Breo	2	1		3	1,0	0,4	0,0	1,4	0,9

SPECIES	COMMON NAME	CT1	CT2	CT3	Total	Lower stratum	Middle stratum	Higher stratum	Psa	Ps%
Tapirira guianensis	Guarupayo	3			3	1,5	0,0	0,0	1,5	1,0
Virola carinata	Carnevaca blanco	3	1	2	6	1,5	0,4	0,2	2,1	1,3
Virola parvifolia	Carnevaca	1	5		6	0,5	2,0	0,0	2,5	1,6
Vismia macrophylla	Punta de lanza		1		1	0,0	0,4	0,0	0,4	0,2
Xylopia emarginata	Majagüillo		1		1	0,0	0,4	0,0	0,4	0,2
Total general		**192**	**149**	**34**	**375**				**160,6**	**100,0**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

The analysis of the absolute sociological position (see Figure 4.149), shows for the Morichal the species: *Mauritia flexuosa* (Moriche) as the most representative, which appears in all the forest strata and assures its place in the vertical structure, with a net value of 57.4 equivalent to 35.7% of the total; other species with some significance are: *Euterpe precatoria* (Manaco), *Protium glabrescens* (Anime), *Calophyllum brasiliense* (Cachicamo) and *Caraipa llanorum* (Saladillo rojo), with net values between 20.4 and 14.2 equivalent to relative values between 12.7 and 8.8%. The other species show values lower than 5% of this relative parameter. In general terms the high representation of a species in the sociological position, suggests a tendency to homogeneity of this coverage in this parameter.

Figure 4.149: Sociological Position in the Morichal.

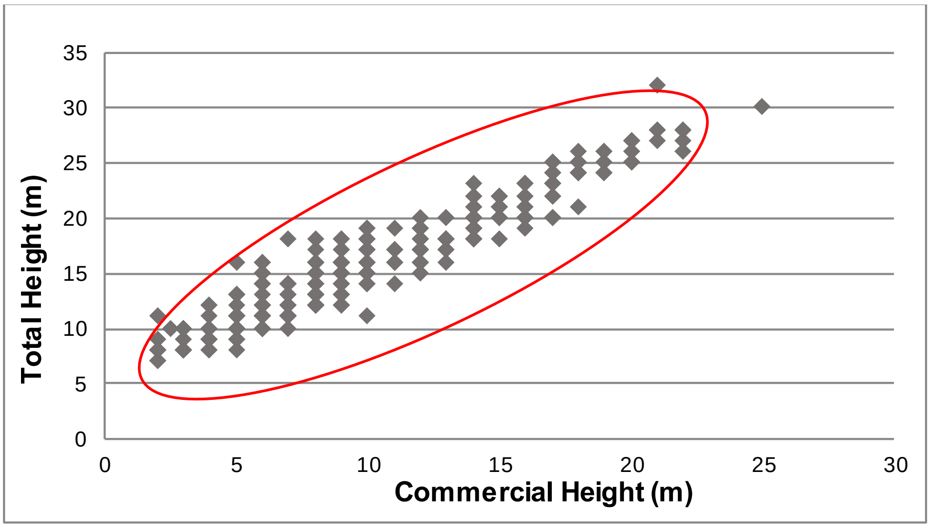


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Ogawa's Stratification

Using Ogawas's technique to analyze the dispersion of treetops, (Figure 4.150), the presence of individuals is observed throughout the canopy in a continuous manner, making it difficult to differentiate stratum. Nevertheless, a certain group of individuals can be seen in a large stratum, with total heights between 8 and 24 meters and commercial heights between 5 and 18 meters.

Figure 4.150: Ogawa's dispersion diagram for the Palm Swamp.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Vegetation Profile

In order to build the Palm Swamp's vegetation structural profile, a graphic representation of the individuals of the 7 species found in the selected type plot (Mor5) was designed, with some of their recorded architectural characteristics. Table 4.83 shows the graphic representation of each of these species.

Table 4.83: Graphic representation of species for the Palm Swamp.

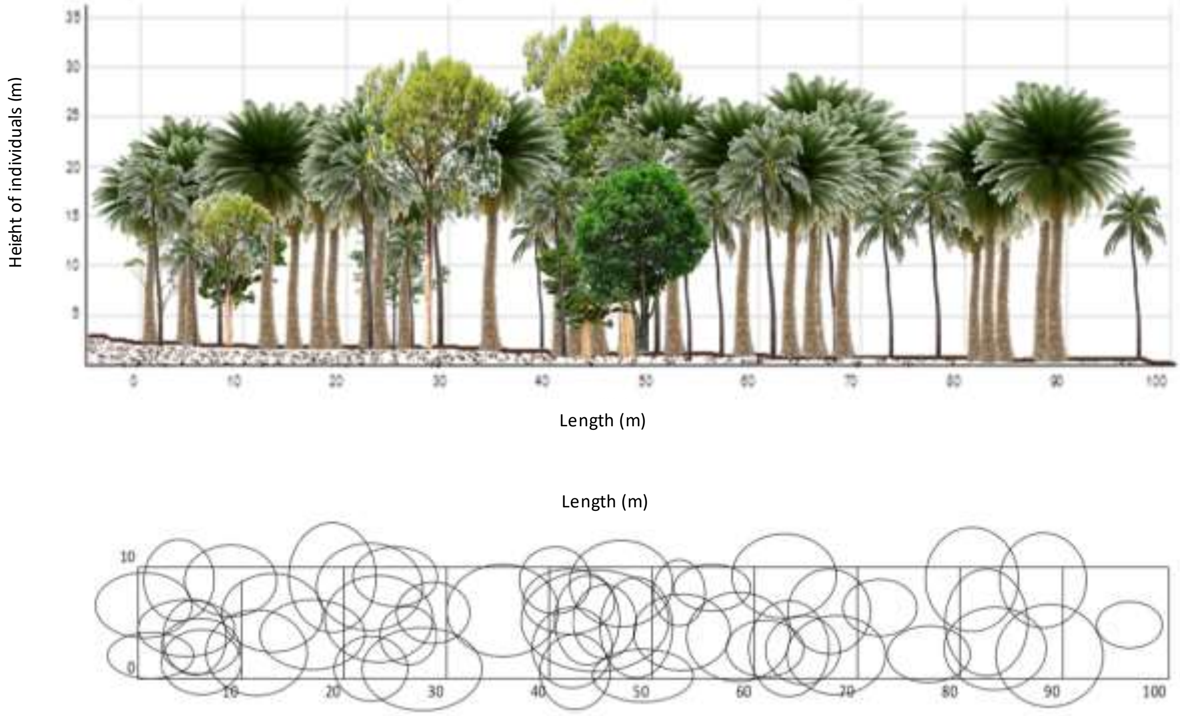
VIEW	SPECIES	COMMON NAME	VIEW	SPECIES	COMMON NAME
	*Cecropia peltata*	Guarumo		*Symphonia globulifera*	Breo
	*Euterpe precatoria*	Manaco		*Virola carinata*	Carnevaca blanco
	*Malouetia virescens*	Palo de boya		*Xylopia emarginata*	Majagüillo
	*Mauritia flexuosa*	Moriche			

Source: (Universidad Distrital Francisco José De Caldas, 2017)

The vegetation structural profile for the palm swamp and for the gallery forest shows a continuous structure of treetops in the vertical visual structure, making it difficult to differentiate the stratum and evidencing the presence of few emerging individuals. Likewise, a clear dominance of the *Mauritia flexuosa* (Moriche) may be observed in the vertical structure, giving its name to the cover area.

On the other hand, for the horizontal structure, a good proportion of cover may be observed on the ground, leaving just a few uncovered areas, making it difficult for the light to penetrate due to the continuous canopy. This condition also evidences a high degree of conservation of this natural cover (Figure 4.151).

Figure 4.151: Vegetation structural profile of the Palm Swamp.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Altimetric distribution by class intervals

In order to distribute the individuals classified as mature, in the corresponding altimetric class interval, the Palm Swamp was divided into 10 intervals, with a class range of 2.5 meters. Table 4.84 shows the altimetric classes with their corresponding range, quantity and percentage of individuals for this cover area.

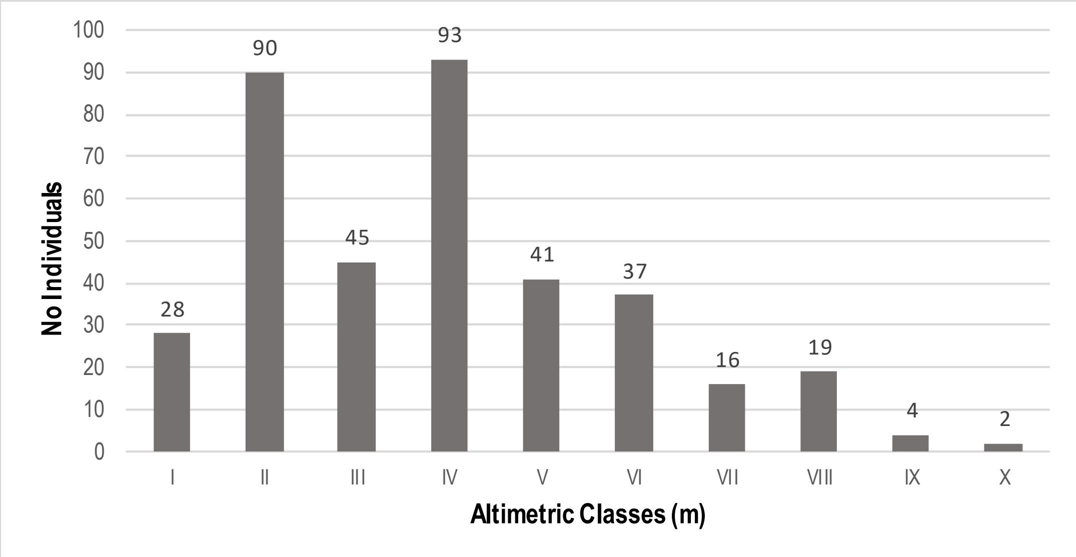
Table 4.84: Altimetric distribution for the Palm Swamp (Morichal).

Altimetric Class	Range (m)	No. Individuals	% Individuals
I	7 - 9,50	28	7,5
II	9,51 - 12,01	90	24,0
III	12,02 - 14,52	45	12,0
IV	14,53 - 17,03	93	24,8
V	17,04 - 19,54	41	10,9
VI	19,55 - 22,05	37	9,9
VII	22,06 - 24,56	16	4,3
VIII	24,57 - 27,07	19	5,1
IX	27,08 - 29,58	4	1,1
X	29,59 - 32,02	2	0,5
Overall total		**375**	**100,0**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Figure 4.152 shows the distribution of individuals in class intervals for the Palm Swamp, in which intermediate classes**Error! Reference source not found.** IV and II present the largest values, with 93 and 90 individuals respectively (24.8% and 24% of the total), followed by classes III, V and VI, ranging between 45 and 37 individuals (between 12 and 9.9%). This is a typical behavior of a natural cover with processes of continuous development, with a good offer of medium low size individuals, consistent with the vertical structure analysis; Nevertheless, it may also suggest intervention processes due to the irregularity that appears within classes, as shown in class III; this was evidenced on site by the fire marks in these ecosystems.

Figure 4.152: Altimetric distribution for the Palm Swamp.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Diametric distribution

In order to distribute the individuals in class intervals according to diameters, 6 intervals were determined in the Palm Swamp, with a fixed class range of 10 centimeters. Table 4.85 shows the diametric classes with their corresponding range and percentage of individuals.

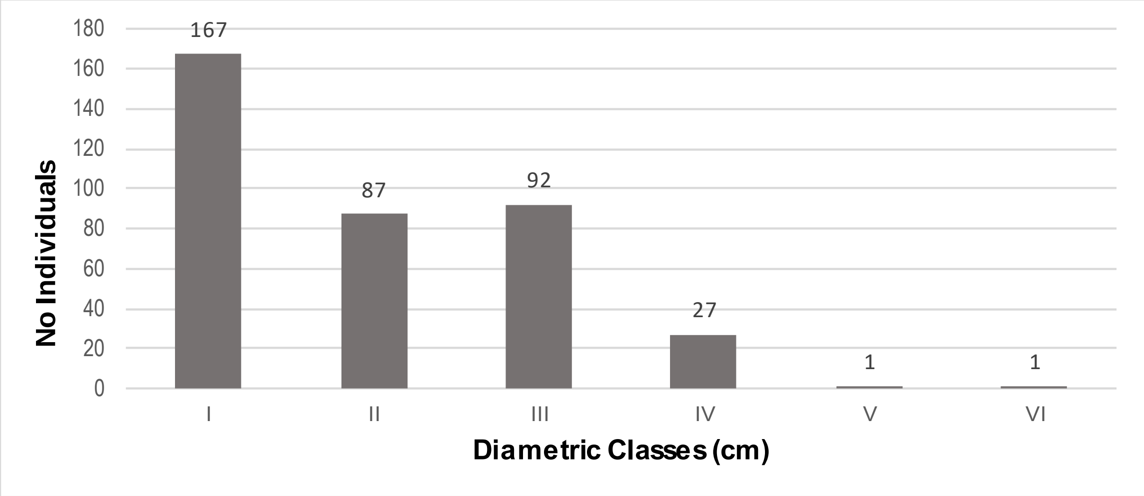
Table 4.85: Diametric distribution of the Palm Swamp.

Diametric Class	Range (cm)	No. Individuals	% Individuals
I	10,01 - 20	167	44,5
II	20,01 - 30	87	23,2
III	30,01 - 40	92	24,5
III	30,01 - 40	92	24,5
IV	40,01 - 50	27	7,2
V	50,01 - 60	1	0,3
VI	60,01 - 70	1	0,3
Overall total		**375**	**100**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Figure 4.153 shows the distribution of individuals in the diametric classes for the Palm Swamp, evidencing a normal behavior, with 44.5% of the individuals in the first class (167 individuals), followed by the third class with 24.5% (92 individuals) and the second class with 23.2% (87 individuals). This behavior, as was state d for the gallery forest, is a characteristic of the natural cover areas in development, with active natural regeneration processes and a good offer of small trees. Nevertheless, for the Palm Swamp we observe irregularity in the classes, which may also show the degree of intervention mentioned before.

Figure 4.153: Diametric distribution for the Palm Swamp.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Basal area and volume per species

Table 4.86 shows the volume recorded in the inventory for each species found in the Palm Swamp for the mature size category in the area of 0,7 hectares analyzed, with its respective value and percentage per hectare.

Table 4.86: Basal area and volume per species for the Palm Swamp.

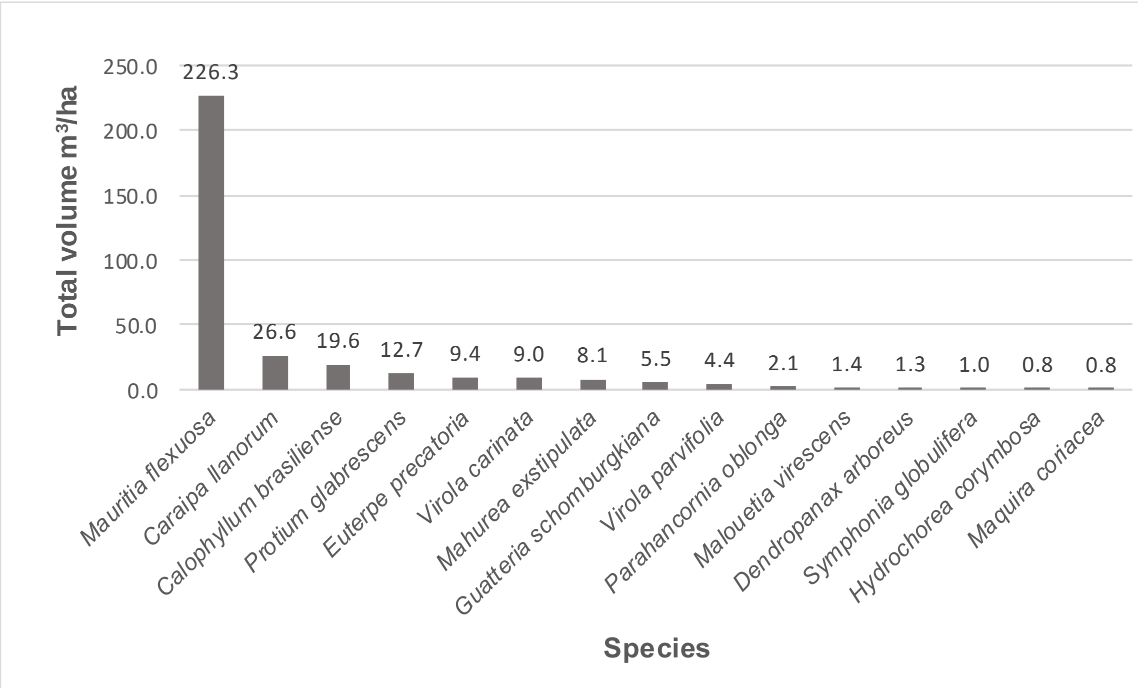
SPECIES	COMMON NAME	BASAL AREA (m^2)	VOL COM (m^3)	VOL TOT (m^3)	VOL TOT / ha (m^3)
Alchornea discolor	Algodoncillo	0,0	0,1	0,3	0,4
Brosimum lactescens	Guáimaro	0,0	0,1	0,2	0,3
Calophyllum brasiliense	Cachicamo	1,2	7,9	13,7	19,6
Caraipa llanorum	Saladillo rojo	1,7	10,1	18,6	26,6
Cecropia peltata	Guarumo	0,0	0,3	0,4	0,6
Dendropanax arboreus	Mantequillo	0,1	0,5	0,9	1,3
Diospyros sericea	Carbonero	0,0	0,1	0,1	0,1
Duroia micrantha	Turmemico	0,0	0,1	0,2	0,3
Endlicheria verticillata	Amarillo	0,0	0,1	0,1	0,1
Eschweilera parvifolia	Coco de mono	0,0	0,2	0,4	0,6
Euterpe precatoria	Manaco	0,5	4,5	6,6	9,4
Garcinia madruno	Madroño	0,0	0,1	0,3	0,4
Guatteria schomburgkiana	Majagüillo negro	0,3	2,4	3,8	5,5
Hirtella elongata	Garrapato	0,0	0,2	0,3	0,5
Hydrochorea corymbosa	Dormilón	0,1	0,3	0,6	0,8
Mahurea exstipulata	Caucho amarillo	0,8	2,9	5,7	8,1
Malouetia virescens	Palo de boya	0,1	0,5	1,0	1,4
Maquira coriacea	Lechero	0,1	0,3	0,5	0,8
Mauritia flexuosa	Moriche	13,2	105,8	158,4	226,3
Myrcia subsessilis	Arrayán	0,0	0,0	0,1	0,1
Pachira sessilis	Ceiba paquira	0,0	0,0	0,1	0,1
Parahancornia oblonga	Pendare	0,1	1,0	1,5	2,1
Protium glabrescens	Anime	0,9	5,1	8,9	12,7
Quiina macrophylla	Guayacán	0,0	0,0	0,0	0,1

SPECIES	COMMON NAME	BASAL AREA (m²)	VOL COM (m³)	VOL TOT (m³)	VOL TOT / ha (m³)
Symphonia globulifera	Breo	0,1	0,4	0,7	1,0
Tapirira guianensis	Guarupayo	0,0	0,1	0,2	0,3
Virola carinata	Carnevaca blanco	0,3	4,4	6,3	9,0
Virola parvifolia	Carnevaca	0,2	2,3	3,1	4,4
Vismia macrophylla	Punta de lanza	0,0	0,1	0,2	0,3
Xylopia emarginata	Majagüillo	0,0	0,2	0,3	0,5
Overall total		**20,0**	**149,9**	**233,5**	**333,5**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

According to the volume analysis (Figure 4.154), the species reporting the highest total volume per hectare for the Palm Swamp is, clearly, the *Mauritia flexuosa* (Moriche) with 226.3 cubic meters, equivalent to 67.9% of the total; other representative species are: *Caraipa llanorum* (Saladillo rojo), *Calophyllum brasiliense* (Cachicamo), *Protium glabrescens* (Anime), *Euterpe precatoria* (Manaco), *Virola carinata* (Carnevaca blanco) and *Mahuerea exstipulata* (Caucho amarillo) with values ranging between 26.6 and 8.1 cubic meters, equivalent to relative values ranging between 8 and 2.4%.

Figure 4.154: Basal area and volume per species for the Palm Swamp.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Floristic diversity

Table 4.87 shows results obtained for the mixing ratio, and the richness and diversity indexes for mature plants of the Palm Swamp, considering the 375 individuals and 30 species reported in an analyzed area of 0.7 hectares.

Table 4.87: Richness and diversity indexes for mature plants in the Palm Swamp.

No. Species	No. Individuals	RICHNESS			DIVERSITY	
		Margalef	Cm		Shannon	Simpson
30	375	4,89	0,08	1:12	2,17	0,20

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Margalef Index

For mature plants of the Palm Swamp cover, a value of 4.89 was determined for the Margalef index, representing a medium high richness, significantly lower than that of the gallery forest.

Mixing ratio

This parameter measures the intensity of the mixing of species within the sampling area. For mature trees in the Palm Swamp it showed a value of 0.08, equivalent to a relation of 1:12, that is, it is assumed that each species is represented by an average of 12 individuals. This value suggests a medium species richness.

Shannon-Wiener Index

This index, considering that the highest possible obtainable value is the natural logarithm of the n umber of individuals (375), which corresponds to a value of 5.93, indicates that all species are equally abundant. For mature trees in the Palm Swamp, a value of 2.17 was determined, a data which represents a medium value of diversity, indicating that the species found in this cover area slightly tend to be equally abundant.

Simpson Index

For mature trees in the Palm Swamp, a value of 0.20 was determined, indicating that the individuals randomly selected have a low probability of being of the same species. This means there exists a specific heterogeneity, although in a lower proportion than that of the gallery forest.

Natural regeneration of the Palm Swamp

Within the subplots of the sampling units performed to determine the characteristics of the Palm Swamp, a total of 204 individuals of natural regeneration were recorded, corresponding to 131 pole trees (in an area of 350 m^2) and 73 saplings (in an area of 56 m^2).

Floristic composition of the natural regeneration

The 204 individuals recorded for natural regeneration in the Palm Swamp are grouped in 22 families, 28 genders and 29 species. The following families stand out at a specific level: Areaceae, with 3 species and Apocynaceae, Calophyllaceae, Clusiaceae, Lauraceae and Myristicaceae, with 2 species each; at a gender level, *Virola,* with 2 species. Table 4.88 shows the floristic composition of the natural regeneration, as well as the number of individuals found per species, for each of the size categories.

Table 4.88: Floristic composition of the natural regeneration in the Palm Swamp.

FAMILY	GENDER	SPECIES	COMMON NAME	Pole	Sapling	Total
Annonaceae	*Guatteria*	*Guatteria metensis* R.E.Fr.	Majagüillo blanco		2	2
Apocynaceae	*Malouetia*	*Malouetia virescens* Spruce ex Müll.Arg.	Palo de boya	3	1	4
	Parahancornia	*Parahancornia oblonga* (Benth. ex Müll.Arg.) Monach.	Pendare	3	1	4
Araliaceae	*Dendropanax*	*Dendropanax arboreus* (L.) Decne. & Planch.	Mantequillo	3	2	5
Arecaceae	*Astrocaryum*	*Astrocaryum aculeatum* G.Mey.	Cubarro	1		1
	Euterpe	*Euterpe precatoria* Mart.	Manaco	11	11	22
	Mauritia	*Mauritia flexuosa* L.f.	Moriche	34	8	42
Boraginaceae	*Cordia*	*Cordia nodosa* Lam.	Nudillo	3	1	4
Burseraceae	*Protium*	*Protium glabrescens* Swart	Anime	32	15	47
Calophyllaceae	*Caraipa*	*Caraipa llanorum* Cuatrec.	Saladillo rojo		4	4
	Mahurea	*Mahurea exstipulata* Benth.	Caucho amarillo	3	3	6
Clusiaceae	*Calophyllum*	*Calophyllum brasiliense* Cambess.	Cachicamo	8	4	12
	Symphonia	*Symphonia globulifera* L.f.	Breo	4	2	6
Ebenaceae	*Diospyros*	*Diospyros sericea* A.DC.	Carbonero		1	1
Euphorbiaceae	*Alchornea*	*Alchornea discolor* Poepp.	Algodoncillo	1		1
Hypericaceae	*Vismia*	*Vismia macrophylla* Kunth	Punta de lanza	2		2

FAMILY	**GENDER**	**SPECIES**	**COMMON NAME**	**Pole**	**Sapling**	**Total**
Lacistemataceae	*Lacistema*	*Lacistema aggregatum* (P.J.Bergius) Rusby	Laurel rosado	4	2	6
Lauraceae	*Licaria*	*Licaria canella* (Meisn.) Kosterm.	Amarillo		1	1
	Ocotea	*Ocotea cernua* (Nees) Mez	Laurel 3		1	1
Leguminosae	*Macrolobium*	*Macrolobium multijugum* (DC.) Benth.	Dormilón		1	1
Melastomataceae	*Henriettea*	*Henriettea goudotiana* (Naudin) Penneys, F.A. Michelangeli, Judd & Almeda	Tuno	5	2	7
Myristicaceae	*Virola*	*Virola carinata* (Spruce ex Benth.) Warb.	Carnevaca blanco	6	1	7
		Virola parvifolia Ducke	Carnevaca	3	1	4
Myrtaceae	*Myrcia*	*Myrcia subsessilis* O.Berg	Arrayán	4	4	8
Ochnaceae	*Quiina*	*Quiina macrophylla* Tul.	Guayacán	1		1
Polygonaceae	*Coccoloba*	*Coccoloba mollis* Casar.	Uvero		1	1
Primulaceae	*Stylogyne*	*Stylogyne longifolia* (Mart. ex Miq.) Mez	Mortiño		1	1
Siparunaceae	*Siparuna*	*Siparuna guianensis* Aubl.	Romadizo		1	1
Urticaceae	*Cecropia*	*Cecropia peltata* L.	Guarumo		2	2
Overall total				**131**	**73**	**204**

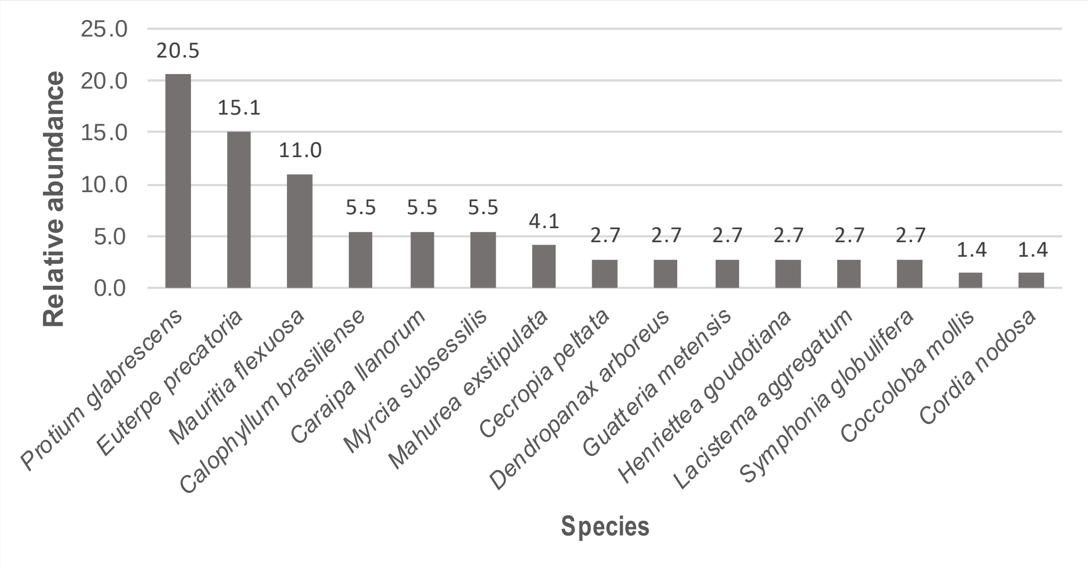
Source: (Universidad Distrital Francisco José De Caldas, 2017)

- Relative abundance of the natural regeneration

Pole Trees

In the analysis of relative abundance for pole trees in the Palm Swamp, the *Protium glabrescens* (Anime) species stands out, with 20.5% of the parameter, with 15 individuals, followed by *Euterpe precatoria* (Manaco) with 15.1% (11 individuals) and *Mauritia flexuosa* (Moriche) with 11% (8 individuals); the remaining species show values below 6% of relative abundance (Figure 4.155). The relative abundance for pole trees in this cover area and for mature trees, shows a structure with a homogenous trend.

Figure 4.155: Relative abundance of pole trees in the Palm Swamp.

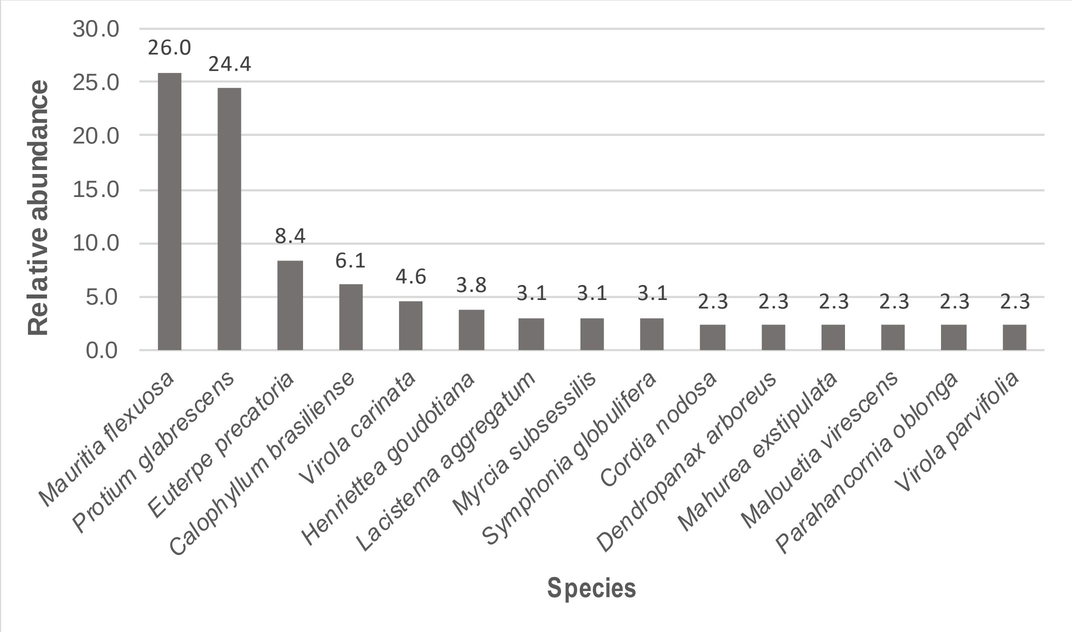


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Saplings

In relation to relative abundance of Saplings, the following species stand out: *Mauritia flexuosa* (Moriche) and *Protium glabrescens* (Anime), with 26 and 24.4%, respectively (34 and 32 individuals), followed by *Euterpe precatoria* (Manaco) and *Calophyllum brasiliense* (Cachicamo), with 8.4 y 6.1%, respectively (11 and 8 individuals); the remaining species show values below 5% (Figure 4.156). This size category maintains the structural trend towards homogeneity of the forest.

Figure 4.156: Relative abundance of saplings in the Palm Swamp.



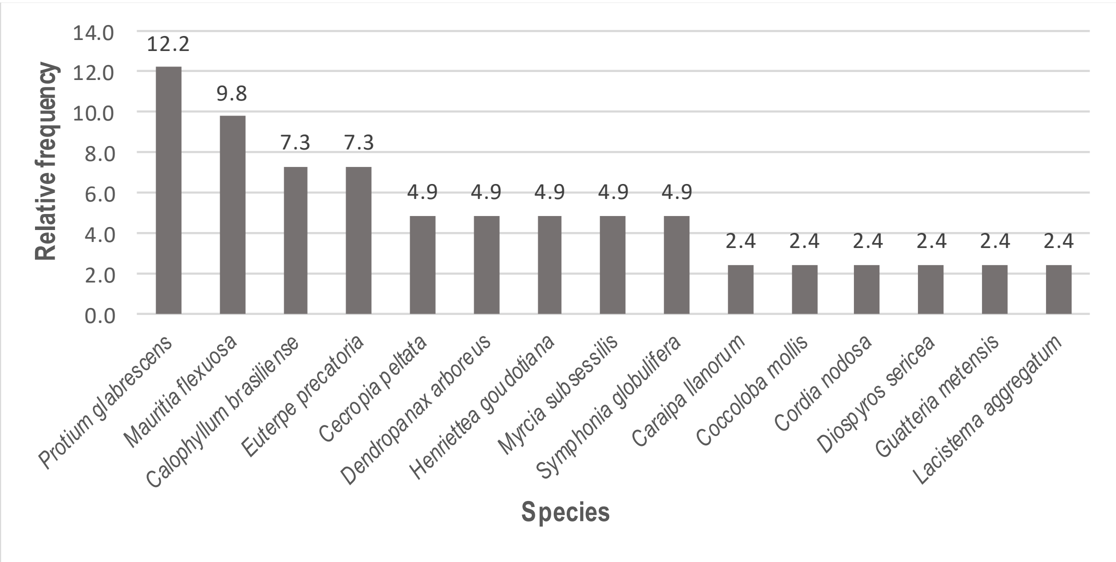
Source: (Universidad Distrital Francisco José De Caldas, 2017)

Relative frequency of the natural regeneration

Pole Trees

The most representative species in this parameter for pole trees are: *Protium glabrescens* (Anime), *Mauritia flexuosa* (Moriche), *Calophyllum brasiliense* (Cachicamo) and *Euterpe precatoria* (Manaco), with values between 12.2 and 7.3%, that is, reports between 5 and 3 plots, respectively); the remaining species report values below 5% in 2 or less plots (Figure 4.157). This parameter shows a similar trend to that of the mature trees, indicating an homogenous cover regarding the appearance of species in the sample units.

Figure 4.157: Relative frequency of pole trees in the Palm Swamp

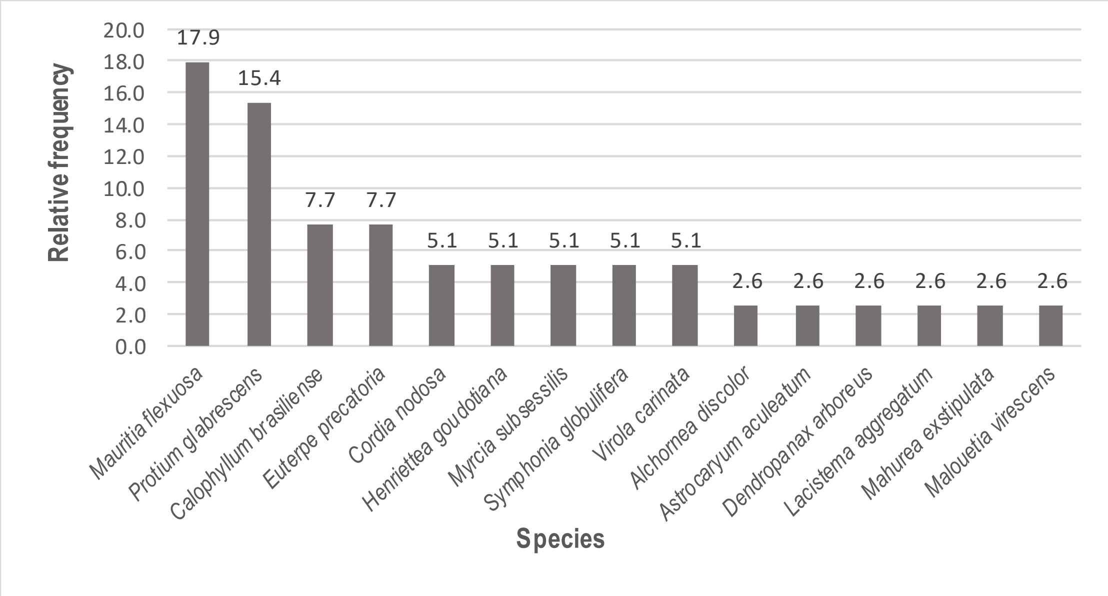


Source: (Universidad Distrital Francisco José De Caldas, 2017)

Saplings

In the analysis of relative frequency for saplings in the Palm Swamp, *Mauritia flexuosa* (Moriche) and *Protium glabrescens* (Anime), appear as the most representative species with values between 17.9 and 15.4%, reported in 7 and 6 plots, respectively; the remaining species report values below 6%, reported in 3 or less plots (Figure 4.158). The Palm Swamp saplings show the same trend seen in the entire cover area in relation to structural homogeneity.

Figure 4.158: Relative frequency of saplings in the Palm Swamp.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

Forbidden, endemic, threatened or commercially restricted species

According to the list of species found in the inventory of endemic, commercially restricted, forbidden or threatened species, Table 4.89 records the resulting information.

Table 4.89: Forbidden, endemic, threatened or commercially restricted species.

SPECIES	COMMON NAME	RESOL 0192/2014 MADS	RED BOOKS COLOMBIA	REDLIST UICN	CITES	ENDEMIC	FORBIDDEN
Astrocaryum aculeatum	Cubarro	--	LC	--	--	--	--
Attalea maripa	Cucurita	--	LC	--	--	--	--
Enterolobium schomburgkii	Dormidero	--	--	LC	--	--	--
Eschweilera parvifolia	Coco de mono	--	LC	--	--	--	--
Euterpe precatoria	Manaco	--	LC	--	--	--	--
Hirtella elongata	Garrapato	--	LC	--	--	--	--
Hirtella racemosa	Huesito	--	LC	--	--	--	--
Hymenaea courbaril	Algarrobo	--		LC	--	--	--

SPECIES	COMMON NAME	RESOL 0192/2014 MADS	RED BOOKS COLOMBIA	REDLIST UICN	CITES	ENDEMIC	FORBIDDEN
Licania hypoleuca	Escobo blanco	--	LC	--	--	--	--
Licania leucosepala	Aceituno	--	LC	--	--	--	--
Licania parvifructa	Escobo colorado	--	LC	--	--	--	--
Mauritia flexuosa	Moriche	--	LC	--	--	--	--
Parinari pachyphylla	Escobo	EN	EN	--	--	--	--
Socratea exorrhiza	Choapo	--	LC	--	--	--	--
Virola parvifolia	Carnevaca	--	--	VU	--	--	--
Key: **CR** = In critical danger; **EN** = In danger; **VU** = Vulnerable**; LC** = Minor concern							

Source: (Universidad Distrital Francisco José De Caldas, 2017)

The *Parinari pachyphylla* (Escobo) species, is reported in the In Danger (EN) category, which corresponds to those species facing a very high risk of extinction in a wildlife state, according to Volume 1 of the Red Book of Plants of Colombia and Resolution 0192 of 2014 of the MADS (Ministry of Environment and Sustainable Development).

The *Virola parvifolia* (Carnevaca) species is reported in the Vulnerable (VU) category in the IUCN red list and corresponds to species facing a high risk of extinction in a wildlife state.

The remaining species reported in the LC category are not considered threats in Resolution 0192 of 2014 issued by the MADS. Nevertheless, they were included here, as they appear in these sources.

4.3.1.5 Analysis of characteristics

Overall, wild flora within the area of study, although restricted to riparian or gallery vegetation, presents an acceptable degree of conservation, with a rich floristic composition and a good vertical and horizontal structure. In addition, it provides very important environmental and ecosystem services, as an exclusive habitat for local fauna. The characteristics of each type of cover are described below:

- ***<u>GALLERY FOREST</u>***

This cover, which appears more often associated with rivers, streams and bodies of water, shows a significant composition and species richness (106 species in the Mature category and 82 species in natural regeneration), and a horizontal and vertical structure quite heterogenous and developed, even though it evidences anthropic affectations (slash and burn), and is restricted to areas with poor soil conditions and constant floods. A good presence of natural regeneration could also be observed as a result of the efforts for local conservation over the past years, which ensure the survival of the forest.

- ***PALM SWAMP***

This cover, which appears in a lower proportion within the area of study, and is relegated to small areas with special conditions to adapt the Moriche palm (*Mauritia flexuosa*), shows different conditions to those of the gallery forest, with a lower composition and richness (30 species in the Mature category and 29 in natural regeneration), as a result of these special conditions of continuous floods. Likewise, its horizontal structure is quite homogenous due to the dominance of this species, while its vertical structure shows a greater heterogeneity and development, similar to that present in the forest. Regarding natural regeneration, a high presence was observed, suggesting a good response to the conservation efforts of the company, a relevant factor with respect to conditions seen in other regions, where this natural regeneration in Palm Swamps is almost non-existent.

Table 4.90: Cover areas in the plots.

Name		Area Ha
Paraiso (PC)	Thick grassland in dry land	717,63
	Gallery and riparian forest	25,62
	Floodable thick grassland	364,87
La Cordobeza	Thick grassland in dry land	1163,11
	Gallery and riparian forest	91,91
Garza Morena	Thick grassland in dry land	917,02
	Burnt areas	5,19
	Gallery and riparian forest	107,55
	Floodable thick grassland	263,93
La Pista	Floodable thick grassland	864,77
	Burnt areas	160,22
San Cristobal	Rivers (50 m)	14,70
	Floodable high thick forest	290,23
	Gallery and riparian forest	98,86
	Sandy open grassland	152,84
	Thick grassland in dry land	545,67
	Sandy open grassland	121,60
	Forest plantation	37,56
	Mosaic crops	32,56
Paraiso (PR)	Thick grassland in dry land	532,97
	Gallery and riparian forest	57,97
	Burnt areas	553,35
Paraiso (II)	Road, railway network and associated plots	27,49
	Thick grassland in dry land	1147,45
	Clean pastures	26,12
	Forest plantation	1,73
	Floodable thick grassland	41,72
	Thick grassland in dry land	304,87
	Floodable high thick forest	21,40
	Gallery and riparian forest	193,51
Paraiso (I)	Rivers (50 m)	0,00
	Thick grassland in dry land	959,33

Name		Area Ha
	Sandy open grassland	87,15
	Forest plantation	161,85
	Gallery and riparian forest	61,19
	Floodable thick grassland	65,33
	Road, railway network and associated plots	49,65
Los palmares	Road, railway network and associated plots	21,50
	Floodable high thick forest	33,00
	Thick grassland in dry land	1139,23
	Gallery and riparian forest	100,30
Hato Nuevo	Road, railway network and associated plots	70,53
	Thick grassland in dry land	1845,50
	Floodable high thick forest	90,43
	Gallery and riparian forest	153,80
	Floodable thick grassland	697,03
	Burnt areas	57,50

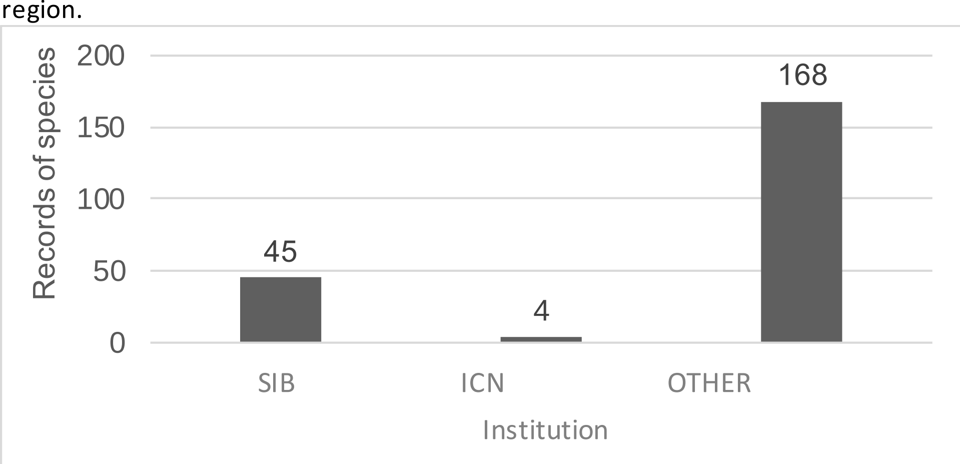
4.3.2 Fauna

4.3.2.1 Secondary information

4.3.2.1.1 Herpetofauna

Overall, 217 records of species were obtained for the Orinoquía region, in which 69 records correspond to amphibians and 148 to reptiles. The largest number of recorded species was obtained from other sources such as scientific articles, books and scientific reviews, with a total of 168, followed by the Colombian Biological Information System (SIB)[39] with 45 records and the Institute of Natural Sciences (ICN)[40] with 4 records (Figure 4.159).

Figure 4.159: Number of records of amphibians and reptile species by institution, in the Colombian Orinoquía region.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

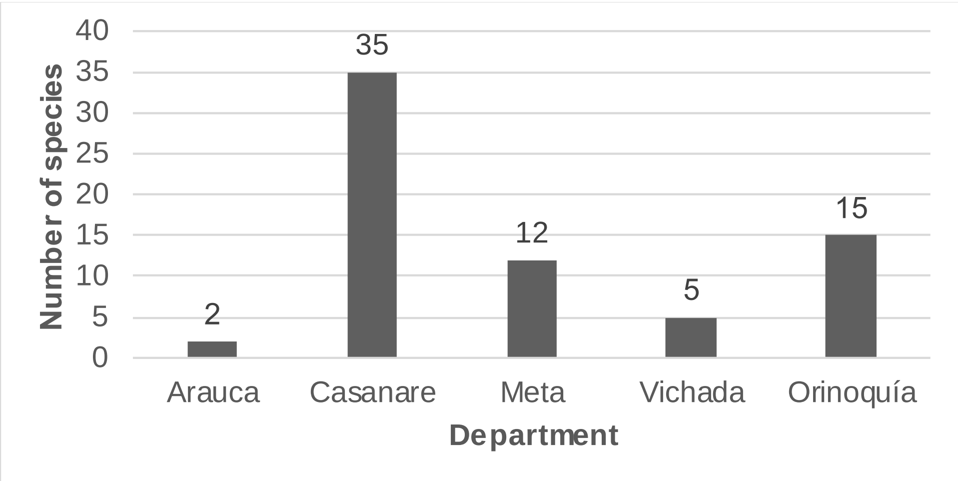
[39] (Biological Information System for Colombia, SIB)

40 (Instituto of Natural Sciences, ICN)

- ***Amphibians***

In the review of information of secondary sources for amphibians, records of 69 species were found, corresponding to 2 orders and 13 families. Of the 4 departments reviewed, Casanare presented the largest number of records with 35 species, followed by Meta with 12 species, Vichada with 5, Arauca with 2 and finally, the Orinoquía with 15 species (Figure 4.160).

Figure 4.160: Number of species of amphibians by department in the Colombian Orinoquía region.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

On the other hand, the order with the largest number of species was Anura with 65, followed by Gymnophiona with 2 (Figure 4.161). The families with the largest number of species were Hylidae with 25, Leptodactylidae with 14 and Bufonidae with 7 species. In the remaining 10 families 21 species were recorded (Figure 4.162).

Figure 4.161: Number of species of amphibians by Order in the Colombian Orinoquía region.

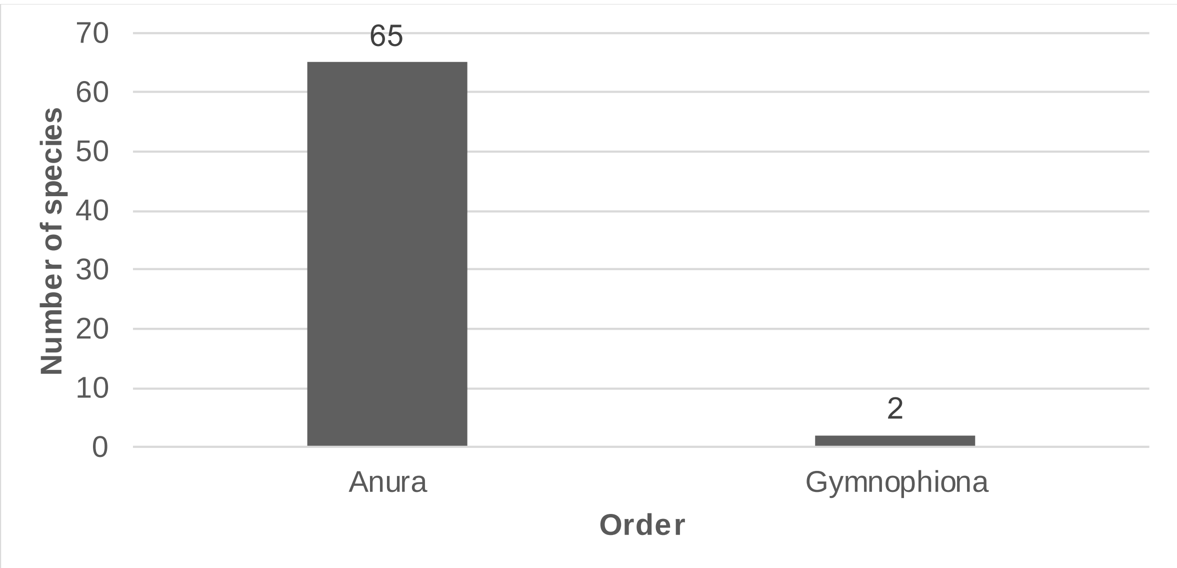
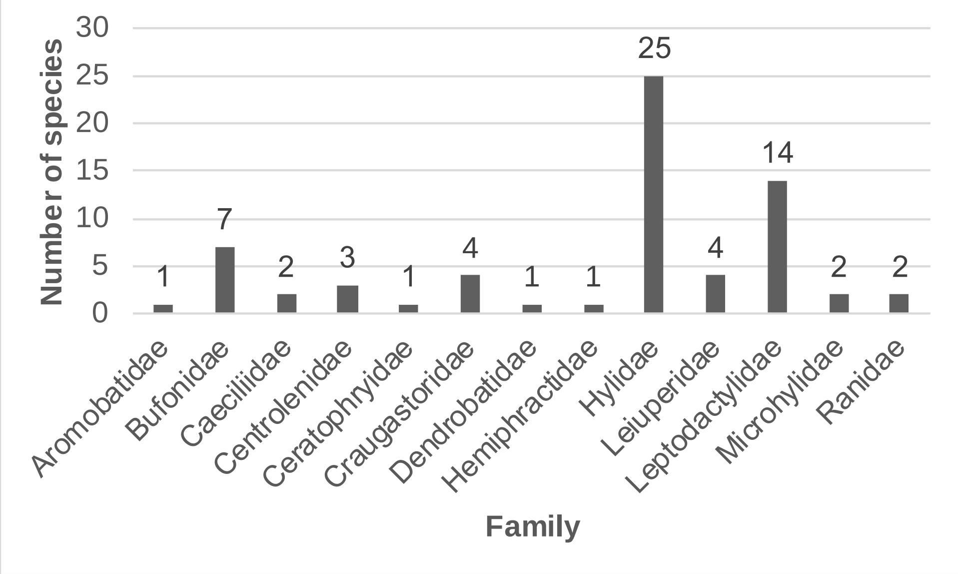


Figure 4.162: Number of species of amphibians by Family in the Colombian Orinoquía region.

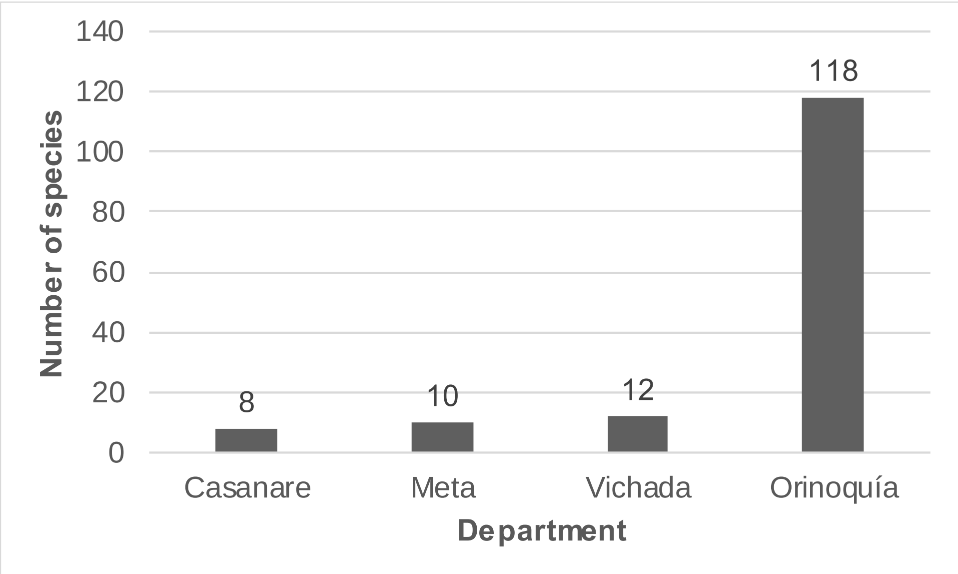


Source: (Universidad Distrital Francisco José De Caldas, 2017)

- ***Reptiles.***

In the review of secondary sources of information for reptiles, 148 species were recorded, corresponding to 3 orders and 26 families. Of the four departments reviewed, the largest number of species was recorded for the Orinoquía region with 118; Vichada presented 12 records of species, Meta 10 and Casanare 8 species (Figure 4.163).

Figure 4.163: Number of species of reptiles by department in the Colombian Orinoquía region.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

On the other hand, the order with the largest number of recorded species was Squamata with 129, followed by Testudines with 14 and Crocodylia with 5 (Figure 4.164:). The families with the largest number of recorded species were Colubridae with 31 species and Dipsadidae with 30. In the remaining 23 families 83 species were recorded (Figure 4.165).

Figure 4.164: Number of species of reptiles by Order in the Colombian Orinoquía region.

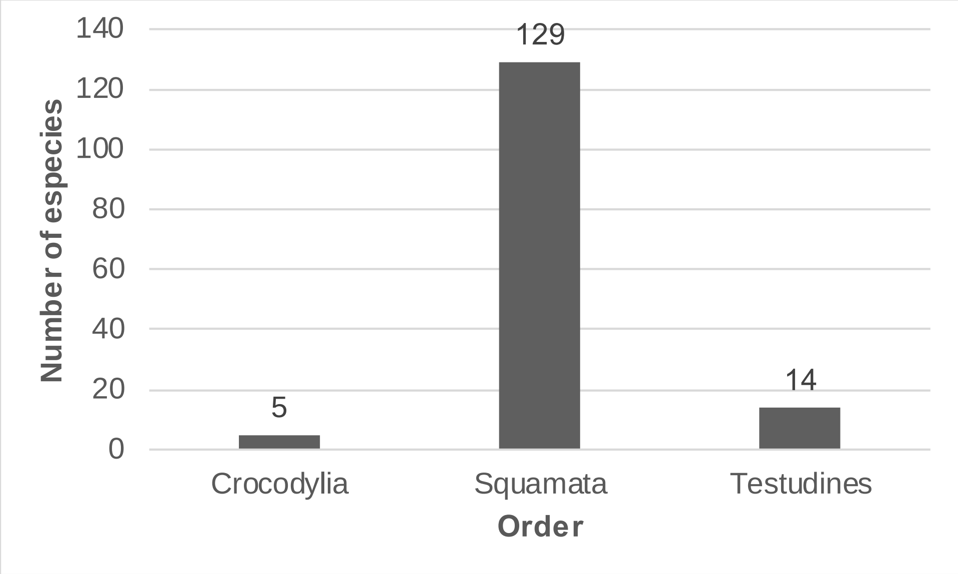
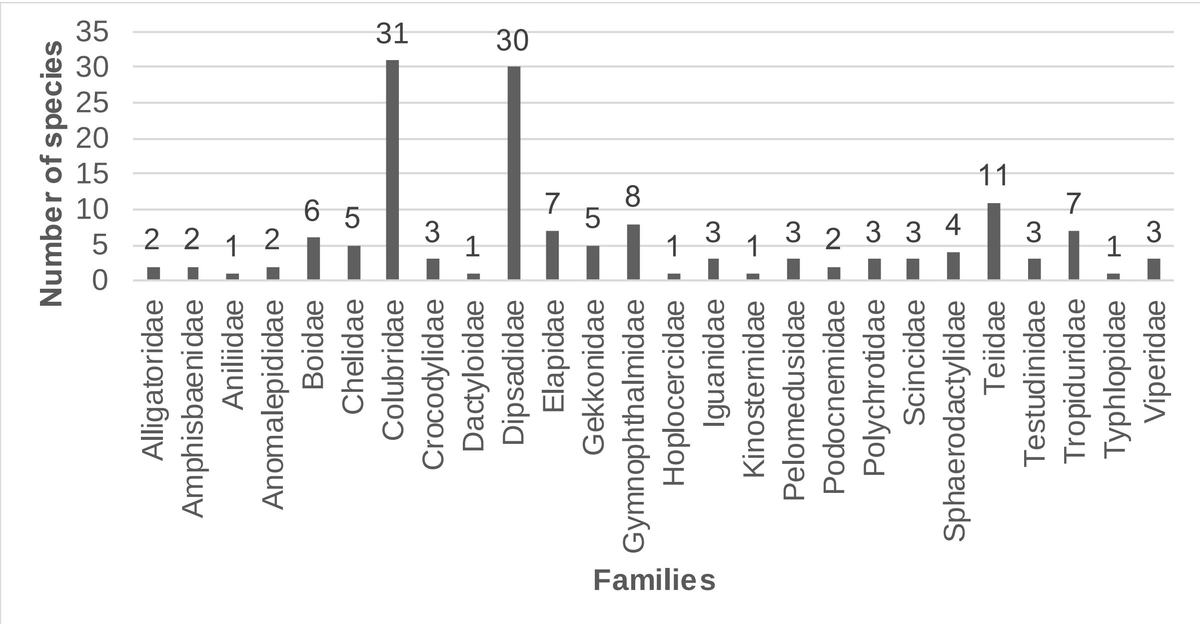


Figure 4.165: Number of species of reptiles by Family in the Colombian Orinoquia region.



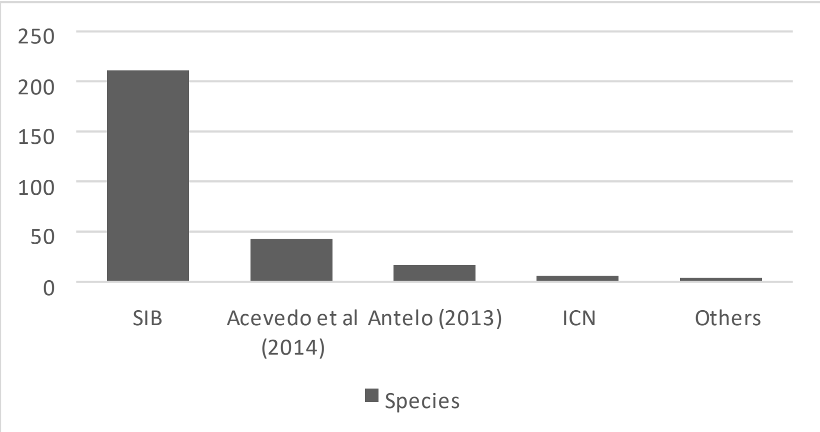
Source: (Universidad Distrital Francisco José De Caldas, 2017)

Even though much of the fauna found in Vichada is widely distributed, there are some groups, such as frogs of the Leptodactylidae family, which are found only at a local level, or shared with the Amazon fauna and only inhabit low lands and are not found in the inter-Andean valleys. The fauna is strongly associated with the seasonality of the Orinoquia, Therefore, the species adjust to the times of the year when several microhabitats are flooded and many amphibians and reptiles use these seasons for reproduction processes.

4.3.2.1.2 Birds

A total of 280 bird species was obtained. The highest number of species was obtained from the SIB[41] database with 244, followed by Acevedo[42] with 43, Antelo[43] 16, ICN[44] with 6 and other sources 4 (Figure 4.166).

Figure 4.166: Number of species present in bird lists for the departments of Arauca, Meta, Casanare and Vichada.



Source: (Universidad Distrital Francisco José De Caldas, 2017

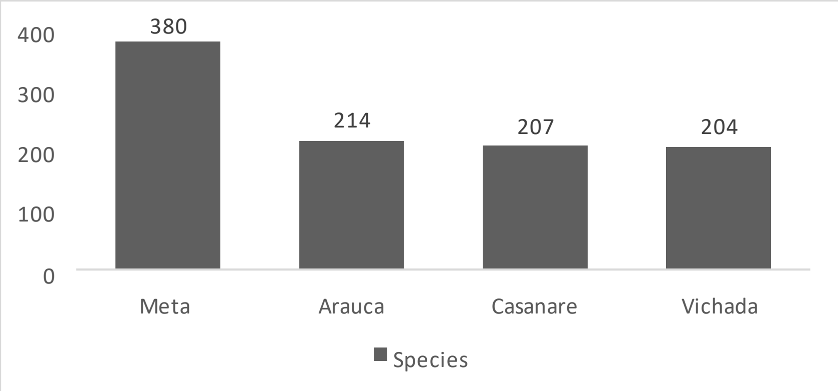
Among the institutions consulted by the SIB database are: National Natural Parks of Colombia (PNN); Cornell Lab of Ornithology (CORL); National Network of Bird Watchers of Colombia (RNOA); Institute for the Research of Biological Resources Alexander Von Humboldt (IAVH); the Royal Ontario Museum (RYOM) and several universities such as Universidad Nacional de Colombia, Universidad de Antioquia (UDEA); Universidad de Nariño (UNAR) and Universidad del Valle (UVAL) among other institutions.

- ***GEOGRAPHIC DISTRIBUTION***

The number of records by department showed that Meta presented the richest variety with 380 spe cies, followed by Arauca with 214, Casanare with 207 and Vichada with 204 (Figure 4.167). These records are in accordance with the accessibility to the areas in question, and to the country's period of conflict, which prevented many bird watchers from carrying out observations or research in some departments such as Vichada.

[41] (Sistema de Información Biológica para Colombia, SIB, s.f.)
[42] (Acevedo, 2014)
[43] (Antelo, 2013)
[44] (Instituto de Ciencias Naturales, ICN, s.f.)

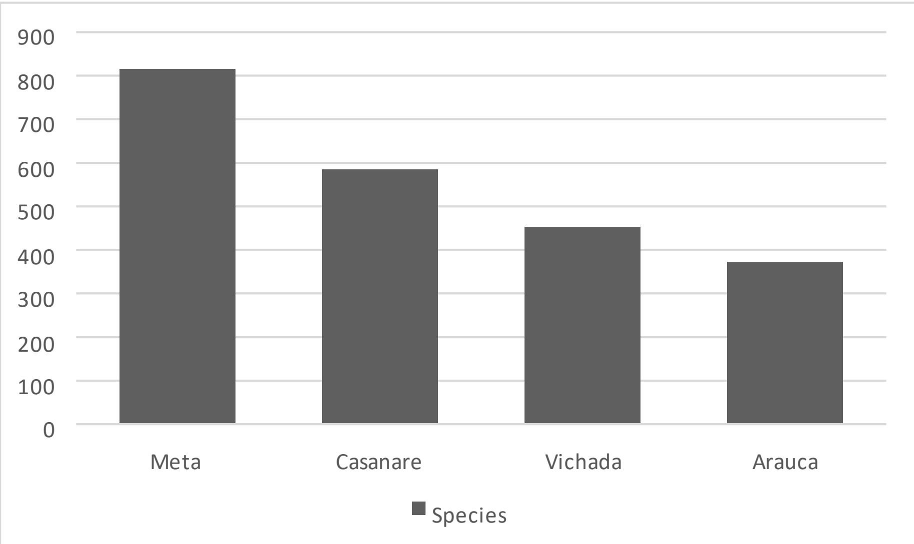
Figure 4.167: Number of species by department according to databases and publications.



Source: (Universidad Distrital Francisco José De Caldas, 2017

The review of species for these three departments on the eBIRD[45] platform, a project developed by the Cornell Lab of Ornithology and the National Audubon Society of the United States, which records information related to bird observations and audios obtained by ornithology professionals and amateurs throughout the world, established that the highest number of species was found in the department of Meta, with 815, followed by Casanare with 585, and in third place Vichada, with 453, and finally Arauca with 372 (Figure 4.168).

Figure 4.168: Number of bird species by department according to the eBIRD platform (Cornell Lab of Ornithology and the National Audubon Society). August 2017 inquiry.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

- ***COMPOSITION OF SPECIES***

24 orders, 65 families and 426 species were recorded. The order of Passerine birds recorded the richest variety with 110 species, followed by the Apodiformes with 47, Falconiformes 38 and Accipitriformes with 36 (Figure 4.169). Regarding families, the Accipitridae showed the highest number of species with 56, Trochilidae with 45 and Tyrannidae with 22. (Figure 4.170).

45 (eBIRD, s.f.)

Figure 4.169: Number of bird species by order for the departments of Arauca, Casanare, Meta and Vichada.

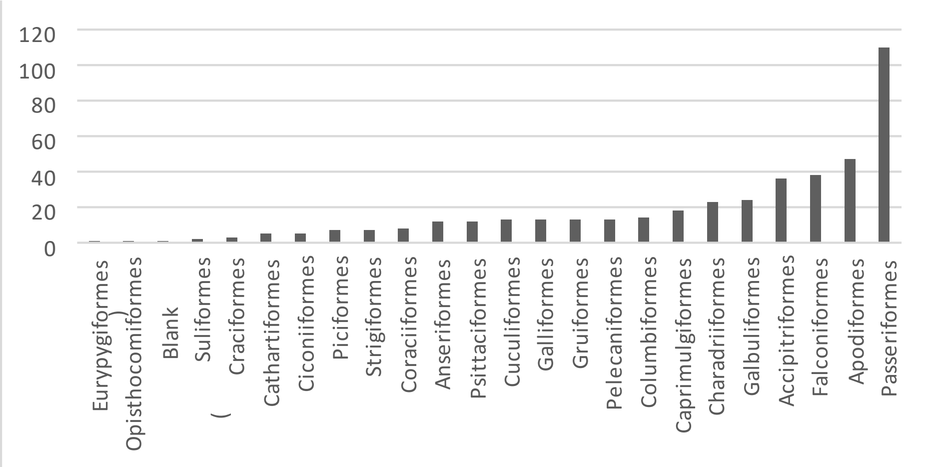
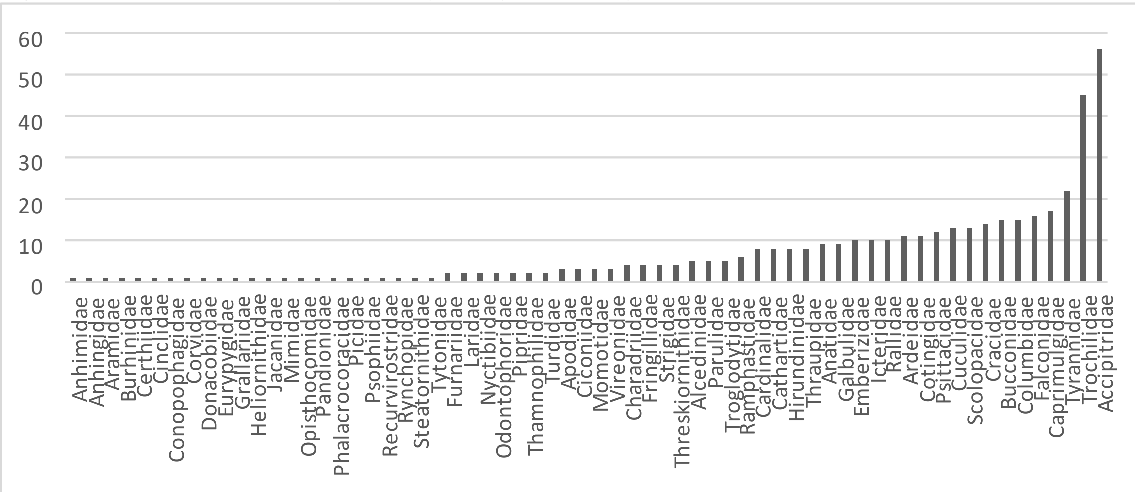


Figure 4.170: Number of bird species by family for the departments of Arauca, Casanare, Meta and Vichada.



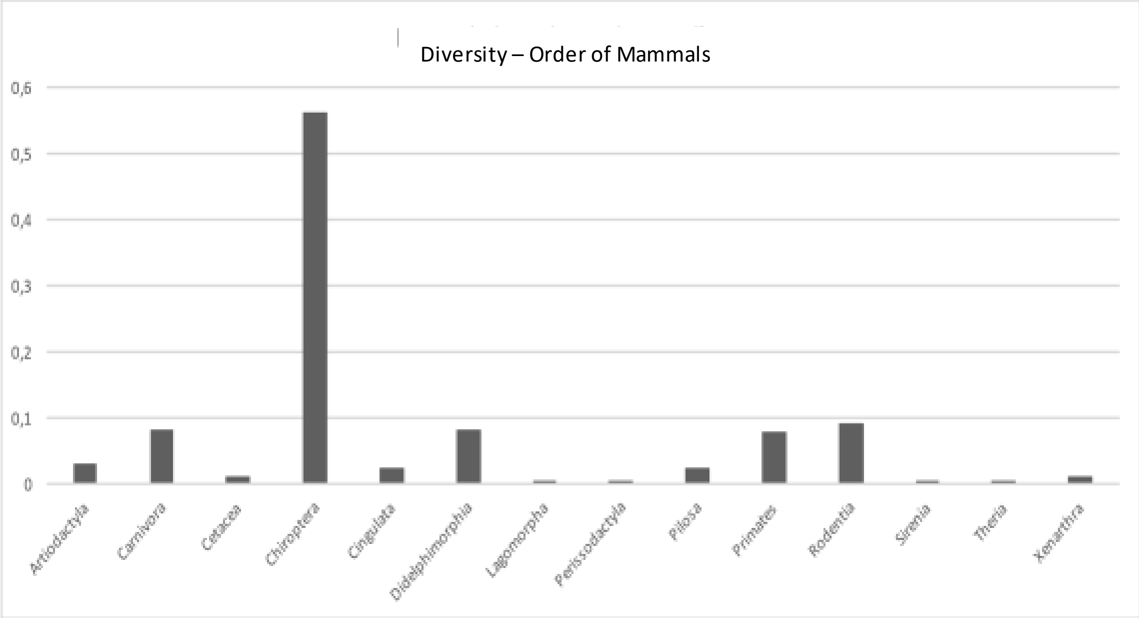
Source: (Universidad Distrital Francisco José De Caldas, 2017)

4.3.2.1.3 Mammals

- ***<u>COMPOSITION OF SPECIES</u>***

A potential record of a total of 232 species was obtained for the Orinoquía, distributed in 14 orders of mammals, the most representative being the Chiroptera Order with 56% of the species, followed by the Rodentia with 9%, Carnivora and Didelphimorphia with 8%, and primates with 7%, the remaining orders do not exceed 3%, which is equivalent to a maximum of 5 species by order (Figure 4.171).

Figure 4.171: Representativity of species by order for the Colombian Orinoquia.

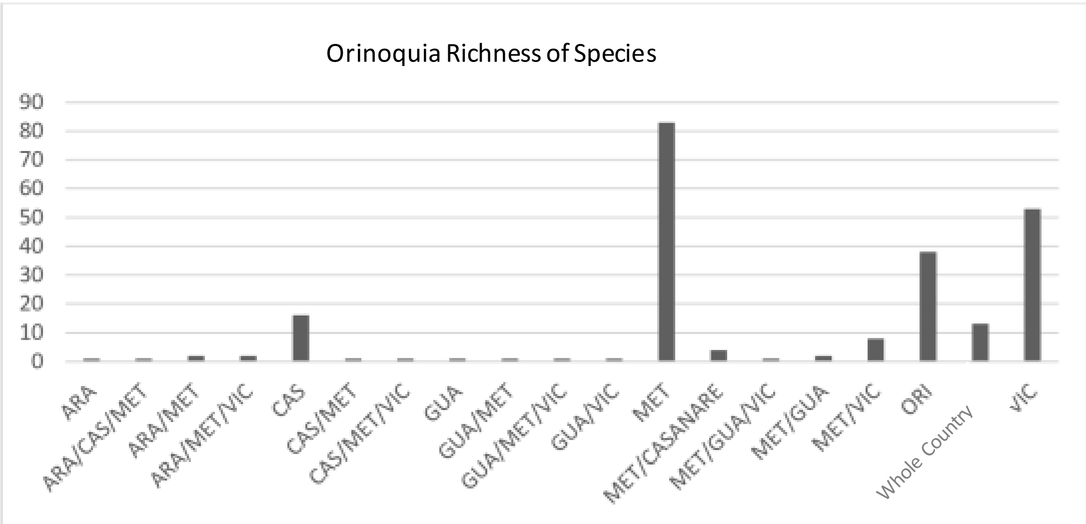


Source: (Universidad Distrital Francisco José De Caldas, 2017)

- ***GEOGRAPHIC DISTRIBUTION***

When comparing and reviewing the diversity in the 5 main departments of the Orinoquia component, according to Solari[46], the department of Vichada may contain 73 species of mammals; this diversity is shared with at least one of the neighbouring departments (Figure 4.172).

Figure 4.172: Graphic of species richness of mammals by department.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

[46] (Solari, Muñoz, & Rodríguez, 2013)

4.3.2.2 Methodology

4.3.2.2.1 Amphibian Herpetofauna

- ***FIELD PHASE***

A field phase was carried out covering the most relevant areas, including those areas which presented the highest potential in finding the greatest number of representative species; cover area, proximity to bodies of water and microhabitats, lifting of tree trunks and rocks, as well as visual inspection of underwood and high layers of vegetation were taken into consideration, to search for amphibians and snakes. Likewise, 2 boat trips were made along the Banks of Caño Muco and the Bita river, although the rainy season flooded the areas where the largest number of herpetofauna could be found, such as beaches and overflow areas, leaving areas of palm swamps and floodable forests in sight (Figure 4.173).

Figure 4.173: Survey on canoe along the Banks of the Brita river searching for herpetofauna.

Free and unrestricted search

To determine the composition of amphibians in each of the environmental units, Angulo's[47] free and unrestricted search technique was used, carrying out day and night walks, without following special rules other than thoroughly reviewing all available microhabitats with the purpose of recording the greatest possible number of species (Figure 4.174).

[47] (Angulo, 2006)

Figure 4.174: Searching for herpetofauna in Palm Swamp-Grassland ecotones.

Source: (Universidad Distrital Francisco José De Caldas, 2017)

With the purpose of inferring the variables or influences which explain and determine the presence of species, the effort to collect them during the free and unrestricted search was standardized within each sampling area. This methodology was used to record the information regarding the individual presence and absence of species, as well as the number of animals observed by sampling unit. All individuals captured were photographed and georeferenced. Due to the abundance of some species and the difficulty to access and capture some of them as a consequence of the altitude or flood levels, several specimens were recorded by visual identification or by their singing and were georeferenced but not captured. Metadata associated to each event was recorded using the field and data matrix format designed for this project. Data was collected using Duellman[48] and McDiarmid's[49] standard methodology.

Sampling by free and unrestricted search was carried out in 2 types of cover on a general level, in 5 sampling areas (Gallery forest and Palm Swamp with transition areas to grasslands), with 3 or 4 effort days for each one, for a total of 21 field days and 31 walks (Figure 4.175). Within each area, daily walks took place, divided in two time slots (day and night), with a total of 9 effective hours. Walks were carried out reviewing all possible microhabitats to capture amphibians and reptiles (puddles, streams, litter), as well as man-made structures, dumps and gardens (many specimens migrate to areas with high anthropogenic activity, searching for shelter or food such as insects and small invertebrates). Each captured and collected individual will be measured morphologically as follows: face-cloacal length (LRC), femur length (LF), rostral length (LR), rostral width (AR); individuals were grouped in morphotypes considering a series of shared characteristics.

Table 4.91: Location of sampling points for herpetofauna in the property of Forestal de la Orinoquia.

Code	STARTING POINT		ENDING POINT	
	X	Y	X	Y
Rh1	916872,9	1171773	916888,3	1171770
Rh2	917645,4	1168921	917748	1168881
Rh3	917726,5	1168897	917793,6	1168942
Rh4	917685	1168918	917890,1	1169139
Rh5	917920,5	1169089	917953	1169287
Rh6	917966,9	1169327	917732,9	1168881

[48] (Duellman, 1962)
[49] (McDiarmid, 1994)

Code	STARTING POINT		ENDING POINT	
	X	Y	X	Y
Rh7	917717,9	1168915	917709	1168900
Rh8	916242,6	1172009	916538,7	1172192
Rh9	916459,7	1172241	916108,7	1172094
Rh10	916071,4	1172020	916150,5	1172121
Rh11	915909,5	1160808	915951,8	1160931
Rh12	915828,2	1171850	915836,2	1171836
Rh13	916050	1172105	917472,5	1172227
Rh14	914585,6	1170300	914569,7	1170384
Rh15	915522,4	1160826	915632,2	1161094
Rh16	997570,9	1151824	997683,1	1151641
Rh17	994628,7	1154251	994619,8	1153918
Rh18	994618,5	1153901	994247,9	1153597
Rh19	997677,3	1151823	997559,5	1151987
Rh20	996082,8	1154613	995904,1	1154703
Rh21	995884,1	1154717	995692,8	1154193
Rh22	1002222	1169434	1001852	1169852
Rh23	1001852	1169856	1001923	1169568
Rh24	1001948	1169550	1001525	1169792
Rh25	1001921	1169528	1001317	1170173
Rh26	1001332	1170186	1001965	1169586
Rh27	1001598	1169284	1001347	1169561
Rh28	1001102	1169519	1001195	1169538
Rh29	1001837	1169458	1001055	1168880
Rh30	1001070	1168912	1001057	1168847
Rh31	1001048	1168931	1001074	1169155

Source: (Universidad Distrital Francisco José De Caldas, 2017). Planar Coordinates Magna Colombia East East

Figure 4.175: Sampling points for herpetofauna in the property of Forestal de la Orinoquia.

Source: Satellite images provided by Digitalglobe remote sensor. Google Earth.

- ***LAB PHASE***

Following Angulo's[50] methodology, collected individuals were sacrificed with Roxicaína®, fixed with a solution of formaldehyde at 10% in plastic plates and labelled. Each label provides a unique code for each specimen, referred to a database containing information regarding the date of collection, collector's code, geographic coordinates, altitude above sea level and place of capture, detection method and site code, which is related to the field format code, containing detailed information. (Figure 4.176:). Collected specimens are deposited, with the corresponding collection permit, in the herpetological collection of the High Mountain Biodiversity Research Group of the Universidad Distrital and the Universidad de los Andes.

[50] (Angulo, 2006)

Figure 4.176: Identification of reptiles taken to the laboratory.

Source: (Universidad Distrital Francisco José De Caldas, 2017)

- ***STATISTICAL ANALYSIS OF DATA.***

Sampling effort

In order to obtain an adequate representativity of amphibian species found in the area, it is important to conduct a sampling effort that covers the largest possible area of study with a habitat heterogeneity, which depends in many occasions on the ability of the researcher in the field. Thus, the importance of captures and record of species.

The sampling effort is evaluated, as stated by Villarreal[51], in total detection hours and distance covered. This calculation was made recording the hours per day used, and the distance covered. In the end, the sampling effort is defined as the amount of work invested to obtain sampling data.

Species accumulation curve

One of the graphic ways to determine if the sampling effort is optimal is through the species accumulative curves, which compare the values of richness observed, with the expected values, by means of non-parametric estimators, to calculate expected values. The EstimateS program is generally used. The accumulation curves graphically show how species appear according to sampling units or to the number of recorded individuals. When the accumulation curve is asymptotic, the increase in the number of species does not depend on the number of sampling units. This also indicates the effectiveness of the sampling; sometimes, it is necessary to apply accumulation models to evaluate the extent of the sampling and the number of species that may be potentially captured, considering that the sampling success, according to Moreno[52], depends on the variable conditions subject to randomness. For example, statisticians may provide a sampling representativity of 50% of potential species; nevertheless, the accumulation curves are asymptotic, that is, for field conditions given

[51] (Villareal H., 2006)

[52] (Moreno, 2001)

(season, present covers, human activities, etc.), the sampling effort was appropriate and those are the species found at that moment; the remaining percentage of species not observed may be migrating, in a state of estivation or latency, or in stratum impossible to be observed with conventional methods, according to Moreno[53] and Angulo[54].

Species richness

For field inventories, one of the most effective ways to assess diversity is the specific richness (S); this is strictly based on the number of species found at a specific location. The most effective way to evaluate the specific richness, is to create an inventory which allows to record the total number of species (s) obtained through sampling. Fisher's diversity index is applied to provide a statistical approach of the level of diversity of the area. This index refers to a logarithmic series related to the distribution of abundance of species (Magurran, 1998). This value (α), may be estimated through statistical programs such as Biodiversity Professional Beta 1 (McAleece, 1997) or Past (Paleontological Statistics Software Package for Education and Data Analysis) (Hammer, Ø., Harper, D. A. T., & Ryan, P. D. 2001). It is important to bear in mind that the number of species obtained is strongly linked to the size of the selected sample, that is, that the sampling effort must be the same in each area in which the information is obtained. Nevertheless, the nature of the index does not depend, necessarily, on the size of the sample; thus, Fisher's index may be appropriate to evaluate diversity in this type of surveys. (Moreno, 2001; Angulo *et al*, 2006).

4.3.2.2.2 Reptile herpetofauna

In relation to reptiles, the same methodology and statistical analysis is used, as the sampling effort for reptiles is the same as for amphibians, due to their affinity in sharing similar habitats; the accumulation curve and the species richness is managed with the same statistical procedure, but with an independent set of data for amphibians.

- ***FIELD PHASE***

To determine the composition of reptiles in each of the environmental units, the free and unrestricted technique was used (Angulo et al., 2006), carrying out day and night walks without following special rules, other than thoroughly reviewing all available microhabitats with the purpose of recording the largest possible number of species.

With the purpose of inferring the variables or influences which explain and determine the presence of species, the effort to collect them during the free and unrestricted search was standardized within each sampling area. This methodology was used to record the information regarding the individual presence and absence of species, as well as the number of animals observed by sampling unit. All individuals captured were photographed and georeferenced. Due to the abundance of some species and the difficulty to access and capture some of them, as a consequence of the altitude or flood levels, several specimens were recorded by visual identification or by their singing and were georeferenced but not captured. Metadata associated to each event was recorded using the field and data matrix format designed for this project. Data collection was carried out using Duellman[55] and McDiarmid's[56] standard methodology.

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[53] Ibid., p. 68.
[54] (Angulo, 2006)
[55] (Duellman, 1962)
[56] (McDiarmid, 1994)

Figure 4.177: Ad libitum walks to search for day herpetofauna.

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Sampling by free and unrestricted search was carried out in 2 types of cover on a general level, in 5 sampling areas (Gallery forest and Palm Swamp with transition areas to grasslands), with 3 or 4 effort days for each one, for a total of 21 field days and 31 walks (Figure 4.175). Within each area, daily walks took place, divided in two time slots (day and night), with a total of 9 effective hours. The walks were carried out reviewing all possible microhabitats to capture amphibians and reptiles (puddles, streams, litter), as well as man-made structures, dumps and gardens (many specimens migrate to areas with high anthropogenic activity, searching for shelter or food such as insects and small invertebrates). Each captured and collected individual will be measured morphologically as follows: face-cloacal length (LRC), femur length (LF), rostral length (LR), rostral width (AR); individuals were grouped in morphotypes considering a series of shared characteristics.

Table 4.92: Location of sampling points for herpetofauna

Code	STARTING POINT		ENDING POINT	
	X	Y	X	Y
Rh1	916872,9	1171773	916888,3	1171770
Rh2	917645,4	1168921	917748	1168881
Rh3	917726,5	1168897	917793,6	1168942
Rh4	917685	1168918	917890,1	1169139
Rh5	917920,5	1169089	917953	1169287
Rh6	917966,9	1169327	917732,9	1168881
Rh7	917717,9	1168915	917709	1168900
Rh8	916242,6	1172009	916538,7	1172192
Rh9	916459,7	1172241	916108,7	1172094
Rh10	916071,4	1172020	916150,5	1172121
Rh11	915909,5	1160808	915951,8	1160931
Rh12	915828,2	1171850	915836,2	1171836
Rh13	916050	1172105	917472,5	1172227
Rh14	914585,6	1170300	914569,7	1170384
Rh15	915522,4	1160826	915632,2	1161094

Code	STARTING POINT		ENDING POINT	
	X	Y	X	Y
Rh16	997570,9	1151824	997683,1	1151641
Rh17	994628,7	1154251	994619,8	1153918
Rh18	994618,5	1153901	994247,9	1153597
Rh19	997677,3	1151823	997559,5	1151987
Rh20	996082,8	1154613	995904,1	1154703
Rh21	995884,1	1154717	995692,8	1154193
Rh22	1002222	1169434	1001852	1169852
Rh23	1001852	1169856	1001923	1169568
Rh24	1001948	1169550	1001525	1169792
Rh25	1001921	1169528	1001317	1170173
Rh26	1001332	1170186	1001965	1169586
Rh27	1001598	1169284	1001347	1169561
Rh28	1001102	1169519	1001195	1169538
Rh29	1001837	1169458	1001055	1168880
Rh30	1001070	1168912	1001057	1168847
Rh31	1001048	1168931	1001074	1169155

Source: (Universidad Distrital Francisco José De Caldas, 2017)

- ***LAB PHASE.***

Collected individuals were sacrificed with Roxicaína®, fixed with a solution of formaldehyde at 10% (Angulo et al., 2006), in plastic plates and labelled. (Figure 4.178). Each label provides a unique code for each specimen, which refers to a database containing information regarding the date of collection, collector's code, geographic coordinates, altitude above sea level and place of capture, detection method and site code, related to the field format code, containing detailed information. Collected specimens are deposited, with the corresponding collection permit, in the herpetological collection of the High Mountain Biodiversity Research Group of the Universidad Distrital and the Universidad de los Andes.

Figure 4.178: Identification of reptiles taken to the laboratory.

Source: (Universidad Distrital Francisco José De Caldas, 2017)

- ***STATISTICAL ANALYSIS.***

Sampling effort

In order to obtain an adequate representativity of amphibian species found in the area, it is important to conduct an optimal sampling effort covering the largest possible area of study with a habitat heterogeneity, which depends in many occasions on the ability of the researcher in the field. Thus, the importance of captures and record of species.

The sampling effort is evaluated, as stated by Villarreal[57], in total detection hours and distance covered. This calculation was made recording the hours per day used, and the distance covered. In the end, the sampling effort is defined as the amount of work invested to obtain sampling data.

Species accumulation curve

One of the graphic ways to determine if the sampling effort is optimal, is through the species accumulative curves, which compare the values of richness observed with the expected values, by means of non-parametric estimators, to calculate expected values. Colwell & Coddington[58] and Colwell[59] 2013 EstimateS program is generally used. The accumulation curves show in graphs how species appear according to sampling units or to the number of recorded individuals. When the accumulation curve is asymptotic, the increase in the number of species does not depend on the number of sampling units. This also indicates the effectiveness of the sampling; sometimes, it is necessary to apply accumulation models to evaluate the extent of the sampling and the number of species that may be potentially captured, considering that the sampling success, according to Moreno[60], depends on the variable conditions subject to randomness. For example, statisticians may provide a sampling

[57] (Villareal H., 2006)
[58] (Colwell, 1994)
[59] (Colwell, 2013)
[60] (Moreno, 2001)

representativity of 50% of potential species; nevertheless, the accumulation curves are asymptotic, that is, for field conditions given (season, present covers, human activities, etc.), the sampling effort was appropriate and those are the species found at that moment; the remaining percentage of species not observed may be migrating, in a state of estivation or latency, or in stratum impossible to be observed with conventional methods, according to Moreno[61] and Angulo[62].

Species richness

For field inventories, one of the most effective ways to assess diversity is the specific richness (S); this is strictly based on the number of species found at a specific location. The most effective way to evaluate the specific richness, is to create an inventory, recording the total number of species (s) obtained through sampling. Fisher's diversity index is applied to provide a statistical approach of the level of diversity of the area. Magurran[63] states that this index refers to a logarithmic series regarding the distribution of abundance of species. This value (α), may be estimated through statistical programs such as Biodiversity Professional Beta 1 (McAleece, 1997) or Past (Paleontological Statistics Software Package for Education and Data Analysis) (Hammer, Ø., Harper, D. A. T., & Ryan, P. D. 2001). It is important to bear in mind that the number of species obtained is strongly linked to the size of the selected sample, that is, that the sampling effort must be the same in each area in which the information is obtained. Nevertheless, the nature of the index does not depend necessarily on the size of the sample; thus, Fisher's index may be appropriate to evaluate diversity in this type of studies.

4.3.2.2.3 Birds

- ***FIELD PHASE***

The sampling design consisted of 5 stations or points associated with vegetation covers of gallery forests and palm swamps found in the property of Forestal de la Orinoquía. Two main methodologies were implemented in each point (direct observation of birds and bird catch with mist nets) to include both types of vegetation covers. The team was formed by an ornithologist and a local expert or "baqueano" who determined the characteristics of the avifauna during the rainy season (Figure 4.179 and Figure 4.180).

61 Ibid., p. 68.
62 (Angulo, 2006)
63 (Magurran, 1998)

Figure 4.179: Gallery forest. Photo by Nadezhda Bonilla. 2017

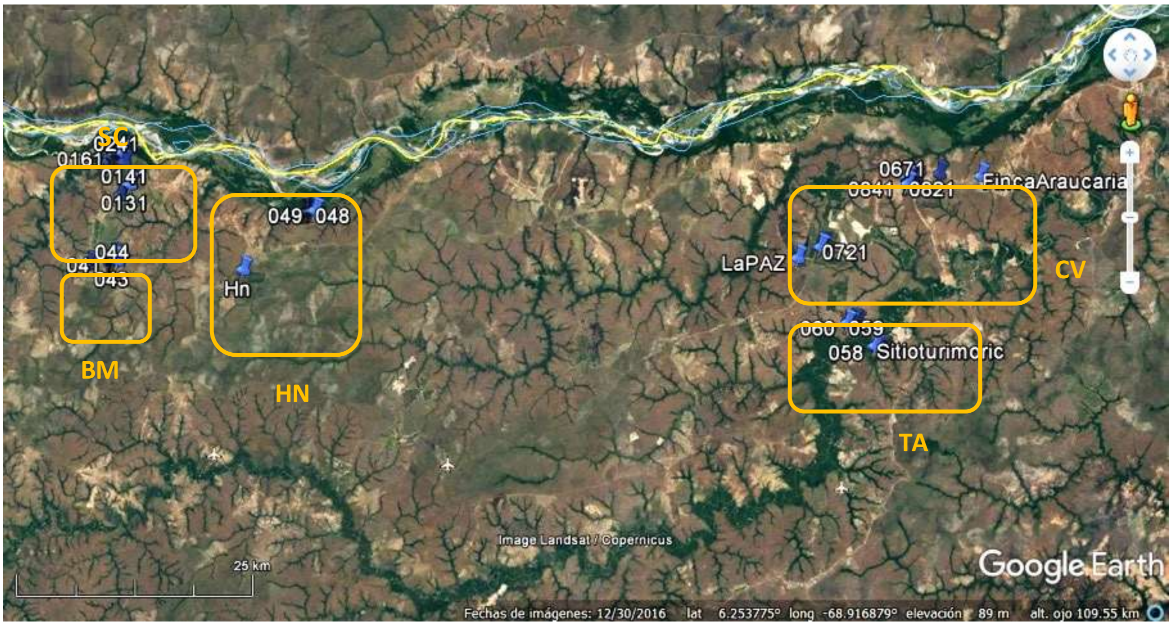
Source: (Universidad Distrital Francisco José De Caldas, 2017)

Figure 4.180: Palm Swamp. Photo by Nadezhda Bonilla. 2017

Source: (Universidad Distrital Francisco José De Caldas, 2017)

The points are: San Cristóbal (SC), Base Mono (BM), Hato Nuevo (HN), Tierra Adentro (TA) and Cuernavaca (CV) (Figure 4.181). Each of these points is near or influenced by a main water resource, SC to the Muco river, BM to Chiquichaque, HN to the Meta river, TA to the Vita river and CV to Juriepe

Figure 4.181: Map with sampling points. Landsat/Copernicus image. Google Earth. 2017



Source: Satellite images provided by Digitalglobe remote sensor. Google Earth.

Elevation data and geographic coordinates were taken in each point using a *Garmin cetrex GPS.* The type of habitat and degree of intervention was described, supported with photographs for each sampling unit. The methods implemented for bird sampling in the 5 points included visual and listening detection in fixed point counts combined with transects (5 Km/h walks), bird catch with mist nets, collecting specimens based on the professional's opinion, and non-systematic observations in different habitats with no restrictions regarding methodology or time, as established by Ralph[64] & Bibby.[65]

According to Villarreal[66], this combination of methods increases the probability of detecting species, as well as obtaining data regarding abundance and provides a quick and relatively reliable and repeatable way to evaluate the state of conservation, based on the quantitative analysis regarding the composition and structure of the avifauna at the landscape level. Each of these methods are described below:

Bird catch with mist nets

Mist nets have been used as the only tool to create bird inventories in several neotropical forests, as they substantially reduce observer bias, compared to point count methods and vocalization recordings, even though Remsen & Good[67], Stiles & Roselli[68], mention several studies which have proved their low efficiency compared with other methods. Nevertheless, according to Villarreal[69], bird capture not only allows the detection of less conspicuous species, but also helps to obtain morphological and physiological data, such as molt, reproduction, age, gender and condition of the bird.

5 to 7, 12 m long by 2.6 m wide mist nets were used, with an extended mesh of 30 to 36 mm. The initial plan included 10 mist nets, but the weather conditions and the state of the points assessed made it impossible to

[64] (Ralph, 1996)
[65] (Bibby, 2000)
(Villareal H., 2006)
[67] (Remsen, 2017)
[68] (Stiles, 1998)
[69] (Villareal H., 2006)

place the total number of nets. Due to the rainy season, the areas were flooded and the density of the underwood restricted the area's extension, not allowing the implementation of the method established by Villareal et al., (2016) (Figure 4.182).

Figure 4.182: Flooded covers due to the rainy season. Photo by Nadezhda Bonilla. 2017

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Capture sessions started around 05:15, the nets remained opened for three and a half to 6 consecutive hours during the morning and the afternoon and were checked every 20 minutes following protocols as established by Ralph et al[70]. Each session lasted one and a half days per point, in which information regarding the location, starting and ending time, type of habitat, date, weather conditions, responsible personnel, elevation and geographic coordinates, and the number of nets was recorded (Figure 4.183).

Figure 4.183: Placement of mist nets. Photo by Nadezhda Bonilla. 2017

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Captured birds were transported in cloth bags to a processing station where they were measured and marked cutting the external tail feathers, and then released. Each captured bird was identified with the help of Ridgely

70

& Tudor[71] and Proaves field guides. The following information was obtained from each bird: wing, tarsus and tail length, total culmen, exposed culmen, height and width of beak, gender, presence or absence of cloacal protuberance, brood patch, comments and photographic records (Figure 4.184, Figure 4.185 and Figure 4.186).

Figure 4.184: Removal of an individual from the mist net. Photo by Yonathan Ordaz. 2017.

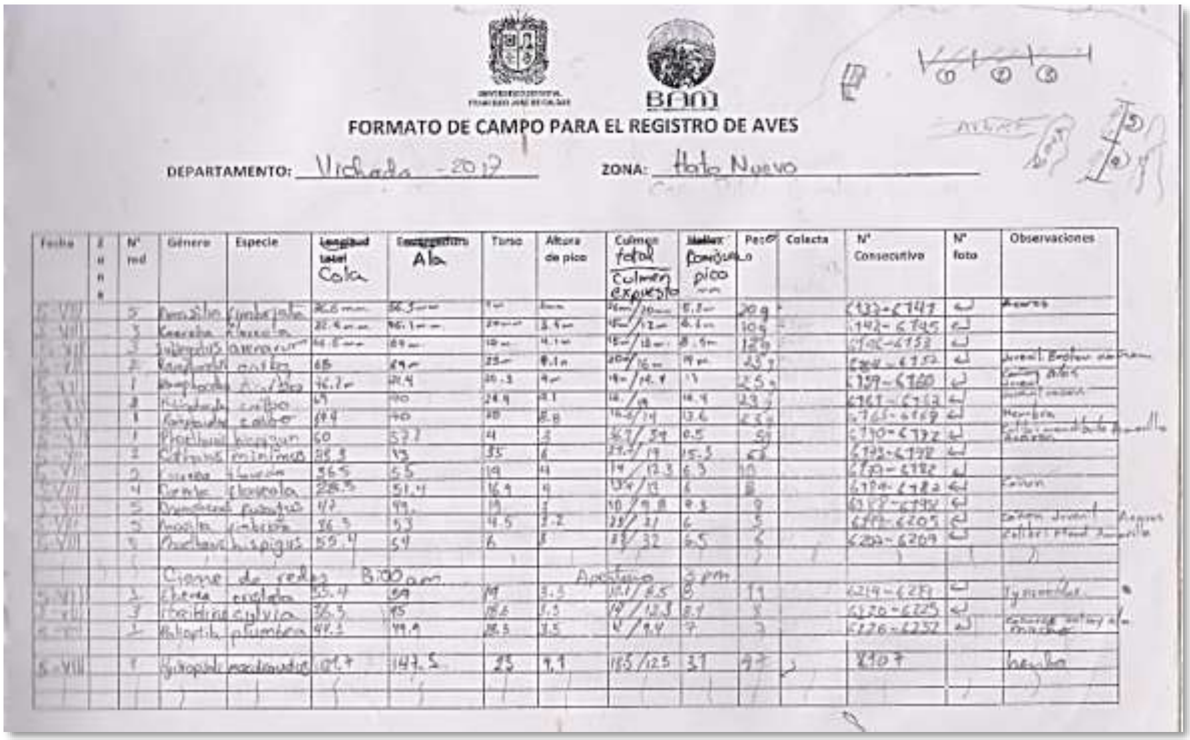
Source: (Universidad Distrital Francisco José De Caldas, 2017)

Figure 4.185: Taking morphometric measurements. Photo by Yonathan Ordaz. 2017.

Source: (Universidad Distrital Francisco José De Caldas, 2017)

[71] (Ridgely, 2009)

Figure 4.186: Form used for bird capture sessions with mist nets. Photo by Nadezhda Bonilla. 2017



FORMATO DE CAMPO PARA EL REGISTRO DE AVES

DEPARTAMENTO: Vichada - 2017 ZONA: Hato Nuevo

Fecha	Zona	N° red	Género	Especie	~~Longitud total~~ Cola	~~Envergadura~~ Ala	Tarso	Altura de pico	Culmen total / Culmen expuesto	~~Ancho~~ Comisura pico	Peso	Colecta	N° Consecutivo	N° foto	Observaciones
5-VIII		5	[illegible]	[illegible]	26.8 mm	56.3 mm	[illegible]	[illegible]	[illegible]	5.3 mm	20 g		6133-6141		[illegible]
5-VIII		3	Coereba	flaveola	22.4 mm	46.1 mm	[illegible]	3.4 mm	[illegible]	6.6 mm	10 g		6142-6145		
5-VIII		3	[illegible]	[illegible]	46.8 mm	69 mm	[illegible]	[illegible]	[illegible]	8.5 mm	12 g		[illegible]-6153		
5-VIII		2	[illegible]	[illegible]	65	69 mm	25 mm	9.1 m	20/16 mm	19 mm	23 g		[illegible]-6152		[illegible]
5-VIII		1	[illegible]	[illegible]	46.7 mm	60.4	20.3	9 mm	19 mm/14.4	13	25 g		6159-6160		[illegible]
5-VIII		2	[illegible]	[illegible]	69	90	24.9	2.1	16/18	14.4	23 g		6161-6163		[illegible]
5-VIII		1	[illegible]	[illegible]	69	40	20	8.8	14.5/14	13.6	23 g		6165-6169		Hembra
5-VIII		1	Phaethornis	[illegible]	50	57.7	4	3	36.7/34	0.5	5 g		6170-6172		[illegible]
5-VIII		2	[illegible]	minimus	35.3	43	35	6	23.7/19	15.3	63		6173-6178		
5-VIII		2	[illegible]	[illegible]	36.5	55	19	4	14/12.3	6.3	10		6180-6182		
5-VIII		4	[illegible]	flaveola	28.5	51.4	16.9	4	13.4/13	6	8		6184-6182		[illegible]
5-VIII		5	[illegible]	[illegible]	47	49	19	3	10/9.8	9.3	9		6188-6192		
5-VIII		5	[illegible]	[illegible]	36.3	53	14.5	3.2	23/21	6	5		6199-6205		[illegible]
5-VIII		4	Phaethornis	hispidus	59.4	54	6	3	33/32	6.5	5		6207-6209		[illegible]
			Cierre de redes	8:00 am					Apertura	3 pm					
5-VIII		3	[illegible]	[illegible]	55.4	69	19	3.5	10.1/8.5	8	19		6219-6221		[illegible]
5-VIII		3	[illegible]	sylvia	36.3	45	18.6	3.5	14/12.3	8.1	8		6220-6225		
5-VIII		2	[illegible]	plumbea	47.3	44.4	18.5	3.5	[illegible]/9.4	7	7		6226-6232		[illegible]
5-VIII		1	[illegible]	[illegible]	107.7	147.5	25	9.1	18.5/12.5	31	97		8407		[illegible]

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Bird observation: Transects and point counts

Methods to carry out bird inventories have varied through time, according to their implementation and thoroughness; this has presented problems in standardizing a sampling method to compare designs and reproductions.

According to Ralph[72] bird point counts are a standard method to monitor birds all around the world, due to their efficiency in different types of habitats. The inclusion of point counts in quick diversity evaluations has the advantage of concentrating totally on the birds and their habitats, since they are located in fixed points, and provide more time to identify the species and detect those cryptic and territorial (for example birds of the underwood); it also allows an association between the presence of birds and their abundance, with the structural and environmental characteristics of the habitat, as described by Bibby[73].

Nevertheless, one of its limitations refers to the sampling of one single point, which may provide an unprecise indication of species richness in an area, especially in those areas with high richness, thus requiring many repetitions to obtain a relatively reliable calculation. For this reason, combining point counts with transects generates indexes of sampling efforts and ensures a more precise estimate of the species richness.

In each sampling path, a minimum of 5 point counts were established, separated by a distance of 100 m in forest areas, in order to avoid recounting the individuals, and ensuring the independence in detecting the birds between points. In each point, the birds watched and heard were recorded within a fixed radius of 50 m during

[72] (Ralph, 1996)

[73] (Bibby, 2000)

a period of 30 minutes, as described by Ralph[74]. Information related to elevation, geographic position with GPS, type of vegetation cover, degree of intervention, etc. was also recorded (Figure 4.187).

Counts started at dawn and continued until sunset, interrupted at the time of less bird activity (11:00 to 14:00), or in periods of heavy rain. Using 10 x 42 mm binoculars, all the birds detected within the fixed radius were recorded. Individuals in and outside the fixed radius were recorded separately for each species. Any bird that escaped the moment the observer arrived to the counting position, was also recorded. Transient birds flying over the area without stopping were recorded in the same format, as well as all the birds detected moving between point counts (transect) (Figure 4.188).

During counting, the following data was recorded in the field format: Location, distance, observers, date, weather conditions, starting time, point count code, time of each detection, species and evidence code (GPS or photo) gender (male, female, undetermined), number of individuals, approximate distance between the individual and the point, vertical location (in meters), detection radius, activity observed (vocalizing, foraging, perching, mixed flock, reproduction) and comments (Figure 4.189).

Figure 4.187: Bird observation: Point count. Photo by Yonathan Ordaz. 2017

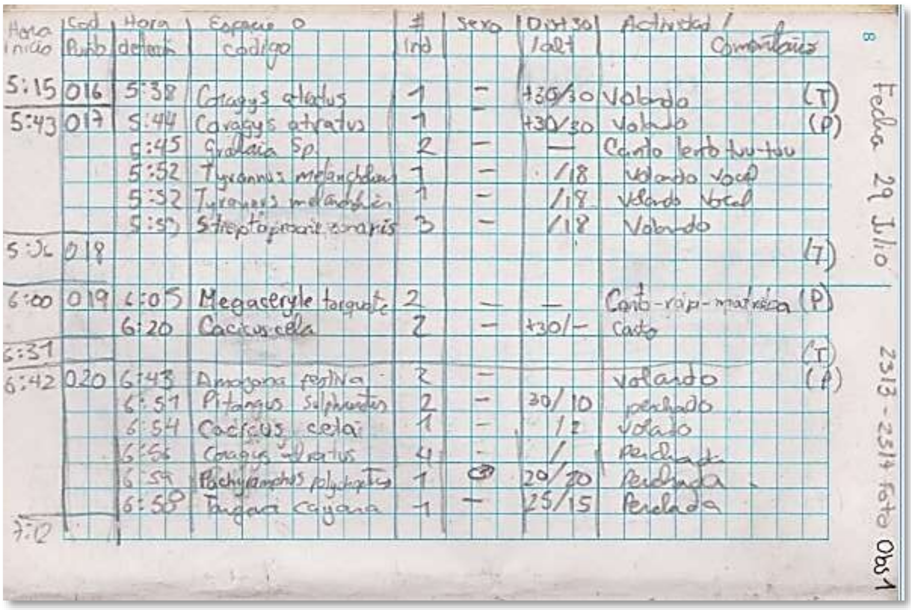
Source: (Universidad Distrital Francisco José De Caldas, 2017)

Figure 4.188: Bird observation: Transects and non-systematic observations. Photo by Nadezhda Bonilla. 2017

[74] (Ralph, 1996)

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Figure 4.189: Format in the field book for bird observation sessions. Photo by Nadezhda Bonilla. 2017



Hora inicio	Cod Punto	Hora detecc	Especie o código	# Ind	Sexo	Dist 30/alt	Actividad / Comentarios
5:15	016	5:38	Coragyps atratus	1	–	+30/30	Volando (T)
5:43	017	5:44	Coragyps atratus	1	–	+30/30	Volando (P)
		5:45	Grallaria sp.	2	–	–	Canto lento tuu-tuu
		5:52	Tyrannus melancholicus	1	–	/18	Volando vocal
		5:52	Tyrannus melancholicus	1	–	/18	Volando vocal
		5:57	Streptoprocne zonaris	3	–	/18	Volando
5:56	018						(T)
6:00	019	6:05	Megaceryle torquata	2	–	–	Canto-rap-matraca (P)
		6:20	Cacicus cela	2	–	+30/–	Canto
6:31							(T)
6:42	020	6:43	Amazona festiva	2	–		Volando (P)
		6:51	Pitangus sulphuratus	2	–	30/10	perchado
		6:54	Cacicus cela	1	–	/2	Volando
		6:56	Coragyps atratus	4	–	/	Perchado
		6:59	Pachyramphus polychopterus	1	♂	20/20	Perchado
		6:58	Tangara cayana	1	–	25/15	Perchada
7:12							

8 Fecha 29 Julio 2313 - 2314 foto Obs 1

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Taxonomic determination and lab phase.

The taxonomic determination is carried out, in general, directly in the field phase, using the bird guides mentioned before. Birds which could not be identified in the field were recorded by photographs, to be identified in the lab phase, comparing them with specimens included in ornithology collections of the Institute of Natural Sciences (Universidad Nacional) and the Universidad Distrital Francisco José de Caldas.

- ***STATISTICAL ANALYSIS OF DATA***

Sampling effort

In order to have representativeness of the number of species found in the different points, a sampling effort is conducted recording the total number of hours dedicated to the detection or implementation of a methodology.

This calculation is made recording the hours per day used, and the distance covered. In the end, the sampling effort is defined, according to Villarreal[75], as the amount of work invested to obtain data in a survey.

The purpose was to balance the number of hours dedicated in implementing these methodologies, that is, dedicating the same number of sessions for each one: 3 sessions (one day and a half) to observation and 3 sessions (one day and a half) to capture using mist nets, trying to include the greatest possible sampling distance in the vegetation covers selected. The units are expressed in sampling hours for the first and hours/net for the second.

Species accumulation curve

A species accumulation curve is used to show in graphs the sampling effort and values of richness obtained in relation to expected values, by means of non-parametric estimators, to calculate expected values. This curve is determined using the *EstimateS version 9* program created by Colwell & Coddington[76] 1994 bb and Colwell 2006[77], introducing data and creating a graph indicating the number of sessions, compared with the values obtained and the estimators (Chao 1, Jackniff and ACE). This shows the species which appear as the sessions increase. When the accumulation curve is asymptotic, the increase in the number of species does not depend on the number of sampling units. This also indicates the effectiveness of the sampling.

Considering the results of this curve, we must point out that, according to Moreno[78] there are conditions subject to randomness, which prevent optimal results, due mainly to field conditions (time of year, coverage, areas intervened, among others) or migration of species, hunting season or stratums out of reach with traditional methods, that is, conditions beyond the control of the investigator, but that do not necessarily indicate that the sampling was insufficient.

Species richness

The specific richness was determined by means of Fisher's Alpha index. This index is based on the logarithmic model of distribution of abundance of species, regardless of the size of the sample (Magurran, 1988); Fisher's Alpha index was estimated with the PAST 3.16 program (Paleontological Statistics Software Package for Education and Data Analysis).

According to Moreno[79], it should be noted that the number of species obtained is related to the size of the sample, that is, to the sampling effort, which should be homogeneous in each area where the survey is carried out; although Fisher's index may not adjust to the size of the sample, it is adequate to measure diversity in this type of surveys, where some assumptions do not comply with certain parameters, due to the random conditions mentioned above.

Capture success with mist nets, was determined by the number of individuals captured in relation to the sampling effort (Individuals-session/hours-net), taking into account the total number of nets, multiplied by the total number of sessions and hours/day. Thus, the number of opened nets, the opening and closing time and the meters of each net should be considered.

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[75] (Villarreal H., 2006)
[76] (Colwell R, &., 1994)
[77] (Colwell R., 2013)
[78] (Moreno, 2001)
[79] Ibid., p.88

4.3.2.2.4 Mammals

- ***FIELD PHASE.***

In relation to mammals, the field phase applied different techniques to collect information, taking into account Jone's (1986) classification, which divides them in flying mammals, small mammals (<1000), medium size mammals (1000-5000g), and large mammals (> 5000g). Mist nets were used for flying mammals, Sherman traps for small mammals and for the medium size and large mammals, camera traps and identification of signs such as footprints, hair, scrapers, and traces (osadero), etc.

Small Mammals

Small mammals are characterized by having a length of less than 500mm and wighing between 3 and 1000g. Within this range is the Rodentia Order with small rodents, the Didelphimorphia order (marsupials) and Paucituberculata (shrews).

The sampling of small mammals was carried out with 60 Sherman traps per sampling area, during 3 effective sampling days. The location of the Sherman traps was recorded in a Garmin Montana 650® GPS navigator. The traps were checked daily at 8 am. Each trap was baited with a mixture of Nutella, sardines or tuna fish, oatmeal, vanilla essence and Areparina to give consistency to the baits. Traps were placed in linear transects in the forest considering the degree of flood, which prevented the distribution of these traps in other sites. Traps were positioned at an average distance of 10-20 meters one from the other.

Captured individuals were then collected for identification in the lab: Nevertheless, each specimen was recorded with its standard morphometric measurements as follows: Total Length (LT), Tail Length (LC), Head-Body Length (LCC), Paw Length (LP), Ear Length (LO) and weight; all small morphometric measurements were taken with a Vernier caliper, while LT, LC, and LCC were done with a metallic rule; body measurements were recorded in millimeters, while weight was recorded in grams (Figure 4.190).

Collected specimens are deposited in the Scientiic Collection System of the High Mountain Biodiversity Research Group (Museum of Natural History of the Universidad Distrital Francisco José de Caldas).

Figure 4.190: Installed Sherman Trap and collected Zygodontomys specimen (Photo – Gabriel Pantoja Peña, 2017)

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Medium size and Large Mammals

Medium size and large mammals exceed 500 mm in length and 1000 grams in weight. The Didelphimorphia, Cingulata, Pilosa, Lagomorpha, Carnivore and Cetartiodactyla. Orders [sic]. To record these types of mammals sampling techniques such as photo-traps and indirect traces were used. In the first case, 33 *Bushnell Trophy Cam* active camera traps were used (Figure 4.191). The cameras were installed ad libitum in the gallery forests, in each of the five sampling points. Each point had 10 camera traps, for a total of 50 traps throughout the sampling. The cameras were located at a height between 50cm and 1 meter, depending on the height of pastures or placement of litter. Each camera was programed in mixed mode (video and photography) with repetitions of 3 photos and videos of a maximum of 30 seconds. The location of the cameras was recorded in a Garmin Montana GPS navigator. Each location was baited with raw fish brought from Puerto Carreño's market, and with bananas and fruits.

Figure 4.191: Installed Bushnell Camera Trap and marking of trees for recognition (Photo – Gabriel Pantoja Peña, 2017)

Source: (Universidad Distrital Francisco José De Caldas, 2017)

For the second recording method, ad libitum walks were carried out in the area, recording footprints, hair, excreta, vocalizations, marks on trees and excavations. Dead specimens found in the area were left in the place, except when the skeletons were clean, which made the gathering of skulls easier (Figure 4.192).

Figure 4.192: Signs found on sites of Forest First – Footprints and removal of vegetation cover and soil in search of food (Photo – Gabriel Pantoja-Peña, 2017).

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Flying mammals

To record bats, mist nets with a length of 12 m and a height of 2.6 meters were used. Based on the structure of the forests and flood limits, the nets were installed in ecotone areas or in the interior of the forests. The idea was to install around 10 nets, but at the end, only 5 to 7 nets were installed (Figure 4.193). Samplings were done between 18:00 and 00:00 in each point during 3 consecutive nights. All captured specimens were measured recording their standard morphometric measurements as follows: Total Length (LT), Tail Length (LC), Forearm Length (LA), Shin Length (Lti), Paw Length LP), Ear Length (LO), and weight (W); All morphometric measurements were taken with a Vernier caliper and were recorded in millimeters, while the weight was recorded in grams, taken with Pesola scales of 100g.

When the captured species was recorded for the first time in the sampling, or if the species could not be identified on site, the specimen was collected, labelled and preserved in ethanol at 96%, in order to be deposited in the theriologic collection of the Universidad Distrital.

Figure 4.193: Installed mist nets (Photo – Edgar Bernal, 2017)

Source: (Universidad Distrital Francisco José De Caldas, 2017)

- ***LAB PHASE.***

The lab phase included the identification of species from skulls processed by dermestid beetles and skins obtained and preserved on site; likewise, species were identified from photos taken with camera traps. Information was organized in matrixes and then analyzed statistically.

Evaluation of capture success

Sherman Traps

Sherman traps were active 24 hours for 18 days, divided in three areas. The sampling effort is measured as the number of traps installed in each site, by the number of sampling days.

Effort = Number of traps * Number of days

Sampling success was measured considering the number of individuals captured, multiplied by the correction factor 100.

$$\textbf{Trap success} = \frac{\textbf{N. of captured animal}}{\textbf{Capture effort}}$$

Camera Traps

The sampling effort for this type of methodology may be measured using the number of sampling nights (nights/trap), the number of sampling days (days/trap) or its equivalent in hours trap, as answer units, Each of the camera traps functioned 24 hours, for 15 to 20 days in average. Thus, the sampling effort was measured individually for each camera trap, taking into account the number of effective sampling days, according to the number of days in which the cameras functioned.

Effort = Number of hours * Number of sampling days

Capture success was measured considering the number of photos per individual of each species, divided by the number of effective sampling days, multiplied by the factor 100. This estimate was done individually for each camera trap.

$$\textbf{Success camera traps} = \frac{\textbf{N. of photos per individual}}{\textbf{N. of sampling days}}$$

Mist Nets

The sampling effort was measured considering the total sum of meters-net by the number of sampling hours and the number of sampling nights.

Effort = meters-net * sampling hours*sampling nights

Capture success indicates relative abundance of species and is measured with the following formula:

$$E = \frac{\mathbf{N}}{\mathbf{m\ x\ h}}\ \mathbf{X\ 100}$$

Where **N** = number of individuals captures; **m** = square meters of the net; **h** = number of sampling hours.

Species Accumulation Curves

With the purpose of evaluating the normality of the information recorded on site, the Shapiro-Wilk normality test was performed. This test determines the type of method (parametric / non-parametric) to which data adjusts best for the corresponding statistical analysis. Accumulation curves make it possible to learn the manner in which species accumulate, as the sampling effort increases, according to Villarreal[80]. Curves were graphed for each sampling method and were carried out using the number of effective sampling days (in the case of Sherman traps) and the number of effective sampling nights (in the case of mist nets), as answer units. The set of data was randomized 1000 times to eliminate any bias derived from the order in which data was included in the analysis, using the EstimateS 9.1.0. Software program. With the purpose of measuring the expected number of species, non-parametric estimators Chao 1, ACE and Jacknife 1 were used.

Species Richness

To quantify richness found in the area, Fisher's Alpha index was used, calculated with the PAST program. According to Moreno[81], this index considers the distribution of abundance of species, and is not affected by the size of the sample, unlike other indexes. Thus, it is widely used and considered one of the most robust indexes.

$$\boldsymbol{S} = \propto \boldsymbol{ln}\frac{\mathbf{1}+\boldsymbol{N}}{\propto}$$

4.3.2.3 Field phase results

4.3.2.3.1 Amphibian herpetofauna

- ***EFFORT AND CAPTURE SUCCESS.***

[80] (Villareal H., 2006)
[81] (Moreno, 2001)

A total of 378 sampling hours were carried out, distributed in 21 days, in 5 areas of Forestal de la Orinoquia, with two persons, for a total of 189 man/hours. Samplings covered mainly gallery forests and palm swamps, as well as their corresponding floodable grassland and woodland ecotones surrounding high covers (Table 4.93).

Table 4.93: Sampling effort of amphibians and reptiles in lands of FFC – Vichada.

Sampling area	**Days**	**Man/Hours**	**Persons**	**Sampling effort (Man/Hours)**
Area 1 San Cristóbal	5	9	2	90
Area 2 Base Mono	4	9	2	72
Area 3 Hato nuevo	4	9	2	72
Area 4 Tierradentro	4	9	2	72
Area 5 Cuernavaca	4	9	2	72
TOTAL (Man/Hours)				**378**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

From the total of herpetofauna found in the five areas, a total of 247 sightings of amphibians were reported (Table 4.94) belonging to 18 species of Anurans (frogs and toads) including 9 genders and 3 families (Figure 4.194 and Figure 4.195). The most abundant family, regarding the number of species, is the Leptodactylidae family, which also has the highest abundance. The low presence of other taxonomic families may be due to the season in which the sampling was performed, as many of the areas and ground microhabitats used by species belonging to other anuran families were flooded. In this case, animals estivate or move to higher areas.

Figure 4.194: Trachycephalus venulosus found in the palm swamp (area 1 San Cristobal) on a palm leaf

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Figure 4.195: Scinax Kennedyi found in flooded grassland associated with the palm swamp (Area 2 Base mono)

Source: (Universidad Distrital Francisco José De Caldas, 2017)

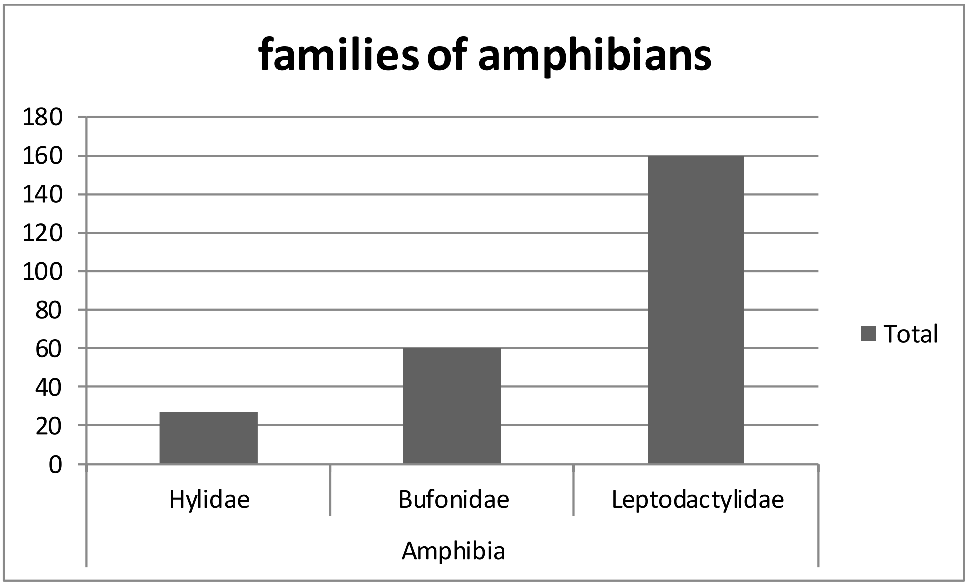
Table 4.94: Species of amphibians recorded on the lands of FFC – Vichada.

Gender	Areas					
Species	**1**	**2**	**3**	**4**	**5**	**Total**
Amphibia	**46**	**46**	**54**	**52**	**49**	**247**
Boana	**7**	**1**	**3**		**2**	**13**
boans	1					1
crepitans	6	1				7
pugnax			3		2	5
Dendropsophus			**6**			**6**
mathiassoni			6			6
Leptodactylus	**12**	**8**	**18**	**20**	**5**	**63**
fragilis	9	3	2			14
fuscus	1	5	10	7	5	28
knudseni				3		3
lithonaetes				10		10
macrosternum	2		6			8
physalaemus			**5**			**5**
fisheri			5			5
Pseudopaludicola		**22**	**12**	**9**	**38**	**81**
boliviana		12	2	9	23	46
llanera		10	10		15	35
pseudopaludicola		**8**		**3**		**11**
boliviana		8		3		11
Rhinella	**26**		**10**	**20**	**4**	**60**
granulosa	24		6	11		41
margaritifera	1			1		2
marina	1		4	8	4	17
Scinax		**7**				**7**
kennedyi		7				7
Trachycephalus	**1**					**1**
venulosus	1					1

Gender	Areas				
Total	**46**	**46**	**54**	**52**	**49**	**247**

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Figure 4.196: Families of amphibians recorded on lands of FFC -Vichada.

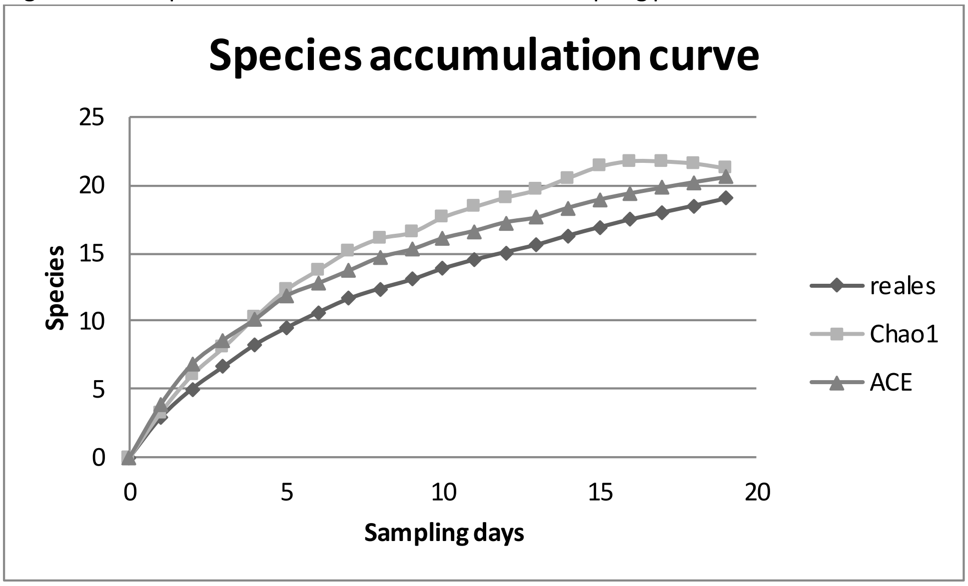


Sourcee: (Universidad Distrital Francisco José De Caldas, 2017)

Species accumulation curve

To evaluate the effectiveness of the sampling carried out in the 5 areas of FFC in Vichada, accumulation curves were drawn (Figure 4.197) using the EstimateS 9.10 program; abundance data were recorded represented by the Chao 1 and Ace Mean indexes, considered appropriate with these sets of data, using the classic Chao 1 model, with intervals of 95% reliability. We observe that the species accumulation curves are very close to their asymptotes and they all tend towards the point of balance. Consequently, the sampling effort was deemed appropriate to identify the largest possible number of specimens; on the other hand, the sampling showed a representativity ranging between 89% (Chao 1) and 92% (ACE), which is relevant considering that, in the case of amphibians, representativity may be, in general, of 70% for these types of surveys. (observations on site).

Figure 4.197: Species accumulation curve in the 5 sampling points.



Source: (Universidad Distrital Francisco José De Caldas, 2017)

- ***RICHNESS INDEX.***

Table 4.95: Diversity indexes for Amphibians in the 5 sampling points.

Areas	1. San Cristóbal	2. Base Mono	3. Hato Nuevo	4. Tierradentro	5. Cuernavaca	Overall Total
Species	9	6	10	7	5	19
Individuals	46	46	54	52	49	247
Fisher_alpha	3.344	1.842	3.61	2.178	1.394	4.797
Chao-1	14	6	10	7	5	20

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Fisher's richness index may be interpreted as the number of new species which may be found each time twice the number of individuals is taken. Therefore, we observe that the highest diversity is found in the area of Hato nuevo (Point 3), followed by San Cristobal (Point 1.). This is explained by the fact that these two areas possess the highest heterogeneity in terms of landscape units, and a combination of microhabitat characteristics, combining lotic, lentic, permanent and seasonal bodies of water, shrub, herbaceous and canopy vegetation, conditions of high and low humidity, as well as hiding and reproduction sites. This allows a greater number of species to inhabit this area, which is reflected in the indexes (Table 4.95).

4.3.2.3.2 Reptile herpetofauna

- ***EFFORT AND CAPTURE SUCCESS.***

A total of 378 sampling hours were carried out, distributed in 21 days and 5 areas in the property of Forestal de la Orinoquia, with two persons, for a total of 189 man/hours. Sampling covers were based mainly on gallery forests and Palm Swamps, as well as floodable grassland and woodland ecotones surrounding high covers (Table 4.96).

From the total herpetofauna found in the 5 areas, a total of 120 sightings of reptiles were reported, belonging to 31 species, of which 14 species are lizards, 11 species are snakes, 4 species are turtles and 2 species are crocodilians, including 28 genders and 16 families. The most abundant family, in relation to the number of species, is the Teiidae family (Figure 4.198, Figure 4.199 and Figure 4.200). It is also the one with the highest abundances. Overall, the species richness is high, and the estimators showed that there could be many more species. This may be due to the rainy season which generates migrations within these groups; snakes, for example, were very active and were reported in all the sampled points. Teiidae lizards inhabit in sympatry, finding up to 3 species in the same microcover; possibly, the good quality of the habitat and the presence of abundant food such as insects, allow them to coexist in harmony, as several species of lizards are very aggressive, even cannibalistic.

Table 4.96: Species of reptiles found in areas of FFC – Vichada.

Gender	Areas					
Species	**1**	**2**	**3**	**4**	**5**	**Overall Total**
Amphisbaena	**1**					**1**
alba	1					1
Anolis		**1**	**2**			**3**
auratus		1	1			2
ortonii			1			1
Atractus				**1**		**1**
crassicaudatus				1		1
Boa					**1**	**1**
constrictor					1	1
Bothrops			**1**		**1**	**2**
atrox			1		1	2
Caiman	**2**		**9**			**11**
crocodilus	2		9			11
Chelonoidis		**4**	**1**			**5**
carbonaria		3	1			4
denticulata		1				1
Chelonoiis	**3**					**3**
carbonaria	3					3
Chironius		**1**	**1**	**1**		**3**
carinatus		1	1	1		3
Cnemidophorus			**2**			**2**
lemniscatus			2			2
Cnemidophorus		**3**	**1**	**4**		**8**
lemniscatus		3	1	4		8
corallus	**1**				**1**	**2**
ruschenbergerii	1				1	2
Crotalus					**1**	**1**
durissus					1	1
Drymarchon					**1**	**1**
corais					1	1
Gonatodes			**1**			**1**
consignatus			1			1

Gender	Areas					
Helicops		**1**	**1**	**2**		**4**
angulatus		1	1	2		4
Hemydactylus	**1**	**1**	**2**	**6**		**10**
brookii	1		1	1		3
frenatus		1	1	2		4
palaichthus				3		3
Iguana		**2**	**8**			**10**
iguana		2	8			10
Iguana		**2**				**2**
iguana		2				2
Kentropyx			**1**			**1**
striata			1			1
Leptodeira		**4**		**1**		**5**
annulata		4		1		5
Mabuya		**1**	**1**	**1**		**3**
mabouya		1		1		2
sp			1			1
Oxybelis					**1**	**1**
aeneus					1	1
Paleosuchus	**1**					**1**
palpebrosus	1					1
Podocnemis	**9**		**16**			**25**
unifilis	7		1			8
vogli	2		15			17
Spilotes		**1**				**1**
pullatus		1				1
Tropidurus			**6**	**3**	**1**	**10**
hispidus			6	3	1	10
Tupinambis	**1**	**1**				**2**
teguixin	1	1				2
Overall total	**19**	**22**	**53**	**19**	**7**	**120**

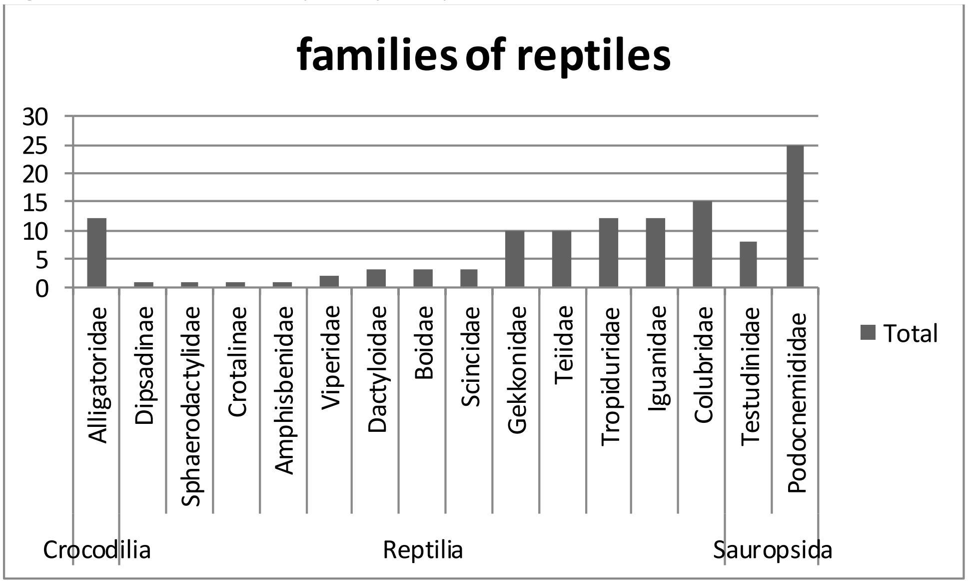
Figure 4.198: *Chironius carinatus* found in point 4 (Tierradentro), in floodable Forest.

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Figure 4.199: *Anolis ortonnii* found in point 3 (Hato nuevo), in riparian vegetation associated with grassland.

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Figure 4.200: Abundance by family of reptiles.

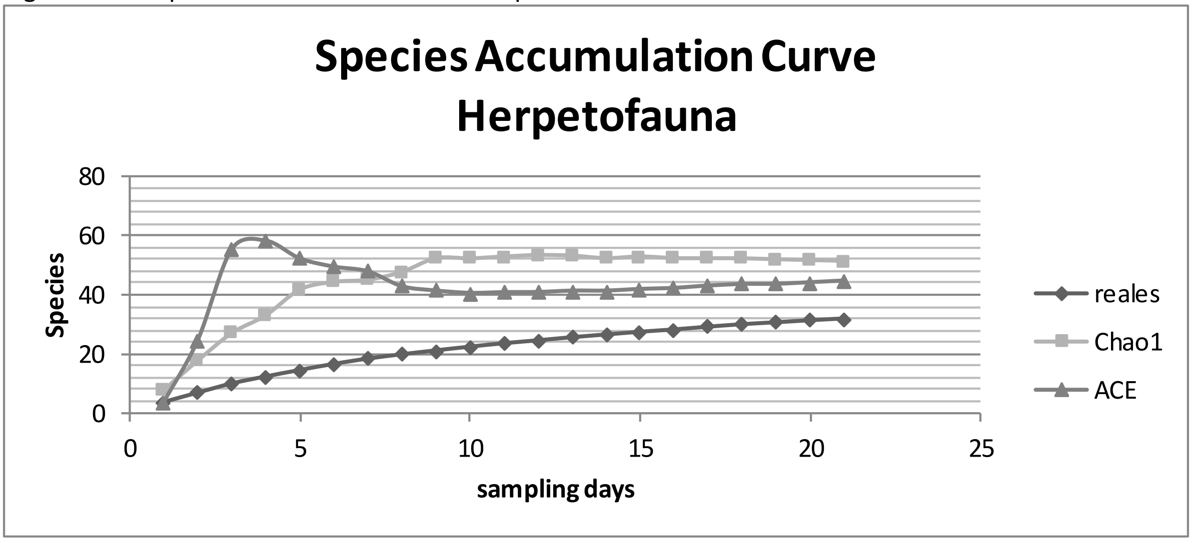


Source: (Universidad Distrital Francisco José De Caldas, 2017)

- ***SPECIES ACCUMULATION CURVE.***

To evaluate the effectiveness of the sampling carried out in the 5 areas of FFC in Vichada, accumulation curves were drawn using the EstimateS 9.10 program; abundance data were recorded represented by the Chao 1 and Ace Mean indexes, considered appropriate with these sets of data, using the classic Chao 1 model, with intervals with a reliability of 95%. We observe that the species accumulation curves are somewhat distant in reaching the point of balance. Consequently, the sampling effort was deemed appropriate as they all reached the asymptote, even though more species may be found if the sampling continues in another season. The sampling showed a representativity ranging between 62% (Chao 1) and 71% (ACE), which is relevant considering that, in the case of reptiles, representativity may be, in general, of 50% to 60% for these types of surveys. (observations on site).

Figure 4.201: Species accumulation curve of reptiles in areas of FFC – Vichada



Source: (Universidad Distrital Francisco José De Caldas, 2017)

- ***RICHNESS INDEX.***

Table 4.97: Diversity indexes for Amphibians in the 5 sampling points

Areas	1. San Cristobal	2. Base Mono	3. Hato nuevo	4. Tierradentro	5. Cuernavaca	Overall Total
Species	**9**	**12**	**17**	**10**	**7**	**31**
Individuals	19	22	53	19	7	120
Fisher_alpha	6.688	10.81	8.661	8.541	0	13.55
Chao-1	12.33	40	83	13.33	28	44

Source: (Universidad Distrital Francisco José De Caldas, 2017)

Fisher's richness index may be interpreted as the number of new species which may be found each time twice the number of individuals is taken. Therefore, we observe that the highest diversity is found in the area of Base Mono (Point 2), followed by Hato Nuevo (Point 3.). This is explained by the fact that Base Mono is relatively away from human settlements or main roads, which are one of the main reducers of reptile diversity, as many snakes are sacrificed by the farmers or hit by cars; this also happens with lizards. The other area near the Bita river possessed one of the highest heterogeneities in terms of landscape units and a combination of microhabitat characteristics, combining lotic, lentic, permanent and seasonal bodies of water, shrub, herbaceous and canopy vegetation, conditions of high and low humidity, as well as hiding and reproduction sites. This allows a greater number of species to inhabit this area, which is reflected in the indexes (Table 4.97).

4.3.2.3.3 Birds

Considering the areas selected to perform the samplings, Table 4.98 presents a georeferenced showing the location of the 5 points where the proposed methodologies were implemented:

Table 4.98: Main data of the location of the 5 points characterized in the two covers (gallery forest and palm swamp)

Area	Code	Name of point	X	Y	Altitude
San Cristobal	SC	*Entrance 1*	917701,62	1168915,039	92 m
	SC	*23*	916814,66	1172323,261	89 m
	SC	*27*	917775,56	1169022,46	78 m
	SC	*31*	915703,99	1171845,58	74 m
Base Mono	BM	*Entrance 2 MONO*	915851,46	1160859,44	89 m
	BM	*35*	915814,41	1160748,896	87 m
	BM	*38*	915500,55	1160632,595	92 m
Hato Nuevo	HN	*Entrance hn3*	937088,75	1165976,027	72 m
	HN	*Hn*	929876,88	1159873,77	76 m
	HN	*49*	937583,95	1166092,243	62 m
	HN	*55*	936424,53	1165949,082	70 m
Tierra Adentro	TA	*Sitioturimoric*	997580,42	1151809,361	62 m
	TA	*EntranceTA5*	994652,7	1154267,022	66 m
	TA	*56*	998078,64	1151449,938	61 m
	TA	*60*	994606,57	1154224,02	65 m
Cuernavaca	CV	*EntranceCV6*	1001980,9	1169567,712	78 m
	CV	*FincaAraucaria*	1008957,3	1169715,804	82 m
	CV	*68*	1001153,9	1169659,846	68 m
	CV	*100*	1001055,5	1168879,592	70 m
	CV	*108*	1001058,6	1168855,017	69 m

Source: (Universidad Distrital Francisco José De Caldas, 2017). Planar coordinates Magna Colombia East East

- ***COMPOSITION AND STRUCTURE OF SPECIES.***

530 individuals were identified for a total of 132 species, including a ***Incertae Sedis*** species, belonging to 20 orders and 42 families in the 5 selected points: San Cristóbal, Base Mono, Hato Nuevo, Tierra Adentro and Cuerna Vaca (Table 4.99); this list is obtained from the implementation of the methodologies proposed (Bird observation: Transects and Point counts and captures with mist nets).

Table 4.99: List of species of avifauna in each selected point in areas of FFC in the department of Vichada. SC: San Cristóbal; BM: Base Mono; HN: Hato Nuevo; TA: Tierra Adentro; and CV: Cuernavaca

Order/Family/*Species*	**BM**	**CV**	**HN**	**SC**	**TA**	**Total**
Accipitriformes						

Order/Family/*Species*	BM	CV	HN	SC	TA	Total
Accipitridae						
Accipiter superciliosus				1		1
Buteogallus meridionalis	4	1	2	2		9
Buteogallus schistaceus			1			1
Buteogallus urubitinga				1		1
Geranoaetus albicaudatus				1		1
Harpagus bidentatus	1					1
Leptodon cayanensis			1			1
Leucopternis melanops	1					1
Rupornis magnirostris				1		1
Anseriformes						
Anatidae						
Dendrocygna autumnalis		8	2			10
Dendrocygna viduata				2		2
Apodiformes						
Apodidae						
Chaetura cinereiventris				5		5
Streptoprocne zonaris				2		2
Trochilidae						
Amazilia fimbriata	1	1	3	1	1	7
Anthracothorax nigricollis					1	1
Campylopterus largipennis	1			1		2
Chlorostilbon mellisugus		1				1
Glaucis hirsutus			1			1
Hylocharis cyanus		1		1		2
Phaethornis hispidus	1	2	3	3		9
Polytmus guainumbi		1				1
Caprimulgiformes						
Caprimulgidae						
Hydropsalis maculicaudus		1	1	3		5
Nyctiprogne leucopyga				5	1	6
Nyctibiidae						
Nyctibius griseus		8		1		9
Cathartiformes						
Cathartidae						
Cathartes aura	3	1		5		9
Coragyps atratus		5		6		11
Sarcoramphus papa	1					1
Charadriiformes						
Burhinidae						
Burhinus bistriatus	2					2

Order/Family/*Species*	**BM**	**CV**	**HN**	**SC**	**TA**	**Total**
Charadriidae						
Vanellus cayanus				1		1
Vanellus chilensis		2		1		3
Recurvirostridae						
Himantopus mexicanus	2					2
Ciconiiformes						
Ciconiidae						
Jabiru mycteria					1	1
Columbiformes						
Columbidae						
Columbina minuta				8		8
Columbina passerina		1		5		6
Columbina squammata	8					8
Columbina talpacoti	5					5
Patagioenas cayennensis			2			2
Zenaida auriculata		1				1
Coraciiformes						
Alcedinidae						
Chloroceryle amazona					3	3
Chloroceryle americana			1			1
Megaceryle torquata			6	7		13
Cuculiformes						
Cuculidae						
Crotophaga ani		2			2	4
Crotophaga major				2		2
Piaya cayana		1	3	3		7
Tapera naevia				1		1
Eurypygiformes						
Eurypygidae						
Eurypyga helias				1	1	2
Falconiformes						
Falconidae						
Caracara cheriway	1	4	2	1		8
Falco femoralis		2				2
Falco sparverius		1				1
Milvago chimachima			1			1
Galbuliformes						
Galbulidae						
Galbula ruficauda	1	1	2	2		6
Galliformes						
Cracidae						

Order/Family/*Species*	BM	CV	HN	SC	TA	Total
Mitu tomentosum	1			1		2
Penelope jacquacu					1	1
Odontophoridae						
Colinus cristatus		3	4			7
Opisthocomiformes						
Opisthocomidae						
Opisthocomus hoazin	3					3
Passeriformes						
Emberizidae						
Ammodramus humeralis		3				3
Furnariidae						
Dendrocincla fuliginosa				1		1
Dendroplex picus		1				1
Synallaxis albescens	1					1
Xiphorhynchus obsoletus			1			1
Hirundinidae						
Riparia riparia		18				18
Tachycineta albiventer				3		3
Icteridae						
Cacicus cela			1	3	4	8
Gymnomystax mexicanus				1		1
Icterus cayanensis			1			1
Quiscalus lugubris				1		1
Sturnella magna		1				1
Sturnella militaris				1		1
Incertae Sedis						
Piprites chloris				1		1
Mimidae						
Mimus gilvus		5	3	6		14
Motacillidae						
Anthus lutescens				1		1
Parulidae						
Geothlypis aequinoctialis					1	1
Pipridae						
Pipra filicauda				2		2
Polioptilidae						
Polioptila plumbea			1			1
Thamnophilidae						
Sakesphorus canadensis		3	3	2	3	11
Thamnophilus nigrocinereus			2	2		4
Thraupidae						

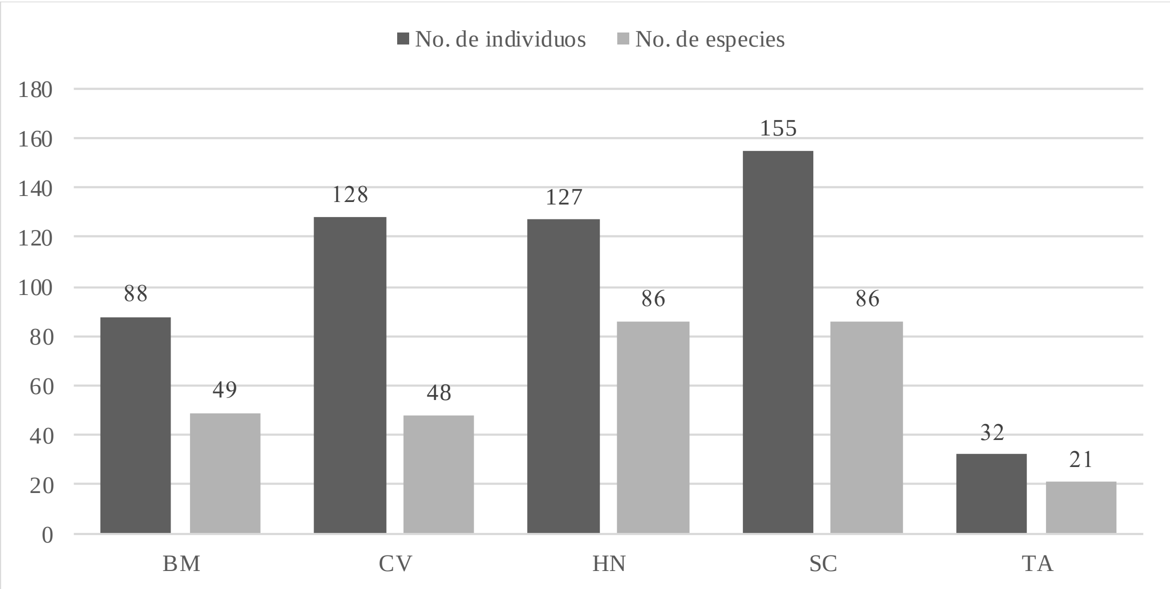
Order/Family/*Species*	BM	CV	HN	SC	TA	Total
Coereba flaveola	7	1	12	1		21
Paroaria gularis		1	1		1	3
Ramphocelus carbo		2	8	2	1	13
Schistochlamys melanopis	1				1	2
Sicalis columbiana				1		1
Sicalis luteola	1					1
Sporophila minuta		1				1
Sporophila nigricollis	1	1			1	3
Sporophila plumbea	2					2
Tangara cayana			1	10	2	13
Thraupis episcopus				2		2
Thraupis palmarum	2		5	4		11
Tityridae						
Pachyramphus polychopterus				1		1
Tityra cayana					1	1
Troglodytidae						
Campylorhynchus griseus				1		1
Troglodytes aedon		1				1
Turdidae						
Catharus minimus			1			1
Turdus ignobilis	1			1		2
Tyrannidae						
Camptostoma obsoletum			1	1		2
Capsiempis flaveola			2			2
Cnemotriccus fuscatus			1			1
Elaenia cristata			1			1
Elaenia flavogaster			1	1		2
Knipolegus poecilocercus				1		1
Megarynchus pitangua	1		1			2
Myiarchus ferox				2		2
Myiarchus tuberculifer				2		2
Myiarchus tyrannulus				1		1
Myiozetetes cayanensis			1	2		3
Pitangus sulphuratus	1		1	2		4
Poecilotriccus sylvia			1			1
Pyrocephalus rubinus		2				2
Sublegatus arenarum	1		1			2
Todirostrum cinereum			1			1
Tolmomyias flaviventris			1			1
Thectocercus acuticaudatus		17				17
Strigiformes						

Order/Family/*Species*	BM	CV	HN	SC	TA	Total
Strigidae						
Megascops choliba					1	1
Total general	**88**	**128**	**127**	**155**	**32**	**530**

Fuente: (Universidad Distrital Francisco José De Caldas, 2017)

Of the five sampling points, San Cristóbal was the one where the greatest abundance (155 species) was recorded, although with the same number of species as Hato Nuevo (86 species), followed by Cuernavaca with 128 individuals and 48 species, Hato Nuevo with 127 individuals, Base Mono with 88 individuals and 49 species and, finally, Cuernavaca with 32 individuals recorded and 21 species identified (see Figure 4.202).

Figure 4.202: Number of individuals and number of species per sampling point. BM: Base Mono; CV: Cuernavaca; HN: Hato Nuevo; SC: San Cristóbal; TA: Tierradentro. In-house production, 2017.



Source: Universidad Distrital Francisco José De Caldas, 2017.

117 species were identified in total during the observation sessions, with an abundance figure of 242 and a total of 48 individuals belonging to 48 species caught using mist nets, while three migratory species (*Tyrannus savana, Riparia riparia* and *Catharus minimus*) were also identified, both caught and observed (Figure 4.203, Figure 4.204 and Figure 4.205).

Figure 4.203: *Tyrannus savana*, male, perched. Migratory species. Photograph: Nadezhda Bonilla, 2017.

Source: Universidad Distrital Francisco José De Caldas, 2017.

Figure 4.204: *Riparia riparia,* perched. Migratory species. Photograph: Nadezhda Bonilla, 2017.

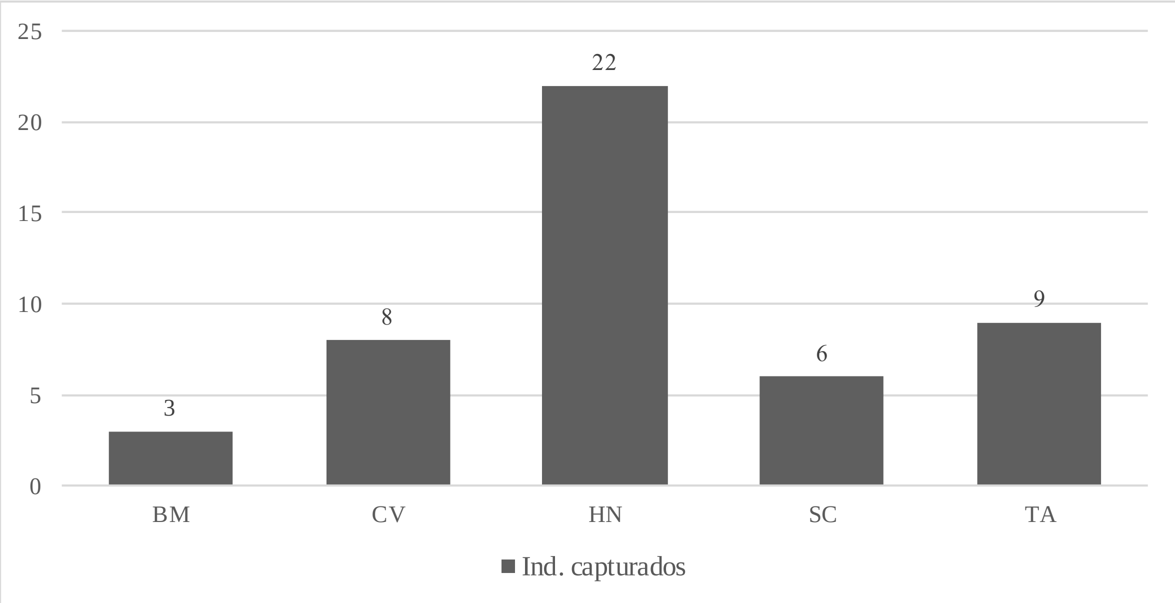
Source: Universidad Distrital Francisco José De Caldas, 2017.

Figure 4.205: *Catharus minimus*, caught in mist net. Migratory species. Photograph: Nadezhda Bonilla, 2017.

Source: Universidad Distrital Francisco José De Caldas, 2017.

Hato Nuevo was the sampling point where the highest number were caught in mist nets, with 22 individuals, followed by Tierradentro with 9 and Cuernavaca with 8. Finally, San Cristóbal and Base Mono caught 6 and 3 individuals, respectively (see Figure 4.206).

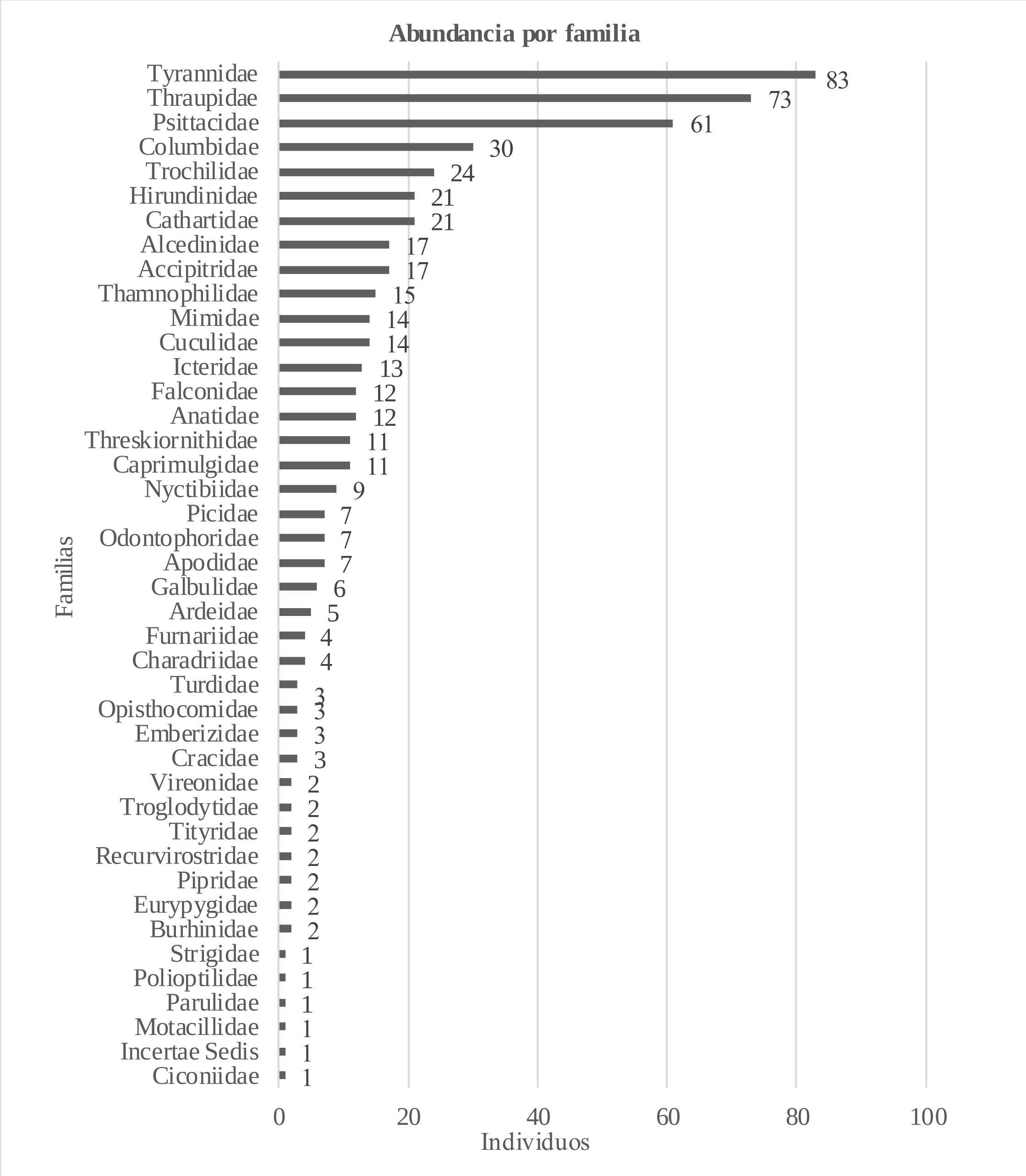
Figure 4.206: Number of individuals caught at each sampling point. BM: Base Mono; CV: Cuernavaca; HN: Hato Nuevo; SC: San Cristóbal; TA: Tierradentro. In-house production, 2017.



Source: Universidad Distrital Francisco José De Caldas, 2017.

The most representative families, in terms of abundance, are the Tyrannidae, with a total of 16 individuals, followed by the Thraupidae with 14%, Psittacidae with 12%, Columbidae with 6% and Trochilidae with 5% of the total sampled (see Figure 4.207).

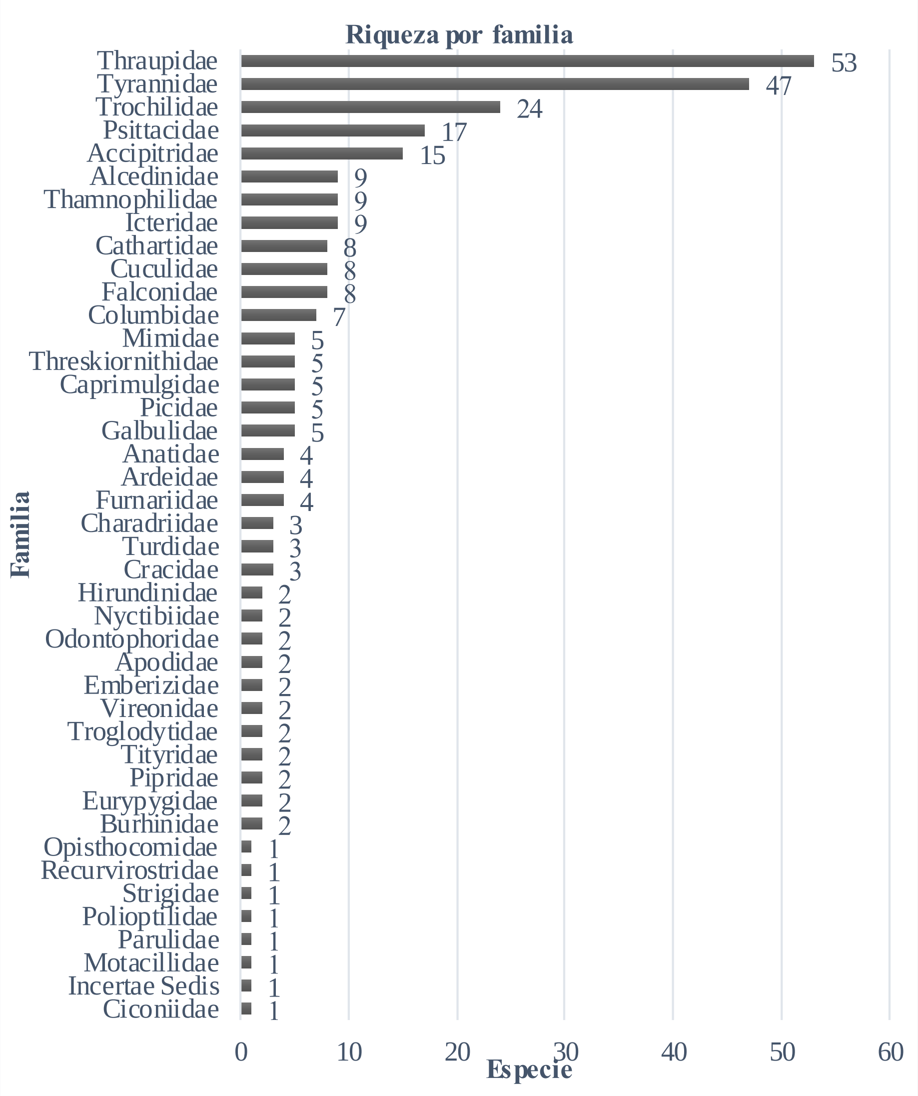
Figure 4.207: Total number of individuals by family in the study. In-house production, 2017.



Source: Universidad Distrital Francisco José De Caldas, 2017.

If the number of species per family (richness) is determined, the most representative are Thraupidae with 18%, Tyrannidae with 16%, Trochilidae with 8%, Psittacidae with 6% and Accipitridae with 5% of the total species in the sample recorded (see Figure 4.208).

Figure 4.208: Total number of species by family in the study. In-house production, 2017.

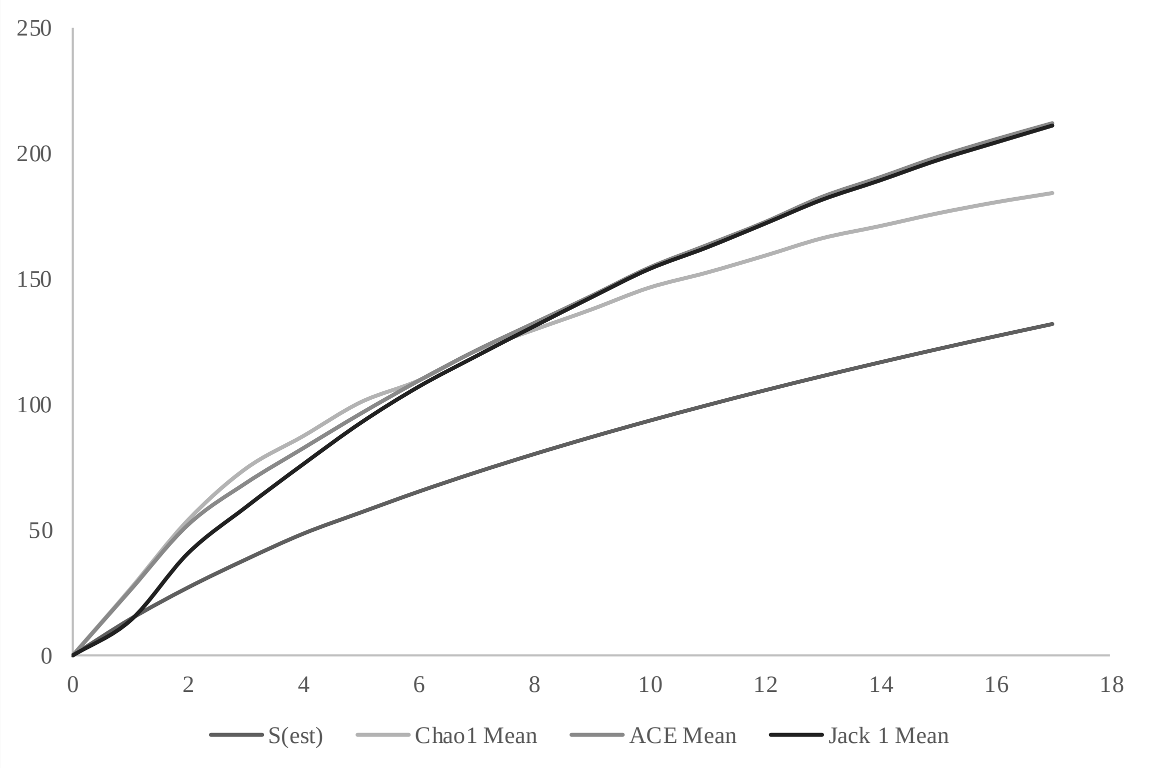


Source: Universidad Distrital Francisco José De Caldas, 2017.

<u>SPECIES ACCUMULATION CURVE</u>

A total of 62 hours was spent sampling, using visual and auditory detection (5 hours in the morning and 4 in the afternoon), plus 961 hours per net with mist nets (6 hours in the morning and 3.5 in the afternoon). The accumulation curve for the whole sample can be seen below (see Figure 4.209), This was established using the most appropriate indices for this set of data (Chao 1, ACE and Jacknife 1) and the classic Chao 1 model, with reliability intervals of 95%, where the result for the study was 71% and for other indices it was 62%.

Figure 4.209: Birdlife species accumulation curve.



Source: Universidad Distrital Francisco José De Caldas, 2017.

Despite it not being possible to obtain 100% and the fact that, graphically, the accumulation curve is not asymptotic, the sample has an adequate percentage (71%) in view of the weather conditions and the behavior of the different species at the time of year in question.

SAMPLING EFFORT AND CATCHMENT SUCCESS

In view of the variations in the number of nets set up in each zone, the georeferencing of each one by sampling point can be seen below (see Table 4.100).

Table 4.100: Nets installed by sampling point with georeferencing.

Zone	Code	Point Name	X	Y	No. Nets
San Cristóbal	SC	SCred1	917320,7097	1169192,058	6
	SC	SCred2-3	917317,6217	1169182,846	
	SC	SCred4	917317,6431	1169198,206	
	SC	SCred5-6	917323,8051	1169207,414	
Base Mono	BM	Monred1	915467,4543	1161151,83	5
	BM	Monred2	915489,0158	1161176,377	
	BM	Monred3	915470,5331	1161154,898	
	BM	Monred4	915476,6671	1161142,601	
	BM	Monred5	915479,7297	1161133,38	
Hato Nuevo	HN	Hnred1	936686,246	1166274,437	5
	HN	Hnred2	936686,2362	1166265,221	

Zone	Code	Point Name	X	Y	No. Nets
	HN	Hnred3	936683,148	1166252,936	
	HN	Hnred4	936664,6913	1166246,812	
	HN	Hnred5	936670,8352	1166240,661	
Tierradentro	TA	Red1-2	997192,9093	1152110,418	10
	TA	Red3-4	997177,5346	1152177,999	
	TA	Red5-6	997177,536	1152208,718	
	TA	Red7	997146,7778	1152153,426	
	TA	059, 060, 061	994209,8664	1154543,529	
Cuernavaca	CV	Red 11	1001980,949	1169567,712	5
	CV	Red21	1001599,683	1169902,534	
	CV	Red4	1001608,908	1169884,103	
	CV	Red5	1001618,132	1169899,462	

Source: Universidad Distrital Francisco José De Caldas, 2017. Coordinates: Magna Colombia Este Este plans.

As far as mist net results are concerned, as mentioned above, sessions with these nets lasted 6 hours in the morning and 3 hours in the afternoon, and the nets themselves covered an area of 12 meters, resulting in a sampling effort of 961 with a catchment success rate of 0.019 individuals per net hour (see Table 4.101).

Table 4.101: Catchment success and effort for the birdlife sample using mist nets during the dry season (2017). Each sampling point selected was in areas belonging to FFC in Vichada province.

Sampling sessions	7*6h and 10*3.5h
Sampling hours	77
Total nets	31
Individuals caught	48
Sampling effort (hours/net)	961
Catchment success	0.0192 individuals / net-hours

<u>RICHNESS INDEX</u>

If the figures obtained per sampling point are considered, the result using the *Alpha Fisher* index was 22.8% for Base Mono, 18.3% for Cuernavaca, 31.6% for Hato Nuevo, 42.1% for San Cristóbal and 19.7% for Tierradentro, with *Chao-1* index values of 57.4%, 59.4%, 83.5%, 92.3% and 45%, respectively (see Table 4.102).

Table 4.102: Indices with results for birdlife sampling during the dry season (2017) for each point in areas belonging to the company FFC in Vichada province. BM: Base Mono; CV: Cuernavaca; HN: Hato Nuevo; SC: San Cristóbal, and TA: Tierradentro.

	BM	CV	HN	SC	TA
Species	36	38	51	65	19
Individuals	88	128	127	155	32
Fisher Alpha	22.74	18.27	31.63	42.12	19.68
Chao-1	57.38	59.38	83.5	92.35	45

Source: Universidad Distrital Francisco José De Caldas, 2017.

The Alpha Fischer richness index can be interpreted as the number of new species that can be found whenever twice the number of individuals is taken. On this basis, the highest diversity rate can be found at San Cristóbal, followed by Hato Nuevo, given that vegetation cover and area are similar, resulting in a similar distribution of bird species at each of these locations. Base Mono is a sampling point far removed from human settlements but with less cover, resulting in an intermediate figure, compared to the other areas. Cuernavaca and Tierradentro have similar richness values and are similar to the first two points, but it should be noted that they are more subject to flooding, due to the major influence of nearby rivers, which makes species disperse more in the area.

4.3.2.4 Mammals

SMALL MAMMALS

a) Sherman Traps

Samples were taken from Sherman traps on a total of three days at each sampling point, using 60 traps in total, equivalent to 900 traps per day for the zone. Catchment efficiency was low, despite the effort, with a total of four examples, equivalent to 0.4% (see Figure 4.210). Catchments were achieved at San Cristóbal (2 examples), Tierradentro (1 example), and Cuernavaca (1 example).

Table 4.103: List of species of small mammals caught in Sherman traps in Puerto Carreño.

Order	Family	Species	San Cristóbal	Tierradentro	Cuernavaca
Rodentia	Cricetidae	*Zygodontomys brevicauda*	2		
		Zygodontomys brevicauda		1	
		Sigmodon alstoni			1
		Total			4

Source: Universidad Distrital Francisco José De Caldas, 2017.

Figure 4.210: Example collected. (Photograph: Gabriel Pantoja-Peña, 2017).

Source: Universidad Distrital Francisco José De Caldas, 2017.

Figure 4.211: Diagnostic features of the foot of specimen recorded in the field. (Photograph: Gabriel Pantoja-Peña, 2017).

Source: Universidad Distrital Francisco José De Caldas, 2017.

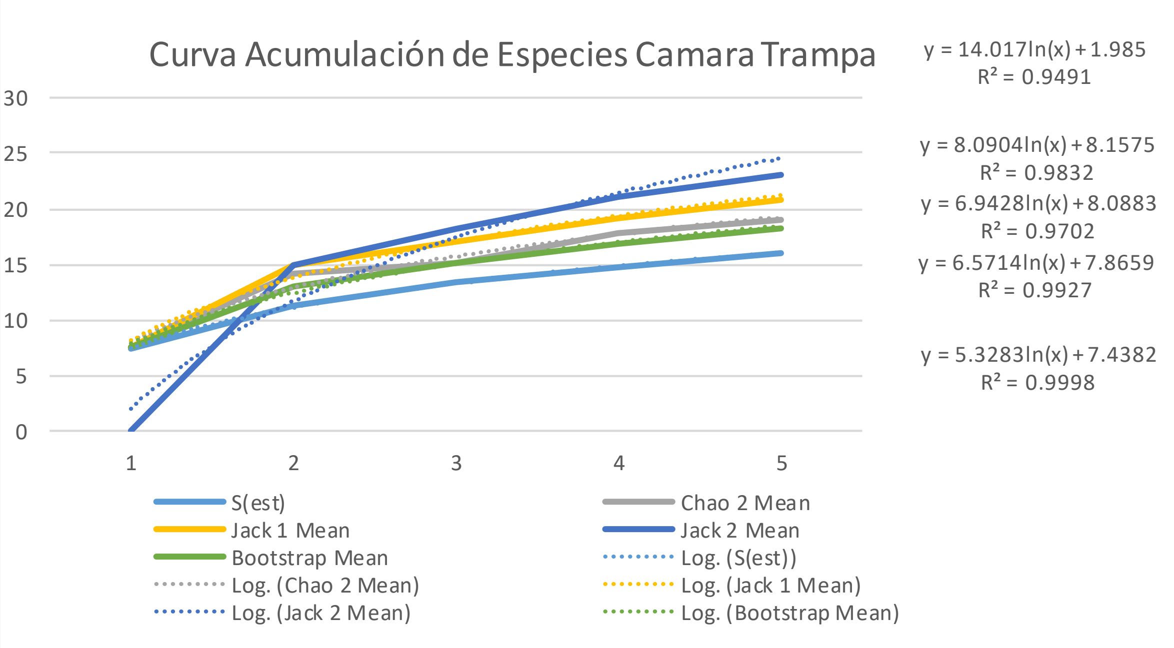
<u>MEDIUM-SIZED AND LARGE MAMMALS</u>

a) Cameras

The sampling effort was based on the use of 50 camera traps for 19 days, with the cameras recording 24 hours per day; this is equivalent to 22,800 hours of effective sampling. The success of the sampling can be seen in the total of 3,269 images, 2,114 of which correspond to records of mammals, resulting in a mammal recording efficiency of 112.8 images per day. Ten cameras were installed at each sampling point. Given that 17 species were recorded using this method, the species accumulation curve was estimated using the Colwell EstimateS 9.1 Program[82]. The curve obtained indicates a logarithmic trend in the recording of new species and a low gradient, which means that the sampling effort for the zone should be increased, with more camera traps installed or more time spent. The models indicate that the complete sample is around 94-99% in the rainy season, resulting in a good indicator of the quality of the sample in this area during this season (see Figure 4.212).

[82] (Colwell R., 2013)

Figure 4.212: Species accumulation curve, based on the camera trap sample for properties belonging to FFC and using Chao 2, Jacknife 1, Jacknife 2 and Bootstrap estimators.



Source: Universidad Distrital Francisco José De Caldas, 2017.

The sampling point with the highest number of recordings was Hato Nuevo, with 1,119 photographic records, followed by Cuernavaca and Base Mono (see Table 4.104). The camera traps recorded not only mammals but also other taxa, such as birds and reptiles.

Table 4.104: Photographic records by sampling point and percentage of mammals recorded vs. other taxa.

	San Cristóbal		**Cuernavaca**		**Hato Nuevo**		**Tierradentro**		**Base Mono**
	Mammals	**Other**	**Mammals**	**Other**	**Mammals**	**Other**	**Mammals**	**Other**	**Mammals**
Records	95	64	788	103	600	519	350	132	281
Total	159		891		1,119		482		618
%	59.7	40.3	88.4	11.6	53.6	46.4	72.6	27.4	45.5

However, the fact that more images were obtained on some properties is related to the abundance and the visiting frequency of certain taxa, such as the peccary at Hato Nuevo, which is not only abundant but also travels consecutively over the same routes. The number of species recorded at each sampling point is therefore a better richness indicator (see Table 4.105).

Table 4.105: Mammal species recorded by sampling point, and occurrence ratio between properties.

Order	**Family**	**Genus**	**Species**	**San Cristóbal**	**Base Mono**	**Hato Nuevo**	**Tierradentro**	**Cuernavaca**	**Record / property**
Artiodactyla	Tayssuidae	*Tayassu*	*Tayassu pecari*	0	0	1	0	0	1
Carnivora	Canidae	*Cerdocyon*	*Cerdocyon thous*	0	0	1	0	0	1
Carnivora	Felidae	*Leopardus*	*Leopardus pardalis*	0	0	1	1	1	3

Order	Family	Genus	Species	San Cristóbal	Base Mono	Hato Nuevo	Tierra dentro	Cuernavaca	Record / property
Carnivora	Felidae	*Puma*	*Puma concolor*	1	0	1	0	0	2
Carnivora	Mustelidae	*Eira*	*Eira barbara*	1	0	0	1	0	2
Chiroptera	Phyllostomidae	Bat	Murciélago Msp 1	0	0	0	0	1	1
Cingulata	Dasypodidae	*Priodontes*	*Priodontes maximus*	0	0	0	0	1	1
Didelphimorphia	Didelphidae	*Didelphis*	*Didelphis marsupialis*	1	1	1	0	1	**4**
Didelphimorphia	Didelphidae	*Metachirus*	*Metachirus nudicaudatus*	0	1	1	1	1	**4**
Perissodactyla	Tapiridae	*Tapirus*	*Tapirus terrestris*	1	0	1	0	1	3
Pilosa	Myrmecofhagidae	*Tamandua*	*Tamandua tetradactyla*	1	1	0	1	1	4
Rodentia	Caviidae	*Hydrochoerus*	*Hydrochoerus hydrochaeris*	1	0	1	0	0	2
Rodentia	Cricetidae	Mouse	Ratón Msp1	0	1	0	0	0	1
Rodentia	Cuniculidae	*Cuniculus*	*Cuniculus paca*	1	1	0	1	0	3
Rodentia	Dasyproctidae	*Dasyprocta*	*Dasyprocta fuliginosa*	1	0	1	1	1	**4**
Rodentia	Erethizontidae	*Coendou*	*Coendou prehensilis*	0	0	1	0	0	1
Rodentia	Sciuridae	*Sciurus*	*Sciurus igniventris*	0	1	0	1	0	2
#Spp/P.M				**8**	6	**10**	7	**8**	

Source: Universidad Distrital Francisco José De Caldas, 2017.

It can be seen from the above that 17 species were recorded in the area by camera traps (CT), the properties with the highest richness figures being San Cristóbal with 8 species, followed by Hato Nuevo with 10 species and Cuernavaca with 8. The most commonly recorded species were *Didelphis marsupialis* (opossums), *Metachirus nudicaudatus*, *Tamandua tetradactyla* (collared anteater) and *Dasyprocta fuliginosa* (agouti), which were found at four of the five sampling points, followed by *Cuniculus paca* (limpet), *Leopardus pardalis* (ocelot), and *Tapirus terrestris* (tapir) on three of the five properties. Meanwhile, the least frequently recorded species were *Priodontes maximus* (giant armadillo) and *Coendou prehensilis* (porcupine); this latter lives on land and in trees.

It should be stressed that three of the species are classified as being in the VULNERABLE (VU) category, according to International Union for the Conservation of Nature (IUCN)[83] criteria. These are:

Tayassu pecari – (VU): white-lipped peccary, recorded at Hato Nuevo;
Priodontes maximus – (VU-EN): giant armadillo, recorded at Cuernavaca; and

[83] Institute of Natural Sciences, ICN, s.f.

Tapirus terrestris – (VU-EN): tapir, recorded at San Cristóbal, Hato Nuevo and Cuernavaca.

The threat to these endangered species is due to anthropic pressure caused by hunting and the expansion of the agricultural frontier, as a result of which they are **Conservation Objects** in the area.

It should also be stressed that there are many large carnivores in the area, such as *Puma concolor* and *Leopardus pardalis*, which are viewed as species that indicate ecosystem health. On the other hand, despite the fact that they are not considered internationally to be Vulnerable (VU), their threat level is such that they are viewed as a minor concern in Colombia, due to the effect that hunting and deforestation have on population reproduction dynamics.

Figure 4.213: *Cerdocyon thous* (crab-eating fox) camera trap photographic record. (Photograph: Gabriel Pantoja Peña, 2017).

Source: Universidad Distrital Francisco José De Caldas, 2017.

b) Indications and observations

Results of the second type of sampling, which was based on *ad libitum* observations, indicated the presence of 16 species of mammal; reports were based on vocalizations, observation of examples, and indications such as animal footprints and excrement (see Table 4.106).

Indications and observations on the San Cristóbal property enabled 10 species to be recorded, while the figure for Base Mono was 2 species and for Hato Nuevo it was 7, Tierradentro 8, and Cuernavaca 2. The species most frequently recorded were *Alouatta seniculus* (red howler monkey), *Lontra longicaudis* (neotropical river otter), and *Sylvilagus floridanus* (rabbit). It is important to point out that indications of a *Priodontes maximus* (giant armadillo) presence were found at Base Mono, where a gallery was found and earth had been removed by this animal on a large scale. The gallery was in the flood zone, and was observed when it was covered with water as far as the middle of the zone.

Notable among all the species recorded were the *Puma yagouaroundi* (jaguarundi, wild cat), which is a small feline generally associated with conserved areas, and the otter (*Lontra longicaudis, Pteronura brasiliensis*), giant armadillo (*Priodontes maximus*), and savannah armadillo (*Dasypus terrestris*) species. These species are listed by IUCN as subject to certain degrees of threat, which makes them conservation objects and ecosystem conservation status indicators, because they are, in turn, emblematic species and have an umbrella effect on local diversity, due to the role they play in the ecosystem.

Table 4.106: Species recorded at the five FFC sampling sites, based on observations and indications. The abbreviations used are: Voc. – vocalizations, Hue. – footprints, Ex. – excrement, Mag. – burrow, and Obs. – observation.

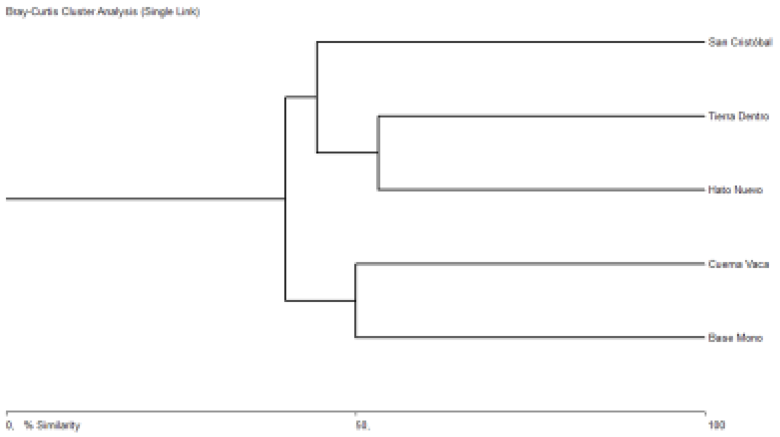
Property	Order	Family	Species	Indication		Quan.	EN	IUCN
San Cristóbal	Artiodactyla	Cervidae	*Odocoileus cariacou*	Hue.	Obs.	3	Plan.	LC
San Cristóbal	Carnivora	Felidae	*Puma yagouaroundi*		Obs.	1	Plan.	LC
San Cristóbal	Carnivora	Mustelidae	*Lontra longicaudis*		Obs.	1	C. Muco	**NT**
San Cristóbal	Carnivora	Procyonidae	*Potos flavus*		Obs.	1	Plan.	LC
San Cristóbal	Cetacea	Iniidae	*Inia geoffrensis*		Obs.	1	C. Muco	DD
San Cristóbal	Didelphimorphia	Didelphidae	*Didelphis marsupialis*		Obs.	1	Corr.	LC
San Cristóbal	Pilosa	Myrmecophagidae	*Tamandua tetradactyla*		Obs.		SB.	LC
San Cristóbal	Primates	Atelidae	*Alouatta seniculus*	Voc.			BG.	
San Cristóbal	Rodentia	Cuniculidae	*Cuniculus paca*	Hue.			SB.	LC
Base Mono	Carnivora	Mustelidae	*Lontra longicaudis*		Obs.	1	IUCN	**NT**
Base Mono	Cingulata	Dasypodidae	*Priodontes maximus*	Hue.		1	BG.	**VU**
Base Mono	Lagomorpha	Leporidae	*Sylvilagus floridanus*		Obs.		Pas.	LC
Hato Nuevo	Artiodactyla	Cervidae	*Odocoileus cariacou*	Hue.	Obs.	2	BG.	LC
Hato Nuevo	Artiodactyla	Cervidae	*Odocoileus cariacou*	Voc.	Obs.		BG.	LC
Hato Nuevo	Carnivora	Felidae	*Puma concolor*	Hue. / Ex.			BG.	LC
Hato Nuevo	Perissodactyla	Tapiridae	*Tapirus terrestris*	Hue.			SB.	VU
Hato Nuevo	Primates	Atelidae	*Alouatta seniculus*	Voc.			BG.	
Hato Nuevo	Rodentia	Cricetidae	*Ratón MSp 1*		Obs.	1	Arb.	

Property	Order	Family	Species	Indication		Quan.	EN	IUCN
Hato Nuevo	Rodentia	Cricetidae	*Ratón MSp 2*		Obs.	1	Arb.	
Tierra Dentro	Carnivora	Mustelidae	*Lontra longicaudis*	Voc.	Obs.		Inun.	**NT**
Tierra Dentro	Carnivora	Mustelidae	*Pteronura brasiliensis*		Obs.		Bita	**EN**
Tierra Dentro	Cetacea	Iniidae	*Inia geoffrensis*		Obs.		Bita	DD
Tierra Dentro	Lagomorpha	Leporidae	*Sylvilagus floridanus*		Obs.		Pas.	LC
Tierra Dentro	Perissodactyla	Tapiridae	*Tapirus terrestris*	Hue.			SB.	**VU**
Tierra Dentro	Primates	Atelidae	*Alouatta seniculus*	Voc.			Bita	
Tierra Dentro	Rodentia	Cricetidae	*Ratón MSp 1*		Obs.		Arb.	
Tierra Dentro	Rodentia	Cricetidae	*Ratón MSp 2*		Obs.		Arb.	
Cuernavaca	Cingulata	Dasypodidae	*Dasypus sabanicola*		Obs.		Pas.	**NT**
Cuernavaca	Lagomorpha	Leporidae	*Sylvilagus floridanus*		Obs.	1	Pas.	LC
Cuernavaca	Perissodactyla	Tapiridae	*Tapirus terrestris*	Hue.			SB.	**VU**

Source: Universidad Distrital Francisco José De Caldas, 2017.

On the question of similarity between properties, the most dissimilar properties, in terms of species composition, are Base Mono and Cuernavaca, compared to Hato Nuevo and Tierradentro (see Figure 4.214).

Figure 4.214: Bray Curtis graph showing species composition similarity, based on indications, for the FFC polygons, Vichada.



Source: Universidad Distrital Francisco José De Caldas, 2017.

Figure 4.215: Footprint of a *Tapirus terrestris* (tapir) recorded in the FFC polygons (Vichada – Colombia). (Photograph: Gabriel Pantoja Peña, 2017).


Source: Universidad Distrital Francisco José De Caldas, 2017.

Figure 4.216: Photographic record of *Odocoileus cariacou* (white-tailed deer) in the FFC polygons (Vichada – Colombia). (Photograph: Gabriel Pantoja Peña, 2017).

Source: Universidad Distrital Francisco José De Caldas, 2017.

FLYING MAMMALS

MIST NETS

a) Catchment effort and success

Samples were taken on the five properties selected by Forestal de la Orinoquía. Mist nets 12 meters long by 2.6 meters high and with a 30mm. hole in the mesh were used for catchment purposes. The number of nets used on each property varied from 5 to 7, with a maximum of 10 at Tierradentro; this variation in the number of nets used was due to the structure of the gallery forests, which have dense undergrowth, and this ruled out installing nets. Additionally, the time of year was not favorable for sampling, since the forests were flooded and the tree vegetation was underwater in some cases. Since catchment took place during a period of 6 hours between 18.00 and 00.00 hours, the sampling effort for the zone was 6,480 h/m/net.

Table 4.107: Nets installed by sampling point, sampling effort, and sampling efficiency.

Sampling Point	Net Code	Coordinates		No. of Nets	m-Net	Effort	Catchments	Efficiency
		X	Y					
San Cristóbal	R01	917320,71	1169192,058	5	60	1080	62	0.057
San Cristóbal	R02	917317,622	1169182,846					
San Cristóbal	R03-4	917317,643	1169198,206					
San Cristóbal	R05	917323,805	1169207,414					
Base Mono	Monred1	915467,454	1161151,83	5	60	1080	9	0.008
Base Mono	Monred2	915489,016	1161176,377					
Base Mono	Monred3	915470,533	1161154,898					
Base Mono	Monred4	915476,667	1161142,601					
Base Mono	Monred5	915479,73	1161133,38					
Hato Nuevo	Hnred1	936686,246	1166274,437	5	60	1080	7	0.006

Sampling Point	Net Code	Coordinates		No. of Nets	m-Net	Effort	Catchments	Efficiency
		X	Y					
Hato Nuevo	Hnred2	936686,236	1166265,221					
Hato Nuevo	Hnred3	936683,148	1166252,936					
Hato Nuevo	Hnred4	936664,691	1166246,812					
Hato Nuevo	Hnred5	936670,835	1166240,661					
Tierradentro	Red1-2	997192,909	1152110,418	10	120	2160	7	0.003
Tierradentro	Red3-4	997177,535	1152177,999					
Tierradentro	Red5-6	997177,536	1152208,718					
Tierradentro	Red7	997146,778	1152153,426					
Tierradentro	Red8-9-1	994209,866	1154543,529					
Cuernavaca	Red 11	1001587,38	1169911,749	5	60	1080	30	0.028
Cuernavaca	Red21	1001599,68	1169902,534					
Cuernavaca	Red4	1001608,91	1169884,103					
Cuernavaca	Red5	1001618,13	1169899,462					

Source: Universidad Distrital Francisco José De Caldas, 2017. Coordinates: Magna Colombia Este Este plans.

As far as the catchment of samples is concerned, 117 were caught in total, from 4 families, 8 sub-families, 17 genera and 22 species. Notable among the species recorded are *Glyphonycterys silvestris*, *Leptonycteris curasoe* and *Vampirum spectrum*, which are species of bat listed by IUCN as subject to certain degrees of threat, thus making them conservation objects (see Table 4.108).

Table 4.108: Species of bat recorded in sampling polygons on FFC properties – Vichada.

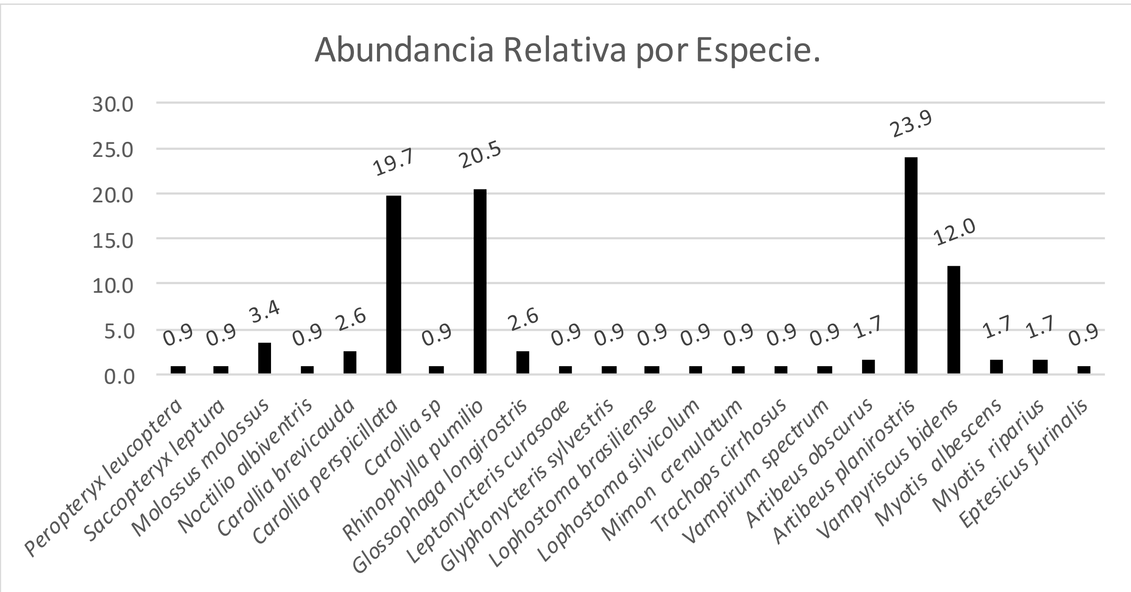
Taxon	San Cristóbal	Base Mono	Hato Nuevo	Tierradentro	Cuernavaca	General Total	IUCN
Emballonuridae						2	
Peropteryx leucoptera		1				1	LC
Saccopteryx leptura				1		1	LC
Molossidae						4	
Molossus	1		1	1	1	4	LC
Noctilionidae						1	
Noctilio albiventris			1			1	LC
Phyllostomidae						105	
Artibeus obscurus	1				1	2	LC
Artibeus planirostris	20				8	28	LC
Carollia brevicauda			1		2	3	LC
Carollia perspicillata	12	1			10	23	LC
Carollia sp					1	1	
Glossophaga longirostris			1	1	1	3	LC

Taxon	San Cristóbal	Base Mono	Hato Nuevo	Tierradent ro	Cuernava ca	General Total	IUC N
Glyphonycteris Sylvestris			1			1	**NT**
Leptonycteris curasoae		1				1	**VU**
Lophostoma Brasiliense			1			1	LC
Lophostoma silvicolum			1			1	LC
Mimon crenulatum					1	1	LC
Rhinophylla pumilio	16	4			4	24	LC
Trachops cirrhosus		1				1	LC
Vampirum spectrum					1	1	**NT**
Vampyriscus bidens	12	1			1	14	LC
Vespertilionidae						5	
Eptesicus furinalis				1		1	LC
Myotis albescens				2		2	LC
Myotis riparius				2		2	LC
General Total	**62**	**9**	**7**	**8**	**31**	**117**	

Source: Universidad Distrital Francisco José De Caldas, 2017.

With respect to the relative abundance per taxon, the most abundant were the great fruit bat (*Artibeus planirostris*), with 23.93% of the examples recorded, the Amazon small fruit bat (*Rhynophylla pumilio*) with 20.51%, the Seba's short-tailed bat (*Carollia perspicillata*) with 19.66%, and the bidentate yellow-eared bat (*Vampyriscus bidens*) with 11.97%. The percentages for the remaining 18 species were low, fluctuating between 3% and 1%.

Figure 4.217: Graph showing relative abundance by species in FFC polygons – Vichada

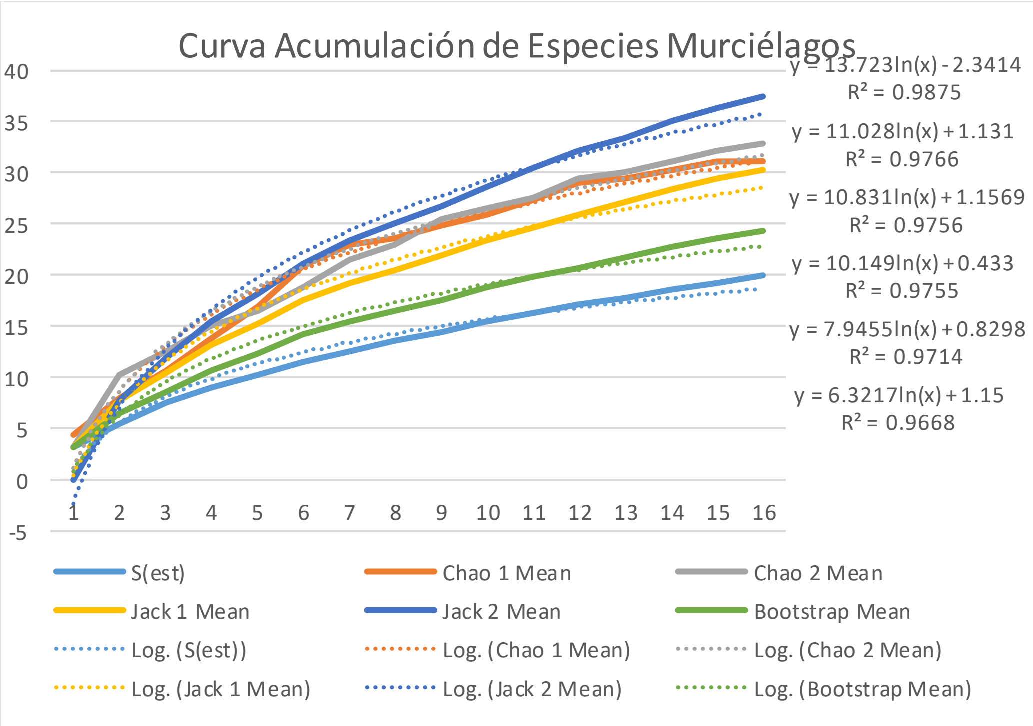


Source: Universidad Distrital Francisco José De Caldas, 2017.

b) Species accumulation curve

It is relevant here to mention once more that sampling took place during the rainy season and that this increased flows, both in streams and in rivers, and caused flooding in forests, where the vegetation was underwater in some cases; in others, water levels reached approximately 30 centimeters at the edge of the forest. However, models based on Jacknife 2 estimators reflect the fact that the sample has a logarithmic trend and that the data compiled for the zone are 98% complete, based on the R^2 value. Irrespective of the estimation model used, R^2 values are above 965, which reflects the trend in the sample (see Figure Figure 4.218).

Figure 4.218: Species accumulation curve for bats present on FFC properties, based on Chao 1, Chao 2, Jacknife 1, Jacknife 2 and Bootstrap estimators.



Source: Universidad Distrital Francisco José De Caldas, 2017.

c) Richness Index

The Fischer index was used for evaluating diversity and comparing sampling points. This is based on the probability of new species being found, and hence indicates the site with the greatest diversity. The index decreases as and when common species are found. The most diverse property, therefore, is Tierradentro, since it is the one where private species occurred most frequently, with *Saccopteryx leptura*, *Eptesicus furinalis*, *Myotis albescens* and *Myotis riparius* all being recorded. The second most diverse sampling point is Base Mono, where the *Peropteryx leucoptera, Leptonycteris curasoae* and *Trachops cirrhosus* species were found, and this was followed by Cuernavaca, with *Mimon crenulatum* and *Vampirum spectrum* (see Table 4.109). It should be stressed that the Fischer index only takes new species into account, and does not refer to the abundance thereof.

Table 4.109: Indices for FFC (Vichada) sampling points in the rainy season.

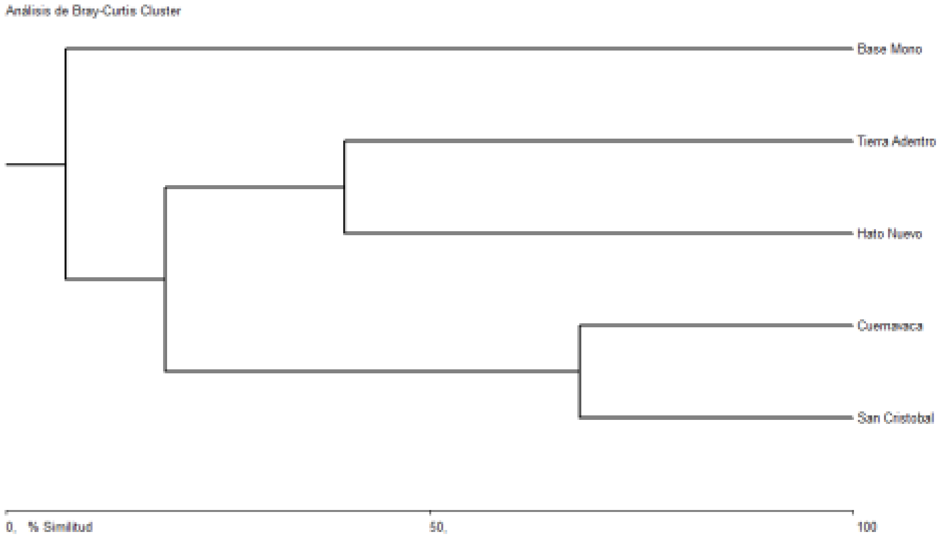
Zones	San Cristóbal	Base Mono	Hato Nuevo	Tierradentro	Cuernavaca
Taxa	6	6	7	6	11
Individuals	62	9	7	8	31

Zones	San Cristóbal	Base Mono	Hato Nuevo	Tierradentro	Cuernavaca
Fisher Alpha	1.64	7.867	0	10.91	6.087
Chao-1	7	16	28	8	21,5
	6	**6**	**7**	**6**	**11**

Source: Universidad Distrital Francisco José De Caldas, 2017.

The above is reflected in the Bracy Curtis similarity index, which shows that the most similar properties, in terms of bat composition, are San Cristóbal and Cuernavaca, which make up 67.7% of the total, followed by Tierradentro and Hato Nuevo with 40%, while the most dissimilar property is Base Mono (see Figure 4.219).

Figure 4.219: Bray Curtis similarity analysis of FFC sampling polygons



Source: Universidad Distrital Francisco José De Caldas, 2017.

Figure 4.220: Photographic record of *Peropteryx leucoptera* present in FFC polygons (Vichada – Colombia). (Photograph: Gabriel Pantoja Peña, 2017).

Source: Universidad Distrital Francisco José De Caldas, 2017.

Figure 4.221: Photographic record of *Trachops cirrhosus* present in FFC polygons (Vichada – Colombia). (Photograph: Gabriel Pantoja Peña, 2017).

Source: Universidad Distrital Francisco José De Caldas, 2017.

4.3.2.5 Characterization Analysis

4.3.2.5.1 Herpetofauna

In general terms, the zone appears to have many beneficial properties for the local herpetofauna. The typical ecosystems of the Vichada plains, together with their microhabitats and ecotones, are widely represented in all the properties and are conserved even in camp areas, where human intervention is significant. All development stages can be observed in various species (young and adult can be seen regularly), which shows that species are reproducing in the zone. The fact that snakes, which are hunted throughout Colombia, are plentiful, together with the abundance of such animals as red-footed tortoises (*Chelonoidis carbonaria*), shows that the numbers of deaths of these due to human consumption or illegal wildlife trafficking are very low in the zone. The amphibians and reptiles caught were in good health and were found to be robust. Abundant quantities of many of the amphibians found were engaged in mating or reproduction activities.

Figure 4.222: Physical state of herpetofauna examples found.

Source: Universidad Distrital Francisco José De Caldas, 2017.

All examples found appeared to be robust and in good health (*Physalaemus Fischeri*, Fischer's dwarf frog), and also in sizes found only in conserved areas, such as this *Drymarchon corais* snake, which is almost 2 meters long.

All these considerations indicate that Vichada herpetofauna are well represented and well conserved on properties belonging to Forestal de la Orinoquía, that they are in a good state of health and, with the exception of a few areas, such as the camps, that fauna prefer to remain in their native surroundings rather than migrate to crops.

In addition to the work done on drawing up the inventory, awareness sessions were held on the importance of identifying snakes and caring for them, since the general pattern of indiscriminately killing these animals continues, due to fear of them which is often groundless. Accordingly, an attempt was made to make workers aware of the fact that many species they consider to be poisonous and dangerous are, in fact, harmless, and also of their importance in controlling pests and in the food chain of the entire plains ecosystem.

Figure 4.223: Awareness talk for FFC workers about the importance of identifying snakes in the zone.

Source: Universidad Distrital Francisco José De Caldas, 2017.

According to Ministry of the Environment and Sustainable Development Resolution 0192 of 2014, no threatened species were reported, although the IUCN worldwide threatened species list categorized the red-footed tortoise

(*Chelonoidis carbonaria*) as endangered (EN), and this species was recorded at four of the five sampling points. It was generally recorded on few occasions, but plenty of examples were found in the zone, in comparison with other samplings conducted on the plains. The examples were healthy and various couples were found, which indicates that these tortoises are well conserved and engage in reproduction processes in the zone, since shells of hatched eggs were also found on various occasions.

4.3.2.5.2 Birds

Although there tends not to be a large number of endemic bird species in Colombia's Orinoquía region, according to McNish[84], since part of the savannah zones is shared with Venezuela, and also, the endemic and quasi-endemic update in the article by Chaparro[85] states that the species identified are not in this type of category, it should be stressed that this region is considered to be a single *eco region* that is home to a large quantity of birds particular to this habitat, and it is accordingly considered to be of great importance in biological, social and cultural terms.

According to Ministry of the Environment and Sustainable Development Resolution 0192 of 2014, no threatened species were reported in the study, although the IUCN worldwide threatened species list categorized the crestless curassow (*Mitu tomentosum*) as Nearly Threatened (NT), and this species was recorded at two of the five sampling points.

Figure 4.224: *Mitu tomentosum*. Camera trap photograph: Gabriel Pantoja, 2017.

Source: Universidad Distrital Francisco José De Caldas, 2017.

In view of the above, because of their living habits and restricted habitat, coupled to the fact that it is a species much sought after for its meat by inhabitants of the Orinoquía region, birds like *Mitu tomentosum* have almost come to be threatened, and conservation efforts for this type of species should accordingly be directed toward benefitting flagship and/or charismatic species such as the macaw (*Ara macao, Ara chloropterus* and *Thectocercus acuticaudatus*) and jacamar (*Galbula ruficauda*), plus the whole host of birds of prey, humming birds, herons and warbles that can be found in the plains landscape.

These conservation efforts can be expanded to include migratory species, which have certain requirements to increase their amount of body fat so that they can continue their travels through America. If these sampling

[84] (McNish, 2006)
[85] (Updated list of endemic and quasi-endemic birds in Colombia, 2014)

points are to continue to be visited by these species, the food supply and vegetation cover associated with the gallery forest and the palm swamp, including savannah cover, should be maintained, due to the type of food and habitat these birds require.

It should be remembered that birds provide ecosystem services as biological controllers and seed dispersers, since flycatchers (*Tyrannidae* 16%), tanagers (*Thraupidae* 14.6%) and macaws and parrots (*Psittacidae* 12%) predominate, and these eat insects (the first), and fruits and seeds (the latter).

It should nevertheless be pointed out that abundance results were not as expected, due to the time (rainy season) when the sampling was done, since bodies of water swelled and flooded land, meaning that birds had to go further afield to forage, build nests, reproduce, carry out parental care, and molt (illustrated in the examples caught, most of which were young or in the process of shedding their feathers), although, on the other hand, more food is available when it rains in comparison with the dry season, when species mobility tends to be restricted.

Figure 4.225: Adult *tangara cayana* (left), young *tangara cayana*. Photograph: Nadezhda Bonilla, 2017.

Source: Universidad Distrital Francisco José De Caldas, 2017.

The records are in line with the foregoing and consist of common birds associated with forest edges and gallery forest, but with few individuals. Examples include *Coragyps atratus, Eupsittula pertinax, T. acuticaudatus, Mimus gilvus, Tyrannus melancholicus, T. savana, R. riparia* and *Coereba flaveola,* among others, where many of them tend to be in flocks, which inflates the records in comparison with other species but does not indicate that these will always be the most abundant in the dry season.

It is confirmed that the species found on Forestal de Orinoquía properties are representative of the most iconic species of the eastern plains, as well as other less common, rare or cryptic ones, and the sampling points evaluated are therefore of vital importance to birdlife subsistence; also, the presence of differential vegetation cover and bodies of water means that there is a heterogeneousness in the landscape which helps the various species to associate with each other, since cultivated zones do not offer all the necessary resources for supporting them, nor do they provide the necessary heterogeneousness for ample ecological niches to develop for birds.

4.3.2.6 Mammals

In the sampling polygons and in the zone in general, 45 mammal species were recorded, distributed in 44 genera, 25 families and 11 orders (see Table 4.110).

Table 4.110: Mammals recorded in the FFC polygons, and recording method. CT: Camera traps; Ind.: Indications; Nie: Mist nets; and SH: Sherman traps.

Order	Family	Sub-family	Genus	Species	CT	Ind	Nie	SH	Tot
ARTIODACTYLA					1	3			4
	Cervidae	Capreolinae	*Odocoileus*	*Odocoileus cariacou*		3			3
	Tayssuidae		*Tayassu*	*Tayassu pecari*	1				1
CARNIVORA					4	7			11
	Canidae		*Cerdocyon*	*Cerdocyon thous*	1				1
	Felidae	Felinae	*Puma*	*Puma concolor*	1	1			2
			Leopardus	*Leopardus pardalis*	1				1
	Mustelidae	Lutrinae	*Lontra*	*Lontra longicaudis*		3			3
			Pteronura	*Pteronura brasiliensis*		1			1
			Eira	*Eira Barbara*	1				1
	Procyonidae		*Potos*	*Potos flavus*		1			1
CETACEA						2			2
	Iniidae		*Inia*	*Inia geoffrensis*		2			2
CHIROPTERA					1		21		22
	Emballonuridae	Emballonurinae	*Peropteryx*	*Peropteryx leucoptera*			1		1
			Saccopteryx	*Saccopteryx leptura*			1		1
	Molossidae						1		1
		Molossinae	*Molossus*	*Molossus*			1		1
	Noctilionidae		*Noctilio*	*Noctilio albiventris*			1		1
	Phyllostomidae	Carollinae	*Carollia*	*Carollia brevicauda*			1		1
				Carollia perspicillata			1		1
				Carollia sp			1		1
			Rhinophylla	*Rhinophylla pumilio*			1		1
		Glossophaginae	*Glossophaga*	*Glossophaga longirostris*			1		1
			Leptonycteris	*Leptonycteris curasoae*			1		1
		Phyllostominae	*Lophostoma*	*Lophostoma Brasiliense*			1		1
				Lophostoma silvicolum			1		1
			Mimon	*Mimon crenulatum*			1		1
			Trachops	*Trachops cirrhosis*			1		1
			Vampirum	*Vampirum spectrum*			1		1

Order	Family	Sub-family	Genus	Species	CT	Ind	Nie	SH	Tot
		Stenodermatinae	*Artibeus*	*Artibeus obscurus*			1		1
				Artibeus planirostris			1		1
			Vampyriscus	*Vampyriscus bidens*			1		1
			Murciélago	*Murciélago Msp 1*	1				1
	Vespertilionidae	Myotinae	*Myotis*	*Myotis albescens*			1		1
				Myotis riparius			1		1
		Vespertiloninae	*Eptesicus*	*Eptesicus furinalis*			1		1
CINGULATA					1	2			3
	Dasypodidae		*Dasypus*	*Dasypus sabanicola*		1			1
			Priodontes	*Priodontes maximus*	1	1			2
DIDELPHIMORPHIA					2	1			3
	Didelphidae	Didelphinae	*Didelphis*	*Didelphis marsupialis*	1	1			1
			Metachirus	*Metachirus nudicaudatus*	1				1
LAGOMORPHA						3			3
	Leporidae		*Sylvilagus*	*Sylvilagus floridanus*		3			3
PERISSODACTYLA					1	3			4
	Tapiridae		*Tapirus*	*Tapirus terrestris*	1	3			4
PILOSA					1	1			2
	Myrmecofhagidae		*Tamandua*	*Tamandua tetradactyla*	1				1
PRIMATES						3			3
	Atelidae	Alouatinae	*Alouatta*	*Alouatta seniculus*		3			3
RODENTIA					6	5		3	14
	Caviidae		*Hydrochoerus*	*Hydrochoerus hydrochaeris*	1				1
	Cricetidae	Sigmodontinae	*Mouse*	*Ratón MSp 1*	1	2			2
				Ratón MSp 2		2			2
			Sigmodon	*Sigmodon alstoni*				1	1
			Zygodontomys	*Zygodontomys brevicauda*				2	2
	Cuniculidae		*Cuniculus*	*Cuniculus paca*	1	1			2
	Dasyproctidae		*Dasyprocta*	*Dasyprocta fuliginosa*	1				1
	Erethizontidae		*Coendou*	*Coendou prehensilis*	1				1

Order	Family	Sub-family	Genus	Species	CT	Ind	Nie	SH	Tot
	Sciuridae		*Sciurus*	*Sciurus igniventris*	1				1
				General Total	**17**	**30**	**21**	**3**	**71**

Source: Universidad Distrital Francisco José De Caldas, 2017.

The most representative orders in terms of species richness are *Chiroptera* (bats) with 21 species, *Rodentia* (rodents) with 7 species and *Carnivora* (carnivores) with 6 species, while the remaining orders are represented by only one or two species. Being able to report diversity figures for a zone like this of 45 confirmed species, plus at least two others of mice that it proved impossible to collect, clearly indicates the great diversity in the region and the good state of conservation.

Bearing in mind that each methodology is evaluated independently and that it is impossible to add up data and analyze it as a consolidated whole, it is even more significant to be able to appreciate that a review of camera traps, indications and observations reveals that these methods produced records of new species until the very last day of sampling, which indicates that the sampling asymptote has not been reached and that species can continue to be identified if the sampling intensity is increased or maintained. This is even clearer in the record of bats, where the species accumulation curves show that diversity increases logarithmically and in a constant manner.

In the case of rodents, it is clear that the Sherman traps failed to achieve the goal of a good number of catchments, due in part to the extensive flooding in the zone and the fact that the mice it was possible to observe in the field were in the canopy, whereas the Sherman traps were at ground level.

The presence of 8 species of mammal that are listed by IUCN as subject to certain degrees of threat is notable, and it is also, without doubt, relevant to be able to make these species conservation objects, either because they are charismatic species or because of the ecological role they play, or because they are umbrella species where studying populations could become a fundamental part of conservation processes in the region.

In the particular case of chiropters, it is clear that the species registered during this particular season were not very active, in reproduction terms, because most of the male examples had abdominal testicles while the majority of the females showed no signs of pregnancy or breastfeeding, since no mammary gland growth, nipple alopecia or presence of milk was visible. However, a female *Vampyriscus bidens* with offspring was recorded, and this is a valuable record for the species. Despite no large number of individuals by species (abundance) being obtained, a good richness record was achieved.

It can be inferred from the above that the zone is in a good state of conservation and that the diversity observed is less than what could be expected in the dry season. It is therefore suggested that a new biodiversity sampling be conducted in the dry season, with a reduction in the number of sampling points and an increase in sampling efforts at each point, as follows.

Small Mammals: install drop traps on the ground, in order to increase potential catchments in times of drought, and install Sherman traps and Havahart traps in trees, to collect rodent species and small mammals that can be seen on the canopy.

Flying Mammals: install mist nets inside forests in the dry season and place these at different levels, in order to catch species located in the mid-cover zone and on the canopy.

Medium-sized and large mammals: increase the number of camera traps at each sampling point and increase the number of cameras that are installed.

Bear in mind the fact that low water levels in the dry season increase the size of the territory that is to be sampled, and that this could affect the occurrence and extent of wildlife species dispersals.

4.4 Human environment

4.4.1 Demographic Component

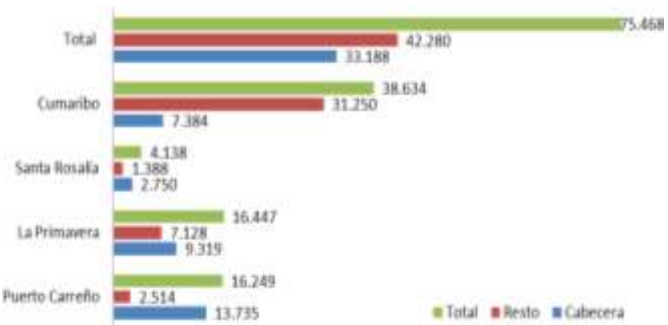
4.4.1.1 Area of Indirect Influence

4.4.1.1.1 Population Structure

Based on the DANE projections for 2017, the current population of the department of Vichada represents 0.15% of the country's population. The total population estimate for the department is 75,468 inhabitants, located in an area of 105,947 km², equivalent to the 9.2% of the national territory.

Graph 1: Population distribution in Vichada.

Population distribution by area and municipality in Vichada.

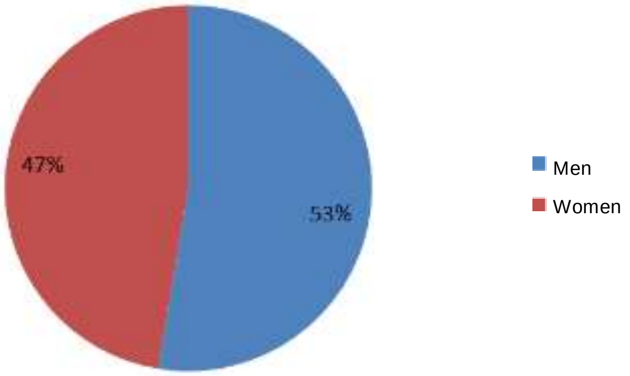


Source: 2017 DANE projections

According to the population distribution by areas, we find that 43.9% of the inhabitants are located in the municipal head towns, while 56% live in the rural areas (Graph 1). The population density is approximately 0.7 inhabitants per square kilometer (h/km²), while the national population density is estimated at 43 h/km².

Graph 2: Population distribution by sex

Population distribution by sex, Puerto Carreño



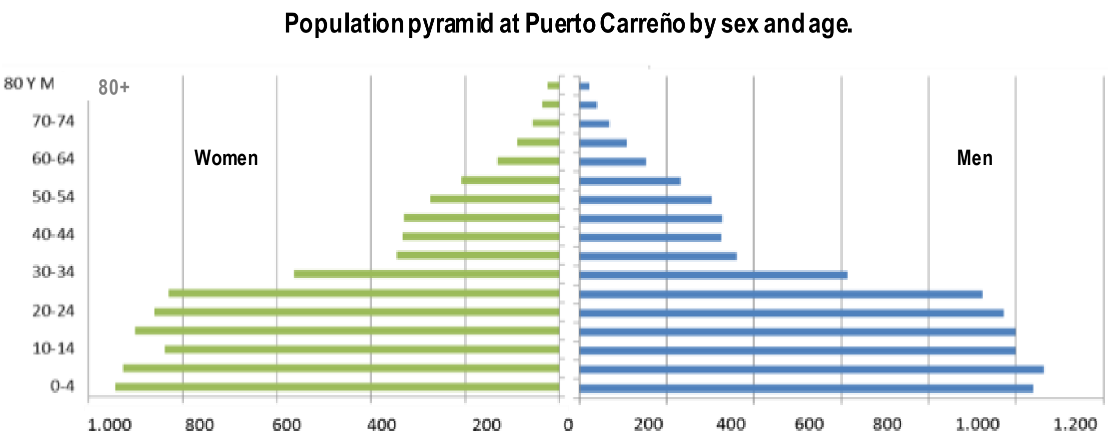
Source: 2017 projections, 2005 DANE census

Puerto Carreño, a municipality in the AII of the first plantations of FFC is projected for this year with a population of 16,447 inhabitants, representing 21.5% of the total population of the department. In terms of distribution by area, it is estimated that the majority of the population (85%) lives in the population center while 15% is dispersed in the rural zone.

With respect to population distribution by sex, there is a difference of 1% between the number of men and women in Vichada, with the majority of the population being male (Graph 2). At the national level there is a 1% difference in the population distribution by sex; nevertheless, in this case the majority are women. At Puerto Carreño the male population is 8550 and exceeds the female population (7699) by 6%.

Regarding population distribution by age, it can be said that the department of Vichada, as well as its capital Puerto Carreño, present a young population structure (Graph 3). At the department and municipal level nearly 70% of the population falls within an age range between 0 and 29 years, while at the department level the estimate is that 8% of the inhabitants are senior citizens and in Puerto Carreño this population represents 4.5%. At the national level, 52% of all inhabitants fall within an age range between 0 and 29 years, while seniors represent approximately 12% of the population.

Graph 3: Population pyramid in Puerto Carreño

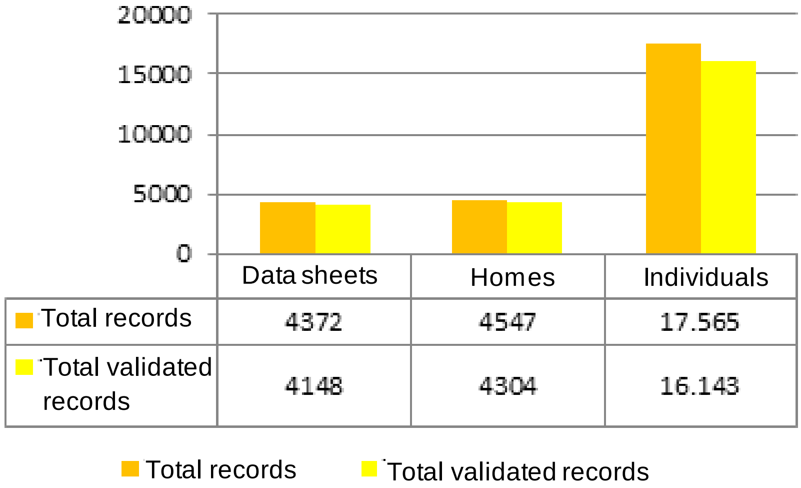


Source: 2017 projections, 2005 DANE census

4.4.1.1.2 SISBEN Information for Puerto Carreño

According to the SISBEN (Social Program Beneficiary Selection System), Puerto Carreño has a confirmed population of 16,143 people, in 4,304 homes (DNP, 2017). Graph 4.

Graph 4: SISBEN Information 2017



Source: DNP, 2017. On line: https://terridata.dnp.gov.co/#/perfiles

4.4.1.1.3 Armed conflict victim population

In 2016, 6,798 people were registered as victims (RUV) in the department of Vichada, 4,053 of which were residents of the municipality of Puerto Carreño, 1,053 of Cumaribo, 194 of La Primavera and 298 of Santa Rosalía, which are receiving, in line with the institutional offer, attention in registration, requests for humanitarian aid, PAARI appointment booking, participation in assistance and comprehensive reparation plans, guidance and individual reparation (Victims Unit, 2016).

4.4.1.1.4 Ethnic population in the department of Vichada

According to the percentages presented by the DANE in the 2005 census of ethnic groups in the department of Vichada, and considering the projections to 2017 regarding the total population, the following population distribution by ethnic groups is estimated at the department level. Table 4.111.

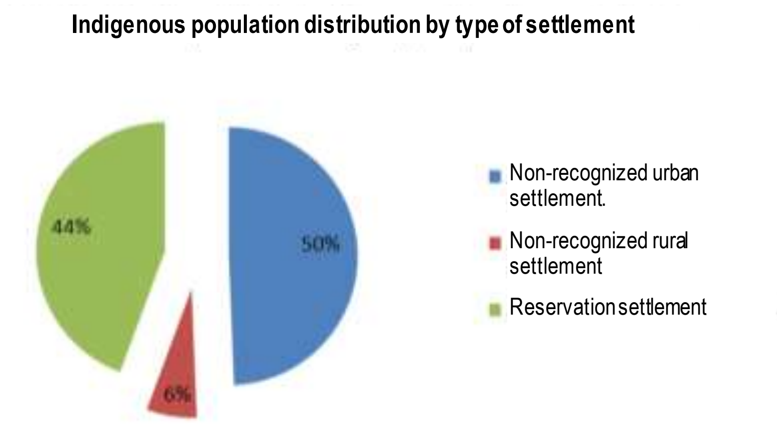
Table 4.111: Ethnic population in Vichada.

ETHNIC GROUP	INHABITANTS
Indigenous	33432
Afro	2264
Farmers and Settlers	39772
Total	75468

Source: Fundación Etnollano, 2013

According to DANE data for 2015, in the municipality of Puerto Carreño there are approximately 657 Afro-Colombian inhabitants and 8 *raizal* population inhabitants. There are discrepancies in the figures reported for the indigenous population. While the DANE records a total population of 2,753 inhabitants, municipal Indigenous Affairs reports for the same period a total of 3,239 individuals. Under this latter figure and according to the "Puerto Carreño somos todos" municipal development plan, the indigenous population located in the urban area without recognition and organization in reservations is 50%, 44% is located in 6 reservations recognized by the Ministry of the Interior and the remaining 6% live in non-recognized rural settlements. (PDM, 2016-2019). Graph 5.

Graph 5: Indigenous population distribution by type of settlement. Municipality of Puerto Carreño



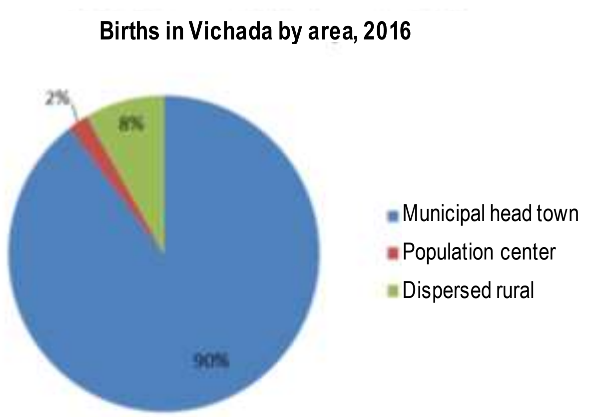
Source: "Puerto Carreño somos todos" Development Plan 2016-2019

4.4.1.1.5 Demographic behavior Puerto Carreño and department of Vichada

Birth rate

For the year 2016, a total of 653 births were recorded in the department of Vichada, 90% of which were reported in the municipal head towns, 8% in dispersed rural areas and 2% in the population centers (DANE, 2016). Graph 6.

Graph 6: Births in the department of Vichada by area, 2016

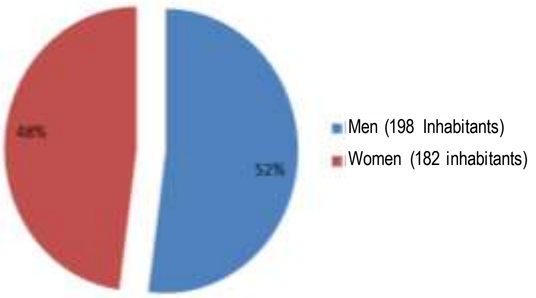


Source: DANE preliminary report (2016)

For the same period, births in Puerto Carreño represent 58% of the total for the department, with 380 births distributed 97.6% in the municipal head town and population center and 2.4% in the dispersed rural area. By sex, the distribution indicates a 52% male population and a 48% female population. Graph 7.

Graph 7: Distribution of births in Puerto Carreño by sex

Distribution of births by sex in Puerto Carreño, 2016



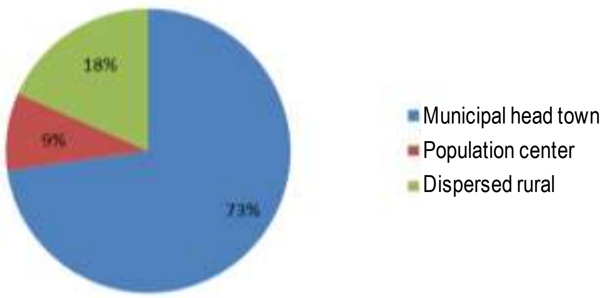
For the department of Vichada, the birth rate was 8%, decreasing 2% compared to the previous year in which there were 724 births in a population of approximately 71,974 inhabitants. At Puerto Carreño the birth rate was 23 per 1000 inhabitants.

<u>Mortality and Morbidity</u>

According to preliminary statistics presented by the DANE, there were a total of 184 deaths at the department level in 2016, the majority of cases occurring at the municipal head towns. Graph 8. The department distribution by sex is 36% women and 64% men. In terms of age ranges, 52% of all cases occur between the ages of 45 and 80, while the age range of 5 to 14 years represents 2% of all cases.

Graph 8: Deaths by area in Vichada 2016

Non-fetal deaths in Vichada by area



Source: Prepared by FFC social group 2017 based on DANE preliminary report (2016)

50% of all deaths in the department occurred in Puerto Carreño, with 71 cases, 60% of which were among the male population and 40% among the female population. Ischemic heart disease and homicide are the main causes of death in the municipality. The death rate for 2016 was 4.3 per one thousand inhabitants, with a small increase compared to the previous year, in which the rate was 4.1, with 68 cases.

<u>Unsatisfied Basic Needs</u>

For the year 2015, a 67% index of unsatisfied basic needs (UBN) was estimated for Vichada, Puerto Carreño being the municipality facing the greatest issues and challenges in this regard. Displaced populations from other departments and municipalities on account of the armed conflict have caused an increase in unemployment and extreme poverty in the municipality. According to data of the current Municipal Development Plan, in 2015 46.62% of the population had UBN, "*21.7% presents UBN for housing, 15% UBN for public utilities, 27.3% UBN* *due to overcrowding, 6.8% school non-attendance and 13.8% UBN of economic dependence*" (Alcaldía de Puerto Carreño, 2016).

It is worth noting that the recent arrival of Venezuelan population in the municipality is a factor that clearly increases UBN percentages. However, there no official figures yet to support this statement.

4.4.1.2 Area of Direct Influence

4.4.1.2.1 Population Dynamics

La Venturosa Police Precinct

According to information compiled in the field[86], the estimated number of inhabitants in the Police Precinct of La Venturosa is currently 235, 70% men and 30% women, making up approximately 48 families. The population consists predominantly of farmers and indigenous peoples, because the indigenous community of Morichalito of the Amorúa ethnic group is located in the surrounding area of the population center.

La Venturosa has a young population structure. 31% of the total population is between 0 and 12 years old, while people above the age of 65 are 13% of all inhabitants. Zero (0) deaths were reported in 2016 and so far in 2017 (November) there have been no registered cases either. During the same period, there were four (4) births, three (3) males and one (1) female. Table 4.112.

Table 4.112: Population structure La Venturosa Police Precinct

POPULATION	FAMILIES	% M	% F	0 - 12 YEARS	13 - 65 YEARS	OVER 65
235	48	70 %	30%	75	128	32

Source: Social Group, Social Capital Fact Sheet, 2017

- The population dynamics of La Venturosa is in line with that found at the national level. Migration processes resulting from the armed conflict, drug trafficking, the search for better living conditions, the development of certain companies and the Venezuelan crisis, are, among others, determining factors in the current social composition. The arrival of two families from Casanare, two from Venezuela and one from Cumaribo has been recorded during the past year, resulting in a total of 21 individuals looking for work and for places at the educational institution for their children. On the other hand, the records show that during the past year only one person left the police precinct. Photograph 1.

Photograph 1: Population Center of La Venturosa

[86] Social Capital survey applied to a focus group of community leaders at La Venturosa. See in Exhibits.

Source: Advisory group, 2017

The unsatisfied basic needs (UBN) indexes in the community are high; the difficult conditions for access to public utilities such as potable water, 24-hour electricity, the health post conditions, and the limited job and educational offer are proof of this. At the department and municipal level, the UBN figures for this population are unknown.
Photograph 2.

Photograph 2: La Venturosa Center. Drone image.

Source: Forestal de la Orinoquia, 2017

Aceitico Police precinct

The Police Precinct of Aceitico currently consists of an estimated 168 inhabitants. In the years 2014 and 2015, the total recorded population was 305 inhabitants, evidencing a 48% population decrease. According to the inhabitants, this situation is due to the very limited job and educational opportunities in the territory. Children reach the ninth grade and their parents must transfer them to other educational institutions to continue their education, whether in Puerto Carreño or in the municipality of Primavera or the department of Meta.

73% of the reported 41 families live in the population center and 27% are dispersed throughout the rural area. By sex, the adult male population represents 54% and the female population, 46%. The population structure of Aceitico is young; 50% of its inhabitants are between the ages of 0 and 17, while 7% are adults over the age of 65. Table 4.113.

Table 4.113: Population structure Aceitico Police Precinct

POPULATION	FAMILIES	FARMERS	% M	% F	0 - 17 YEARS	OVER 35 YEARS	WOMEN OVER 18 YEARS	MEN OVER 18 YEARS
168	32	11	54%	46%	80	11	35	42

Source: Social Group, Social Capital Fact Sheet, 2017

One birth and one death from cancer were reported in 2016. So far this year, November 2017, there has been one birth, two men died through homicide, and 1 person died of cancer. Photograph 3.

Photograph 3: Housing at Aceitico Population Center.

Source: Advisory group, 2017.

The poor condition of the access roads, the 5 hours per day of electricity, the 3 hours per day of water supply, the non-existence of garbage collection, the difficult Internet access and the homes built with walls of canvas and wattle (bareque), with palm and zinc roofs, evidence the fact that the community located in the police precinct of Aceitico has a high percentage of unsatisfied basic needs.

4.4.2 Cultural Dimension

4.4.2.1 Area of Indirect Influence

4.4.2.1.1 Historical references and current structures

The territory that currently makes up the department of Vichada has been historically inhabited by indigenous communities, some of which have disappeared such as the Mellas, Patmo and Yamú, others that remain at risk of extinction such as the Chiricoa and Cuiva (Ministerio de Cultura, 2009) and others with greater presence such as the Sikuanis, Amoruas, Sálivas, Piapocos, Piaroas, Curripacos and Puinaves. According to information contained in the development plans of the municipalities making up the department, there are currently 32 indigenous reservations in Vichada.

Nevertheless, various forms of distribution of the population and appropriation of the territory have existed over time and space, bringing other inhabitants such as Spanish "conquistadores", rural communities of mestizo ancestry, settlers from the interior of the country, an Afro-Colombian population and foreigners. The official history records that exploration of the Eastern Llanos began towards the 16th century by Spaniards, who founded towns such as San Juan de Los Llanos (1544), in order to provide themselves with food and other supplies. Subsequently, in the second half of the 17th century, the Jesuit community is recognized for the first time in the region, carrying out their evangelization processes with difficulty among the indigenous tribes found in the area where the Meta River flows into the Orinoco.

River routes were and are determining factors for the settlement dynamics that have taken place in Vichada. By the end of the 17th century, when the first road to the Eastern Llanos is built, the importance of rivers such as the Ariari and the Guayabero is confirmed, being "routes of vital importance to ship provisions to the cities of San Martin, San Juan de Los Llanos and San Fernando". (Fundación Mundo Espiral, 2015).

At the start of the 19th century, the dynamics of independence weakened the evangelizing missions, both in their economy and in the control they had gained over the indigenous communities. At the end of the 19th century and beginning of the 20th century, the general economy of the region is established based on the trade of skins and rubber. The evangelizing process of the native communities was continued by the Congregation of Missionaries of the Company of Mary (the Montfortians), who left a large number of boarding schools, chapels and educational institutions.

The institutional independence of Vichada occurs in 1913 when "it is created as a Special *Comisaría* within the territory of Meta" (Fundación Mundo Espiral, 2015), with its capital at San José de Maipure. However, given the emerging political-administrative transformations at the national level, it is only in the year 1991 that it is designated as a special department and in 1995 when it starts to make use of these powers.

By the year 1930, in view of the difficult international relations due to the rubber boom, the country is forced to establish its sovereignty in all the frontier areas, which contributed to the designation of Puerto Carreño as the capital of the special *comisaria* of Vichada, allowing for an important domestic investment in physical and social infrastructure for the municipality. Photograph 4.

Photograph 4: Port on the Orinoco River. Pto Carreño.

Source: Advisory group, 2017

From that period until now, Puerto Carreño has been established as an "…intermediate trade and transit port for people and products (cattle, natural resources) coming from both the high Orinoco and Meta (Orocué and Puerto López) and going abroad or to the interior of the country; it has served as an international control post, a supply and marketing point for extractive economy products, border trade and administrative center" (PDM, 2016-2019).

This position has led to urban growth in the municipality and has enabled the settlement of the rest of the territory. Nevertheless, another factor that has led to population growth in Puerto Carreño and in the department of Vichada from 1990 to date has been the displacement of populations as a result of the country's internal armed conflict. There are records showing the arrival of families from the departments of Arauca, Meta and Casanare (PDM, 2016-2019). In addition, another factor that has strongly impacted social and settlement dynamics at the department and municipal level has been the arrival of Venezuelan population over the past two years, as a result of the social and political crisis in the neighboring country. Some of the more relevant facts mentioned in the press and which took place in Puerto Carreño in 2017 were:

May 2017: seizure of 6,740 gallons of hydrocarbons illegally brought into Colombian territory through Puerto Carreño (HSB Noticias, 2000).

July 2017: with 1,690 votes in favor and 115 against, out of a total of 1,906 voters, an attempt to revoke the mayor of Puerto Carreño fails. (RCN).

August 2017: "delivery of the high speed Internet network, in addition to two WiFi Zones, six Vive Digital Kiosks, two Vive Digital Points, connection of 10 Public Institutions and delivery of 920 Broadband accesses". (Llanera, 2017)

September 2017: nearly 70 vessels participating in the Nautical Rally "Our Rivers are Navigable Venezuela" arrived at the main dock in Puerto Carreño (Armada Nacional de Colombia, 2017), an activity seeking to promote the area as a destination for ecotourism.

November 2017: a boat transporting nearly 18 people sank; they were apparently members of a Venezuelan indigenous community.

December 2017: a supervisory judge sent **20 people to prison**, among them nine military officers, investigated for **drug traffic** and alleged connections with the organized crime structure (Minuto 30, 2017).

4.4.2.1.2 Cultural references

Within the multiculturalism of the department of Vichada and the municipality of Puerto Carreño, we find indigenous practices such as weaving, language, dance and *cachi pipi* music; the *llanero* and farmer culture are reflected in *correrías* with cattle, music, song and *joropo* dancing and the customs of merchant settlers that predominate in the urban area. Photograph 5 and Photograph 6.

Photograph 5: Indio Venancio House of Culture.

Source: Advisory group, 2017

Photograph 6: Indio Venancio House of Culture.

Source: Advisory group, 2017

Among the best-known festivities at the municipal level are (Programa de Turismo, 2017):

- International Corrío Llanero tournament
- Binational Coleo championship
- 'Soga de Oro' festival
- 'Chigüiro de Oro' festival
- Children's Festival of La Palometa.

For the development and promotion of culture in the municipality there is the Indio Venancio House of Culture, the municipal library located near the airport, the fair complex located in the San Mateo neighborhood and several covered football fields. (Programa de Turismo, 2017).

Among the cultural heritage of Puerto Carreño we find: (Fundación Mundo Espiral, 2015), Table 4.114.

Table 4.114: Puerto Carreño cultural heritage

CULTURAL HERITAGE	DESCRIPTION
Cerro de la Bandera	Sample of the Guayanés Massif in Colombian territory. The place where the Meta and Bita Rivers flow into the Orinoco can be seen from it.
Cerro El Bita	Rocky outcrop. Declared a botanical garden in 1998. Viewpoint of the confluence of the Bita and Orinoco Rivers.
Raíces Llaneras Monument	Identity reference point of the Llanero culture, a place to remember the miscegenation and relationship between Colombians and Venezuelans.
Avenida Orinoco and Malecón del Puerto	Transportation artery that highlights the importance of the Orinoco River. Built early in the 20th century and remodeled at the end of that century.
Cathedral of Nuestra Señora del Carmen	Built in 1950 with the support of the Montfortian community. Symbol of identity and belonging.

Source: Fundación Mundo Espiral, 2015

4.4.2.1.3 Appropriation of natural resources

The relationship established by the population of the department of the Vichada with its natural resources is one of extraction and survival. Everyday practices such as pollution of water sources, burning of garbage mostly in the rural areas that do not have garbage collection services, hunting of animals, consumption of hunting meat and felling of trees in the proximity of rivers and creeks currently cause an imbalance in the ecosystem.

In this regard, the petitions of the community for the current development plan establish the need to:

- "Update the Solid Waste Integral Management Plan" of the municipality.
- Support and lead the environmental education of the community around the Interinstitutional Committee for Environmental Education (CIDEA), the Environmental Education Civic Projects (PROCEDAS) and the School Environmental Projects (PRAES).
- Articulate the formulation of Environmental Management Plans with the Afforestation Companies" (PDM, 2016-2019). Table 4.115.

Table 4.115: Appropriation of natural resources Puerto Carreño Ecosystem services in the ADI

WATER	SOIL	FLORA AND FAUNA
The Water System of the urban area obtains the water it distributes from the Orinoco River and supplies the entire urban population.	Presence of reforestation entities with forest plantations including Eucalyptus, Pine and Acacia.	There is hunting of deer, capybaras (*chigüiros*), turtles, and wild boars in rural areas. Fishing is carried out for on-farm consumption in the Meta,

There is no management plan for solid wastes, many of which end up in the water sources.	Burning of soils as a method to prepare them for planting pasture lands for grazing. Burning of garbage. Presence of subsistence farming and cattle raising. Food supply.	Orinoco, Bita and several smaller rivers. Felling of trees, for on-farm consumption. There are grasslands and other ecosystems that contribute biodiversity and wealth to the area.

Source: Advisory group, 2017

The main tourist sites at the department and municipal level are related to natural resources. Nevertheless, there is no municipal policy for the care of these areas, among them the Cerro de la Bandera, the Cerro Bita or botanical garden, the beaches of the Orinoco River, the Meta River, the beaches of the Bita River, the sighting of Toninas (pink dolphins), and the island of Santa Helena. There are also sites of great tourist and ecosystem importance such as the natural reserves. (Programa de Turismo, 2017). Photograph 7.

Photograph 7: Beaches of the Meta River.

Source: Advisory group, 2017

La Pedregoza Natural Reserve: Is a 2,013 hectare plantation, a 1,000 ha natural reserve with over 691 species of flora and fauna.

Doñana Natural Reserve: 1,200 ha of conservation with the presence of a river, lake, gallery forests, educational paths.

Bojonawi Natural Reserve: formed by 4,682 ha in savanna, gallery forests and flooded forests. Is part of the AICA zone and the conservation corridor, together with the El Tuparro park.

4.4.2.2 Area of Direct Influence

4.4.2.2.1 La Venturosa Police Precinct

<u>Historical references and current structures - La Venturosa Police Precinct</u>

The presence of the Police Precinct of La Venturosa is recognized during the 1960s. However, the building of the police station only begins in 1974 in the premises where it is currently located. By then, some policemen and their families, coming mainly from Bogotá and Santander, who looked after the cattle and its transportation in the area had already settled here. The school was established shortly afterward. Photograph 8.

Photograph 8: La Venturosa Police Precinct

Source: Advisory group, 2017.

During the 1990s, the arrival of the Pinoquia company created expectations among the community due to the possibility of improving their living conditions and accessing better job opportunities, which also led to the settlement of new inhabitants in the Precinct. The road and bridge over the Muco Stream were built during this same period.

Subsequently, at the end of the century, the Pinoquia company left the territory. According to the inhabitants, this was mainly due to the country's armed conflict, which materialized in constant extortions by armed rebel groups against company workers and staff. The departure of the company caused unemployment, new migration processes in the community and left a land title problem that is still unresolved. The community indicates that at one point Pinoquia had nearly ninety thousand (90,000) hectares of planted forests which, after its departure, were again taken over by the inhabitants and new settlers.

Towards the year 2005, there are reports regarding the presence of paramilitary and drug traffickers. The inhabitants recall the arrival of a front of the FARC in 2006 and the Police Substation of Venturosa was installed at the Precinct in 2007. Among the important events recorded by the community during the past decade are the arrival of FFC in 2010 and a seismic study exploring for hydrocarbons that did not yield positive results.

<u>Cultural references - La Venturosa Police Precinct</u>

The traditional festivities that seek to recover and strengthen cultural expressions at La Venturosa are the "Trompo and Saranda Festival", held during the Holy Week, and the "Fiestas Patronales de la Soga", held annually during the second week of December. Other dates of importance and celebration are: Women's Day on March 8, Mother's Day on May 8, Tree Day on April 27, October 31 and December 24. Photograph 9 and Photograph 10.

Photograph 9: La Venturosa Coleo Track

Source: Advisory group, 2017.

Photograph 10: Traditional architecture and use of local resources.

Source: Advisory group, 2017.

Among the activities that generate cohesion and community interaction are the micro football sports championship, the mini-tejo championship and the cleanup campaigns. The predominant religions in the community are Catholic and Evangelical, each with its own church.

Appropriation of natural resources - La Venturosa Police Precinct

The community settled in La Venturosa uses and appropriates the natural resources in order to supply and meet its immediate needs. As is the case at the municipal, department and national levels, there are no programs for utilization and conservation of the available resources. Everyday practices, such as the burning of garbage, cooking with firewood and hunting of animals, cause imbalances in the ecosystems. Table 4.116.

Table 4.116: Appropriation of resources La Venturosa Ecosystem services in the ADI

WATER	SOIL	FLORA AND FAUNA
Solid wastes are deposited in surrounding areas of water sources. Water comes from the La Venturosa stream, from which it is taken for consumption. Water is not treated. Enjoyment of the landscape.	Implementation of subsistence farming and cattle raising. Garbage is disposed of in open-air dumps or burned. Gravel (*ripio*) production.	Hunting of deer and wild boars. Fishing of caribemo, yamú, catfish. Use of wood for construction. Biological wealth and savanna ecosystems, among others.

Source: Advisory group, 2017

Within the current development plan, the community requests Management of "environmental compensations with the forestation companies that have properties near their precinct. These compensations should be used to reforest and recover creeks and water sources through tree-planting." (PDM, 2016-2019).

Landscape and tourist attractions

The following are important tourist attractions: the beach of the Meta River which forms during the months of December to March, the Bridge over the Muco Stream, the viewpoints in farms and the Llanos sunset that can be seen from the Chiquichaque Stream. Photograph 11.

Photograph 11: Port on the Meta River.

Source: Advisory group, 2017.

4.4.2.2.2 Aceitico Police Precinct

Historical references and current structures - Aceitico Police Precinct

The dynamics of population settlement at Aceitico are in line with the national trend. The armed conflict, the search for a better quality of life, forced displacement, the economy surrounding drug trafficking, etc., have been determining factors of the social configuration of the police precinct. The arrival of the first families from the departments of Arauca, Casanare and Boyacá is recorded in 1970. The Community Action Board is subsequently created in 1975 and the health post is set up two years later.

There is no exact record of the establishment and construction of the school. However, the inhabitants indicate that at the start of the 1980s the educational institution was already operating as a boarding school at the location built on the slope of the Meta River. At the time, the school led to the settlement of new inhabitants. At the end of the 1990s, the 16th front of the Colombian Revolutionary Armed Forces (FARC) sporadically visited the area.

In the year 2003, Aceitico ceased to be a *vereda* attached to the *corregimiento* of Murillo and was created as a Police Precinct. Consequently, and in response to the possible arrival of displaced population as a result of the armed conflict prevailing in the country, a process of clarification and definition of territorial limits was begun in 2004 by the farmers inhabiting the area.

During the year 2011, the community was highly impacted by the arrival of a company called Indupalma. This brought the construction of a residential complex of 42 houses projected for 1400 workers. The boarding school was moved from the bank of the Meta River to the edge of the population center along the road situated near the residential complex. Expectations of work and improvement of the quality of life grew among the community and new settlers arrived. Nevertheless, the Indupalma project failed after 3 years[87], the company was forced to

[87] Agribusiness project that intended to plant nearly 25,000 hectares of rubber throughout the department of Vichada. On line: http://lasillavacia.com/historia/el-proyecto-del-nuevo-minagricultura-en-vichada-no-es-del-modelo-riopaila-45598

leave the area and the homes that had been built were abandoned. As a result, Aceitico started having a new migration flow. Many of its inhabitants left in search of employment and better opportunities at Puerto Carreño. Photograph 12 and Photograph 13.

Photograph 12: Streets of the Aceitico precinct

Source: Advisory group, 2017.

Photograph 13: Residential complex abandoned by Indupalma.

Source: Advisory group, 2017.

Cultural references – Aceitico Police Jurisdiction

The main festivity and traditional meeting of the community settled in the Aceitico Police Precinct is the Chigüiro Festival on the Meta River, held during the month of October and lasting two days, during which there are folk music contests. Other celebration dates are: July 20, festivity organized by the educational institution; Mother's day, Women's day and Father's day. Photograph 14.

Photograph 14: Volleyball court, Aceitico

Source: Advisory group.

As entertainment and recreation activities in collective spaces there are football and billiard games, where most participants are men. Church attendance is also mentioned in this respect.

The inhabitants of Aceitico are Christians and Catholics. There are currently two Christian churches, one belonging to the United Pentecostal Church of Colombia and one Catholic church.

Appropriation of natural resources – Aceitico Police Precinct

The appropriation of its natural resources by the community of Aceitico cannot be separated from the social and cultural conditions that have formed it. The lack of public utilities, access roads and communication, and the unsatisfied basic needs in general, create a subsistence relationship with the environment, leading to an inappropriate use of resources. Table 4.117.

Table 4.117: Appropriation of resources, Aceitico Ecosystem services

WATER	SOIL	FLORA AND FAUNA
The Meta River has historically been the main communication route. Water consumption There is no management plan for solid wastes, many of which end up in the water sources. Enjoyment of the landscape.	Burning of garbage. Burning of soils for preparation. Use for on-farm consumption agriculture. Use for cattle.	Hunting of deer, capybaras (*chigüiros*), turtles, wild boars. Fishing is carried out for on-farm consumption in the Meta River. Use of wood for cooking. Use of the savanna for cattle raising.

Source: Advisory group, 2017

The requests made by the community in this regard in the current development plan are:

- "A site to dispose of solid wastes as well as a management plan for these to prevent them from ending up in the water sources such as the Meta River."
- "Support for tree planting together with the community in public areas, training in recycling processes, reutilization or adequate disposal of solid wastes."
- "Support to recover the protection zones of creeks and water sources."

4.4.2.3 Ethnic population - area of indirect influence

As previously mentioned, the department of Vichada is characterized by being multicultural and multi-ethnic. The indigenous population living there represents approximately 44% of its total inhabitants, organized in 32 reservations throughout the territory. By municipalities, they are divided as follows[88]:

- Cumaribo, 21 reservations with a total population of 28,712
- Santa Rosalía, 2 reservations with a total population of 666

[88] As previously mentioned in the demographic dimension, the official figures presented by the DANE for 2015 do not match up with those found by the municipal SISBEN and the Office for Indigenous Matters.

- La Primavera, 3 reservations with a total population of 3,591
- Puerto Carreño, 6 reservations with a total population of 1436 and a population of 1599 outside the reservations. Table 4.118.

Table 4.118: Indigenous Reservations in Puerto Carreño

NAME OF RESERVATION	ETHNIC GROUP	HECTARES	POPULATION[89]
Caño Guaripa	Amorúa	7,056	310
Caño La Hormiga	Amorúa	4,327	67
Caño Bachaco	Amorúa - Sikuani	6,047	239
Guacamayas Maipore	Amorúa	17,000	160
Caño Mesetas Dagua and Murciélago	Sikuani	41,746	290
Cachicamo	Piaroa	16,562	143

Source: Office of Indigenous Matters and Social Development, 2017

The indigenous communities found in Puerto Carreño belong to the Sikuani, Piaroa and Amorúa ethnic groups. Despite the fact that many of their traditions and forms of organization still remain, settlement dynamics and the acculturation processes, including religion, the economy and politics, have altered their uses and customs, leading to problems such as malnutrition, beggary, "a significant increase in morbidity and mortality, an increase in consumption of legal and illegal psychoactive substances, pregnancy among minors, increase in sexually transmitted diseases and domestic violence" (PDM, 2016-2019). Table 4.119.

Table 4.119: General characteristics of the indigenous communities present in Puerto Carreño

ETHNIC GROUP	LOCATION	SOCIOCULTURAL CHARACTERISTICS	ECONOMIC CHARACTERISTICS
Sikuani	Between the Meta, Vichada, Orinoco and Manacacias Rivers in the open grasslands.	Language: Of the Guahibo linguistic family. Rituals. Praying of the Fish is the initiation ceremony marking the life cycle and baptism of the ethnic group. The purpose of the ceremony is to prepare young women for adult life. Another important ritual for the sikuani is the Itomo, which is part of the second burial cycle ceremonies.	At present, "they engage in subsistence agriculture in the so-called abi conucos (smallholdings), planting cassava, plantain, yam, beans, sweet potatoes, mapuey and pineapple. Near their homes they also plant fruit trees such as guama, mango, papaya, citrus fruits, condiments and medicinal plants. In some reservations located in the department of Vichada, the sikuani combine agriculture with cattle raising and hunting" (ONIC, 1999)
Piaroa	Along the border with the Republic of Venezuela	Linguistic family saliba-piaroa. *"The Piaroa state that they come from Jotó Kiyú, a place name they use to refer to the mountainous areas and foothills found in the Cuao Massif, just where the*	"The piaroa have been considered the most reliable and honest business partners in the Venezuelan Amazon. Trade activity with their neighbors, (...) remains an everyday event. However, it has changed in many ways; it used to be extremely diversified, both in terms of

[89] As previously mentioned in the demographic dimension, the official figures presented by the DANE for 2015 do not match up with those found by the municipal SISBEN and the Office for Indigenous Matters.

ETHNIC GROUP	LOCATION	SOCIOCULTURAL CHARACTERISTICS	ECONOMIC CHARACTERISTICS
		mythical hills are located" (ONIC, 1999)	the items involved in the activity and of the lines of business: work instruments, food, ornaments, ritual elements, resins and colorants. By contrast, contemporary piaroa trade tends to be more restricted every day to agricultural products required by the native populations."
Amorua	Between the Meta and Orinoco Rivers, current reservation of Guáripa-La Hormiga	Language: Guahíbo linguistic family Figure of the Chamán (shaman) as the principal character in the ritual and spiritual life of the ethnic group. The Yopo is the main psychotropic plant, essential in any ceremony or ritual.	"Cassava, as the staple food, characterizes the horticulture of the Amorúa groups. Alternating varieties of bitter cassava (yuca amarga) are planted, up to a dozen per chagra, to achieve better and longer production in the land. Plantains are planted in low areas and humid zones. Pineapple, beans, sweet potatoes and yam are grown in small areas beside the cassava plantations, while fruit trees such as guama, mango, papaya, citrus fruits, condiments and medicinal plants are planted near the homes." (ONIC, 1999)

Source: Prepared by FFC Social Group 2017, based on ONIC records

4.4.2.3.1 Morichalito indigenous community – Venturosa Police Precinct

The indigenous community of Morichalito[90], located in the police precinct of La Venturosa, belongs to the Amorúa ethnic group. Its forms of settlement previously reflected their nomadic customs. Nevertheless, the settlement processes and during the past 30 years the dynamics of the country's internal armed conflict have deeply changed their way of inhabiting the territory.

As of 1990, the Amorúa families that lived in the area were forced to leave their lands due to harassment and threats by armed groups. Since then and until 2015 they settled in the Caño Mochuelo reservation located in the department of Casanare. According to the community, two families were able to remain despite the dynamics of violence, which enabled the return of the rest of the community by 2016, arguing that the area where they are currently located has a surface area of 14 thousand hectares. Photograph 15.

Photograph 15: Morichalito indigenous community housing.

[90] Name given to this settlement which does not have the status of a reservation.

Source: Advisory group, 2017

However, this return process has not been suitably supported by the Government to guarantee the rights of the Amorúa community. On the contrary, various social issues have been triggered in La Venturosa as a result of the theft and beggary to which the indigenous population is forced in view of the scarcity of resources to ensure their survival and quality of life.

At present, the Amorúa indigenous community of Morichalito is receiving support from the ONIC national organization to carry out the process required in order to be recognized as a reservation, as well as from the UMATA with productive projects, the Office of Indigenous Matters of the Mayor's Office, and Family Welfare programs, as well nutrition talks and health campaigns conducted approximately every 2 months.

Language: receives the same name as the ethnic group, Amorúa. According to studies it belongs to the Arawak family. At present, the entire community speaks the language, from children to adults. There are also nearly 25 individuals whose second language is Spanish.

Demographic Aspects. The community is formed by an estimated number of 28 families and 121 inhabitants, belonging to the Amorúa ethnic group. The age distribution reports 21.4% of children under the age of 12, 7.4% of the population between the ages of 13 and 18 and 3% over 65 years old. Three births were registered during 2016 and so far this year (November 2017) six more, 4 boys and 2 girls, have been reported. Some of these births took place in Puerto Carreño, while others were assisted by community midwives. The most recent deaths recorded took place in 2016: a newborn girl and an older adult in 2017. Table 4.120.

Table 4.120: Amorúa ethnic population.

ETHNIC POPULATION	FAMILIES	CHILDREN UNDER 12	MINORS BETWEEN 13 AND 18	ADULTS OVER 18	ADULTS OVER 65	CHILDREN ATTENDING THE SCHOOL
121	28	26	9	82	4	18

Source: Advisory group, 2017

Basic needs are totally unsatisfied in the community: there is no access to potable water, electricity, bathrooms and showers or garbage disposal. Homes are built with *moriche* roofs and canvas walls which last approximately 5 years, using *chinchorros* (hammocks) to sleep in, an item which, as informed by the community, is scarce, as are mosquito nets. Water is taken from a stream called Mochalito, which during the 'summer' months runs dry and the community must resort to the Meta River to obtain water. Photograph 16.

Photograph 16: Morichalito indigenous community housing.

Source: Advisory group, 2017

Health. Based on their world view, they make use of traditional medicine using medicinal plants they grow themselves or find in the territory. There are 4 traditional doctors who work in both their spiritual and their physical health. Morbidity occurs mostly in the form of stomach infections caused by non-potable water consumption; some children present characteristic malnutrition traits (short stature and “flag type” hair discoloration). There are no supplies, equipment or spaces to handle a health emergency in the community.

The community wishes to develop a project to recover their traditional medicine, from plants to midwifery. They report that they receive monthly health campaigns from the municipality.

Education. The community does not currently have its own education system. The school age population attends the “La Conquista” educational Institution, which offers up to the fifth grade. For secondary schooling the nearest place is the police precinct of Aceitico and for additional studies community members must travel 4 hours to Puerto Carreño. They are currently requesting a bilingual teacher for school-age children in the community (18 children).

Culture, uses and customs. The main character in the ritual and spiritual life of the Amorúa is the chamán, also known as a traditional doctor, who begins training from the age of 9. The most important medicinal plant, which guides celebrations and rituals is the Yopo. It is consumed together with other hallucinogenic plants, as well as tobacco. Young people in the community are allowed to marry once they reach the age of 15.

The traditional celebration of the community is the “Prayer of the Fish”, which honors a girl's first menstruation, she is prepared for adult life and to prevent diseases. Other important festivities are birthdays and weddings. Photograph 17.

Photograph 17: Traditional Doctor Morichalito indigenous community

Source: Advisory group, 2017

Economy. The economic activities carried on by the inhabitants of Morichalito are mainly for subsistence. The cultivation of cassava, plantain, corn, pineapple, yam, sweet potatoes, and pumpkin is mostly for on-farm consumption and a small percentage is taken to be sold at the population center of La Venturosa. This activity is carried out predominantly by the men. The women weave *mochilas* in *casabe* and *mañoque*, offering them for sale to visitors at the community. It is important to note that there are very few people traveling through and the community has not had a chance to effectively market its weaves and give them their real commercial and cultural value. Fishing and hunting are two other activities carried out by community members. They fish mainly in the Meta River and eat species such as the caribe, catfish and zaino. Photograph 18.

Photograph 18: Morichalito indigenous community women weaves

Source: Advisory group, 2017

<u>Sociocultural organization</u>

The political and social organization within the settlement consists of a governor, a male captain, a female captain and 12 bailiffs. The organizations with which they establish relations are the UMATA, which assisted them in the planting of plantain, the company Forestal de la Orinoquia, which provided supplies for planting cassava and wood to build a community meeting space. Finally, it is mentioned that the Social Welfare section of the Municipal Mayor's Office has implemented a monitoring program for the children of the community.

Appropriation of natural resources.

Water: Water is taken from the Mochalito stream. During the 'summer' months it runs dry and the community is left without water.

Soil: Garbage disposed of in open air, plantain and cassava planted for on-farm consumption.

Flora and fauna: Hunting of capybara, fishing of caribe, catfish, burning of bees to obtain honey, cooking with firewood and housing built of palm and wood.

Archaeological aspects

The Municipality of Puerto Carreño contains an important archaeological wealth. There have been numerous findings, "from ceramic and lithic material to cave art". (Fundación Mundo Espiral, 2015) The greatest presence of these elements is found in the rural subdivision (*corregimiento*) of Cazuarito, where ceramic pieces as well as carved stones and pictograms have been found, which reveal the view of the world of ancient indigenous inhabitants. However, there is no study that might provide greater knowledge regarding the authors and meaning of these pieces.

4.4.3 Organizational Political Dimension

4.4.3.1 Area of indirect influence

Given that the department capital is part of the area of indirect influence, due to this situation and to the fact that it is a frontier zone municipality, there are a number of official institutions in this territory with which the activities of FFC might possibly interact.

TERRITORY	ENTITY	ADDRESS
Foreign - National	Migration – Ministry of Foreign Affairs. River migration control post, Orinoquia regional office.	Carrera 10 # 18-08 / Barrio Centro
	Vichada Police Department	Carrera 9 No. 18-55 Centro Puerto
	Venezuelan Consulate	Avenida Orinoco N° 6 - 67, zona Centro
	Controller's Office, Vichada Collegiate Department Management	Carrera 8 # 19-72
	National Navy - Naval Force of the East	Calle 20 No.9-11 Barrio Centro
	Superintendency of Notaries and Registrars	Carrera 6 N° 18-81
	Public Defender's Office Vichada regional office	Calle 13 No. 11 61 Avenida Victoria Regia
	Colombian Ministry of Defense DIMAR Puerto Carreño Port Authority	Carrera 1 No. 17 - 121, Barrio El Puerto

Regional Entities	Governor's office of the department of Vichada	Carrera 8 # 18-2
	Autonomous Regional Entity of the Orinoquía	Carrera 23 No 18-31 of Barrio Gabán Yopal - Casanare
		Regional Headquarters of La Primavera, Vichada Carrera 9 Calles 4 y 5
	Department public health laboratory	Av. Orinoco Calle 10 7-48 - Puerto Carreño
	Colombian Red Cross - Vichada section	Carrera 11 No. 19-93 Barrio Las Acacias
	Sena	Carrera 10 No. 15-71

Source: Advisory group, 2017

The Governor's Office has the following citizen service units: Governor's office, Legal Advice Office, Secretary of Agriculture and Economic Development, Secretary of Indigenous Matters and Social Development, Secretary of Education and Culture, Secretary of Government and Administration, Secretary of Department Finance, Secretary of Planning and Regional Development and Secretary of Health.

The organizational structure of the municipality of Puerto Carreño consists of four control bodies: the Council, the Ombudsman's office, the Controller's office and the Attorney-General's office. In turn, there are 8 units making up the municipal government team: Family Police Station, Mayor's Office, Internal Control Office, Social Development Secretary, Finance Secretary, Planning Secretary, General Secretary and UMATA.

There are 37 community action boards in the municipality, 9 of which are part of the rural area. There are also two indigenous organizations:

- Association of Sikuani Indigenous Cabildos
- Amorúa (ASOCSIAM), Organization of Indigenous Peoples of the Lower Orinoco (ORPIBO).

The information provided by the Mayor's Office did not include details regarding these organizations.

4.4.3.2 Area of direct influence

At the police precincts making up the area of direct influence of the first plantations of Forestal de la Orinoquía, the first reference point for social organization is the Community Action Board (JAC). At La Venturosa, we also highlight the presence and influence of the Christian church and the Fundarte foundation, which works hand-in-hand with the family welfare institute. At Aceitico, in addition to the JAC, there are two Christian churches which also have organizational importance.

It is worth mentioning that, given the geographical position of the police precincts, located on the banks of the Meta River, they have been affected from the political and organizational points of view by the presence legal e illegal armed groups.

4.4.3.3 Case Studies

In order to have a better knowledge of the realities of the areas of direct influence, 9 case studies were carried out, which contributed the following results for the demographic, cultural and political-organizational dimension. Figure 4.226.

Figure 4.226: Case study results. Venturosa and Aceitico police precincts.

Demographic Dimension

- A total of 31 inhabitants were reported in the nine cases: 61% men and 39% women. In 8 cases the families are of the nuclear type and in one case, single-parent.
- There is an adult population structure and in 80% of all cases the inhabitants are between the ages of 18 and 65.
- The basic needs are not satisfied. Of the 9 cases, only one reports having access to the rural water supply system. Electric power is supplied in 6 cases by a solar plant, 5 hours a day, and two cases use natural case and firewood.

Cultural Dimension

- All inhabitants have come from other municipalities and departments. In 5 cases, they indicate that they settled in these areas in search of better opportunities. There are no adult individuals born at the police precincts.
- Most people engage daily in farming and cattle raising tasks. In 4 cases the main economic occupation is recorded as care and marketing of cattle.
- The most common recreational activity is watching television, followed by attending the churches and practicing sports. In one case, voluntary 'llanero' music lessons are given.
- The use of natural resources is the basis for the cultural tradition in the area. In 6 cases fishing activities are carried out, 5 of them 100% for own consumption. In 4 cases there are hunting activities, without a license, for own consumption. In 4 cases, trees are felled for own consumption.
- Garbage in handled in all cases by burning non-organic residues. There is no recycling.
- The educational level of the people interviewed indicates that 4 cases have complete and 2 cases incomplete elementary schooling, 1 case of complete technical education, 1 case of complete secondary education and 1 case with no education at all.

Political-organizational Dimension

- Two cases are members of the JAC.
- One case reports aid from the ICBF and another, aid from the Ministry of Agriculture to grow plantain.

Source: Case Studies. Advisory group, 2017

4.4.4 Spatial Component

In analyzing this dimension, the quality and coverage of public utilities and social services have been taken into account for both the area of indirect influence –AII (Municipality of Puerto Carreño in relation to the department) and the territorial units of the area of direct influence -La Venturosa and Aceitico Police Precincts; for the AII the information is based on secondary data and for the ADI, on primary data.

4.4.4.1 Area of indirect influence

4.4.4.1.1 Public Utilities in the Municipality of Puerto Carreño

Water and Sewerage

In the urban area, the municipality has primary water supply networks, known as the main or primary network, understood as the collection of pipes, fittings, structures and equipment that take potable water from the treatment plants or tanks to the local or secondary distribution networks. According to the 2016-2019 PDM, water supply services at the municipal head town are provided by the Public Utility Company of Puerto Carreño –SEPPCA SA ESP-; the water is obtained from a surface source, concessioned by Corporinoquia, under Resolution No. 140.15.004 dated March 19, 2004, with a volume of flow of 60 L/S, extracted from the Orinoco River; water supply coverage at the municipal head town is 98.5%.

As to the treatment plant (Photograph 19), it is described in the mentioned document as consisting of a settling tank (3000 m^3), stilling chamber, six high-rate filters, eight slow filters, two potable water outlet boxes, a post-chlorination system, bypass, high-rate and slow filter distribution boxes, and two tanks with storage capacity of 500 and 600 m^3, from which treated water comes out and is distributed through a pipe network (CORPORINOQUIA, 2012); for the current Municipal Development Plan the water supplied to the population is not potable. To handle sewage, they have a concession awarded under Resolution No. 140.15.005 of March 19, 2004, for the collection of ground waters, with a volume of flow of 2.3 L/S. Nevertheless, said collection was suspended for technical reasons in the operation of the water supply system.

Photograph 19: Water Storage and Treatment Plant, Municipality of Puerto Carreño

Source: Advisory group, 2017

According to the National Planning Department –DNP- for the year 2005, water supply coverage in the municipality of Puerto Carreño was 70.8%, while for the department it was 43.5%. Although coverage is considered to exist, the non-potability of the water, as well as the difficulty to maintain permanent distribution to users, would back the assertion that water quality and distribution are minimal.

According to the sectoral diagnosis carried out in 2008, the situation of public utility service providers of water, sewerage and garbage collection in the department of Vichada was considered normal and developing, in the sense that at the municipal head towns of its four municipalities there are two Cooperative Public Administrations (Aguas Claras de La Primavera and Aguas de Santa Rosalía), one specialized operator (SEPPCA S.A. ESP in Puerto Carreño) and two direct providers (Mayor's Office of Puerto Carreño for garbage collection and the Municipality of Cumaribo); at the time the coverage percentages for the municipal head towns were as follows: Table 4.121.

Table 4.121: Coverage percentage of Public Utilities at Municipal Head Towns in the Dpt. of Vichada

PUBLIC UTILITY	%
Water supply	74.41
Sewerage	23.44

Garbage collection	85.60

Source: Department Plan for Entrepreneurial Management of Water Supply and Sewerage, 2010.

It is important to clarify that this information does not take into account the coverage for the rural areas of the department.

Table 4.122: Water supply – Sewerage Coverage, Municipalities Dpt. Vichada

MUNICIPALITY	WATER SUPPLY		SEWERAGE
	% COVERAGE	HOURS OF SERVICE / DAY	% COVERAGE
Puerto Carreño	86.7%	6	5.67%
Cumaribo	94.9%	2	42.67%
La Primavera	42.1%	12	1.20%
Santa Rosalía	86.3%	7	1.72%

Source: Department Plan for Entrepreneurial Management of Water Supply and Sewerage, 2010

Based on Table 4.122, for the department capital there is a relatively high percentage of water supply coverage. This figure is in contrast with the minimum time of service each day, which is only 33.33%, 8.33% for Cumaribo, 50% for La Primavera and 29.16% for Santa Rosalía. The mentioned report also provides the actual water quality index, which shows that it is fit for drinking only in Puerto Carreño; in the remaining three municipalities it is not considered suitable for human consumption.

According to the municipal Development Plan for Puerto Carreño, at the municipal head town water supply coverage is 98.5%. It also mentions that in July 2015 there were 3,494 registered users with utility connections, 2,865 of which were active. The PDM contradicts the water potability information given by the Departmental Plan, underscoring that it is in line with technical opinion No. 800.10.1.16-0058 of March 22, 2016 issued by Corporinoquia, which reported that in the Municipality of Puerto Carreño there was no Efficient Water Use and Saving Program (PUEAA). Therefore, the water supplied to the town is not potable.

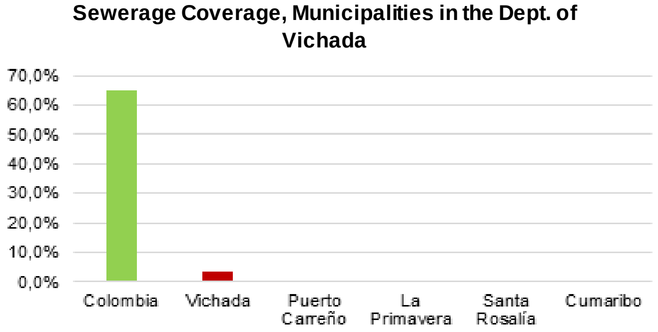
The information for sewerage services in the department capital, as well as in two other municipalities, indicates coverage percentages with minimal figures (Table 4.122), with the exception of Cumaribo. These data mean that the inadequate disposal of sewage translates into a high risk of diseases for the inhabitants of these municipalities.

According to the Conpes 3797 document, in the areas where there is no sewerage, waste water is poured into individual systems such as septic tanks or latrines or into open fields or nearby water sources; however, the current municipal government indicates that they have 30% sewerage networks, but these are not in operation; domestic waste water is deposited in septic tanks located in each home. For the rural area, it proposes the construction of rural water supply systems, as well as improvement in quality, quantity and continuity through multistage projects.

The municipal authority mentions in its current PDM the performance of various activities to implement its correct operation. Among these it highlights: the Master Sewerage Plan Study, expansion of sewerage network coverage, extension of future sewerage networks, construction of the WWTP, the waste water pumping system, reconditioning and maintenance of the sanitary landfill, the Education Plan for separation at the source as well as construction of storm drains. The final disposal of sewage from the municipality was authorized by Corporinoquia through the rainwater drainage channel which leads to a branch of the Meta River.

As can be seen in figure 9, coverage of sewerage services for the four municipalities in the department is null; in the department it is minimal and compared to the national territory, the gap is substantial.

Graph 9: Sewerage Coverage in Municipalities of the Dpt. of Vichada



Source: Terridata.dnp.gov.co

Solid waste collection and disposal

With respect to collection and disposal of solid wastes, the adequate disposal coverage percentage for all municipalities is 0% (Ministry of Environment, 2010), i.e., proper management of waste disposal is nonexistent; therefore, there can be no reference to quality in the provision of this service. This situation has negative repercussions on public health at each municipal head town.

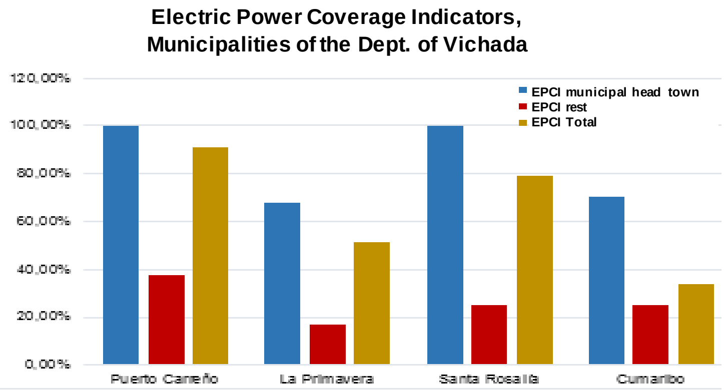
The Conpes 3797 document mentions that in the department of Vichada garbage collection coverage is 72.7%. Approximately 502 tons of solid wastes are produced monthly, 365 of which are collected. The percentage of sweeping and cleaning services in roads and public areas is low (21% of the towns). Out of the total residues produced in the department, 7% of all organic and inorganic residues are used. As to final disposal, 86% is carried out in open air dumps or without any proper technical and environmental management, and 7% is handled through other final disposal systems.

According to the 2016-2019 PDM, at the municipal head town of Puerto Carreño there is 95% coverage of garbage collection services in the urban area, with a frequency of collection and transportation of twice a week per neighborhood, generating 18 tons per day on average and approximately 396 tons per month. The Residential Sewerage and Garbage Collection Public Utility Unit created under municipal agreement No. 028 dated August 2013 is in charge of collecting and transporting solid wastes. The municipality has a recycling plant; however, it is not used due to lack of machinery and maintenance. They have a compactor collection vehicle with capacity for approximately 7 tons. The final disposal is done in the sanitary landfill. Garbage is collected twice a week, by neighborhood, distributed in two shifts and there are six routes, the first of these starting at 5:00 a.m. and ending at 12:00 m, and the second starting at 12:01 m and ending at 6:00 p.m., Monday through Saturday.

The sanitary landfill is located in the Merey sector, which was licensed and approved by the Corporation through Resolution No. 140.15.04.019 dated September 1, 2004, amended through Resolution No. 200.41.11.0404 of March 07, 2011. The compliance level as of 2015 was 22.07%. For the rural sector they have not implemented any collection or final disposal system. This is done in the open field and the coverage percentage of the garbage collection system in the rural sector is 0%. At present, the municipality of Puerto Carreño has a Plan for the Integral Management of Solid Wastes - PGIRS adopted under Municipal Agreement 016 of 2006.

At the six police precincts and the two *veredas* that make up the rural territory of the municipality of Puerto Carreño, there are no sewerage services. The municipal administration provides garbage collection services only in the Precinct of Casuarito.

Graph 10: EPCI municipalities Dpt. Vichada



Source: siel.gov.co[91]

<u>Electric power service</u>

In the CONPES 3792 document of 2014, we find that the electrical connectivity of the Altillanura is defined as a mixed zone, given that one portion of the region's users are connected to the National Interconnected System –SIN- and others are part of the Non-Interconnected Zone –ZNI-. Graph 10 shows the electric power coverage indicators as of 2015, according to the SIEL[92].

This information highlights the fact that in the municipalities of Puerto Carreño and Santa Rosalía coverage is 100%; in the municipalities of La Primavera and Santa Rosalía it is merely 60% for the rural areas; the remaining municipalities present limited coverage, under 30%, with the exception of Puerto Carreño which has somewhat over 35%. In the rural zones, coverage is difficult due to the size of the territories and dispersion of the population, which makes it difficult to extend the electric power network.

At the start of 2016, the municipality of Puerto Carreño provided electric power services thr ough the Electric Power Company of the Department of Vichada – Electrovichada S.A. E.S.P. through the power substation with 34.5 kVA transmission lines, from the territory of the Bolivarian Republic of Venezuela. To this end they have 6 engine-generators (Cummins, Perkins and Caterpillar generator sets). In Puerto Carreño, as of January 2016 the number of electric power users was the following (PDM, 2016-2019). (Table 4.123).

Table 4.123: Electric Power service users in Puerto Carreño

MUNICIPALITY OF PUERTO CARREÑO						
Location		Stratum			Commercial	Official
		1	2	3		
Municipal head town		2.474	3.220	136	400	117
Police Precinct	Aceitico	43	0	0	11	4
	Puerto Murillo	24	0	0	0	4

[91] Colombian Electrical Information System –SIEL
[92] Colombian Electrical Information System –SIEL

	La Venturosa	39	0	0	6	5
	Casuarito	145	0	0	52	7
Total		2,725	3,220	136	469	137

Source: Puerto Carreño PDM, 2016-2019

Payment is collected through joint invoicing with Electrovichada. With respect to the police precincts, at Casuarito there is no electric power coverage at all, at Aceitico service is provided five hours a day, at Puerto Murillo five hours a day and at La Venturosa four hours a day. Service coverage and quality in the urban area of the capital is good; however, in the rural areas it is deficient. Table 4.124.

Table 4.124: Hours of electric power service Police precincts - Puerto Carreño

POLICE PRECINCT	SERVICE PROVISION HOURS
Aceitico	5
Puerto Murillo	4
La Venturosa	5

Source: Puerto Carreño PDM, 2016-2019

Telecommunications and connectivity

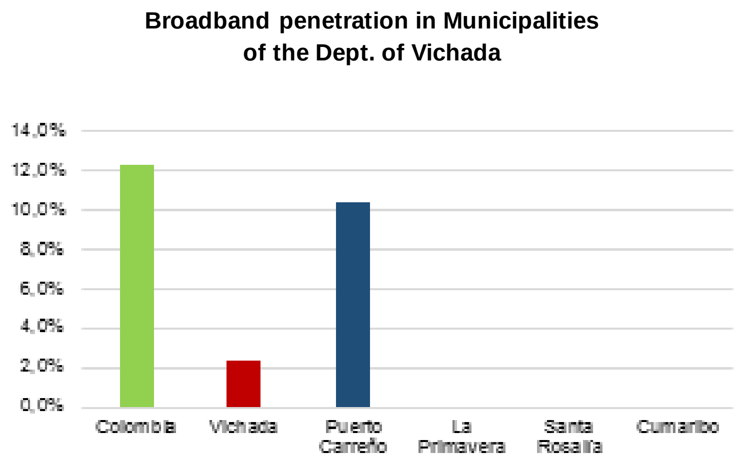
In the matter of telecommunications and connectivity through Information and Communications Technologies –TIC-, at the municipal head towns of the four municipalities in the department there is mobile telephony network coverage. Thus, it is possible to access the offers of companies such as Movistar, Claro, Avantel, Tigo, and other. However, in the municipal head town of Puerto Carreño service continuity is often difficult, and there are frequent periods of time during which there is no mobile telephony signal; at the rural level, the operator with a relatively permanent signal is Avantel.

Recently, in August 2017[93], the MIN-TIC, through its minister, delivered the following equipment in the municipality of Puerto Carreño, intended particularly for students, young people and adults:

- Two Wifi Zones with permanent free access for inhabitants, located in the Gloria Lara and Santander parks, enabling users of mobile devices –such as smartphones and tablets – to access the free Internet signal.
- Opening of a Vive Digital Point, on Avenida Luis Carlos Galán.
- One Vive Digital Plus Point, installed in the CERES (Regional Higher Education Center). The Vive Digital Points are community access centers installed by the MinTIC in the municipal head towns of the country.
- Internet installation at 10 public institutions that required the service; these are the facilities of the Eduardo Carranza and José Eustasio Rivera Educational Institutions, the Governor's Office of Vichada, the Municipal Mayor's Office, the San Juan de Dios Hospital, the House of Sports, the Public Defender's Office, the Federico Lleras Acosta Teacher Training Institution, the María Inmaculada School and the Department Assembly of Vichada.
- Six Vive Digital Kiosks, community Internet connection spaces located in rural perimeters, were opened in the military garrison Brigada de Selva #28 and in the educational institutions José Celestino Mutis, Biling Cachicamo, La Esmeralda Boarding School (main location), Caño Hormiga and Antonia Santos Schools (main location).
- It also facilitated access to 920 strata 1 and 2 homes, at social benefit rates.

[93] On line http://www.mintic.gov.co/portal/604/w3-article-57261.html

Graph 11: Broadband penetration in Municipalities of the Dpt. Vich



Source: terridata.dnp.gov.co

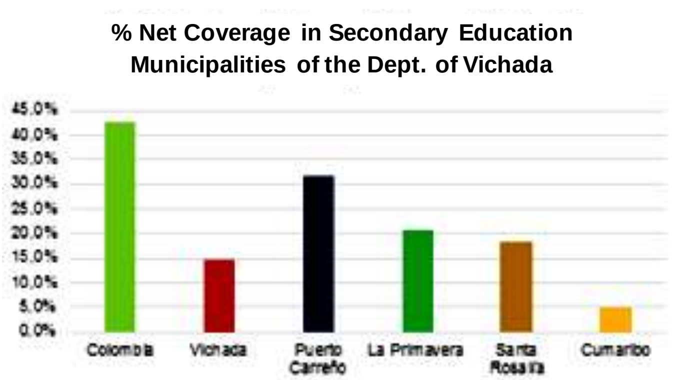
As can be seen in Graph 11, the dedicated fixed Internet penetration index[94] for the year 2017 in the four municipalities of the department of the Vichada is minimal; in three of these it is 0% and only in the department capital does it exceed 10%. However, compared to the percentage for the country the difference is not too great, which indicates that in the rest of the national territory accessibility to this means of telecommunication is low.

Social Services

Education services

The educational policy in the municipalities of the department of Vichada is under the direction of the Secretary of Education of the Department, as is the planning and implementation of the human resources of the sector, given that the municipality of Puerto Carreño is not certified by the Ministry of Education. Net secondary education coverage for the year 2016 in the municipalities of the department is low; only Puerto Carreño exceeds 30%; the municipality of Cumaribo presents the lowest percentage figures of the four municipalities. The percentages may be interpreted from Graph 12.

Graph 12: Net coverage percentage in secondary school education in Municipalities of the Dept. of Vichada



[94] On Line https://terridata.dnp.gov.co/#/perfiles

Source: https://terridata.dnp.gov.co/#/perfiles

The administration of Puerto Carreño manages and distributes the resources obtained from the General Participation System. Table 4.125 describes the locations of the educational institutions at Puerto Carreño; the municipal head town has five educational institutions with eight campuses and in the rural area there are six institutions and 10 campuses.

Table 4.125: Educational institutions in the municipality of Puerto Carreño

LOCATION	EDUCATIONAL INSTITUTION	CAMPUSES	No. STUDENTS	No. TEACHERS
Municipal Head Town	Escuela Normal Superior Federico	Main	609	26
		Primary	461	16
	IE José Eustasio Rivera	José Eustasio Rivera - Main	605	20
		Miguel of Cervantes Saavedra	189	7
	IE Internado Eduardo Carranza	Eduardo Carranza - Main	504	26
	Centro Educativo Jorge Eliecer Gaitán	Main Location	205	7
		Bilingüe Calarcá	60	5
	IE María Inmaculada	Main	744	26
Total	**5**	**8**	**3377**	**133**
Casuarito Police Precinct	IE Antonia Santos	Preschool and Primary	236	8
Garcitas Police Precinct		Main	152	9
		Garcitas Main	48	1
Aceitico Police Precinct	IE Internado Aceitico	Main	91	7
La Venturosa Police Precinct		La Conquista – La Venturosa	76	3
Puerto Murillo Police Precinct		Carlos Palau Ospina – Puerto Murillo	26	1
La Esmeralda Police Precinct	IE Internado La Esmeralda	Main	78	7
Puerto Colombia Community	Center Educativo Jorge Eliecer Gaitán	Puerto Colombia	29	1
Caño Hormiga Community		Caño Hormiga	79	3
El Merey Sector	IE Internado Eduardo Carranza	José Celestino Mutis - Main	316	6
Total	**5**	**10**	**1131**	**46**

Source: Vichada Secretary of Education and Culture, 2017[95]

In the urban area there is an average of 25.39 students per teacher, and in the rural area the number is 24.58 students. At the location of the Antonia Santos Educational Institution, preschool and primary section, we find the largest number of students, followed, in terms of quantity, by the population of this same institution at the

[95] Reply to information request No.2017PQR6659 Municipality of Puerto Carreño, November 2017.

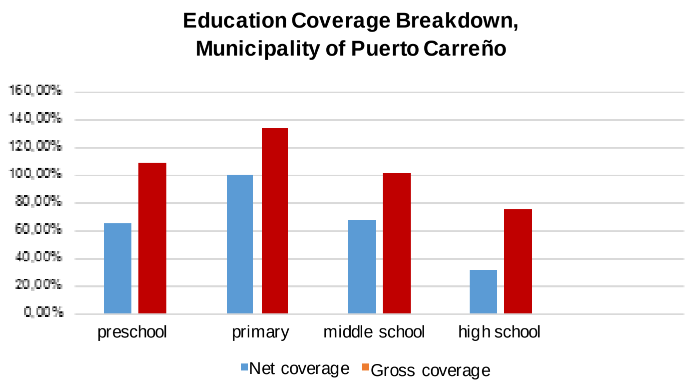
main campus, followed by Aceitico main campus. In the urban area, the largest population is found at the Internado María Inmaculada institution.

Photograph 20: José Eustasio Rivera Institution in Puerto Carreño

Source: Advisory group, 2017

There is also an Educational Institution for the indigenous population, which operates at two locations in the rural area, with 44 students, and two locations at the municipal head town, with 185 students in 2015. High school education is available only at the municipal head town. Regarding educational supplementation programs, they are developing the PAE (School Meal Program - Food Supplement), school meals for boarding school students in the municipality and school transportation. Graph 13 shows the percentages of net and gross coverage per education level in the municipality of Puerto Carreño. Based on this information we can say that a large percentage of the student population is extra age, that is, above the age corresponding to each grade. Table 4.126 shows the differences, which exceed 30%.

Graph 13: Education Coverage Breakdown Municipality of Puerto Carreño



Source: https://terridata.dnp.gov.co/#/perfiles

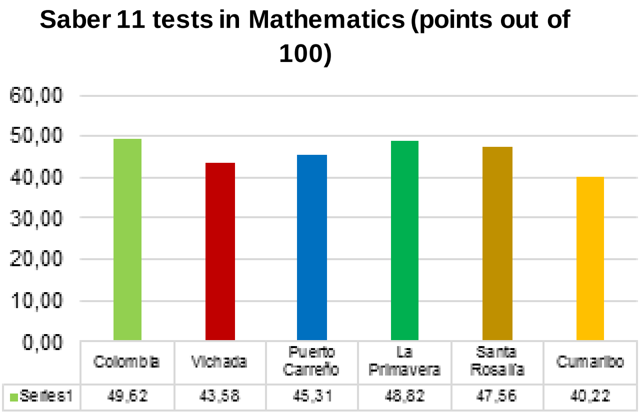
Table 4.126: % Extra Age School Population Municipality of Puerto Carreño

EDUCATION	DIFFERENCE %
Preschool	44,27%
Primary	34,55%
Middle School	33,97%
High School	42,99%

Source: Consulting group, 2017

In order to obtain an idea of the quality of education (when finishing high school), the scores of the Saber 11 Tests in Mathematics in the four municipalities, the department and the country have been taken into consideration. In Graph 14, for the Saber 11 Tests in Mathematics, the information yields a point average below 50 points, with the municipality of La Primavera showing the best results; the department capital occupies the third place among the four municipalities. It can therefore be said that, in general terms, the quality of mathematical knowledge must improve, as it does not even reach half the total number of points possible.

Graph 14: Saber 11 Tests in Mathematics



Source: https://terridata.dnp.gov.co/#/perfiles

Regarding technical education, the young population of the municipality of Puerto Carreño has access to the Center for Agricultural Production and Transformation of the Orinoquía, set up by the SENA; the educational offer varies depending on the socioeconomic needs of the region. Thus, the offers recently focus on the following programs:

- Document management technology.
- Computer equipment maintenance.
- Structured cabling design and installation.
- Agriculture and livestock enterprise management.
- Administrative management.

At the technical level it offered programs on: creation of audiovisual material, outboard motor maintenance, musical performance with functional instruments, livestock production, food agribusiness and photovoltaic solar system installation and maintenance. This institution also has a Public Employment Agency, where local companies can offer jobs required for their activities in the region and in each municipality of the department of Vichada. Photograph 21.

Photograph 21: Sena Puerto Carreño facilities

Source: Advisory group, 2017

As to higher education options, the following institutions have educational offers in Puerto Carreño:

- Universidad Nacional Abierta y a Distancia.
- Institución Universitaria Politécnico Gran Colombiano.
- Universidad Cooperativa de Colombia which operates the CERES; this latter offer with several technological education institutions in the country in the virtual education mode.

Health infrastructure

The department has 23 health service providers and 28 registered locations qualified with a special registration for health service providers. Table 4.127.

Table 4.127: Health Infrastructure Municipalities Dpt Vichada

MUNICIPALITY	Private		Total Private	Public	Total Public	Grand total
	Institutions - IPS	Independent Professional		Institutions - IPS		
Puerto Carreño	3	10	13	1	1	14
Cumaribo	2	0	2	2	2	4
La Primavera	1	2	3	0	0	3
Santa Rosalía	1	1	2	0	0	2
Grand total	**7**	**13**	**20**	**3**	**3**	**23**

Source: Department Secretary of Health, 2017

In addition, they have two public IPSs: Matsuldani Indigenous IPS (with two locations, the main one in the municipality of Cumaribo and the other in the municipality of La Primavera, with temporarily closed services), and the Unuma Acim Indigenous IPS (main location in Cumaribo with temporarily closed services). There are also six private IPSs: Mavesalud Indigenous IPS with two locations in Cumaribo, Jiwisalud S.A.S. IPS with its main location in Cumaribo, Corporación Social La Fontana with its main location in Puerto Carreño, Imágenes Médicas Centro de Ayudas Diagnosticas S.A.S. with its main location in Puerto Carreño, Diposalud S.A.S. IPS with its main location in Puerto Carreño, and Inci Salud S.A.S. IPS with its main location in Santa Rosalía. They have 12 independent professionals, nine of them in Puerto Carreño. (Department Secretary of Health, 2017).

The Nueva EPS is active in the department, currently with coverage in the subsidized and contributory systems in the municipalities of Puerto Carreño, La Primavera and Santa Rosalía; Mallamas EPS is also active in the municipality of Cumaribo. Health promotion and prevention programs for children, young people and adults carried out in the department are designed to be managed and implemented by the health service provider IPSs and by the collective intervention plans (PIC). The departmental ESS "San Juan de Dios" is highlighted as a public provider network in the department, in compliance with the current regulations. They also emphasize that all programs established in Ministry of Health Resolution 412 are guaranteed for users in the department of the Vichada.

The department capital has the largest number of health provider institutions, with a greater number of private entities and only one public entity, the E.S.E. Hospital Departmental "San Juan de Dios" (Photograph 36), which is a Level II State Social Enterprise of a departmental nature, attached to the Sectional Secretary of Health, created through Ordinance No. 048 dated November 22, 1994 of the Department Assembly of Vichada, under which it was transformed into the Regional Hospital of Puerto Carreño. In addition to the Puerto Carreño location, this institution has other locations in each of the three municipalities in the department. Table 4.128 describes the services it provides in the Municipality of Puerto Carreño.

Table 4.128: Health services - E.S.E. Hospital Departamental San Juan de Dios

SERVICE GROUP	SERVICES
Surgical	General surgery, gynecological surgery.
Outpatient consultation	Anesthesia, general surgery, endodontics, nursing, obstetrics and gynecology, general medicine, internal medicine, nutrition and dietetics, general dentistry, ophthalmology, optometry, orthopedics and/or traumatology, pediatrics, psychology, priority consultation, pediatric cardiology, pediatric pneumology.
Emergencies	Emergency service
Ambulance service	Basic ambulance transportation.
Diagnostic Support and Therapeutic Supplementation	Cardiovascular diagnostics, clinical laboratory, X-rays and diagnostic images, clinical laboratory sample taking, blood transfusions, pharmaceutical service, ultrasound, taking and interpretation of dental X-rays, electrodiagnosis, respiratory therapy, echocardiography, physical therapy, cervical cancer screening.
Specific Protection and Early Detection	Specific protection - childbirth, newborn care, early detection - growth and development alterations (under 10 years), early detection – adolescent development alterations (10 to 29 years), early detection - pregnancy alterations, early detection - adult alterations (over 45 years), early detection - cervical cancer, early detection - breast cancer, early detection - visual acuity alterations, specific protection vaccination, specific protection - preventive oral health care, specific protection - family planning for men and women.
Proceedings	Sterilization proceeding

Source: Department Secretary of Health, 2017

For specialized care and high-complexity surgeries, users must be referred to Villavicencio, Yopal or Bogotá. The intensive care unit has permanent support from the Telemedicine Service of the Cardiovascular Foundation, financed by the Ministry of Social Protection. In terms of installed capacity, Table 4.129 describes the hospital facilities.

Table 4.129: Installed Capacity E.S.E. “San Juan de Dios” Department Hospital - Pto Carreño

CAPACITY DESCRIPTION	CAPACITY GROUP	QUANTITY
Basic	Ambulances	5
Pediatric	Beds	12
Adults		15
Obstetrics		6
Pediatric intermediate care		1
Adult intermediate care		1
Operating room	Rooms	2

CAPACITY DESCRIPTION	CAPACITY GROUP	QUANTITY
Births		2
Procedures		1

Source: Department Secretary of Health, 2017

Photograph 22: E.S.E. location San Juan de Dios Department Hospital

Source: Advisory group, 2017

Table 4.130 and Table 4.131 below describe the public health interest events with respect to morbidity and mortality as of November 2017. Diseases caused by vectors such as Malaria (1290 cases), Dengue (46 cases) and Chikungunya (1) are highlighted, while acute malnutrition events in children under 5 total 229 cases, which is truly alarming, given that these events directly affect the performance of individuals during adulthood.

Table 4.130: Morbidity in the Department of Vichada

EVENT	REPORTED CASES
Ophidian accident	31
Low birth weight	20
Breast and cervical cancer	2
Cancer in children under 18	1
Chagas	2
Chikungunya	1
Congenital defects	18
Dengue fever	46
Acute malnutrition in children under 5	229
Disease transmitted by food or water (eta)	19
Orphan - rare diseases	1
Diseases similar to Influenza-Serious Acute Respiratory Infection	15
Fluoride exposure	1
Yellow fever	3
Hepatitis A	1
Hepatitis B, and co-infection hepatitis B and delta	1

EVENT	REPORTED CASES
Device associated infections - individual	1
Serious rare acute respiratory infection	2
Suicide attempt	17
Food poisonings	20
Skin leishmaniasis	8
Leptospirosis	1
Externally caused injuries	21
Injuries by explosive artifacts (gunpowder and landmines)	2
Malaria	1290
Meningitis	20
Extreme maternal morbidity	46
Parotitis	5
Congenital syphilis	1
Gestational syphilis	3
Whooping cough	62
Tuberculosis	21
Individual chickenpox	221
Gender violence surveillance in public health	123

Source: Department Secretary of Health, 2017

Regarding mortality events, the cases of perinatal and late neonatal mortality, as well as reported cases of mortality due to malnutrition and respiratory infections, are highlighted.

Table 4.131: Mortality in the Department of Vichada

EVENT	CASES
Perinatal and late neonatal mortality	23
Mortality due to and associated with malnutrition in children under 5	13
Mortality due to Acute Respiratory Infection in children under 5	13
Mortality due to Acute Diarrheal Disease in children under 5	2
Maternal Mortality	3
Mortality caused by Dengue Fever	1

Source: Department Secretary of Health, 2017

The municipality of Puerto Carreño has five health posts, one in each police precinct: Aceitico, Puerto Murillo, La Venturosa, La Esmeralda and Casuarito.

Recreational infrastructure

Regarding recreational and sports infrastructure, the Sports and Recreation Institute of Vichada –IDER- operates in the department, at the facilities of the Governor's Office. In the Municipality of Puerto Carreño there is the Municipal Sports Institute IMDER, which offers sports training schools in the categories of football, volleyball, cheerleading, futsal and basketball, Monday to Friday starting at 3:00 p.m. This training is offered for boys, girls and adolescents, at no cost; the activities are carried out at the IMDER sports complex of the municipality. They also have a municipal multipurpose field (Photograph 23), sports facilities in the Camilo Torres neighborhood, coleo track and the Indio Venancio House of Culture.

Photograph 23: Municipal multipurpose court

Source: Advisory group, 2017

Among the recreational options offered by the Municipality of Puerto Carreño are natural sites that can be accessed by the inhabitants. This program is known as "Puerto Carreño Turístico" and consists of contemplating the landscape, observing geographical and natural icons, photographing nature, bird and night sky watching in areas located near the municipal head town, as well as in farms in the surroundings. The program includes the following natural attractions, as well as pedestrian, river and land routes connecting them: Bita River Beaches, Meta River Beaches, Canaletes Lake, Juriepe Stream, Juriepe Stream Beaches, Aceite Forest, Boro Forest, Canastilla Voladora Forest, Cerro el Bita, Cerro la Bandera (Photograph 24), Ecosystem viewpoint, Caimán Lake, El Rabanal Lake and Bita River - El Tiestero.

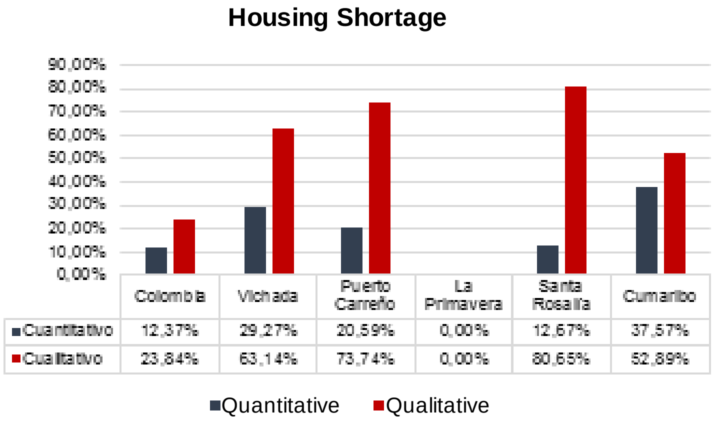
Photograph 24: Cerro La Bandera - Mouth of the Bita River at the Orinoco

Source: Advisory group, 2017

Housing Infrastructure

With respect to housing in the department and its municipalities, based on DANE information (2005 census), we find that 89.1% of all homes in the department capital are of the house type, 6.6% are apartments and 4.2% are of the room-other type. Graph 15 shows that there is a high percentage of qualitative and quantitative housing shortage compared to the percentage for the country, in terms of quality; except for Santa Rosalía, which is near the average for the country (quantitative shortage). There was no information available for the municipality of La Primavera.

Graph 15: Housing shortage in municipalities Dpt Vichada



Source: https://terridata.dnp.gov.co/#/perfiles

According to the 2016-2019 PDM, the number of homes in Puerto Carreño is 5,350, 4,585 of which are located in the urban area, representing 85.7%, and 14.3% correspond to the rural area, with 765 homes. The municipality has greater housing demand pressure at the municipal head town, due to the arrival of victim population and indigenous population who have abandoned their reservations and have moved to the department capital. This latter population generally settles in invasion sectors.

During 2014 and 2015, a Priority Interest Housing (VIP) program called Village Gladys was developed in the sector of La Esperanza. This is a complex of 194 Priority Interest Housing (VIP) units, 105 of which were already distributed among victim population and population of the Red Unidos program.

Road, air and river infrastructure

Regarding road, air, train and river transport infrastructure in the municipality of Puerto Carreño, we can say that in order to access it from the municipality of Puerto Gaitán, department of Meta, one must travel on route 40 (Photograph 25), a road that is mostly unpaved, except for the 22-km paved stretch recently completed by Invias in the sector from Puerto Carreño to Puente Juriepe. The road can be used only in the dry season, as it is difficult to travel on during the rainy season. This road provides access to the precincts of Aceitico, Puerto Murillo, and La Venturosa, as well as to the municipalities of La Primavera and Santa Rosalía.

Photograph 25: Route 40 in area near the Aceitico Police Precinct. Flooded during the rainy season

Source: Advisory group, 2017

The same road can be used to travel from Bogotá D.C. to Villavicencio and then to Puerto Gaitán and Puerto Carreño, on vehicles of the La Macarena commercial fleet; service is provided only during the dry season with an approximate travel time of 48 hours.

The inhabitants of Puerto Carreño also use the Orinoco River and Meta River as travel routes (Photograph 26); at the municipal head town there is a pier on the Orinoco River (Photograph 27) supervised by the Dimar with the Port Authority of Puerto Carreño. Companies such as Transporte Fluvial El Boral S.A.S., with over 30 years of operation, travel on the Meta River during the rainy season; they provide services from the municipality of Puerto Gaitán (department of Meta) to Puerto Carreño.

Photograph 26: Transportation on the Meta River

Source: Advisory group, 2017

Photograph 27: Pier on the Orinoco River

Source: Advisory group, 2017

Another company, Transporte Fluvial Oriente offers two routes, one from Puerto Gaitán - Orocue - Santa Rosalía - La Primavera, where it connects with the second route: La Primavera - Santa Barbara - Nueva Antioquia - La Venturosa - Aceitico - Puerto Carreño. Another company is Transturpial, which moves cargo and passengers using the Meta River and its tributaries, from the municipality of Puerto López (department of Meta), on the Metica River, which flows into the Meta River, reaching the municipalities of Orocué in the department of Casanare, Santa Rosalía, La Primavera to Puerto Carreño in the department of Vichada.

There are airports in the department of the Vichada at the municipality of Cumaribo and at the municipality of Puerto Carreño. A flight from Bogotá D.C. to Puerto Carreño, operated by SATENA (only commercial airline traveling to the area) lands at the Germán Olano airport; the approximate flight time is one hour and ten minutes, with 1 daily frequency. Other air routes of the region also use this airport. There is no rail network in the department.

Centers of influence for marketing and access to social services

The department capital must be mentioned in this regard, as it concentrates the socioeconomic services of the region. Although some product marketing offer may be found at the police precincts, the great distances to access these make mass product supply and demand difficult. We could say that there is some commercial offer at the police precinct of Garcitas, as it is a transit point to the Tuparro National Natural Park, in addition to being a port on the Orinoco River. On the Meta River, the population center of La Venturosa may be a site for commercial activitation. We can also mention the municipality of La Primavera, as it is the closest to Puerto Carreño.

Mass media

Below is a description of the media such as radio, press and community radio stations operating in the department of Vichada. In this regard, the Foundation for Freedom of the Press (Flip[96]) indicates that in the department of Vichada, 78% of the population lives in municipalities where there are no media that produce local news; thus, for example, in the capital of Vichada, the inhabitants do not have an offer with sufficient local information. There are no public media in the department; there are three commercial media: two newspapers and one web portal. There is only one community medium, a television channel, and four radio stations of the Armed Forces (Table 4.132).

Table 4.132: Radio stations in Dpt. of Vichada

RADIO	DIAL	DESCRIPTION
FM Emisora Fuerza Aérea	92.3 MHz	Ministry of Defense Radio Station.
FM Radio Nacional de Colombia	94.3 MHz	National public radio station, broadcasts for all regions in the country.
FM Colombia Estéreo	97.3 MHz	The station is part of a network of 33 radio stations belonging to the National Army and has been in operation since 2014. It has coverage at La Primavera and Santa Rosalía. The entire program schedule is musical, with the exception of a newscast connected with Bogotá.
FM Policía Nacional	99.3 MHz	The station is part of the network of 34 institutional radio stations belonging to the National Police. It has operated since 2010.

[96] http://flip.org.co/cartografias-informacion/content/vichada

		It has coverage throughout the municipality of Puerto Carreño, Casuarito, and Puerto Ayacucho, Venezuela. It has no local news bulletin, and connects with the newscast from Bogotá. It includes slots for the Governor's Office, the Mayor's Office, the Catholic and Christian Churches. La programming consists of 20 hours of music.

Source: Advisory group, 2017. 2017

With respect to printed media, there is the "Nuevo Correo del Orinoco", a medium in circulation since 2004. It has coverage in all municipalities of the department with 3,000 copies and sends 20 copies to the governor's offices and mayor's offices of Casanare, Arauca, Meta and Guainía. It does not generate local information, only institutional information from the Governor's Office.

Another written medium is the newspaper called "El Morichal", which has been in circulation since 2016 and distributes 8,000 copies a month in the department, 2,000 in each municipality and 2,000 in Guainía. The newspaper includes eight pages of news, two pages for public institutions and one page for environmental issues. There is a digital medium, Teleorinoco, which operates since 2009. This medium receives 200 visits each day. It is a news aggregator on Vichada. It does not generate local information.

There is a local television channel in the municipality of La Primavera called Primavisión, which operates since 2001 with 30% coverage in the municipality. At Puerto Carreño and in general in Vichada, there is access to cable television, through which private channels such as Caracol, RCN and others can be seen; there is also access to satellite television such as Directv.

4.4.4.2 Area of Direct Influence

4.4.4.2.1 Public Utilities - La Venturosa Police Precinct

Table 4.133 shows a summary of the coverage of the current supply systems at the Police Precinct of La Venturosa.

Table 4.133: Public utility access and supply. La Venturosa

Police precinct	Water supply system	Water supply hours/day	Sanitation service	Other waste water management	Garbage disposal	Electric power service
Venturosa	Communal water supply. Covers 77% of all housing.	3 hours/day	Toilet connected to septic tank	Sewerage coverage (0%)	Burning and burial.	Covers 100% of housing with 4 hours of service per day.

Source: Advisory group, 2017

Water supply service

The inhabitants of the precinct do not have access to water supply systems installed by the municipal mayor's office. Water is obtained from the La Venturosa stream and distributed through a communal water supply system to 37 of the 48 homes making up the population center. In other words, 77% of all homes have access to this service. This water is not treated. It is normally used for human consumption, domestic and production activities. Families that do not have access to the local water supply obtain water from deep wells or cisterns located in their properties or with motor pumps in creeks near their homes, for example the Joropo Creek[97].

Sewerage service.

The population center does not have a sewerage system. Homes, both in the rural area and in the population center generally use a toilet connected to a septic tank; waste water is disposed of in septic tanks and, where these do not exist, it is disposed of in the open field.

Electric power and telecommunications

Electricity is supplied by an electric power plant provided by the municipal mayor's office; the service is available from 5:00 p.m. to 9:00 p.m. (four hours a day) and sometimes only three hours. Based on this information, it can be said that out of the 24 hours of possible access to this service, only 17% is available. According to the inhabitants, the cost of the service is high: commercial premises must pay $40,000 a month, homes $20,000 and those who use a single lightbulb, $10,000. In view of the minimum availability of this service, the inhabitants supply their needs using diesel fuel plants and solar plants.

With regard to telecommunications, they do not have access to land lines; there are only mobile services, with the operators TIGO, Avantel and Claro, which have the best signal in the sector. In the population center there is access to Internet services at the digital kiosk, with service from 3 p.m. to 6 p.m. This service it is not possible at the farms. The radio stations they listen to are few, as it is not easy to get their signal. They mentioned listening to Colombia Estéreo.

Solid waste collection service

There is no solid waste management in the community. For the most part, it is burned and some families bury it. The inhabitants of this police precinct use propane gas, electricity and firewood to cook their food. Some people recycle beer cans which are then transported to Puerto Carreño. Photograph 28.

Photograph 28: Recycling actions

Source: Advisory group, 2017

Social services - La Venturosa Police Precinct

[97] Advisory group, 2017. Case studies - La Venturosa, 2017

Education

The facilities of the Internado La Conquista educational institution are located in the population center of La Venturosa (Photograph 29). They have three teachers, and students may attend up to the 5th grade. The main location is in the population center of the precinct of La Venturosa. Students have difficulties to continue their education, as they then have to go to Aceitico to study up to the 9th grade and must complete their secondary education at the municipal head town of Puerto Carreño (six hours away), a situation which most families cannot afford, because supporting their children at these locations is expensive.

Photograph 29: Location of Internado La Conquista educational institution, Venturosa precinct.

Source: Advisory group, 2017

Five individuals from La Venturosa have obtained professional degrees as environmental engineers, lawyers and doctors. However, they are living elsewhere because at the precinct they have no chance to practice their profession. Most adults at the precinct have completed their primary schooling, and some are validating their secondary education.

The condition of the educational institution's infrastructure is considered good. There are currently 81 students enrolled there. At the beginning of 2017 there were 118 students, given that it served the indigenous population. However, this population generally drops out, because they are continuously moving throughout the territory. Indigenous children were given 20 bicycles so that they could go to the school. However, even so they stopped attending classes, arguing that they have no school supplies to work with and, on the other hand, the children speak their language and not Spanish. The school does not have teachers for the indigenous population.

Health

There is a health center at the population center (Photograph 30), served by an auxiliary nurse. They receive medicines every three months (support from the company Forestal de la Orinoquia), and the collective intervention plan brings a doctor and a dentist to the center each month. There they handle health problems of the child population such as colds and stomach problems due to water consumption; with the adult population they treat dengue, colds, fevers, viruses, hypertension, kidney and gall bladder diseases (isolated cases); the population is in general considered healthy.

Photograph 30: Health Center and Community Room, Venturosa police precinct.

Source: Advisory group, 2017

Regarding recreation spaces, there are sports facilities at the school; there is a football field and a coleo track (Photograph 31), and mini-soccer and mini-tejo championships are held among the inhabitants. In addition, during the dry season, they have the beaches of the Meta River, the bridge on the Muco Stream, the viewpoints at the farms, and the Llanos sunsets at Caño Chiquichaque.

Photograph 31: Coleo track, Venturosa precinct

Source: Advisory group, 2017

Housing

The information compiled in the case studies (9) for this police precinct indicated that the homes in the precinct have been built of wood and bricks; for the floors they use cement, the roofs are usually zinc sheets and moriche palm and, to a lesser extent, Eternit tiles. Inside they usually have a dining room, one or two bedrooms, a bathroom connected to a septic tank, and some have a storeroom. The most frequent problems are humidity and wear from use. There are 48 homes and 22 farms in the police precinct. Photograph 32.

Photograph 32: Streets and housing of the Venturosa police precinct

Source: Forestal de la Orinoquia, 2017.

Access roads

The inhabitants of La Venturosa have two means of access to the precinct: route 4015 (road from Gaucacias in Santa Rosalia to Puerto Carreño, 95.76 km long), which is a national road; however, it is mostly covered with gravel and can only be used during the dry season, because vehicles will get stuck during the rainy season. 10.32% of the Puerto Carreño – Juriepe road, which connects the precincts is paved. In other words, 89.68% is unpaved, even though it is a national road. Invias began studies in 2016 to build the new road corridor that would connect the departments of Vichada and Meta. Its designs cost 22,400 million pesos within the intermodal transportation Master plan and are being prepared by the Consorcio Interventoría Conexión Puente Arimena and should be completed by December 31, 2017[98]. (Photograph 33)

Photograph 33: Main Street in the population center. La Venturosa police precinct

Source: Advisory group, 2017

During the rainy season, the inhabitants use the waters of the Meta River (Photograph 34) to travel to Puerto Carreño. Two companies provide this service from Puerto Carreño to Puerto Gaitán and vice versa, stopping at the La Venturosa dock (Transporte Fluvial El Boral S.A.S., Transporte Fluvial Oriente). Tickets cost $80,000 each way to Puerto Carreño. Near the population center there is a runway for use (Photograph 35) by small planes. According to the inhabitants it was built and used by drug traffickers but is not currently in use.

Photograph 34: Transportation on the Meta River

[98]On line: http://www.eltiempo.com/archivo/documento/CMS-16523228

Source: Advisory group, 2017

Photograph 35: La Venturosa police precinct runway

Source: Advisory group, 2017

At the population center of this police precinct, inhabitants have basic economic dynamics, depending on family revenues. The closest municipality is Puerto Carreño, six hours away, which requires the inhabitants to plan their visits to it in a very practical way, given that transportation costs are high. At the population center there are five shops, 1 hotel, 1 restaurant and entertainment site and 1 butcher shop. The inhabitants frequently buy at the bongos (barges) that make the trip every week and stop at the dock in La Venturosa, competing with the shops in the population center.

4.4.4.3 Aceitico Police Precinct

4.4.4.3.1 Public utilities

Table 4.134 summarizes the coverage of the current supply systems at the Police Precinct of Aceitico.

Table 4.134: Public utility access and supply. Aceitico

Police Precinct	Water supply system	Water supply hours/day	Sewerage service	Other waste water management	Garbage disposal	Electric power service
Aceitico	Communal water supply. Covers 61.5% of all homes.	3 hours/day	Toilet connected to septic tank	Sewerage coverage (0%)	Burning and burial.	Covers 100% of all housing with 5 hours of service each day.

Source: Advisory group, 2017

Water supply service

The inhabitants of this police precinct do not have access to water supply systems from the municipal mayor's office. They obtain water from a deep well through a pump and store it in a high tank, (Photograph 36) in poor condition, which is located at the entrance to the population center. This water is distributed through the communal water supply system to 42 of the 52 homes in the population center, that is, there is 81% coverage. Water is used for domestic consumption and food preparation. Water supply is available only three hours a day, that is only 12.5% of the time (24 hours). At the farms, the inhabitants extract water from deep wells with a motor pump, and also from reservoirs (*jagueys*) and cisterns, according to the case studies (9).

Photograph 36: Water storage tank, Aceitico Police Precinct

Source: Advisory group, 2017

Sewerage service.

The population center does not have a sewerage system. Homes, both in the rural area and in the population center, generally use a toilet connected to a septic tank; with respect to waste water, they dispose of it in septic tanks or in the open field.

Electric power and telecommunications

Electricity at the population center is supplied by an electric power plant (Photograph 37) with service availability five hours a day (from 5:00 p.m. to 10:00 p.m.), that is 16.66% of a continuous 24-hour distribution. In view of the minimum availability of this service, the inhabitants who can do so have solved the problem using solar plants, in particular at the farms.

Photograph 37: Electric power plant shed

Source: Advisory group, 2017

With respect to telecommunications, they do not have access to land lines; there are only mobile services, with the operators TIGO, Avantel and Claro, which have the best signal in the sector. There is no Internet access at the population center. At the farms, the community president has Internet access. However, this service is scarce.

Solid waste collection service.

There is no solid waste management in the community. Solid wastes are for the most part burned or buried and organic elements such as peels are buried or scattered in the pastures to decompose, while inorganic elements are burned. The inhabitants of this police precinct use firewood, gasoline, propane gas, or electricity for cooking, depending on their needs and the family economy.

Social Services.

Education

The facilities of the Internado Aceitico Educational Institution are located at the population center of this precinct. The institution has six teachers, two of them women, and the 91 students can study up to the 9th grade. There is constant mobility among families, which affects the continuity of students at this institution. The institution is located at the entrance to the population center of Aceitico, approximately 2 km away. (Photograph 38, Photograph 39, Photograph 40 and Photograph 41).

Photograph 38: Internado Aceitico Educational Institution

Source: Advisory group, 2017

Photograph 39: Solid waste management. Internado Aceitico Educational Institution

Source: Advisory group, 2017

Photograph 40: Productive projects. Aceitico Educational Institution

Source: Advisory group, 2017

Photograph 41: Pigsty, Aceitico Educational Institution

Source: Advisory group, 2017

This location was moved outside the population center, because at the time, due to the presence of housing for the company Indupalma, they were able to obtain approval from the Governor's Office for the transfer, with the purpose of serving the school-age population that would occupy the Indupalma homes, something that never occurred. The children have transportation to and from the school (Photograph 42).

Photograph 42: School transportation

Source: Advisory group, 2017

The inhabitants have difficulties with the continuity of the children's education, as they must complete their high school at the municipal head town of Puerto Carreño (four to six hours away), at Primavera or move to the department of Meta, a situation that many families are unable to afford. Supporting their children's education is expensive and their income is minimal. 60% of all adult inhabitants have completed their primary education and five individuals are illiterate. They indicated that the condition of the educational institution's infrastructure is average.

Health

There is a health center at the population center (Photograph 43), served by one nursing assistant; they have a minimum supply of medicines and on occasion there is medical care through medical campaigns sent by the municipal mayor's office. They handle health problems in the child population such as colds, rashes, conjunctivitis; with the adult population they handle the presence of viruses. Generally speaking the population is considered healthy.

Photograph 43: Aceitico Police Precinct Health Center

Source: Advisory group, 2017

According to information collected in the field, at the Aceitico police precinct there are cases of drug addiction and micro-trafficking of narcotics, a situation that has not been solved yet, after a history of illegal drug trafficking.

Social infrastructure

With respect to recreation spaces there is a football field in poor condition and a space for volleyball (Photograph 44). They also have a coleo track and a small park for the children (Photograph 45). During the dry season, the inhabitants organize outings and bathe in the Caño Las Viejas.

Photograph 44: Aceitico volleyball court

Source: Advisory group, 2017

Photograph 45: Aceitico children's park

Source: Advisory group, 2017

Housing

There are 52 homes in the police precinct of Aceitico, whose condition was described by field leaders as worn, with a predominance of wood, cement and canvas walls (Photograph 46), as well as zinc and moriche palm roofs. Floors are usually earthen or covered with cement and floor tiles. The better homes may have up to four bedrooms and a storeroom. The most frequent problems are cracks and wear.

Photograph 46: Housing in the Aceitico Police Precinct

Source: Advisory group, 2017

Roads

The inhabitants of Aceitico access the precinct through a road connecting them from the population center to route 40, approximately 6 km long and covered with gravel. Using route 4015 they can travel to the municipalities of Puerto Carreño and La Primavera; this is a national road; however, it is mostly a gravel road. They indicate that the roads are in poor condition (Photograph 47).

Photograph 47: Rural access roads

Source: Advisory group, 2017

During the dry season the trip can take up to four hours in the Flota La Macarena vehicles; the fare is $25,000. They also use private vehicles, motorcycles, and horses, which reduce travel time by one hour, and somewhat more on a motorcycle. At the population center, there is one main street covered in gravel, which gives access to other streets. During the rainy season, they use the waters of the Meta River to travel to Puerto Carreño. Two companies provide this service from Puerto Carreño to Puerto Gaitán and vice versa, stopping at the dock of the population center (Photograph 48). According to the community, the constant use of this dock by small boats, has caused an undermining of the bank, which could affect the stability of the zone in the short term.

Photograph 48: Dock at the population center of Aceitico on the Meta River

Source: Advisory group, 2017

4.4.5 Economic Dimension

4.4.5.1 Area of Indirect Influence

4.4.5.1.1 Orinoquia Region – General Diagnosis

As a region, the Colombian Orinoquia is part of the Orinoco river bi-national basin, encompassing the departments of Arauca, Casanare, Vichada, Meta, Guaviare and Guainía, which in turn include 64 municipalities with an area of 380.600 km2 representing 33% of the national territory. Within this region there are 140 reservations, 10 National Natural Parks and forest reserve areas that amount to 54% of the Orinoquia territory (Conpes 3797, 2014).

According to Conpes (3797 / 2014), the historical, economic, social, cultural and political conditions of the zone have shaped the population's structure, which is how settlers, *llaneros* (plainsmen), farmers, indigenous groups and Venezuelan immigrants have been brought together in this area, and who require differentiated State policies that acknowledge their cultural traits. In this sense, the region has been affected by the territorial settlement process, where the dispersion and concentration of inhabitants in the foothill zone is observed, with urban systems in the municipalities as well as mainly rural scattered settlements traversed by rivers, creeks and savannas. The Foothills is the most significant settlement area, concentrating 80% of the region's population, while cities such as Villavicencio, Yopal, Arauca, Inírida, San José del Guaviare and Puerto Carreño have bloomed as a consequence of extraction or foreign trade bonanzas.

From the environmental component perspective, the Orinoquia is characterized by its contribution to water supply, considering that there are 14 sub-basins in the region according to IGAG-DNP (2002) calculations, thus enabling the performance of agricultural, cattle farming and energy supply (mining) activities, population mobility and water supply for human and animal consumption. In demographic terms, a population amounting to 1.7 million people has been estimated, 71% of which is located in municipal head towns (Conpes 3797, 2014) while DANE's 2005 census reported that 6.3% of the Orinoquia population acknowledged themselves as part of an ethnic group, 60% of them as indigenous and 40% as Afro-Colombian.

In this region, 11.4% of the land is legally classified as a protected area, equivalent in size to Costa Rica. It has been estimated that there are 156 ecosystems and forests that capture 8 billion tons of CO_2, equivalent to China's annual emissions. Likewise, 25.3%, i.e. 87 of the country's river basins, are located in this region, along with over 15 million hectares, which may be potentially used for agricultural, cattle farming and agroforestry purposes (DNP, 2016).

As for the economic component, the production of hydrocarbons, rice, soybean, sorghum and palm agroindustrial crops, planted forests, as well as extensive cattle farming are all part of the region's productive structure. The economic growth of the departments that are part of the Orinoquia has shown growing trends. Proof of this is the estimation of the Gross Domestic Product - GDP at current prices, which leaped from $13.192 (in billions of pesos) in 2000 to $46.804 in 2016 (DANE, 2017). This significant increase is due to the positive growth of the extraction industry (hydrocarbons and mines); however, the industry is currently showing low performance. (Table 4.135).

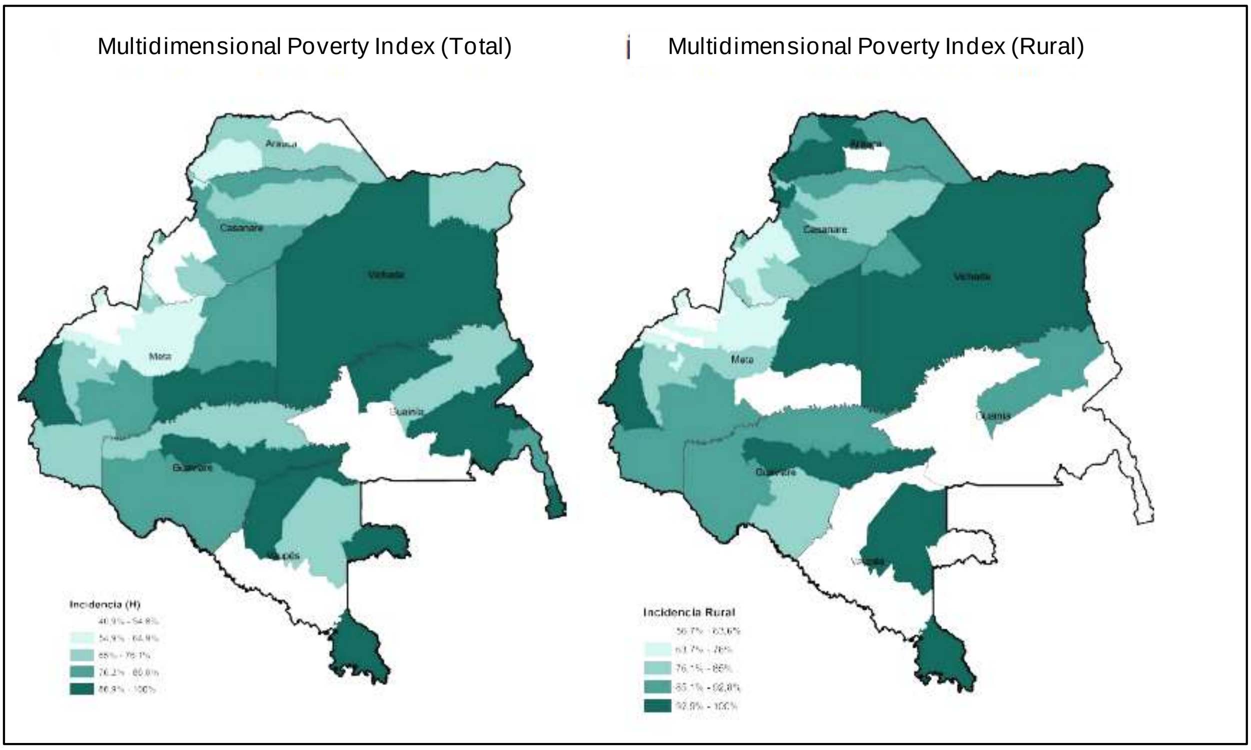
Table 4.135: Gross Domestic Product by Region, at current prices In billions of pesos 2000 - 2016pr

ORINOQUIA DEPARTMENTS	YEAR 2000	% PARTICIPATION	YEAR 2016^{PR}	% PARTICIPATION
Arauca	1.895	0,909	4.545	0,527
Casanare	6.784	3,253	12.059	1,398
Guainía	83	0,116	284	0,033
Guaviare	241	0,116	767	0,089
Vichada	135	0,065	456	0,053
Meta	4.054	1,944	28.693	3,326
Total Orinoquia	13.192	6,326	46.804	5,425
TOTAL COLOMBIA	**208.531**		**862.675**	

Source: Prepared based on current GDP by region - DANE, 2017
Pr: preliminary

Despite the region's potential, poverty indexes (Figure 4.227) exceed the national average. In this sense, the DNP (2016) stated that the Orinoquia presented a 56% poverty incidence, i.e. 7 points above the national poverty incidence, with the rural area being the most affected, with a poverty incidence of 77%. The departments with the greatest poverty figures are Vichada (84.3%), followed by Vaupés (77.8%), Guainía (78.8%) and Guaviare (75%) (DANE, 2013).

Figure 4.227: Total Multidimensional Poverty Index and Rural Multidimensional Poverty Index.



Source: DNP, 2016

__Property Ownership Structure__

In Vichada the property ownership structure is highly inequitable, as reflected in the Gini coefficient[99] which was 0.91 in 2014, far from the national average of 0.73[100], and with a 9.33 property concentration, which is closer to the national figure of 9.56 (UPRA, 2015). This inequity leads to lands owned by few, the underuse of lands by their owners and the resulting intensive use of lands owned by medium-sized owners, thus fostering the extension of agricultural and cattle farming borders whose management affects the savannas. Table 4.136.

Table 4.136: Distribution indicators by department for the 2014 period.

DEPARTMENT	GINI	CONCENTRATION
Vichada	0.91	9.33
Colombia	0.73	9.56

Source: UPRA, 2015

At a department level, lack of knowledge of the property ownership structure (legal possession and property map), along with an outdated rural cadastre mean less resources for the municipalities collecting the property tax in these territories as provided by the law (PNUD, 2011) and therefore greater informality rates. According to Conpes 3717 (2014), "there are conflicts relating to the social management of property" in the Altillanura, meaning that the data reported on land ownership, dispossessed lands and forms of possession is outdated, which in turn leads to judicial insecurity and falling behind in terms of cadastral update and formation.

[99] The GINI coefficient as a distribution indicator of rural premises shows: total equality =0, Total inequality =1 regarding land ownership at a regional level.
[100] Colombia is one of the countries with the highest inequality in rural ownership in Latin America and the world, according to the UNDP (2011).

The Conpes (3797 / 2014) indicates that in the department of Vichada, only the Cumaribo municipality has cadastral records. Regarding land titles, in 2012 Puerto Carreño issued a total of 1,597,648 land titles, 36.4% of which were given to indigenous groups, i.e. over 500 thousand hectares. However, it would be appropriate to consider the quality of the lands granted and their location, as in the Orinoquia there are “forest areas not suitable for agricultural production and cattle farming” (PNUD, 2011), which makes it difficult for these indigenous peoples to meet their basic food needs.

Ownership vis-à-vis the size of properties in Vichada falls mainly into the large properties category. Of the total properties reported, 67% are larger than 200 hectares, followed by properties of under 3 hectares with 19%, which reflects great inequality in the size of the lands owned. Out of the total rural properties shown in Table 4.137, approximately 2,229 do not have a real estate registration number and 38,381 are registered (UPRA, 2017).

Table 4.137: Land size. Dept. of Vichada

SIZE	RANGE	PROPERTIES
Micro-holding	Under 3 has	1,036
Smallholding	From 3 to 10 has	127
Small property	From 10 to 20 has	73
Medium-size property	From 20 to 200 has	627
Large Property	Over 200 has	3,747
Total		5,610

Source: UPRA, Dept. of Vichada. 2017

In Vichada, 46% of the properties belong to private parties, while the greater percentage – 53% - is State-owned. Ethnic communities are entitled to 1% of the properties according to this UPRA classification. Refer to Table 4.138 and Figure 4.228.

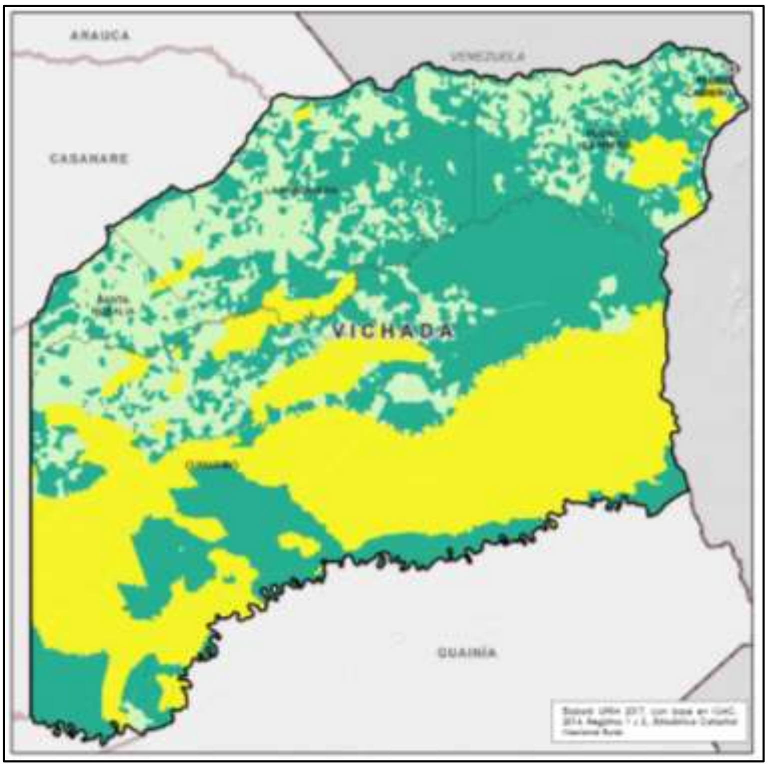
Table 4.138: Property classification by type of rural owner

Private Parties **2,585 Properties (46%)**
State-Owned **2,984 Properties (53%)**
Ethnic communities* **41 Properties (1%)**

* Includes lands of indigenous communities that have not been formalized into reservations but appear as indigenous community property

Source: UPRA, 2017

Figure 4.228: Classification of properties by rural owner



Source: UPRA, 2017

On the other hand, the 2014 National Agricultural and Cattle Farming Census indicated that the prevailing ownership system in the municipalities of Vichada is collective ownership, trailed by single-owner units. The Cumaribo and Puerto Carreño municipalities have a greater collective ownership proportion in the department total, while the municipalities of Primavera and Santa Rosalia show more single-owner units. In Puerto Carreño, 795 properties were registered in the census, although it failed to include all territorial units. Table 4.139.

Table 4.139: Ownership system of Vichada municipalities

Municipality	Total units registered in the census	Single-owner units	Leased Units	Units under Tenant Farming	Units in Usufruct	Units in Commodatum	Units under de facto occupation	Units under collective property	Units held by an awardee or co-owner	Units under other forms of possession	Combined units
Total Vichada	6.565	1.590	48	6	6	1	5	3.273	294	57	9
Puerto Carreño	795	150	3	0	1	0	1	130	0	7	1
La Primavera	913	698	7	0	3	0	1	82	4	26	0
Santa Rosalía	355	140	6	0	0	0	0	77	16	7	1
Cumaribo	4.502	602	32	6	2	1	3	2.984	274	17	7

Source: Geoportal DANE. National Agricultural and Cattle Farming Census, 2014

The rural stratification of the municipality of Puerto Carreño, based on the average Family Agricultural Unit UAF[101], in accordance with Resolution 041 / 1996, covers a range from 956 to 1294 hectares for the relatively homogenous zone type Savannas 3 and 1275 to 1725 hectares for type 4 savannas.

Land use and suitability

In 2017, the UPRA identified that lands in Vichada were being sub-utilized (27%) and over-utilized (4%), thus creating conflicts in the use of land in the department. The total surface area of Vichada is 10,008,757 hectares, 17% of which are suitable for agriculture, 14% for agrofrestry, 7% for forests and only 6% for cattle farming. However, it is observed that only 0.7% of the area is being used for agriculture, while 39% is used for grazing. The same occurs with forest production, as only 0.06% is being used for these activities when the land allows for greater investments in this sector. Table 4.140.

Table 4.140: Land suitability, Dept of Vichada

How should land be used?	
Agriculture (17%)	Forest production (7%)
Cattle Farming (6%)	Agroforestry (14%)
How is land being used in Vichada?	
Agriculture (0.7%)	Forest production (0.06%)
Grazing (39%)	Water surface (1%)

Source: UPRA, 2017

These calculations indicate that the use of the land should be dedicated to the performance of agricultural (17%) and Agroforestry (14%) activities and, in a smaller proportion, to cattle farming. Vichada, as is the case in the rest of the country, has seriously sub-utilized its forestry potential (PNUD, 2011): forestry activities are currently carried out in 0.06% of the area, while its potential has been estimated at 21%, i.e. over 2,100,000 hectares for forestry and agroforestry exploitation. On the other hand, cattle farming uses 39% of the area for grazing to maintain the herd, while only 6% of the land is suitable for this activity.

At a municipal level, the National Agricultural and Cattle Farming Census found that this situation is quite close to the figures at the department level. It is observed that in Puerto Carreño the use of the lands of the properties registered in the census is mainly for cattle farming (99.9%). Table 4.141.

Table 4.141: Predominant use of land (hectares) in properties registered in the census. National Agricultural and Cattle Farming Census. Vichada department.

Municipality	Total Units hectares	Predominant agricultural activities hectares	Predominant cattle farming activities hectares	Natural woods hectares
Total Vichada	**10,022,494**	**419**	**3,468,978**	**6,553,096**
Puerto Carreño	1,216,199	92	1,216,107	0
La Primavera	1,862,582	249	1,862,332	0
Santa Rosalía	390,617	78	390,539	0
Cumaribo	6,553,096	0	0	6,553,096

[101] A Family Agricultural Unit [*Unidad Agrícola Familiar* (UAF)] is a land unit that produces an income of at least two legal monthly minimum wages.

Source: Geoportal DANE. National Agricultural and Cattle Farming Census, 2014

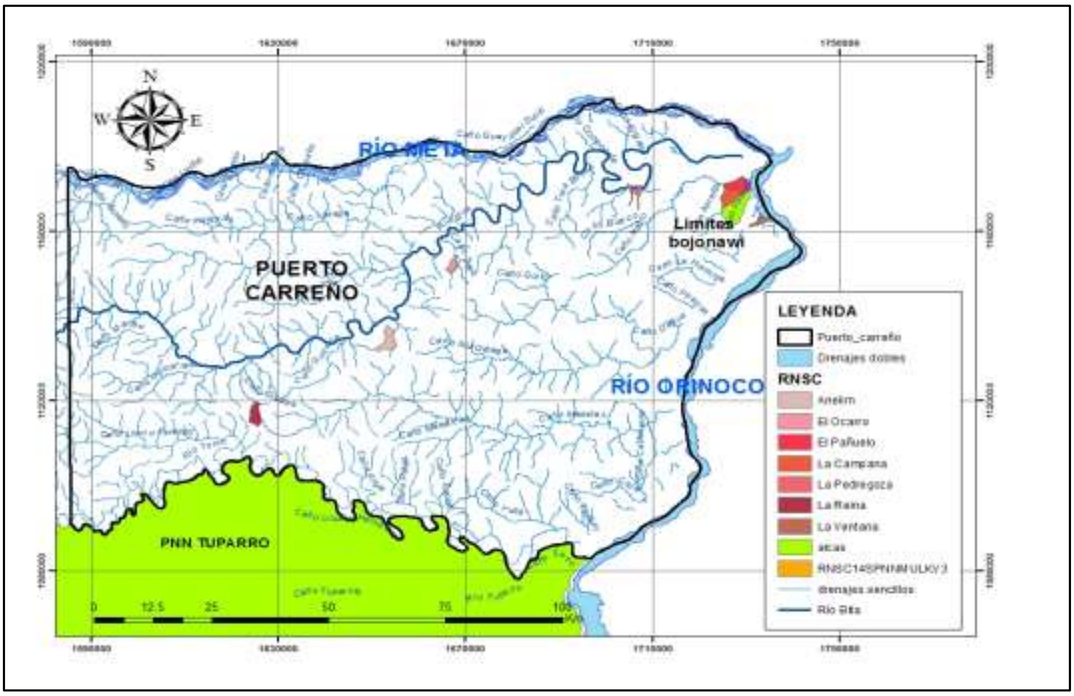
In 2017, 8 protected areas distributed in natural reservations of civil society and one AICA[102] in the Bojonawi Reservation (Table 4.142 and Figure 4.229) were recognized in Puerto Carreño. The private natural reservation Bojonawi is a member of the Civil Society Reservation Network owned by Fundación Omacha, which is one of the 124 AICAS registered in Colombia. In 2016, the Environmental Agency issued a technical opinion that deemed feasible the registration of the "La Reina" civil society natural reservation– RNSC, which is located in the rural subdivision of La Esmeralda in Puerto Carreño, and whose area is 1047.73 hectares. (CORPORINOQUIA, 2016).

Table 4.142: Protected areas and Resolution in Puerto Carreño

Protected Areas	Name	AREA (hectares)	Resolution
AICA	Bojonawi	5,153.3	-
Natural reservations belonging to civil society	La Reina	1,047.7	135 (October 10, 2016)
	La Campana	1,268.2	135 (October 19, 2016)
	El Pañuelo	1,310.8	152 (December 03, 2014)
	La Ventana	1,310.9	193 (December 26, 2014)
	La Pedregoza	465.7	192 (December 26, 2014)
	Anelim	1,235.0	0096 (August 28, 2014)
	El Ocarro	508.1	011 (February 10, 2017)
Total hectares		12,309.9	-

Source: SIG, 2017

Figure 4.229: Reservation zones and protected areas in Puerto Carreño.



Source: Advisory group, 2017

In addition to the foregoing, the Office of the Municipal Mayor of Puerto Carreño also recognized 4 ecological reserve and protection areas in the municipality, to which, according to the 2016-2019 Municipal Development

[102] AICA refers to an 'Area that is important for birdlife conservation'. Online: http://www.humboldt.org.co/es/test/item/525-areas-importantes-para-la-conservacion-de-las-aves-aicas

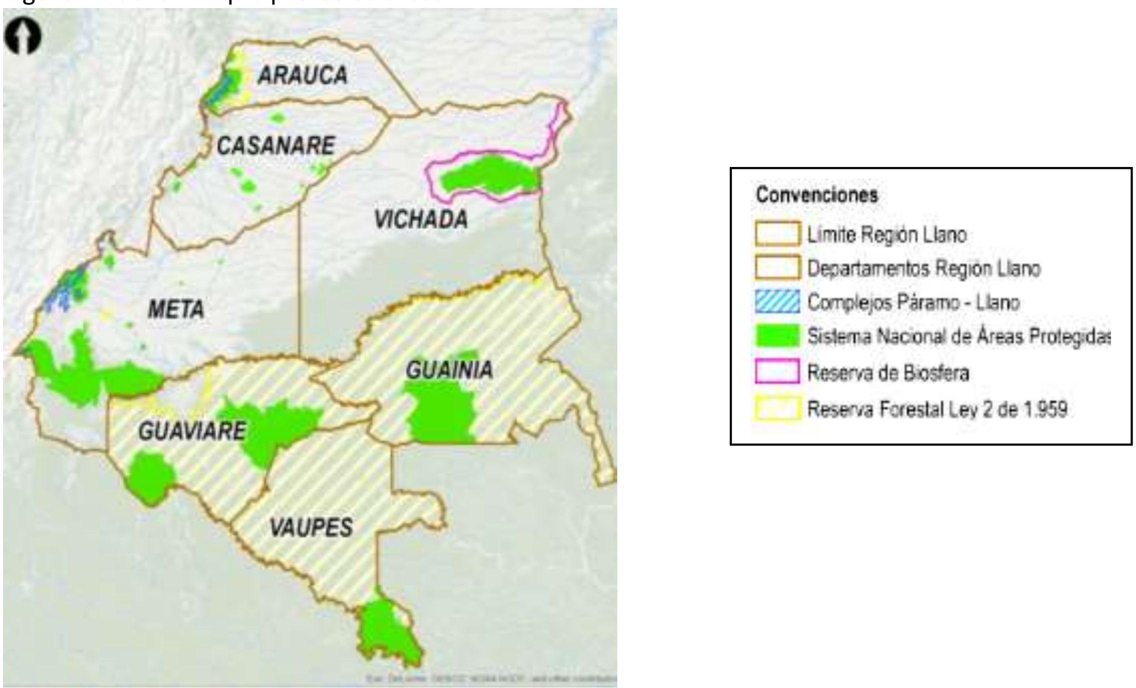
Plan, municipal policies do not apply for their protection and conservation, which has fostered the invasion of these areas. Such is the case with Cerro del Vita and the Guiana Shield formation (Photograph 49 and Photograph 50) which surround the town. Table 4.143 identifies the areas and the Municipal Agreements and Figure 4.230 shows the group of conservation areas at a municipal level.

Table 4.143: Ecological reserve areas per Municipal Agreement.

NAME OF PUERTO CARREÑO AREA	MUNICIPAL AGREEMENT
La Playa Tourism Reserve	Agreement 016 issued March 9, 1995
El Tiestero Tourism Reserve	Agreement 013 issued March 8, 1995
El Cerro del Vita Ecological Reserve, Botanical Garden area, Germplasm Bank and archaeological zone	Agreement 021 issued June 18, 1996
Guiana Shield Outcrop. Cultural and Landscape Heritage	Agreement 011 / 1998

Source: Puerto Carreño Municipal Development Plan, 2016-2019

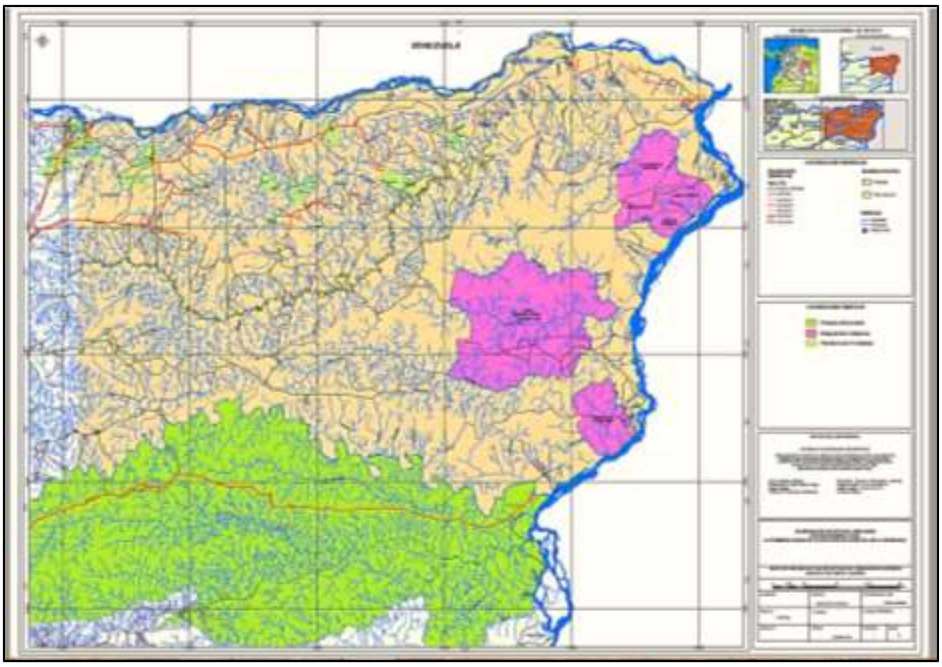
Figure 4.230: Orinoquia protected areas.



Source: Orinoquia Master Plan. DNP (2016).

Figure 4.231 shows the indigenous reservations identified in Puerto Carreño, the area of El Tuparro Park and the Plantation areas of Forestal de la Orinquia.

Figure 4.231: Indigenous reservations in Puerto Carreño and protected areas.



Source: SIG Advisory group, 2017

Photograph 49: Rocky outcrops of Guiana Shield – Puerto Carreño

Source: Advisory group, 2017

Photograph 50: Inhabited rock outcrops in Puerto Carreño

Source: Advisory group, 2017

Productive processes

Agriculture in the area of indirect influence

From ancient times, Puerto Carreño's economic potential has focused on agricultural and cattle farming production, planted forests and border trading. According to the "*Somos Todos*" 2016-2019 National Development Plan, the municipality has been displaying its great economic potential based on agricultural and cattle farming production and forest exploitation. Products such as savanna rice, corn, cassava, plantain and cotton are grown, consumed locally and sold along with cattle. The plateau has a significant potential for expanding crop areas and for human occupation. However, the Conpes (3797) has highlighted the area's low land productivity by hectare, high production costs, the incipient development of scale economies and the absence of technological packages as stumbling blocks in the path to competitiveness, especially for small local producers.

In spite of the difficult conditions, we observed that there is an increasing amount of areas planted in Puerto Carreño with products sold in local and foreign markets. It has been estimated that over 4,428 tons of food were produced in 2016 from among the main produce, considering the areas planted. Table 4.144 shows the agricultural base of Puerto Carreño comparing 2010 and 2016 for the main agricultural produce, planted areas and production:

Table 4.144: Agricultural base 2010-2016. Main products from Puerto Carreño

CROP	PERIOD	PLANTED AREA HECTARES	PRODUCTION (T)
Traditional corn	2010 A	100	110
	2010 B	150	140
Watermelon	2010 A	40	114
	2010 B	45	120
Cotton	2010 B	164	494
Plantain	2010	40	260
Cassava	2010	40	300
Subtotal		579	1538
Crop	Period	Planted area hectares	Production (t)
Traditional corn	2016 A	150	365
	2016 B	182	292
Watermelon	2016B	26	80
Cashew	2016	2000	2720
Plantain	2016	47	252
Cassava	2016	60	720
Subtotal		2465	4429

Source: Prepared based on the 2010-2017 national agricultural base. Ministry of Agriculture.

When comparing the figures of planted areas and production, there is a rise in agricultural production resulting from the increasing presence of cashew crops and of the areas used to plant traditional products. An area of 2,465 hectares was reported in 2016 as planted, which greatly exceeded the planted area of 2010, which was reported at 579 hectares.

2017 showed a planted area of 3,000 hectares of cashew. The initiative *Mas Marañon Vichada*[103], expects to replace the current volume of almond imports by 2023 (140 tons in 2015). In 2015, 11 tons of almonds were processed from 904 production hectares in Puerto Carreño. According to the "*Mas Marañón Vichada*" project,

[103] Alliance of the Vichada Governorship, Universidad de los Andes and Corpoica.

Puerto Carreño has 15 cashew producers, some of whom started working in 2007 and continue to do so (Table 4.145).

Table 4.145: Cashew-producing companies in Puerto Carreño

COMPANY	FARM	YEAR
La Pedregoza	La Pedregoza	2011
Marañones de la Orinoquia	Pericuara	2013
Nimajay	Nimajay	2006
El Toro	El Toro	-
Agrobiz	El Manantial	2016
Marallanos	Nuevo Horizonte	2001
Canapro	La Sonora	2012
El Diamante	El Diamante	2013
Serranías	Serranías	2008
Carlina Rojas	Santa María de Juriepe	2007
Cafmato S.A	Mariola Kassube	2016
Sadith Bustos y Hilda Ojeda	Sadith Bustos e Hilda Ojeda	2006
Asociación Pequeños Campesinos	Asociación Pequeños Campesinos	-
Leopoldo Albarracín	Leopoldo Albarracín	-

Source: Mas Marañón Vichada. Online: http://www.xn--masmaraonvichada-dub.com/mas-maranon-vichada/contenido-actores

At the regional level, the DNP (2016) calculated that rice and corn crops in Orinoquia exceeded national yields, thus representing an opportunity to supply the internal market and substitute imports. As for cotton crops, an area of 210 hectares was reported in Puerto Carreño in 2011 and later on, in 2015, the report was 150 hectares.

Cattle Farming in Puerto Carreño

The ICA (2017) estimated that Puerto Carreño had an inventory of 24,820 bovines throughout 235 cattle farms, Puerto Carreño being the municipality with the lowest participation in the general total (Table 4.146). Cattle raising is 90% for meat production, while the other 10% has a dual purpose, with breeds such as zebu and brown swiss (PDM, 2016-2019). Nationwide, bovine population is distributed throughout 514,794 properties and encompasses nearly 23,475,022 animals located mainly in Antioquia (11.75%), Córdoba (8.74%) and Casanare (7.93%) (ICA, 2017).

Table 4.146: Bovine census Vichada department, 2017

MUNICIPALITY	TOTAL BOVINES 2017	TOTAL BOVINE FARMS – 2017
Puerto Carreño	24,820	235
Cumaribo	38,989	385
La Primavera	130,960	660
Santa Rosalia	36,915	179
Total Vichada	231,684	1459

Source: ICA, 2017

Vichada's cattle farming sector is characterized by an intensive exploitation system with low added value, since the implementation of technology in the production process is minimal (CORPORINOQUIA, 2012) and each animal uses up to 10 hectares, meaning that use is intensive and there is no proper management of vast areas of the savanna. The raising of minor species (backyard and penned poultry) has become one of the productive sectors with a positive outlook in the region's economy and one of the self-supporting elements of farmers' economy. In Puerto Carreño there are approximately 5,603 animals distributed throughout 13 avian properties and 190 backyard properties (ICA, 2017).

Beekeeping activities

Finally, we have included beekeeping activities in Vichada, due to their relationship with planted woods, as an activity that has a positive impact on the environment and can be linked to forest plantations (Castro-Mercado, et al., 2016). In Vichada, beekeeping activities produced 16 tons of *Apis mellifera* honey in 2015 from beekeepers on acacia tree plantations, exceeding the production of departments with greater experience such as Arauca, San Andrés, La Guajira and Vaupés (Castro, et al., 2016). Among the forestry companies that have implemented this practice are: Ecoforestal, La Paz, Inverbosques, Unión Temporal Horizonte Verde, Canapro, Refuturo and La Pedregosa (Universidad Nacional, 2016).

As published by Castro-Mercado (2016), in 2016 the plantations in Vichada had 1592 beehives, which involved professionals and indigenous peoples, as well as organizations such as Fundación Mujeres Vichadenses en Acción. This organization was established in 2014 and works with women who have been victims of forced displacement, are heads of households or are impoverished, who process products such as Acacia honey, honey candy, hibiscus flower wine and mead. The idea is that over time the plantations and native woods of Vichada will produce up to 3632 tons of honey/year averaging 30 kg per hive/year. (Photograph 51 and Photograph 52).

Photograph 51: Hibiscus flower wine and mead.

Source: MUVEA website, 2017[104]

Photograph 52: Apiaries on plantations in Vichada.

[104] Online: https://www.facebook.com/muveacolombia/photos/a.621968054638159.1073741829.514320205402945/686610601507237/?type=3&theater

Source: Unimedios. UN News Agency, 2016[105]

Forestry sector at a national level

At a national level the forestry sector's contribution to the agricultural and cattle farming GDP is 5.5% and according to the UPRA's zoning study of Colombia, circa 7,258,000 hectares are highly suitable for forest plantations (MINAGRICULTURA, 2017). The departments of Antioquia (96,000 hectares), Vichada and Córdoba, represent 51% of the total planted area in the country, calculating that the planted area increased from 391,974 hectares in 2012 to 470,000[106] hectares in 2017 with a forecasted production of 2,350,000 (m3) (MINAGRICULTURA, 2017), thus growing from 8,000 to 20,000 hectares per year.

The area suitable for the commercial forest plantations in Colombia has been estimated at 24.8 million hectares and only 1.2% contains this type of plantation (UPRA, 2017). Over the last 18 years the annual average net rate of commercial reforestation reached 9500 hectares, way below the 60,000 hectares a year required to achieve the goal set by the 2000 National Forestry Development Plan, which foresaw the creation of a mass of 1.5 million hectares of new forest plantations by 2025 (UPRA, 2016).

Forestry Sector in Puerto Carreño

As a productive system, forest plantations in Vichada started appearing in the 70s and, as of 2007, the department began to stand out as an agricultural and forestry development hub (Fundación Etnollano, 2013). In Vichada the plantations are mainly found in the municipalities of La Primavera and Puerto Carreño, calculating that Puerto Carreño has 29,930 hectares planted with trees (Castro-Mercado et al., 2016) (Table 4.147) and the potential use of land for forestry activities amounts to 302,478 hectares, corresponding to 52% of the total potential area. (Universidad del Norte, 2013).

This figure (29,930 hectares) contrasts with that presented in the Puerto Carreño 2016-2019 Municipal Development Plan, which calculated the existence of 48,400 hectares planted with tree species by 2014, indicating that there is no accurate and easily accessible forestry data, which in turn influences the development of municipal and departmental forestry-related policies focused on the productive chain. In addition, there are no statistics on tree plantation areas commercially established and grown each year in the country and the total area currently planted in Colombia is unknown (UPRA, 2016). (Table 4.148).

Table 4.147: Hectares with commercial plantations – Dept. of Vichada

[105] Universidad Nacional, Unimedios (2016). Miel del Vichada, rica en antioxidantes.
Online: http://agenciadenoticias.unal.edu.co/detalle/article/miel-del-vichada-rica-en-antioxidantes.html
[106] In Chile an area of 2.8 million hectares planted was calculated in 2011. Taken from: World Bank (2015). Colombia: Potential for commercial reforestation. Diagnosis.

MUNICIPALITY	PLANTED AREAS IN HECTARES
Puerto Carrreño	29,930
Cumaribo	6,300
La Primavera	36,600
Total Vichada	72,830

Source: AGAF (2016) quoted by Castro-Mercado et al., (2016)

Table 4.148: Tree species and planted areas

Puerto Carreño Municipality 2014	
PLANTED SPECIES (COMMON NAME)	PLANTED AREA
Acacia	22,000
Eucalypt	20,000
Rubber	1,200
Pine	5,200
Total Puerto Carreño	48,400

Source: Municipal Development Plan 2016-2019

Table 4.149 shows the list of planted areas by company in the Orinoquia and the species group as of February 2016.

Table 4.149: List of planted areas by company in Orinoquia and species group (February 2016)

COMPANY	MUNICIPALITY/DEPARTMENT	SPECIES	PLANTED AREA (HECTARES)	REMARK
Centro de investigaciones Las Gaviotas	Vichada	*Pinus caribaea*	8.000	Non-sawable wood given that it is mainly used for resin.
Campo Capital	San Martin, Meta	*Eucalyptus pellita, E. urograndis, E. urophylla.*	4.300	Projected to 10,000 hectares by the end of the project's 2018-2019 Horizon
Horizonte Verde	Puerto Carreño , Vichada	*Eucalyptus tereticornis, E. pellita; 1119 en mangium*	2.732	Forecasted to reach 3,000 by 2016
Equiforest	Vichada	No Information	975	Different trials and species. Not operational.
Aldea Forestal	Primavera, Vichada	No Information	3,400	
Proyectos Forestales La Primavera	Primavera, Vichada	*Pinus caribaea, Acacia mangium, Eucalyptus pellita*	32,000	No field verification.

COMPANY	MUNICIPALITY/DEPARTMENT	SPECIES	PLANTED AREA (HECTARES)	REMARK
Forestal de la Orinoquia	Puerto Carreño, Vichada	*Acacia mangium, Eucalyptus pellita*	5,200	
Inverbosques	Puerto Carreño, Vichada	*Acacia mangium, Eucalyptus pellita, urograndis*	7,875	
Reforestadora La Paz	Puerto Carreño, Vichada	*Acacia mangium, Eucalyptus pellita, Pinus caribaea*	3,000	
Rancho Victoria	Puerto López, Meta	*Acacia mangium, Eucalyptus pellita, Pinus caribaea*	1,117	
Ecologic S.A.S.	Puerto Gaitán, Meta	*Pinus caribaea, eucalyptus pellita.*	200	
Forestal El Vergel	Meta	No Information	723	
Instituto Financiero del Casanare	Yopal, Casanare	No Information	1,860	
Canapro forestal Ganadores del premio emprender paz, 2016.	Puerto Carreño, Vichada	*Acacia mangium,* Caucho natural	1,250	Casa Nacional del Profesor –Canapro is a cooperative that brings together over 30 thousand teachers providing them with savings, loans and welfare options. It decided to implement sustainable productive projects.
Reforestadora Dages	Puerto Carreño, Vichada	*Acacia mangium, Pino Caribeño*	No Information	Located in the Aceitico Police Precinct
Total Orinoquia region			72,632	

Source: Nieto, 2016. *Online: http://www.emprenderpaz.org/node/169

SD: no data

The Colombian forestry sector created in 2005 approximately 57,615 jobs (47,500 in forestry and 10,115 in wood transformation), representing 1.7% of the jobs created in the agricultural and cattle farming and the agroindustrial sector (Nieto, 2016). The Ministry of Agriculture has estimated that the jobs created by this activity are generated in the establishment phase, considering that 1 planted hectare requires 4 direct jobs, while the maintenance phase only creates 1 job per 11 hectares. In 2016, 140,583 direct and indirect jobs were created nationwide (MINAGRICULTURA, 2017 thus positively impacting the urban and rural job market.

Wood from tree plantations still has a modest participation in the national production, estimating that the production of wood from Colombian tree plantations in the national production went from a 25% average during the 1995-1997 period to a 50% average during the 2010-2013 period. (UPRA, 2016).

<u>Mining sector in the capital of Vichada</u>

Mining production in the department of Vichada mainly takes place in Cumaribo and Puerto Carreño, the latter producing tin, niobium, wolfram and black sands, which combined represent a 38.7% contribution of the department to the national production of these natural resources (2012 period to the first quarter of 2017). Construction materials are also produced in Puerto Carreño and Santa Rosalía, with a 0.01% representation in the national total (National Mining Agency, 2017).

As of May 2017, the Colombian mining cadastre reported 10 valid mining titles, representing an area of 8,644.39 hectares, corresponding to 0.09% overlapping in the department, 1 of which is for exploration and the other nine for exploitation. There are also 3 contract proposals and temporary authorization applications for coltan. According to UMATA (2017), large mining areas have not been identified in Puerto Carreño, there being only one concession contract to exploit the river sands. However, informal exploitation of construction materials for housing without any mining title currently occurs in the municipality.

To date there are no hydrocarbon exploration or exploitation applications in Puerto Carreño. The main projects of this type are currently located in the Santa Rosalia, Cumaribo and Primavera municipalities, involving companies such as HOCOL, TALISMAN, GRAN TIERRA, CEPCOLS S.A. and ECOPETROL. (CORPORINOQUIA, 2012, ANLA).

<u>Tertiary sector: trade and services in Puerto Carreño</u>

Seven hundred thirty trade and services establishments have been reported in Puerto Carreño in 2017, according to information provided by the Municipal Secretary of Finance for this study (Table 4.150 and Table 4.151) (Schedule. List of establishments). There are also many organizations and associations, the main office of most of them in Bogotá, Villavicencio and Barrancabermeja, among them:

- Fundación de Mujeres Vichadenses, which works with women who have been victims of violence and poverty, in the production of honey and its byproducts.
- Asociación Gremial Agroforestal Vichadense AGAF, which works with agroforestry producers in Puerto Carreño.
- Fundación Omacha, whose work is focused on environmental projects in the Bojanawi Reservation.
- Asociación de Productores de Marañones del Vichada – ASOMARVI, along with the associative company MARALLANO.
- ASORINOQUIA, a private entity created by entrepreneurs who work in the entire Orinoquia region.

Commercial activities including hotels, restaurants, shops, trading companies, and entertainment services are the most widespread in the capital.

Table 4.150: Main trade and service establishments - Puerto Carreño, 2017

NAME	TRADE AND SERVICE ESTABLISHMENTS
Agrochemicals	6
Banks	6
Hotels	15
Restaurants	29
Hardware shops	5
Plant nurseries	1
Shops	16
Auto repair shops	9
Bakeries and supermarkets	8
Trading companies and warehouses	10
Office supply stores	10

Source: Municipal Secretary of Finance, 2017

Table 4.151: Organizations reported in Puerto Carreño

NAME	SERVICE ESTABLISHMENTS
Associations -ASOCIACION DE CONFECCIONISTAS DEL VICHADA -ALFAGAVI (ASOCIACION FORESTADORA) -EMPRESA ASOCIATIVA DE TRABANO DISEÑO Y CONFECCIONES VICHADA -ASOCIACION DE ARTESANOS DEL VICHADA	4
Reforestation companies -Reforestadora LA PAZ -Reforestadora DAGES S.A.S -ALFAGAVI (ASOCIACION FORESTADORA)	3
Engineering services -CESMA LTDA (CESMA INGENIERIA LIMITADA) -PRIAR PROYECTOS INGENIERIA Y ARQUITECTURA S.A.S (CONSORTIUM) -UNINGECOL S.A. -ITANSUCA PROYECTOS DE INGENIERIA S.A.S -INGENIERO CIVILES Y ARQUITECTOS CONSTRUCTORES ICIARCO S.A.S -INGECOPER LTDA -INGENIERIA STRYCON S.A.S -GRECON INGENIEROS S.A.S -GEOINGENIERIA S.A.S -K2 INGENIERA S.A.S	11
Consultancy -CGA LTA (CONSULTORIA GEOLOGICA Y AMBIENTAL LTDA) -COMPAÑÍA DE CONSULTORIA AMBIENTAL LTDA -YARIMTIA LEC BUILD Y CONSULT S.A.S	3

NAME	SERVICE ESTABLISHMENTS
Local companies -EMPRESA COLOMBIANA DE PROCESOS TECNOLOGICOS Y COMUNICACIONES -EMPRESA UNION DE CAUCHEROS DEL VICHADA E.A.T -EMPRESA CAUCHEROS DEL JURIEPE E.A.T. -Consorcio Beta Oil -Interbosque -ECOPETROL S.A.	6

Source: Municipal Finance Secretariat, 2017

Product purchase and sale activities are related to small shops (Photograph 53), while hotel and restaurant services are based on Tourism, which could be boosted with the natural conditions and the beauty of the landscape in this region.

Photograph 53: Shops – Puerto Carreño

Source: Advisory Group, 2017

As for the trade balance, exports from Vichada in 2016 were $ 0 million. (MinCIT, 2017). In this regard, the Office of the Governor of Vichada has stated that this situation reflects a phenomenon that is inherent to border departments, where foreign trade, mainly with Venezuela, takes place informally. In 2007, the Colombian Orinoquía accounted for 80% of the total national exports of ornamental fish (Office of the Governor of Vichada, 2009). However, this type of figure is not taken into account. Minerals such as niobium and tin were exported in 2014 and 2015. As for imports, iron pipes and manufactures were imported from China in 2016. (MinCIT, 2017). (Table 4.152).

Table 4.152: Trade Balance Vichada and Colombia

VARIABLES & INDICATORS	COLOMBIA	VICHADA
GDP per capita 2015	U$5,800	U$2,028
Exports per capita 2016	U$637.9	U$0
Imports per capita 2016	U$ 920.8	U$ 6.4

Source: MinCIT, 2017

Job market in Puerto Carreño

In this section we will use as reference the DANE's Technical Newsletter of April 2017, which provides data on the new departments created under the Constitution of 1991, namely Amazonas, Arauca, Casanare, Guainía, Guaviare, Putumayo, Vaupés and Vichada. The total unemployment rate for 2016 in the 8 capital cities of the new departments was 12% and the occupation rate was 59.7%. [107]

Puerto Carreño's job market showed the highest unemployment rate from among all capital cities in 2016, with 18.5%, a 7 point increase compared to 2015, trailed by Arauca. This reality is mainly due to the difficult border relations, the absence of new companies to create jobs in the region, and the low professional education of its inhabitants, which does not foster the establishment of new entrepreneurial initiatives. Figure 4.232.

Figure 4.232: Job market indicators. Total capital cities new departments.

Source: DANE (2017).

The job market in the region according to DANE (2017) is linked to the economic activities of trade, hotels and restaurants (35.6%), community, social and personal services (28.3%), construction (10.8), while the percentage of people occupied in agriculture, cattle farming, hunting and forestry activities only accounts for 3.5% of the 157 thousand total occupied inhabitants of the region. In spite of the foregoing, the sectors that showed the largest growth compared to 2015 were agriculture, cattle farming, hunting and forestry, which increased 19.7%.

In addition to agricultural and cattle farming activities, the working-age population is also employed in transportation and trading activities, either by land or river, to the distribution centers. Cattle ar e generally transported by land and the main distribution centers for trade in the region are located in Puerto Carreño, Yopal and Villavicencio. Self-employed workers, construction workers and privately-hired employees were the occupational positions representing the greatest participation among the occupied population with a combined figure of 78.4% (DANE, 2017).

Private, public and/or community programs or projects scheduled or under way, whose registration and knowledge of their characteristics is relevant to the development of the project.

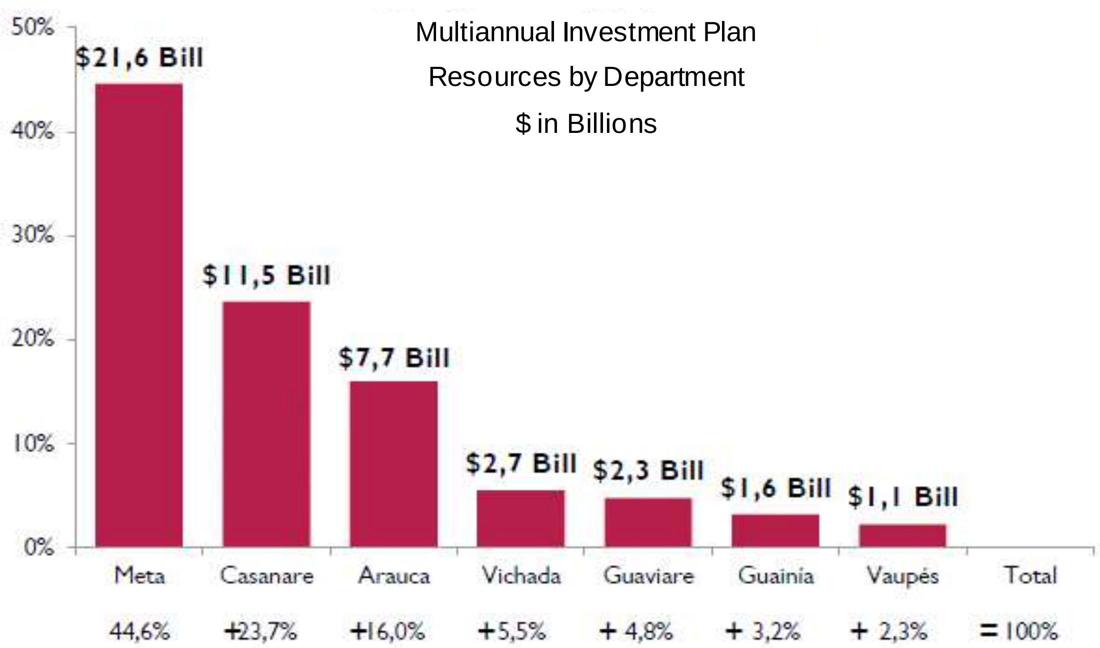
National Development Plan, 2014-2018

The 2014 – 2018 National Development Plan designated the Orinoquia region as a protection zone for the environment, agroindustry and human development, whose institutional stre ngthening, organizational and planning instrument is set out in the Orinoquia Master Plan (DNP, 2016). This plan includes 7 departments (Arauca, Casanare, Vichada, Meta, Guaviare, Guainía, Vaupés) and has set a goal of investing 48.5 billion pesos in the Orinoquia region in 2015-2018, 5.5% of which, amounting to 2.7 billion, would be allocated to Vichada

[107] The occupation rate is the percentage ratio between the occupied population (OC) and the number of people making up the working-age population (PET).

during this period. Figure 4.233 shows the estimated investments for this area separated by department, in which Vichada ranks fourth.

Figure 4.233: Multiannual investment plan by department



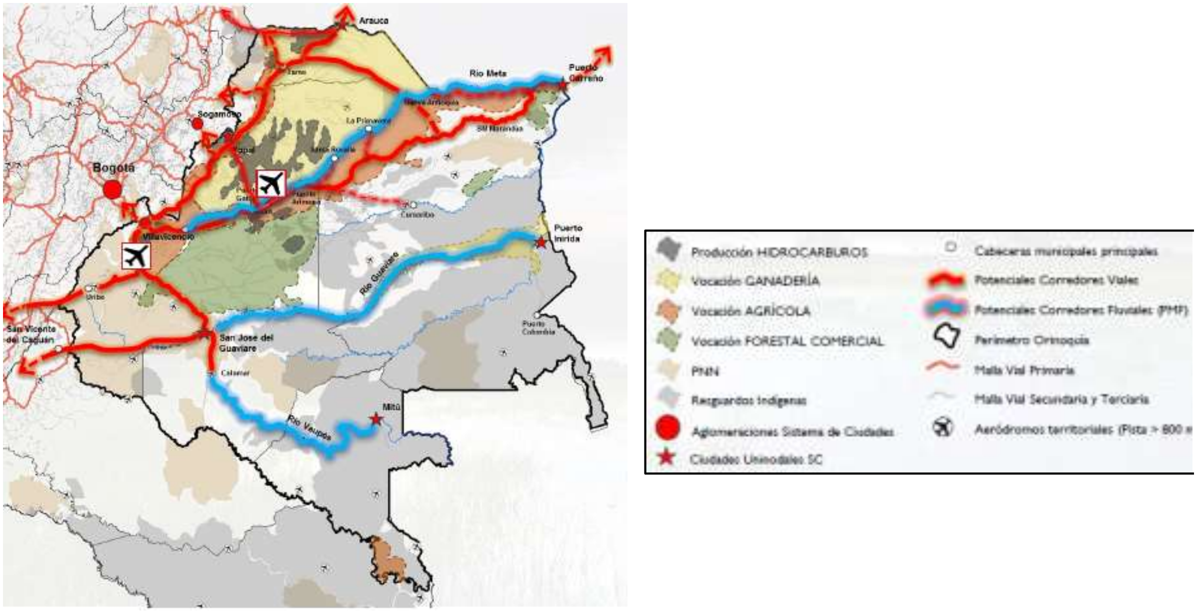
Source: Orinoquia Master Plan. DNP (2016).

The policy elements taken into account for public investment under the plan include: competitiveness and strategic infrastructure with 43.6% of the total investment, social mobility (30.7%), transformation of the countryside (0.5%), security, justice for peace (3.5%) and sustainable growth (0.9%) and good governance. The 4 priorities that bring legal security and investment conditions are: sustainable productive development, water resources and the environment, infrastructure and logistics, and land management plan.

Regarding transportation – Orinoquia Master Plan (DNP, 2016) includes:

- Roads: The potential Orinoquía network (improved and new roads) is over 1800 km long, which exceeds all projects of the second 4G phase.
- Rivers: The navigability potential of the Orinoquía is 2700 km, which is over twice the navigable length of the Magdalena River.

Figure 4.234: Long-term milestones for Transportation in the Orinoquia.



Source: Orinoquia Master Plan. DNP (2016).

- Puente Arimena– Puerto Carreño Road: studies to December 2017.
- La Macarena Through-road: Baraya – Colombia-La Uribe- Mesetas- San juan de Arama route.
- Construction of the new Puerto Gaitán – Meta airport and studies for a new airport in Villavicencio – Meta

Regarding electricity–Orinoquia Master Plan (DNP, 2016) includes:

- Execution of the Casanare-Vichada (Santa Rosalía-La Primavera) electric interconnection project - Investment: $82 billion
- Execution of the sustainable rural energy supply plan - PERS Orinoquía (Arauca, Vichada, Casanare and Meta) with an investment of $4.541 billion. Identification and structuring of sustainable rural energy projects.

<u>Conpes 3396 / 2005. Strategic projects of the National Roads Institute INVIAS. Recovering of the Meta River's navigability.</u>

According to Conpes 3396, recovering navigability of the Meta River was defined as one of the priorities towards consolidating river transportation in the departments of Meta, Arauca, Casanare and Vichada. The study entitled "Meta River study and design update for navigability between Puerto Texas (k674) and Puerto Carreño (k0)" prepared by INVIAS under the responsibility of Universidad del Norte was published in 2013.

<u>Social infrastructure and habitat projects (Social prosperity, 2017)</u>

Improving housing in Puerto Carreño, Vichada department (procurement process about to start).

<u>Intermodal transportation master Plan</u>

Studies for the construction of a new road corridor connecting the departments of Vichada and Meta for a total of 22.400 billion pesos. The study must be submitted in December 2017. The designs were commissioned to Consorcio Interventoría Conexión Puente Arimena.

Puerto Carreño municipal planning projects

According to information provided by Municipal Planning, there are currently 28 projects that have been completed and are under way in 2017, as well as 4 in the formulation phase. Attached is the list of projects and report.

Revision of public policies included in the Municipal Development Plans

Puerto Carreño Municipal Development Plans, 2016-2019

The PDM proposes various components and a group of sectors made up of programs which could lead to a process with a view to improving the quality of life and the socioeconomic and environmental conditions of the rural and urban communities of Puerto Carreño. Considering the foregoing, these programs could constitute the basis for social management and the baseline for potential tripartite support (companies, mayor's office and communities) in the areas of influence. Below are the main components and programs of the Development Program:

Socioeconomic component

Educational sector

1. Program for the Construction, Extension and Adjustments to educational infrastructure for Peace.
2. Program – Maintenance of Educational Infrastructure.
3. Program – Institutional Provision of Educational Infrastructure.
4. Program – Institutional Provision of Teaching Material and Means for Learning within the Peace framework.
5. Program – School Meals
6. Program – School Transportation
7. Program – Quality – Cost-Free Status

Healthcare sector

1. Healthcare coverage assurance, sustainability and extension.
2. Public Health Program
3. Environmental Health Dimension
4. Public Health Management Dimension – Strengthening of Health Authority.
5. Public Health Dimension in Emergencies and Disasters
6. Vulnerable Population Differentiated Management Cross-cutting Dimension

Drinking water and basic sanitation sector

1. Program – Puerto Carreño with greater coverage and improved Water Supply, Sewerage and Garbage Collection. This program aims at covering the basic needs relating to coverage and improving the provision of the Water Supply, Sewerage and Garbage Collection public utilities in the city of Puerto Carreño and each of the rural police precincts of the municipality concerning water supply and garbage collection.

Cultural sector

1. Program – Foster, support and disseminate artistic and cultural manifestations and events.
2. Program –Historical Memory and Cultural Heritage Protection.
3. Program – Construction of Artistic and Cultural Infrastructure for Peace.
4. Program – Maintenance and Adaptation of Artistic and Cultural Infrastructure.

5. Program – Maintenance and Supplies for Libraries.
6. Program – Municipal Cultural Facilitators and Creators with Social Security.

Housing Sector

1. Program – Prioritized Government-Subsidized Housing (VIP, in Spanish) Financing and Co-financing programs.
2. Program- Housing Improvement and Basic Sanitation Financing and Co-financing.
3. Program – Government Subsidized Housing (VIS) Financing and Co-financing on owned lands.
4. Program – Plans and projects for purchase and/or construction of housing "Puerto Carreño Sin Invasiones".

Care for vulnerable groups – social promotion sector

1. Adaptation of infrastructure to provide care to Infants, Children and Adolescents.
2. Program – Care of and support to victims.
3. Program – Care of and support to Reintegrated Populations or undergoing Peace Processes.
4. Program – Care of and support to Indigenous Groups in Investment Projects.
5. Program – National Programs -Red Unidos – Mas Familias en Acción - Financing and Co-financing.

Economic sector

Development promotion sector

1. Program – Puerto Carreño fosters the Promotion of Associations and Alliances for Entrepreneurial Development.
2. Program – Puerto Carreño Somos Todos with technical assistance for production, distribution and sales processes and access to financing sources.
3. Program – Puerto Carreño committed to the promotion of tourism development
4. Program – Educational Fund for Higher Education.

Agricultural and cattle farming sector

1. Program – Construction and maintenance of land irrigation and preparation systems towards a more competitive countryside.
2. Program – Direct Rural Agricultural and Cattle Farming Technical Assistance Project.
3. Program – Financing of rural area development programs.

Transportation sector

1. Program – Construction of Roads for peace.
2. Program – Road improvement.

Differentiated public utilities sector

1. Program – Construction, Adaptation and Maintenance of Public Utilities Infrastructure. The goal is to ensure the provision of electricity and public lighting services through strategic agreements for the exploitation and use of alternative energies in the precincts and urban areas of the municipality, along with the construction and maintenance of the existing public lighting network.
2. Program – Alternative Electrification Works in the Rural Areas of the Precincts, Indigenous Communities and Disperse Rural Population.

Community Development Sector

1. Program – Training, advice and technical assistance to consolidate citizen participation and social control processes.

Institutional Strengthening Sector

1. Program – Update of SISBEN Puerto Carreño Somos Todos.
2. Program – Socioeconomic stratification.
3. Program – Cadastral update. Purpose: join efforts with other regional and national entities to update the municipal cadastre and acquire the technological tools that will allow enhancing the information and ensuring the collection of property taxes.
4. Program – Preparation and Update of the Land Management Scheme [*Esquema de Ordenamiento Territorial*] (EOT)

Environmental Sector

1. Program – Conservation, Protection, Restoration and Exploitation of Natural Resources and the Environment.
2. Program – Informal Environmental Education – Active and participative community – Environmental education for all.

Development Hubs

The department of Vichada is strategically relevant towards achieving environmental balance and sustainability in the country and in the world. The sustainable exploitation of natural resources and biodiversity is an option for economic competitiveness that would enable the introduction of sustainable markets and fair trade alternatives, with the acknowledgement of the indigenous culture and reservations (Molano, 2016). Likewise, the forests' biological potential would become an incentive to leave behind social precariousness and strengthen infrastructure for trade, which is currently disjointed from the local natural conditions, such as the roads to and from the department, which collapse during the rainy season (De Lisio, et al., 2016).

The department's location on the basin of the Meta river and Puerto Carreño's port facilities, considering the multimodal connection with the Orinoco river to access the markets of Venezuela and Brazil, have significant potential towards structuring a more dynamic and sustainable economy for the department (Molano, 2016).

For many years the lands of Vichada were classified as not suitable for agriculture due to their high acidity; however, current investment projects had proven that it is essential to reclassify the use of the land in accordance with its true capacities. The Strategic Plan for Science, Technology and Innovation of the Department of Vichada 2012-202 states that there are 30 hectares of *Jatropha curcas* and 160 hectares of Cacay growing in Santa Rosalía; in Puerto Carreño, la Primavera and el Marañón, there are 400 hectares of rubber and 3050 hectares of timber that could contribute to the regional GDP once production has started.

This plan also takes into account that in order to manage the critical demands of the department's critical social and economic situation, the following population and territorial issues must be addressed:

1. Reduce the unsatisfied basic needs of the households.
2. Improve regional competitiveness factors (ICR).
3.

4. Develop the territory's environmental sustainability factors.

4.4.5.2 Area of Direct Influence

4.4.5.2.1 Venturosa and Aceitico Police Precincts

Considering that there are few socioeconomic studies and diagnoses in the area of influence, the methodology to gather primary information by applying socioeconomic description data sheets was implemented, supplemented by 9 case studies, which will be used to place the area into context, as well as using secondary information.

Ownership structure and land use in Venturosa and Aceitico

The area of influence encompasses a total estimate of 100 homes occupied by families whose main economic activities are cattle farming, agriculture, day labor and formal jobs in forestry companies. For instance, in Aceitico, the leaders have identified, along with the homes, 45 cattle farms in their jurisdiction, 14 of which have no home, while in Venturosa there are 22 farms. Land holding in the area of direct influence is mainly exercised under the legal form of private property. However, due to the fact that Vichada's cadastral formation has fallen behind, most properties have no titles or the owners appear as holders.

Ownership is concentrated in the hands of a few farmers whose extension limit according to the UAF is 1200 hectares, which creates a close link to the high index of use of land in pastures for cattle grazing. This situation does not invalidate land holding for cattle farming, but there is, however, the need to implement cattle farming practices that will use the land more intensively and create more jobs, along with the proper management of the savanna by implementing forest grazing systems.

Based on the social mapping exercise carried out with the support of the communities in the area of direct influence, it was possible to calculate the area of each of the precincts. Even though this is not official data, it will allow identifying the land uses and occupation of the area's territory. Table 4.153.

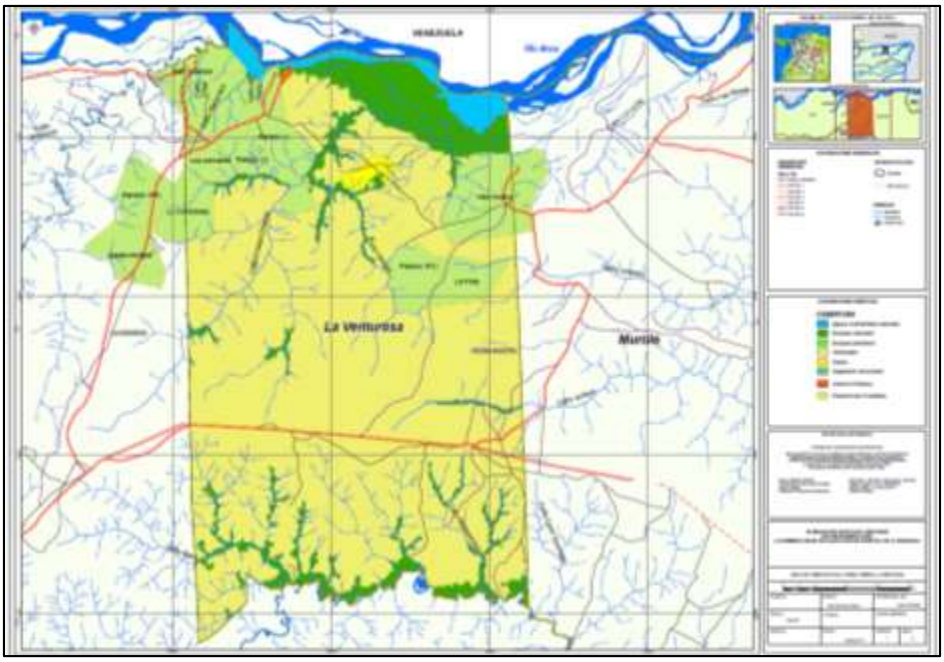
Table 4.153: Territorial areas according to information obtained in the field.

PRECINCT	AREA IN HECTARES
Venturosa	68.160.1
Aceitico	221.853.6
Total	290.013.7

Source: SIG Advisory group, with data from IGAC, 2017

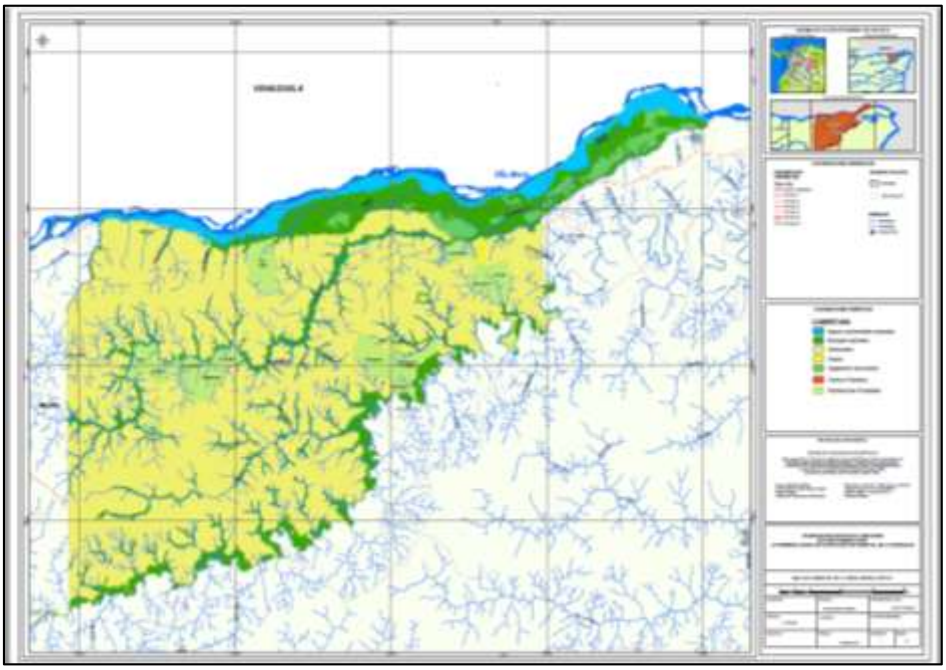
With data from IGAC and the social mapping (with territorial limits) it was possible to construct the land use map for Venturosa and Aceitico. Figure 4.235 and Figure 4.236.

Figure 4.235: Land use map- La Venturosa.



Source: SIG Advisory group with data from IGAC, 2017

Figure 4.236: Land use map - Aceitico



Source: SIG Advisory group with data from IGAC, 2017

It was determined that there are over 68,000 hectares of land in La Venturosa, 11.9% of which are natural forests, while in Aceitico this figure amounts to 18.5%, with over 41 thousand hectares of natural forests located mainly on the banks of Bita and Meta rivers, thus constituting important relicts to be protected. The grasslands in these territories account for a total of 234,369.65 hectares. These include both natural and man-made covers created for maintaining cattle herds, possibly in floodable soils, as this area is part of the Meta, Bita and Orinoco river compounds, which are subject to burnings and floods. As already mentioned in the section on land use and capacity in Orinoquia, it is possible that these ecosystems were transformed without considering their true capacity. (Table 4.154, Table 4.155 and Photograph 54).

Table 4.154: Land use by vegetation cover – La Venturosa

Coverage	Area (has)	%
Natural forests	8,1001.66	11.9
Planted forests	111.51	0.2
Grasslands	58,935.74	86.5
Grass	1,011.11	1.5
Total	68,160.01	100

Source: SIG Advisory group with data from IGAC, 2017

Table 4.155: Land use by vegetation cover – Aceitico

Coverage	Area (has)	%
Natural forests	41,020.97	18.5
Grasslands	175,433.92	79.1
Grass	164.21	0.1
Secondary vegetation	5,234.53	2.4
Total	221,853.63	100

Source: SIG Advisory group with data from IGAC, 2017

Photograph 54: Cattle farming in the area of direct influence.

Source: Advisory group, 2017

4.4.5.2.2 Productive and technological processes

Cattle farming in Venturosa and Aceitico

The main economic activity in the area of direct influence is bovine cattle farming, having identified a total herd of 6,504 head of cattle (ICA Puerto Carreño, 2017). In Venturosa it has been estimated that there are 4,592 head of cattle (in 32 farms) with an 8 to 10 hectare requirement per head, assuming that there are 45,000 hectares for cattle, while in Aceitico there are 1,912 head of cattle (in 31 farms) (ICA Puerto Carreño, 2017). Given the characteristics of the territorial units, it is possible to identify the livestock exploitation model in place. In this model, the farms adjust to the cattle farming production, in which labor depends on the owner or administrator, who is responsible for hiring the day laborers in the area, along with an important percentage of family laborers as well, also implementing a few areas for agricultural production for on-farm consumption. Photograph 55.

Photograph 55: Cattle farming activities in the area of direct influence.

Source: Advisory group, 2017

Cattle farming production in Aceitico and Venturosa targets sales, which are negotiated by making visual estimates of the animal, which is then sold alive. The livestock is transported by the buyer to Puerto Carreño, Puerto López –Meta and Villavicencio mainly. Live cattle cost between $750,000 and $1,000,000 each. The sale is made directly on the farm to the wholesaler, who travels to the place of purchase any time of year. A day laborer in the area of direct influence earns $35.000.

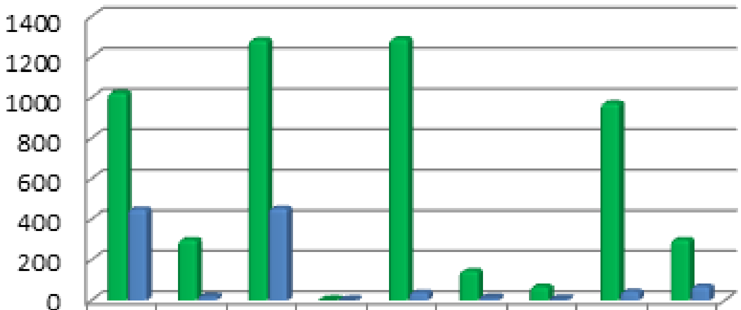
We carried out 9 surveys or case studies in the territorial units, finding the following bovine inventory in properties located in Venturosa and Aceitico. (Table 4.156 and Graph 16). This case inventory quantified more than 5,300 hectares that are used for a bovine population of 1,101 head of cattle, i.e. some areas are sub-utilized mainly due to the investment costs required to increase the number of heads per property. In the case studies, only one property was reported as exploiting beef and milk, as in general the livestock is used to supply the beef markets. The gross value of the cattle (before deducting costs) for the total cases studied is estimated at over one billion pesos.

Table 4.156: Bovine inventory – Case studies

TERRITORIAL UNIT	PROPERTY	HAS	BOVINE POPULATION	GROSS VALUE OF AVERAGE HERD
Venturosa	Ana Betilde	1025	450	450,000,000
	El Portico	300	20	20,000,000
	Hato de Los Merecures	1285	455	455,000,000
	Carmen Atilan	80 mts2	0	0
Aceitico	Aceitico 2	1290	40	40,000,000
	Jayonuanca	146	14	14,000,000
	El Paraíso	69	7	7,000,000
	El Brillante	973	45	45,000,000
	Las Bahamas	300	70	70,000,000
Total		5.388	1.101	1,101,000,000

Source: Case studies. Advisory group, 2017

Graph 16: Bovine inventory – Case studies. Estimates for AID, 2017



	Ana Betilde	El Portico	Hato de los Merecu res	Carmen Atilan	Aceitico 2	Jayonua nca	El Paraíso	El Brillant e	Las Bahama s
Has Predios	1025	300	1285	0	1290	146	69	973	300
Población bovina	430	20	435	0	40	14	7	43	70

Source: Advisory group, 2017

Parallel to bovine cattle there is also the raising of minor species such as fowl and pigs, as well as fishing in the Meta River and creeks adjacent to the precincts. The Muco and Caño Juriepe creeks and the Meta River are places where these ecosystemic services are provided and supplied. The fish caught there is used for on-farm consumption and sometimes for sale, especially in August and October thanks to upstream migration at that time of year. The descent in the water levels leads to fish migrations and turtle nesting in the beaches of rivers and creeks, also allowing for the capture of ornamental fish from November to May. (PDM, 2015-2015).

The fishing operations catch species such as Cachama [*Colossoma macropomum*], Caribe, Yamù [*Brycon amazonicus*], catfish, peacock bass [*Cichla ocellaris*], Permit [*Trachinotus blochii*] and Cocoros, using hooks and fishing nets. It is possible to catch up to 4 kilos on average each day.

Hunting meat consumption in the rural communities

Hunting meat is essential to local sustenance, as it is linked to cultural traditions, the generation of income and food security in the communities (Gómez, et al., 2016). Regionally speaking, hunting meat is consumed and sold in meat retailers during Easter and sold to restaurants and known clients. (Gómez, et al., 2016).

This practice, which is used by farmers, settlers and indigenous peoples in rural areas, where they mainly hunt on their own properties, at water sources or in the savanna, was found in the area of direct influence. Hunting meat is for consumption at the home mainly due to the changing flavors of the meat from animals such as deer, wild hog, turtles and capybara. In general, forestry companies are banned from this practice within the planted areas, as more deer, hare and other species in the planted woods, which are endangered in many parts of Colombia, have been spotted there.

The consumption of hunting meat is a common activity in which parents and children partake using carbines and arrows to gain access to other protein sources and for recreation. (Table 4.157).

Table 4.157: Consumption of hunting meat. Case studies

TERRITORIAL UNIT	PROPERTY	HUNT (SPECIES) / USE AND TECHNOLOGY USED	LOCATION
Venturosa	Ana Betilde	Deer. Greater production year-round. On-farm consumption. Technology, carbine. No permit required	Savanna ecosystems

	Hato de los Merecures	Wild deer and hog. Technology, shotgun and arrows.	Muco and Morichalitos creek banks.
	Carmen Atilan	Guabina turtle. 100% on-farm consumption	Las Viejas creek
Aceitico	Aceitico 2	Capybara. Year-round. Technology, carbine and harpoon.	Meta river islands.
	Jayonuanca	No	NA
	El Paraíso	Capybara. 100% on-farm consumption. No permit required	Savanna ecosystems

Source: Case studies. Advisory group, 2017

<u>Agriculture and consumption of local produce in Venturosa and Aceitico</u>

In order to obtain a close approximation to the production areas and volumes, the socioeconomic description data sheets used in the primary information collection process were used, along with the municipal EVA and surveys among 9 land owners.

The agricultural production model at the Venturosa and Aceitico Police Precincts is based on traditional cultivation methods for on-farm consumption, mainly using family labor. It is estimated that in the ADI there are multiple on-farm consumption crops such as cassava, corn, plantain, rice, watermelon, pineapple, orange, papaya, lettuce and tomato to supplement the family diet. In the properties identified in the case studies, 17.6 hectares are used for crops, which produce 159 tons of food, cassava and plantain being the main products, with 95 and 55 tons produced respectively.

The communities of Venturosa and Aceitico have especially allocated the land to cattle farming and, to a lesser extent, to crops for on-farm consumption, due, among other things, to low soil quality and management, little use of seed banks, high transportation costs and difficult access to market chains, both at a rural and a municipal level. (Table 4.158 and Table 4.159). (Photograph 56).

Table 4.158: Agricultural and cattle farming production in the area of direct influence – Case studies.

TERRITORIAL UNIT	PROPERTY	PRODUCT	AREA HAS	PRODUCTION (T/HAS)
Venturosa	Ana Betilde	Cassava	0.12	1.44
		Plantain	0.13	0.91
	El Pórtico	Plantain	0.25	1.75
		Cassava	0.5	6.00
	Hato de los Merecures	Plantain	4	28.00
		Cassava	0.25	1.75
	Carmen Atilan	Cassava	0.25	1.75
Aceitico	Aceitico 2	Plantain	0.3	2.10
		Cassava	0.5	6.00
	Jayonuanca	Plantain	1	7.00
		Cassava	0.5	6.00
		Sugar Cane	0.25	1.75
	El Paraíso	Plantain	0.25	1.75

TERRITORIAL UNIT	PROPERTY	PRODUCT	AREA HAS	PRODUCTION (T/HAS)
		Cassava	4	48.00
		Pumpkin	0.25	0.50
	El Brillante	Cassava	1	12.00
		Plantain	1	7.00
		Corn	1	1.70
	Las Bahamas	Plantain	1	7.00
		Cassava	0.5	12
		Pineapple	0.64	4.288
Total			17.69	158,69

Source: Case studies. Advisory group, 2017. EVA, 2017

Table 4.159: Product, area and total production in the area of direct influence. – Case studies.

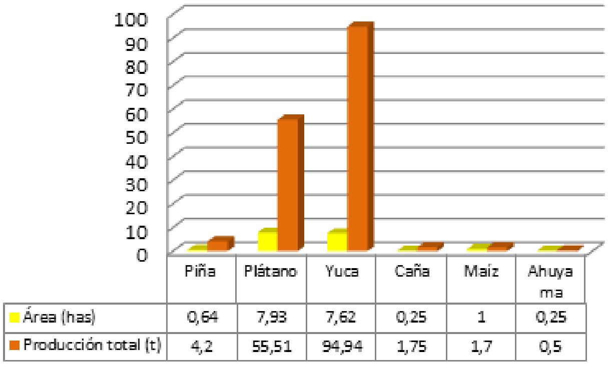
PRODUCT	AREA (HAS)	TOTAL PRODUCTION (T)
Pineapple	0,64	4,2
Plantain	7,93	55,51
Cassava	7,62	94,94
Sugar cane	0,25	1,75
Corn	1	1,7
Pumpkin	0,25	0,5
Total	17,69	158,6

Source: Case studies. Advisory group, 2017

Photograph 56: Papaya plants. Aceitico Precinct

Source: Advisory Group, 2017

Graph 17: Areas for on-farm consumption agriculture and total production.



Source: Case studies. Advisory Group, 2017

Parallel to the use of land for agricultural and cattle farming activities (Photograph 57), the surveyed properties stated that they allocated up to 13.75 hectares to woodland conservation areas, especially on the banks of water sources, with species such as *Caraipa llanorum* which is considered endemic to the Orinoco and Vichada rivers' basins, and its wood is highly appreciated.[108] (Table 4.160).

Photograph 57: Crops at educational institution. Aceitico Police Precinct

Source: Advisory Group, 2017

Table 4.160: Wooded areas and species reported. Case studies.

TERRITORIAL UNIT	PROPERTY	WOODED AREA (HAS)	SPECIES
Venturosa	El Portico	0.5	Acacia
	Hato de los Merecures	3	Sd
Aceitico	Aceitico 2	0.25	Sd
	Las Bahamas	10	Saladillo rojo (*Caraipa llanorum*)
Total		13.75	

Source: Case studies. Advisory group, 2017

[108] Online: http://www.myreforestation.com/espanol/descargas/perfil_saladillo_rojo%20ESP.pdf

As for coca crops in Puerto Carreño and its rural areas, no coca plantations have been reported, but there have been seizures of coca and marihuana. The former is illegally taken to the Venezuelan border to then be transformed into cocaine hydrochloride (MINJUSTICIA, 2013).

4.4.5.2.3 Commercial and Service Activities in Venturosa and Aceitico

There are 13 commercial retail establishments in the precincts. These shops supply the communities with their day-to-day elements and are family-managed. The hotel, restaurant, entertainment sites and butcher shop initiatives are highlighted. (Table 4.161).

Table 4.161: Services sector. Total establishments Venturosa and Aceitico Police Precincts.

SERVICES SECTOR	
Activity	Number
Shops	6
Transportation piers	3
Hotels	2
Restaurants	1
Entertainment sites	3
Butcher shop	1

Source: Advisory group, 2017

Regarding the total number of establishments, it was observed that the Venturosa Precinct has 10 establishments out of the 13. This situation is due to its proximity to forestry company facilities, which not only create jobs in the region, but also consume goods and services. This, in addition to the arrival of families from Venezuela, Casanare and Cumaribo, who travel attracted by employment alternatives and study options for children (21 people arrived in 2017). The opposite occurs in Aceitico, as its settlement dynamics have been affected by human migrations.

According to the social description data sheet, the Aceitico 2014-2015 census reported 305 people, while there are currently only 168 inhabitants, i.e. 137 people have left for places like Puerto Carreño, Meta or the Primavera municipality in Vichada. This migration status is the result of many factors: 1) few job opportunities in the area, 2) the internal violence situation that is still present (2 violent deaths in 2017), 3) low educational coverage, as children can only complete the ninth grade, which means that their parents have to look elsewhere for other opportunities for them, and 4) the economic boom dynamics linked to legal and illegal trade on the border.

Purchase and sale activities are related to small shops or commercial units. Since they must include the cost of transporting the goods by river in the rainy season or during the dry season in their prices, they are forced to transfer these costs to the consumer, which accounts for the significant differences between their prices and those of the market in Puerto Carreño. This situation creates conflicts among the community, which must resort to the markets in the capital and to speedboat traders who travel the Meta River selling their goods at prices that are more accessible to the end consumers, especially homemakers. (Table 4.162).

Table 4.162: Commercial establishments by Police Precinct

PRECINCT	ESTABLISHMENTS	TYPE
Aceitico	1	Shop
	1	Hotel
	1	Entertainment site

Venturosa	5	Shops
	1	Hotel
	1	Restaurant
	2	Entertainment site
	1	Butcher's shop
Total	13	Establishments

Source: Advisory group, 2017

The transportation infrastructure includes 3 piers on the Meta River which are in poor condition, thus leading to the deterioration of the river bank, undermining it with the arrival of the boats. The social infrastructure of the Police Precincts includes: (Table 4.163).

Table 4.163: Socioeconomic infrastructure. Venturosa and Aceitico Precincts

Educational Institutions	Police Stations	Healthcare Facilities	Cemeteries	Church	Landing strip	Coleo Track	Police Precincts	Abandoned construction
2	1	2	1	4	1	2	2	1

Source: Advisory group, 2017

Photograph 58: Commercial units at Police Precincts.

Source: Advisory group, 2017

Photograph 59: Shop. Aceitico Police Precinct.

Source: Advisory group, 2017

4.4.5.2.4 *Job market in Venturosa and Aceitico*

At the territorial units, jobs gravitate around cattle farming, agriculture and to a lesser extent, fishing and own businesses. The men of the Aceitico community mostly engage in economic activities relating to:

1) Growing corn on the plains of the Meta River
2) Work for reforestation companies
3) Employed as school workers
4) Work on cattle farms
5) Fishing
6) Producing cheese to sell in the community or in Puerto Carreño.

Day laborers in the Aceitico Police Precinct are paid $25,000 pesos per workday. Women in this territorial unit are mostly homemakers (90% of them) and the other 10% work for the school or for the company Nutricodes, which is in charge of providing the food to the boarding students at the school.

At Venturosa, the men mostly work in cattle farming, fishing, reforestation companies, and in own businesses such as shops or trade and service establishments. Women, on the other hand, support their husbands at home or in formal jobs at Forestal de la Orinoquia, where approximately 10 women work. Men usually take care of cattle-related tasks, providing their services as day laborers, for which they are paid at rates that range from $25,000 to $35,000 per day of work. This constitutes informal employment that has no continuity over time.

In Aceitico it has been estimated that 42% of the population (66 people) are at an age to enter into an employment contract (between 18 and 65 years old), while in Venturosa this figure is larger: there are 84 people of working age (Table 4.164). This population has mostly completed primary education and in La Venturosa a few people are getting their high school equivalence degree.

Table 4.164: Total working-age population by Precinct

PRECINCT	PEOPLE AGE (18 TO 65)
Aceitico	66
Venturosa	84
Total	150

Source: Advisory group, 2017

During the meetings at the territorial units there were questions regarding access to information regarding both professional and non-professional employment offers. The attendees also stated that the plantations could increase the migration processes, which would increase the population during the production phase. However, they thought this would be beneficial, as there are no new initiatives and enterprises that could improve the offer of activities, as well as of goods and services in the rural areas.

4.4.5.2.5 *Private, public and/or community programs or projects scheduled or under way, whose registration and knowledge of their characteristics is relevant to the development of the project.*

Below are the projects under way and in formulation for the Venturosa and Aceitico Police Precincts, according to information provided by the Puerto Carreño Municipal Planning Office, 2017. (Table 4.165 and Table 4.166).

Table 4.165: Projects under way and in formulation at the Venturosa Precinct

PURPOSE OF THE CONTRACT	CONTRACT PRICE	DOWN PAYMENT $	STARTING DATE	TERM FOR PERFOR MANCE/ DAYS	STATUS
Adaptation of Intelligent Classroom of the La Conquista Educational Institution at La Venturosa Precinct in the Puerto Carreño Municipality –Vichada.	$18,819,016.00	$18,819,016.00	04/04/2017	30	COMPLETED
Inter-administrative agreement to guarantee the continuous supply of electricity in the Urban Zone of the Aceitico, Puerto Murillo and La Venturosa Precincts in the Puerto Carreño Municipality – Vichada.	$50,000,000.00	$25,000,000.00	17/08/2017	90	UNDER WAY
Construction, adaptation and supply of accessories for setting up and enhancing the integrated park "Las escudillas" in the city of Puerto Carreño and the Central Park of the Venturosa Precinct.	$76,176,659.82	IN FORMULATION			

Source: Municipal Planning Secretariat. Puerto Carreño, 2017

Table 4.166: Projects under way and in formulation at the Aceitico Precinct

PURPOSE OF THE CONTRACT	CONTRACT PRICE	DOWN PAYMENT $	STARTING DATE	TERM FOR PERFORM ANCE/DA YS	STATUS
Construction of Physical Infrastructure for creation of the Cultural Formation Center for Promoting the Folk Identity and Culture of the Aceitico Precinct, Puerto Carreño Municipality - Vichada.	$148,507,421.00	$0.00	25/07/2017	120	UNDER WAY
Inter-administrative agreement to guarantee the continuous supply of electricity in the Urban Zone of the Aceitico, Puerto Murillo and La Venturosa Precincts in the Puerto Carreño Municipality – Vichada	$50,000,000.00	$25,000,000.00	17/08/2017	90	UNDER WAY

Source: Municipal Planning Secretariat. Puerto Carreño, 2017

It is observed that the projects that are in formulation or under way do not currently include the needs of the communities stated in the formulation of the 2016 PDM, as shown below:

4.4.5.2.6 2016-2019 PDM Formulation - Aceitico Precinct

The most relevant needs, problems and alternatives proposed by the Aceitico community in the 2016-2019 Development Plan formulation meetings were the following:

- Plan with the UMATA a scale production with the relevant technical assistance; support to the region before the ZIDRES and that the administration be the one to defend the region; separate the local economy from Venezuela; provide support with a machinery bank for soil preparation, and support crop transportation in some way.
- Set up a definitive water supply system.
- Define the place to dispose of solid wastes and a management plan for them, and avoid them from getting dumped into water sources, such as the Meta River.
- Extend the electricity provision schedule.
- Provide the healthcare facilities with basic equipment and medications.
- Articulate training processes conducive to creating income-generating projects, such as tailoring and/or beauty.

4.4.5.2.7 2016-2019 PDM Formulation – Venturosa Precinct

The most relevant needs, problems and alternatives proposed by the Venturosa community in the 2016-2019 Development Plan formulation meetings were the following:

- Relevant technical assistance from UMATA, as there is no access to machinery to prepare the soil and, even though food is produced, there is no transportation to sell it. This, in addition to the lack of alternatives to mitigate the impact of the dry season.
- Waste management is deficient; garbage is disposed of in the open and next to water sources, thus creating environmental problems. Articulation is requested to address this problem.
- In the environmental sector the community requests that there be environmental compensations with the forestry companies. These compensations should be to reforest and recover the creeks and water sources by planting trees.
- Training by SENA in solid waste management, recycling, tailoring and business.
- Integral care for the children, with parks and computers for the school.
- Improve sectors of the road that complicate access from Puerto Carreño.

4.4.5.2.8 Indigenous communities participating in the 2016-2019 PDM

Event carried out on February 25, 2016 with the participation of forty-two (42) representatives of the indigenous communities. The most relevant petitions made by the indigenous communities in the Puerto Carreño Development Plan formulation were the following:

- Participation in the different programs offered by the municipal administration.
- Access to healthcare, education, water supply and basic sanitation services.
- Support for productive projects that guarantee food security in the urban and rural areas.
- Equip educational infrastructure and provide it with teaching materials and media.
- Support in the recovery of their ancestral customs with dance instructors.
- Support to carry out identification, registration or identity card-issuance processes for those who have no identification document.
- Include the senior indigenous population in programs designed for them.

- Provide integral support to children and adolescents.

4.5 Landscape

Landscape analysis

According to the Land Regulation Scheme for the town of Puerto Carreño, the following geographical formations can be found in the area covered by the study.

FORMATIONS WITH AN ALLUVIAL ORIGIN

The formations resulting from river dynamics consist of the recent floodplains of the rivers Meta and Orinoco, the River Meta terraces, and the flat high plain. These together make up flat topographical systems with heights of between 80 and 130 meters above sea level.

Current and recent floodplains of the Rivers Meta and Orinoco

Both the Meta and the Orinoco are rivers with contrasting flow systems, where water levels rise by up to 5 meters during the rainy season, resulting in lower beds than during the dry season and meadows that are flooded in the rainy season because of the rising waters.

The alluvial plain landscape consists of minor alluvial valleys in mixed alluvial and colluvial deposits. The relief ranges from flat to slightly flat, with gradients of from 0% to 3%, and a concave-convex micro-relief that is affected by flooding and waterlogging. Soils are superficial to moderately deep, with textures that vary between fine and coarse, and are imperfectly and poorly drained, highly acid, and with low fertility.

FORMATIONS WITH A COLLUVIAL-ALLUVIAL ORIGIN

These are found in valleys on the flat, high plain and consist of gently inclined surfaces that link the edges of the high plain to the bottoms of the valleys. In the upper parts are sands ranging from 10 to 50 centimeters thick that rest on a line of stones in the form of ordinary and fine, ferruginous gravel which, in turn, lies on a layer of reddish, sandy clays.

These formations are highly permeable, and their water retention capacity is low. In the rainy season they form temporary phreatic levels above the line of stones. These sands show a marked water deficit from the very start of the rainy season.

As a result, a herbaceous savannah formation forms a low-grade cover that is periodically affected by the burning of stubble associated with extensive cattle raising.

Colluvial-alluvial strips between 0.5 and 3 kilometers wide appear all along the Bita and Tomo rivers, while the valleys are boxed in, compared to the high plain, with a difference in level of between 20 and 50 meters. The edges of these valleys look like slopes at an angle of from 45 to 90 degrees at places where they are eroded by rivers or landslips from the high plain. They are covered by forest that has adapted to the prolonged flooding conditions during the rainy season, when water levels can vary by 3 to 5 meters. This flooding restricts human intervention to certain timber activities. Since they are refuges for numerous varieties of wildlife, they also act as river flow regulators.

Landscape unit visibility, fragility and quality analysis

Based on the information relating to geological formations and soil cover, seven landscape units were defined in the area of the study, and these are described and analyzed below.

Continental waters in colluvial-alluvial valley

These are lentic and lotic bodies of water deriving from rivers and streams, as well as abandoned meanders or river beds (see Figure 4.237). Since these units consist of water and are associated with tall vegetation, and also because they are viewed as extremely natural, they are considered to be high-quality landscape. Their fragility level is medium, since they are areas devoted to conservation and, despite being affected by extraction activities, they are well able to absorb disturbances. As far as visibility is concerned, this type of unit is considered to be highly visible, because it can be observed from close up; in other words, the observer can be directly involved with the forms and can perceive all the immediate details.

Figure 4.237: Continental waters in colluvial-alluvial valley (River Muco)

Source: Universidad Distrital Francisco José De Caldas, 2017.

Gallery forest in colluvial-alluvial valley

This unit is related to such bodies of water as natural lakes, streams and rivers where the vegetation is tall (see Figure 4.238). The general characteristics of this landscape unit are a water presence and a varied relief and vegetation that result in it having high-quality landscape and medium fragility, due to the denseness of the vegetation, which enables it to absorb any visual impacts that might occur. As far as visibility is concerned, the individual features of the area combine to provide it with what is considered to be an intermediate visibility level, due to the presence of tall vegetation. Strategic and ecologically sensitive landscapes are a notable feature of this type of unit.

Figure 4.238: Gallery forest in colluvial-alluvial valley (Cuernavaca property)

Source: Universidad Distrital Francisco José De Caldas, 2017.

Palm swamps in colluvial-alluvial valley

This unit is related to bodies of water, but the tall vegetation consists of palm swamps (see Figure 4.239). The general characteristics of this landscape unit are a constant water presence and varied relief and vegetation, which combine to make for a high-quality landscape. Its fragility level is considered to be medium, due to the denseness of the vegetation. As far as visibility is concerned, it is considered to be intermediate, because of the tall vegetation. As with gallery forest, this unit is relevant because of its natural state, based on aesthetic criteria and its usefulness for recreation and contemplation.

Figure 4.239: Gallery forest in colluvial-alluvial valley (Cuernavaca property)

Source: Universidad Distrital Francisco José De Caldas, 2017.

Gallery forest on floodplain

The feature that marks this visual unit is the presence of dense vegetation which, together with an interesting structure and distribution and moving water that nevertheless does not dominate the landscape, makes for a high-quality landscape. Its fragility level is considered to be medium, due to its resilience capability, while as far as visibility is concerned, the level is considered to be high, because it can be observed from close up; in other words, the observer can be directly involved with the forms and can perceive all the immediate details (see Figure 4.240).

Figure 4.240: Gallery forest on floodplain (Hato Nuevo property).

Source: Universidad Distrital Francisco José De Caldas, 2017.

Palm swamps on floodplain

Like gallery forest on a floodplain, the palm swamps in the zone (*morichales*) stand out visually because of the dense vegetation and their heterogeneous structure and distribution, which together make for a high-quality landscape. The fragility level is medium, for the reasons already mentioned, while as far as visibility is concerned, the level is considered to be high, because of their location (see Figure 4.241).

Figure 4.241: Palm swamps on floodplain (Hato Nuevo property)

Source: Universidad Distrital Francisco José De Caldas, 2017.

Pastures on flat, high plain

This landscape is notable for the fact that it occurs on flat terrain where there is little chromatic variation and little variation in type of vegetation, which results in a low landscape quality rating. The visual fragility level is high, due to the presence of low vegetation and the fact that this landscape is accessible, and also because of the constant burning of stubble. As far as visibility is concerned, it is considered to be high, since it can be observed from close up (see Figure 4.242).

Figure 4.242: Pastures on flat, high plain (San Cristóbal property)

Source: Universidad Distrital Francisco José De Caldas, 2017.

Forestry plantation on flat, high plain

This unit is notable for its single-crop, transformed, low landscape on flat land in areas that are highly accessible because they are near roads (see Figure 4.243). The parameters for granting it a low landscape quality and a high fragility level for plantation exploitation considerations are not unusual, because such landscapes are very common in the region. The extent to which the landscape is transformed and the uniformity and denseness of the cover, which coincides with large areas with no vegetation at all or discontinuous vegetation, make for a big contrast between soil and vegetation, as does the accessibility of these landscapes, which increases both the visual perception and visibility.

Figure 4.243: Forestry plantation on flat, high plain (Tierradentro property)

Source: Universidad Distrital Francisco José De Caldas, 2017.

*** Description of the project in the landscape context**

The FFC commercial reforestation project is situated in an area where the landscape consists of pastures on a flat, high plain (see Figure 4.244) which, as already mentioned, is noted for its infertile soil and for having flat to slightly undulating terrain and scanty vegetation that is constantly affected by the burning of stubble. The pastures are generally located on banks in the upper, non-floodable part of the flat, high plain, with slightly convex peaks and very gentle gradients (0.5 to 2 degrees), and with slightly concave transitions towards marshes and lower land, where the difference in level is never more than five meters. These areas are principally used for extensive cattle raising, where productivity is very low and there are patches of rock that hinder management activities.

Figure 4.244: Example of project location in a landscape context (Tierradentro property).

Source: Satellite images from the remote Digitalglobe sensor. Google Earth.

Identification of places of landscape interest, and Landscape Ecology

PLACES OF LANDSCAPE INTEREST

River Bita

The study area is noted for the presence of bodies of water, principally rivers, which are responsible for the high quality of the landscape, quite apart from the fact that it is they that determine people's overall perception of the landscape, because they are the principal places of interest. The River Bita is unquestionably the most attractive, due to the purity of its water and its natural surroundings, with lush gallery forest and a rich and varied wildlife along its entire length, all of which mean that it is of great interest to local communities and tourists alike (see Figure 4.245).

Figure 4.245: River Bita (Tierradentro property)

Source: Universidad Distrital Francisco José De Caldas, 2017.

Hato Nuevo viewpoint

Another very interesting site, in landscape terms, is the viewpoint on the Hato Nuevo property, on the very edge of the high plain, from which the current floodplain of the River Meta can be seen, together with all its components, such as meadows, terraces and minor beds, as well as the large gallery forests in the study area that are located on the river's abandoned meanders (see Figure 4.246).

Figure 4.246: Hato Nuevo viewpoint

Source: Universidad Distrital Francisco José De Caldas, 2017.

Gallery forests

There can be no doubt that the gallery forests, which constitute the majority of the natural vegetation in the area, are a great attraction, since they make a major contribution to the overall quality of the landscape because of their heterogeneous textures and tones and their natural state. They also provide a wide range of environmental and ecosystem services (see Figure 4.247).

Figure 4.247: Gallery forest (San Cristóbal property)

Source: Universidad Distrital Francisco José De Caldas, 2017.

Palm swamps (*morichales)*

Palm swamps are also of particular interest, in landscape terms, since they are located in areas that are permanently flooded and hence are always associated with water and all wildlife groups for which these ecosystems are their primary source of food. They are also much appreciated for their natural state and for the ecosystem services they provide (see Figure 4.248).

Figure 4.248: Palm swamp (Base Mono property)

Source: Universidad Distrital Francisco José De Caldas, 2017.

LANDSCAPE ECOLOGY

The landscape in the study area is determined by the difficult conditions for vegetation to develop in areas of high plains and alluvial valleys, in addition to the influence of fires during dry seasons, all of which result in a predominance of pastures. But it is also determined by anthropic activities, especially extensive cattle raising, and to a lesser degree by agriculture, notably commercial forestry plantations. This has given rise to a mosaic landscape pattern where the matrix is represented by pastures, with grasses predominating, riparian-type vegetation corridors (gallery forests and palm swamps), and added patches determined by the geometric figures of commercial plantations.

Water riches are among the principal characteristics of Vichada province (*this is another factor that determines spatial patterns when modelling landscape and determining ecological aspects on this scale*), and these consist of a complex set of lotic and lentic elements in the abundant rivers and streams that make up the intricate drainage network formed by the main rivers, namely the Orinoco, Meta, Tomo, Vichada and Guaviare. The high plains of non-floodable Orinoquia (in Meta and Vichada provinces) cover a total area of 9,238,277 hectares, or 27 per cent of the Orinoco basin. This physiographical sub-province lies to the south of the River Meta and extends as far as the alluvial plain of the Vichada and Guaviare rivers and their tributaries. According to Correa et al. (2005), one factor that determines ecological water ecosystem conditions in Orinoquia is the spatial and hydrological relationship between these and the principal lotic systems originating on the eastern slope of the Andes. This explains the dependence of the Orinoco basin on the Andean system and the Atlantic Andean axis which, in turn, influence climate, hydrography and hydrological cycles.

Meanwhile, in landscape ecology terms, the River Meta contributes spatially to the division into two areas with environmentally different influences. In the western sector (Andean foothills) there is more moisture and fluctuating river flooding dynamics (only on the left, or western, bank) during the rainy season, which influences soil quality, since sediments from the Andean cordillera that are relatively rich in nutrients accumulate during these periods. The eastern sector, referred to as the high plain, has a long dry season and its soils and surface waters are oligotrophic (poor in nutrients) and drain not through the River Meta but through the residual Bita, Tomo, Tuparro and Vichada rivers. The complex dynamics of the aquatic ecosystems, their productivity, especially in terms of fishing, and the goods or services they offer are closely related to the hydrological cycle. With respect to the rivers in the Orinoco basin, for example, four cycles have been identified: rising water (April-June), high water (July-August), falling water (September-December), and low water (January-March). (Ramirez and Ajiaco, 2001).

The plains landscape is that of the alluvial plain which forms the lowlands that extend from the foothills to the River Meta, and is the result of materials deposited by Andean rivers as they lose their carrying capacity and gradually and selectively deposit materials from the cordillera onto the plains. The Alluvial Floodplain remains flooded as the rivers overflow for short or long periods ranging from twelve hours to several days, depending on how high the river rises. These sectors have allowed floodable forest in the alluvial floodplain zone and along watercourses to adapt. They have a complex vertical structure, and therefore are formed of big trees on sites that are better drained, and swamp-type vegetation. In addition to gallery forests and floodable forests, secondary forests can be seen in the form of patches with different dimensions that are generally isolated from the savannahs. Details of the principal species found in the forests described can be found in the results of the flora and structural analysis which follows. As will be seen, the general trend is toward a set of species with primary and secondary successional states, generated through anthropic pressure and the virtual absence of commercial species in the landscape being extracted and replaced by rapidly growing heliophile species.

The floodable plains are areas that should not be intervened under any circumstances, precisely because they flood, which means that they are in no way suitable for forestry or agriculture. On the other hand, they offer a different type of less-conventional benefit, namely for scientific research and as flora and fauna refuges. As mentioned elsewhere in this report, these areas are located on low land near rivers, such as the Bita, Meta and Orinoco, and also in swampy areas, on marshy soils in abandoned watercourses, in palm swamps, lakes, and forest remains all along the watercourses in the zone.

As has been seen, various factors model and define ecological aspects at landscape level and, as Correa-Gómez and Stevenson (2010) describe, the fluctuations in rainfall figures, together with humidity conditions, flooding rates and soil characteristics, only serve to increase the complexity of vegetation formations and create a forest mosaic throughout the region such that states ranging from deciduous and semi-deciduous to evergreen can be found, or ones that are associated with savannahs with trees and seasonal, hyper-seasonal or semi-seasonal open savannahs. This structural and functional heterogeneity is fundamental, and means that gallery forests are likewise fundamental to conserving the flora and fauna of Colombia's Orinoquia region.

Table 4.167: Key to ecosystem map

Type of Ecosystem
Continental natural waters in the Amazonia and Orinoquia floodable area biome
Natural forests in the Amazonia and Orinoquia floodable area biome
Natural forests in the Amazonia and Orinoquia savannah biome
Planted forests in the Amazonia and Orinoquia savannah biome
Pastures in the Amazonia and Orinoquia floodable area biome
Pastures in the Amazonia and Orinoquia savannah biome
Grassland in the Amazonia and Orinoquia floodable area biome
Grassland in the Amazonia and Orinoquia savannah biome