ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PEDREGAL – CATAMBUCO SPAN OF THE RUMICHACA – PASTO DUAL CARRIAGEWAY ROAD PROJECT, FU 4 AND FU 5.1, CONCESSION CONTRACT UNDER PPP ARRANGEMENT NO. 15 / 2015

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CHAPTER 5. Characterization of the Area of Influence. 5.2. Biotic Environment. Flora

San Juan de Pasto, March 2017

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5.2. BIOTIC ENVIRONMENT

The biotic environment is related to the characterization of the different ecosystems present in the AI (Area of Influence) of the Pedregal – Catambuco Span of the Rumichaca – Pasto Dual Carriageway Road Project, Concession Contract under PPP Arrangement No. 15 / 2015.

The components characterized in the biotic environment correspond to land cover, land ecosystems (flora and fauna), aquatic ecosystems and strategic ecosystems. This made it possible to determine the characteristics of the functionality, structure and sensitivity thereof.

- *Life Zones*

In order to identify the life zones the project's area of influence, it was classified according to the methodology proposed by Leslie Holdridge, who defines a biogeographical area based on environmental factors and conditions such as temperature, precipitation or evapotranspiration.

In this system, the life zone is the first level of the environmental divisions.

On the second level of association proposed by Holdridge, it includes factors such as soil, drainage, topography, strong winds, fog and the varied patterns of distribution of precipitation.

In this sense, the life zones were identified for the area of influence of the road project using the Holdridge Life Zone Classification Scheme as a reference. See Figure 5.2.1 taken from IGAC 1977 at 1:500,000.

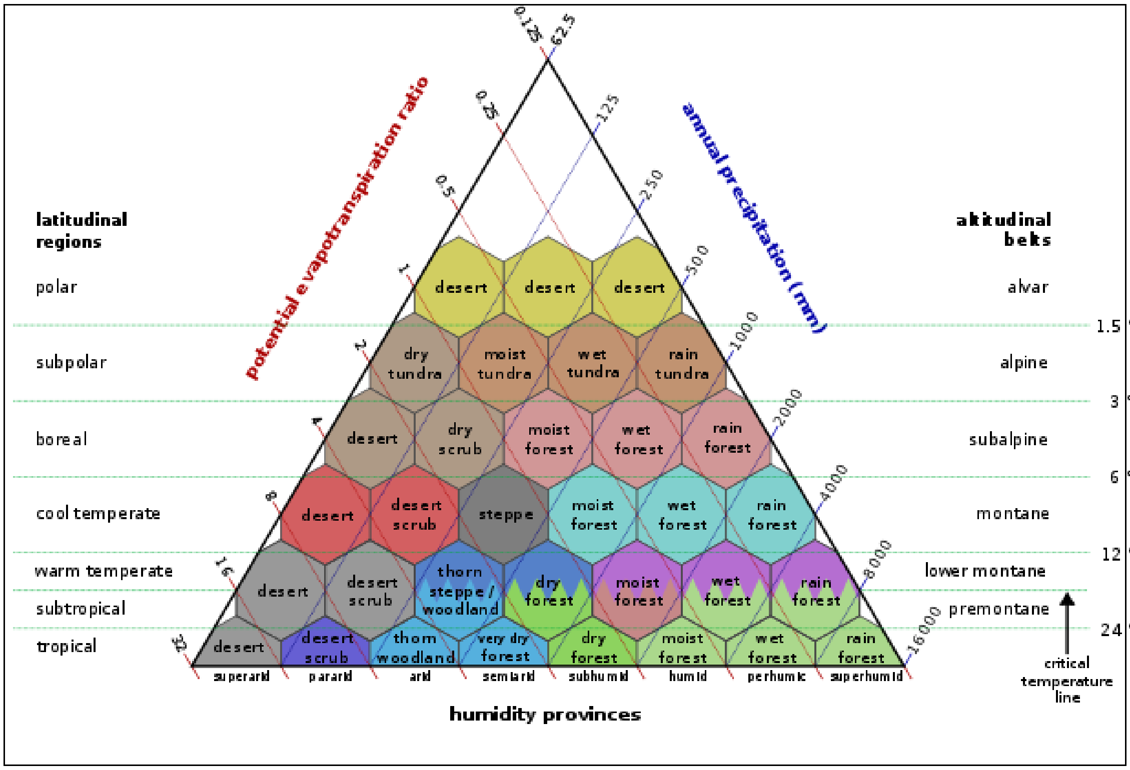


Figure 5.2.1 Holdridge Triangular Life Zone Classification Scheme used to identify the life zones of the project's area of influence.

Source: https://www.google.com.co/search?q=zonas+de+vida+y+biomas+de+colombia&rlz

In this sense, the following life zones were identified for the project's area of influence (Table 5.2.1):

- Lower montane forest (LM)
- Lower montane moist forest (LMm)
- Montane moist forest (Mm)
- Premontane moist forest (PMm)

The description thereof is presented below.

Table 5.2.1 Life Zones of the Pedregal-Catambuco Sector.

LIFE ZONE	CHARACTERISTICS			
	ALTITUDE masl	precipitation mm/year	Temperature ºC	SECTOR-PK
Lower montane dry forest (LMd)	1800-2500	500-1000	12/16	Tangua-Yacuanquer 34+000 35+000
Lower montane moist forest (LMm)	2000-3000	1000-2000	12/18	Tangua. 6+000-11+000
Montane moist forest (Mm)	3000	500-1000	6/12	Tangua-Pasto. 23+000 - 34+000
Premontane moist forest (PMm)	100-2000	1000-2000	17/24	Imués-Yacuanquer. 1+000-6+000

Source: Géminis Consultores Ambientales, 2016.

Lower montane moist forest (LMm):

Average annual precipitation varies between 1000 and 2000 mm with an average annual temperature between 12ºC and 18ºC; the latitudinal strip ranges from 2000 to 3000 masl, covering the areas located to the north and center of the municipality, corresponding to the middle basin of the Pasto River.

The terrain is hilly to rugged; the land cover is represented by temporary crops, pasture and permanent crops (IGAC, 2008). It is located mainly in the municipalities of Imués and Tangua. It is represented by species such as *Alnus acuminata* (Alder), *Tecoma stans (L.) Juss. Ex Kunth* (Yellow trumpetbush), *Baccharis latifolia (Ruiz & Pav.) Pers.* (Coyote bush), *Euphorbia lauroflia* (Pillo), Weinmannia tomentosa (Encenillo), *Befaria resinosa* (Carbonero) and *Arundo donax* (Carrizo).

Montane moist forest (Mm):

The average temperature is from 6 to 12°C, with an average annual precipitation of 500 to 1000 mm and a maximum altitude of 3000 masl, with a rugged to steep hilly terrain; the vegetation cover is represented by the presence of natural pastures and secondary forest (IGAC, 2008). It is located mainly in the municipalities of Tangua and Pasto.

The vegetation of the Montane moist forest (Mm) is represented by species such as *Saurauia ursina* (Moquillo), *Pyracantha coccinea* (Mortiño), *Myrica pubescens* (Laurel de cera), *Sambucus peruviana* (Elderberry), *Oreopanax floribundum* (Mano de oso) and *Clusia multiflora* (Guaque).

Lower montane dry forest (LMd)

The temperature ranges between 12 and 18 °C. There is an average annual rainfall between 500 and 1,000 mm; however, since there is little rain, the climate is relatively sub-humid due to the low temperatures, and there are frosts.

This formation can be found between the altitudes of 2,000 and 3,000 masl. The natural vegetation has been virtually eliminated, due to intense human intervention to carry out agricultural and livestock activities (IGAC, 2008).

It is located on the left and right sides of the Guáitara River canyon, and its existence has been identified in the municipalities of Tangua, Yacuanquer and Pasto.

The primary vegetation of this formation has been almost completely destroyed and/or altered by human action; at present, there are very few areas of dense bushes and natural areas in the plains of the Bobo River, characterized by evergreen species and the presence of *Tillanssia sp* (barbacha or barbas de viejo).

The vegetation of the Lower montane dry forest (LMd) is represented by *Mimosa quitensis Benth* (guarango), *Dodonea viscosa* (hayuelo), *Baccharis cassiniaefolia* (ciro), *Croton* sp., *Agave* sp., *Opuntia aff. Schumanni* (tunas or tabios*)* and *Mammillaria colombiana*; *Lantana boyacana* and *Lantana aff. Canescens*, (venturosas*), Artemisia sodiroi (alcanfor).* Other characteristic species of this life zone are *Evolvulus bogotensi,* *Selaginella aff. sellowi; Euphorbia orbiculat, Bouteloua simplex, Hypoxis decumbens, Peperomia alpina e Ipomea spp., Solanum lycioides, lichens and epiphytic mosses* (CONIF, 2008).

Premontane moist forest (PMm):

Located between 1000 and 2000 masl, it is characterized by a temperature ranging between 17 and 24 °C and 1000 to 2000 mm annual precipitation. Its landscape is made up of alluvial valleys, river basins, steep topography, and gentle to very rugged hills and slopes. (CORPONARIÑO, 2009).

Its anthropogenic affectation is intense, predominated by scattered agricultural and livestock activity; however, there are forest species such as *Albizia carbonaria Britton* (Carbonero) and Eucalyptus *globulos* (Eucalyptus).

The figure below (Figure 5.2.2) illustrates the life zones identified for the area of influence of the Pedregal-Catambuco sector of the road project, according to the above description.

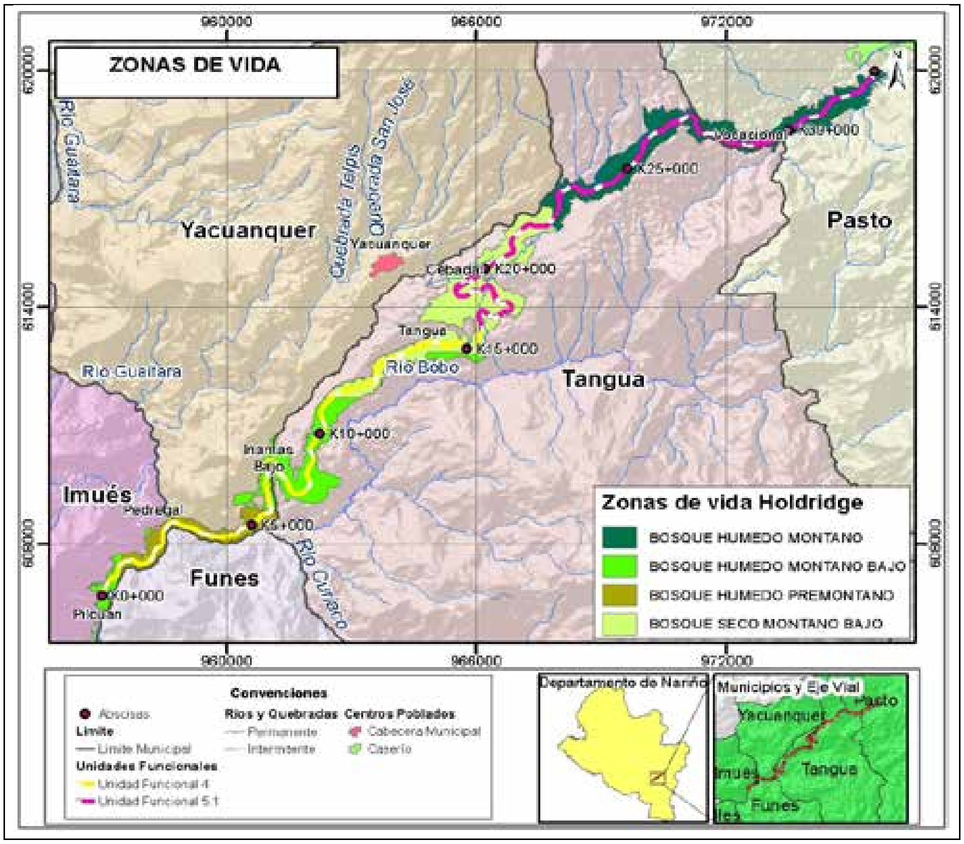


Figure 5.2.2 Life zones identified in the area of influence of the Pedregal-Catambuco sector of the road project

Source: Géminis Consultores Ambientales, 2016.

In this sense, the most representative life zone in terms of surface area is the Montane moist forest (Mm), followed by the Lower montane dry forest (LMd), Lower montane moist forest (LMm) and to a lesser degree, the Premontane moist forest (PMm).

- *Biogeographical Provinces*

The multiple levels of hierarchical organization within a particular biological element range from the level of genes, populations, species, communities, ecosystems, landscape, biogeographical province and biomes, to the biosphere. Each of these levels is characterized by a structural, functional and composition-based diversity, which are contained simultaneously when we see a biotic component to establish the classification; and it is all these contained levels that move through space and time.

In the case of the biogeographical provinces based on the classification proposed by Hernandez Camacho in 1992, there are nine for Colombia, which is close to the complexity of the biota in the country; this work is pending complementation due to the diversity present throughout the national territory.

Specifically, the area corresponding to the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project is located in province nine, within the classification by Hernández - IX. North Andean biogeographical province, in which one (1) of its forty-five (45) districts represents the biogeographical features of the ecosystems related to this project, that is to say district (17): Western Nariño Andean Forest District (Hernandez, *et al*. 1992).

In particular the North Andean province includes the Sierra Nevada of Santa Marta, Serrania del Perija, the Eastern, Central and Western mountain ranges, the valleys of the Magdalena and Cauca rivers, the Colombian Massif and the Nudo de los Pastos [Knot of the Pastos, also known as the Massif of Huaca] in the department, which is represented by the Andean massif «formed by the external eastern and western slopes of the cordilleras, the Inter-Andean basins, plateaus and volcanoes, as well as the canyons and valleys between the two mountain ranges» (Hernández *et al.* 1992; Ramírez and Churchill, 2002) (See Figure 5.2.3).

The Western Nariño Andean Forest District includes the municipalities of Yacuanquer, Tangua and Pasto (Delgado *et al.* 2008), that is to say, one hundred percent (100%) of the area of influence of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road construction project is located in the Western Nariño Andean Forest District biogeographical district.

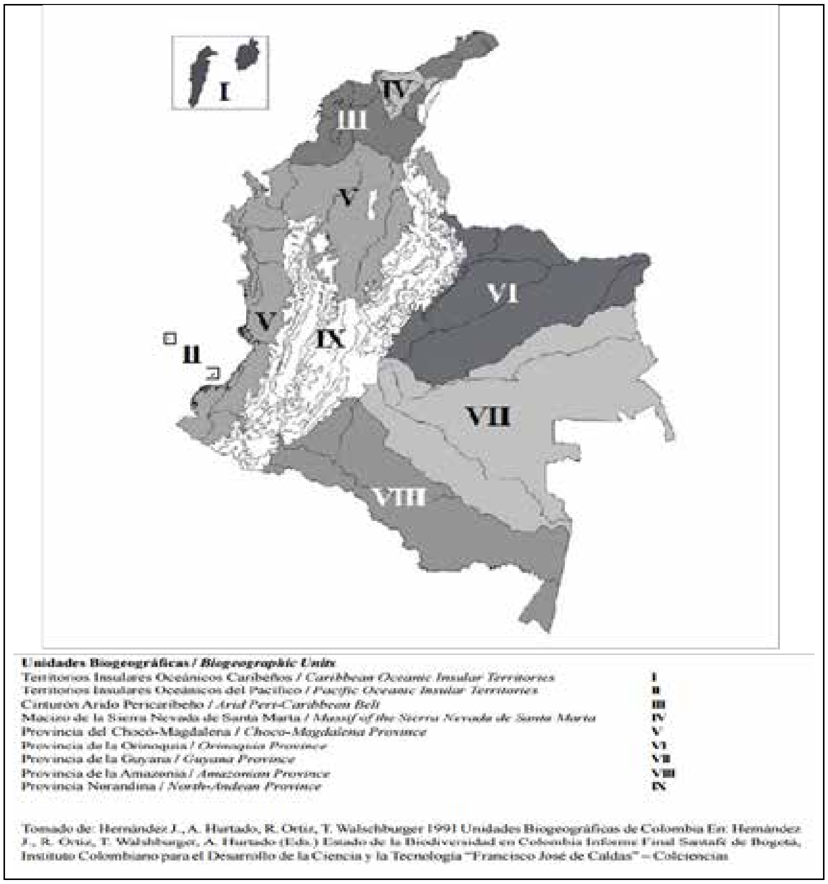


Figure 5.2.3 Biogeographical Provinces of Colombia

Source: http://www.redalyc.org/pdf/491/49150103.pdf.

5.2.1 Ecosystems

The Convention on Biological Diversity defines the ecosystem as "a dynamic complex of plant, animal and micro-organism communities in their non-living environment interacting as a functional unit materialized in a territory, which is characterized by consistency, in their biophysical conditions and human-induced hazards" (IAvH, 2003).

Continental Ecosystems

Continental ecosystems are defined as those located within continents, and involve both terrestrial and aquatic ecosystems.

Terrestrial ecosystems are understood as those that are under the dominion of the soil, the land and fresh water, generally located between the coast and the snowline.

Aquatic ecosystems are open systems that exchange mass and energy with their environment and depend on these exchange processes for their sustenance (INVEMAR, 2012).

Major Biomes

On a planetary scale, the dense tropical jungle or tropical rainforest, savanna, steppe, the deciduous or mixed temperate forests and tundra, are the major biomes that characterize the biosphere and have a zonal distribution, that is to say, that do not exceed certain latitudinal values (Gallego, 2016).

In this sense, the area of influence of the road project is part of the major biome of the tropical rainforest as follows:

- <u>Tropical Rainforest</u>

The major biome of the tropical rainforest, which is part of the area of influence of the road project, is located on a narrow strip around the equator, up to approximately 10º latitude north and south.

The top is characterized by not having variations of temperature and very abundant and regular precipitation throughout the year.

The vegetation consists of evergreen trees with lianas and climbing plants that form dense forests.

- *Biomes*

Biomes are understood as "large, uniform environments of the geobiosphere that correspond to a homogeneous area in biophysical terms, located within one and the same biogeographical formation"; therefore, a biome may be seen as a set of terrestrial ecosystems linked by their structural and functional features, which are differentiated by plant characteristics. IDEAM et al. (2007) defined three major biomes in the country: major biome of the tropical desert, major biome of the tropical dry forest and the major biome of the tropical rainforest and within these, they identified 34 biomes throughout the national territory.

According to this classification, it is determined that the project's area of influence from the municipality of Imués to the capital city of the department of Nariño, is located between the Middle Andean Orobiome and the Upper Andean Orobiome.

It is important to note that, due to the high level of anthropogenic intervention in the project's area of influence, the ecosystems do not retain their natural characteristics. There are few forest covers and semi-natural ecosystems, because they are highly intervened due to the expansion of agricultural and livestock frontiers, replacing the native vegetation with grazing areas and monoculture plantations.

- Middle Andean Orobiome

It is characterized by three main types of climate: cold dry, cold humid and dry temperate. For the most part, the orobiome is exposed to frequent mists, located altitudes of 1800 and 2800 masl, with temperatures ranging between 1°C and 18ºC.

The geomorphological units most representative of this orobiome are the mountain and the Plateau.

- Upper Andean Orobiome

It is located in the different sections of the upper slopes of the Central and Eastern and Western mountain range, surrounding the Guaitara river basin and bordering the moorland area (altitudes above 3,000 masl) in andisol soils formed from volcanic ash, not very evolved, superficial and with low fertility, on hilly to rugged and very rugged terrain with slopes greater than 75% ; In conditions of permanent high humidity (relative humidity greater than 80%), temperatures between 8°C and 12°C, strong, moderate and constant winds, and the occurrence of frosts. The influence of the fog and low potential evapotranspiration (between 0.25 and 0.5), less than the amount of rainwater, (annual average rainfall of 1,000 to 2,000 mm per year) generates excess water on a permanent basis.

5.2.1.1 Terrestrial Ecosystems

The terrestrial ecosystems were characterized based on the identification of the flora present in the covers defined in the biotic area of influence, taking into account its location with respect to the biomes described above. This characterization identified a composition and state of intervention of the existing ecosystems, where there is evident anthropogenic disturbance in the natural vegetation since there are predominant covers in which agricultural and livestock activities are carried out.

- *Ecosystems Identified in the Project's Area of Influence.*

The ecosystems located within the area of influence of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project , were determined based on the existing vegetation covers, as listed in the figures presented below (Figure and Figure 5.2.5).

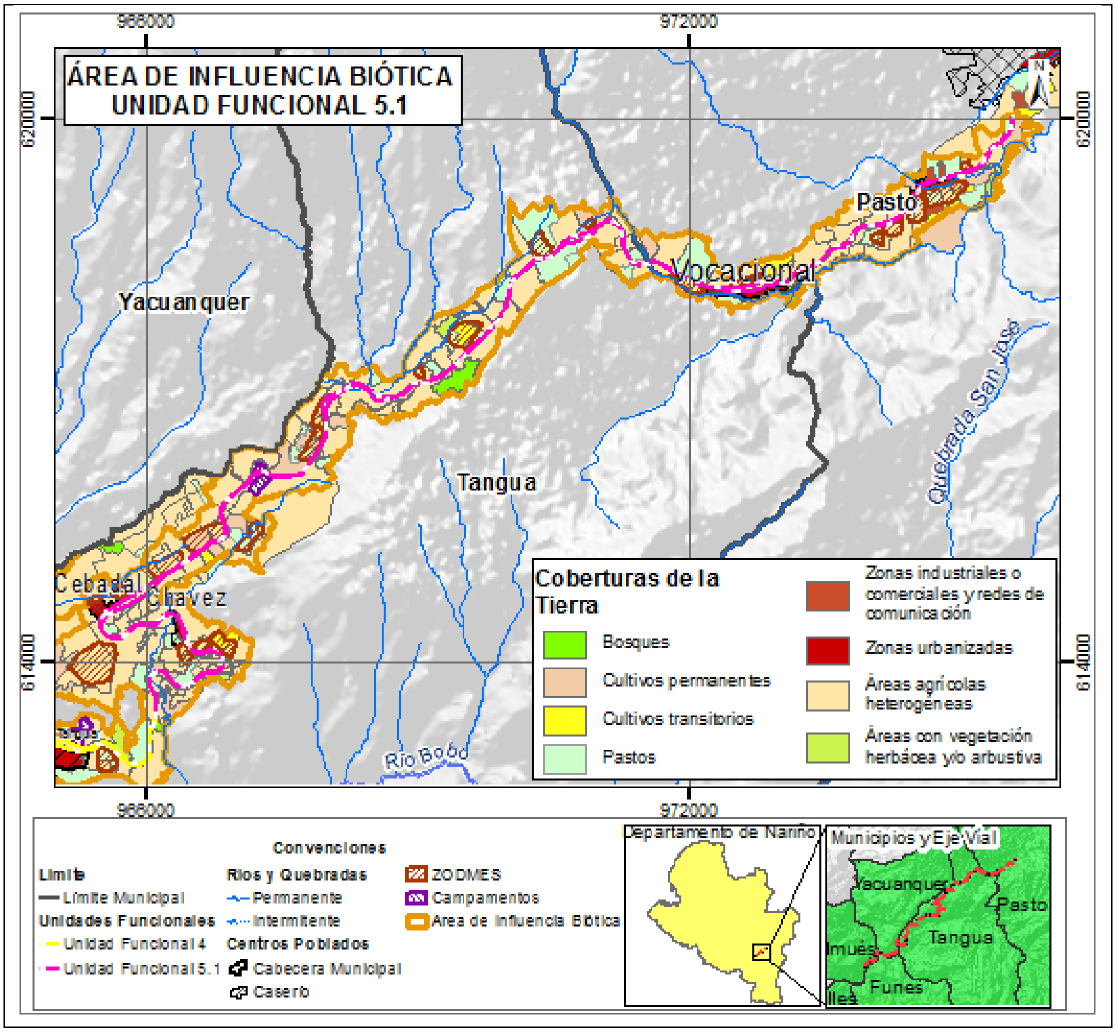


Figure 5.2.4 Biotic area of influence of Functional Unit 5.1

Source: Géminis Consultores Ambientales, 2016

See: GDB/cartografía/PDF/ EIADCRP_PC_003.1

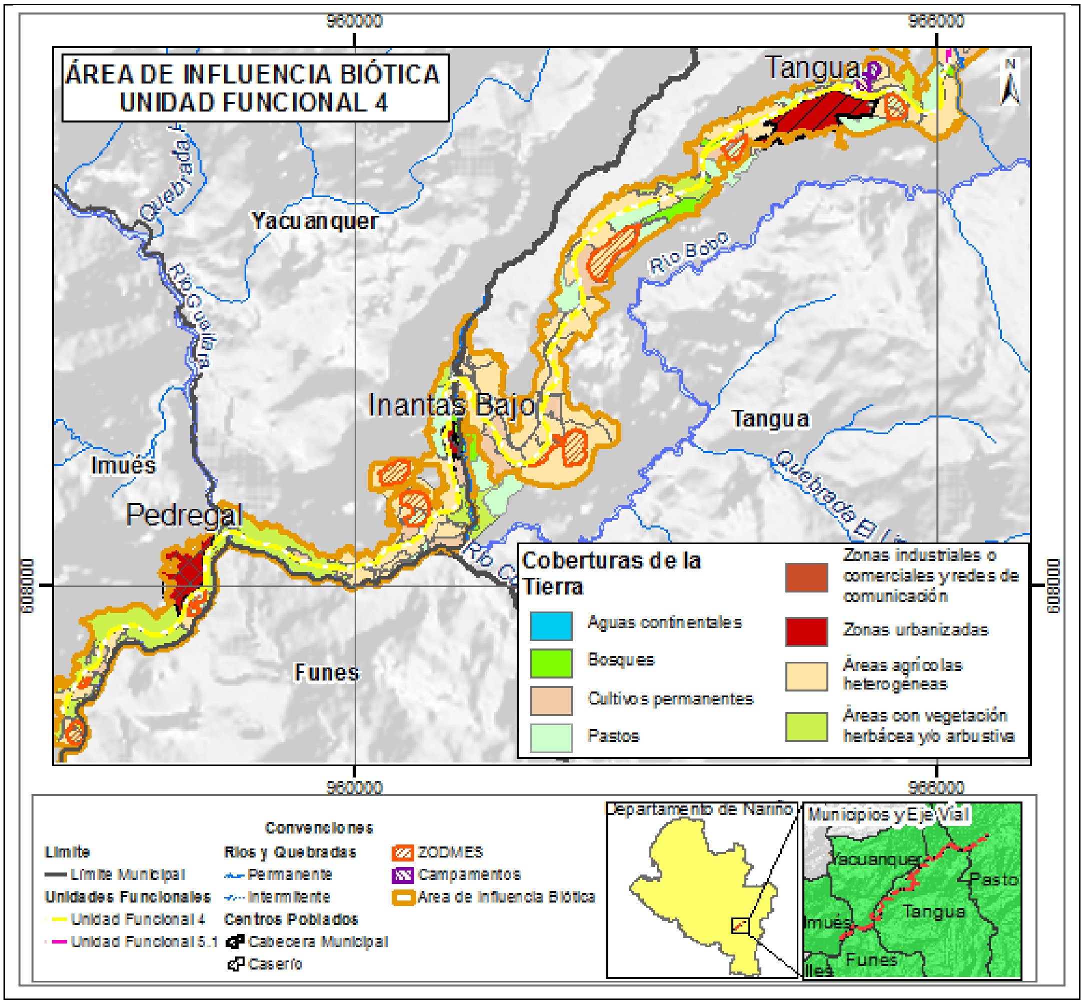


Figure 5.2.5 Biotic area of influence of Functional Unit 4

Source: Géminis Consultores Ambientales, 2016.

See: GDB/cartografía/PDF/ EIADCRP_PC_003.1

Once the covers within the area of influence were identified, existing terrestrial ecosystems were determined from their overlapping with the map of continental, coastal and marine ecosystems of Colombia, (IDEAM, et al., 2007) where three major biomes were defined for the country: major biome of the tropical desert, major biome of the tropical dry forest and the major biome of the tropical rainforest, and within them, 34 biomes were identified throughout the national territory.

According to this classification, the Pedregal-Catambuco Span corresponds to the major biome of the tropical rainforest, specifically to the Middle Andean Orobiome and the Upper Andean Orobiome.

In this sense, and taking into account the ecosystems map of Colombia, for the Pedregal-Catambuco sector, the ecosystem map at 1:25000 scale was generated, identifying 38 types of ecosystems distributed in 1933.62 hectares, of which 22 ecosystems are part of the Middle Andean Orobiome and 16 are part of the Upper Andean Orobiome.

Within them, there is a patchwork of pastures and crops of the Middle Andean Orobiome with 226.91 hectares, representing 11.73% of the total area of influence of the road project. This is followed by the patchwork of crops, pasture and natural spaces of the Middle Andean Orobiome with 146.70 has, representing 7.59%. This was followed by a patchwork of crops of the Middle Andean Orobiome representing 6.93% of the total area of influence of the road project.

The table below lists the ecosystems identified in the Pedregal-Catambuco sector (Table), as discussed above.

Table 5.2.2 Ecosystems identified in the area of influence of the Pedregal – Catambuco sector of the road project

MAJOR BIOME	BIOME	ECOSYSTEM	*NOMENCLATURE	AREA (Ha)	(%)
Tropical Rainforest	Middle Andean Orobiome	Continuous urban fabric of the Middle Andean Orobiome	20111	55.36	2.86
		Discontinuous urban fabric of the Middle Andean Orobiome	20112	40.77	2.11
		Industrial or commercial areas of the Middle Andean Orobiome	20121	0.06	0.00
		Road and railway network and associated lands of the Middle Andean Orobiome	20122	34.55	1.79
		Other temporary crops of the Middle Andean Orobiome	20211	4.53	0.23

MAJOR BIOME	BIOME	ECOSYSTEM	*NOMENCLATURE	AREA (Ha)	(%)
		Potato of the Middle Andean Orobiome	202151	5.18	0.27
		Coffee of the Middle Andean Orobiome	202222	8.36	0.43
		Planted pastures and trees of the Middle Andean Orobiome	202241	58.52	3.03
		Planted crops and trees of the Middle Andean Orobiome	202242	33.87	1.75
		Clean pastures of the Middle Andean Orobiome	20231	67.96	3.51
		Wooded pastures of the Middle Andean Orobiome	20232	3.15	0.16
		Weedy pastures of the Middle Andean Orobiome	20233	56.37	2.92
		Patchwork of crops of the Middle Andean Orobiome	20241	134.06	6.93
		Patchwork of pastures and crops of the Middle Andean Orobiome	20242	226.91	11.73
		Patchwork of crops, pastures and natural spaces of the Middle Andean Orobiome	20243	146.70	7.59
		Patchwork of pastures with natural spaces of the Middle Andean Orobiome	20244	114.71	5.93
		Patchwork of crops and natural spaces of the Middle Andean Orobiome	20245	21.02	1.09
		Gallery and/or riparian forest of the Middle Andean Orobiome	20314	21.32	1.10
		Forest plantation of the Middle Andean Orobiome	20315	14.97	0.77
		Dense shrubland of the Middle Andean Orobiome	203221	15.03	0.78
		Open rocky grassland of the Middle Andean Orobiome	2032122	112.19	5.80
		Rivers (50 m) of the Middle Andean Orobiome	20511	20.89	1.08
	Upper Andean Orobiome	Discontinuous urban fabric of the Upper Andean Orobiome	21112	8.10	0.42
		Industrial or commercial areas of the Upper Andean Orobiome	21121	4.62	0.24
		Road and railway network and associated lands of the Upper Andean Orobiome	21122	13.99	0.72
		Other temporary crops of the Upper Andean Orobiome	21211	10.58	0.55
		Clean pastures of the Upper Andean Orobiome	21231	84.07	4.35
		Weedy pastures of the Upper Andean Orobiome	21233	24.53	1.27

MAJOR BIOME	BIOME	ECOSYSTEM	*NOMENCLATURE	AREA (Ha)	(%)
		Patchwork of crops of the Upper Andean Orobiome	21241	68.01	3.52
		Patchwork of pastures and crops of the Upper Andean Orobiome	21242	254.69	13.17
		Patchwork of crops, pastures and natural spaces of the Upper Andean Orobiome	21243	77.98	4.03
		Patchwork of pastures with natural spaces of the Upper Andean Orobiome	21244	82.35	4.26
		Patchwork of crops and natural spaces of the Upper Andean Orobiome	21245	10.97	0.57
		Gallery and/or riparian forest of the Upper Andean Orobiome	21314	8.01	0.41
		Forest plantation of the Upper Andean Orobiome	21315	10.32	0.53
		Potato of the Upper Andean Orobiome	212151	6.85	0.35
		Planted pastures and trees of the Middle Andean Orobiome	212241	64.34	3.33
		Dense shrubland of the Upper Andean Orobiome	213221	7.70	0.40
Total				**1933.62**	**100**

*The nomenclature code corresponds to the classification given on the ecosystems map of Colombia
Source: Géminis Consultores Ambientales, 2016.

The figures below (Figure and Figure 5.2.7) illustrate the ecosystems identified, which are part of the road project for the Pedregal-Catambuco sector.

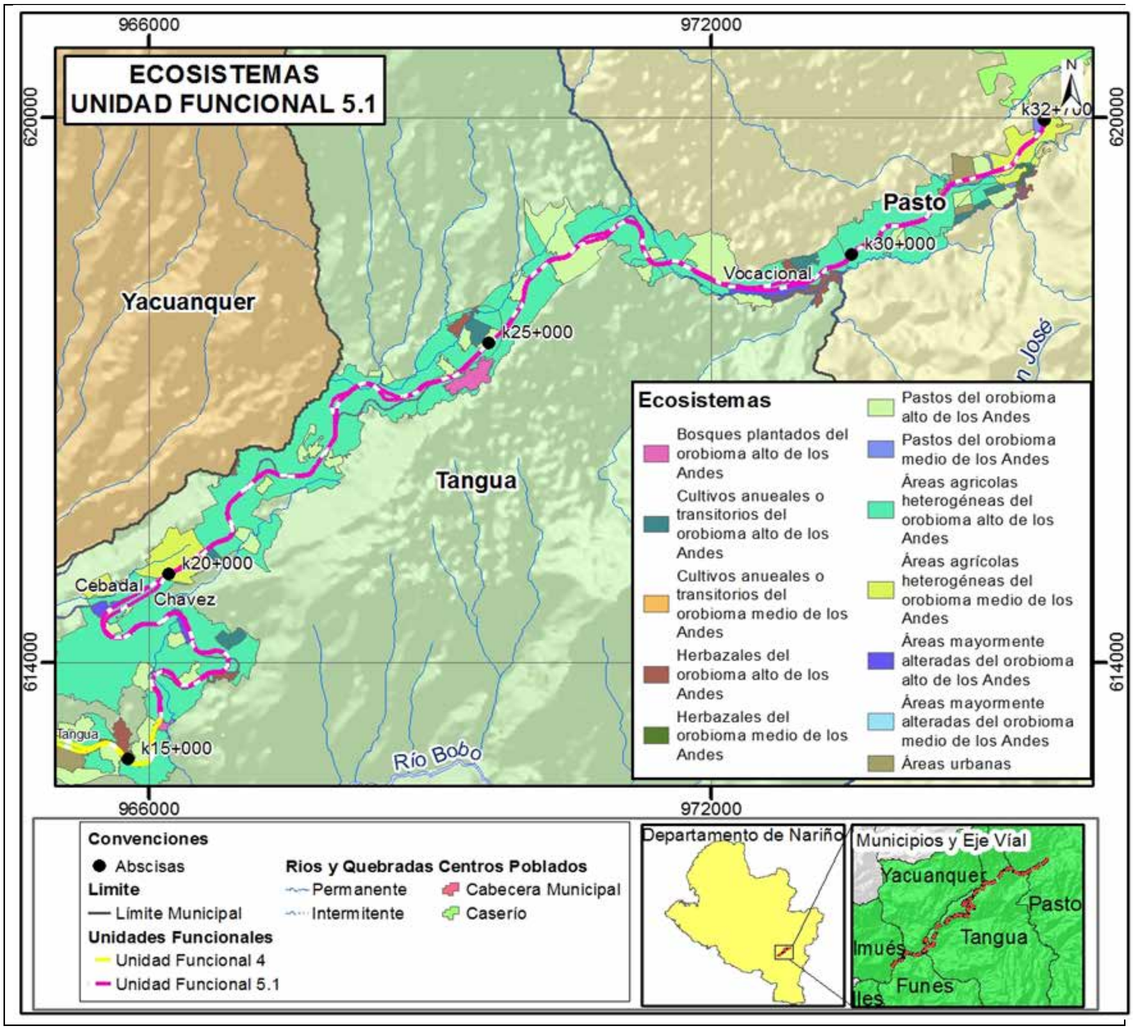


Figure 5.2.6 Ecosystems identified in the physical-biotic area of influence of Functional Unit 5

Source: Géminis Consultores Ambientales, 2016.

See: GDB/cartografía/PDF/ EIADCRP_PC_023.

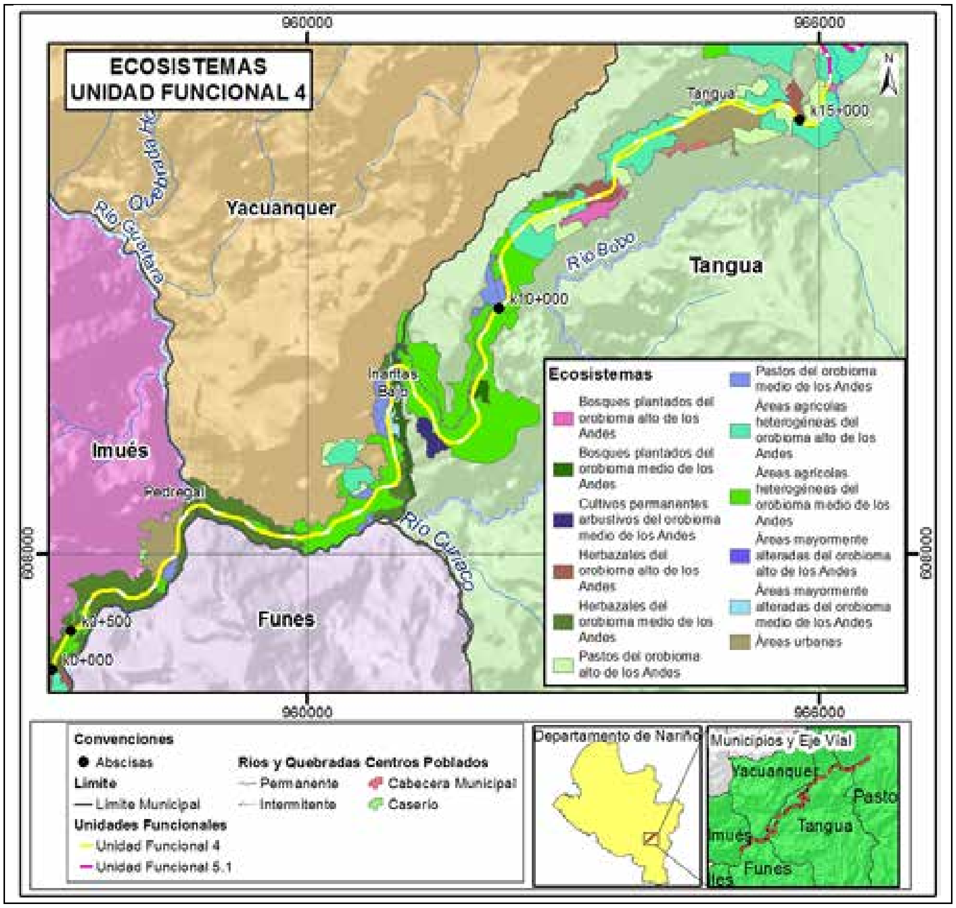


Figure 5.2.7 Ecosystems identified in the area of influence of functional unit 4

Source: Géminis Consultores Ambientales, 2016

See: GDB/cartografía/PDF/ EIADCRP_PC_023.

- Units of Land Cover

Land cover can be defined as the distinguishable unit that emerges from an analysis of the spectral responses determined by its physiognomic and environmental features, which are differentiable with respect to the next (IDEAM, 1997).

In this sense, the characteristics of high anthropogenic intervention in the AI of the Pedregal-Catambuco Span of the Rumichaca-Pasto road project, which includes the municipalities of: Imués, Yacuanquer, Tangua and Pasto, which in turn make up functional units four (FU4) and five (FU5.1), show two predominant trends in the structure of vegetation covers; one of them is intensive human use, where the tree and shrub-like native vegetation is scarcely regenerated.

Methodology for defining and characterizing units of land cover

In order to delimit and characterize the covers in the project's area of influence, we started with the information contained in orthophotos, satellite photos and RapidEye, image processing, using a software that classifies the image at the pixel level; after that, a limit editing process was carried out, along with a categorization according to the Corin Land Cover methodology adapted for Colombia by IDEAM, based on which initial maps were generated for use in the field for gathering information and the respective verification of each polygon, so the characteristics of the cover defined match those stipulated by said methodology and what was observed in the field.

Results

Below is a description of the land covers identified in the area of influence of the Pedregal-Catambuco sector of the Rumichaca - Pasto road project (functional units 4 and 5).

It is important to note that the graphical output of covers listed for each functional unit were generated at level 2 according to the Corin Land Cover methodology; however, level 4 was reached for the description of each of them for artificialized territories, agricultural territories, forests and semi-natural areas and water surfaces, and level 5 for open rocky grasslands. Below, we begin with the description of the covers present in Functional Unit 4, followed by those of Functional Unit 5.

- Functional Unit 4

The area of influence of the Rumichaca-Pasto road corridor for functional unit four (FU4) covers an area of 747,035 hectares. This includes the municipalities of Imués, Tangua and Yacuanquer.

By applying the Corine Land Cover methodology for the characterization of land covers on Functional Unit 4, 19 units of cover were identified, 4 of which are Forests and Semi-Natural Areas and 11 are Agricultural Territories, where the latter have the highest prevalence in terms of surface area. The information obtained in the identification and characterization process is provided in Table 5.2.3 for Functional Unit 4.

Table 5.2.3. Land covers identified in functional unit four (FU4)

LEVEL					Code	Area (ha)	%
1	2	3	4	5			
1. ARTIFICIALIZED TERRITORIES	1.1. Urbanized areas	1.1.1. Continuous urban fabric			1,1,1	55.36	7.41
		1.1.2. Discontinuous urban fabric			1,1,2	4.27	0.57
	1.2. Industrial or commercial areas and communication networks	1.2.2 Road and railway network and associated lands			1,2,2	20.29	2.71
2. AGRICULTURAL TERRITORIES	2.2. Permanent crops	2.2.2. Permanent bush-like crops	2.2.2.2. Brown		2.2.2.2	8.36	1.12
		2.2.4. Agroforestry crops	2.2.4.1 Planted pastures and trees		2.2.4.1	37.58	5.03
			2.2.4.2. Planted crops and trees		2.2.4.2	9.21	1.23
	2.3. Pastures	2.3.1. Clean pastures			2.3.1	53.68	7.18
		2.3.2 Wooded pastures			2.3.2	3.15	0.42

LEVEL					Code	Area (ha)	%
1	**2**	**3**	**4**	**5**			
		2.3.3. Weedy pastures			2.3.3	46.12	6.17
	2.4. Heterogeneous agricultural areas	2.4.1. Patchwork of crops			2.4.1	34.51	4.62
		2.4.2. Patchwork of pastures and crops			24.2	130.19	17.42
		2.4.3. Patchwork of crops, pastures and natural space			2.4.3	76.32	10.21
		2.4.4. Patchwork of pastures with natural spaces			2.4.4	68.69	9.19
		2.4.5. Patchwork of crops and natural spaces			2.4.5	21.02	2.81
3. FORESTS AND SEMI-NATURAL AREAS	3.1. Forests	3.1.4. Riparian forest			3.1.4	21.32	2.85
		3.1.5. Forest plantation			3.1.5	13	1.74
	3.2. Areas with herbaceous and/or shrub-like vegetation	3.2.1. Grassland	3.2.1.2. Open grassland	3.2.1.2.2. Open rocky grassland	3.2.1.2.2	112.19	15.01
		3.2.2. Shrubland	3.2.2.1. Dense shrubland		3.2.2.1	11.21	1.50
5. WATER SURFACES	5.1. Inland waters	5.1.1. Rivers			5.1.1	20.89	2.80
TOTAL						**747.36**	100

Source: Géminis Consultores Ambientales, 2016.

As shown in the figure below (Figure), the predominance of Heterogeneous Agricultural Areas is remarkable.

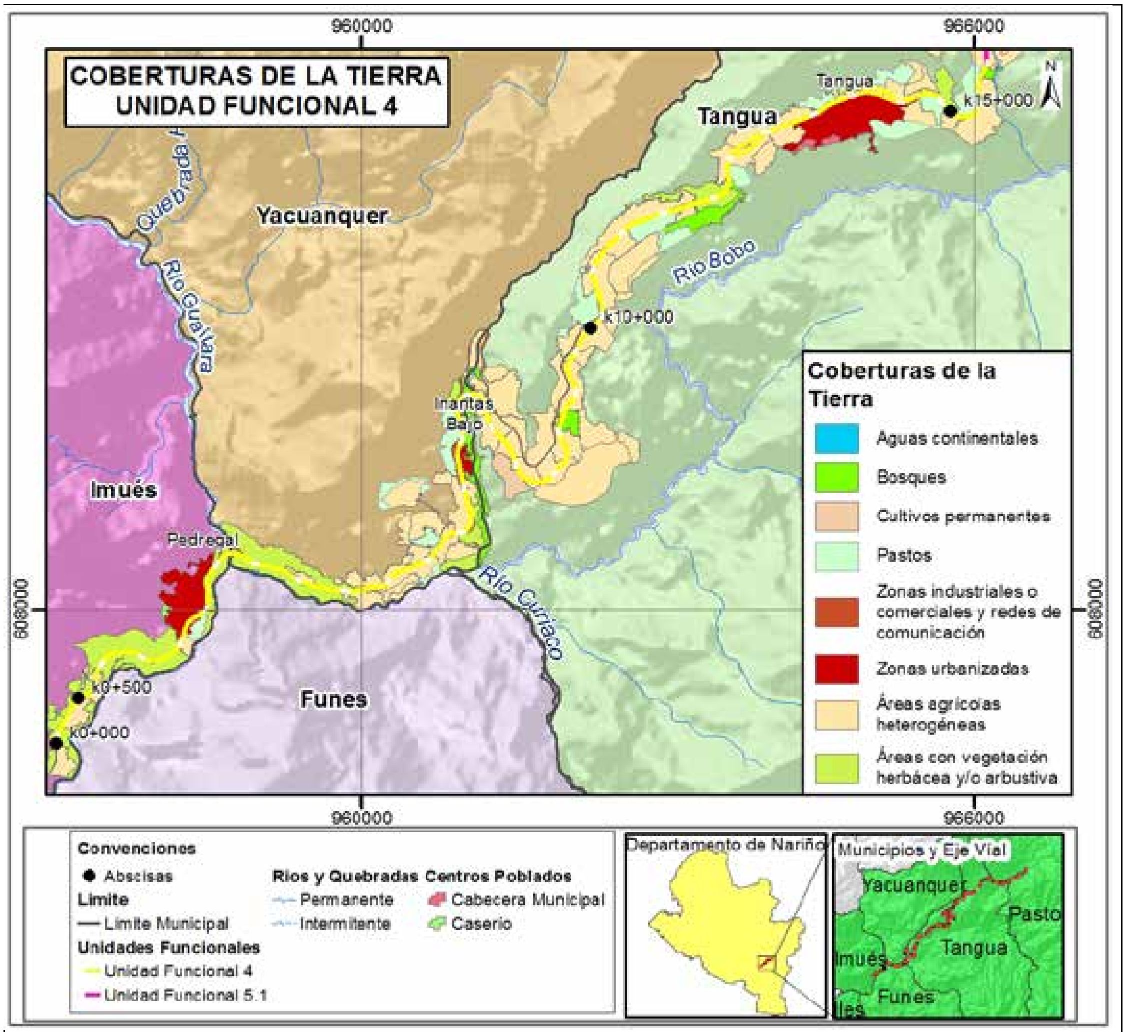


Figure 5.2.8. Land covers present in Functional Unit 4

Source: Géminis Consultores Ambientales, 2016.

It should be noted, that in order to avoid the saturation of information on the land cover maps presented in this section, the graphical output only shows up to level two, as they are only intended as a general illustration for the reader. However, it is important to clarify that the text and cartographic annexes provide detailed information thereof, up to the highest level reached, i.e., Level Five (5).

The following is a description of each of the covers identified in the area of influence of Functional Unit 4.

- Artificialized territories [1]: Artificialized territories are rare, since this area is mostly rural.

    - Urbanized areas [1.1.]: Include hamlets and peasant communities in districts, mainly in the Pedregal district, municipality of Imués and in the municipality of Tangua.

Continuous urban fabric. [1.1.1.]: Continuous urban fabric occupies 7.41% of FU4, represented by one and two-story homes, built of materials such as cement and brick, with their respective gardens, in addition to roads and small buildings of schools, chapels and businesses, which are located in the municipalities of Imués and Tangua. (See Photo 5.2.1).

Photo 5.2.1. Continuous urban fabric, El Pedregal district, municipality of Imués-Nariño. PK 0+ 800

Magna Sirgas coordinates origin West X 958396.31 Y 607983.72

Source: Géminis Consultores Ambientales, 2016.

Discontinuous urban fabric [1.1.2.]: The total area of this fabric occupies 0.57% of the total cover of functional unit 4. It is represented by El Pedregal district and a large part of the municipality of Tangua. This area is characterized by its peasant-type homes, in materials such as cement, brick and mud, with their respective gardens, orchards, trails and small schools and chapels, scattered among vegetation covers. (See Photo 5.2.2)

Photo 5.2.2. Discontinuous urban fabric, El Pedregal district, municipality of Imués-Nariño. PK 1+400.
Magna Sirgas coordinates origin West X 957895.9 Y 607497.24
Source: Géminis Consultores Ambientales, 2016.

Road and railway network and associated lands [1.2.2.]: The total area of this fabric occupies 2.71% of the total cover of functional unit 4. It is extended throughout the entire area of influence.

- Agricultural territories [2.]: This cover within the functional unit covers the largest area at 488.83 ha, with a percentage of 65.41%, because it is located in the rural areas of the municipalities included in the functional unit.

  - Permanent crops. [2.2.]: Are crops whose growth cycle is more than one year, which implies that they generate various crops. This unit includes coffee shrub crops, agroforestry crops among which silvopastoral and agroforestry arrangements stand out. It occupies a total area of 55.15 hectares, representing 7.38% of the total area of influence for this functional unit.

Permanent bush-like crops [2.2.2.]: These crops are characterized by being bushy, represented by crops of *Coffea arabica* (coffee).

Coffee [2.2.2.2.]: In functional unit four (FU4), there is farming of *Coffea arábica* (café), with a *percentage of 1.12%,* making it one of the most important commercial crops of the region. (See Photo 5.2.3).

Photo 5.2.3. Coffee growing, El Pedregal district, municipality of Imués-Nariño. PK 7+600.
Magna Sirgas coordinates origin West X 960288.51 Y 608326.29
Source: Géminis Consultores Ambientales, 2016.

Agroforestry crops [2.2.4.]: These are areas occupied by arrangements or combinations of crops of different species, with herbaceous, shrub and arboreal habits, where the main characteristic of the cover is the fact that the increase in detail does not imply the subdivision in pure units, because they are combined in the same area, alternated by furrows or rows of trees with crops or trees with grasses. The area of these crops as a percentage of the functional unit is 6.26%.

Planted pastures and trees [2.2.4.1.]: Cover occupied by spatial arrangements where pastures for livestock are combined with tree plantations for all kinds of production (wood, timber, fruit trees, resins, etc.), often called silvopastoral practices. Their area as a percentage of the functional unit is 5.03%. In this cover, grass from the Poaceae family are identified, along with tree species, such as: *Citrus sinesis* (Orange), *Fraxinus chinensis Roxb.* (Chinese ash) and *Lafoensia acuminata* (Guayacán). This type of cover is found mainly in the municipality of Tangua.

Planted crops and trees [2.2.4.2.]: Cover occupied by spatial arrangements where crops are combined with tree plantations for all kinds of production (wood for construction, wood-based bioenergy, fruit trees, resins, etc.). The area of these crops as a percentage of the functional unit is 1.23%.

- Ø Pastures: [2.3.]: These are areas used for permanent grazing over long periods of time. This area includes land covered by dense grass that is mostly from the Poaceae family. The grass cover is of great importance, since cattle raising is one of the main activities of these municipalities. The area within the functional unit amounts to 102.95 ha, which is a percentage of 13.78%. The main pasture species are *Pennisetum clandestinum (*Kikuyu grass) and *Holcus lanatus* (Yorkshire fog).

Clean pastures [2.3.1.]: The areas with clean pasture cover, on which cleaning or fertilization, as well as management practices are carried out, represent the area in a percentage of 7.18% of functional unit 4. In this type of cover, it is common to find forest species outlining meadows or properties, predominated by introduced species such as eucalyptus, white cedar and pine (See Photo 5.2.4)

Photo 5.2.4. Clean pastures, functional unit 4.
PK 13 + 800
Magna Sirgas coordinates origin West: X 964451.72 Y 613069.56
Source: Géminis Consultores Ambientales, 2016.

Wooded pastures [2.3.2.]: This type of coverage is characterized by providing environmental services that generate stability for the soil and water. This cover makes up 0.42% of functional unit 4. The main grass species is *Pennisetum clandestinum* (Kikuyu grass) and the main tree species is, *Citrus sinesis* (Orange), *Fraxinus chinensis Roxb.* (Urapan), *Inga spectabilis (Vahl) Willd.* (Shimbillo) and *Lafoensia acuminata* (Guayacan). Corresponding to the municipality of Yacuaquer.

Weedy pastures [2.3.3.]: This type of cover receives little management on the part of the farmer, as you can see the free growth of grass and shrub species on the land. This cover makes up 6.17% of functional unit 4.

- Ø Heterogeneous agricultural areas. [2.4.]: This cover is characterized by having a greater proportion of patchwork of pastures and crops, patchwork of crops, pastures and natural spaces, followed by patchwork of pasture with natural spaces. Within the functional unit, it has an area of 330.73 has, with a percentage of 44.25% of the total area.

Patchwork of crops [2.4.1.]: This cover makes up an area of 4.62% of functional unit 4. The crops are *Solanum tuberosum* (potato) *Zea mais* (Maize), *Triticum aestivum* (wheat), *Musa paradisiaca* (plantain) and *Coffea arabica* (coffee).

Patchwork of pastures and crops [2.4.2.]: The patchwork of pastures and crops are small areas of pastures in spatial distribution with crops. In functional unit 4, comprising an area of 17.42% in percentage of 17.42%, there are crops such as *Triticum aestivum* (wheat) and pastures such as *Penisetum clandestinum* (Kikuyu).

Patchwork of crops, pastures and natural space. [2.4.3.]: This cover makes up an area of 10.21% of functional unit 4, in which there are mainly crops such as *C. arabica* (coffee), P. *vulgaris* (beans), and *Z. mais* (maize) and natural pastures combined with natural spaces of shrubs such as *Baccharis latifolia (Ruiz & Pav.) Pers.* (Coyote bush) and *Euphorbia laurifolia Juss. ex Lam.* (Lechero). (See Photo 5.2.5).

Photo 5.2.5. Patchwork of crops, pastures and natural space
Magna Sirgas coordinates origin West X 966143.53 Y 613401.11
PK 15 + 400
Source: Géminis Consultores Ambientales, 2016.

Patchwork of pastures with natural space [2.4.4.]: This cover makes up an area of 9.19% of functional unit 4, It includes sectors where pastures are interspersed with groups of shrub species, such as *Albizia carbonaria Britton* (Carbonero), *Baccharis latifolia (Ruiz & Pav.) Pers.* (Coyote bush), *Piper bogotence* (Cordoncillo), *Sambucus nigra L.* (Elderberry), *Tecoma stans (L.) Juss. ex Kunth* (Yellow trumpetbush) and *Herperomeles Obtusifolia* (Cerote). (See Photo 5.2.6).

Photo 5.2.6. Patchwork of pastures with natural space, functional unit 4.
Magna Sirgas coordinates origin West X 964863.54 Y 613146.92
PK 14 + 100
Source: Géminis Consultores Ambientales, 2016.

ü Forests and semi-natural areas. [3.]: This class includes the areas where forest, shrub or grass species of natural growth prevail, along with forest plantations, secondary vegetation or vegetation in transition. It has an area of 157.72 ha, which is 21.1% of the cover of functional unit 4.

Ø Forests. [3.1.]: These are areas where groups of trees, either natural or planted, are growing. This cover makes up an area of 34.32 ha, corresponding to 4.59% of functional unit 4.

Riparian forest [3.1.4.]: These covers are made up of arboreal vegetation located on the borders of permanent or temporary watercourses. This type of cover is limited by its size, as it runs along watercourses and natural drains. This cover is located in El Placer district, occupying an area corresponding to 2.85%. Introduced species are commonly found in these areas, such as *Fraxinus chinensis* Roxb. (Chinese ash), *Tecoma stans* (L.) Juss. ex Kunth (Quillotoco), *Lafoensia acuminata* (Ruiz & Pav.) DC. (Guayacán), and numerous fruit trees, which have replaced the native flora, for which the original composition and structure of these forests have been affected significantly. (See Photo 5.2.7).

Photo 5.2.7. Riparian forest, functional unit 4.
Magna Sirgas coordinates origin West: X 963594.61 Y 612251.38
PK 12+300
Source: Géminis Consultores Ambientales, 2016.

Forest plantation [3.1.5.]: Cover made up of tree plantations by direct intervention of man for forest management purposes. In this process, forest patches have been created, established by plantation and/or planting during the reforestation process for the production of wood (commercial plantations) or environmental assets and services (protective plantations).

The cover of forest plantations occupies 1.74% of the area of the functional unit, made up mainly of the species *Eucalyptus globulus Labill.* (Eucalyptus). (See Photo 5.2.8).

Photo 5.2.8. Forest plantation, functional unit 4.
Magna Sirgas coordinates origin West: X 963594.61 Y 612251.38
PK 12+300
Source: Géminis Consultores Ambientales, 2016.

- Area with herbaceous and/or shrub-like vegetation. [3.2.]: In functional unit 4, an area of 123.4 ha has been identified, with a percentage of 16.51%, in which there is land that shows natural regeneration and fallowed lands.

Grassland [3.2.1.]: It is characterized by having non-lignified plants that have not been intervened, or whose intervention has been selective without altering their original structure or functional characteristics.

Open grassland [3.2.1.2]: According to the Corine Land Cover *methodology,* this cover is made up of a plant community dominated by typically herbaceous elements developed naturally in different substrates, which form an open cover (occupation of 30% to 70%). These plant formations have not been intervened, or their intervention has been selective without altering their original structure or functional characteristics.

Open rocky grassland [3.2.1.2.2]: These are the areas dominated by natural open herbaceous vegetation. They make up an area of 112.19% of the functional unit. There are no tree elements here. These grasslands are developed on areas with predominantly rocky substrates that do not retain moisture (See Photo 5.2.9).

Photo 5.2.9. Open rocky grassland, functional unit 4.
Magna Sirgas coordinates origin West X 958607.85 Y 608503.40
PK 3 + 200
Source: Géminis Consultores Ambientales, 2016.

Shrubland. [3.2.2.]: These are lands with natural clusters of woody species less than two meters in height.

Dense shrubland [3.2.2.1.]: According to the Corine Land Cover methodology, this cover is made up of a plant community dominated by regularly distributed shrub elements, which make up a discontinuous layer of treetops (canopy) representing between 30% and 70% of the total area of the unit. There are species such as *E. lauroflia*, *B. arbórea and C. tomentosa*, in thick plant conformations, making up a percentage of 1.50% of the functional unit.

- Water surfaces [5]: These are permanent, intermittent and seasonal bodies and channels of water, located within the continent and those that border or run adjacent to the continental coastline.

  - Inland waters [5.1]: These are permanent, intermittent and seasonal bodies of water and water courses that include lakes, lagoons, marshes, reservoirs and natural or artificial fresh water ponds, reservoirs and bodies of water in motion, such as rivers and channels.

Rivers [5.1.1]: This cover is represented mainly by the Guiatara River. It consists of an area of 20.89 ha, which is 2.80% of the functional unit.

o Functional Unit 5

The area of influence of functional unit five (FU5.1) covers 1,186.27 hectares and 22,199 km. On its course, it runs through the municipalities of Tangua and Pasto.

As noted in Table 5.2.4, three (3) of the 17 units of cover that make up the area of influence are Forests and Semi-natural Areas, and eleven (11) are Agricultural Territories. This is because most of the land is being intensively used by the communities in the area.

Table 5.2.4. Land covers identified in functional unit five (FU5.1)

LEVEL				Code	Area (ha)	%
1	2	3	4			
1. ARTIFICIALIZED TERRITORIES	1.1. Urbanized areas	1.1.2. Discontinuous urban fabric		1.1.2	44.6	3.76
	1.2. Industrial or commercial areas and communication networks	1.2.1. Industrial or commercial areas		1.2.1	4.69	0.40
		1.2.2. Road and railway network and associated lands		1.2.2	28.25	2.38
2. AGRICULTURAL TERRITORIES	2.1. Temporary crops	2.1.1. Other temporary crops		2.1.1	15.11	1.27

LEVEL				Code	Area (ha)	%
		2.1.5. Tubers	2.1.5.1. Potato	2.1.5.1	12.03	1.01
	2.2. Permanent crops	2.2.4. Agroforestry crops	2.2.4.1. Planted grass and trees	2.2.4.1	85.28	7.19
			2.2.4.2. Planted crops and trees	2.2.4.2	24.65	2.08
	2.3. Pastures	2.3.1. Clean pastures		2.3.1	98.35	8.29
		2.3.3. Weedy pastures		2.3.3	34.79	2.93
	2.4. Heterogeneous agricultural areas	2.4.1. Patchwork of crops		2.4.1	167.55	14.12
		2.4.2. Patchwork of pastures and crops		2.4.2	351.41	29.62
		2.4.3. Patchwork of crops, pastures and natural space		2.4.3	148.36	12.51
		2.4.4. Patchwork of pastures with natural spaces		2.4.4	128.38	10.82
		2.4.5. Patchwork of crops with natural spaces		2.4.5	10.97	0.92
3. FORESTS AND SEMI-NATURAL AREAS	3.1 Forests	3.1.4. Riparian forest		3.1.4	8.01	0.68
		3.1.5 Forest plantation		3.1.5	12.3	1.04
	3.2. Areas with herbaceous and/or shrub-like vegetation	3.2.2. Shrubland	3.2.2.1. Dense shrubland	3.2.2.1	11.53	0.97
TOTAL					1186.26	100

Source: Géminis Consultores Ambientales, 2016.

As shown in the figure below (Figure 5.2.9), the predominance of Heterogeneous Agricultural Areas is remarkable.

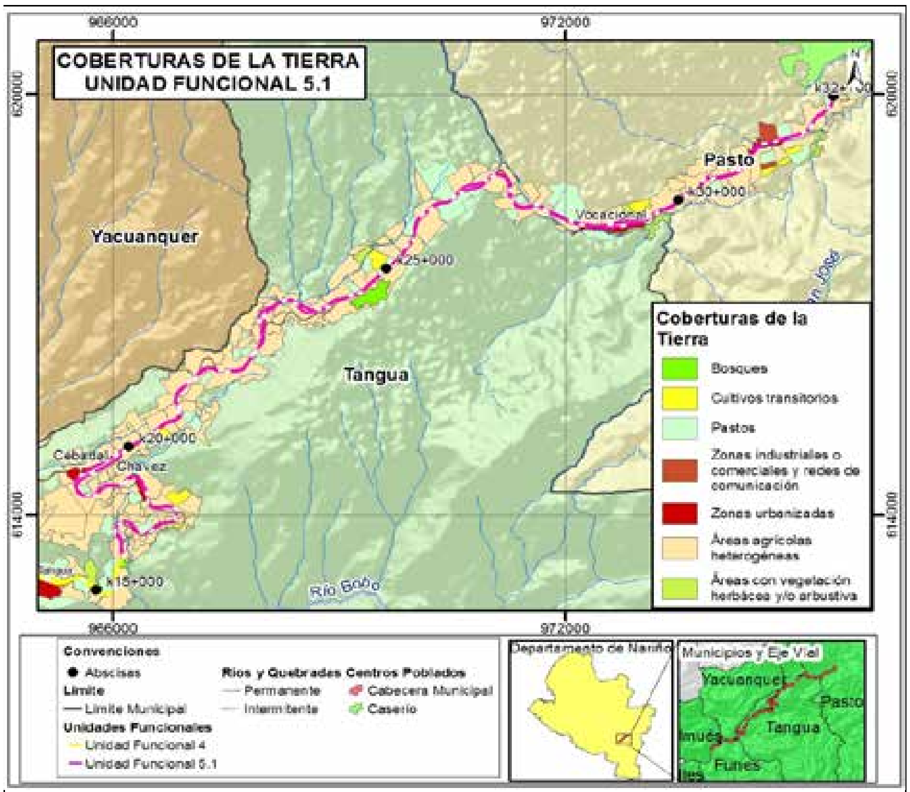


Figure 5.2.9. Land covers present in Functional Unit 5

Source: Géminis Consultores Ambientales, 2016.

See: GDB/cartografía/PDF/EIADCRP_PC_046.

It should be noted, that in order to avoid the saturation of information on the land cover maps presented in this section, the graphical output only shows up to level two, as they are only intended as a general illustration for the reader. However, it is important to clarify that the text and cartographic annexes provide detailed information thereof, up to the highest level.

The following is a description of each of the covers located in the area of influence of this functional unit.

- Artificialized territories [1]: Artificialized territories are in low space proportion, since the area where functional unit 5 is located is mainly rural.

  - Urbanized areas [1.1.]: Include hamlets and peasant communities in districts and townships of the municipalities of Tangua and Pasto.

Discontinuous urban fabric [1.1.2.]: It makes up an area of 3.76% of the functional unit. It is made up of peasant-type homes, in materials such as cement, brick or mud, with their respective gardens, orchards, trails and small schools and chapels, scattered among vegetation covers. This cover can be found in districts such as El Tambor and El Cebadal, in the municipality of Tangua, and in Catambuco township, in the municipality of Pasto. (See Photo 5.2.10).

Photo 5.2.10. Discontinuous urban fabric, Catambuco township, municipality of Pasto-Nariño. PK 36+200
Magna Sirgas coordinates origin West X 976973.68 Y 622213.05
Source: Géminis Consultores Ambientales, 2016.

- Industrial or commercial areas and communication networks. [1.2.]: Catambuco township has increasingly concentrated industrial and commercial type infrastructure associated with the regional and national economy.

Industrial or commercial areas [1.2.1.]: Represented by 0.40% of the total area. This cover includes warehouses and factories of different companies. (See Photo 5.2.11).

Photo 5.2.11. Bavaria Brewery Distribution Center, Catambuco Township, municipality of Pasto.
PK 31+900
Magna Sirgas coordinates origin West X 974480 Y 619216
Source: Géminis Consultores Ambientales, 2016.

Road and railway network and associated lands [1.2.2]: The area of the road network and associated land is occupied by the existing road, returns and roundabouts in the Catambuco sector, with 2.38% of the total cover. (See Photo 5.2.12).

Photo 5.2.12. Road and railway network and associated lands, Catambuco Township, municipality of Pasto. PK 33+200
Magna Sirgas coordinates origin West X: 975649; Y: 620233
Image taken from Google Earth, 2016.

ü Agricultural territories [2.]: These territories constitute most of the area of the functional unit, as they are located in the rural areas of the municipalities of Tangua and Pasto. They occupy 90.76% of the total area of influence of this functional unit, which shows intensive use of the territory by agricultural activities and a low representation of natural covers.

Ø Temporary crops. [2.1.]: They are the most common in the sector, with crops that are harvested on a quarterly and semi-annual basis, such as potato, vegetables and grains.

Other temporary crops. [2.1.1.]: This classification includes covers such as fodder, mainly pastures, such as *Dactylis glomerata* (orchard grass) and fallows of several crops, this cover occupies 1.27% of the functional unit. (See Photo 5.2.13).

Photo 5.2.13. Wheat fallow, El Cebadal district, municipality of Tangua-Nariño. PK19+100
Magna Sirgas coordinates origin West X 965564.86 Y 614274.73
Source: Géminis Consultores Ambientales, 2016.

Tubers. [2.1.5.]: In the municipalities of Tangua and Pasto, a variety of tubers are grown for household consumption, such as *Oxalis tuberosa* (Oca) and *Ullucus tuberosus* (Ulluco) and commercially, *Solanum tuberosum* (potato).

Potato [2.1.5.1.]: There are. *S. tuberosum* crops in functional unit 5, as one of the most extensive commercial crops in the cold area of the Department of Nariño. This crop currently covers 1.01% of the total area. (See Photo 5.2.14)

Photo 5.2.14. Potato crop, Catambuco Township, municipality of Pasto
PK 28+800
Magna Sirgas coordinates origin West X: 972087; Y: 618144
Source: Géminis Consultores Ambientales, 2016.

Agroforestry crops [2.2.4.]: These are areas occupied by arrangements or combinations of crops of different species, with herbaceous, shrub and arboreal habits, where the main characteristic of the cover is the fact that the increase in detail does not imply the subdivision in pure units, because they are combined in the same area, alternated by furrows or rows of trees with crops or trees with grasses. The area of these crops as a percentage of the functional unit is 9.27%.

Planted pastures and trees [2.2.4.1.]: Cover occupied by spatial arrangements where pastures for livestock are combined with tree plantations for all kinds of production, often called silvopastoral practices. Their area as a percentage of the functional unit is 7.19%.

Planted crops and trees [2.2.4.2.]: Cover occupied by spatial arrangements where crops are combined with tree plantations for all kinds of production (wood for construction, wood-based bioenergy, fruit trees, etc.). The area of these crops as a percentage of the functional unit is 2.08%.

- Pastures. [2.3.]: In addition to agriculture, livestock is an important part of the peasant economy in the area of the functional unit. Therefore, grazing lands have been established with species, such as *Pennisetum clandestinum (*Kikuyu grass*)* and *Lolium multiflorum* (Ray grass) as well as several pastures, such as *Axonopus scoparius* (Imperial grass), mainly used to feed cattle.

Clean pastures [2.3.1.]: The areas covered by clean pastures represent 8.29% of functional unit 5. (See Photo 5.2.15)

Photo 5.2.15. Clean pastures, Catambuco Township, municipality of Pasto.
PK 31+700
Magna Sirgas coordinates origin West X 974613.95 Y 619294.04
Source: Géminis Consultores Ambientales, 2016.

Weedy pastures [2.3.3.]: This type of cover receives little management on the part of the farmer, as you can see the free growth of grass and shrub species on the land. It covers 2.93% of the functional unit. (See Photo 5.2.16)

Photo 5.2.16. Weedy pastures, Catambuco Township, municipality of Pasto.
PK 32+100
Magna Sirgas coordinates origin West X 974847.68 Y 619349.31
Source: Géminis Consultores Ambientales, 2016.

- Heterogeneous agricultural areas. [2.4.]: These areas are predominant in this functional unit, with a greater proportion of patchworks of pastures and crops.

Patchwork of crops [2.4.1.]: Represents 14.12% of the cover occupied by the functional unit, where crops, such as *Solanum tuberosum* (potato), *Daucus carota* (carrot), *Brassica oleracea var. capitata* (cabbage), *Allium fistulosum* (onion), *Brassica oleracea var. italica* (broccoli), *Zea mais* (maize), *Ullucus tuberosus* (Ulloco), *Triticum aestivum* (wheat), *Hordeum vulgare* (barley) and *Avena sativa* (oats) stand out, as illustrated in Photo 5.2.17.

Photo 5.2.17. Patchwork of crops, El Cebadal district, municipality of Tangua-Nariño. PK 20+800
Magna Sirgas coordinates origin West X: 966833; Y: 615291
Source: Géminis Consultores Ambientales, 2016.

Patchwork of pastures and crops [2.4.2.]: The patchworks of pastures and crops are small areas of pastures, interspersed between crops of *Solanum tuberosum*, vegetables and grains, which make up 29.62% of the total area. (See Photo 5.2.18).

Photo 5.2.18. Patchwork of pastures and crops, El Cebadal district, municipality of Tangua-Nariño. PK 17+200
Magna Sirgas coordinates origin West X 966432.95 Y 613721.75
Source: Géminis Consultores Ambientales, 2016.

Patchwork of crops, pastures and natural space. [2.4.3.]: Due to the possession of the land in smallholdings and microholdings in the area, the division of lots and plots for the different activities is carried out in very small proportions. The patchworks represent 12.51% of the total cover, where small plots of crops (mainly vegetables and tubers) are adjacent to area of natural and cultivated pastures and groups of shrub species, such as *Baccharis latifolia (Ruiz & Pav.) Pers.* (Coyote bush*)*, *Sambucus sp. (*Elderberry), *Euphorbia lauroflia* (Pillo or Lechero*)* and *Mimosa quitensis Benth* (Guarango). (See Photo 5.2.19)

Photo 5.2.19. Patchwork of crops, pastures and natural spaces, Catambuco Township, municipality of Pasto.
PK 30+800
Magna Sirgas coordinates origin West X: 966833; Y: 615291
Source: Géminis Consultores Ambientales, 2016.

Patchwork of pastures with natural space [2.4.4.]: These include sectors where there are interspersed pastures with clusters of grassland and shrub species, and trees to a lesser extent. This unit of cover occupies 10.82% of the total area of the functional unit, in which there are combined areas of natural or cultivated pastures, with naturally growing lots of *B. latifolia*, *Sambucus sp.*, *E. lauroflia* and *C. espinosa*. (See Photo 5.2.20)

Photo 5.2.20. Patchwork of pastures with natural spaces , Chávez district, municipality of Tangua.
PK 16+800
Magna Sirgas coordinates origin West X 966143.53 Y 613434.29
Source: Géminis Consultores Ambientales, 2016.

Patchwork of crops with natural spaces. [2.4.5.]: Sector where the lands are covered by crops, separated by small forests or relict forests The patchwork of crops and natural shrub and/or herbaceous spaces represent 0.92% of the total cover, where small plots of crops (mainly vegetables and tubers) contain groups of shrub species in hedges, including *Baccharis latifolia (Ruiz & Pav.) Pers.* (Coyote bush*)*, *Sambucus sp. (*Elderberry), *Euphorbia lauroflia* (Pillo or Lechero*)* and *Mimosa quitensis Benth* (Guarango).

- Forests and semi-natural areas. [3.]: This class includes the areas where forest, shrub or grass species of natural growth prevail, along with forest plantations, secondary vegetation or vegetation in transition. This cover makes up an area of 31.84 ha, corresponding to a percentage of 2.69%.

Forests are tree clusters, which may be natural or planted.

Riparian forest [3.1.4.]: These covers are made up of arboreal vegetation located on the borders of permanent or temporary watercourses. This type of cover is limited by its size, as it runs along watercourses and natural drains. This cover makes up an area of 0.68% of the area of study. It is important to mention that the areas of riparian forest in this functional unit are small; their composition and structure has been altered by the planting of introduced species, mainly eucalyptus, so it is common in these forests that the lower strata are dominated by native species and the upper strata by very large eucalyptus trees that are often scattered (See Photo 5.2.21).

Photo 5.2.21. Riparian forest, Catambuco Township, municipality of Pasto.
PK 30+000
Magna Sirgas coordinates origin West X: 973356; Y: 618343
Source: Géminis Consultores Ambientales, 2016.

Forest plantation [3.1.5.]: The cover of forest plantations occupies 1.04% of the area of Functional Unit 5, made up mainly of monoculture plantations of the species *Eucalyptus globulus Labill.* (Eucalyptus).

- Area with herbaceous and/or shrub-like vegetation. [3.2.]: In functional unit 5, areas are identified where this use is not very extensive, due to anthropogenic pressure exerted in the area, where natural regeneration and fallow lands are minimal. This cover makes up an area of 11.53 ha, corresponding to a percentage of 0.97%.

Shrubland. [3.2.2.]: These are lands with natural clusters of woody species less than two meters in height.

Dense shrubland [3.2.2.1.]: In this cover, the species observed include *Miconia theaezans (*Morochillo*), Hesperomeles glabrata (*Cerote*), Baccharis latifolia (Ruiz & Pav.) Pers. (*Coyote bush*), Lantana camara* (Big sage*)* in thick plant conformations, making up a percentage of 0.97% of the functional unit. (See Photo 5.2.22).

Photo 5.2.22. Dense shrubland, El Cebadal district, municipality of Tangua. PK 317+200
Magna Sirgas coordinates origin West X 966722.34 Y 613865.4725
Source: Géminis Consultores Ambientales, 2016.

- Flora and Fauna

o Flora

The characterization of the flora in the biotic area of influence (AI) and in the area of intervention was carried out based on sampling for both forest and epiphytic species.

Inventory of species per unit of cover and ecosystem

In order to learn the current status of the flora component in the areas of influence and the areas of intervention of the Pedregal-Catambuco sector, stratified sampling was carried out by randomly selecting plots in each of the ecosystems with the presence of forest elements (susceptible to analysis in terms of structure and based on the use of ecological indicators), considering the stem stratum to determine the composition and structure of the plant, pole and sapling masses for the analysis of natural generation; in the latter case, samples were taken in the natural and planted forests as well as in shrub masses.

In Chapter 2 of this assessment (Overview), Section 2.3.2.2 discusses the methodological process used for the following characterization. Annex 5.2.1 discusses the results of pre-sampling, determination of sample size, calculation of error, which were carried out in order to establish the representativeness of the information contained in this section.

Sampling Points

Below is a list of the location of the plots in functional units 4 and 5 for the characterization of the area of influence (Table 5.2.5), in accordance with the size of the sample defined in pre-sampling, which is included in Annex 5.2.1.

Table 5.2.5 Plots by cover and ecosystem, area of influence of the Pedregal-Catambuco Sector.

Ecosystem	ID	Sector	PK	X	Y
				Magna Sirgas West	
Middle Andean Orobiome					
Pasture covered by trees	Z4-4	Lower Inantas (Yacuanquer)	5+200	960611.3442	608857.0169
Patchwork of crops, pastures and natural space	4-243-PP1-AI	Lower Inantas (Yacuanquer)	4+300	959981.7381	608186.2196
	4-243-PP2-AI	Lower Inantas (Yacuanquer)	5+400	960911.8503	608757.4637
	4-243-PP3-AI	El Tablon (Tangua)	7+250	961156.8538	609973.78

Ecosystem	ID	Sector	PK	X	Y
				Magna Sirgas West	
	4-243-PP4-AI	El Tablon (Tangua)	9+100	961958.7931	610031.0791
Patchwork of pastures and crops	4-2.4.2-PP1-AI	Pilcuan (Imués)	0+400	957202.1261	606973.2987
	4-2.4.2-PP2-AI	Lower Inantas (Yacuanquer)	4+600	960310.7633	608304.1673
	4-2.4.2-PP3-AI	Lower Inantas (Yacuanquer)	5+000	960702.2396	608514.882
	4-2.4.2-PP4-AI	Municipal Center (Tangua)	13+200	964062.1393	612782.1037
	5-2.4.2-PP1-AI	Chavez (Tangua)	18+200	966212.2898	614562.16
	5-2.4.2-PP2-AI	El Cebadal (Tangua)	18+600	965893.8798	614445.42
Patchwork of pastures with natural spaces	4-244-PP1-AI	El Pedregal (Imués)	1+900	958262.7164	607718.3495
	4-244-PP2-AI	Cocha Verde (Tangua)	8+400	961878.6979	609412.0799
	4-244-PP3-AI	San Pedro (Tangua)	11+500	962915.6443	611941.8472
	4-244-PP4-AI	El Vergel (Tangua)	14+600	965404.6871	613117.3399
	5-244-PP1-AI	Chavez (Tangua)	16+500	966283.3099	613738.97
Planted grass and trees	4-2241-PP1-AI	El Tablon (Tangua)	7+700	961401.6802	609630.9645
	4-2241-PP2-AI	San Pedro (Tangua)	10+500	962282.3768	611288.2993
	4-2241-PP3-AI	San Pedro (Tangua)	12+500	963538.9878	612450.431
Patchwork of crops and natural spaces	4-245-PP1-AI	Cocha Verde (Tangua)	8+000	961622.9157	609329.6182
	4-245-PP2-AI	San Pedro (Tangua)	9+900	962100.4479	610735.7682
Planted crops and trees	4-2242-PP1-AI	El Pedregal (Imués)	0+800	957403.1945	607415.5828
	4-2242-PP2-AI	Lower Inantas (Yacuanquer)	3+800	959464.8592	608293.2075
Riparian forest	4-314-PP1-AI	Lower Inantas (Yacuanquer)	6+100	961101.1598	609597.8254
	4-314-PP2-AI	Lower Inantas (Yacuanquer)	6+200	961145.6671	609476.1859
	4-314-PP5-AI	Lower Inantas (Yacuanquer)	6+400	609387.7258	961134.5268
Forest plantation	4-315-PP1-AI	San Pedro (Tangua)	11+700	963227.28	611864.4095

Ecosystem	ID	Sector	PK	X	Y
				Magna Sirgas West	
	4-315-PP2-AI	El Vergel (Tangua)	12+700	963639.1673	612527.8236
	4-315-PP5-AI	El Cebadal	15+600	966065.6034	613235.2568
Dense shrubland	4-3221-PP1-AI	El Vergel (Tangua)	14+000	964841.2852	613146.9228
	5-3221-PP1-AI	Chavez (Tangua)	17+100	975320.1938	619269.076
Upper Andean Orobiome					
Patchwork of crops, pastures and natural space	5-243-PP1-AI	El Cebadal (Tangua)	20+200	966388.5613	615059.7319
	5-243-PP2-AI	Vocacional (Pasto)	30+400	973811.889	618751.06
Patchwork of pastures and crops	5-2.4.2-PP3-AI	El Páramo (Tangua)	25+100	969672.1428	617547.3701
	5-2.4.2-PP4-AI	Vocacional (Pasto)	29+300	972933.8695	618176.75
	5-2.4.2-PP5-AI	Vocacional (Pasto)	29+600	973193.5797	618318.02
	5-2.4.2-PP6- AI	La Merced (Pasto)	31+000	974334.4450	618886.1457
	5- 2.4.2-PP7- AI	La Merced (Pasto)	31+150	974417.9201	619042.8001
Patchwork of pastures with natural spaces	5-244-PP1-AI	Chavez (Tangua)	16+500	966283.3099	613738.97
	5-244-PP2-AI	El Tambor (Tangua)	21+700	967245.6929	616264.93
Planted pastures and trees	5-2241-PP1-AI	El Tambor (Tangua)	20+900	966948.1995	615501.9797
	5-2241-PP2-AI	El Tambor (Tangua)	22+100	967606.7802	616088.5799
	5-2241-PP3-AI	La Palizada (Tangua)	27+200	970961.4328	618809.6963
	5-2241-PP4-AI	Catambuco (Pasto)	31+800	974968.2494	619359.13
Forest plantation	5-315-PP1-AI	El Páramo (Tangua)	24+650	969393.8648	617226.73
	5-315-PP2-AI	El Páramo (Tangua)	24+650	969371.6071	617248.8399
Dense shrubland	5-3221-PP2-AI	Catambuco (Pasto)	32+100	975255.816	619460.513
Riparian forest	5-3.1.4-PP1-AI	Vocacional (Pasto)	29+500	973187.9043	618195.2528
	5-3.1.4-PP2-AI	Vocacional (Pasto)	29+600	973212.1702	618228.9763
	5-3.1.4-PP3-AI	Vocacional (Pasto)	29+700	973289.417	618296.5316
	5-3.1.4-PP4-AI	Vocacional (Pasto)	29+100	618033.6314	972710.6426

Source: Géminis Consultores Ambientales, 2016

As listed in the table above, in the area of influence 31 plots were made in the Middle Andean Orobiome and 20 plots were made for the Upper Andean Orobiome. A total of 51 plots were made for the entire project. See map EIADCRP_IP_026 attached hereto.

Composition and Structure

With the units of cover identified for the two biomes in the project's area of influence, a total of 17 ecosystems were found with the presence of tree species, either in stem, pole or sapling stage; of these, only four corresponded to homogeneous tree areas (natural forests or planted trees), two were shrubs and the others were patchworks and cultivated areas with the presence of planted trees.

The structure analysis does not apply to the latter, because the tree masses are highly intervened, with no characteristics of a continuous forest; therefore, only the floristic composition was completed.

In each of the ecosystems of the road corridor, the successional state of the natural plant masses present were taken into account, followed by their distribution for the structural analysis, either for the stem, pole or sapling stages.

To this effect, ecosystems with the possibility of succession processes were identified, which are those that suffer less alteration due to human activity; after that, the ecosystems related to patchworks and cultivated areas are discarded, because in order to carry out agricultural activities, the emergence of new plants in these areas is avoided, thus allowing the presence of tree species in small masses or lines, in sectors that are not suitable for production, boundaries, hedges and small areas for the protection of water sources, so there is no natural successional process, and there is a clear selection of species according to the preference of the agricultural producer.

As for the remaining ecosystems, there was evidence of the presence of forest in the early and middle successional state in the project's area of influence, as is the case of the riparian forest.

Another natural cover present in the area is dense shrubland, which shows that there is no successional process toward the formation of a forest here, given the absence of tree habit species.

As regards the floristic composition, 94 species were reported in the sampling area, among which there are mostly tree, shrub and several herbaceous species, in addition to agricultural species and those for livestock use in the case of patchworks.

In addition, the calculation of the blend coefficients or "floristic heterogeneity factor" (C.M.) was considered, which consists of dividing the number of species found in the sample by the total number of individuals, indicating heterogeneity or homogeneity.

Below is the characterization of each of the ecosystems mentioned above:

Floristic Composition

Wooded pastures of the Middle Andean Orobiome (20232)

In this ecosystem, which has a high degree of anthropogenic intervention, there were seven tree species, belonging to seven different families, showing a clear predominance of fruit species (Table 5.2.6).

Considering the number of individuals found in the sample and the number of species, it can be said that the wooded pastures of the Middle Andean Orobiome is highly heterogeneous, with a CM of 1/8.29 due to the few individuals per unit of area and several species.

Table 5.2.6. Floristic composition in the wooded pasture ecosystem of the Middle Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Avocado	*Persea americana* Mill.	Lauraceae	3

2	Cherimoya	*Annona cherimola* Mill	Annonaceae	14
3	Shimbillo	*Inga spectabilis* (Vahl) Willd.	Mimosaceae	4
4	Common guava	*Psidium guajava* L.	Myrtaceae	1
5	Guayacan	*Lafoensia acuminata (Ruiz & Pav.) DC.*	Lythraceae	2
6	Orange	*Citrus sinensis* (L.) Osbeck	Rutaceae	1
7	Chinese ash	*Fraxinus chinensis* Roxb.	Oleaceae	33
			Total	**58**
			CM	**1/8.29**

Source: Géminis Consultores Ambientales, 2016

Patchwork of pastures and crops with natural spaces of the Middle Andean Orobiome (202241)

As can be seen in Table 5.2.7Table 5.2.7, the sample taken showed a total of 12 species, belonging to 12 different families, predominated as expected by shrub-like tree species, such as *Baccharis latifolia* (Ruiz & Pav.) Pers.

Although this ecosystem has been intervened, it is heterogeneous according to the blend ratio, at 1/14.75, i.e. for every 15 individuals, there is one new species.

Table 5.2.7. Floristic composition in the ecosystem Patchwork of pastures and crops with natural spaces of the Middle Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Coyote bush	*Baccharis latifolia* (Ruiz & Pav.) Pers.	Asteraceae	21
2	Cherimoya	*Annona cherimola* Mill	Annonaceae	1
3	Common guava	*Psidium guajava* L.	Myrtaceae	2
4	Guayacan	*Lafoensia speciosa* (Kunth) DC.	Lythraceae	3
5	Big sage	*Lantana camara L.*	Verbenaceae	1
6	Lechero	*Euphorbia laurifolia* Juss. ex Lam.	Euphorbiaceae	4
7	Leucaena	*Leucaena leucocephala* (Lam.) de Wit	Fabaceae	74
8	Loquat	*Eriobotrya japonica (Thunb.) Lindl.*	Rosaceae	3
9	Yellow	*Tecoma stans* (L.) Juss. ex Kunth	Bignonaceae	56

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
	trumpetbush			
10	Rose mallow	Hibiscus sp	Malvaceae	2
11	Elderberry	*Sambucus nigra* L.	Caprifoliaceae	7
12	Zancia	*Coriaria ruscifolia* L.	Coriariaceae	3
			Total	**177**
			CM	**1/14.75**

Source: Géminis Consultores Ambientales, 2016

There is a variety of cultivable species in the patchworks of this type, both with tree as well as shrub spaces, with extensions ranging from a few square meters to one hectare; in the middle orobiome, there are temporary and permanent crops and several pastures, as illustrated in Table 5.2.8.

Table 5.2.8. Cultivated species in ecosystems of Patchwork of pastures and crops with natural spaces of the Middle Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY
1	Coffee	*Coffea arabica*	Rubiaceae
2	Bean	*Phaseolus vulgaris*	Fabaceae
3	Maize	*Zea mays* L.	Poaceae
4	Potato	*Solanum tuberosum*	Solanaceae
5	Pea	*Pisum sativum*	Fabaceae
6	Barley	*Hordeum vulgare*	Poaceae
7	Wheat	*Triticum aestivum* L.	Poaceae
8	Raspberry	*Rubus glaucus Benth*	Rosaceae
9	Arracacha	*Arracacia xanthorrhiza.*	Apiaceae
10	Lima bean	*Vicia faba*	Fabaceae
11	Ulluco	*Ullucus tuberosus*	Basellaceae
12	Cabbage	*Brassica oleracea var. capitata*	Cruciferae
13	Lettuce	*Lactuca sativa L.*	Cichorioideae
14	Kikuyu grass	*Pennisetum clandestinum*	Poaceae

No.	COMMON NAME	SPECIES	FAMILY
15	Ryegrass	Lolium perenne	Poaceae
16	Yorkshire fog	*Holcus lanatus*	Poaceae

Source: Géminis Consultores Ambientales, 2016

Patchwork of pastures and crops of the Middle Andean Orobiome (202.4.2)

In the Patchwork of pastures and crops of the Middle Andean Orobiome, a total of 19 species were found, predominated by the Rutaceae family with three species and the Myrtaceae family with two species. It is important to point out that, in this ecosystem, since it has been highly intervened, there is a wide variety of fruit trees forming the tree masses. (See Table 5.2.9Table 5.2.9).

This ecosystem is highly heterogeneous with a BR of 1/10.74; in the case of the patchworks with a wide variety of species, this is more related to human action than to natural processes.

Table 5.2.9. Floristic composition in the ecosystem Patchwork of pastures and crops of the Middle Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Avocado	Persea americana Mill.	Lauraceae	9
2	Cherimoya	Annona cherimola L.	Annonaceae	36
3	White cedar	Cupressus lusitanica Mill.	Cupressaceae	13
4	Eucalyptus	Eucalyptus globulus Labill.	Myrtaceae	40
5	Shimbillo	Inga spectabilis (Vahl) Willd.	Mimosaceae	4
6	Tara	Caesalpinia spinosa (Molina) Kuntze	Caesalpiniaceae	10
7	Common guava	Psidium guajava L.	Myrtaceae	18
8	Guayacan	Lafoensia speciosa (Kunth) DC.	Lythraceae	1
9	Lemon	Citrus limon (L.) Osbeck	Rutaceae	4
10	Maco	Cabralea oblongifoliola C.DC.	Meliaceae	2

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
11	Tangerine	Citrus reticulata Blanco	Rutaceae	3
12	Nacedero	Trichanthera gigantea (Humb. & Bonpl.) Nees	Acanthaceae	2
13	Orange	Citrus sinensis (L.) Osbeck	Rutaceae	4
14	Loquat	Eriobotrya japonica (Thunb.) Lindl.	Rosaceae	1
15	Patula pine	Pinus patula Schiede ex Schltdl. & Cham.	Pinaceae	34
16	Yellow trumpetbush	Tecoma stans (L.) Juss. ex Kunth	Bignonaceae	5
17	Sachapanga	Siparuna echinata (Kunth) A. DC.	Siparunaceae	8
18	Elderberry	Sambucus nigra L.	Caprifoliaceae	3
19	Chinese ash	Fraxinus chinensis Roxb.	Oleaceae	7
			Total	204
			CM	1/10.74

Source: Géminis Consultores Ambientales, 2016

Patchwork of pastures with natural spaces of the Middle Andean Orobiome (20244)

The Table 5.2.10. Composición florística en el Ecosistema Mosaico de pastos con espacios naturales del orobioma medio de los Andessample for this ecosystem showed a total of 16 species, predominated by the families Asteraceae, Myrtaceae, and Fabaceae with two species each.

The BR for this case is 1/9.05, concluding that for every nine individuals, one new species could be found.

Table 5.2.10. Floristic composition in the ecosystem Patchwork of pastures with natural spaces of the Middle Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Carbonero	*Albizia carbonaria* Britton	*Mimosaceae*	1
2	Coyote bush	*Baccharis latifolia* (Ruiz & Pav.) Pers.	*Asteraceae*	26
3	Colla	*Dendrophorbium lloense* (Hieron. ex Sodiro) C.Jeffrey	*Asteraceae*	3
4	Cordoncillo	*Piper bogotence* C.DC.	*Juglandaceae*	4
5	Cucharo	*Myrsine guianensis* (Aubl.) Kuntze	*Myrsinaceae*	5
6	Tara	*Caesalpinia spinosa*(Molina) Kuntze	*Caesalpiniaceae*	1
7	Common guava	*Psidium guajava* L.	*Myrtaceae*	2
8	Guayabillo	*Psidium acutangulum* Mart. ex DC.	Myrtaceae	1
9	Guayacan	*Lafoensia speciosa* (Kunth) DC.	*Lythraceae*	5
10	Lechero	*Euphorbia laurifolia* Juss. ex Lam.	*Euphorbiaceae*	50
11	Mayorquín	*Cordia divaricata* Kunth.	*Boraginaceae*	4
12	Morochillo	*Miconia theaezans* (Bonpl.) Cogn.	*Melastomataceae*	6
13	Pichuelo	*Senna spectabilis* (DC.) H.S.Irwin & Barneby	*Fabaceae*	5
14	Pispura	*Dalea coerulea* (L.f.) Schinz & Thell.	*Fabaceae*	11
15	Yellow trumpetbush	*Tecoma stans* (L.) Juss. ex Kunth	Bignonaceae	6
16	Elderberry	*Sambucus nigra* L.	*Caprifoliaceae*	9
			Total	**139**
			CM	**1/7.32**

Source: Géminis Consultores Ambientales, 2016

In Table 5.2.11. Especies cultivadas en ecosistemas de Mosaico de pastos con espacios naturales del orobioma medio de los Andes there are three pasture species found in the area of influence, within the ecosystems of the patchwork of pastures with natural spaces of the Middle Andean Orobiome.

Table 5.2.11. Cultivated species in ecosystems of Patchwork of pastures with natural spaces of the Middle Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY
1	Kikuyu grass	*Pennisetum clandestinum*	Poaceae

2	Ryegrass	Lolium perenne	Poaceae
3	Yorkshire fog	*Holcus lanatus*	Poaceae

Source: Géminis Consultores Ambientales, 2016

Planted pastures and trees of the Middle Andean Orobiome (202242)

This ecosystem is known for its highly intervened characteristics. However, it has a large number of species in its wooded spaces (orchards, boundaries and hedges) at a total of 16, among which the Asteraceae and Myrtaceae families stand out with two species each. (See Table 5.2.12)

The BR for this ecosystem is 1/6.81, indicating species heterogeneity.

Table 5.2.12. Floristic composition in the ecosystem of pastures with planted trees of the Middle Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Black wattle	*Acacia decurrens* Willd.	Fabaceae	2
2	Caspirosario	*Llagunoa nitida* Ruiz & Pav	Sapindaceae	1
3	Coyote bush	*Baccharis latifolia* (Ruiz & Pav.) Pers.	Asteraceae	6
4	Colla	*Dendrophorbium lloense* (Hieron. ex Sodiro) C.Jeffrey	Asteraceae	1
5	Cucharo	*Myrsine guianensis* (Aubl.) Kuntze	Myrsinaceae	7
6	Eucalyptus	*Eucalyptus globulus* Labill.	Myrthaceae	27
7	Soursop	*Annona muricata* L.	Annonaceae	1
8	Common guava	*Psidium guajava* L.	Myrtaceae	22
9	Guayacan	*Lafoensia acuminata (Ruiz & Pav.) DC.*	Lythraceae	6
10	Lechero	*Euphorbia laurifolia* Juss. ex Lam.	Euphorbiaceae	1
11	Mayorquín	*Cordia divaricata* Kunth	Boraginaceae	5
12	Morochillo	*Miconia theaezans* (Bonpl.) Cogn.	Melastomataceae	5

13	Pichuelo	*Senna spectabilis* (DC.) H.S.Irwin & Barneby	Fabaceae	10
14	Patula pine	*Pinus patula* Schiede ex Schltdl. & Cham.	Pinaceae	7
15	Yellow trumpetbush	*Tecoma stans* (L.) Juss. ex Kunth	Bignonaceae	5
16	Elderberry	*Sambucus nigra* L.	Caprifoliaceae	3
			Total	**109**
			CM	**1/6.81**

Source: Géminis Consultores Ambientales, 2016

Patchwork of crops with natural spaces of the Middle Andean Orobiome (20245)

As illustrated inTable 5.2.13, eight species were found in the shrub masses of this ecosystem, including two species of tree habits in the pole and sapling stages, predominated by Asteraceae with two species.

With a BR of 1/3.13, there is a high level of heterogeneity of species, given that in a count of few individuals, there is a considerable number of species.

Table 5.2.13. Floristic composition in the ecosystem Patchwork of crops with natural spaces of the Middle Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Cerote	Hesperomeles obtusifolia (DC.) Lindl.	Rosaceae	1
2	Coyote bush	*Baccharis latifolia* (Ruiz & Pav.) Pers.	Asteraceae	14
3	Colla	*Dendrophorbium lloense* (Hieron. ex Sodiro) C.Jeffrey	Asteraceae	1
4	Cueche	*Piper catripense* Yunck.	Piperaceae	1
5	Morochillo	*Miconia theaezans* (Bonpl.) Cogn.	Melastomataceae	2
6	Pichuelo	*Senna spectabilis* (DC.) H.S.Irwin & Barneby	Fabaceae	2
7	Yellow trumpetbush	Tecoma stans (L.) Juss. ex Kunth	Bignonaceae	3
8	Elderberry	*Sambucus nigra* L.	Caprifoliaceae	1
			Total	**25**
			CM	**1/3.13**

Source: Géminis Consultores Ambientales, 2016

The covers of the patchwork of crops with natural tree, as well as shrub spaces in the Middle Andean Orobiome, in addition to the species of these spaces, show a variety of agricultural species, as illustrated in Table 5.2.14.

Table 5.2.14. Cultivated species in ecosystems of Patchwork of crops with natural spaces of the Middle Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY
1	Bean	*Phaseolus vulgaris*	Fabaceae
2	Maize	*Zea mays* L.	Poaceae
3	Potato	*Solanum tuberosum*	Solanaceae
4	Pea	*Pisum sativum*	Fabaceae
5	Barley	*Hordeum vulgare*	Poaceae
6	Wheat	*Triticum aestivum* L.	Poaceae
7	Raspberry	*Rubus glaucus Benth*	Rosaceae
8	Lima bean	*Vicia faba*	Fabaceae
9	Ulluco	*Ullucus tuberosus*	Basellaceae
10	Cabbage	*Brassica oleracea var. capitata*	Cruciferae
11	Lettuce	*Lactuca sativa L.*	Cichorioideae

Source: Géminis Consultores Ambientales, 2016

Crops with planted trees of the Middle Andean Orobiome (202242)

The wooded spaces of this ecosystem have 12 different species, predominated by the Rutaceae family with three exponents. It is important to note that half of the species found are fruit trees. (See Table 5.2.15)

The blend ratio is 1/8.52, indicating a high level of heterogeneity of the species in this patchwork.

Table 5.2.15. Floristic composition in the ecosystem of crops with planted trees of the Middle Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Avocado	*Persea americana* Mill.	Lauraceae	7
2	Carbonero	*Albizia carbonaria*Britton	Mimosaceae	5
3	Cedar	*Cedrela odorata* L.	Meliaceae	6
4	Cherimoya	*Annona cherimola* Mill.	Annonaceae	56
5	Common guava	*Psidium guajava* L.	Myrtaceae	9
6	Guayacan	*Lafoensia acuminata (Ruiz & Pav.) DC.*	Lythraceae	11
7	Castorbean	*Ricinus communis* L.	Euphorbiaceae	1
8	Lemon	*Citrus limon* (L.) Osbeck	Rutaceae	1
9	Orange	*Citrus sinensis* (L.) Osbeck	Rutaceae	2
10	Loquat	*Eriobotrya japonica* (Thunb.) Lindl.	Rosaceae	1
11	Pichuelo	*Senna spectabilis* (DC.) H.S.Irwin & Barneby	Fabaceae	1
12	Elderberry	*Sambucus nigra* L.	Caprifoliaceae	2
			Total	**102**
			CM	**1/8.50**

Source: Géminis Consultores Ambientales, 2016

Riparian forest of the Middle Andean Orobiome (20314)

Since this is an ecosystem in conservation, there is a wider variety of species compared to the others in the area, a total of 14, among which the Myrsinaceae and Melastomataceae families stand out with two species each. In this case, the samples were taken in remote areas of the intervention area, because the representative vegetation of this ecosystem is concentrated in one sector and the rest of the area is made up of planted species (Table 5.2.16).

Given the above, the BR of this ecosystem reflects a certain degree of heterogeneity of species at 1/7.19; however, in the stem stage, there is a strong dominance of the species*Handroanthus chrysanthus* (Jacq.) S.O.Grose (Guayacan amarillo).

Table 5.2.16. Floristic composition in the Riparian Forest ecosystem of the Middle Andean Orobiome

No.	Common Name	SPECIES	FAMILY	No. INDIVIDUALS
1	Balsa	*Ochroma pyramidale* (Cav. ex Lam.) Urb.	Malvaceae	3
2	Charmolan	*Geissanthus serrulatus* (Willd. ex Roem. & Schult.) Mez	Myrsinaceae	1
3	Cordoncillo	*Piper bogotense* C.DC.	Juglandaceae	1
4	Cucharo	*Myrsine guianensis* (Aubl.) Kuntze	Myrsinaceae	10
5	Common guava	*Psidium guajava* L.	Myrtaceae	1
6	Guayacan	*Lafoensia acuminata (Ruiz & Pav.) DC.*	Lythraceae	4
7	Guayacan amarillo	*Handroanthus chrysanthus* (Jacq.) S.O.Grose	Bignoniaceae	75
8	Majua	*Palicourea sp*	Rubiaceae	1
9	Morochillo	*Miconia theaezans* (Bonpl.) Cogn.	Melastomataceae	5
10	Munchiro	*Miconia versicolor* Naudin	Melastomataceae	1
11	Loquat	*Eriobotrya japónica* (Thunb.) Lindl.	Rosaceae	1
12	Pendo	*Citharexylum kunthianum* Moldenke	Verbvenaceae	4
13	Yellow trumpetbush	*Tecoma stans* (L.) Juss. ex Kunth	Bignonaceae	6
14	Chinese ash	*Fraxinus chinensis* Roxb.	Oleaceae	2
			Total	**115**
			CM	**1/7.19**

Source: Géminis Consultores Ambientales, 2016

Forest plantation of the Middle Andean Orobiome (20315)

Although this is a planted forest, the incipient management received by the area is remarkable, given the proliferation of different naturally growing species mixed with the moreabundant species (*Eucalyptus globulus* Labill.); the families that stand out in terms of number of species are Asteraceae, Myrtaceae and fabaceae, with two species each (Table 5.2.17).

In this case, it is clear that the homogeneity of the ecosystem is greater, given the condition of the plantation, at a BR of 1/12.24; what makes it heterogeneous is the presence of opportunistic species in early stages of development, given that the dominant species in this case is *Eucalyptus globulus* Labill.

Table 5.2.17. Floristic composition in the Forest plantation ecosystem of the Middle Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Coyote bush	*Baccharis latifolia* (Ruiz & Pav.) Pers.	Asteraceae	9
2	White cedar	*Cupressus lusitanica* Mill.	Cupressaceae	1
3	Colla	*Dendrophorbium lloense* (Hieron. ex Sodiro) C.Jeffrey	Asteraceae	4
4	Cucharo	*Myrsine guianensis* (Aubl.) Kuntze	Myrsinaceae	4
5	Eucalyptus	*Eucalyptus globulus* Labill.	Myrtaceae	140
6	Guayabillo	*Psidium acutangulum* Mart. ex DC.	Myrtaceae	2
7	Big sage	*Lantana sp*	Verbenaceae	3
8	Lechero	*Euphorbia laurifolia* Juss. ex Lam.	Euphorbiaceae	2
9	Mayorquín	*Cordia divaricata* Kunth.	Boraginaceae	1
10	Morochillo	*Miconia theaezans* (Bonpl.) Cogn.	Melastomataceae	6
11	Walnut	*Juglans neotropica* Diels	Juglandaceae	1
12	Pichuelo	*Senna spectabilis* (DC.) H.S.Irwin & Barneby	Fabaceae	2
13	Patula pine	*Pinus patula* Schiede ex Schltdl. & Cham.	Pinaceae	3
14	Pispura	*Dalea coerulea* (L.f.) Schinz & Thell.	Fabaceae	2
15	Yellow trumpetbush	*Tecoma stans* (L.) Juss. ex Kunth	Bignonaceae	15
16	Sachapanga	*Siparuna echinata* (Kunth) A. DC.	Siparunaceae	3
17	Elderberry	*Sambucus nigra* L.	Caprifoliaceae	10
			Total	208
			CM	**1/12.24**

Source: Géminis Consultores Ambientales, 2016

Dense shrubland of the Middle Andean Orobiome (203221)

On the list of 13 species in this ecosystem, there is no evidence of species with tree habits in early stages of growth, where the Melastomataceae family stands out with three species (Table 5.2.18).

In the case of the dense shrubland ecosystem of the Middle Andean Orobiome, the blend ratio (1/10.93) indicates a certain degree of homogeneity, given that there are shrub species with high multiplication capacity occupying the area with several individuals.

Table 5.2.18. Floristic composition in the dense shrubland ecosystem of the Middle Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Cerote	Hesperomeles obtusifolia (DC.) Lindl.	Rosacea	2
2	Coyote bush	Baccharis latifolia (Ruiz & Pav.) Pers.	Asteraceae	43
3	Colla	Dendrophorbium lloense (Hieron. ex Sodiro) C.Jeffrey	Asteraceae	5
4	Tara	Mimosa quitensis Benth.	Caesalpiniaceae	8
5	Big sage	Lantana camara L.	Verbenaceae	3
6	Lechero	Euphorbia laurifolia Juss. ex Lam.	Euphorbiaceae	9
7	May	Tibouchina lepidota (Bonpl.) Baill.	Melastomataceae	6
8	Morochillo	Miconia theaezans (Bonpl.) Cogn.	Melastomataceae	33
9	Munchiro	Miconia versicolor Naudin	Melastomataceae	4
10	Pilampo	Barnadesia spinosa L.f.	Asteraceae	2
11	Santa María	Liabum igniarium Less.	Asteraceae	23
12	Uvilan	Monnina aestuans (L.f.) DC.	Polygalaceae	5
13	Zancia	Coriaria ruscifolia L.	Coriariaceae	10
			Total	153
			CM	1/10.93

Source: Géminis Consultores Ambientales, 2016

Patchwork of pastures and crops with natural spaces of the Upper Andean Orobiome (21243)

In the shrub spaces of this ecosystem, there were 12 species, most of them shrub-type, where the Asteraceae family stood out with three species and the Melastomataceae family with two. (SeeTable 5.2.19)

This ecosystem has a high level of heterogeneity of species, according to the blend ratio at 1/5, i.e. for every 5 individuals, there is one new species.

Table 5.2.19. Floristic composition in the ecosystem Patchwork of pastures and crops with natural spaces of the Upper Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Australian blackwood	*Acacia melanoxylon* R.Br.	Fabaceae	1
2	Charmolan	*Hyeronima macrocarpa Müll.Arg.*	Euphorbiaceae	1
3	Coyote bush	*Baccharis latifolia* (Ruiz & Pav.) Pers.	Asteraceae	9
4	Colla	*Dendrophorbium lloense* (Hieron. ex Sodiro) C.Jeffrey	Asteraceae	17
5	Cordoncillo	*Piper bogotenc* C.DC.	Juglandaceae	4
6	Lechero	*Euphorbia laurifolia* Juss. ex Lam.	Euphorbiaceae	9
7	May	*Tibouchina lepidota* (Bonpl.) Baill.	Melastomataceae	6
8	Mote	*Saurauia ursina*Triana & Planch.	Actinidiaceae	2
9	Pelotillo	*Viburnum triphyllum* Benth.	Caprifoliaceae	2
10	Pilampo	*Barnadesia spinosa L.f.*	Asteraceae	7
11	Roso	*Miconia thaezans* (Bonpl.) Cogn.	Melastomataceae	1
12	Uvilan	*Monnina aestuans* (L.f.) DC.	Polygalaceae	1
			Total	60
			CM	**1/5**

Source: Géminis Consultores Ambientales, 2016

The ecosystems that include crops and pastures in the Upper Andean Orobiome have mainly 17 species of agricultural use, as illustrated in Table 5.2.20.

Table 5.2.20. Cultivated species in ecosystems of Patchwork of pastures and crops with natural spaces of the Upper Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY
1	Bean	*Phaseolus vulgaris*	Fabaceae
2	Maize	*Zea mays* L.	Poaceae
3	Potato	*Solanum tuberosum*	Solanaceae
4	Pea	*Pisum sativum*	Fabaceae
5	Barley	*Hordeum vulgare*	Poaceae
6	Wheat	*Triticum aestivum* L.	Poaceae
7	Raspberry	*Rubus glaucus Benth*	Rosaceae
8	Lima bean	*Vicia faba*	Fabaceae
9	Ulluco	*Ullucus tuberosus*	Basellaceae
10	Cabbage	*Brassica oleracea var. capitata*	Cruciferae
11	Lettuce	*Lactuca sativa L.*	Cichorioideae
12	Carrots	*Daucus carota* L.	Apiaceae
13	Chard	*Beta vulgaris var. Cicla (L) K. koch.*	Amaranthaceae
14	Kikuyu grass	*Pennisetum clandestinum*	Poaceae
15	Ryegrass	Lolium perenne	Poaceae
16	Yorkshire fog	*Holcus lanatus*	Poaceae
17	Orchard grass	*Dactylis glomerata*	Poaceae

Source: Géminis Consultores Ambientales, 2016

Patchwork of pastures and crops of the Upper Andean Orobiome (21242)

Eleven species were identified, distributed in ten different families, as shown in Table 5.2.21.

The blend ratio for this ecosystem shows greater homogeneity of species (1/16.55).

Table 5.2.21. Floristic composition in the ecosystem Patchwork of pastures and crops of the Upper Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Australian blackwood	*Acacia melanoxylon* R.Br.	Fabaceae	38
2	Alder	*Alnus acuminata* Kunth	Betulaceae	8
3	Angel's trumpet	*Brugmansia arborea* (L.) Steud.	Solanaceae	2
4	Zancia	*Coriaria ruscifolia* L.	Coriariaceae	5
5	White cedar	*Cupressus lusitanica* Mill.	Cupressaceae	4
6	Colla	*Dendrophorbium lloense* (Hieron. ex Sodiro) C.Jeffrey	Asteraceae	26
7	Eucalyptus	*Eucalyptus globulus* Labill.	Myrthaceae	49
8	Patula pine	*Pinus patula* Schiede ex Schltdl. & Cham.	Pinaceae	8
9	Moquillo	*Saurauia bullosa* Wawra	Actinidiaceae	21
10	Mote	*Saurauia ursina* Triana & Planch.	Actinidiaceae	20
11	Yellow trumpetbush	*Tecoma stans* (L.) Juss. ex Kunth	Bignonaceae	1
			Total	**182**
			CM	**1/16.55**

Source: Géminis Consultores Ambientales, 2016

Patchwork of pastures with natural spaces of the Upper Andean Orobiome (21244)

In the natural shrubland spaces of this ecosystem, only three species were found from three different families (Table 5.2.22).

The BR for this ecosystem indicates greater homogeneity of species (1/13.33).

Table 5.2.22. Floristic composition in the ecosystem Patchwork of pastures with natural spaces of the Upper Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Cerote	*Hesperomeles obtusifolia* (DC.) Lindl.	*Rosaceae*	1

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
2	Coyote bush	*Baccharis latifolia* (Ruiz & Pav.) Pers.	*Asteraceae*	20
3	American black nightshade	*Solanum nigrum var. Americanum (Mill.) O.E. Schulz*	*Solanaceae*	19
			Total	**40**
			CM	**1/13.33**

Source: Géminis Consultores Ambientales, 2016

The patchwork ecosystems of pastures in the Upper Andean Orobiome have mainly 4 grass species, as illustrated in Table 5.2.23.

Table 5.2.23. Cultivated species in ecosystems of Patchwork of pastures with natural spaces of the Upper Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY
1	Kikuyu grass	*Pennisetum clandestinum*	Poaceae
2	Ryegrass	Lolium perenne	Poaceae
3	Yorkshire fog	*Holcus lanatus*	Poaceae
4	Orchard grass	*Dactylis glomerata*	Poaceae

Source: Géminis Consultores Ambientales, 2016

Planted pastures and trees of the Upper Andean Orobiome (212241)

In the sampling for the Pasture ecosystem with planted trees in the Upper Andean Orobiome, 21 species were identified distributed in 19 different families, as illustrated in Table 5.2.24.

The blend ratio indicates heterogeneity at 1/7.73, indicating that for approximately every eight individuals, one new species could be found.

Table 5.2.24. Floristic composition in the ecosystem of pastures with planted trees of the Upper Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Black wattle	*Acacia decurrens* Willd.	*Fabaceae*	1
2	Australian blackwood	*Acacia melanoxylon* R.Br.	Fabaceae	11
3	Alder	*Alnus acuminata* Kunth	*Betulaceae*	2
4	Amarillo	*Miconia nodosa* Cogn	*Melastomataceae*	5
5	Black cherry	*Prunus serotina* Ehrh.	*Rosaceae*	8
6	Cedrillo	*Phyllanthus salviifolius* Kunth.	*Phyllanthaceae*	1
7	Mountain papaya	*Carica pubescens* Lenné & K. Koch	*Caricaceae*	1
8	White cedar	*Cupressus lusitanica* Mill.	*Cupressaceae*	75
9	Colla	*Dendrophorbium lloense* (Hieron. ex Sodiro) C.Jeffrey	Asteraceae	8
10	Cujaco	*Solanum ovalifolium Dunal.*	*Solanaceae*	5
11	Eucalyptus	*Eucalyptus globulus* Labill.	*Myrthaceae*	7
12	Lechero	*Euphorbia laurifolia* Juss. ex Lam.	*Euphorbiaceae*	14
13	Majua	*Palicourea sp*	*Rubiaceae*	2
14	Miconia	*Miconia acutifolia* ule.	*Melastomataceae*	2
15	Mote	*Saurauia ursina* Triana & Planch.	*Actinidiaceae*	8
16	Walnut	*Juglans neotropica* Diels.	*Juglandaceae*	1
17	Pelotillo	*Viburnum triphyllum* Benth.	*Caprifoliaceae*	1
18	Roso	*Vallea stipularis L.f.*	Elaeocarpaceae	1
19	Elderberry	*Sambucus nigra* L.	*Caprifoliaceae*	7
20	Chinese ash	*Fraxinus chinensis* Roxb.	*Oleaceae*	2
21	Uvilan	*Monnina aestuans* (L.f.) DC.	*Polygalaceae*	1
			Total	**163**
			CM	**1/7.76**

Source: Géminis Consultores Ambientales, 2016

Forest plantation of the Upper Andean Orobiome (21315)

The ecosystem formed by planted forests of the Upper Andean Orobiome is mostly made up of *Eucalyptus globulus* Labill.; however, the natural regeneration of four species of the area is observed. (See Table 5.2.25)

As expected, the forest plantation is more homogeneous (1/16), given that most the area is occupied by just one species.

Table 5.2.25. Floristic composition in the Forest plantation ecosystem of the Upper Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Amarillo	*Miconia nodosa* Cogn	*Melastomataceae*	1
2	Colla	*Dendrophorbium lloense* (Hieron. ex Sodiro) C.Jeffrey	Asteraceae	2
3	Eucalyptus	*Eucalyptus globulus* Labill.	Myrthaceae	69
4	Alstonville	*Tibouchina lepidota* (Bonpl.) Baill.	Melastomataceae	5
5	Uvilan	*Monnina aestuans* (L.f.) DC.	Polygalaceae	3
			Total	80
			CM	**1/16.00**

Source: Géminis Consultores Ambientales, 2016

Dense shrubland of the Upper Andean Orobiome (213221)

This ecosystem has a total of four species, which are part of four different families, among which the Asteraceae family stands out with one species and 16 individuals. (See Table 5.2.26)

As illustrated the BR indicates an average heterogeneity of species (1/8.60), i.e., for approximately every nine individuals, there may be one new species. It is important to point out that, in this type of ecosystem, we find species that grow in thickets or groups of several individuals, such as the case of *Baccharis latifolia* (Ruiz & Pav.) Pers. (Coyote bush).

Table 5.2.26. Floristic composition in the dense shrubland ecosystem of the Upper Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Coyote bush	*Baccharis latifolia* (Ruiz & Pav.) Pers.	Asteraceae	16
2	Tara	*Mimosa quitensis* Benth.	Caesalpiniaceae	8
3	Lechero	*Euphorbia laurifolia* Juss. ex Lam.	Euphorbiaceae	3
4	Mano de oso	*Oreopanax bogotensis* Cuatrec	Araliaceae	8
			Total	**35**
			CM	**1/8.75**

Source: Géminis Consultores Ambientales, 2016

Riparian forest of the Upper Andean Orobiome (21314)

This ecosystem has a greater variety of species, given the condition of low anthropic intervention in several years, thus allowing the colonization of new species following a disturbance of the site; the families with greater presence in the area are the Melastomataceae, Asteraceae and Actinidaceae. *Eucalyptus globulus* Labill. (eucalyptus) is the most abundant species, given the plantation of these individuals during stages prior to the development of the native vegetation (Table 5.2.27).

The blend ratio calculated for the riparian forest of the Upper Andean Orobiome indicates a heterogeneity of species with a value of 1/10.55; i.e., for every 10 individuals, there is one new species.

Table 5.2.27. Floristic composition in the Riparian Forest ecosystem of the Upper Andean Orobiome

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
1	Black wattle	*Willd.Acacia decurrens*	Fabaceae	10
2	Australian blackwood	*Acacia melanoxylon* R.Br.	Fabaceae	25
3	Alder	*Alnus acuminata* Kunth	Betulaceae	5
4	Amarillo	*Miconia nodosa*	Melastomataceae	4
5	Black cherry	*Prunus serotina Ehrh.*	Rosaceae	1

No.	COMMON NAME	SPECIES	FAMILY	No. INDIVIDUALS
6	Charmolan	*Geissanthus serrulatus (Willd. ex Roem. & Schult.) Mez*	Euphorbiaceae	1
7	Coyote bush	*Baccharis latifolia (Ruiz & Pav.) Pers.*	Asteraceae	11
8	White cedar	*Cupressus lusitanica*	Cupressaceae	1
9	Colla	*Dendrophorbium lloense (Hieron. ex Sodiro) C.Jeffrey*	Asteraceae	13
10	Cujaco	Solanum hazenii Britton	Solanaceae	4
11	Encenillo	*Weinmannia tomentosa*	Cunoniaceae	1
12	Eucalyptus	*Eucalyptus globulus Labill.*	Myrthaceae	116
13	Laurel	*Morella pubescens (Humb. & Bonpl. ex Willd.) Wilbur*	Myricaceae	3
14	Alstonville	*Tibouchina lepidota (Bonpl.) Baill.*	Melastomataceae	2
15	Moquillo	*Saurauia bullosa* Wawra.	Actinidiaceae	7
16	Morochillo	*Miconia theaezans* (Bonpl.) Cogn.	Melastomataceae	1
17	Mote	*Saurauia ursina* Triana & Planch.	Actinidiaceae	7
18	Pelotillo	*Viburnum triphyllum* Benth.	Caprifoliaceae	3
19	Patula pine	*Pinus patula* Schiede ex Schltdl. & Cham.	Pinaceae	8
20	Roso	*Vallea stipularis* L.f.	Elaeocarpaceae	7
21	Elderberry	*Sambucus nigra* L.	Caprifoliaceae	1
22	Zarcillejo	*Cavendishia bracteata* (Ruiz & Pav. ex J.St.Hil.) Hoerold	Ericaceae	1
			Total	**232**
			CM	**1/10.55**

Source: Géminis Consultores Ambientales, 2016

a. Biodiversity index of delimited plant cover units

alpha (α) diversity

In order to analyze the structure of the community of forest species in each of the assessed ecosystems, using statistical tool PAST 3.07 (Hammer et al, 2015), we studied the riparian forest ecosystems of the Middle Andean Orobiome, the riparian forest of the Upper Andean Orobiome, the dense shrubland of the Middle Andean Orobiome and dense shrubland of the Upper Andean Orobiome, in addition to the forest plantation ecosystems that were used as a point of comparison.

It was found that in ecosystems such as riparian forest of the Middle Andean Orobiome (2.0.3.1.4); the forest plantation of the Middle Andean Orobiome (2.0.3.15.); the dense shrubland of the Middle Andean Orobiome (2.0.3.2.2.1), the forest plantation of the Upper Andean Orobiome (2.1.3.1.5), and riparian forest of the Upper Andean Orobiome (2.1.3.1.4);the abundance distribution model that best fits the data set ($p > 0.05$) was the normal logarithmic series (See Figure 5.2.10, Figure 5.2.11, Figure 5.2.12, Figure 5.2.13 and Figure 5.2.14),

This model describes distributions where the populations of the species grow exponentially and respond independently to different factors, or a set of populations that are in balance in small patches. At the biological level, the adjustment of the data to this model denotes that the niche of each species is dependent on a multitude of factors that determine the extent of said niche and, consequently, the resources of the ecosystem should be distributed among the species in a manner equivalent to a normal curve. The abundant and rare species will be located toward the ends of the distribution, while most of the species with an intermediate frequency will occupy the central part of the curve; i.e., the abundance of the species at the peak of the curve corresponds to the mode of distribution.

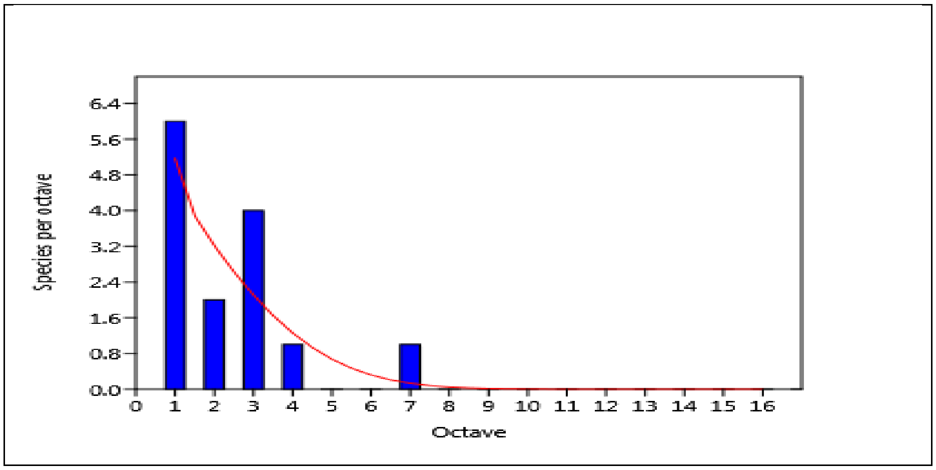


Figure 5.2.10 Abundance distribution model (normal logarithmic series) identified for the Riparian forest ecosystem of the Middle Andean Orobiome (2.0.3.1.4) Pedregal-Catambuco Sector.

Source: Géminis Consultores Ambientales, 2016

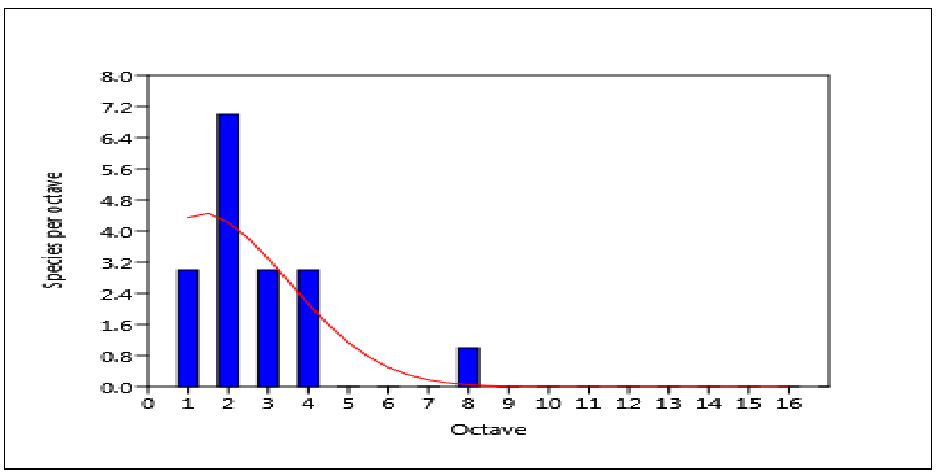


Figure 5.2.11 Abundance distribution model (normal logarithmic series) identified for the forest plantation ecosystem of the Middle Andean Orobiome (2.0.3.1.5) Pedregal-Catambuco Sector.

Source: Géminis Consultores Ambientales, 2016

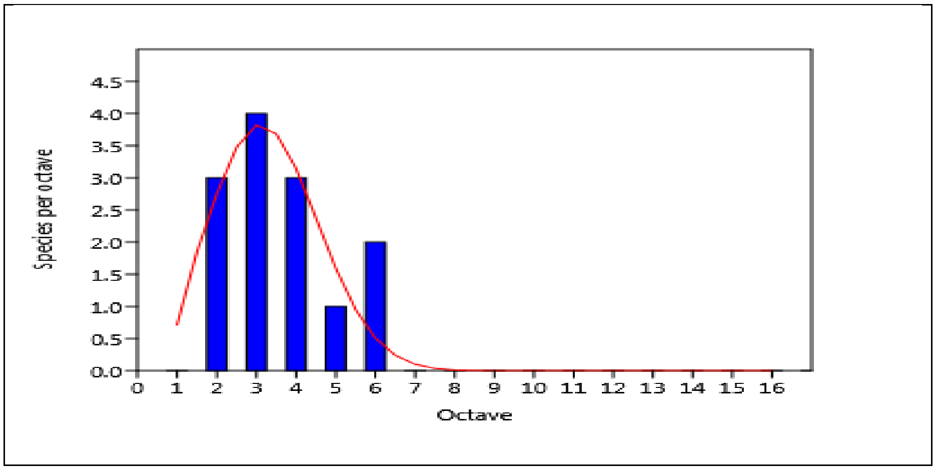


Figure 5.2.12 Abundance distribution model (normal logarithmic series) identified for the Dense shrubland ecosystem of the Middle Andean Orobiome (3.2.2.1) Pedregal-Catambuco Sector.

Source: Géminis Consultores Ambientales, 2016

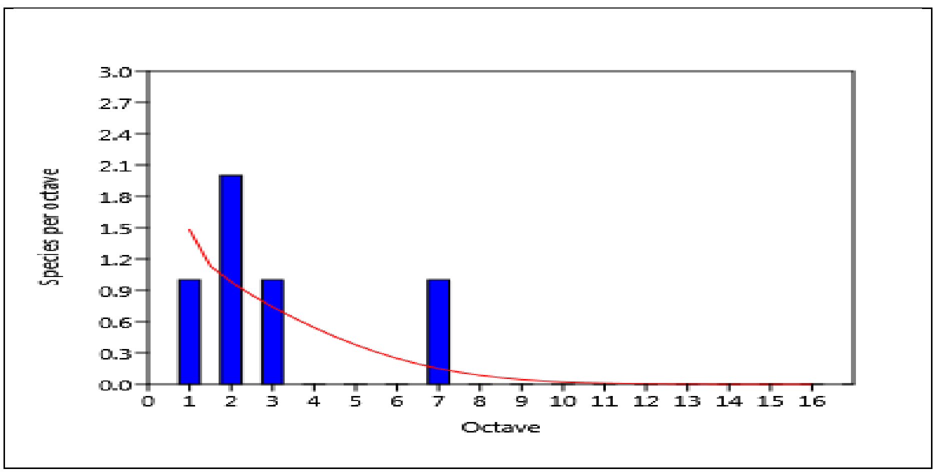


Figure 5.2.13 Abundance distribution model (normal logarithmic series) identified for the Riparian forest ecosystem of the Upper Andean Orobiome (2.1.3.1.5, Pedregal-Catambuco Sector.

Source: Géminis Consultores Ambientales, 2016

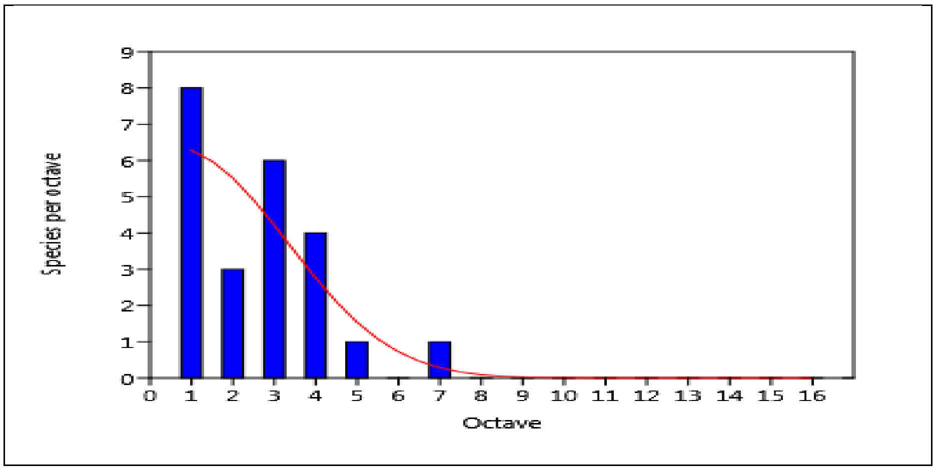


Figure 5.2.14 Abundance distribution model (normal logarithmic series) identified for the Riparian forest ecosystem of the Upper Andean Orobiome (2.1.3.1.4), Pedregal-Catambuco Sector.

Source: Géminis Consultores Ambientales, 2016

For the dense Shrubland ecosystem of the Upper Andean Orobiome (2.1.3.2.2.1), the abundance distribution model that best fits ($p > 0.05$) was the geometric series model (See Figure 5.2.15); according to this model, the dominant species takes a proportion k of a limiting resource based on the right of priority, the second most dominant species takes the same proportion k from the rest of the resource, and so on until all species have been accommodated. Since the proportion of abundance of each species with its predecessor is constant throughout the sequential list of species, the series appears as a straight line the logarithm of abundance is represented graphically in relation to the recurrence of species (Magurran, 1988).

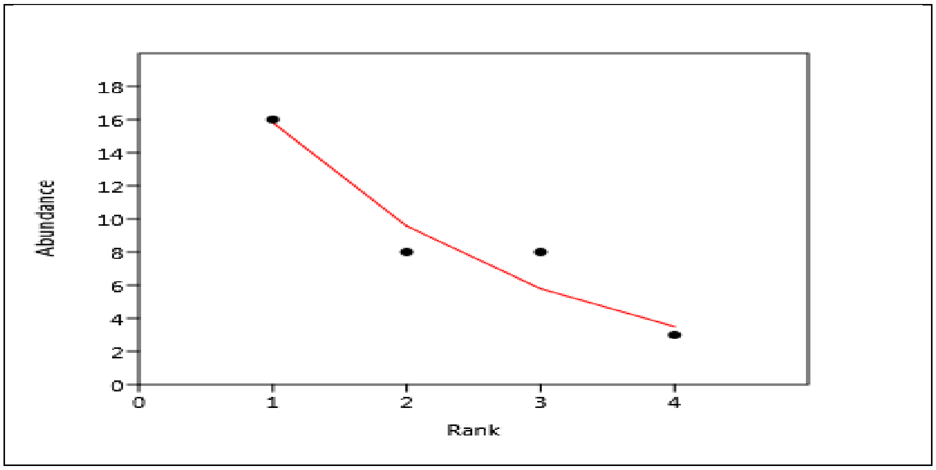


Figure 5.2.15 Abundance distribution model (logarithmic series) identified for the Open forest ecosystem of the Middle Andean Orobiome (2.1.3.2.2.1), Pedregal-Catambuco Sector.

Source: Géminis Consultores Ambientales, 2016

As mentioned earlier, there are several types of indexes to assess the different components of biological communities. Based on the mathematical tools of the program PAST 3.07 (Hammer et al, 2015), the following estimators of heterogeneity were calculated on the basis of the data obtained in the field for natural ecosystems of functional units 4 and 5 (FU4 and FU5.1), (See Table 5.2.28), which combine the value of importance of species and wealth based on dominance and evenness.

Table 5.2.28 Diversity indices for ecosystems in the Pedregal-Catambuco Sector.

Indices / Covers	2.0.3.1.4	2.0.3.1.5	2.0.3.2.2.1	2.1.3.1.4	2.1.3.1.5	2.1.3.2.2.1
Taxa	14	17	13	23	5	4
Individuals	115	209	153	233	80	35
Dominance_D	0.4414	0.467	0.1637	0.272	0.75	0.3208
Simpson_1-D	0.5586	0.533	0.8363	0.728	0.25	0.6792
Shannon_H	1.428	1.426	2.108	2.021	0.571	1.243
Brillouin	1.276	1.311	1.967	1.877	0.5026	1.099

Indices / Covers	2.0.3.1.4	2.0.3.1.5	2.0.3.2.2.1	2.1.3.1.4	2.1.3.1.5	2.1.3.2.2.1
Menhinick	1.306	1.176	1.051	1.507	0.559	0.6761
Margalef	2.74	2.995	2.385	4.036	0.9128	0.8438
Equitability_J	0.5412	0.5034	0.8219	0.6445	0.3548	0.8967
Vegetation Covers Riparian forest ecosystem of the Middle Andean Orobiome (2.0.3.1.4), Riparian forest of the Upper Andean Orobiome (2.1.3.1.4), forest plantation of the Middle Andean Orobiome (2.0.3.1.5), forest plantation of the Upper Andean Orobiome (2.1.3.1.5), dense shrubland of the Middle Andean Orobiome (2.0.3.2.2.1) dense shrubland of the Upper Andean Orobiome (2.1.3.2.2.1).						

Source: Géminis Consultores Ambientales, 2016.

The Margalef index, which lists the number of species and the number of individuals, shows that none of the ecosystems under study shows high values of diversity (values greater than 5). It is important to bear in mind that this index has several disadvantages, including their dependence on the size of the sample. However, there is the Menhinick index, which also measures wealth and that is less biased; according to this index, the cover Riparian forest of Upper Andean Orobiome (2.1.3.1.4) shows the greatest biodiversity with respect to the other covers in the study as illustrated in Table 5.2.28.

Also, the Shannon (H' and Brillouin indices reaffirm that the assembly with the greatest value of diversity were the dense shrubland ecosystems of the Middle Andean Orobiome (2.0.3.2.2.1) followed by the Riparian forest of the Upper Andean Orobiome (2.1.3.1.4) as illustrated in Figure 5.2.16 and Figure 5.2.17. These types of vegetation cover seem to show a high level of environmental heterogeneity that generates optimal conditions, thus determining more restricted niches and more species per unit of area (Krebs, 2001); these conditions favor diversity and abundance (Crump, 1971).

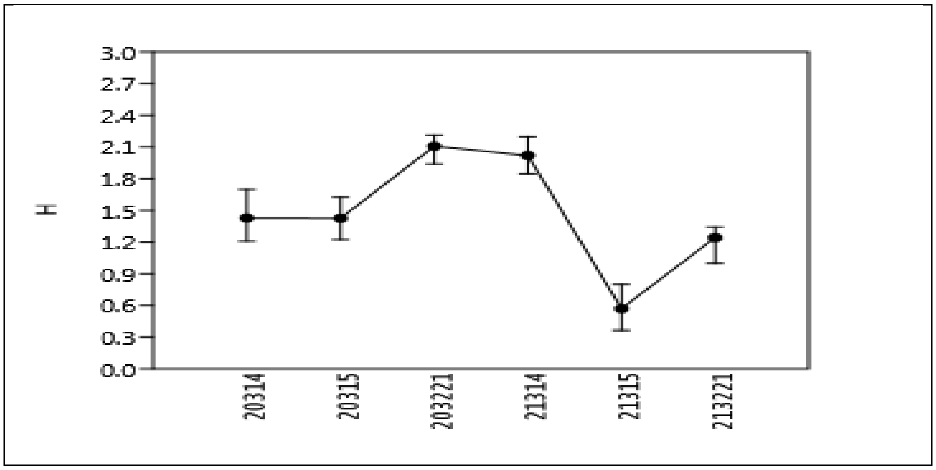


Figure 5.2.16 Shannon H' Indices (CI 95%) for ecosystems in the area of influence of the Pedregal-Catambuco sector of the Rumichaca - Pasto road project.

Source: Géminis Consultores Ambientales, 2016.

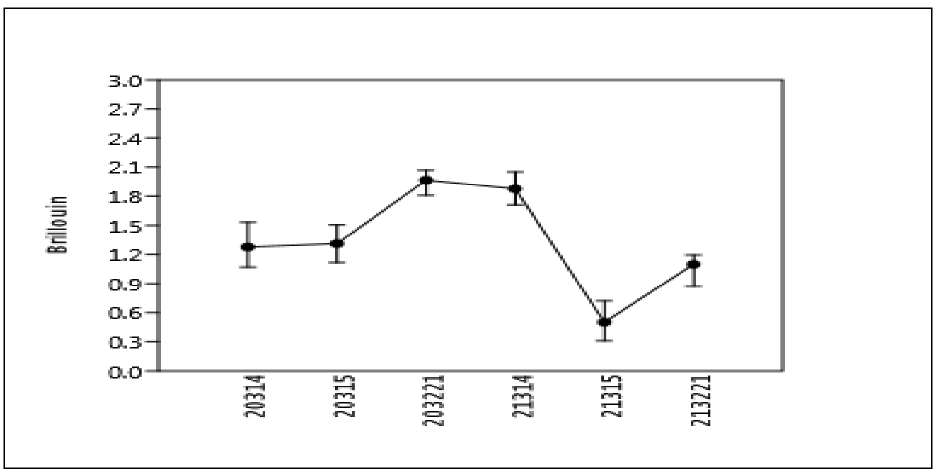


Figure 5.2.17 Brillouin Indices (CI 95%) for ecosystems in the area of influence of the Pedregal-Catambuco sector of the Rumichaca - Pasto road project.

Source: Géminis Consultores Ambientales, 2016.

It is important to highlight the correspondence between the Simpson (1-D) and the Pielou Equity (j) indices, which show that the assemblies with the most evenness in their abundance distribution of species, are those that are part of the dense shrubland ecosystems of the Middle Andean Orobiome (2.0.3.2.2.1) and the Riparian forest of the Upper Andean Orobiome (2.1.3.1.4), while the less equitable ecosystem in composition and abundance was the forest plantation of the Upper Andean Orobiome (2.1.3.1.5) as illustrated in Figure 5.2.18 and Figure 5.2.19.

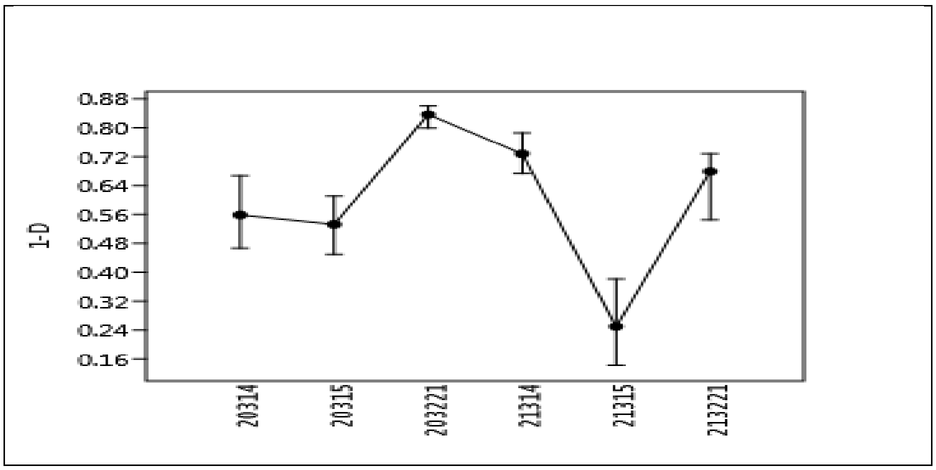


Figure 5.2.18 Simpson (1-D) Indices (CI 95%) for ecosystems in the area of influence of the Pedregal-Catambuco sector of the Rumichaca - Pasto road project.

Source: Géminis Consultores Ambientales, 2016

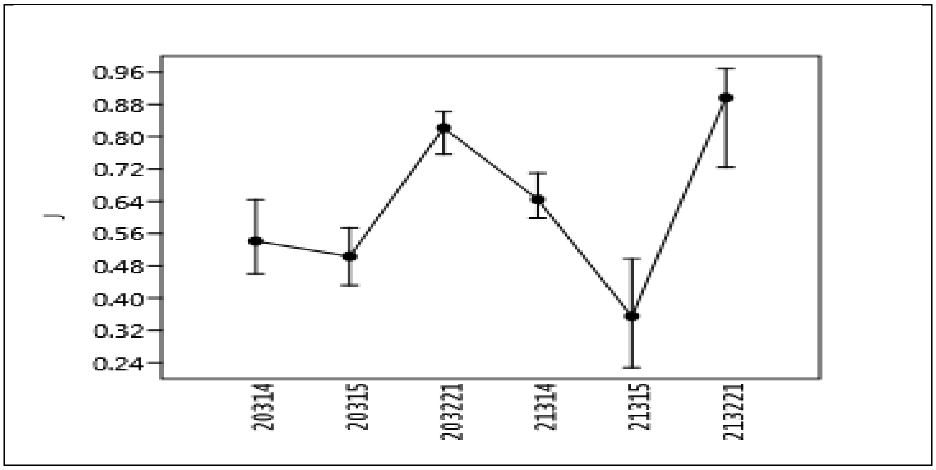


Figure 5.2.19 Pielou (J) Evenness Indices (CI 95%) for ecosystems in the area of influence of the Pedregal-Catambuco sector of the Rumichaca - Pasto road project.

Source: Géminis Consultores Ambientales, 2016.

On a reciprocal basis, upon observing the results of the Simpson dominance index (D), it was found that the ecosystem with a high degree of dominance in the proportion of abundance of its species was the Forest Plantation of the Upper Andean Orobiome (2.1.3.1.5), where it was found that the assembly was dominated by *Eucalyptus globulus* Labill. (Eucalyptus) (See Figure 5.2.20).

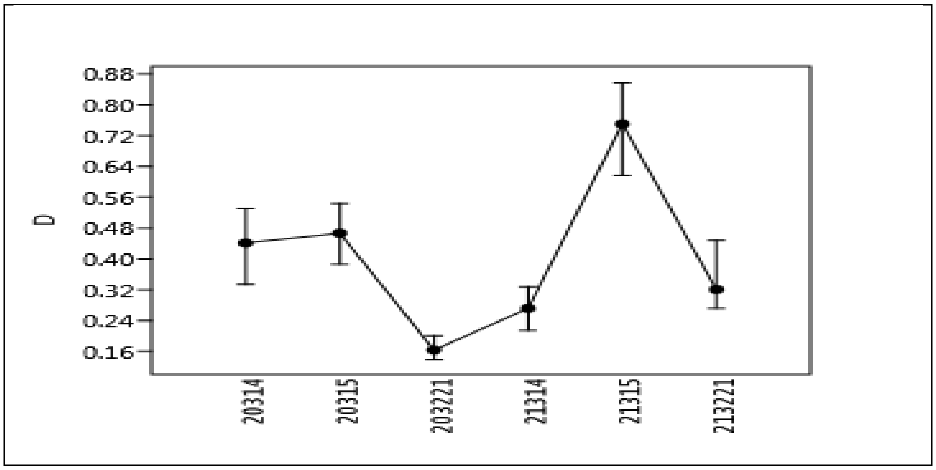
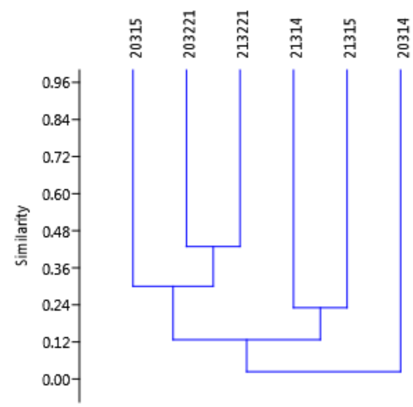


Figure 5.2.20 Simpson (D) Dominance Indices (CI 95%) for ecosystems in the area of influence of the Pedregal-Catambuco sector of the Rumichaca - Pasto road project.

Source: Géminis Consultores Ambientales, 2016.

beta (β) diversity

The percentage of similarity between the ecosystems assessed was estimated in accordance with their composition of forest species, using the Jaccard similarity index, which is based on presence/absence data, regardless of the specific abundance of each species, and with this information, a hierarchical cluster analysis was carried out using the Paired group method, from which a similarity dendogram was obtained. All the analyses were carried out using PAST 3.07 (Hammer et al, 2015) (Figure 5.2.21)



Vegetation Covers: Riparian forest ecosystem of the Upper Andean Orobiome **(2.1.3.1.4)**, Riparian forest of the Upper Andean Orobiome **(2.0.3.1.4)**, forest plantation of the Middle Andean Orobiome **(2.0.3.1.5)**, forest plantation of the Upper Andean Orobiome **(2.1.3.1.5)**, dense shrubland of the Middle Andean Orobiome **(2.0.3.2.2.1)** dense shrubland of the Upper Andean Orobiome **(2.1.3.2.2.1)**.

Figure 5.2.21 (Jaccard) similarity dendogram for ecosystems in the area of influence of the Rumichaca - Pasto road project. Pedregal- Catambuco sector.

Source: Géminis Consultores Ambientales, 2016.

According to the dendogram, the dense shrubland ecosystems of the Middle Andean Orobiome (2.0.3.2.2.1) and the dense shrubland of the Upper Andean Orobiome (2.1.3.2.2.1) have the highest percentage of similarity (42%) in the composition of their species. It was also found that the composition of the riparian forest of the Middle Andean Orobiome (2.0.3.1.4) at 0.6%, is very different in its composition to the rest of the ecosystems, (See Figure 5.2.21), which is logical considering that it is the only existing tropophic forest in the area of influence of the Pedregal-Catambuco sector, with the species *Handroanthus chrysanthus* (Jacq.) S.O.Grose (Guayacan amarillo) showing a high level of dominance.

The similarity between the forest plantation of the Upper Andean Orobiome and the riparian forest of the Upper Andean Orobiome is due to the fact that the latter does not have the typical vegetation of the ecosystems in the area, where it is evident that, in the protection area of the Miraflores stream, introduced species were planted in the area in order to recover the water course following its complete deforestation; this area later underwent a natural process of regeneration under the canopy, which is still in the early stages.

b. Degree of sociability and spatial structure

This parameter was established for the natural ecosystems identified in the Pedregal - Catambuco sector, i.e. excluding those where anthropic intervention is so strong that the species cannot express their natural habits, as in the case of the patchwork. In addition, the forest plantations of the Middle Andean Orobiome were analyzed, because their floristic composition shows the incidence of naturally growing species, indicating little human intervention in recent times; this is not the situation in the plantations of the Upper Andean Orobiome, where there is a widespread dominance of the species *Eucalyptus globulus* Labill.

In the riparian forest ecosystem of the Middle Andean Orobiome, it was determined that most of the species identified had a high degree of sociability at 1, 2 and 3; the species Handroanthus chrysanthus (Jacq.) S.O.Grose (Guayacán amarillo) showed a degree of sociability of 3; with regard to the structural base of the habitat, the species found showed a hierarchy of 1, 2 and 4, i.e. the cover of the species on the plots is no more than 75%, as indicated in Table 5.2.29.

Table 5.2.29 Degree of sociability and spatial structure in the riparian forest ecosystem of the Middle Andean Orobiome.

No.	Common Name	Scientific Name	Degree of Sociability					Abundance-Dominance				
			1	2	3	4	5	1	2	3	4	5
1	Balsa	*Ochroma pyramidale* (Cav. ex Lam.) Urb.	X					X				
2	Charmolan	*Geissanthus serrulatus* (Willd. ex Roem. & Schult.) Mez	X					X				

3	Cordoncillo	*Piper bogotense* C.DC.	X					X				
4	Cucharo	*Myrsine guianensis* (Aubl.) Kuntze		X					X			
5	Common guava	*Psidium guajava* L.	X					X				
6	Guayacan	*Lafoensia acuminata* (Ruiz & Pav.) DC.	X					X				
7	Guayacan amarillo	*Handroanthus chrysanthus* (Jacq.) S.O.Grose			X			X			X	
8	Majua	*Palicourea sp*	X					X				
9	Morochillo	*Miconia theaezans* (Bonpl.) Cogn.	X					X				
10	Munchiro	*Miconia versicolor* Naudin	X					X				
11	Loquat	*Eriobotrya japonica* (Thunb.) Lindl.	X					X				
12	Pendo	*Citharexylum kunthianum* Moldenke	X					X				
13	Yellow trumpetbush	*Tecoma stans* (L.) Juss. ex Kunth	X						X			
14	Chinese ash	*Fraxinus chinensis* Roxb.	X					X				

Abundance-Dominance 5 covers more than 75% of the plot; 4 covers between 50% and 75% of the plot, 3 covers between 25% and 50% of the plot, 2 covers between 5% and 25% of the plot and 1 covers about 5% of the plot. Degree of Sociability: 5 almost pure population of the plot, 4 in almost continuous colonies, 3 in scattered spots, 2 in clumps or thickets and 1 isolated individuals.

Source: Géminis Consultores Ambientales, 2016

In the dense shrubland of the Upper Andean Orobiome, it was determined that most of the species found on the plots analyzed had degrees of sociability of 2 and 3, which is characteristic of the growth and development of the species listed as near endemic. Regarding the structural base of the habitat, most of the species found had a hierarchy of 2, i.e. the cover of the species on the plots is no more than 25%, and the species *Baccharis latifolia (Ruiz & Pav.) Pers. (Ruiz & Pav.) Pers.* (Coyote bush) has a hierarchy of 4, i.e. it has a coverage of 50 to 75%, as illustrated in Table 5.2.30.

Table 5.2.30 Degree of sociability and spatial structure in the Dense shrubland ecosystem of the Middle Andean Orobiome.

No.	Common Name	Scientific Name	Degree of Sociability					Abundance-Dominance				
			1	2	3	4	5	1	2	3	4	5
1	Coyote bush	*Baccharis latifolia (Ruiz & Pav.) Pers. (Ruiz & Pav.) Pers.*		x							X	
2	Tara	*Mimosa quitensis Benth*		x					x			
3	Alstonville	*Tibouchina lepidota*			x				x			
4	Morochillo	*Miconia theaezans (Bonpl.) Cogn.*			x				x			

Abundance-Dominance 5 covers more than 75% of the plot; 4 covers between 50% and 75% of the plot, 3 covers between 25% and 50% of the plot, 2 covers between 5% and 25% of the plot and 1 covers about 5% of the plot. Degree of Sociability: 5 almost pure population of the plot, 4 in almost continuous colonies, 3 in scattered spots, 2 in clumps or thickets and 1 isolated individuals.

Source: Géminis Consultores Ambientales, 2016

In the riparian forest of the Upper Andean Orobiome, it was determined that most of the species identified had a degree of sociability of 1 and 2; the species *Eucalyptus globulus* Labill. (Eucalyptus) showed a degree of sociability of 3; with regard to the structural base of the habitat, the species found showed a hierarchy of 1, 2 and 3, i.e. the cover of the species on the plots is no more than 50%, as indicated in Table 5.2.31.

Table 5.2.31 Degree of sociability and spatial structure of Riparian forest ecosystem of the Upper Andean Orobiome

No.	Common Name	Scientific Name	Degree of Sociability					Abundance-Dominance				
			1	2	3	4	5	1	2	3	4	5
1	Black wattle	*Acacia decurrens* Willd.		X				X				
2	Australian blackwood	*Acacia melanoxylon* R.Br.		X					X			
3	Alder	*Alnus acuminata* Kunth	X					X				
4	Amarillo	*Miconia nodosa* Cogn	X					X				
5	Black cherry	*Prunus serotina* Ehrh.	X					X				
6	Charmolan	*Geissanthus serrulatus* (Willd. ex Roem. &	X					X				

No	Common Name	Scientific Name	Degree of Sociability					Abundance-Dominance				
		Schult.) Mez										
7	Coyote bush	*Baccharis latifolia* (Ruiz & Pav.) Pers.		X				X				
8	White cedar	*Cupressus lusitanica* Mill.	X					X				
9	Colla	*Dendrophorbium lloense* (Hieron. ex Sodiro) C.Jeffrey		X					X			
10	Cujaco	*Solanum ovalifolium* Dunal	X					X				
11	Encenillo	*Weinmannia tomentosa* L.f.	X					X				
12	Eucalyptus	*Eucalyptus globulus* Labill.			X					X		
13	Laurel	*Morella pubescens* (Humb. & Bonpl. ex Willd.) Wilbur	X					X				
14	Alstonville	*Tibouchina lepidota* (Bonpl.) Baill.	X					X				
15	Moquillo	*Saurauia bullosa* Wawra	X					X				
16	Morochillo	*Miconia theaezans* (Bonpl.) Cogn.	X					X				
17	Mote	*Saurauia ursina* Triana & Planch.	X					X				
18	Pelotillo	*Viburnum triphyllum* Benth.	X					X				
19	Patula pine	*Pinus patula* Schiede ex Schltdl. & Cham.	X					X				
20	Roso	*Vallea stipularis* L.f.	X					X				
21	Elderberry	*Sambucus nigra* L.	X					X				
22	Zarcillejo	*Cavendishia bracteata* (Ruiz & Pav. ex J.St.Hil.) Hoerold	X					X				

Abundance-Dominance 5 covers more than 75% of the plot; 4 covers between 50% and 75% of the plot, 3 covers between 25% and 50% of the plot, 2 covers between 5% and 25% of the plot and 1 covers about 5% of the plot. Degree of Sociability: 5 almost pure population of the plot, 4 in almost continuous colonies, 3 in scattered spots, 2 in clumps or thickets and 1 isolated individuals.

Source: Géminis Consultores Ambientales, 2016

In the riparian forest of the Upper Andean Orobiome, most of the species identified on the plots analyzed had degrees of sociability of 1, 2 and 3; and the species *Cupressus lusitanica* (White cedar), *Eucalyptus globulus Labill.* (Eucalyptus) and Pinus *patula Schiede ex Schltdl. & Cham.* (Pine) showed a degree of sociability of 5, which is characteristic of introduced and invasive species; with regard to the structural base of the habitat, the species found showed a hierarchy of 1, i.e. the cover of the species on the plots is no more than 5%, and the species *Eucalyptus globulus Labill*. (Eucalyptus) has a hierarchy of 4, i.e. it has a coverage of 50-75% as illustrated in Table 5.2.32.

Table 5.2.32 Degree of sociability and spatial structure in the Forest plantation ecosystem of the Middle Andean Orobiome.

No.	Common Name	Scientific Name	Degree of Sociability					Abundance-Dominance				
			1	2	3	4	5	1	2	3	4	5
1	Coyote bush	*Baccharis latifolia (Ruiz & Pav.) Pers. (Ruiz & Pav.) Pers.*		x				x				
2	White cedar	*Cupressus lusitanica*					x	x				
3	Colla	*Dendrophorbium lloense (Hieron. ex Sodiro) C.Jeffrey*			x			x				
4	Cucharo	*Myrsine guianensis (Aubl.) Kuntze*	x					x				
5	Eucalyptus	*Eucalyptus globulus Labill.*					x				x	
6	Guayabillo	*Psidium acutangulum*	x					x				
7	Big sage	*Lantana camara*	x					x				
8	Lechero	*Euphorbia laurifolia Juss. ex Lam. Juss. ex Lam.*		x				x				
9	Mayorquín	*Cordia curassavica (Jacq.) Roem. & Schult.*		x				x				
10	Morochillo	*Miconia theaezans (Bonpl.) Cogn.*			x			x				
11	Walnut	*Juglans neotropica*	x					x				
12	Pichuelo	*Senna spectabilis (DC.) H.S.Irwin & Barneby*	x					x				
13	Patula pine	*Pinus patula Schiede ex Schltdl. & Cham.*					x	x				
14	Pispura	*Dalea coerulea*			x			x				
15	Yellow trumpetbush	*Tecoma stans (L.) Juss. ex Kunth (L.) Juss. ex Kunth*			x				x			
16	Sachapanga	*Siparuna echinata (Kunth) A. DC.*		x				x				

No.	Common Name	Scientific Name	Degree of Sociability					Abundance-Dominance				
			1	2	3	4	5	1	2	3	4	5
17	Elderberry	*Sambucus nigra L. L.*		x				x				

Abundance-Dominance 5 covers more than 75% of the plot; 4 covers between 50% and 75% of the plot, 3 covers between 25% and 50% of the plot, 2 covers between 5% and 25% of the plot and 1 covers about 5% of the plot. Degree of Sociability: 5 almost pure population of the plot, 4 in almost continuous colonies, 3 in scattered spots, 2 in clumps or thickets and 1 isolated individuals.

Source: Géminis Consultores Ambientales, 2016

In the dense shrubland ecosystem of the Upper Andean Orobiome, the species found on the plots analyzed had degrees of sociability of 2 and 3, which is characteristic of the growth and development of the species listed as near endemic. Regarding the structural base of the habitat, the species found had a hierarchy of 1, 2 and 3, i.e. the cover of the species on the plots is no more than 50%, as indicated in Table 5.2.33.

Table 5.2.33 Degree of sociability and spatial structure in the Dense shrubland ecosystem of the Upper Andean Orobiome.

No.	Common Name	Scientific Name	Degree of Sociability					Abundance-Dominance				
			1	2	3	4	5	1	2	3	4	5
1	Cerote	*Hesperomeles obtusifolia*	x						x			
2	Coyote bush	Baccharis latifolia		x					x			
3	Colla	Dendrophorbium lloense (Hieron. ex Sodiro) C.Jeffrey			x				x			
4	Tara	*Mimosa quitensis Benth*		x				x				
5	Big sage	Lantana camara		x				x				
6	Lechero	*Euphorbia laurifolia Juss. ex Lam. Juss. ex Lam.*		x					x			
7	Morochillo	Miconia thaezans			x					X		
8	Pilampo	Barnadecia spinosa		x				x				
9	Sance	*Indeterminada*		x					x			
10	Santa Maria	*Liabum igniarium*		x					x			
11	Sarza	*Mimosa albicans*		x					x			

Abundance-Dominance 5 covers more than 75% of the plot; 4 covers between 50% and 75% of the plot, 3 covers between 25% and 50% of the plot, 2 covers between 5% and 25% of the plot and 1 covers about 5% of the plot. Degree of Sociability: 5 almost pure population of the plot, 4 in almost continuous colonies, 3 in scattered spots, 2 in clumps or thickets and 1 isolated individuals.

Source: Géminis Consultores Ambientales, 2016

c. Abundance, dominance and frequency

Using the data of individuals in the stem state reported in the inventory, the abundance, dominance and frequency parameters were calculated for the continuous ecosystems listed below with the results of each. See annexes 5.2.1.4-a to 5.2.1.4-c.

Wooded pastures of the Middle Andean Orobiome

As illustrated in Figure 5.2.22, the species *Fraxinus chinensis* Roxb. (Chinese ash) is the one with the greatest relative dominance, in relation to the occupied area at 64.18%, followed by *Annona cherimola* Mill. (Cherimoya) at 18.20%.

As regards relative abundance, the predominant species is *Persea americana* Mill. (Avocado), at 52.38%, followed by *Inga spectabilis* (Vahl) Willd. (Shimbillo); the remaining species showed values lower than 10%. In terms of relative frequency, the distribution is similar for all the species.

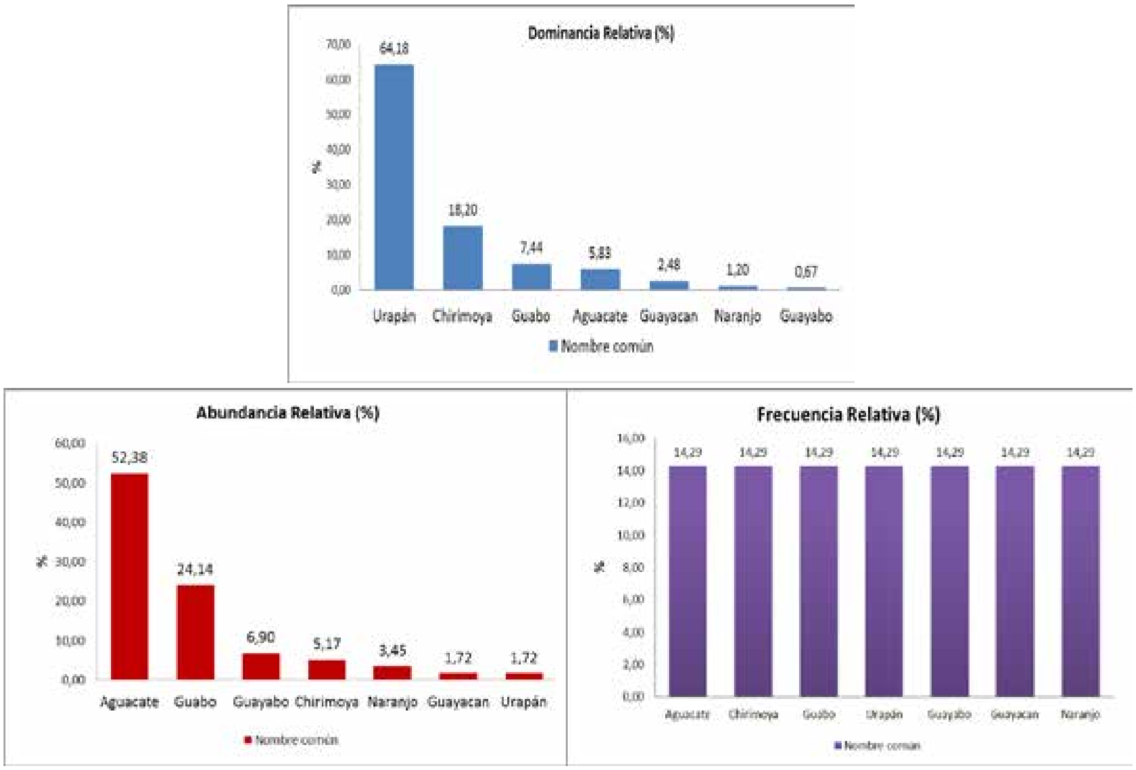


Figure 5.2.22 Abundance, dominance and frequency in the Wooded pasture ecosystem of the Middle Andean Orobiome

Source: Géminis Consultores Ambientales, 2016

Riparian forest of the Middle Andean Orobiome

As illustrated in Figure 5.2.23, the species *Handroanthus chrysanthus (Jacq.) S.O.Grose*. (Guayacan amarillo), stands out in the parameters of abundance, dominance and frequency, with values of 88.19%, 82.56% and 25%, respectively.

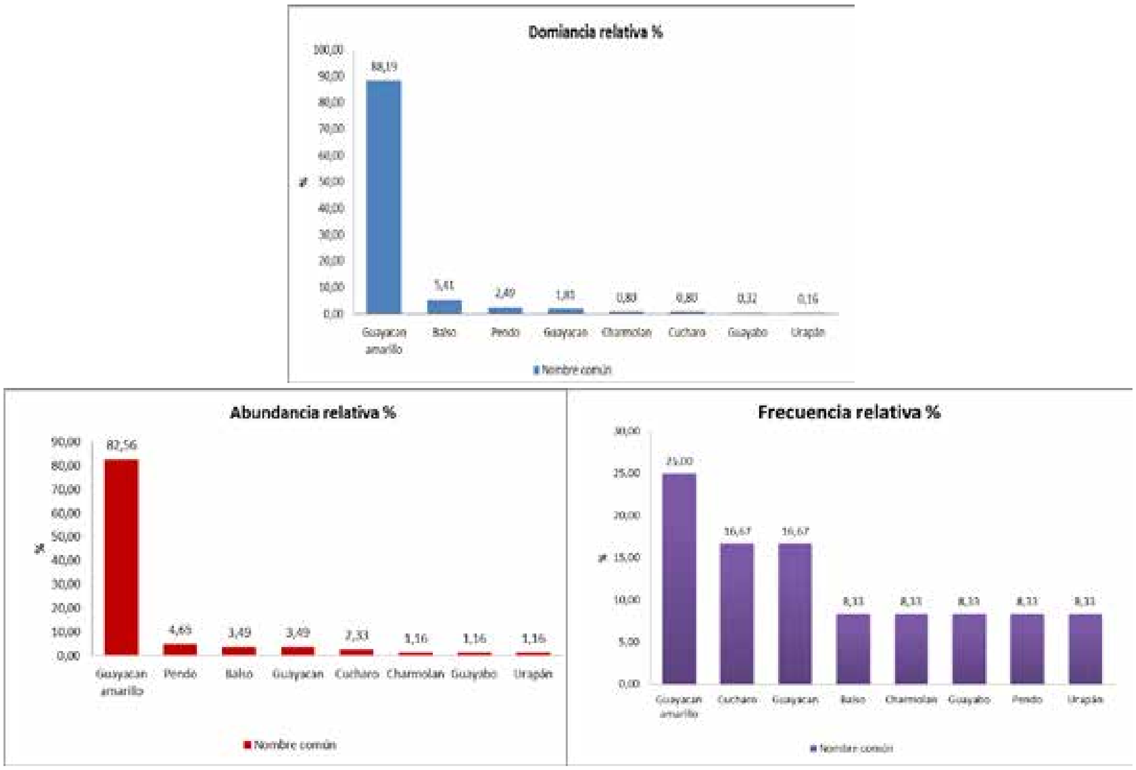


Figure 5.2.23 Abundance, dominance and frequency in the Riparian forest ecosystem of the Middle Andean Orobiome

Source: Géminis Consultores Ambientales, 2016

Riparian forest of the Upper Andean Orobiome

Figure 5.2.24 illustrates that the species *Eucalyptus globulus* Labill. (Eucalyptus), shows strong predominance in terms of horizontal structure, both in abundance and in dominance and frequency, denoting the possible presence of a forest or plantation of this species in the area, followed by disturbance, thus giving rise to the regeneration of the species together with other pioneer species in the area, in addition to introduced species, whose seeds are scattered by nearby trees..

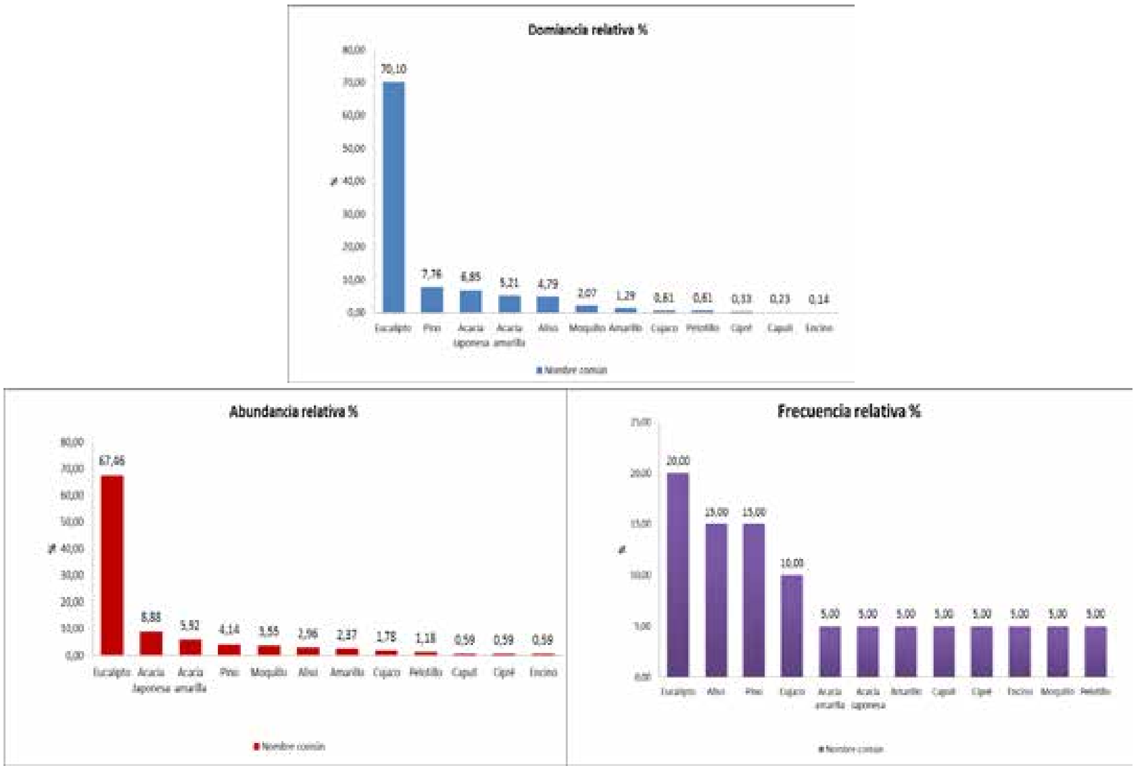


Figure 5.2.24 Abundance, dominance and frequency in the Riparian forest ecosystem of the Upper Andean Orobiome

Source: Géminis Consultores Ambientales, 2016

d. Importance Value Index - IVI

Wooded pastures of the Middle Andean Orobiome

The species *Fraxinus chinensis* Roxb. (Chinese ash), is the most important in this ecosystem, followed by *Annona cherimola* Mill. (Cherimoya) for which there are significant values of both presence in the ecosystem and dominance with respect to the area (Figure 5.2.25).

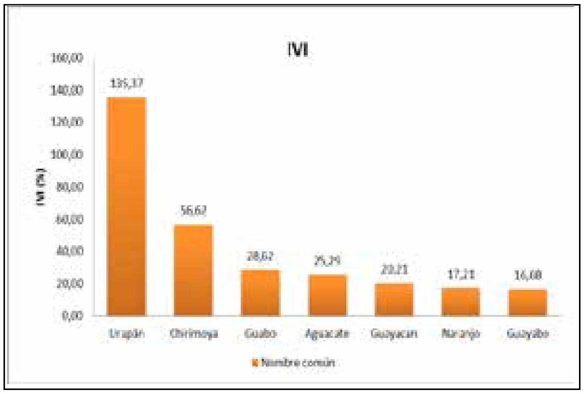


Figure 5.2.25 Importance Value Index (IVI) of the Wooded pasture ecosystem of the Middle Andean Orobiome

Source: Géminis Consultores Ambientales, 2016

Riparian forest of the Middle Andean Orobiome

In the ecosystem associated with the riparian forest, the most important species is *Handroanthus chrysanthus (Jacq.) S.O.Grose*. (Guayacan amarillo), in the least intervened area thereof; in the area near the road, there is evidence of plantation of species, such as *Eucalyptus globulus* Labill and *Fraxinus chinensis* Roxb. in order to recover the water source protection areas (Figure 5.2.26).

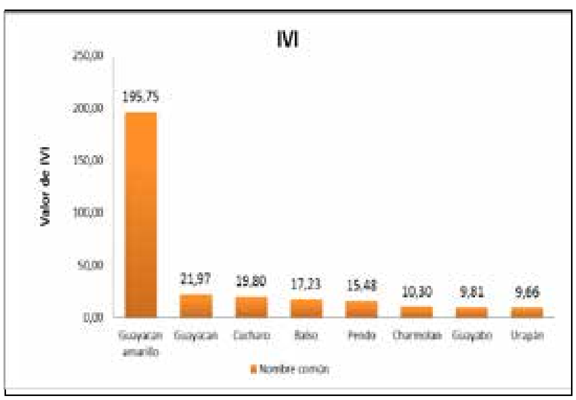


Figure 5.2.26 Importance Value Index (IVI) in the Riparian forest ecosystem of the Middle Andean Orobiome

Source: Géminis Consultores Ambientales, 2016

Riparian forest of the Upper Andean Orobiome

As mentioned above, for this ecosystem, the species *Eucalyptus globulus* Labill. (Eucalyptus) has the highest values in terms of horizontal structure, so it has the highest importance value index (Figure 5.2.27).

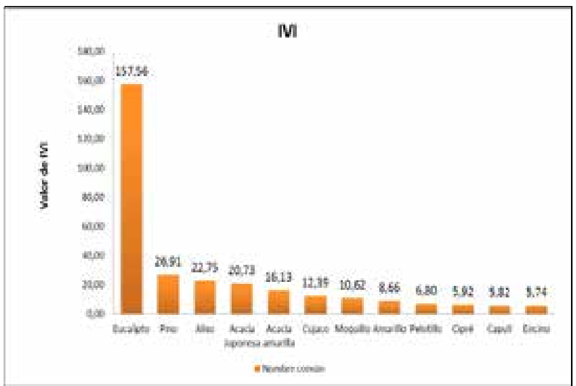


Figure 5.2.27 Importance Value Index (IVI) in the Riparian forest ecosystem of the Upper Andean Orobiome

Source: Géminis Consultores Ambientales, 2016

e. Distribution density by diametric and altimetric class

Wooded pastures of the Middle Andean Orobiome

As illustrated in Table 5.2.34, Table 5.2.35 and Figure 5.2.28, most of the individuals are located in the first two strata of altimetric distribution, as well as in the first two diametric strata, indicating a low level of development of the individuals, either due to their age or the intrinsic conditions of the species.

Table 5.2.34 Distribution density by alimetric class in the Wooded pasture ecosystem of the Middle Andean Orobiome

Altimetric distribution		No. of trees per stratum	Total %
Lower	<=8	29	50.00
Middle	> 8 - <= 11	23	39.66
Upper	> 11 - <= 16	6	10.34
Tree	> 16 - <= 20	0	0.00
Emerging	>20	0	0.00
TOTAL		**58**	**100**

Source: Géminis Consultores Ambientales, 2016

Table 5.2.35 Distribution density by diametric class in the Wooded pasture ecosystem of the Middle Andean Orobiome

Diametric class		No. of trees per class	Total %
1	10 - <= 30	30	51.72
2	> 30 - <= 60	28	48.28
3	> 60 - <= 90	0	0.00
4	> 90	0	0.00
TOTAL		**58**	**100**

Source: Géminis Consultores Ambientales, 2016

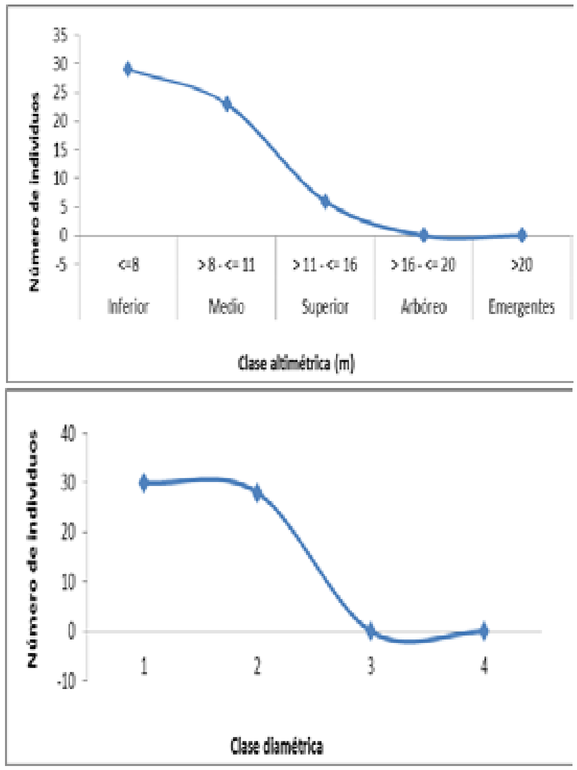


Figure 5.2.28 Distribution density by diametric and alimetric class in the Wooded pasture ecosystem of the Middle Andean Orobiome

Source: Géminis Consultores Ambientales, 2016

Riparian forest of the Middle Andean Orobiome

As illustrated in Table 5.2.36, Table 5.2.37 and Figure 5.2.29, most of the individuals are concentrated in the first three strata (lower, middle and upper) with values of 31.69%, 49.73% and 14.21%, predominated by the middle stratum. This result indicates that these are relatively young trees, which is reaffirmed with the results of diametric distribution, where the individuals of this ecosystem are clustered in the lower class; the upper classes do not have individuals, which leads to the deduction that the tree component has medium and short stems that have not reached their full development.

Table 5.2.36 Distribution density by altimetric class in the Riparian forest ecosystem of the Middle Andean Orobiome

Altimetric distribution		No. of trees per stratum	Total %
Lower	<=8	0	0.00
Middle	> 8 - <= 11	3	3.49
Upper	> 11 - <= 16	19	22.09
Tree	> 16 - <= 20	36	41.86
Emerging	>20	28	32.56
TOTAL		**86**	**100**

Source: Géminis Consultores Ambientales, 2016

Table 5.2.37 Distribution density by diametric class in the Riparian forest ecosystem of the Middle Andean Orobiome

Diametric class		No. of trees per class	Total %
1	10 - <= 30	79	92
2	> 30 - <= 60	7	8
3	> 60 - <= 90	0	0
4	> 90	0	0
TOTAL		**86**	**100**

Source: Géminis Consultores Ambientales, 2016

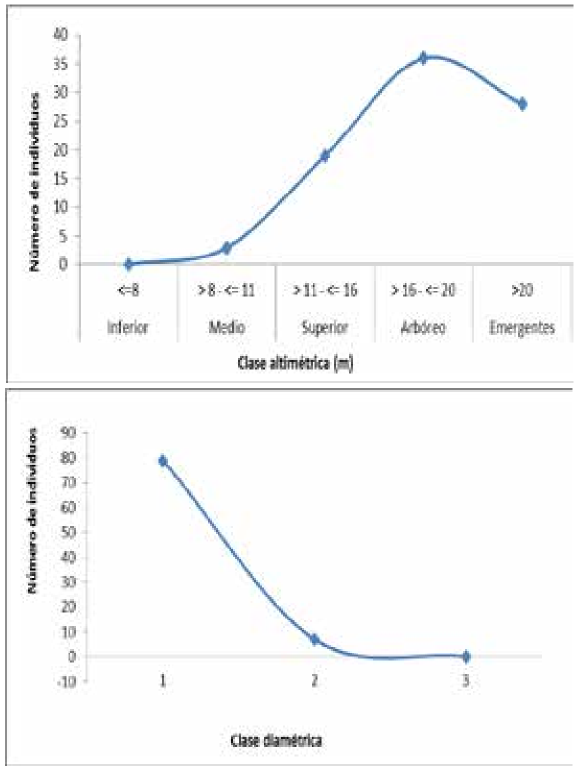


Figure 5.2.29 Distribution density by diametric and altimetric class in the Riparian forest ecosystem of the Middle Andean Orobiome

Source: Géminis Consultores Ambientales, 2016

Riparian forest of the Upper Andean Orobiome

Table 5.2.38, Table 5.2.39 and Figure 5.2.30 illustrate that most of the individuals of this ecosystem are in the first two strata and that all the individuals are concentrated in diametric class 1, indicating that the threes are at their middle stage of development.

Table 5.2.38 Distribution density by altimetric class in the Riparian forest of the Upper Andean Orobiome

Altimetric distribution	No. of trees per stratum	Total %

Lower	<=8	33	19.53
Middle	> 8 - <= 11	44.00	26.04
Upper	> 11 - <= 16	56.00	33.14
Tree	> 16 - <= 20	18.00	10.65
Emerging	>20	18	10.65
TOTAL		**169**	**100**

Source: Géminis Consultores Ambientales, 2016

Table 5.2.39 Distribution density by diametric class in the Riparian forest of the Upper Andean Orobiome

Diametric class		No. of trees per class	Total %
1	10 - <= 30	157	92.90
2	> 30 - <= 60	12	7.10
3	> 60 - <= 90	0	0.00
4	> 90	0	0.00
TOTAL		**169**	**100**

Source: Géminis Consultores Ambientales, 2016

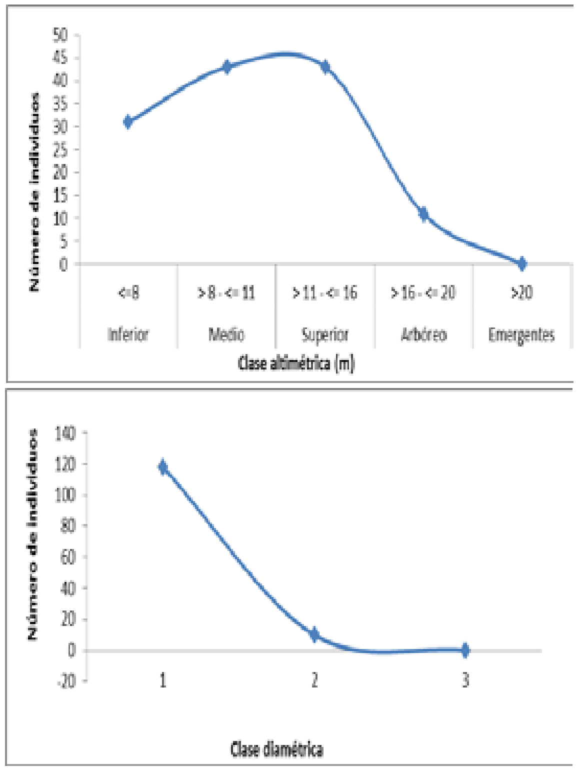


Figure 5.2.30 Distribution density by diametric and altimetric class in the Riparian forest ecosystem of the Upper Andean Orobiome

Source: Géminis Consultores Ambientales, 2016

f. Diagnosis and analysis of natural regeneration

This parameter considers the natural ecosystems in which the species with tree habits in the sapling and seedling stages were found, excluding the patchworks in which human intervention disturbs the natural regeneration processes. See annex 5.2.1.7. Reports on the calculation of natural regeneration indices.

Riparian forest of the Middle Andean Orobiome

The species *Myrsine guianensis* (Aubl.) Kuntze is the predominant species in this ecosystem at a natural relative regeneration of 29.35%, followed by *Tecoma stans (L.) Juss. ex Kunth* (Yellow trumpetbush) at 24.31% and *Handroanthus chrysanthus* (Jacq.) S.O.Grose (Guayacan amarillo) at 19.02%, as illustrated in Table 5.2.40; there is good regeneration potential in this over with seven different tree species, thanks to the little human disturbance suffered by the areas, since they are dedicated to the protection and conservation of watercourses.

Table 5.2.40 Analysis of natural regeneration of the Riparian forest of the Middle Andean Orobiome

Common Name	Scientific Name	Size Category						CTrRN	CTaRN	AaRNi	Ar RN	FaRN	FrRN	RNr
		I. 0.1-0.99 m		II. 1.0-1.9 m		III. >2.0 m								
		No.	Vfi	No.	VFm	No.	VFs							
Cucharo	*Myrsine guianensis* (Aubl.) Kuntze	0	0	1	1	5	9	46.00	28.05	6	30.00	100	30.00	29.35
Guayacan	*Lafoensia acuminata (Ruiz & Pav.) DC.*	0	0	0	1	1	9	9.00	5.49	1	5.00	33	10.00	6.83
Guayacan amarillo	*Handroanthus chrysanthus* (Jacq.) S.O.Grose	0	0	1	1	3	9	28.00	17.07	4	20.00	67	20.00	19.02
Majua	*Palicourea sp*	0	0	0	1	1	9	9.00	5.49	1	5.00	33	10.00	6.83
Loquat	*Eriobotrya japónica* (Thunb.) Lindl.	0	0	0	1	1	9	9.00	5.49	1	5.00	33	10.00	6.83
Yellow trumpetbush	*Tecoma stans* (L.) Juss. ex Kunth	0	0	0	1	6	9	54.00	32.93	6	30.00	33	10.00	24.31
Chinese ash	*Fraxinus chinensis* Roxb.	0	0	0	1	1	9	9.00	5.49	1	5.00	33	10.00	6.83

Continued														
TOTAL	TOTAL	0		2		18		164.00	100	20	100	333	100	
V.Fitos	V.Fitos	0.00		10.00		90.00		100						
Simpl.	Simpl.	0.00		1.00		9.00								
Round	Round	0		1		9								

Source: Géminis Consultores Ambientales, 2016

Dense shrubland of the Upper Andean Orobiome

In this ecosystem, there is only one tree habit species, *Dendrophorbium lloense* (Hieron. ex Sodiro) C. Jeffrey, i.e. the result of the natural relative regeneration index is 100%.

Riparian forest of the Upper Andean Orobiome

This ecosystem has the characteristics of a forest in the first stages of plant succession. In addition to shrub-type colonizing species, there are 9 tree-type species at the sapling and stem stages, among which *Dendrophorbium lloense (Hieron. ex Sodiro) C.Jeffrey* (Colla) is the predominant species in terms of the natural relative regeneration index at 20.43%, followed by *Acacia melanoxylon R.Br.* (Australian blackwood) at 17.10% (Table 5.2.41).

Table 5.2.41 Analysis of natural regeneration, Riparian forest of the Upper Andean Orobiome

Common Name	Scientific Name	Size Category						CTrRN	CTaRN	AaRNi	Ar RN	FaRN	FrRN	RNr
		I. 0.1-0.99 m		II. 1.0-1.9 m		III. >2.0m								
		No	Vf	No	VF	No	VFs							

Common Name	Scientific Name	Size Category						CTrRN	CTaRN	AaRNi	Ar RN	FaRN	FrRN	RNr
		.	i	.	m	.								
Australian blackwood	*Acacia melanoxylon R.Br.*	0	1	0	2	10	7	67.35	26.72	10	20.41	25	4.17	17.10
Charmolan	*Geissanthus serrulatus (Willd. ex Roem. & Schult.) Mez*	1	1	0	2	0	7	1.02	0.40	1	2.04	50	8.33	3.59
Colla	*Dendrophorbium lloense (Hieron. ex Sodiro) C.Jeffrey*	0	1	7	2	6	7	56.12	22.27	13	26.53	75	12.50	20.43
Eucalyptus	*Eucalyptus globulus Labill.*	0	1	0	2	2	7	13.47	5.34	2	4.08	75	12.50	7.31
Laurel	*Morella pubescens (Humb. & Bonpl. ex Willd.) Wilbur*	0	1	0	2	3	7	20.20	8.02	3	6.12	50	8.33	7.49
Alstonville	*Tibouchina lepidota (Bonpl.) Baill.*	0	1	0	2	2	7	13.47	5.34	2	4.08	50	8.33	5.92
Moquillo	*Saurauia bullosa Wawra.*	0	1	0	2	1	7	6.73	2.67	1	2.04	50	8.33	4.35
Mote	*Saurauia ursina Triana & Planch.*	2	1	2	2	3	7	26.73	10.61	7	14.29	50	8.33	11.08
Pelotillo	*Viburnum triphyllum Benth.*	0	1	0	2	1	7	6.73	2.67	1	2.04	25	4.17	2.96
Patula pine	*Pinus patula Schiede ex Schltdl. & Cham.*	0	1	0	2	1	7	6.73	2.67	1	2.04	50	8.33	4.35
Roso	*Vallea stipularis L.f.*	2	1	1	2	4	7	31.22	12.39	7	14.29	50	8.33	11.67

Common Name	Scientific Name	Size Category						CTrRN	CTaRN	AaRNi	Ar RN	FaRN	FrRN	RNr
Elderberry	*Sambucus nigra L.*	0	1	1	2	0	7	2.24	0.89	1	2.04	50	8.33	3.75
Continued														
TOTAL	TOTAL	5		11		33		252	100	49	100	600	100	100
V.Fitos	V.Fitos	10.20		22.45		67.35		100						
Simpl.	Simpl.	1.02		2.24		6.73								
Round	Round	1		2		7								

Source: Géminis Consultores Ambientales, 2016

g. Plant profiles

Riparian forest of the Middle Andean Orobiome

The plant profile for this cover shows just one stratum, where *Fraxinus chinesis* (Urapán) dominates the canopy. There is a high density of individuals and the presence of clearings and sectors with homogeneous clusters of the dominant species (Figure 5.2.31).

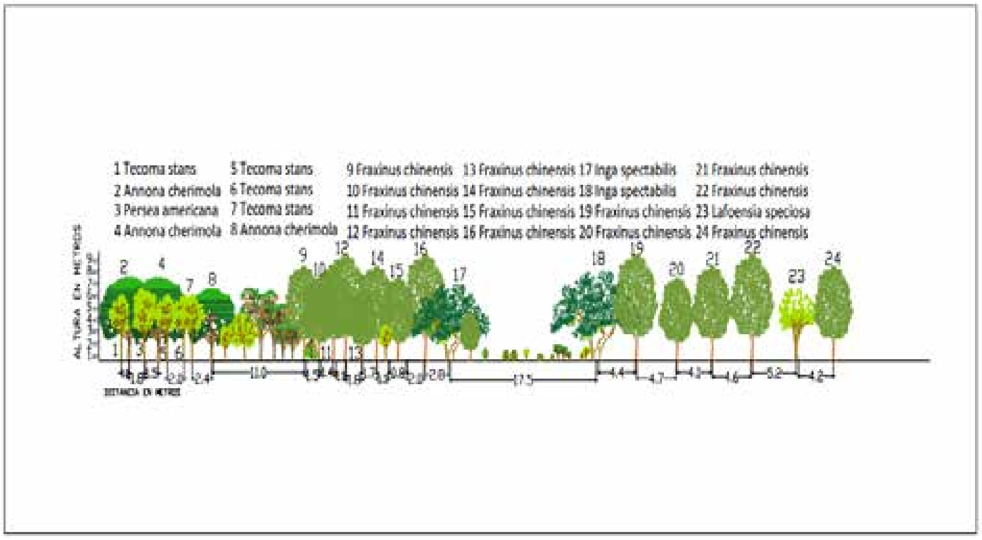


Figure 5.2.31. Plant profile of the Riparian forest cover of the Middle Andean Orobiome
Source: Géminis Consultores Ambientales, 2016

Riparian forest of the Upper Andean Orobiome

The plant profile for this covers shows two strata, where *Eucalyptus globulus Labill*. (eucalyptus) dominates the canopy, allowing little presence of clearings, due to the high growth density of the individuals (Figure 5.2.32).

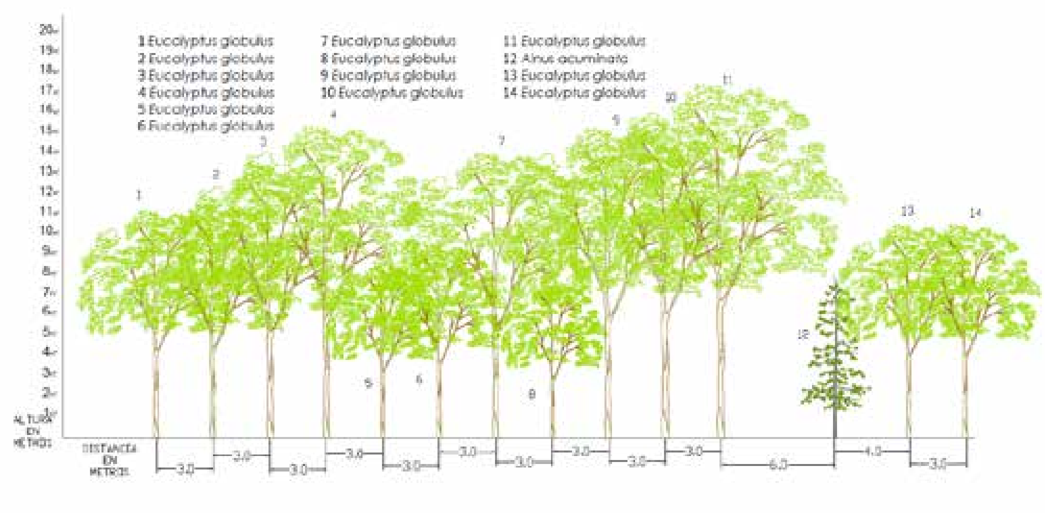


Figure 5.2.32. Secondary plant profile of the Upper Andean Orobiome
Source: Géminis Consultores Ambientales, 2016

Economic, ecological and cultural importance of the species

As illustrated in Table 5.2.67, there are species of different types of importance in functional units 4 and 5; most of them are ecological, as they are typical species of the region, and although they do not produce large volumes of wood, they provide ecosystemic services, such as the regulation of the water flow in basins and watersheds, food and habitat for wildlife, protection of water sources and mooring, among others.

The economic importance of the species in the Pedregal-Catambuco sector lies in the production of wood, for building and furniture, as well as for wood-based bioenergy use, in addition to the fruit trees that are sold in some sectors, which represent income for the producer.

As regards cultural importance, there are mainly the species that offer benefits in terms of landscaping, or are used for ritual or medicinal purposes, or traditionally in the preparation of sweets, as is the case of *Carica pubescens* (Mountain papaya). (Table 5.2.42)

Table 5.2.42 Economic, ecological and cultural importance of the species

No.	Common Name	Scientific Name	Family	Importance		
				Economic	Ecological	Cultural
1	Black wattle	*Acacia decurrens*	Fabaceae	X		
2	Australian blackwood	*Acacia melanoxylon*	Fabaceae	X		
3	Avocado	*Persea americana*	Lauraceae	X		
4	Caper	*Senna pistaciifolia*	Fabaceae	X		
5	Alder	*Alnus acuminata*	Betulaceae	X		
6	Altamisa	*Ambrosia arborescens*	Asteraceae		X	X
7	Amarillo	*Miconia nodosa*	Melastomataceae	X	X	X
8	Monkey puzzle tree	*Araucaria araucana*	Araucariaceae		X	
9	Arrayanes	*Myrcianthes rhopaloides*	Myrtaceae	X	X	
10	Angel's trumpet	*Brugmansia arborea*	Solanaceae		X	X
11	Black cherry	*Prunus serotina*	Rosaceae		X	X
12	Carbonero	*Albizia carbonaria Britton*	Mimosaceae		X	
13	Caspirosario	*Llagunoa nitida*	Sapindaceae	X	X	
14	Cedrillo	*Phyllanthus salviifolius*	Phyllanthaceae		X	
15	Cerote	*Hesperomeles obtusifolia*	Rosaceae		X	
16	Charmolan	*Geissanthus serrulatus*	Theaceae	X	X	
17	Mountain papaya	*Carica pubescens*	Caricaceae	X		X
18	Coyote bush	*Baccharis latifolia*	Asteraceae		X	X
19	Cherimoya	*Annona cherimola*	Annonaceae	X	X	
20	White cedar	*Cupressus lusitanica*	Cupressaceae	X		
21	Colla	*Dendrophorbium lloense*	Asteraceae		X	
22	Cordoncillo	*Piper bogotense*	Juglandaceae		X	
23	Cucharo	*Myrsine guianensis*	Myrsinaceae	X	X	

No.	Common Name	Scientific Name	Family	Importance		
				Economic	Ecological	Cultural
24	Cueche	*Piper catripense*	Piperaceae		X	
25	Cujaco	*Solanum hazenni*	Solanaceae		X	
26	Peach	*Prunus persica*	Rosaceae			X
27	Encenillo	*Weinmannia tomentosa*	Cunoniaceae		X	
28	Eucalyptus	*Eucalyptus globulus*	Myrtaceae	X		
29	Shimbillo	*Inga spectabilis*	Mimosaceae	X	X	
30	Soursop	*Annona muricata*	Annonaceae	X		
31	Tara	*Mimosa quitensis Benth*	Mimosaceae		X	
32	Guayabillo	*Psidium acutangulum*	Myrtaceae		X	
33	Common guava	*Psidium guajava*	Myrtaceae	X		
34	Guayacan	*Lafoensia acuminata*	Lythraceae	X		
35	Guayacan amarillo	*Handroanthus chrysanthus*	Bignoniaceae		X	
36	Castorbean	*Ricinus communis*	Euphorbiaceae		X	
37	Big sage	*Lantana camara*	Verbenaceae		X	
38	Laurel	*Morella pubescens*	Myricaceae	X	X	X
39	Lechero	*Euphorbia laurifolia*	Euphorbiaceae		X	
40	Leucaena	*Leucaena leucocephala*	Fabaceae		X	
41	Lemon	*Citrus limon*	Rutaceae	X		
42	Maco	*Cabralea oblongifoliola.*	Meliaceae	X	X	
43	Majua	*Palicourea sp*	Rubiaceae		X	
44	Tangerine	*Citrus reticulata Blanco*	Rutaceae	X		
45	Alstonville	*Tibouchina lepidota*	Melastomataceae		X	X
46	Mayorquín	*Cordia divaricata*	Boraginaceae		X	
47	Miconia	*Miconia sp*	Melastomataceae		X	
48	Moquillo	*Saurauia bullosa*	Actinidiaceae		X	
49	American black nightshade	*Solanum nigrum*	Solanaceae		X	
50	Morochillo	*Miconia theaezans*	Melastomataceae		X	

No.	Common Name	Scientific Name	Family	Importance		
				Economic	Ecological	Cultural
51	Mote	*Saurauia ursina*	Actinidiaceae		X	
52	Munchiro	*Miconia versicolor*	Melastomataceae		X	
53	Nacedero	*Trichanthera gigantea*	Acanthaceae		X	
54	Orange	*Citrus sinensis*	Rutaceae	X		
55	Loquat	*Eriobotrya japonica*	Rosaceae	X		
56	Walnut	*Juglans neotropica*	Juglandaceae	X	X	X
57	False nettle	*Boehmeria sp*	Urticaceae		X	
58	Ovo	*Spondias mombin*	Anacardiaceae	X		
59	Palo Lion	*Allophylus mollis*	Sapindaceae		X	
60	Papaya	*Carica papaya*	Caricaceae	X		
61	Pelotillo	*Viburnum triphyllum*	Caprifoliaceae	X	X	
62	Pichuelo	*Senna spectabilis*	Fabaceae	X		
63	Pilampo	*Barnadesia spinosa*	Asteraceae		X	
64	Patula pine	*Pinus patula*	Pinaceae	X		
65	Pispura	*Daela coerulea*	Fabaceae		X	
66	Yellow trumpetbush	*Tecoma stans*	Bignonaceae	X		X
67	Rose mallow	*Hibiscus* sp	Malvaceae		X	X
68	Roso	*Vallea stipularis*	Elaeocarpaceae	X	X	
69	Sachapanga	*Siparuna echinata*	Siparunaceae		X	
70	Common sage	*Salvia officinalis*	Lamiaceae		X	
71	Sance	*Coursetia caribaea var. Astragalina*	Fabaceae		X	
72	Santa María	*Liabum igniarium*	Asteraceae		X	
73	Sarza	*Mimosa albicans*	Mimosaceae		X	
74	Humboldt's willow	*Salix humboldtiana*	Salicaceae	X	X	
75	Elderberry	*Sambucus nigra*	Caprifoliaceae		X	X
76	Chinese ash	*Fraxinus chinensis*	Oleaceae	X		

No.	Common Name	Scientific Name	Family	Importance		
				Economic	Ecological	Cultural
77	Uvilan	*Monnina aestuans*	Polygalaceae		X	
78	Yuca Arbórea	*Yucca filifera*	Asparagaceae		X	X
79	Zancia	*Coriaria ruscifolia*	Coriariaceae		X	
80	Zarcillejo	*Cavendishia bracteata*	Ericaceae		X	

Source: Géminis Consultores Ambientales, 2016.

Uses of the different forest species

In order to determine the importance of the species of the area of study, we started out by getting to know what the forest species in the area of each functional unit were used for; a survey was conducted and it was learned that the species are mainly for domestic use and, to a lesser extent, for commercial and medicinal purposes (Table 5.2.43).

The dominances contained in the GDB correspond to production, familiar animals, cleaning, ceremonial, cultural consumption, farming, material culture, power entity, subsistence, cultural use, housing and other. These were standardized with the uses expressed by the community in the area (food, fodder, medicinal, ornamental, crafts, domestic, commercial, industrial and hedges), as follows.

Table 5.2.43 Uses of forest species with regard to GDB dominance.

GDB Dominance	Use indicated by the community
Production activities	Fodder, hedges, industrial.
Subsistence	Domestic, food, commercial.
Cultural use	Ornamental, medicinal, crafts.

Source: Géminis Consultores Ambientales, 2016

Functional Unit 4

In order to determine the use of the forest species in accordance with the ecological, economic and cultural characteristics they represent for the inhabitants of the AI of the

Pedregal – Catambuco Span of the Rumichaca – Pasto Dual Carriageway Road Project, specifically for FU4, a survey determined that the communities mainly use the forest species for domestic use; to a lesser extent, the species are used for commercial and medicinal purposes. Table 5.2.44 illustrates the species identified by the community for a specific type of use.

Table 5.2.44. Main uses of the species in FU4

No.	Taxonomy			USE								
	Family	Common Name	Scientific Name	Food	Fod	Med	Orn	Art	Dom	Com	Ind	Hedge
1	Fabaceae	Black wattle	*Acacia decurrens* Willd				X		X			
2	Lauraceae	Avocado	*Persea americana*	X								
3	Malvaceae	Balsa	*Ochroma pyramidale*						X	X		
4	Fabaceae	Basul	*Erythrina edulis*	X					X			
5	Annonaceae	Cherimoya	*Annona cherimola*	X						X		
6	Myrtaceae	Eucalyptus	*Eucalyptus globulus*						X			
7	Myrtaceae	Common guava	*Psidium guajava*	X						X		
8	Lythraceae	Guayacan	*Lafoensia acuminata*				X		X			
9	Moraceae	Ficus monckii	*Ficus luschnathiana*				X		X			
10	Euphorbiaceae	Lechero	*Euphorbia laurifolia*									X
11	Fabaceae	Matarraton	*Gliricidia sepium*		X							X
12	Rosaceae	Loquat	*Eriobotrya japonica*	X								
13	Fabaceae	Pichuelo	*Senna spectabilis*									X
14	Bignonaceae	Yellow trumpetbush	*Tecoma stans*				X		X			
15	Salicaceae	Humboldt's willow	*Salix humboldtiana*				x					
16	Adoxaceae	Elderberry	Sambucus peruviana			X			X			
17	Oleaceae	Chinese ash	*Fraxinus chinensis*				X					

Food= Food Dom= Domestic Fod=Fodder Art=Crafts Com=Commercial Med= Medicinal Orn = Ornamental Hedge=Hedges
Source: Géminis Consultores Ambientales, 2016.

§ **Meals**

According to the survey conducted in FU4, the species used most for food are: *Erythrina edulis* (Basul), *Annona cherimola Mill.*(Cherimoya), *Psidium guajava L.* (Common guava), *Eriobotrya japonica (Thunb.) Lindl. (Thunb.) Lindl.*(Loquat), *Persea americana Mill.* (Avocado) and *Mangifera indica* (Mango); it was also reported that these species have a commercial use, as their fruits are sold and it is a source of income for the families.

§ **Fodder**

According to table, the species reported as used for fodder is *Gliricidia sepium* (Matarraton), which is used to feed cattle.

§ **Medicinal**

The population surveyed reported the species *Sambucus nigra L.* (Elderberry), as a species used for medicinal purposes, whose flowers are used in an infusion for cough, along with its leaves to help with the flu and as an aromatic beverage.

§ **Ornamental**

The species used for ornamental purposes are: *Acacia decurrens* Willd (Black wattle), *Ficus luschnathiana* (Ficus monckii), *Tecoma stans (L.) Juss. ex Kunth* (Yellow trumpetbush), *Salix humboldtiana* (Humboldt's willow), *Fraxinus chinensis Roxb.* (Chinese ash), *Lafoensia acuminata (Ruiz & Pav.) DC.* (Guayacan); we found these species around the homes.

§ **Domestic**

The species reported by the community for wood-based bioenergy are: *Acacia decurrens* Willd (Black wattle), *Ochroma pyramidale* (Balsa), *Erythrina edulis* (Basul), *Eucalyptus globulus Labill.* (Eucalyptus), Guayacan (Lafoensia acuminata (Ruiz & Pav.)

DC.), *Ficus luschnathiana* (Ficus monckii), *Tecoma stans (L.) Juss. ex Kunth* (Yellow trumpetbush), and *Sambucus nigra L.* (Elderberry). These species are used for ornamental purposes; however, when needed as firewood, they are felled. Of the above species, Eucalyptus is planted for the sole purpose of firewood production.

Functional Unit 5

The main uses of the forest species in FU5.1 are listed below (Table 5.2.45).

Table 5.2.45. Main uses of the species in FU5.1

No.	Common Name	Scientific Name	Family	USES								
				Food	Fod	Med	Orn	Art	Dom	Com	Ind	Hedge
1	Eucalyptus	*Eucalyptus globulus Labill.*	Myrtaceae			X			X			
2	Alder	*Alnus jorullensis*	Betulaceae				X		X			X
3	Coyote bush	*Bracharis latifolia*	Asteraceae			X						
4	Chinese ash	*Fraxinus chinensis Roxb.*	Oleaceae				X					
5	Moquillo	*Saurauia pruinosa*	Actinidiaceae									X
6	Cerote	*Hesperomeles glabrata*	Rosaceae			X						
7	Glory bush	*Tibouchina lepidota*	Melastomataceae				X		X			
8	Myrtle	*Myrcianthes rhopaloides*	Myrtaceae				X					X
9	Patula pine	*Pinus patula*	Pinaceae						X	X		
10	Laurel de cera	*Myrica pubescens*	Myricaceae			X						
11	Australian blackwood	*Acacia melanoxylun*	Fabaceae				X		X			X
12	White cedar	*Cupressus lusitanica*	Cupressaceae						X			X
13	Encenillo	*Weinmannia tomentosa*	Cunoniaceae						X			

Food= Food Dom= Domestic Fod=Fodder Art=Crafts Com=Commercial Med= Medicinal Orn = Ornamental Hedge=Hedges
Source: Géminis Consultores Ambientales, 2016.

The forest species are mainly used for domestic purposes, as firewood; hedges is another significant use, for which 6 species, of the 14 reported by the community, are used.

§ **Domestic Use**

This classification is made up of the species with wood-based bioenergy potential, used as firewood(Photo 5.2.23) and coal, including: *E. globulus*, *Alnus acuminata* (Alder), *Tibouchina lepidota* (Glory bush), *Pino patula* (Pine), *Acacia melanoxylum (*Australian blackwood), *Cupressus lusitánica* (White cedar) and *Weinmannia tomentosa* (Encenillo).

Photo 5.2.23. Domestic use as firewood of the plant species in the Municipality of Tangua, El Tambor district. PR 22 + 800
Magna Sirgas coordinates origin West X: 967969; Y: 616563
Source: Géminis Consultores Ambientales, 2016.

Eucalyptus *E. globulus* takes on relevance because the population uses this species as wood for posts and firewood (TRUJILLO, 2007), due to its high timber potential; even its side branches can be used (GIRALDO & CAMARGO, 2006) (See Photo 5.2.24).

Photo 5.2.24. Forest Plantation of *Eucalyptus globulus Labill.* (Eucalyptus), El Tambor district.
PK 24+500
Magna Sirgas coordinates origin West X: 968013; Y: 616651
Source: Géminis Consultores Ambientales, 2016.

§ **Commercial Use**

The species used most for commercial purposes is *Pino patula* due to the quality of its wood, which is why several plantations have been established in the AI of the Pedregal – Catambuco Span of the Rumichaca – Pasto Dual Carriageway Road Project (See Photo 5.2.25).

Photo 5.2.25. Plantation of *Pino patula* (Pine) in the district of Cubijan Bajo.
PK 29 + 000

Magna Sirgas coordinates origin West X: 972666; Y: 618111

The wood extracted from the trees of *P. patula* is sold in blocks and used in carpentry processes for the preparation of various elements, such as crates (See Photo 5.2.26).

Photo 5.2.26. Carpentry use of the wood extracted from the forest species in the Catambuco Township in the Municipality of Pasto.
PK 34+000
Magna Sirgas coordinates origin West X: 976194; Y: 620764
Source: Géminis Consultores Ambientales, 2016.

§ **Medicinal**

Species such as *Eucalyptus globulus Labill.* (Eucalyptus), Alnus acuminata (Alder), *Hesperomeles glabrata* (Cerote), *Myrica pubescens* (Laurel), are used for medicinal purposes by the community. For instance, *Baccharis latifolia (Ruiz & Pav.) Pers.* (Coyote bush) is used to cure earaches, *Hesperomeles glabrata* (Cerote) is for swollen kidneys and *Eucalyptus globulus Labill.* (Eucalyptus) for the flu.

§ **Hedges**

Alnus jorullensis (Alder), *Saurauia pruinosa* (Moquillo), Walnut (*Juglans neotropica*), *Myrcianthes rhopaloides* (Myrtle), *Acacia melanoxylum* (Australian blackwood) and *Cupressus lusitanica* (White cedar), are the species used most as hedges because they do not require much investment and they satisfy the basic need of farmers regarding their main objective (Photo 5.2.27).

Photo 5.2.27. Hedges of *Cupressus lusitanica* (White cedar), in El Tambor District, Municipality of Tangua.
PK 23+300
Magna Sirgas coordinates origin West X: 968024; Y: 616884
Source: Géminis Consultores Ambientales, 2016.

Cupressus lusitanica (White cedar) is one of the species used most as hedges due to its architecture, as it allows farmers to protect their crops from air currents. Furthermore, since the crown density is greater than 60%, it allows the branches to intertwine, thus serving as property boundaries (Photo 5.2.28).

Photo 5.2.28. Hedges using the forest species *Cupressus lusitanica* (White cedar). PK 26+600
Magna Sirgas coordinates origin West X: 970540; Y: 618575
Source: Géminis Consultores Ambientales, 2016.

Endemic, endangered or banned species

The categorization of threat to the forest species identified on the road corridor was carried out based on Resolution 0192 / 2014, the Red Book of Colombia's Timber Plants, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the International Union for the Conservation of Nature (IUCN).

Also, information in specialized literature, online databases and/or virtual catalogs of plants, regarding the ranges of distribution of the banned species, and it was found that the fern families Cyatheaceae and Dicksoniaceae, which are banned nationwide by INDERENA Resolution 0801 / 1997, may potentially be in the range of altitudes of the road outline, along with species, such as Walnut (Juglans neotropica), Oak (Quercus humboldtii), Romeron (Retrophyllum rospigliosii) and Colombian pine (Podocarpus oleifolious) that are included in Resolution 0316 / 1974.

Based on this information, in the forest inventory created for functional units 4 and 5, one species that was banned by Resolution 0316 was identified, which is *Junglas* *neotropica* (Walnut), in addition to an endangered species, which is *Cedrela Odorata* (Cedar).

Below is the classification of threat of the species identified, according to category of threat at the National level(Table 5.2.46).

Table 5.2.46. Classification of species according to category of threat

No.	Common Name	Scientific Name	Res. 0192/ 2014	CITES	IUCN	RED BOOK OF COLOMBIA'S TIMBER PLANTS
1	Walnut	*Juglans neotropica*	*Endangered (EN)*	*III*	*Endangered (EN)**	*Endangered (EN)*
2	Cedar	*Cedrela odorata*	*Endangered (EN)*	*III*	*Vulnerable (VU)***	*Endangered (EN)*
	TOTAL					

*http://www.iucnredlist.org/details/32078/0 **http://www.iucnredlist.org/details/32292/0

Source: Géminis Consultores Ambientales, 2016.

As illustrated in Table 5.2.47, seven individuals were found in the stem stage, corresponding to the species *Juglans neotropica* Diels, as well as four individuals of the same species in the pole stage. (Table 5.2.48)

Table 5.2.47. Banned species in the stem stage, functional units 4 and 5

Id. Individual	Common Name	Species	Functional Unit	PK	District	Cover	X	Y
3	Walnut	*Juglans neotropica* Diels	FU 4	14+500	El Placer (Tangua)	2.4.3.2	963717.262	612169.879
12	Walnut	*Juglans neotropica* Diels	FU 4	14+500	El Placer (Tangua)	2.4.3.2	963729.618	612186.795
13	Walnut	*Juglans neotropica* Diels	FU 4	14+500	El Placer (Tangua)	2.4.3.2	963729.618	612186.795
1	Walnut	*Juglans neotropica* Diels	FU 4	43+100	Pilcuam Viejo (Imues)	2.4.3.2	954931.734	605106.372
229.4	Walnut	*Juglans neotropica* Diels	FU5.1	20+900	Cebadal (Tangua)	2.4.3.2	9669445.1	615501.98
662CI	Walnut	*Juglans neotropica* Diels	FU5.1	17+900	San Antonio (Tangua)	1.3	966390.16	614379.91
662.1CI	Walnut	*Juglans neotropica* Diels	FU5.1	17+900	San Antonio (Tangua)	1.3	966389.6	614378.14

Magna Sirgas Coordinates West:
Source: Géminis Consultores Ambientales, 2016.

Table 5.2.48. Banned species in the pole stage, functional units 4 and 5

Id. Individual	Species	Common Name	Planar coordinates* X	Y
ZA2	*Juglans neotropica* Diels	Walnut	956882.618	597820.019
ZA4	*Juglans neotropica* Diels	Walnut	956879.526	597816.947
ZA7	*Juglans neotropica* Diels	Walnut	956854.787	597783.163
ZA8	*Juglans neotropica* Diels	Walnut	956851.695	597783.163

*Magna Sirgas West
Source: Géminis Consultores Ambientales, 2016.

Table 5.2.49 references the six individuals in the pole stage of *Cedrela odorata* L. found in the Pedregal –Catambuco sector, along with their location.

Table 5.2.49. Species in the endangered category, functional units 4 and 5

Individual Identification	Common Name	Species	Functional Unit	Pk	District	X	Y
26	Cedar	*Cedrela odorata* L.	FU 4	PK 0+800	La lima (Imués)	957375.25	607356.98
27	Cedar	*Cedrela odorata* L.	FU 4	PK 0+800	La lima (Imués)	957369.24	607357.09
28	Cedar	*Cedrela odorata* L.	FU 4	PK 0+800	La lima (Imués)	957368.13	607348.47
30	Cedar	*Cedrela odorata* L.	FU 4	PK 0+800	La lima (Imués)	957368.8	607343.16
30v	Cedar	*Cedrela odorata* L.	FU 4	PK 0+800	La lima (Imués)	957368.23	607337.85
V1	Cedar	*Cedrela odorata* L.	FU 4	PK 0+800	La lima (Imués)	957369.79	607338.85

Source: Géminis Consultores Ambientales, 2016.

Habitat of preference and distribution of Juglans neotropica

In the areas adjacent to the area of influence of these functional units, it is common to find *juglans neotropica* individuals, even in the courtyards and gardens of rural homes; however, the number is not very high, because of the strong anthropogenic pressure due to their timber value.

Geographic Distribution

This species grows naturally in the north of the Andes mountain range from Venezuela to Bolivia, between altitudes of 800 and 3000 meters (Ospina - Penagos et al. 2003.). In Colombia, it has been collected practically throughout the Andean region, Antioquia, Boyacá, Caquetá, Cauca, Cundinamarca, Nariño, Norte de Santander, Putumayo, Quindío, Risaralda, Santander and Valle, at altitudes between 1,000 and 3,500 masl. (CÁRDENAS L., 2007)

Ecology

Walnut generally grows in moderately disturbed environments, such as secondary forests, Andean forest relicts, the edges of forests or even in pastures. It blooms annually, but the rainfall and altitude can affect this period, where it does so for shorter periods in the higher regions.. (CÁRDENAS L., 2007)

Juglans neotropica relates well with *Alnus spp*, *Nectandra Spp* and *Ocotea spp*, because it is semi-heliophilous, taking advantage of its shade at early ages. (BARRETO & HERRERA G, 1990)

Habitats of preference and distribution of Cedrela odorata

The species *Cedrela odorata*, was found on the cover "Crops with planted trees", in which the tree component consists primarily of hedges, where the individuals of this species were found.

Geographic Distribution

Cedar is widely distributed from northern Mexico to northern Argentina; in South America It is found in Colombia, Ecuador, Peru, Bolivia and Brazil, as well as in Paraguay and northern Argentina. In Colombia, it is widely distributed throughout all the lower regions and the Andean foothills; it has been reported in almost all the departments of the country, with the exception of Guainía, Norte de Santander, Vaupes and Vichada, where its presence has not yet been confirmed with biological records. **(Cárdenas López, Castaño Arboleda, Sua Tunjano, & Quintero Barrera, 2015)**

Ecology

The bioclimatic conditions of *Cedrela odorata* are warm, temperate and cold with moistures ranging from very wet to very dry, altitudes above sea level of up to 2000 m, annual average temperature of 25°C, varying between 9°C and 18°C for the coldest period and between 20°C and 40°C for the warmest period of the year and an average rainfall throughout the year that varies between 500 and 3200 mm, varying between 250 and 3200 mm for the wettest period and 0 and 1500 mm for the driest period. (CÁRDENAS, 2011)

Species banned by Resolution 0213 / 1977 (Epiphytic and Lithophytic / Terrestrial)

The purpose of bans on species of Colombian flora is to prohibit the removal, harvesting and transport of these species present in ecosystems of Colombian territory in order to promote and encourage their conservation, as well as the maintenance of ecosystem functions and services they provide. Resolution No. 0213 / 1977 establishes the ban on five taxonomic groups that include more than 7,000 species of flora registered in Colombia.

These groups include fungi and lichens (Fungi Kingdom), and within the Plantae Kingdom, the Marchantiophyta (liverwort) and Bryophyta (mosses) divisions and the Bromeliaceae (bromeliads) and Orchidaceae (orchids) families belonging to the Angiospermae subdivision.

In the vast majority of the country's ecosystems, species of these banned taxonomic groups, are established preferentially in epiphytic habitats, i.e., on other plants, without establishing a relationship of parasitism as erroneously believed in the past. In some ecological systems, this type of habitat is the only one in which there are representatives of these banned taxonomic groups (Linares, Krömer 199; et al. 2005).

The biological importance of the species of flora of epiphytic habits lies in the increase of the structural complexity of forests and the contribution of a huge variety of additional resources for the associated fauna, such as microhabitats, food sources and sites of concentration for reproduction (Gentry & Dodson 1987). Similarly, this type of species participate indirectly in the renewal of the canopy, because the excessive weight acquired by compact formations of briophytes and bromeliads, results in the falling of branches and part of the treetops, thus facilitating the processes of forest dynamics, and activating, the recycling of organic matter (Aguirre & Rangel, 2007).

The improvement in air quality due to the intake of CO2 and nitrogen and water regulation, due to the catchment of water due to their life forms, are also attributes valued as ecosystem services, which make the epiphytic species, a primary objective of conservation plans. Below are the results of the study of epiphytic and lithophytic flora conducted on the Pedregal - Catambuco span corresponding to functional units 4 and 5 of the Rumichaca - Pasto dual carriageway road project. It should be noted that the methodology used to obtain and process the information on these species is explained in detail in Chapter 2.

Methodology for the characterization of epiphytic and lithophytic species / Terrestrial

For the characterization of banned flora (Res. 01213) in the area of study, three types of methodologies were used, taking into account the vegetation covers assessed and differentiating the substrate on which they grow.

As for the lithophytic plant species (species that grow on rocky or terrestrial substrates), 5x5 m vertical plots were made on the slopes and rocky outcrops of the existing road; for the epiphytic plant species (species that grow on other plant species), 10x100 m c(0.1 ha) characterization plots were made, in the cases where a great diversity of epiphytic species were found in places where a plot could not be established due to the size of the tree cover, 2x50 m linear transects were made. These methodologies are described in detail later on in the document.

For the species banned by Resolution 0213 within the area of influence (AI) of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project, there were the following totals: 27 plots on slopes, 10 forest plots and three linear transects.
It is important to highlight that the document on banned species for vascular, non-vascular and forest epiphytes, will be submitted to the Ministry of the Environment and Sustainable Development (MADS).

Sampling Sites

In view of the above, for functional unit 4 (FU4) there were six plots on slopes and six forest plots; Table 5.2.50 provides the location coordinates (Datum MAGNA-SIRGAS Colombia Origin West) of the sampling sites in FU4.

Table 5.2.50. Location coordinates of the sampling points of banned species of flora (Res. 0213) in FU4 of the Rumichaca - Pasto dual carriageway road project.

Functional Unit	Plot Name	Coordinates		Covers
		X	Y	
PLOTS ON SLOPES				
FU 4	PT023	959093.1	608441.4	3.2.1.2.2.
	PT024	960933.1	609899.7	2.4.3.1.
	PT025	961125.8	610760	2.4.3.2.
	PT026	961944.9	610387.3	2.4.3.1.
	PT027	962622.9	611812.5	2.4.3.1.

Functional Unit	Plot Name	Coordinates		Covers
		X	Y	
	PT028	963592.4	612187.3	3.2.1.2.2.
FOREST PLOTS				
FU 4	4PP1	958469.8	608025.7	3.2.1.2.2.
	4PP2	960348.6	608311.9	2.4.3.2.
	4PP3	961022.1	609362.3	3.1.2.
	4PP4	961001	609807.9	2.4.3.1.
	4PP5	962282.3	611232	2.4.3.2.
	4PP6	964031	612774.4	2.4.3.2.
Vegetation Covers (1.3.) Artificialized territories, (2.4.3.1.) Patchwork of crops, pastures and natural spaces (2.4.3.2.). Patchwork of pastures and crops (3.1.5.): Forest plantation (3.2.1.2.2) Open rocky grassland (3.2.3) Secondary vegetation (3.3.2) Rocky outcroppings.				

Source: Géminis Consultores Ambientales, 2016.

Figure 5.2.33 illustrates the location of the banned vegetation sampling points (Res. 0213) for functional unit 4 of the project.

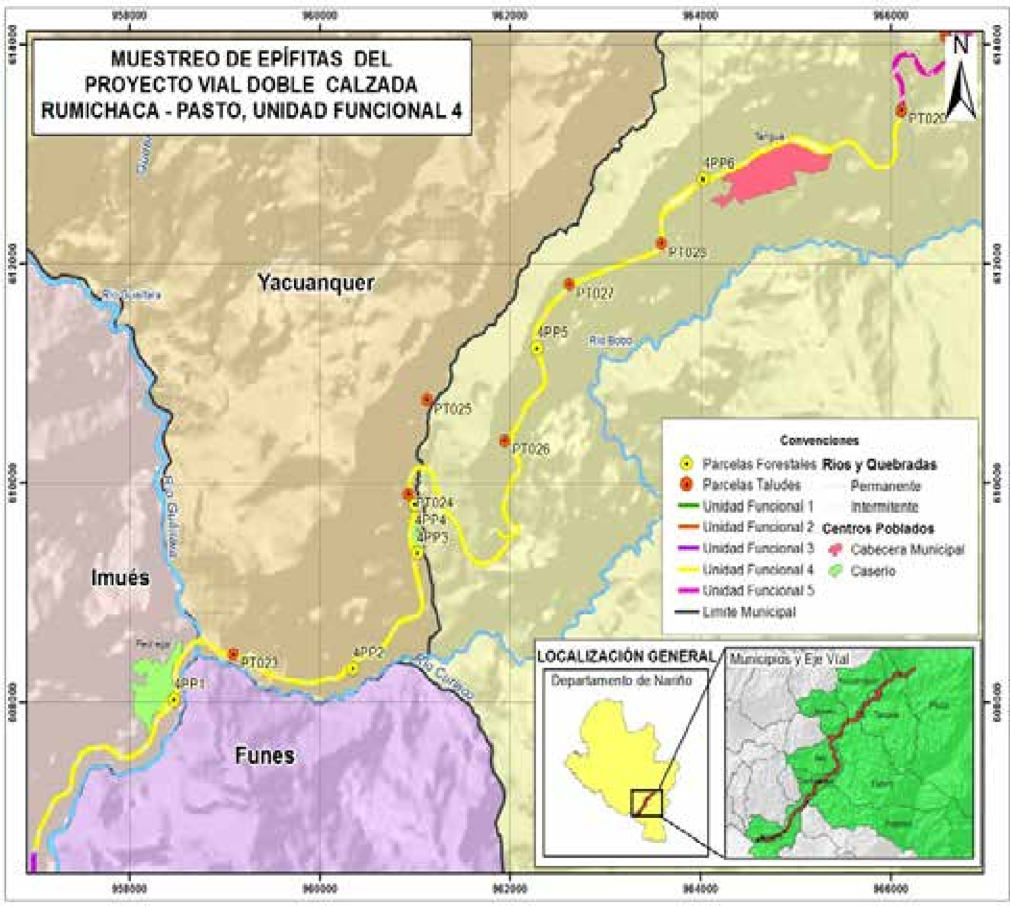


Figure 5.2.33. Location of the sampling points of banned species of flora (Res. 0213) in FU4 of the Rumichaca - Pasto dual carriageway road project.

Source: Géminis Consultores Ambientales, 2016.

In turn, for functional unit 5 (FU5.1), 21 plots were made on slopes; it is important to clarify that it was in this functional unit where the most vegetation associated with slopes was found; four forest plots, and three linear transects. Table 5.2.51 illustrates the location coordinates (Datum MAGNA-SIRGAS Colombia Origin West) of the sampling sites in FU5.1.

Table 5.2.51. Location coordinates of the sampling points of banned species of flora (Res. 0213) in FU5.1 of the Rumichaca - Pasto dual carriageway road project.

Functional Unit	Plot Name	Coordinates		Covers
		X	Y	
PLOTS ON SLOPES				
FU5.1	PT001	976753.3	622092.5	2.4.3.2.
	PT002	976643.1	622033.9	2.4.3.2.
	PT003	976639.8	622031.7	2.4.3.2.
	PT004	976591.9	622000.8	2.4.3.2.
	PT005	976584.1	621999.7	2.4.3.2.
	PT006	976497.3	621869.2	2.4.3.2.
	PT007	976496.2	621863.7	2.4.3.2.
	PT008	976482.8	621832.7	2.4.3.2.
	PT009	976479.5	621821.7	2.4.3.2.
	PT010	976333.7	621472.2	2.4.3.2.
	PT011	976331.4	621467.8	2.4.3.2.
	PT012	976322.5	621456.8	2.4.3.2.
	PT013	976321.4	621447.9	2.4.3.2.
	PT014	976313.6	621438	2.4.3.2.
	PT015	976345.9	621213.5	1.3.
	PT016	976353.7	621202.4	1.3.
	PT017	973170.3	618227.1	2.4.3.2.
	PT018	965755.2	614282.5	2.4.3.2.
	PT019	966113.5	613390.1	2.4.3.1.
	PT020	966113.5	613403.3	2.4.3.1.
	PT033	966569.9	614072.3	2.4.3.1.
FOREST PLOTS				
FU5.1	5PP1	965760.8	614258.1	2.4.3.2.
	5PP2	968306.4	616120	2.4.3.2.
	5PP3	974418	619043.1	2.4.3.2.
	5PP4	973218.2	618272.4	3.2.3.

Functional Unit	Plot Name	Coordinates		Covers
		X	Y	
LINEAR TRANSECTS				
FU5.1	TR1-Start	967521.7	616063.7	2.4.3.2.
	TR1-End	967500.6	616062.6	2.4.3.2.
	TR2-Start	967885.7	616230.6	2.4.3.1.
	TR2-End	967847.8	616190.8	2.4.3.1.
	TR3-Start	967835.6	616180.8	2.4.3.2.
	TR3-End	967802.2	616143.2	2.4.3.2.
Vegetation Covers (1.3.) Artificialized territories, (2.4.3.1.) Patchwork of crops, pastures and natural spaces (2.4.3.2.). Patchwork of pastures and crops (3.1.4.): Riparian forest (3.1.5.) Forest plantation (3.2.1.2.2) Open rocky grassland (3.3.2) Rocky outcroppings.				

Source: Géminis Consultores Ambientales, 2016

Figure 5.2.34 illustrates the location of the banned vegetation sampling points (Res. 0213) for functional unit 5 of the project.

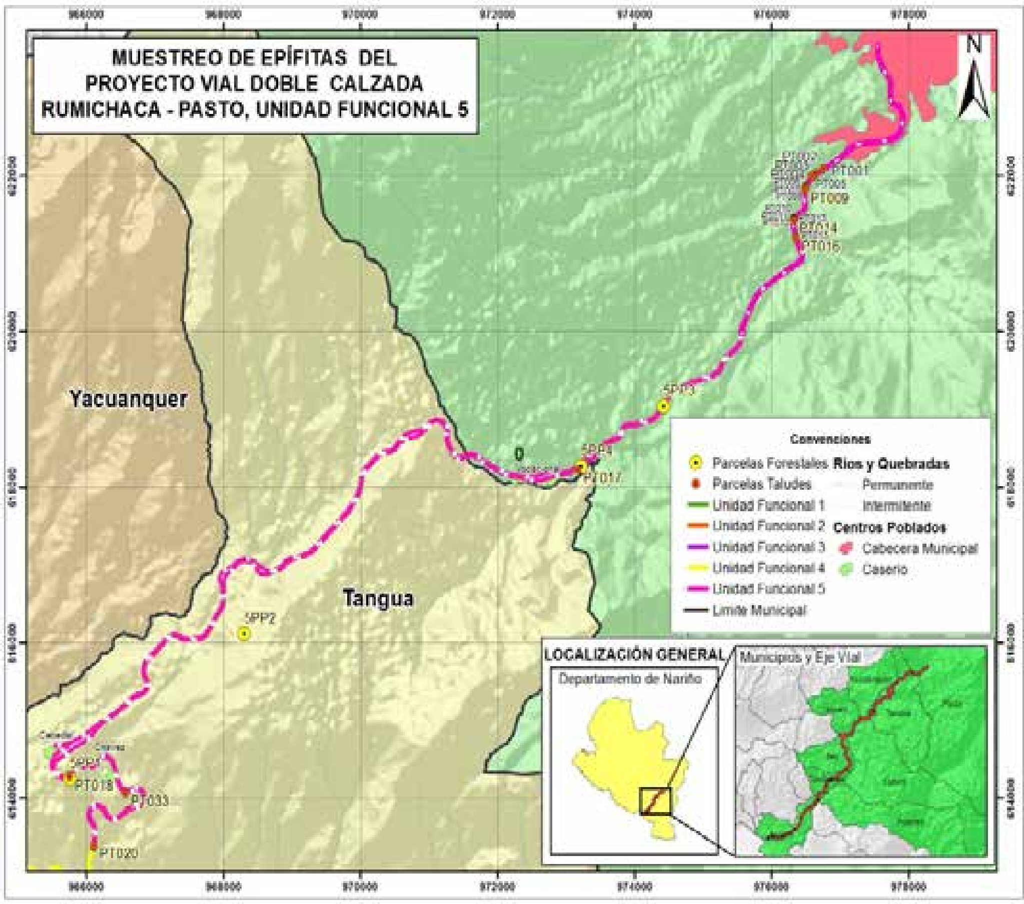


Figure 5.2.34. Location of the sampling points of banned species of flora (Res. 0213) in FU5.1 of the Rumichaca - Pasto dual carriageway road project.

Source: Géminis Consultores Ambientales, 2016.

Composition and general wealth of epiphytic and lithophytic species/Terrestrial

A total of 68 species banned by Resolution 0213 / 1977 issued by INDERENA were identified within the Area of Influence of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project, which include vascular and non-vascular epiphytic and lithophytic species/Terrestrial In general, these 68 species are taxonomically grouped into 51 genera and 33 families (Figure 5.2.35).

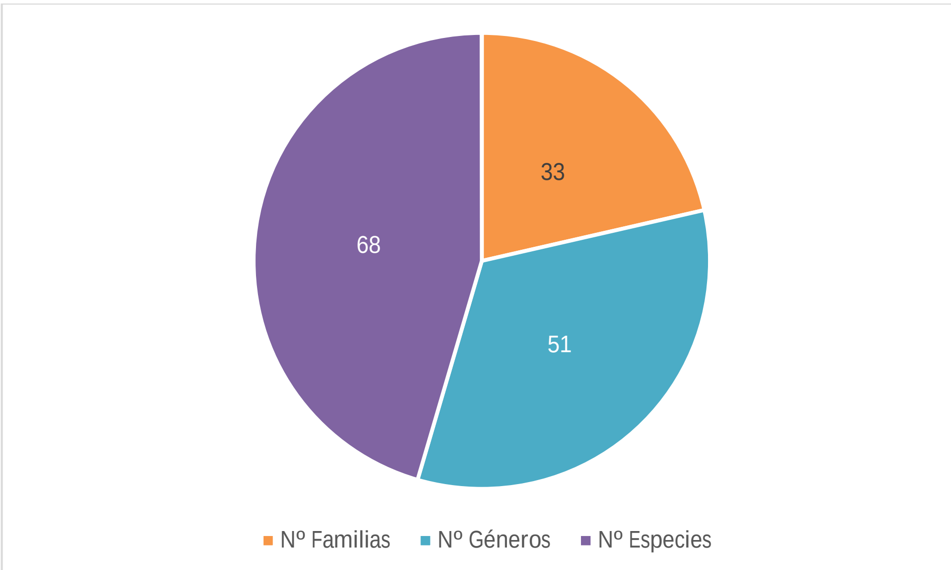


Figure 5.2.35. Overall composition of the banned flora (Res 0213) in the AI of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project.

Source: Géminis Consultores Ambientales, 2016.

Table 5.2.52 provides the taxonomic listing of the species banned by Resolution 0213, which were reported in the area of influence of the project in the Pedregal -Catambuco sector. A request is made to lift the ban on each of these species; however, it is important to highlight that this report presents an analysis of the composition, abundance and wealth of banned species for each of the covers sampled, according to their life form or habit, i.e. epiphytic species (species that thrive on the bark of living trees) and lithophytic species/terrestrial (species that thrive on rock and/or soil).

Table 5.2.52. Taxonomic listing of the banned species(Res 0213) reported in the AI of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project.

Families	Genera	Species	Pattern of Growth	Life Form/Habit
NON-VASCULAR				
LICHENS				
Agyriaceae	Placopsis	*Placopsis* sp.	Custrose lichen	E
Arthoniaceae	Herpothallon	*Herpothallon* sp.	Powdered lichen	E
Candelariaceae	Candelariella	*Candelariella* sp.	Custrose / Flaky lichen	E/ LT
Chrysothricaceae	Chrysothrix	*Chrysothrix* sp.	Powdered lichen	E/ LT
Cladiaceae	Cladia	*Cladia aggregata*	Fruticose lichen	E
Cladoniaceae	Cladonia	*Cladonia ceratophylla*	Dimorphic lichen	LT
	Cladonia	*Cladonia coccifera*	Dimorphic lichen	E/ LT
Collemataceae	Leptogium	*Leptogium cf. phyllocarpum*	Gelatinous lichen	E
	Leptogium	*Leptogium* sp.	Gelatinous lichen	E
Graphidaceae	Diploschistes	*Diploschistes* sp	Custrose lichen	Lt
Lecanoraceae	Lecanora	*Lecanora* sp.	Custrose lichen	E
Parmeliaceae	Canoparmelia	*Canoparmelia* sp.	Foliose lichen	E
	Flavopunctelia	*Flavopunctelia flaventior*	Foliose lichen	E/ LT
	Flavopunctelia	*Flavopunctelia* sp	Foliose lichen	LT
	Hypotrachyna	*Hypotrachyna physcioides*	Foliose lichen	E/ LT
	Hypotrachyna	*Hypotrachyna* sp.	Foliose lichen	E
	Parmelia	*Parmelia* sp.	Foliose lichen	E/ LT
	Parmotrema	*Parmotrema austrosinense*	Foliose lichen	E/ LT
	Parmotrema	*Parmotrema crinitum*	Foliose lichen	E/ LT
	Usnea	*Usnea bogotensis*	Fruticose lichen	E/ LT
	Usnea	*Usnea* sp.	Fruticose lichen	E
	Usnea	*Usnea* sp.1	Fruticose lichen	E

Families	Genera	Species	Pattern of Growth	Life Form/Habit
Physciaceae	Heterodermia	*Heterodermia albicans*	Fruticose lichen	E
	Heterodermia	*Heterodermia* sp.	Fruticose lichen	E
	Physcia	*Physcia albata*	Foliose lichen	E/ LT
Ramalinaceae	Phyllopsora	*Phyllopsora* sp	Powdered lichen	E/ LT
	Ramalina	*Ramalina celastri*	Fruticose lichen	E
Rhizocarpaceae	Rhizocarpon	*Rhizocarpon geographicum*	Custrose lichen	LT
Stereocaulaceae	Stereocaulon	*Stereocaulon* sp.	Dimorphic lichen	LT
Teloschistaceae	Caloplaca	*Caloplaca arnoldii*	Custrose lichen	LT
	Teloschistes	*Teloschistes flavicans*	Fruticose lichen	E/ LT
Verrucariaceae	Agonimia	*Agonimia* sp.	Flaky lichen	E/ LT
LIVERWORT				
Frullaniaceae	Frullania	*Frullania brasiliensis*	Foliose liverwort	E
	Frullania	*Frullania ericoides*	Foliose liverwort	E
	Frullania	*Frullania* sp.	Foliose liverwort	E
Lejeuneaceae	Cololejeunea	*Cololejeunea* cf. *conchifolia*	Foliose liverwort	E
	Lejeunea	*Lejeunea deplanata*	Foliose liverwort	E
Lophocoleaceae	Lophocolea	*Lophocolea bidentata*	Foliose liverwort	E
Metzgeriaceae	Metzgeria	*Metzgeria* sp.	Thallose liverwort	E
Marchantiaceae	Marchantia	*Marchantia berteroana*	Thallose liverwort	LT
Monocleaceae	Monoclea	*Monoclea gottschei*	Thallose liverwort	LT
MOSSES				
Bryaceae	Bryum	*Bryum coronatum*	Acrocarpous moss	LT
	Bryum	*Bryum densifolium*	Acrocarpous moss	LT
	Pohlia	*Pohlia elongata*	Acrocarpous moss	LT
	Schizymenium	*Schizymenium* sp.	Acrocarpous moss	E/ LT
Entodontaceae	Erythrodontium	*Erythrodontium squarrosum*	Pleurocarpous moss	E
Fabroniaceae	Fabronia	*Fabronia ciliaris*	Pleurocarpous moss	E/ LT

Families	Genera	Species	Pattern of Growth	Life Form/Habit
	Fabronia	*Fabronia* aff. *jamesonii*	Pleurocarpous moss	E/ LT
Fissidentaceae	Fissidens	*Fissidens zollingeri*	Acrocarpous moss	LT
Funariaceae	Funaria	*Funaria calvescens*	Acrocarpous moss	LT
Orthotrichaceae	Orthotrichum	*Orthotrichum pungens*	Acrocarpous moss	E/ LT
Polytrichaceae	Polytrichum	*Polytrichum juniperinum*	Acrocarpous moss	E/ LT
Pottiaceae	Barbula	*Barbula indica*	Acrocarpous moss	LT
	Didymodon	*Didymodon* sp.	Acrocarpous moss	E/ LT
	Syntrichia	*Syntrichia fragilis*	Acrocarpous moss	E
Sematophyllaceae	Sematophyllum	*Sematophyllum subsimplex*	Pleurocarpous moss	E
VASCULAR				
BROMELIADS				
Bromeliaceae	Puya	*Puya thomasiana*	-	LT
Bromeliaceae	Racinaea	*Racinaea* aff. *elegans*	-	E/ LT
Bromeliaceae	Tillandsia	*Tillandsia fendleri*	-	E/ LT
Bromeliaceae	Tillandsia	*Tillandsia incarnata*	-	E/ LT
Bromeliaceae	Tillandsia	*Tillandsia recurvata*	-	E/ LT
Bromeliaceae	Tillandsia	*Tillandsia* sp.	-	E/ LT
Bromeliaceae	Tillandsia	*Tillandsia usneoides*	-	E/ LT
ORCHIDS				
Orchidaceae	Crocodeilanthe	*Crocodeilanthe ligulata*	-	E/ LT
	Cyrtochilum	*Cyrtochilum cimiciferum*	-	LT
	Epidendrum	*Epidendrum elongatum*	-	LT
	Epidendrum	*Epidendrum jamiesonis*	-	E/ LT
	Oncidium	*Oncidium aff. saxicola*	-	LT
Life Form/Habit: (E) Ephiphytic habit species, **(LT)** Lithophytic habit species/Terrestrial, **(E/ LT)** Species with both life forms.				

Source: Géminis Consultores Ambientales, 2016.

Of the 68 species reported in the area of study, it was found that 23 species thrive exclusively on trees and/or shrubs, i.e., 33.82% of the species reported show only epiphytic life form in the study area. On the other hand, 19 of the species reported, that is 27.95% were found only on slopes or rock substrates, and are thus cataloged as lithophytic species/terrestrial. Finally, 26 of the 68 species identified in the area of study (38.23%) were found to thrive in both types of substrates (epiphytic/ lithophytic), without showing predilection of habitats.

According to the results illustrated in Figure 5.2.36, no particular life form was predominant with regard to the number of species that represent it, but on the contrary, the wealth of epiphytic, lithophytic species /terrestrial and those that share both life forms seem to be equal in the study area.

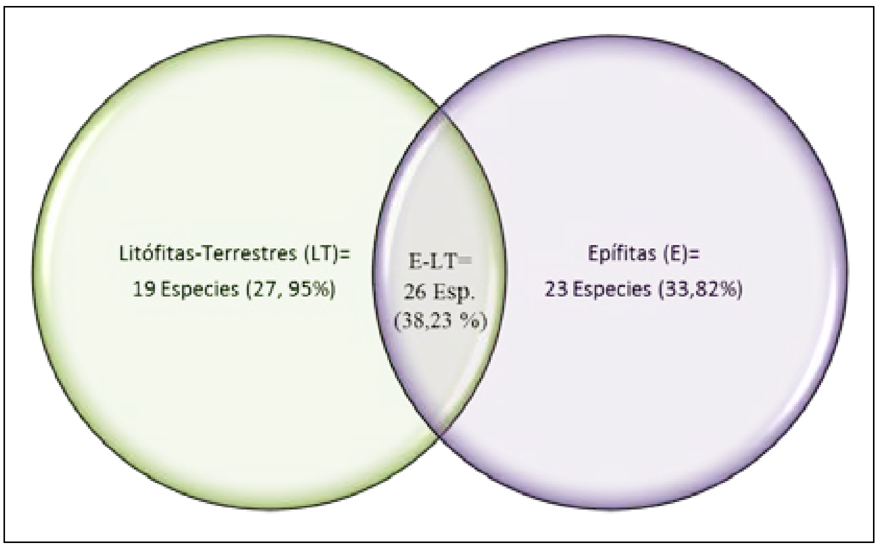


Figure 5.2.36. Composition of the banned flora (Res 0213) according to their life forms
Source: Géminis Consultores Ambientales, 2016

In this report, the species banned by Resolution 0213 were classified into five taxonomic groups widely recognized for their morphological characteristics, even by people with no training in botany, which will facilitate the interpretation of the results obtained.

These groups include fungi and lichens (Fungi Kingdom), and within the Plantae Kingdom, the Marchantiophyta (liverwort) and Bryophyta (mosses) divisions and the Bromeliaceae (bromeliads) and Orchidaceae (orchids) families belonging to the Angiospermae subdivision. Similarly, these groups are traditionally grouped into two more general categories: vascular species (bromeliads and orchids) and non-vascular species (lichens, liverworts and mosses).

Non-vascular Species

- Lichens

The lichens group reported 32 species, thus constituting the most diverse group of the Pedregal-Catambuco span; these species are distributed in 16 families and 24 genera. The most representative family within the group of lichenized fungi was Parmeliaceae, at 11 species. In the second place, there is the Physciaceae family, with three species. The Cladoniaceae, Ramalinaceae, Collemataceae and Teloschistaceae families reported two species, while the remaining had only one representative species (Figure 5.2.37).

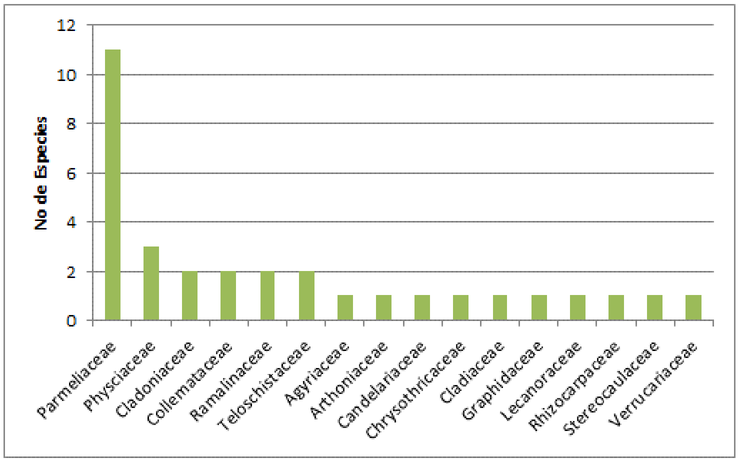


Figure 5.2.37. Distribution of wealth by families of lichens reported in the AI of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project.
Source: Géminis Consultores Ambientales, 2016.

The most common life form among lichens in the area of study is the epiphytic and epiphytic-lithophytic/terrestrial; in this order of ideas, 13 of the 32 lichen species are exclusively epiphytic, while 12 species thrive on a variety of substrates.

The number of lichen species that thrive exclusively on terrestrial and/or lithophytic substrate amounts to seven, and is therefore the least diverse life form among lichens in the area.

Given the importance of lichenized fungi to determine the environmental quality of an area, below are some of the species with different growth forms found in the area of influence of the Pedregal-Catambuco sector of the project (Photo 5.2.29).

Parmotrema crinitum
Foliose lichen

Placopsis sp.
Custrose lichen

Leptogium sp.
Gelatinous lichen

Chrysothrix sp.
Powdered lichen

Teloschistes flavicans
Fruticose lichen

Cladonia coccifera
Dimorphic lichen

Photo 5.2.29. Some of the lichens found in the AI of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project.
Source: Géminis Consultores Ambientales, 2016.

o Mosses

The group of mosses, the second richest in species, with 15 taxonomic entities identified in the area of study; this figure that is two times greater than that provided by the group of the liverworts, but certainly less than that reported for lichens. These species are distributed in nine families and 13 genera. The most representative family was Bryaceae with four species reported, followed by the Pottiaceae, with three species, and Fabroniaceae with two representative species; the other families only reported one (Figure 5.2.38).

In turn, the most common life form among mosses is the lithophytic/terrestrial, because six of the 15 species were found to thrive exclusively on this substrate; also, six species apparently do not have a preference of substrate, while only three species are exclusively epiphytic.

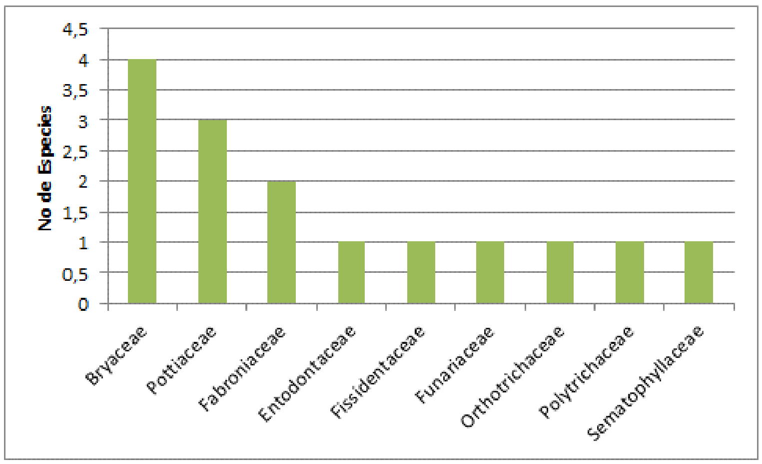


Figure 5.2.38. Distribution of wealth by families of mosses reported in the AI of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project.
Source: Géminis Consultores Ambientales, 2016.

Below are some of the species of mosses found within the area of influence of the Pedregal - Catambuco sector of the project (Photo 5.2.30).

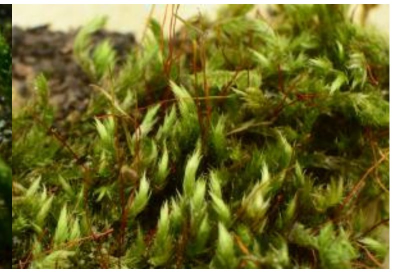

Schizymenium sp.
Acrocarpous moss


Orthotrichum pungens
Acrocarpous moss


Syntrichia fragilis
Acrocarpous moss

Fabronia ciliaris
Pleurocarpous moss

Erythrodontium squarrosum
Pleurocarpous moss



Sematophyllum subsimplex
Pleurocarpous moss

Photo 5.2.30. Some of the mosses found in the AI of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project.
Source: Géminis Consultores Ambientales, 2016.

- Liverworts

The group of liverworts is the third most diverse in the area, with nine species reported, which are distributed in six families and seven genera. The Frullaniaceae family has the largest number of species (three species), followed by the Lejeuneaceae family, with two species; the others only reported one representative species (Figure 5.2.39).

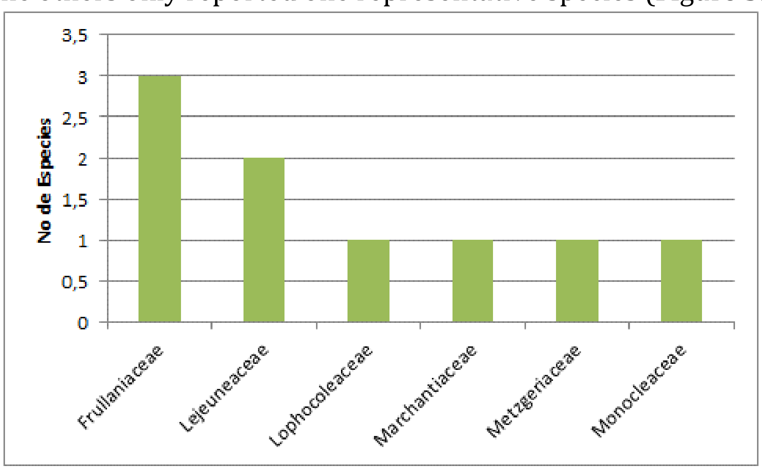


Figure 5.2.39. Distribution of wealth by families of liverworts reported in the AI of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project.

Source: Géminis Consultores Ambientales, 2016.

The species of the group of liverworts, only reported two life forms, both with substrate exclusivity, as seven of these species have exclusively epiphytic habits, while two are exclusively lithophytic/terrestrial; without a doubt, we can say that within this group, the most diverse life form is the epiphytic.

The photographs below illustrate some of the liverwort species reported for the area of influence of the Pedregal - Catambuco sector of the project. (Photo 5.2.31).

Frullania brasiliensis
Foliose liverwort

Frullania ericoides
Foliose liverwort

Cololejeunea cf. *conchifolia*
Foliose liverwort

Metzgeria sp.
Thallose liverwort

Marchantia berteroana
Thallose liverwort

Monoclea gottschei
Thallose liverwort

Photo 5.2.31. Some of the liverworts found in the AI of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project.

Source: Géminis Consultores Ambientales, 2016.

- **Vascular Species**

- Bromeliads

The bromeliad group is represented by seven species, constituting the most diverse group of the vascular plants. These species are distributed in three genera and one family (Bromeliaceae). The most representative genus was the Tillandsia, with five species reported; the Puya and Racinaea genera presented only one (Figure 5.2.40).

This result is not surprising given that the genus Tillandsia is the most diverse of the bromeliad family, with nearly 650 species, distributed throughout the Neotropics in deserts, forests and mountains (Bernal et al, 2016).

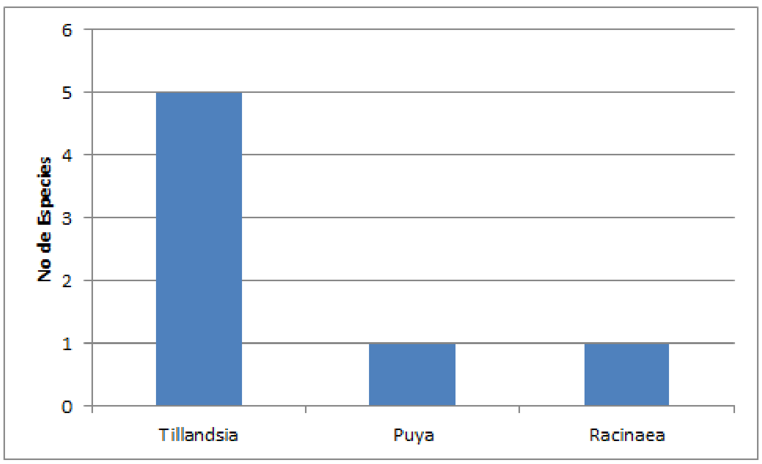


Figure 5.2.40. Distribution of wealth by genera of bromeliads reported in the AI of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project.
Source: Géminis Consultores Ambientales, 2016.

In the area of influence of the Pedregal -Catambuco sector of the project, the bromeliad species reported only two growth forms, and just one of the seven species reported has substrate exclusivity, specifically for the lithophytic/terrestrial substrate, while the six remaining species do not seem to have any substrate specificity.

The photographs below illustrate some of the bromeliad species reported for the area of influence of the Pedregal - Catambuco sector of the project (Photo 5.2.32).


Racinaea aff. *elegans*
Epiphytic / Lithophytic Habit


Tillandsia incarnata
Epiphytic / Lithophytic Habit


Tillandsia fendleri
Epiphytic / Lithophytic Habit


Tillandsia usneoides
Epiphytic / Lithophytic Habit


Tillandsia recurvata
Epiphytic / Lithophytic Habit


Puya thomasiana
Lithophytic Habit

Photo 5.2.32. Some of the bromeliads found in the AI of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project.
Source: Géminis Consultores Ambientales, 2016.

- Orchids

For the orchids group, there were five species reported, which are distributed in four genera and one family (Orchidaceae). It was found that the genus Epidendrum has the best repeatability, with two species, while the others only reported one species (Figure 5.2.41). The genus Epidendrum currently has about 1,000 species of orchids, which mostly have epiphytic habits.

It is characterized by a large inflorescences that carry dozens of tiny, yet very elaborate flowers; they also have secondary, commonly thin stems or reeds, simple to very branched, foliaceous or sometimes thickened in cylindrical pseudobulbs bearing 1 to 5 apical leaves. They are distributed from Florida through Central America and South America, to the north of Argentina (Bernal et al, 2016).

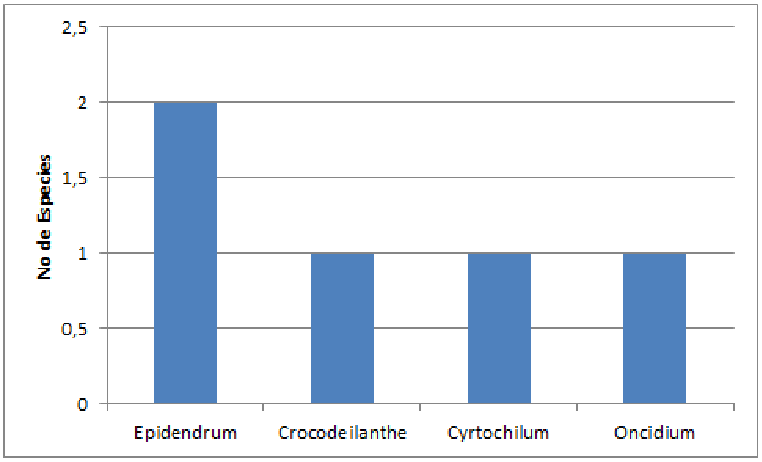


Figure 5.2.41. Distribution of wealth by genera of orchids reported in the AI of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project.
Source: Géminis Consultores Ambientales, 2016.

The orchid species found in the area of study, are represented, like the bromeliads, only by two life forms. Only three species have an exclusively lithophytic/terrestrial life form, while the others were found in different substrates, with no apparent preference for any of them.

Below are some of the orchid found within the area of influence of the Pedregal - Catambuco sector of the project (Photo 5.2.33).

Epidendrum jamiesonis
Epiphytic / Lithophytic Habit

Epidendrum elongatum
Lithophytic Habit

Crocodeilanthe ligulata
Epiphytic / Lithophytic Habit

Cyrtochilum cimiciferum
Lithophytic Habit

Photo 5.2.33. Some of the orchids found in the AI of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project.
Source: Géminis Consultores Ambientales, 2016.

Finally, Figure 5.2.42 summarizes all the aspects discussed in relation to the distribution of the number of species and biological wealth of the different life forms identified for each of the groups of flora banned by Resolution 0213.

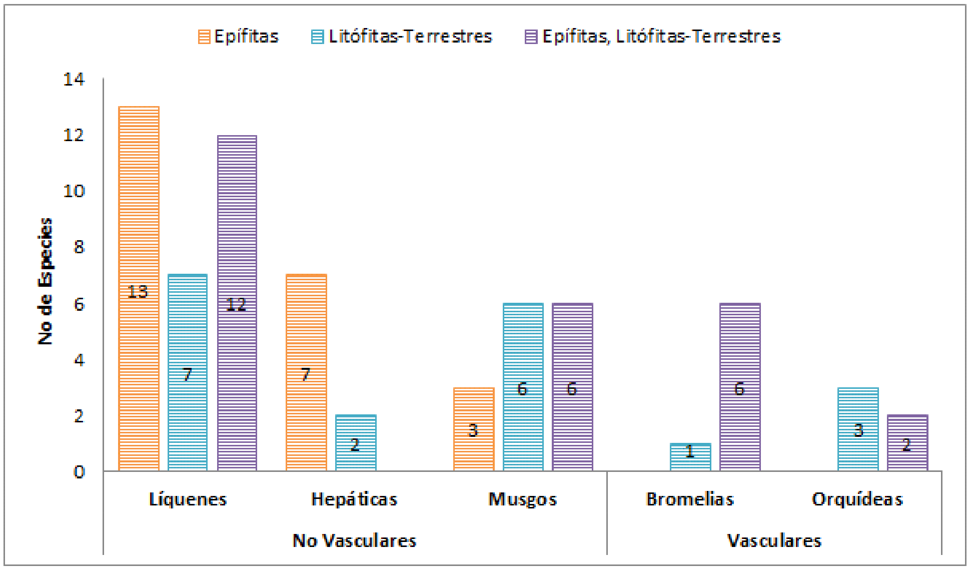


Figure 5.2.42. Distribution of wealth according to the life forms of the banned taxonomic groups (Res 0213) for the AI of the Pedregal -Catambuco sector of the project.

Source: Géminis Consultores Ambientales, 2016.

Composition and wealth of species with epiphytic habits

In general, for the entire area of influence of the Pedregal - Catambuco sector of the project, 49 species were identified with epiphytic life forms (with exclusive preference and mixed with another substrate), declared as banned by Resolution 0213, distributed in 36 genera and 26 families.

Considering that 68 species included in Resolution 0213 were reported for the entire area of intervention of the project, 73% of these species were presented as vascular and non-vascular epiphytes, making it the most diversified life form in species (Figure 5.2.43).

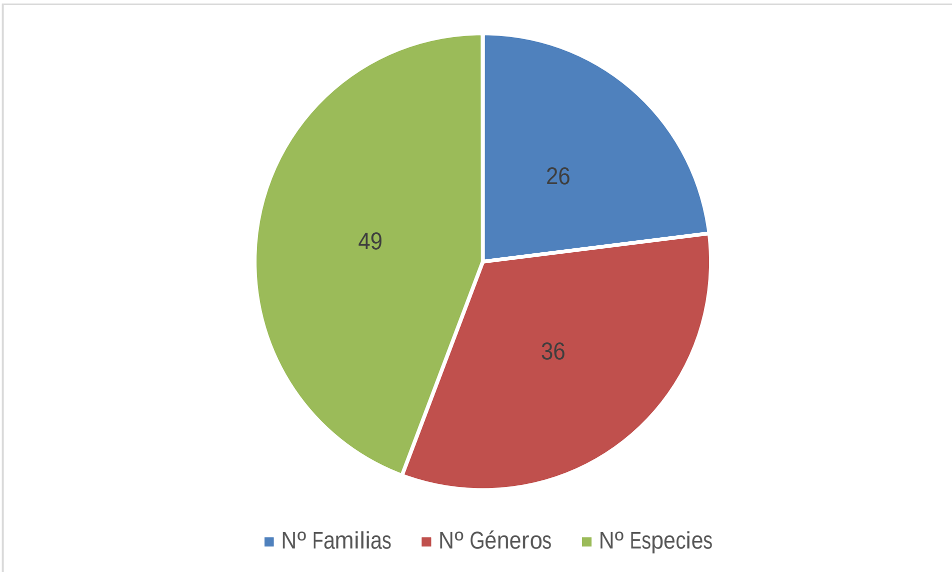


Figure 5.2.43. Composition of the banned epiphytic flora in the AI of the Pedregal-Catambuco sector of the project.

Source: Géminis Consultores Ambientales, 2016.

Lichens are the taxonomic group with greatest biological wealth among species with epiphytic life form, given that it is represented by 25 species in the project's area of influence, which represents 50% of the epiphytic species banned by Resolution 0213; in turn, the group of mosses accounts for less than half of the species mentioned for the lichens, as its biological wealth consists of nine species, followed by liverworts with seven species, bromeliads with six species and orchids with two species (Figure 5.2.44)

In general terms, non-vascular epiphytes are by far the most diverse in the project's area of influence, in the Pedregal-Catambuco - sector, since they account for 82% of the banned species identified in the area.

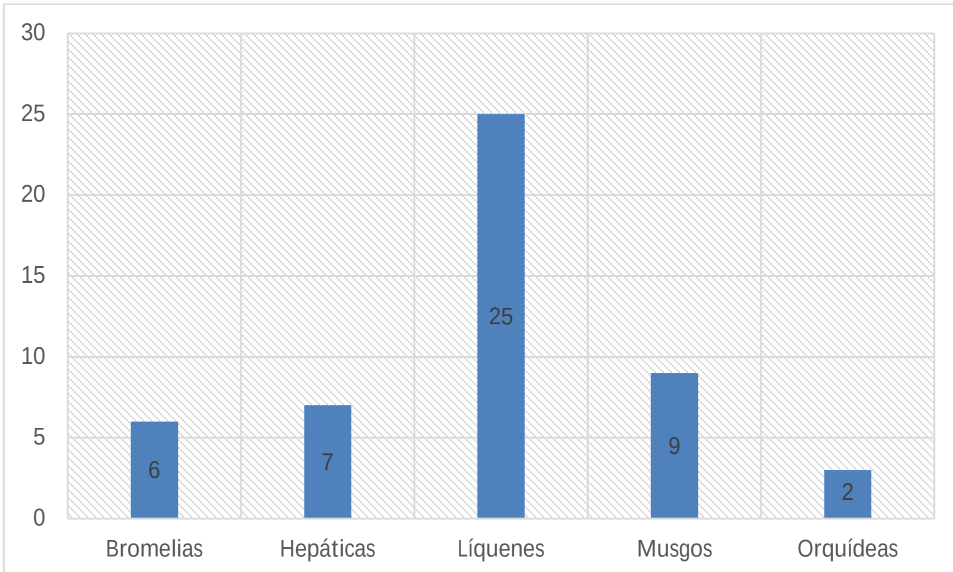


Figure 5.2.44. Biological wealth of banned epiphytic species according to taxonomic group

Source: Géminis Consultores Ambientales, 2016.

The families of the most diverse banned epiphytic species in the project's area of influence, in the Pedregal - Catambuco sector, in terms of number of species and genera, are the Parmeliaceae with five genera and nine species, and Bromeliaceae, with two genera and six species. Although the bromeliad group is not very diverse at the species level, the only family that represents this group has a very high level of diversity, especially considering that 69.23% of families are represented by only one genus and one species (Figure 5.2.45).
A similar result is shown by the Frullaniaceae family, since it is the next most diverse family in the area of study, with three species belonging to the genus Frullania.

Similarly, another three families are made up of two genera and two species; one of these families (Pottiaceae) belongs to the group of mosses, another is a member of the group of lichens (Ramalinaceae) and the other is the Orchidaceae family, which in general terms is the least diverse taxonomic group.

The results so far presented indicate that most families are represented by only one genus and one species; therefore, it is relevant that there are families with more than one genus and one species, especially the family of lichens, Parmeliaceae, and bromeliads Bromeliacea, as they are highly diverse at the local level. Accordingly, Figure 5.2.48 illustrates the 15 most diverse families found in project's area of influence, in the Pedregal - Catambuco sector.

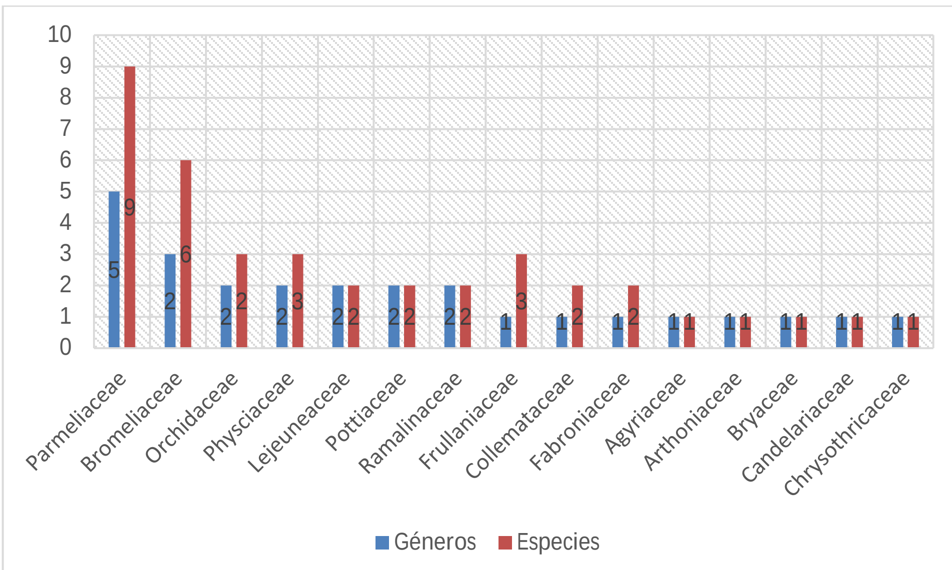


Figure 5.2.45. Biological wealth of species and genera of epiphytes by family

Source: Géminis Consultores Ambientales, 2016.

The size of the forest plots used to sample the banned epiphytes was the same; however, the number of plots changed according to the size of the covers, as indicated in the methodological section of this report.

In this order of ideas, the composition of epiphytic species was compared between each of the covers sampled using the Jaccard similarity analysis, whose coefficient assesses the similarity in species composition in an interval of 0 to 1, such that, the closer the similarity coefficient between two or more covers is to 1, there will be a greater similarity in species composition between them. The vegetation covers that yielded the highest Jaccard coefficient were the shrub patchwork (2.4.3.1) and tree patchwork- (2.4.3.2).

Since the establishment of epiphytes depends heavily on environmental conditions, as well as the availability of appropriate habitats and resources, it is very likely that these conditions are replicated between the covers compared. The remaining covers had coefficients below 0.50, so it is likely that the environmental conditions vary strongly between each of them, particularly those caused by anthropogenic activities, which introduce ecological stress factors (**Figure 5.2.46**).

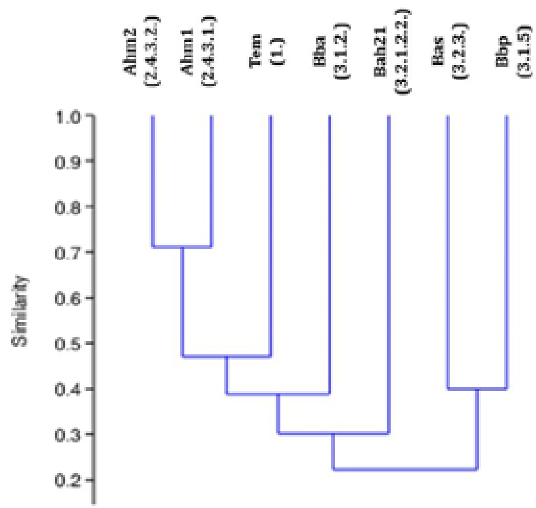


Figure 5.2.46. Composition of epiphytic species between each of the cover sampled using the Jaccard similarity analysis

(1.) Artificialized territories, (2.4.3.1.) Patchwork of crops, pastures and natural spaces (2.4.3.2.). Patchwork of pastures and crops (3.1.5.): Forest plantation (3.2.1.2.2) Open rocky grassland.

Composition and wealth of species with lithophytic habits

Compared to the number of banned epiphytic species found in the project's area of influence, Pedregal - Catambuco sector, the number of lithophytic/terrestrial species banned by Resolution 0213 reported in the area of study does not vary much. However, the total vegetation covers where this species were found is small as they were identified in only five covers, for which the diversity, wealth, abundance and frequency analyses are presented.

In general, throughout the project's area of influence, Pedregal - Catambuco sector - a total of 45 species with a lithophytic/terrestrial habit was reported (which include the species that have an exclusive preference for rocky /terrestrial substrate and those that have mixed habits with other substrates), which are distributed in 35 genera and 22 families (Figure 5.2.47). The sampling methodology for these species was different from the one implemented for banned epiphytes, as mentioned in detail.

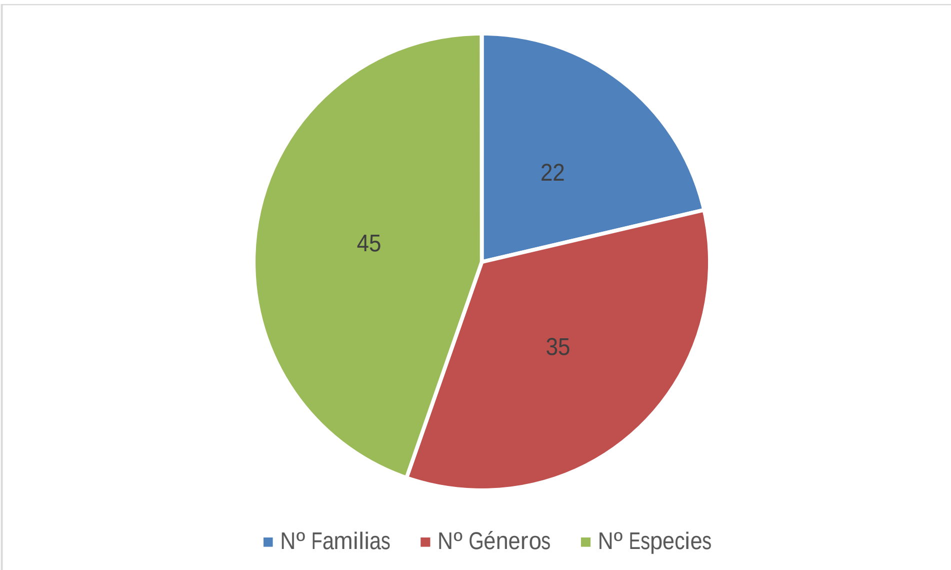


Figure 5.2.47. Composition of the banned lithophytic/terrestrial flora in the AI of the Pedregal-Catambuco sector of the project.
Source: Géminis Consultores Ambientales, 2016.

The taxonomic group richest in lithophytic/terrestrial species in the project's area of influence, Pedregal - Catambuco sector, is that of lichens, at 19 species, followed closely by the group of mosses, at 12 species, bromeliads at seven species, orchids at five species and liverworts at two species.

Despite the similarities found related to the composition of species-at the group level for banned epiphytes, such as the predominance of lichens, in terms of species wealth, the mosses are much more diverse in the lithophytic/terrestrial substrate than epiphytes, bromeliads and orchids.

Furthermore, the diversity of liverwort species is greatly reduced to two species. The species of lichens is also reduced in the lithophytic/terrestrial substrate; however, the group maintains high diversity (Figure 5.2.48).

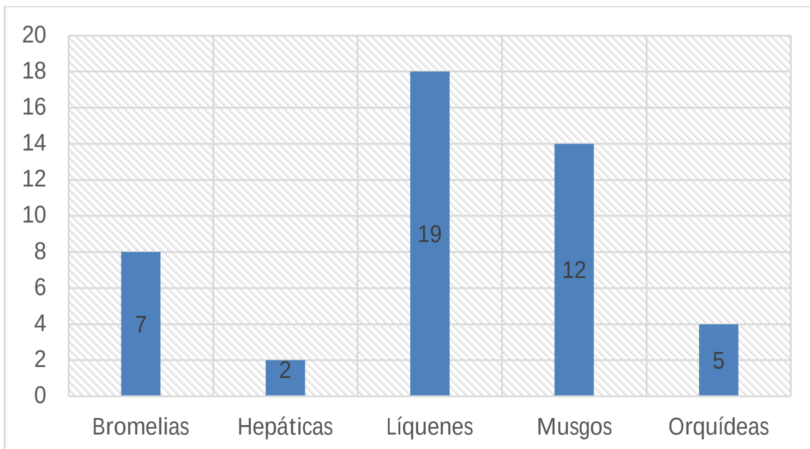


Figure 5.2.48. Number of banned terrestrial species according to taxonomic group

Source: Géminis Consultores Ambientales, 2016.

The most diverse banned lithophytic/terrestrial family in terms of species in the project's area of influence, Pedregal - Catambuco sector, is the Bromeliaceae with seven species, and the most diverse family in terms of genera is the Parmeliaceae with five of them, while the Bromeliaceae is represented by three genera.

The wealth of the Orchidaceae family is interesting, given that it is represented by four genera and five species, as well as the diversity of the Bryaceae moss family, given that it is integrated by three genera and four species. In addition, two families, one of mosses (Pottiaceae) and another of lichens-(Teloschistaceae), are represented by two genera and two species, and the Cladoniaceae (lichen) and Fabroniaceae (mosses) families have one genus and two species.

Among the 22 families reported, 14 are represented by just one genus and a single species, which is equivalent to 59.09% of the lithophytic/terrestrial families.

In this order of ideas, comparing these results with those obtained for the banned epiphytes, we found a larger number of families of lithophytic/terrestrial multi-species in relation to the number of species that make them up (Figure 5.2.49).

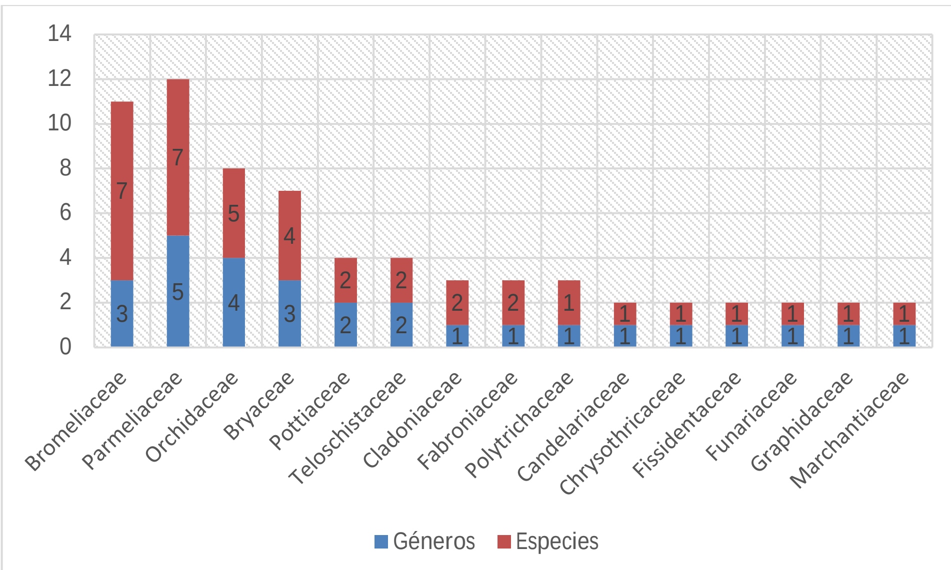


Figure 5.2.49. Number of Lithophytic/Terrestrial species and genera by families

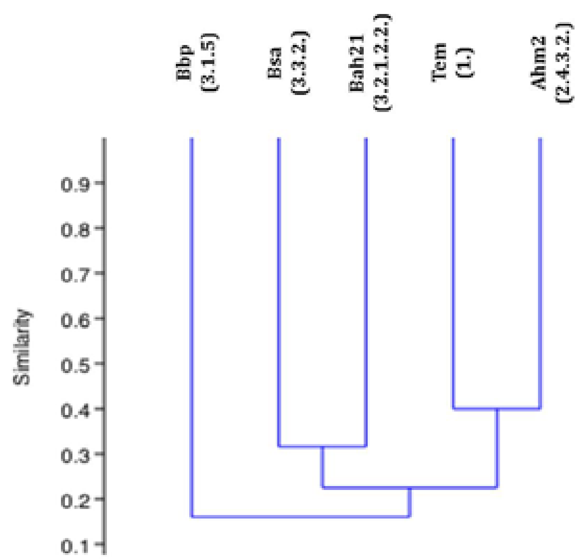
Source: Géminis Consultores Ambientales, 2016.

In turn, the lithophytic/terrestrial species banned by Resolution 0213 were only identified in five vegetation covers: Patchwork of pastures and crops (2.4.3.2); Open rocky grassland (3.2.1.2.2.); Forest plantations (3.1.5.) Artificialized territories; (1.) and Rocky outcroppings (3.3.2.), the latter cover is different from those that were related to the banned epiphytic species according to the Corine Land Cover methodology adapted for Colombia.

This vegetation cover is associated especially with natural slopes with very steep hills, completely devoid of three and/or shrub species that can provide a proper habitat for this type of species.

The calculation of the similarity coefficient for the five covers where the banned lithophytic/terrestrial species were reported, represented in Figure 5.2.50 indicates that the composition of species between each of the covers differs significantly, given that the coefficients are less than 0.5, in an interval that ranges from 0 to 1.

However, the range below 0.5 groups together the Artificialized territory and Tree patchwork covers, as well as the Open rocky grassland and Rocky outcroppings, which denotes a certain degree of similarity between the composition of their species, while Forest plantation seems to differ greatly from the other four covers.



(1.) Artificialized territories, (2.4.3.2.) Patchwork of pastures and crops (3.1.5.): Forest plantation (3.2.1.2.2) Open rocky grassland (3.3.1) Rocky outcroppings.

Figure 5.2.50. Graphic representation of the Jaccard similarity coefficient.

Source: Géminis Consultores Ambientales, 2016.

Epiphytic and lithophytic/terrestrial species exclusive to covers, that are threatened and/or listed in CITES

Table 5.2.53 indicates the number of species identified with just one life for in the project's area of intervention. For instance, in the tree patchworks (2.4.3.2.), 14 species were identified, which were reported in the project's area of influence, Pedregal - Catambuco sector, only as lithophytic/terrestrial species, and therefore, they are present solely in this life form, as were five species identified with exclusively epiphytic life forms .

There are five species with shared life forms, between epiphytic and lithophytic/terrestrial. It should be noted that this cover is predominated by lithophytic/terrestrial species over epiphytic and over those with shared life forms.

The life for corresponding to each of the species banned by Resolution 0213 is mentioned in the chapter on general information in Table 5.2.62. The cover with the largest number of exclusive species is that of Patchwork of pastures and crops.

Table 5.2.53. Exclusive species in terms of covers and life forms

No.	Vegetation covers	Code	Lithophytic /terrestrial	Epiphytic	Epiphytic, lithophytic/terrestrial	No. exclusive species
1	Patchwork of pastures and crops	2.4.3.2.	14	5	4	23
2	Patchwork of crops, pastures and natural space	2.4.3.1.	0	2	1	3
3	Artificialized territories	1.	0	1	1	2
4	Open forest	3.1.2.	0	0	3	3
5	Open rocky grassland	3.2.1.2.2.	0	0	4	4
6	Secondary vegetation	3.2.3.	0	0	0	0
7	Forest plantation	3.1.5.	0	0	0	0

No.	Vegetation covers	Code	Lithophytic /terrestrial	Epiphytic	Epiphytic, lithophytic/terrestrial	No. exclusive species
	Rocky outcroppings	3.3.2.	0	0	0	0
Total banned species exclusive to one cover						**37**

Source: Géminis Consultores Ambientales, 2016.

With regard to the species banned by Resolution 0213, there were no individuals reported in any of the categories of Threat described in the Red Books of Plants in Colombia, especially the volumes and/or chapters that refer to non-vascular plants, bromeliads and orchids, as well as in the listing of threatened species and those referred to in Resolution 0192 / February 2014 issued by the MADS regarding endangered species in Colombia.

However, it was identified that the five species of orchids are listed in Appendix II of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), which includes species not necessarily threatened with extinction, but whose trade must be controlled in order to avoid utilization incompatible with their survival. Table 5.2.54 presents the species found in the project's area of influence, Pedregal - Catambuco sector, that are included in the appendices of CITES.

Table 5.2.54. List of epiphytic and lithophytic/terrestrial species included in the Appendices of CITES

Species	Common Name	CITES Classification (2013)
Crocodeilanthe ligulata	Orchid	II
Cyrtochilum cimiciferum	Orchid	II
Epidendrum elongatum	Orchid	II
Epidendrum jamiesonis	Orchid	II
Oncidium aff. saxicola	Orchid	II
CITES Categories (Appendices in force as of June 12, 2013): (I) Species on which there is greater danger of extinction, whose international trade is prohibited; (ii) species not necessarily threatened with extinction, but may become so unless trade is subject to regulation. (III) Species that any party identifies as subject to regulation within its jurisdiction for the purpose of preventing or restricting exploitation.		

Source: Géminis Consultores Ambientales, 2016.

To conclude, a total of eight vegetation covers were sampled, four of which are common to the epiphytic and lithophytic/terrestrial species banned by Resolution 0213 / 1977 issued by the INDERENA. Not continuous forest fragments were found along the project's area of intervention. The degree of transformation is this high due to the human activities; the most extensive covers are the patchworks of pastures and crops with natural spaces of trees (2.4.3.2) and shrubs (2.4.3.1). These covers are typical of the areas sued for livestock and agriculture in the high mountains of Colombia (IDEAM, 2010).

The characterization of the banned epiphytic flora present in the area of influence of the Pedregal-Catambuco Span of the Rumichaca-Pasto dual carriageway road project, established that the taxonomic group of lichens is the most representative among the groups of banned flora identified there, as it is the most diversified in terms of species, as well as the most abundant and frequent.

With respect to the banned lithophytic/terrestrial species, there is no report of dominance by a specific group, and although the lichens are present in the most diverse covers, they were not always the most frequent and abundant.

With regard to the set of the epiphytic bryophytes (liverworts and mosses), their low diversity at the species level is notable, as well as their low frequency and abundance in the covers, with varying degrees of disturbance, such as secondary vegetation or vegetation in transition, forest plantations and open forests. Their diversity increases significantly in the patchwork of pastures and tree and shrub crops, as well as on artificialized territories.

Also, as for the lithophytic/terrestrial bryophytes,. diversity, abundance and frequency increases significantly in these covers, except for the lithophytic/terrestrial liverworts, which seem to decrease in diversity, compared to the epiphytic liverworts in all the covers.

Linares and Churchill indicate that the optimum altitudinal range in which the diversity of the bryophyte species, especially moss, is highest, is located between the 2000 and

3000 meters above sea level; anything above and below this gradient and the bryophyte species seem to face to a greater or lesser extent, different types of environmental stress factors, such as water availability and lighting among others (Churchill & Linares 1995). Despite the fact that a large part of the project's area of influence, Pedregal - Catambuco sector, is in this range of altitudes, the frequency, abundance and diversity of epiphytic bryophytes compared to epiphytic lichens is low, which could perhaps be related to environmental conditions characterized by high stress, due to water availability and excessive light caused by a high deforestation rate.

However, it is important to bear in mind that the establishment of non-vascular epiphytes, and lithophytic/terrestrial species depends on other factors, such as the availability of suitable substrates or the architecture of the phorophyte, among others.

The diversity, wealth, abundance and frequency of banned vascular species, especially those with an epiphytic and lithophytic/terrestrial life form is low as compared to the other groups of non-vascular species, which was expected for the range of altitudes located in the sub Andean forest. The diversity of the banned epiphytic and lithophytic/terrestrial species will probably be affected by the intensity of anthropogenic activities such as livestock and agriculture, and the disruption caused by the high traffic density that characterizes this road.

Although there are numerous water sources and associated forest fragments that could provide habitats and resources for a larger number of vascular epiphytes, these fragments within the area of intervention are very small and they are exposed to an intensive edge effect and disturbance by grazing and felling.

The available studies regarding the vascular epiphytes of tropical forests indicate that the areas located between 1000 and the 2000 masl., seem to have the highest peaks of diversity of these species, so the lower and higher ranges of altitude are less diverse.

In this order of ideas, the little diversity of these species in the project's area of influence is surprising, although we must be aware of the intensity of human activities in the area.

Not much is known about the reasons that generate the pattern of distribution of vascular epiphytes. However, the hypotheses point to a smaller number of abiotic and biotic stress factors (availability of substrate, light intensity, humidity, etc.) in the range with greater diversity (Gentry & Dodson. 1987; Krömer et al. 2005; Arévalo & Betancur. 2006).

In this sense, it may be that the project's area of influence does not have the light and water conditions necessary for the establishment of a large number of banned vascular epiphytic and lithophytic/terrestrial species.

The analysis of the vegetation covers present in the project's area of influence, Pedregal - Catambuco sector, accounts for the high degree of disturbance to which these areas have been subjected over time, due to the elimination of forested areas to establish grazing or farming areas.

This transformation may play a significant role in the configuration of the patterns of wealth and abundance of banned vascular and non-vascular plant species, given that these plants are known to be sensitive to environmental changes, which alter their patterns of composition, distribution and wealth.

According to the procedure to apply for the lifting of the ban through the Ministry of the Environment and Sustainable Development, the document corresponding to the identification of banned epiphytic, lithophytic and forest vegetation in the project's area of intervention has been filed with the Forests Department under order No. 391 / August 9, 2016, case file ATV 0451.

- **Fragmentation Analysis**

As illustrated in the characterization of land covers and ecosystems in the project's area of influence, there is a marked predominance of Agricultural Territories, with nearly

65% of the total area of influence of Functional Unit 4 and 90% of the AI of Functional Unit 5. Therefore, the area covered by the natural and semi-natural ecosystems in this area represent 21.1% and 2.69% respectively for said functional units. These proportions highlight the importance of agricultural and livestock activities in the area and are indications of the strong pressure placed on the forest ecosystems, and the fact that they are currently so reduced.

The fragmentation is carried out particularly along the "agricultural border", where farmers and ranchers invade forests that were previously intact, mainly on the banks of rivers and streams. However, much of the deforestation also occurs in areas where the crops, pastures and human settlements have already fragmented the forests.

Below is a fragmentation analysis of the natural ecosystems in the project's area of influence, represented by shrubs of the Middle and Upper Andean Orobiomes, riparian forests of the Middle and Upper Andean Orobiomes and grasslands of the Middle Andean Orobiome. This analysis was carried out based on the metrics of the landscape and the landscape context, which led to the conclusion that is high fragmentation and low connectivity for the shrub and riparian forest ecosystems.

The results of the landscape metrics shown below (Table 5.2.55) are the result of a map analysis in which the number of patches (NP) per ecosystem was determined, along with the total area occupied by each of them (CA), based on which the average size of the patch (MPS) was calculated as a result of dividing CA/NP.

Table 5.2.55 Metrics of the landscape by ecosystem

ECOSYSTEM	Cod.	NP	CA (ha)	MPS (ha)
Dense shrubland of the Upper Andean Orobiome	213221	2	7.70	3.85
Dense shrubland of the Middle Andean Orobiome	203221	8	12.98	1.62
Gallery and/or riparian forest of the Upper Andean Orobiome	21314	2	8.01	4.00
Gallery and/or riparian forest of the Middle Andean Orobiome	20314	6	21.32	3.55

ECOSYSTEM	Cod.	NP	CA (ha)	MPS (ha)
Open rocky grassland of the Middle Andean Orobiome	2032122	50	112.19	2.24
Total		**68**	**162.2**	**15.27**

NP: Number of Patches; **CA:** Total Class Area; **MPS:** Mean Patch Size

The information obtained in the table above provides a general idea regarding the degree of fragmentation in the natural ecosystems located in the project's area of influence, which leads to the deduction that the higher the patch number and the smaller the surface thereof, there is an increase in the distance between them.

A total of 68 patches, which occupy a total area of 162.2 hectares, were analyzed. The average surface per patch is approximately 15 hectares, which is a reference value for purposes of comparison with the results obtained for each ecosystem.

The ecosystem with the largest number of patches is that of Open rocky grassland of the Middle Andean Orobiome, with a total of 50, and the highest average of areas per patch are those of Gallery and/or riparian forest of the Upper Andean Orobiome and Dense shrubland of the Upper Andean Orobiome at 4 and 3.85 hectares, respectively.

Based on the above, the Open rocky grassland ecosystem of the Middle Andean Orobiome shows the highest degree of fragmentation; however, it is important to mention that it is the ecosystem with the highest representativity in terms of surface area within the project's area of influence.

The landscape metrics indicates the existence of very reduced areas of shrublands and riparian forests, indicating the disappearance of these natural ecosystems in the area, which is evident in the high degree of transformation to which they have been subjected, as illustrated in the results of the characterization of flora that shows a high prevalence of introduced forest species and low diversity in the floristic composition of these ecosystems.

Connectivity Index

The connectivity of each ecosystem was assessed based on the creation of a 500-meter buffer around each fragment (using ArcGIS), for which it is important to mention that the reduced areas of each patch show the significantly low proportion they occupy within the buffer zone.

As a result of said analysis, Table 5.2.56 shows the landscape context for each ecosystem, where **AN** is the area covered by the natural ecosystem within the AI, **ATF** is the area covered by the 500-meter buffer and **CP** is the landscape context resulting from dividing **AN/ATF**. It is important to mention that the landscape context is calculated within a range from 0 to 1, where the values close to 1 indicate greater ecosystem connectivity.

Table 5.2.56 Landscape context by ecosystem

ECOSYSTEM	Cod.	AN (ha)	ATF (ha)	CP
Dense shrubland of the Upper Andean Orobiome	213221	7.70	5350.50	0.001
Dense shrubland of the Middle Andean Orobiome	203221	12.98	5350.50	0.002
Gallery and/or riparian forest of the Upper Andean Orobiome	21314	8.01	5350.50	0.001
Gallery and/or riparian forest of the Middle Andean Orobiome	20314	21.32	5350.50	0.004
Open rocky grassland of the Middle Andean Orobiome	2032122	112.19	5350.50	0.021
Total		**162.197**	**26752.5**	**0.030**

AN: Natural area within the buffer; **ATF**: Total area of the buffer; **CP:** Landscape context

According to the table above, the sum of the landscape context for all the ecosystems assessed is 0.03, which means low general connectivity, which is more significant in the shrubland and riparian forest of the Upper Andean Orobiome.

As illustrated in the results of the landscape context, for all the ecosystems assessed, they generally tend to be near zero (0), which means very low connectivity between the fragments of these ecosystems, where the Open rocky grassland of the Middle Andean Orobiome is the one with the greatest connectivity.

These results explain the existence of extensive arrays of pasture and monoculture plantations, generally represented by patchwork, among which natural ecosystems are immersed, whose areas are so reduced that it does not allow continuity between fragments.

This situation is particularly worrisome for the fauna, since the existence of habitats, feeding, hanging and lodging sites, as well as the presence of biological corridors is reduced; therefore., it is more common to find generalist species of fauna and those that have adapted to anthropic or intervened ecosystems.

5.2.1.3. Strategic and Sensitive Ecosystems and/or Protected Areas

By means of analysis of secondary information, we ruled out the presence of forest reserve areas of Law 2 / 1959, areas of the national system of Protected Areas, strategic ecosystems or zones, sensitive and protected areas in the area of influence of the dual carriageway road construction project, Pedregal-Catambuco sector, that could be directly affected by the construction of the dual carriageway.

The preliminary verification was carried out using the Tremactos Colombia tool and the overlapping of the project's area of influence with information from the National Park System, the local system of protected areas in the municipality, Reserves of the Galeras Civil Society, National Protective Forest Reserves and Regional Protected Areas (see description in Chapter 5 - Characterization of the Area of Influence, Section 5.2.1.3 Strategic and Sensitive Ecosystems and/or Protected Areas.

To this effect, and in order to validate the information obtained, the Ministry of the Environment and Sustainable Development (MADS) and National Parks of Colombia, as well as the regional environmental authorities, such as CORPONARIÑO, the Pasto Municipal Mayor's Office and the Department Governor's Office, the town halls of Tangua, Yacuanquer and Imués, were asked for information regarding the existence of protected areas or strategic ecosystems in the area of influence of the Rumichaca-Pasto dual carriageway project, which informed that the area of interest N does not overlap with any category recognized by the environmental authorities in the exclusive National Registry of Protected Areas (RUNAP), regulated by Decree 1076 / 2015, Article

2.2.2.1.3.3 "Exclusive Registry of Protected Areas (SINAP)". See annexes 5.2.1.5-a, 5.2.1.5-b, 5.2.1.5-c, 5.2.1.5-d).

Furthermore, the municipality of Imués indicated the presence of areas related to the watercourse of the Guaitara River and other sources; therefore, these areas were quantified in relation to the area of intervention of the project for all the municipalities involved, in order to be taken into account in the ecological compensation processes. See annex 5.2.1.6.

Although there were not protected areas per se, natural ecosystems corresponding to Riparian forest were identified as having an extension of 15.53 hectares, as well as dense shrubland at 22.73 hectares, open rocky grassland at 112.19 hectares (See Table 5.2.120).

On the other hand, in the project's area of indirect influence, there are the Bobo Buesquillo River Reserve of the Civil Society of Galeras, the Galeras Flora and Fauna Sanctuary, the Ovejas-Tauso Protected Area, the Tabano-Campanero Protected Area, the Divina Pastora Protected Area and the Morasurco Protected Area.

The following is a graphic description of the location of the protected areas identified in the area of indirect influence of the road project (Figure 5.2.1).

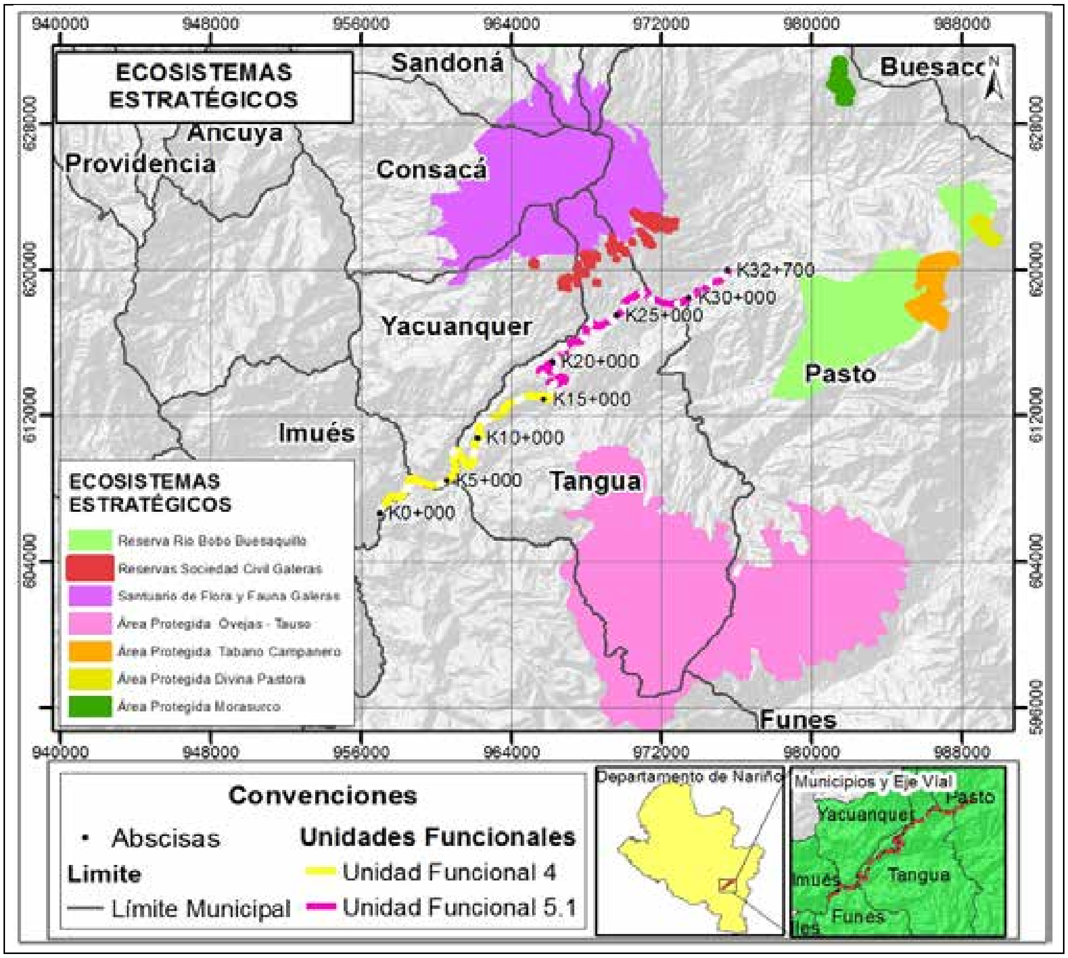


Figure 5.2.51 Protected areas at the local and regional scale vs. Rumichaca-Pasto road corridor, Pedregal-Catambuco sector.

Source: Géminis Consultores Ambientales, 2016.

As illustrated in the figure above, the Bobo Buesquillo River Reserve of the Civil Society of Galeras, the Galeras Flora and Fauna Sanctuary, the Ovejas-Tauso Protected Area, the Tabano-Campanero Protected Area, the Divina Pastora Protected Area and the Morasurco Protected Area have no direct relationship, nor are they part of the area of influence of the road project.

BIBLIOGRAPHY

BARRETO, A., & HERRERA G, J. (1990). “El Nogal” Juglans neotropica Dote. *Plan de acción forestal para Colombia:Programa plan nacional de investigaciones forestales PLANIF*, 60.

CÁRDENAS L., D. &. (2007). *Libro Rojo de plantas de Colombia. Volumen 4. Especies maderables amenazadas: primera parte.* Bogotá: Instituto Amazónico de Investigaciones Científicas SINCHI – Ministerio de Ambiente, Vivienda y Desarrollo Territorial.

Cárdenas López, D., Castaño Arboleda, N., Sua Tunjano, S., & Quintero Barrera, L. [. (2015). *Planes de Manejo para la Conservación de Abarco, Caoba, Cedro, Palorosa, y Canelo de los Andaquíes.* Bogotá: Instituto Amazónico de Investigaciones Científicas - SINCHI.

CÁRDENAS, D. C. (2011). *Evaluación de la distribución potencial actual en Colombia del cedro (Cedrela odorata) y el cocobolo (Dalbergia.* Ginebra (Suiza): Instituto Amazónico de Investigaciones Científicas SINCHI .

Gallego, M. J. (2016). *https://cienciassobrelanaturaleza.wikispaces.com/2.+Los+grandes+biomas*.

Géminis Consultores S.A.S. (s.f.).

Géminis Consultores S.A.S. (2016).

GIRALDO, L., & CAMARGO, J. (2006). *Análisis de sustentabilidad en unidades productivas ganaderas del municipio de Circasia.*

IAvH, I. d. (2003). *Convenio de las Naciones Unidas sobre Diversidad Biológica (Ley 165 de 1994) y Protocolo de Cartagena sobre Seguridad en la Biotecnología.* . Bogotá, D. C.,.

IDEAM. (1997). *Las coberturas vegetales, uso y ocupación del espacio de Colombia. Escala 1:500.000.*

IDEAM, IGAC, IAvH, INVEMAR, I.SINCHI, & IIAP. (2007). *Ecosistemas continentales, costeros y marinos de Caolombia.* Bogotá D.C.

INVEMAR. (2012). *http://siam.invemar.org.co/siam/tesauro_ambiental/E/ECOSISTEMAS%20CONTINENTALES.htm*.

TRUJILLO. (2007). *Guía de reforestación. Cercos vivos con especies forestales.* Bogotá.