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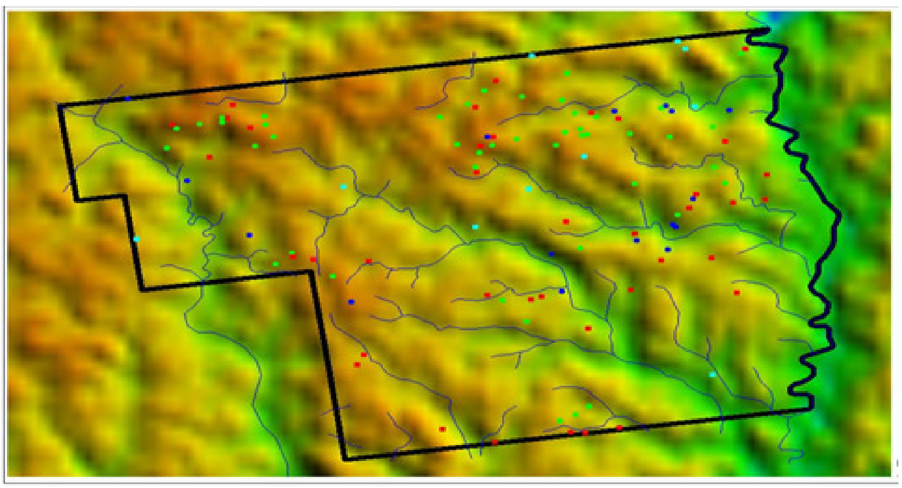
FEDERAL RURAL UNIVERSITY OF THE AMAZON
FOUNDATION FOR SUPPORTING RESEARCH EXTENSION AND TEACHING IN AGRARIAN SCIENCES
INTERNATIONAL TROPICAL TIMBER ORGANIZATION
COMPANY BATISFLOR FLORESTAL LTDA

ECOLOGY AND SILVICULTURE OF MAHOGANY (*Swietenia macrophylla* KING) IN THE WESTERN BRAZILIAN AMAZON



EQUIPE TÉCNICA

Paulo Luiz Contente de Barros[1]
João Olegário Pereira de Carvalho[1]
Marcos Renato Dantas de Almeida[2]
José Luis Fernandes da Silva[2]
Taciana Pantoja da Silva[2]
Luiz Rogério de Oliveira[3]
Joércio Paulino da Costa[3]

[1] Prof. da Universidade Federal Rural da Amazônia
[2] Engenheiros Florestais, Mestrandos do Curso de Ciências Florestais da UFRA
[3] Técnicos da Empresa GERFLOR/BASTIFLOR

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HOST:
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EXECUTING AGENCY:
FOUNDATION FOR SUPPORTING RESEARCH EXTENSION AND TEACHING IN AGRARIAN SCIENCES (FUNPEA)

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PROJECT MAIN STAFF

Project coordinator: Dr. Paulo Luiz Contente de Barros, Lecturer at Federal Rural University of the Amazon

DEPUTY COORDINATOR: DR. JOÃO OLEGÁRIO PEREIRA DE CARVALHO, **LECTURER AT THE FEDERAL RURAL UNIVERSITY OF THE AMAZON**

Deputy coordinator: Forest Engineer, **Luiz Rogério de Oliveira**, **Company BATISFLOR FLORESTAL LTDA**

Silviculture and Management component: Dra. Lia de Oliveira Melo, Lecturer at Federal Rural University of the Amazon

***Hypsipylla grandela* Control: Dr. Orlando Shigueo Ohashi**, Consultant-Lecturer at Federal Rural University of the Amazon
Administration Officer: Carlos Albino Figueiredo Magalhães, Director President, FUNPEA- Foundation for Supporting Research Extension and Teaching in Agrarian Sciences

CORRESPONDING ADDRESS:

FOUNDATION FOR SUPPORTING RESEARCH EXTENSION AND TEACHING IN AGRARIAN SCIENCES
Carlos Albino Figueiredo Magalhães, Director President, FUNPEA
Convênio FUNPEA/UFRA
Av. President Tancredo Neves, 2501-Montese
66.077-530 Belém, Pará, Brazil
Phone/FAX: + 55 91- 3274-6615

UNIVERSIDADE FEDERAL RURAL DA AMAZÔNIA
Instituto de Ciências Agrárias – ICA/UFRA
Av. Pres. Tancredo Neves, nº 2501
66.077-530,Belém, Pará, Brazil
Phone/FAX: + 55 91-3210-5165 (UFRA)
+ 55 91-3210-5156
Coordinator e-mail: paulo.contente@ufra.edu.br
Deputy coordinator email: olegario.carvalho@gmail.com
Deputy coordinator email: wilson.maia@ufra.edu.br

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE

Although the ecology and silviculture of mahogany has already been studied in other studies, there remains challenges, how to manage a native forest with occurrence of mahogany cost-effectively while ensuring the species conservation. A project of sustainable forest management plans (SFMP), which is the objective of this project, has been approved by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) with logging permit AUTEF (Autorização de exploração Florestal) issued by the regional environmental agency (IBAMA/AC). The participation of a timber company (Batisflor), the financial support of ITTO and the implementation by the Federal Rural University of Amazonia (UFRA) was the strategy adopted to achieve the project objectives.

The project basically can be divided in two phases: i) Phase I, consisting of the activities developed before logging, according to the management plan (pre-harvesting activities); and ii) Phase II, consists of the activities to be developed after logging (post-harvesting activities).

Phase I – Pre-harvesting Activities

- Establishment of the annual coupe. According to the forest management plan, an annual coupe (UPA) of 6,000 ha has been established. Each annual coupe is divided into 100 ha working units (Unidade de Trabalho - UT) which are also subdivided into 25 ha harvesting units;
- Making 100% Forest Inventory of all species, including mahogany;
- Preparation of logistic map of the area, including all tree species properly georeferenced;
- Preparation of logistic map of the area, specifically for mahogany species;
- Based on these maps, prepare the planning of the location of Permanent Sample Parcels (PSP) for phytosociological monitoring and specific parcels for monitoring natural regeneration of mahogany;
- Establishment and measurement of PSP (phytosociological) and parcels for monitoring natural regeneration of mahogany;
- Creation of database of all data collected in the field during the first phase;
- Data processing, analysis and discussion of results and drawing conclusions and recommendations from the collected data.

Phase II – Post-harvesting activities

- Second measurement of all permanent sample parcels (phytosociological) and parcels of natural regeneration of mahogany;
- Data processing, analysis and discussion of results and drawing conclusions and recommendations from the collected data in two phases (Phase I and Phase II).

Post-harvesting activities of the project have not been carried out according to the original schedule because of the delay in the approval process of the Annual Operation Plan (POA) and the authorization for harvesting (AUTEF) by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA). The results of the Phase I, so far, will greatly contribute to revising the guidelines for mahogany harvesting in natural forests. Entrepreneurs and environmental agencies will also benefit. Besides these groups, indigenous communities will benefit as well because the species occur in abundance on indigenous lands.

It is expected that with the partial results obtained so far and with the conclusion of the research could contribute to the creation of specific guidelines for the exploitation of mahogany species in natural forests, thereby encouraging entrepreneurs and also environmental agencies.

Data collected in permanent parcels and regeneration induction parcels were processed. These data, although they are partial results, have been analyzed.

This project presents partial results, which will provide an important contribution to the definition of silvicultural practices that ensure the stocks of natural regeneration of mahogany seedlings and also a minimum number of mature trees remaining, which will be necessary to maintain the continuous supply of seeds in the managed area.

The project will also contribute to a better definition of the legal requirements for the standardization of future SFMP of areas with natural occurrence of mahogany in the Brazilian Amazon.

Thus, the objective is to establish silvicultural practices that enable the exploitation of mahogany species in natural forests and suggest improvements in the current regulations of the federal government (IN N° 07, of August 22, 2003) which currently regulates the preparation of forests management plans for species conservation.

1 INTRODUCTION

Swietenia macrophylla King, known as "Amazonian mahogany" or simply "mahogany" is a species that has long been considered the most important in the market for timber exports from the Brazilian Amazon. The high value of this species in the international market triggered a uncontrolled exploitation, reaching an intensity of exploitation of 90% to 95% of the stocks of the species existing mature trees in areas that have been logged.

Swietenia macrophylla King, presents a vast geographical distribution, is a species that occurs in the Neotropics, from Mexico, valleys of Bolivia and large areas of the Brazilian Amazon region. In Brazil, according to Lamb (1966) and Barros et al (1992), the species can be found in the forests of southern Amazonia.

Forest inventories carried out in forests with the occurrence of mahogany in Bolivia, Mexico and Brazil (Verissimo et al, 1995; Snook, 1996; Gullison et al, 1996), as well as carried out in the present study, which shows that the species presents as a characteristic diametric distribution with a low occurrence of individuals among young trees, saplings and seedlings, but increases for mature trees, showing some concern in relation to the conservation of the species, since the exploitation takes place exactly in mature trees, leaving the remaining forest without the stock of regeneration that can ensure its management for future rotations.

In an attempt to curtail the uncontrolled exploitation of mahogany, restrictive measures were adopted in order to reduce the amount of mahogany sawnwood exports through the contingency measures, which was defined by law, annual export quotas for mahogany exporting companies.

For several reasons, only a contingency measure was not enough to reduce pressures on mahogany exploitation. In 1996, Decree N° 1963 of 25 July 1996, established a moratorium prohibiting the exploitation, transportation and marketing of mahogany in the Brazilian Amazon, which was extended in 1998 and 2000, and further extending its effects until 2002.

With the inclusion of mahogany in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II, it was necessary to establish public policies that ensure the exploitation of mahogany and thus international trade, through sustainable management that reduce the risks and threats of extinction ensuring, consequently, the conservation of the species.

On the other hand, the "Action Pro-Amazon", consisting of representatives of all members of the Federation of Timber Industries of the Amazon, among the four recommendations presented to the federal government, the sustainable use of natural stocks of mahogany, the 4th suggestion was "to encourage and strengthen research to determine a silvicultural system for the management of natural forests of mahogany." This suggestion coincided with one of the suggestions made by another discussion forum of non-governmental organizations (NGOs) that favored the inclusion of mahogany in CITES Appendix II. Thus, it was a common understanding that strengthening of research could support the development of a specific legislation for the management of forests with natural occurrence of mahogany, since

2003 mahogany already was listed in CITES Appendix II.

In 2003, Decree N° 4772 of June 5, 2003, its Article 2 states that it is IBAMA´s responsibility to establish the regulations that enable sustainable management of mahogany.

Later, the Technical Scientific Committee was set up and the rules were established by the Normative Instruction of the Ministry of Environment (MMA), IN Nº 07, of 22 August 2003 (IN 07/2003), which regulates the preparation of the Sustainable Forest Management for areas with natural occurrence of mahogany, which is in force to date.

According to current legislation that deals specifically on the exploitation of mahogany, logging can only take place in areas of SFMP prepared according to the requirements set by IN 07/2003, approved by IBAMA, and by the Scientific Committee of CITES; after that, logging permits will be issued (AUTEF – Autorization of Forest Exploitation) which will be given to the company with SFMP to start activities of infrastructure and logging itself.

IN 07/2003 sets all rules already set by MMA/IBAMA IN N° 05, which are required for the exploitation of forest areas without occurrence of mahogany, differing basically, by the need for chain of custody, the requirement to leave the minimum number of remaining mahogany trees per Unit of Work (UT), and 5 trees per UT, control and measurement of permanent sample parcels, which in case of mahogany will be all species remaining in the managed area, as well as 100% inventory (census) of individuals from DBH $\geq$ 20 cm. Moreover, SFMP of areas with occurrence of mahogany will be monitored by inspectors of IBAMA, and also by members of the Scientific Committee of CITES.

On the other hand, even though Brazil already has a specific legislation (IN 07/2003), which regulates and enables the exploitation of mahogany in a legal manner, along with Mexico and Guatemala, which are countries out of the category of "Review of Significant Trade" of CITES, there remains a challenge to adapt this legislation to ensure the sustainability and conservation of the species without the risk of extinction/threats, while enabling an economically viable activity.

This project aims to contribute to the formulation of public policies that can actually ensure the sustainability of the species and its consequent reduction of risks of extinction.

For the implementation of field activities planned for the project, the Batisflor Company made available the area of forest management, infrastructure and manpower.

1.1. PROJECT IDENTIFICATION

The project "Ecology and Silviculture of Mahogany (*Swietenia macrophylla* King) in the Western Brazilian Amazon" was developed through an institutional partnership among the Federal Rural University of the Amazon (UFRA), the International Tropical Timber Organization (ITTO), the Foundation for Supporting Research Extension and Teaching in Agrarian Sciences (FUNPEA) and the private forest company Batisflor Ltda. The project implementation started in March 2009 with duration of 24 months.

1.1.1 Project objectives

The project aims to establish silvicultural practices that enable the exploitation of mahogany species in natural forests and suggest improvements in the current Federal Government regulation (IN 07/2003), which regulates the preparation of forest management plans for the conservation of the species *Swietenia macrophylla* King.

In this way, it is possible to ensure international trade in mahogany timber, and meet the criteria for sustainable management with a view to the conservation of the species.

1.1.2 Project implementation strategy

As a strategy, a partnership was signed among the Federal Rural University of Amazonia (UFRA), ITTO and FUNPEA and logistical support by a private company, the Batisflor Company that provided the area ofSustainable Forest Management Plan, located in the southern region of the state of Amazonas.

Despite the difficulties of access to the project area due to distance, road and/or river and climates conditions, and this location was the only opportunity for the time being for the implementation of this research project.

Under these circumstances, a number of risks presented as difficulties that could hamper the project implementation.

1.1.3 Location and access to the project area

The project "Ecology and Silviculture of Mahogany (*Swietenia macrophylla* King) in the Western Brazilian Amazon" was established at the forest management area, owned by BATISFLOR, located in the border of the Amazonas and Acre states, on the left margin of the Purus River (8° 10' - 8° 45'S and 68º 52'W - 69° 22'W).

Thus, the expeditions of project teams to collect field data, left from Belém to Rio Branco, capital of Acre state, to meet the company Gerflor´s team which, in turn, left from the Vilhena municipality in state of Rondônia.

From Rio Branco, the teams went to the project area, either by the BR-364 highway that connects Rio Branco to Cruzeiro do Sul, to a secondary road, 24 Km distant from the main road, to the margin of Purus River, crossing the river by a ferry boat (Figure 1), or going on the same highway to the municipality of Sena Madureira or Manoel Urbano, both in Acre state.

Figure 1 Project technical team crossing the Purus River by ferry boat

The decision to go either through Sena Madureira or Manuel Urbano for the project area was defined depending on the season and navigability conditions of the Purus River and São Paulo River (Figure 2). Thus, when the trip was through Sena Madureira, the boat trip to the project area would take about 23 hours, while via Manoel Urbano, the trip would take 6 to 8 hours by boat.

Figure 2 A barge known as "Batelão" in the region of the Project area and the technical team by motorboat on Purus River going to the project area

Despite all difficulties faced by the team members of UFRA and the Gerflor Company, the prior planning for each expedition prevented that these difficulties become risks that could hamper the implementation of field activities of the project.

1.1.4 Release of funds from ITTO

The release of financial resources according to the timetable for the payment of installments by ITTO was done as planned, ensuring the smooth progress of the project. Thus, the release of funds was not a problem that could jeopardize the project's implementation.

1.1.5 Logistical support of companies BATISFLOR / Gerflor

The private partner of the project, the BASTIFLOR Company, the owner of the forest area and holder of SFMP and the Gerflor Company hired for the preparation and implementation of SFMP, were always ready to provide logistical support to the project technical team. For instance, to facilitate the expeditions to the area for data collection, the transport to the area, acquisition of tags used in the demarcation of trees, parcels, UT, and so on, as well as hiring local workers, providing food and lodging conditions in the project area. The involvement of private companies in implementing the project did not present any risk that could hinder its implementation.

1.1.6 Academic activities of the project trainees

The trainees of the project, all forest engineers and students enrolled in the Master's Degree in Forestry Sciences at UFRA, always made themselves available to participate in the field trips, to conduct other office tasks, and carrying out any tasks requested for the implementation of the project.

1.1.7 Approval of Sustainable Forest Management Plan (SFMP)

All activities related to the Phase I (Pre-logging) was carried out. However, the activities of the Phase II (post-logging) were not carried out within the project's initial schedule because it depended on logging in the study area.

The SFMP of the area was only approved by IBAMA/AC at the end of January 2010. Moreover, the plan was analyzed by the Scientific Committee of CITES because SFMP involved mahogany species. After its review, the Committee also approved the SFMP in September 2010.

Considering the planned activities and those activities that were actually implemented, the project implementation was successful. The team managed to carry out all pre-logging activities. On the other hand, the post-logging activities were not carried out due to the above mentioned reasons, and also the project ended in February 2011.

The completion of the project activities are planned for the second semester (Summer season) of 2012. The expectation is that the results of the project contributes to the improvement of knowledge on mahogany regeneration, its distribution in open ombrophyla forest, also it will provide forest productivity data in the future, through the analysis of permanent parcels which will be then established and measured.

The data and the results obtained by the phytosociological analysis of permanent parcels will be part of the database of the Brazilian Network of permanent parcels (created by the Brazilian Forest Service) and, thus, providing information on productivity of mahogany forests in the Brazilian Amazon, which is of great importance for such species to be managed sustainably.

The partial results achieved by the project will serve as a basis to guide the regulations on sustainable forest management plans involving the species, and the development of master´s and doctoral theses having mahogany as the main theme.

2 THEORICAL REFERENCIAL

2.1 ECOLOGICAL ASPECTS OF *SWIETENIA MACROPHYLLA* KING

As for the ecological aspects, *Swietenia macrophylla* King belonging to the Meliaceae family, is a species that reach large size, often presenting heights between 25 m and 35 meters, and can reach 50 m, and usually has straight and cylindrical trunks, often buttressed at the base, making it difficult to measure the diameter of mature trees (Lamb, 1966, Barros et al, 1992), see Figure 3.

Figure 3 Straight and cylindrical trunk of Swietenia macrophylla King 31 m high, 158 cm in diameter above the buttresses (tabular roots)

The *Swietenia macrophylla* King, according to Lamb (1966) and Barros et al (1992), given the large area of occurrence of mahogany, and only in the Brazilian Amazon covers about 1.5 million km², it occurs in various soil conditions, from deep soil, poorly drained, acidic clay soils to well-drained alkaline soils that come from limestone plateau.

Thus, soils of natural range of mahogany are those typical of many areas subject to periodic floodings (hydromorphic) and podzolic soil type, typical of the region (Figure 4). However, based on the soil classification adopted by the Project RADAM BRAZIL, considering the soil types that predominate within the range of natural occurrence of the species, it is implied that the Eutrophic Red-Yellow Podzolic soil (PE), with 170,233 km² and Red Yellow Podzolic soil (PV) with 1,620,769 km², equivalent to 3.32% and 3.31.64% of the total area of the Brazilian Amazon, respectively, are interrelated with the occurrence of *Swietenia macrophylla* King (mahogany). According to Sombroek & Sampaio (1962), the predominant soil of occurrence of mahogany, is yellow podzolic soil with high base saturation and predominantly with imperfect drainage and rich in exchangeable bases.

Figure 4 Red-yellow podzolic soil, known as "Tabatinga", occurring in the Project area

Similar to the soil, the climate in general terms given the extent of the species occurrence, some average data can be assumed: i) Average annual rainfall is approximately 2,000 mm; ii) average temperature varies from 23°C to 26°C, but depending on the region temperature may be lower, given the cold phenomenon, which occurs in the region between the states of Acre and Rondonia for 3 to 80 days a year.

According to Lamb (1966), *Swietenia macrophylla*, King presents a high phenotypic plasticity, given its capacity to adapt to survive in different ecotypes, even under prolonged drought conditions, with less than 100 mm of rainfall per month in shallow, well-drained soils.

Mahogany does not grow well in shaded forests and competition at the root system level. Thus, the species behaves as heliophile growing in an open forest. Since the early 1960s, Lamb (1996), noted that natural regeneration of *Swietenia macrophylla* King takes place in places within the forest where sunlight reaches the ground, and where the litter layer is not thick, allowing the radicle to reach the mineral soil easily (Figure 5).

Figure 5 Occurrence of several mahogany seedlings in open areas within the project area

In the forests with occurrence of mahogany, the diametric distribution of species shows low frequency of regenerating individuals (seedlings, saplings and young trees) as also observed in field surveys in Bolivia, Mexico and Brazil, cited by Gullison & Hubbell (1992); Snook (1993); Verissimo (1995); Snook (1996); Gullison et al (1996); Baima (2001). Grogan et al (2007) also reported that density of occurrence of mahogany individuals ranging from 0.04 to 1.17 tree.ha^{-1} in 8 different sites.

The ecological amplitude of mahogany is because the species behave as a pioneer or successional species, which can occur in disturbed areas or zones of ecological tension in greater quantity than in conditions where vegetation can reach balance or climax, presenting a great potential to regenerate artificially.

2.2 PHENOLOGIC ASPECTS OF *SWIETENIA MACROPHYLLA* KING

2.2.1 Flowering and Fruiting

Flowering and fruiting vary with age and also depend on the dry season. This species benefits from dry periods for the opening of its fruit/seed and dispersal of winged seeds. In general, according to Lamb (1966), its reproductive cycle start around 12 years old, under favorable conditions. However, Gullison et al (1996) and Grogan (2001) reports that in natural forests reproduction can be delayed due to a greater or lesser competition of forest canopy after the opening of growing space in the forest.

According to Baima (2001), mahogany flowering occurs from the fall of leaves during the dry season, until immediately after the appearance of new leaves. The mahogany fruit is a brown woody capsule with approximately 16 cm long and 10 cm in diameter, as examined in the project area, and also according to Gaspareto (1998). See Figure 6.

Phenologically, this Meliaceae have winged seeds, with a reddish-brown color, producing a good amount of seed on average 40 - 50 seeds per fruit, the species is classified as abundant in terms of seed production (Figure 7).

Figure 6 Swietenia macrophylla King seeds found in the project area

Figure7 Swietenia macrophylla King seeds in different views found in the project area

The dry season and other associated factors have a strong influence, both during the flowering and fruiting. In 2010, fruiting occurred from the end of July to October in the project area, presenting a greater dispersion in late August and early September, confirming the fruiting period reported by Veríssimo et al (1992), in the Araguaia region, from July to October.

2.2.2 Seed Predation and Pests

As examined in this study, Lamb (1966) also cited seed predation by parrots and macaws, when they are still in the trees. When the seeds are already on the forest ground, these are predated by different rodents. On the other hand, the closed fruits on the ground are often attacked by termites.

In the seedling phase, the attack of yellow caterpillars (*Steniscadia poliophaea*) that destroy the leaflets is common (Figure 8).

Figure 8 Yellow caterpillar attacks in mahogany seedlings sprouts in natural forest at the Project area

Although the seeds, fruits and seedlings present different predation forms, the microlepidopter *Hypsipyla grandella* Zeller attacking the apical branches is considered the major pest of *Swietenia macrophylla* King. The *H. grandella* Zeller, attacks the species in natural forest in the form of enrichment of these forests, but also in environments of open forests.

2.2.3 Shade Tolerance

Barros, *et al* (1992) and Lamb (1996) cited that the seedlings of *Swietenia macrophylla* King in the shade presents low development, given the limited availability of energy for photosynthesis under conditions of understory of dense tropical forests. Mahogany seedlings need light to germinate and develop; therefore, they are classified as heliophila, so that when it occurs in forest openings have excellent growth.

This fact could be seen in the project area because the study area is located in a border between ombrophyla open forest (high light intensity) and dense ombrophyla forest (low light intensity on the forest ground) to the extent that goes to the northern region of the state of Amazonas, and also due to the occurrence of closed forests in the inner part of open forest, locally called "RestIngas" (Figure 9).

Figure 9 Understory of restinga forest area with low light in open ombrophyla forest without the occurrence of mahogany seedlings

2.3 DISTRIBUTION OF NATURAL FORESTS WITH OCCURRENCE OF *SWIETENIA MACROPHYLLA* KING

The Brazilian Amazon has an area of approximately 5 million km², where the phytophysionomy of dense ombrophyla forest areas present different vegetation types with characteristics different from each other (Aragon, Jordy & Fonseca, 1984).

The *Swietenia macrophylla* King occurs mainly in areas of open **o**mbrophyla forests, and may occur at lower density in other areas in other vegetation type. Although the definition of open **o**mbrophyla forest is quite old, Barros et al (1992) reported that for Neotropical ombrophyla vegetation the Project RADAM BRAZIL used the term for the first time in the 1970s.

The concept is a physiognomic-ecological classification of forest in which trees are more widely spaced, with high occurrence of palm trees and sparse shrubs, comprehended in a bioclimate from 30 to 90 days dry, which results in special humidity conditions. In the Amazon region, it is the second most representative forest type, covering an area of slightly over 1 million km² (Barros, 1992).

The open ombrophyla forest (Figure 10) presenting a distinct physiognomy mainly in the southern and western Amazon, in the state of Acre, which is part of the project area. Its floristic composition shows a high incidence of palm trees, vines, and also a strong occurrence of bamboo or “Sororocas”, which determine different formations.

Figure 10 Partial view of open ombrophyla forest with a high occurrence of bamboo in the project area

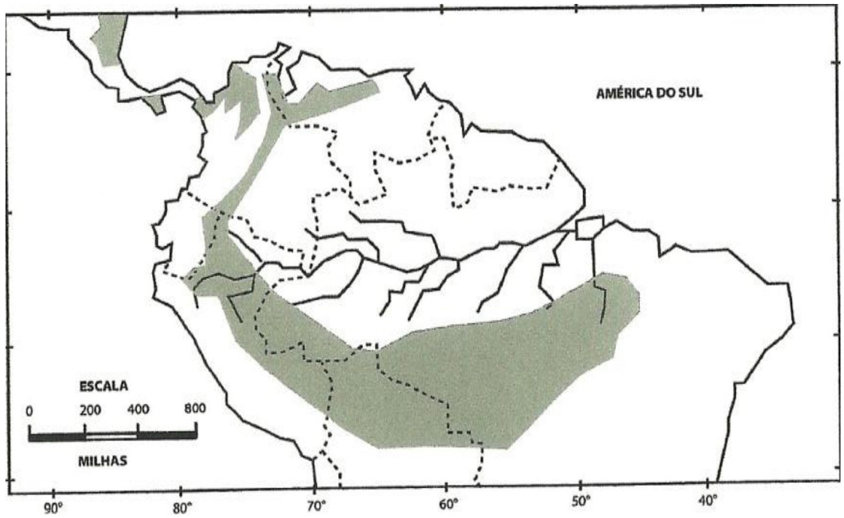
In the project area, in addition to a high occurrence of the genus *Guadua* bamboo also patches of forests locally called "restingas" are found (Figure 11), where decreases the occurrence of mahogany, and reduced light due to closed dense canopies with the consequent reduction of trees and the incidence of bamboos.

Figure 11 Partial view of vegetation patches of "restingas" in the project area

The *Swietenia macrophylla* King is distributed in a wide geographic area in the Neotropics, ranging from the Yucatan Peninsula, Mexico (Latitude 23º N) to a wide arc to the south of the Amazon in Venezuela, Ecuador, Colombia, Peru and Brazil, with maximum latitude of 18º S (Lamb, 1966; Verissimo & Grogan, 1998; Baima, 2001) (Figure 12).

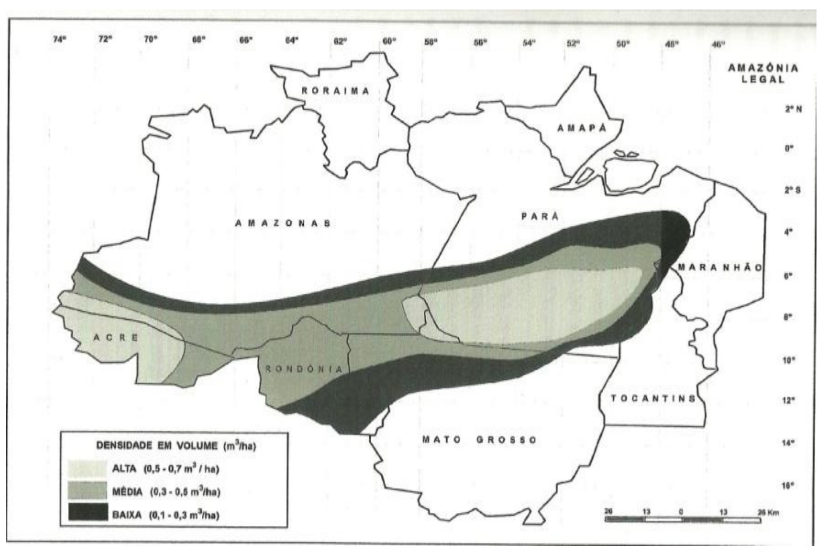
In Brazil, the species occurs in forests of the southern Amazon (Lamb, 1966, Barros et al, 1992; Baima, 2001). According to Barros et al, 1992, the area of occurrence of mahogany in Brazil is estimated at approximately 1.5 million km², going through the states of Acre, Amazonas, Maranhão, Mato Grosso, Pará, Rondônia and Tocantins ranging from 0.27% of the State of Tocantins to 46.7% of the State of Pará (Figure 13).

Figure 12 Geographic distribution of Swietenia macrophylla, King proposed by Lamb (1966), from Mexico to the countries of Central and South America



Source: Baima, 2001

Figure 13 Occurrence of Swietenia macrophylla King in the Brazilian Amazon (Barros et al, 1992)



Source: Baima, 2001

2.4 POPULATIONS STRUCTURE OF *SWIETENIA MACROPHYLLA* KING IN NATURAL FORESTS IN THE AMAZON

The *Swietenia macrophylla* King, as mentioned earlier, occurs in a wide geographical area from Mexico to the southern Amazon region, and only in the Brazilian Amazon, according to Barros, et al (1992), presents an area of natural occurrence of approximately 1.5 million km². Thus, mahogany is distributed in the area due to several factors, such as humidity and soil type, sloppiness, and mainly due to hydrographic/river network of the area.

When considering their distributions in large areas, mahogany adult trees are distributed according to a negative exponential distribution, that is, a gregarious distribution with the formation of large groups of individuals or patches of occurrence. On the other hand, when considering only the groups or patches of mahogany within this gregariousness, trees are distributed according to a Poisson distribution, that is, distributed randomly.

In the Brazilian Amazon, the density of occurrence of adult trees of *Swietenia macrophylla* King depends essentially on the size of the inventoried forest area and location of these areas, that is, occurrence zero if the inventoried area is outside of patches of occurrence or occurrences densities from 4 to 5 trees per hectare in the case of the inventoried area coincide with large patches of natural occurrence. The literature on the subject, as cited in Baima (2001), reports that in natural forests with occurrence of mahogany in Brazil and Bolivia, adult trees are found in the average density from 1 to 2 trees per hectare.

Barros, et al (1992), analyzing secondary data from different sources, particularly sample units surveyed by the RADAM BRAZIL Project in the 1970s during the completion of forest inventory in the Amazon, estimated an average density of 1.022 $tree.ha^{-1}$ equivalent to a volume of 0.4 $m^3.ha^{-1}$ and a basal area of 0.38 $m^2. ha^{-1}$.

Barros, et al (1992) at estimating the area of natural occurrence of *Swietenia macrophylla* King in the Brazilian Amazon (Figure 14), the area was stratified into three density strata: Low density – 0.1 to 0.3 $m^3.ha^{-1}$; average density – 0.3 to 0.5 $m^3.ha^{-1}$; and high density – 0.5 to 0.7 $m^3.ha^{-1}$.

As mentioned above, the density of occurrence of mahogany depends among other factors on the size and location of the inventoried area; Baima (2001) presents an extensive literature review on the density of mahogany in its natural habitat.

2.5 PHYTOSOCIOLOGICAL STRUCTURE

The beginning of the use of phytosociological parameters, such as abundance, dominance, frequency, importance of species in the context of population began with the findings of Cain et al (1956) and Cain and Castro (1959), followed by many other studies, such as Carvalho (1982), Carvalho et al (1986), Barros (1986), among others.

Carvalho (1999) carried out an extensive review of the literature dealing with research carried out in the Amazon, especially those related to the phytosociological structure of tropical forests, where it was found that a considerable part of the work reiterates the concern to know the basic forest structure, in evaluating the degree of behavior of various areas with different levels of exploitation and to recommend management methods and conservation of the species diversity.

According to Husch et al (1972), the structure of a forest is considered as the distribution of species and numbers of trees occurring in an area, and is the result of the growth habits of the species and environmental conditions where the population originated and developed. However, in addition to quantitative measures such as abundance, dominance and frequency, Lamprecht (1964) while recognizing its importance, considers the partial data which, separately, fail to fully characterize the vegetation structure. Thus, it emphasizes the need for the determination of the Importance Value Index (IVI), which characterizes the importance of each species individually in relation to the total species population.

2.5.1 Diametric Distribution

Barros (1980), citing (De Liocourt, 1898)[1], notes that from the establishment of the original concept of the diametric distribution in uneven-aged natural forests was developed numerous mathematical models capable of describing the structure of forest stands.

De Liocourt´s theory suggests that the diametric distribution in heterogeneous forests tends to form a reverse “J” curve, which can be maintained through management of these forests to get closer to a balanced distribution ensuring a sustainable production.

As one of the planned activities in the project area is logging, which will cause some disturbances, even if it is conducted with proper forest planning, the distribution of diameters is far from the balanced distribution of the remnant forest, hence there is a need to know the diametric structure of the area.

The importance of knowing the diametric distribution of forests to be logged in the Amazon lies in the fact that where the ingress, growth and mortality rates, which depend on the natural environment, biotic factors, the species composition and density, are the basic factors to the development of diametric distributions that represents the outcome of this process.

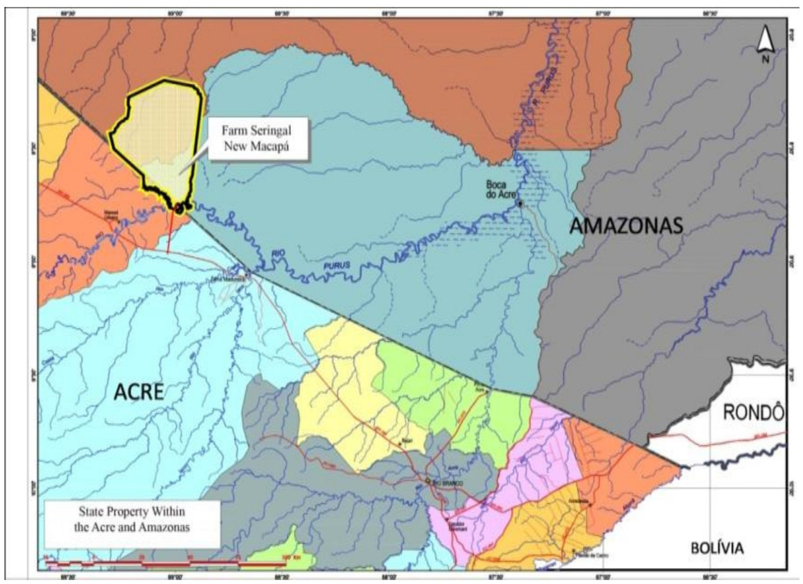
[1]De LIOCOURT, F. L’amenagement de sapinieres. Bull. De La Societe For, Franche-Conte at Belfort. Benascon, 1898

3 MATERIALS AND METHODS

3.1 DESCRIPTION OF THE STUDY AREA

The project study area is owned by the Fazenda SerIngal Novo Macapá (Figure 14), located on the left bank of the Purus River, covering the municipalities of Boca do Acre and Pauini both in the state of Amazonas and the municipality of Manoel Urbano in state of Acre. The property belongs to private firm the Batista & Cia Ltda, having as the main activity production of timber and by-products on a sustainable basis.

Figure 14 Location of the Project Fazenda SerIngal Novo Macapá



The area of Fazenda SerIngal Novo Macapá has 190,210.00 ha, of which 186,000.00 ha (97.78%), is designated to Sustainable Forest Management Plan (SFMP), which was divided into units of annual production (Unidades de Produção Annual - UPA). UPA was called Remnant UPA, with a total area of 1,953.31 ha area that presents an area of effective management (AEM) of 1,620.61 ha which was named the UPA-1R area, which was divided into 19 working units (Unidades de Trabalho – UT) where this research project was established. Table 1 shows the land use in the project area Fazenda SerIngal Novo Macapá.

Table 1 Land use distribution of the Fazenda SerIngal Novo Macapá area

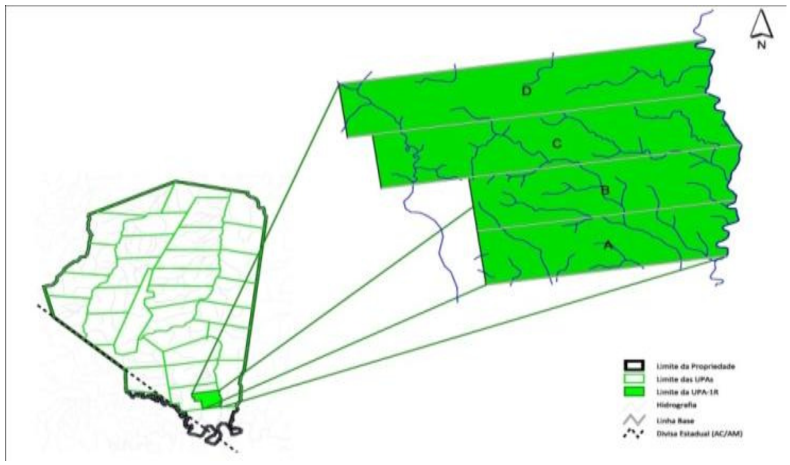
Description	***Área (ha)***
Total property area	190.210,0003
Sustainable Forest Management Area	186.000,0000
Anthropic area	452,2509
Absolute Preservation Area	10.292,4590
Permanent Preservation Area	5.794,2691
Total UPA-1R area	1.620,61

3.2 CHARACTERIZATION OF ANNUAL PRODUCTION UNIT – UPA-1R

3.2.1 Determination and Allocation of the Remnant UPA (UPA-1R)

The Remnant UPA (UPA-1R) refers to the part of an area of UPA that did not suffer any type of logging (Figure 15).

Figure 15 UPA-1R area at the project site as part of UPA 1 area that has not been logged



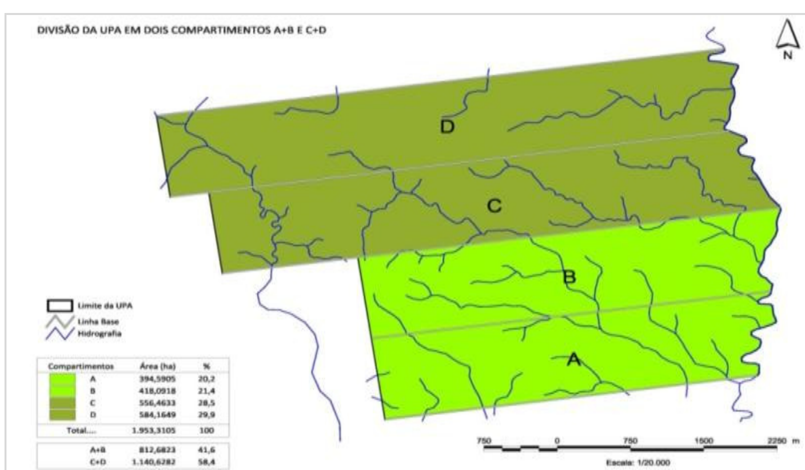
In the baselines, picket posts were established every 50 m and at every 250 m some marks were made with 90° declination that served as a guide for the opening of access trails.

Altogether, 387 access/orientation trails were opened, equidistant in 50 meters.

To ensure optimal UPA-1R data positioning for the inventory, geographic positioning coordinates were collected at various points on baselines, both at the ends and along the baselines, using a Garmin GPS receiver, model GPSmap76CSx.

In order to organize the forest inventory, the UPA-1R was divided into 04 compartments, namely A, B, C and D. Figure 16 shows how the definition of the UPA-1R was determined.

Figure 16 Division of the UPA-1R study area in two compartments (A + B and C + D)



3.2.2 UPA - 1R Vegetation

Due to the strong predominance of the genus *Guadua* bamboo, the vegetation is classified as open ombrophyla forests with bamboos, regionally known as "Tabocal". It was also identified a small proportion (patches) of areas known as "RestIngas".

This forest type presents heterogeneous physiognomic characteristics; however, it can be easily defined. In areas of restIngas, the forest presents dense canopies coverage where bamboo disperses and integrates in the understory vegetation, always as a dominated element or at least it does not present a notable physiognomy.

In areas called "Tabocal", where the forest canopy is sparser, allowing a higher incidence of light on the soil, there is a great density of bamboo, as it happens also in natural forest openings, margins of streams and along the roads.

The dominant species of UPA - 1R forest, that is, the species with the largest basal areas from 30 cm DBH, are: Açacu (*Hura crepitans L.)* (0.392 m²/ha), Cumaru (*Dipteryx odorata*) (0.207 m²/ha), Garapeira (*Apuleia leiocarpa*) (0.185 m²/ha), Sumaúma (*Ceiba pentandra*) (0.157 m²/ha), Bandarra (*Schizolobium amazonicum* Huber ex Ducke) (0.137 m²/ha), Caucho (*Castilla ulei*) (0.099 m²/ha), rubber tree (*Hevea brasiliensis*) (0.096 m²/ha), Jatoba (*Hymenaea Courbaril* L) (0.081 m² / ha) and Mahogany (*Swietenia macrophyla*, King) (0.079 m²/ha), respectively representing 52.9% of total basal area.

3.2.3 Soil

The pedology of the **UPA-1R** area is classified as red-yellow argisol, according to pedological map (Folha SC. 19 – Rio Branco) prepared by the RADAMBRASIL Project (1976), known locally as "TabatInga". These deep clay soils hinder the use of machineries and equipments during the rainy season.

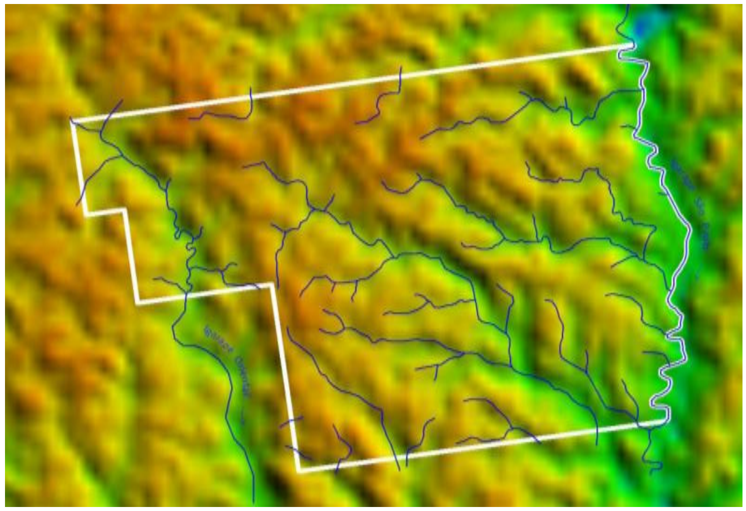
3.2.4 Digital Modeling of Drainage (DMD)

The images are referenced to the Datum WGS84/EGM96 Geoidal. The estimates of accuracy for this product were 20 meters at 95% confidence for vertical data and 30 meters at 95% confidence for horizontal data.

Analyzing the data obtained by digital modeling of drainage, the level curves, ASTER-GDEM images, processed to better histogram equalization, and field observations, it was possible to determine the location of streams, their spring heads and respective Permanent Preservation Areas (Áreas de Preservação Permanentes - APP), complying with the applicable laws.

Therefore, the UPA-1R hydrographic network is defined by São Paulo and Oriental streams and other small unnamed streams, as shown in Figure 17.

Figure 17 Digital modeling of hydrographic network and land relief



Source: Image ASTER-GDEM

3.2.5 Digital Terrain Modeling (DTM)

With the use of stereoscopic images and ArcGIS contour lines were modeled, which are curves that connect points on the surface with the same elevation. In this case, the contour lines representing the level curves were generated at an interval of 3 meters.

Thus, the relief of UPA-1R is classified as softly ondulated, without large altimetric gaps and with declivity toward the drainage network. It is worth noting that areas with the declivity greater than 45° were not identified, considered as APP by law.

From the DTM analysis with the help of ArcGIS, critical zones or restrictive areas to building the infrastructure, that is, roads and timber yards were defined. Figure 18 shows the topography of UPA-1R.

3.2.6 Area with "Tabocal"

As mentioned earlier, the forest type that covers the UPA-1R area is characterized by the predominance of "tabocas" (bamboo *Guadua* sp.) In some places some isolated trees are found in the middle of tabocas (Figure 21).

Figure 18 Occurrence of isolated trees amid strong occurrence of the genus Guadua bamboo (Tabocas)

3.2.7 Area with Vines/Lianas

Although the UPA-1R area presents vines in isolated trees (Figure 19), at the forest inventory census areas, an incidence of vine entangled trees were not identified.

Figure 19 Isolated trees with vines (lianas)

3.3 PRE-LOGGING SURVEYS

3.3.1 Forest Inventory at 100% (Census)

A forest inventory of the species of immediate commercial interest and species considered potential was made. The inventory consisted of determination of qualitative and quantitative characteristics of the species, in which all individuals with commercial interests with circumference at breast height (CBH) ≥ 100 cm were cataloged. For the species *Swietenia macrophylla* King (mahogany) inventories of individuals with DHB ≥ 20 cm were made, in accordance with the law (IN 07/2003).

For data collection in the field of forest inventory at 100% (census), firstly the area was divided into 30 UPA (Units of Annual Production).

Of 30 UPAs, the UPA-1R, the project area with 1,652.4063 ha, in turn, was divided into 19 UT (working units) (Table 2). Each UT has on average an area corresponding to 86.97 ± 15,7291 ha, as shown in Table 2.

Table 2 Distribution of areas per work unit (UT) within UPA-1R

Work Unit (UT)	*Area (ha)*	*Work Unit (UT)*	*Area (ha)*
1	94,8155	11	87,5235
2	97,0282	12	97,0630
3	93,6669	13	92,5130
4	99,5987	14	93,6341
5	76,0685	15	39,6717
6	61,0924	16	90,2960
7	97,4743	17	89,2596
8	99,9713	18	94,7429
9	89,9055	19	65,0260
10	93,0551	-	-

It is worth mentioning that besides the collection of qualitative and quantitative information, the field crews collected the positioning of trees in each field, using the Cartesian system (X, Y), where X is the distance from the tree to orientation trail and Y indicates the distance of tree in relation to baseline. Similarly, useful observations were registered for micro-zoning of UPA-1R, such as hilly areas, streams, watercourses in each orientation trail.

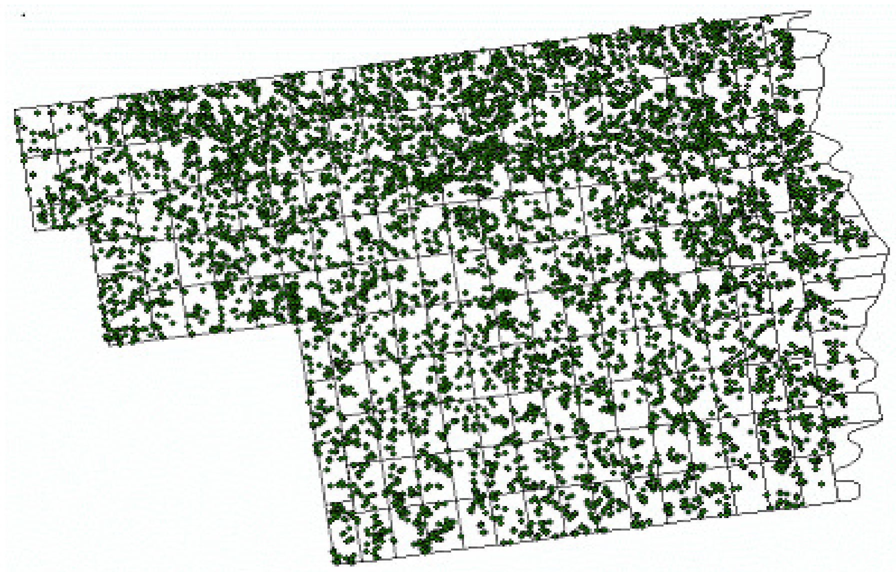
The criteria for selection and retention of trees were based on the laws IN 07/2003, which focuses on sustainable forest management of mahogany and IN 05 of IBAMA, and CONAMA Resolution N° 406/2009. Thus, retention of trees was maintained at a ratio of three trees per each UT (± 100 ha) over the minimum cutting diameter - DMC (DBH = 50 cm) for all species, except for mahogany, which was maintained the limit of five trees per 100 hectares, considering trees with DBH ≥ 60cm.

3.3.1.1 Data Collection for Phytosociological Analysis of Trees Collected in Forest Inventory at 100%

As mentioned earlier, UPA-1R was divided into 19 UT, totaling 1,652.4063 ha, where forest inventory at 100% (census) was carried out for all species with DBH ≥ 30 cm and all mahogany trees with DBH ≥ 20 cm. In order to make the phytosociological analysis of this population, it was necessary to subdivide it into sample units to determine the absolute frequency and the consequent Importance Value Index (IVI) for species occurring in the area. Thus, the entire UPA-1R area was subdivided into an area of 10 ha.

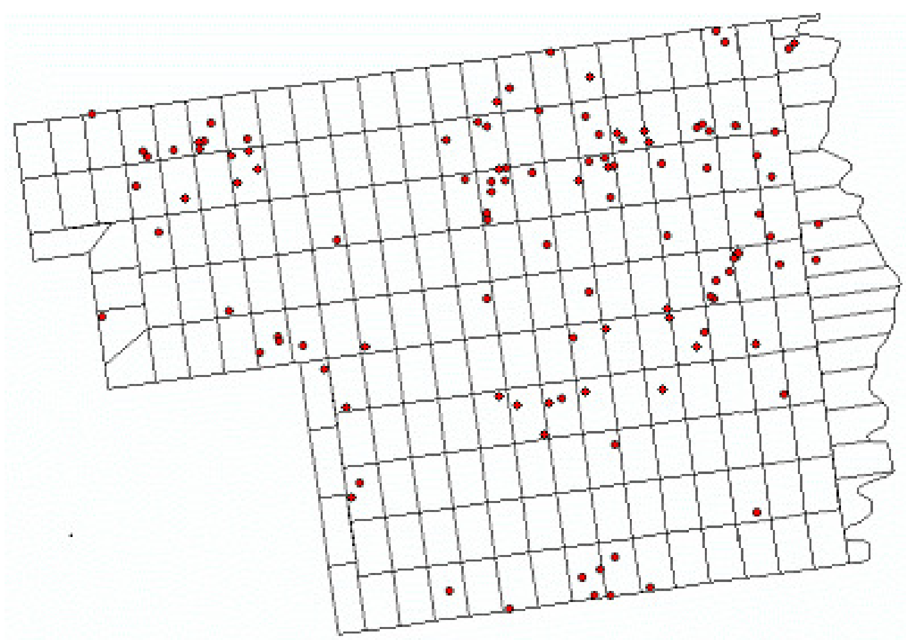
After the subdivision of the area, all individuals of the species surveyed in the area were plotted, as shown in Figure 20.

Figure 20 Division of UPA-1R in units of 10 ha with distribution of all trees of all species inventoried (100%) in the area



Similar to the distribution of all species, the distribution of 10 ha units were carried out, for only *Swietenia macrophylla* King in the UPA-1R, as shown in Figure 21.

Figure 21 Division of UPA-R1 in 10 ha units with the distribution of all trees of Swietenia macrophylla King with DBH ≥ 60 cm per 10ha unit area



3.3.2 Phytosociological Structure

3.3.2.1 Diversity of the species in the area

The species diversity index of an area reveals aspects of the structure of a community which shows overall patterns when comparing communities that differ in species composition (Bulla, 1994). These indices are based on the species abundance ($ni.ha^{-1}$), as it is the case of diversity indices of Shannon-Weaver and Simpson (Magurran, 1988).

The Shannon-Weaver index (H') takes into account the relative abundance of species and assumes that individuals are randomly sampled in an "infinitely large" population (Magurran, 1988), cited by Silveira (2001).

Thus, there are many ways to measure species diversity in the literature, but among them Simpson (1949) shows that the probability of finding two individuals taken randomly in a forest community of "N" individuals, it is computed as a measure of concentration of dominance (Cs). Thus, the higher probability constitutes the lowest diversity. Thus, the diversity measures were obtained by:

Simpson´s Diversity Index (Ds)

$$Ds = 1 - C$$

Where:

$$C = \frac{\left[\sum_{i=1}^{S} n_i(n_i - 1)\right]}{[N(N-1)]}$$

C = Measure of dominance of SIMPSON index;

S = Number of species that occurred in the sample area;

ni = Number of individuals of “ith” species;

N = Total number of sampled individuals.

(b) Shannon-Weaver Diversity Index (H ')

$$H' = -\sum_{i=1}^{S} p_i . log(p_i)$$

Where:

Proportion of the participation of species i in relation to the total of individuals sampled, given by

log = decimal or natural logarithm (ln)

3.3.2.2 Equitability / Uniformity

The equitable or uniform distribution of "N" individuals among the total species (S) in a data set, expresses as the diversity index is close to maximum diversity (Dmax.). Thus, the uniformity index (E) of the sampled data was obtained by:

(a) Simpson´s equitability or uniformity index (Es)

$$Es = \frac{Ds}{D_{máx.}}$$

Where:

Es = Simpson´s Uniformity Index

Ds = Simpson's Diversity Index

$$Ds_{máx.} = \left[\frac{S-1}{S}\right] * \left[\frac{N}{N-1}\right]$$

S = Number of species that occurred in the sampled area;

N = Total number of individuals sampled.

(B) Shannon-Weaver´s equitability or uniformity Index (J ')

$$J' = \frac{E(H')}{H'_{máx}}$$

Where:

E(H')= $H' - \left[\frac{S-1}{2 * N}\right]$, expected value for H'

H' = Shannon-Weaver Diversity Index

$H'_{máx} =$ Shannon-Weaver Maximum Diversity Index, obtained by: $H'_{máx} = log\ S$

S= Number of species.

3.3.2.3 Species dispersion in the area

The Morisita index of aggregation, according to Brower and Zar (1977) is among the methods used for this purpose, the method is less influenced by the size and distribution of sample units, presenting good qualities in detecting the degree of species dispersion in the area, given by:

$$I = \frac{[\sum_{i=1}^{N} n_i(n_i - 1)]}{[n(n-1)]} * 100$$

Where:

I = Morisita Index of aggregation;

N = Total number of sample units;

n_i = Number of individuals in the ith sample unit;

n = total number of individuals in all sample units;

The interpretation of the value obtained from the Morisita index of aggregation, based on the significance of the Chi-square test (X^2) at the 0.05 level of probability is that when the value 1.0 is assumed, the dispersion is random, if that is uniform, the value will be zero and if that is greater than 1.0 will be gregarious. The comparison of the values of Morisita indices calculated in relation to zero.

3.3.2.4 Species Abundance

- Absolute Abundance (Aa)

The absolute abundance (Aa_i) of each species was defined as the number of individuals per unit area (nº.árv.ha^{-1}), so we have:

- Relative Abundance (Ar)

The relative abundance (Ar_i) of each species corresponds to the percentage of species in relation to the total number of trees sampled ($\sum_{i=1}^{S} Aa_i$). Thus the result is:

$$Ar_i = \frac{Aa_i}{\sum_{i=1}^{S} Aa_i} .100$$

3.3.2.5 Species Dominance

- Absolute Dominance (Da)

The absolute dominance ((Da_i)) of one species was calculated as the sum of transversal areas (gi) of trees of the species, expressed in m²/ha. Where:

$$Da_i = \sum_{i=1}^{S} g_i$$

- Relative Dominance (Dr)

The Relative Dominance (Dr_i) on each species was obtained by the share of the absolute dominance of the species in the total sample.

$$Dr_i = \frac{Da_i}{\sum_{i=1}^{S} Da_i} .100$$

3.3.2.6 Species Frequency (F)

- Absolute Frequency (Fa)

The absolute frequency (Fa_i) was defined by the ratio between the number of sample units where the species occurred and the total number of units established, that is:

$$Fa_i = \frac{N^{\underline{o}}\ de\ Unid.\ de\ Amostra\ com\ a\ esp\acute{e}cie}{N^{\underline{o}}\ Total\ de\ Unidades\ de\ Amostra} . 100$$

- Relative Frequency (Fr)

The relative frequency (Fr_i) of the species was obtained by the proportion of each species Fr_i by total absolute frequencies.

$$Fr_i = \frac{Fa_i}{\sum_{i=1}^{S} Fa_i}$$

3.3.2.7 Importance Value Index of species (IVI)

- Importance Value Index of species (IVI)

The Importance Value Index (IVI) of each species was determined by the arithmetic sum of abundance, dominance and relative frequency of each species i, as follows:

$$IVI_i = Ar_i + Dr_i + Fr_i$$

- Relative Importance Value Index (IVI)

The relative Importance Value Index (IVI) was obtained as:

$$IVIr_i = \frac{IVI_i}{\sum_i^S IVI_i} . 100$$

3.3.3 Continuous Forest Inventory (Permanent Parcels)

3.3.3.1 Number and size of Permanent Parcels (PP)

The permanent parcels (PP) were established in the field area, according to the

"Guidelines for Establishment of Permanent Parcels Monitoring," which recommends a ratio of permanent plots of ¼ hectare for each 250 ha of managed area in Annual Production Unit (UPA) greater than 1,000 ha. In the project area, UPA-1R has an area of approximately 1,700 ha, thus the area required the establishment and measurement of 8 permanent parcels, covering an area of 2 ha (sampled area).

3.3.3.2 Area shape, location and establishment of Permanent Parcels (PP)

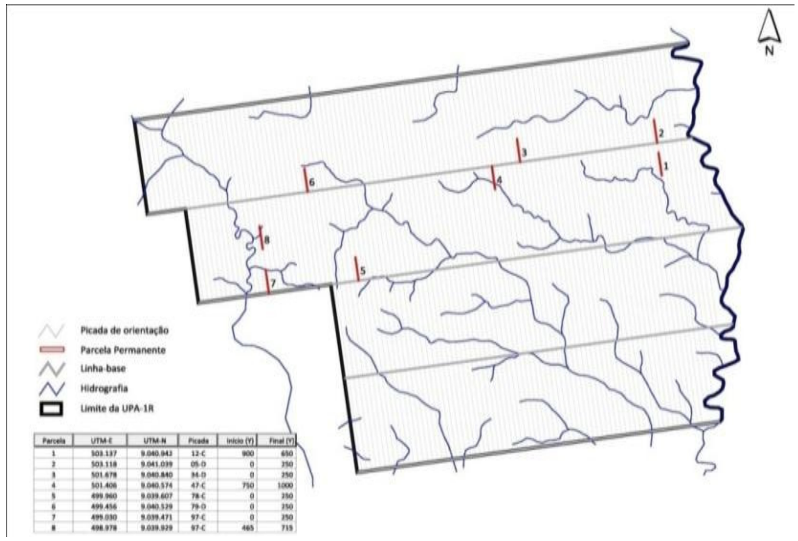
The area shape selected for PP was rectangular measuring 10 m x 250 m (0.25 ha) for each parcel. Picket posts made out of PVC pipe and the upper edges of pickets were painted with color contrasting with the vegetation and to make its location easier (Figure 22).

Figure 22 Use of PVC pipe with the top edge end painted in red to sign permanent parcels and the sub-parcels

Permanent parcels were established in production forest areas and locations that have not undergone any silvicultural intervention to monitor the development of natural forest.

The allocation of parcels was randomly done in areas with different forest types, geo-referenced within UPA-1R, as shown in Figure 23.

Figure 23 Location of 8 Permanent Parcels properly geo-referenced within UPA-1R



To start the establishment of a permanent parcel chosen randomly (Figure 24), a compass, three wooden pickets and a measuring tape were used. With a picket post placed into the ground (Figure 25), adjusted with the compass to form a 90° angle and with a measuring tape measured 10 meters in both directions, forming an "L", starting to subdivide the parcel, which was possible to place other picket posts every 10 meters, completing 25 meters of the length of a parcel.

Figure 24 Demarcation of Work Unit areas (UT) by forest tracks within UPA-1R

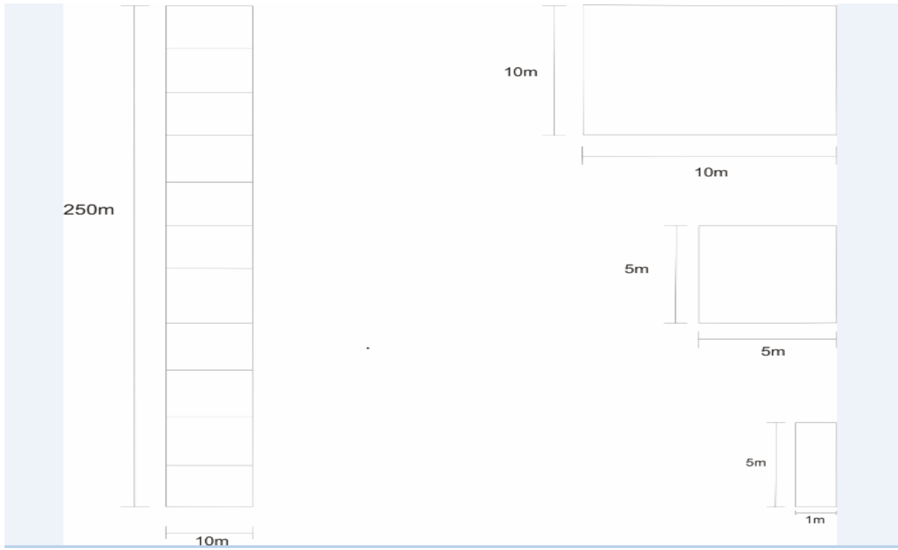
Figure 25 Placement of picket posts for the establishment of permanent parcels

For the placement of picket posts in the internal portion of the parcel was not necessary to open trails. Some procedures such as cutting vines and small branches that hindered the picketing were conducted. Starting from the second picket posts from perpendicular line, placing pickets every 10 meters, forming a parallel line to the line that was established in the edge direction of making the inventory and check the distances between the two lines, in which the distance of 10 meters was kept. The procedure was repeated in other lines until the completion of the full establishment of the parcels.

3.3.3.3 Subdivision of permanent parcels in sub-parcels

Each permanent parcel was subdivided into smaller observations units (0.01 ha) sub-parcels of 10 m x 10 m. The demarcation has resulted in 25 sub-parcels of 100 m², to facilitate control and the location of each tree to be measured and monitored. Thus, each permanent parcel consisted of 25 sub-parcels, in which data on trees were collected. Among these 25 sub-parcels, 5 were selected to conduct the survey of young trees. Within each of these 5 sub-parcels where young trees were measured, one of the four corners of the sub-parcel was selected and delimited an area of 5 m x 5 m, for measuring saplings (2.5 cm $\leq$ DBH <5 cm), and within this an area of 5 m x 1 m was selected to carry put the survey of seedlings (height $\geq$ 30 cm and diameter < 2.5 cm), as shown in Figure 26.

Figure 26 Layout of the subdivision of Permanent Parcels



The establishment and measurement of parcels occurred before any intervention in the area (logging, silvicultural treatments, etc.).

The Guidelines, the source of methodology used in this research, recommends that the second measurement of PP should be carried out in the year following the intervention (logging), to evaluate damage caused by the logging operation. After the second measurement, the intervals between subsequent measurements should be from two to five years. The minimum diameter for measurement was set at 2.5 cm ≤ DBH <5 cm for saplings, 5 ≤ DBH <10 cm DBH for young trees, and DAP ≥ 10 cm for trees.

3.3.3.4 Procedure for data collection in permanent parcels

Each tree received an aluminum tag, with a numbering identifying the tree (six digit number where the first two identify the parcel, the third and fourth numbers identify the sub-parcels and the last two identifies the tree.

The measured trees and each 25 sub-parcels in PP followed a specific numbering ranging from 1 to n.

The tags were placed approximately 10 cm above the diameter measurement (Figure 27). In case of tall trees with buttresses, tags were fixed in place with easy visibility above the buttress.

Figure 27 Aluminum tag with the identification of trees measured in 25 sub-parcels of PP

In the trees selected for logging, the tag will be replaced to the base of the trunk, below the cutting to enable its identification after logging. For trees located in the border of the sub-parcels, it was agreed that the tree must be included in the sub-parcels where more than half of its base is located.

The numberings of trees that die will not be used again for another tree, and in case of individuals entering the sub-parcels will be given a new numbering, a sequence close to that sub-parcel.

3.3.3.5 Measuring the circumference of individuals measured in PP

The circumference measurement was made at a fixed point called Measurement Point (ponto de medição – PDM), with a measuring tape in centimeters. The PDM was set at 1.30 m above the ground (CAP, circumference at breast height) whenever possible. Vine cutting and site cleaning for any other anomalies of tree trunks that could lead to measurement errors were conducted. To mark the measuring point, oil-based paint with a bright color (red), which contrast with the environment was used, to facilitate the identification of the point and avoid reading errors in all subsequent measurements.

In trees with buttresses (tabular roots) or anomalies such as damaged roots or deformation, PDM was changed to a place above, free of these anomalies, noting a proper observation recorded in the field data, indicating the number of tree and the reason for the change.

3.3.3.6 Individual class size

According to the Guidelines and methodology adopted in this study, individual class size used in measurements of permanent parcels is presented in Table 03.

Table 3 Class Size of individuals measured in PP

Size Class	*Limit / interval*
Tree	DAP ≥ 10,0 cm
Young trees	5,0 ≤ DAP < 10,0 cm
Sapling	2,5 ≤ DAP < 5,0 cm
Seedling	Height ≥ 30 cm e DAP < 2,5cm

3.3.3.7 Variables to be collected in the tree stratum

All variables measured or observed within PP followed the methodology proposed by the "Guidelines for Establishment of Permanent Parcels Monitoring," presented by the Network Monitoring Dynamics of Tropical Forests (REDEFLOR), linked to the Brazilian Forest Service (SFB).

- Class identification of trunk (Classe de Identificação do Fuste - CIF)

This variable describes various states in which trees are found in the forest. These states are the result of their own growth, or changes caused by man or nature.

The numbering codes used combine the health of the tree with the state of its trunk. In the first measurement, only living trees are considered. From the second measurement, all trees, including dead or missing trees should be recorded.

Trees that receive the code “dead” are used only in the second measurement after logging, to analyze the impact in the forest.

In cases of trees that do not fit exactly in the situations described in the methodology, they were considered special situations of CIF and received new codes.

In the field survey for individual trees, only the tree codes caused by natural causes were considered.

- **Silvicultural situations of trees**

The silvicultural situation was used to identify the situation of each tree in relation to silvicultural measures applied in the forest.

The codes used in this study were 1 and 5; the remaining will be useful from the second measurement, after logging.

- **Damage to trees**

The observation of the damage is important to evaluate the state of health of trees and to determine the intensity of logging impact on the remaining trees, as well as the impact of silvicultural treatments and winds or storms.

Damages were observed in the trunk and canopy of live trees (whole, broken or fallen) with a diameter ≥ 10 cm. In this pre-logging phase, the codes considered were 1, 2, 5 and 10.

The following situations are considered severe damages:

- Fallen trees (live or dead).

- Trees without canopies (lost all canopy) at any height.

- Trees with more than 50% of the canopy broken, even if there is no damage to the trunk.

- Trees with extensive damage to the trunk (over 3 m high), even if the canopy is still healthy.

- **Tree Rot**

The tree rot damage can be caused by logging, silvicultural treatments or natural agents. Observations on the decay/rot are important for estimating the degree of health of trees.

The rot was observed in the trunk and canopy of live trees (whole, broken or fallen) with a diameter $\geq$ 10 cm.

In the pre-logging survey, only code numbers 1 and 2 were used.

- **Sunlight on canopy of tree**

The variable sunlight on canopy indicates the level of exposure of the canopy to sunlight, and the degree of existing competition with neighboring canopy trees. This variable is important because it represents one of the factors that significantly influence the growth (Silva et al., 1995). In evaluating the sunlight on canopy trees, only live trees and standing (whole or broken) were considered. Four categories were used.

- **Canopy shape of tree**

The shape of canopy is an important characteristic related to tree growth. Individuals with well-formed canopy present, in general, greater growth than those with incomplete or poorly distributed canopy (Smith, 1989). Evaluation of the state and shape of canopies, prior and after logging, allows estimating the intensity of damage caused to the canopy of remaining trees. In the classification of canopies, in terms of shape, criteria ranging from trees with whole canopy to trees without canopies are considered. In this criterion, only live and standing trees were considered.

- **Presence and effect of lianas on trees**

The level of infestation of vines in the trees monitored was estimated through observation. The infestation of vines may be the result of large-scale canopy openings caused by storms, unplanned logging or by great intensity of thinning.

3.3.3.8 Variables to be collected in the young tree stratum

- **Measurement and numbering of young trees**

Young trees are individuals with diameter equal to or greater than 5 cm and less than 10 cm were measured in five randomly selected sub-parcels (20%) among 25 sub-parcels existing in a parcel.

Each young tree received an aluminum tag with two-digit numbering, placed above PDM. Each sub-parcel of saplings had its own numbering sequence, regardless of sequence used for trees. For young trees with more than a tree bole received one more digit, for example 01.1, 01.2.

For common names, silvicultural situation, diameter, damage, rot, sunlight of canopy, canopy shape, vines effect, were used which are the same instructions for trees.

- **Class identification of young tree trunks (CIF)**

Similarly to the evaluation of trees, this variable describes various states of trunks of young trees in the forest. The codes used for young trees combine the health of young trees with the state of its trunk.

The young trees that received the code numbers from 5 to 9, in a measurement, will not be considered in future measurements, and their numbers will not be used again in other young trees in the same sub-parcel.

3.3.3.9 Variables to be collected in the sapling stratum

- **Measurement and numbering of saplings**

Saplings which are individuals with a diameter equal to or greater than 2.5 cm and less than 5 cm, are measured in the same sub-parcels where they recorded young trees, but in sub-parcels of 5 m x 5 m.

Each sapling received an aluminum tag with two digit numbers preceded by the letter "V" in order to differentiate it from the numbering of young trees (e.g. v.01), and placed just above PDM. Each sub-parcel of saplings has its own numbering sequence, regardless of sequence used for the other size classes. In case of saplings that had more than one tree bole, the numbering of each trunk received more than one digit (e.g., V.01.1, V01.n).

The variables considered for the class-size of saplings are: common name, CIF and diameter. For the measurement of diameter, the same guidelines for trees and young trees were considered.

- **Trunk class identification (CIF) of saplings**

Similar to trees and young trees, the class identification of trunks was used to describe the various states of saplings in the forest.

Saplings that reach 5 cm or more in diameter during the successive measurements will be classified in the sapling stratum and joined in the young tree stratum. In this case, they lose their original numbering as sapling, which shall not be recorded in this population, and receives a new numbering (the next in the sequence of the sub-parcels of young trees). Its original number should not be used in another individual.

In the case of special situations of saplings, CIF that did not fit exactly in the foreseen situations, new codes were used.

3.3.3.10 Variables to be collected in the seedling stratum

- **Registration of seedlings**

Seedlings are individuals with height more than 30 cm and a diameter less than 2.5 cm. The sub-parcels to record seedlings were established within sub-parcels of saplings in an area of 5 m x 1 m. Its location was selected randomly within a range among the five possible places to be established. Only the number of individuals, respective species and CIF were recorded.

- **Trunk Class Identification (CIF) of Seedlings**

Among the codes used for seedlings survey, only code numbers 1 and 2 are used in the first measurement, and code numbers 3, 4 and 5 will be used in subsequent measurements or after logging.

Seedlings that reach 2.5 cm or more in diameter from the second measurement of the parcel are classified as egress from the seedling stratum and ingress to the young tree stratum. In this situation, they lose their original numbering as seedlings that should no longer be recorded in this population, and a new numbering is given (the next in the sequence of young tree parcel). Its original numbering should not be used in another individual.

3.3.4 Parameters of Horizontal Structure: Abundance, Frequency and Dominance

The calculations of parameters abundance, dominance and frequency that explain the horizontal structure of the tree, young tree and sapling strata measured in permanent parcels were carried out following the methodology presented in the section on phytosociological structure.

3.3.4.1 Forest inventory of natural regeneration of *Swietenia macrophylla* King

The forest inventory of natural regeneration of *Swietenia macrophylla* King (mahogany) was conducted to obtain information on the conditions that lead to successful establishment and growth of mahogany seedlings in natural forests, specifically, the effects of canopy disturbance, competitors to regeneration of other species and the interaction with mahogany seedlings, with mahogany shoot borer *Hypsipyla grandella*, Zeller populations in natural forests. This will ultimately relate strictly to the development of silvicultural systems to enhance mahogany regeneration.

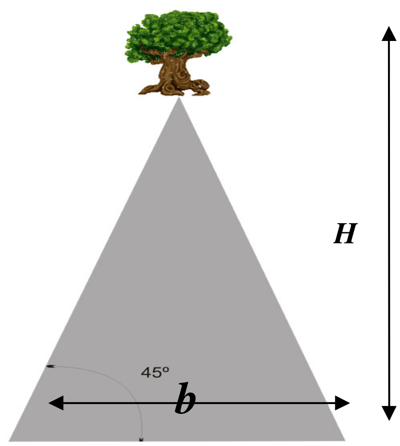
As mentioned above, the study of the establishment and growth of natural regeneration of the species was impaired by the non-measurement of parcels after logging, as originally planned.

Observations of the ecology of seedlings are consistent with the theory that mahogany regenerates as a result of periodic disturbances, such as opening of forests, drought or fire (Lamb 1966, Nelson et al 1994; Snook 1992). Seeds dispersed by adult survivors, adult mahogany trees, can find the ideal conditions for the establishment in forest openings and relatively free of competition from the conditions created by these types of disturbances (Gullinson & Hubbell, 1992, Lamb, 1966, Snook, 1992, Snook, 1996; Veríssimo et al., 1995).

3.3.4.2 Application of silvicultural treatments

For openings of at least 1,000 m^2 were made in the direction of prevailing winds in all trees selected for sampling. These forest openings were made in a triangular shape of approximately 30 m long by 70 m wide, with the apex of triangle in the trunk of mahogany tree (Figure 28).

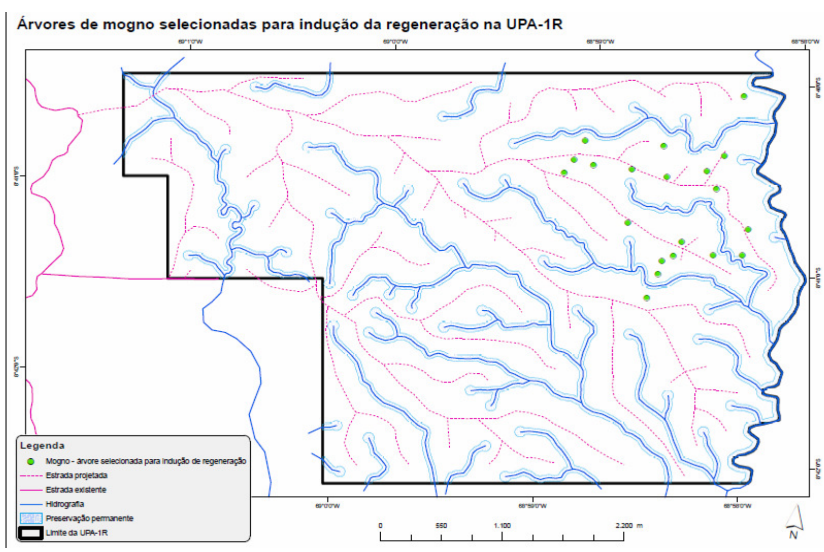
Figure 28 Forest openings in prevailing wind direction



3.3.4.3 Situation of mahogany regeneration

Twenty mahogany trees of reproductive age were selected in the annual production unit (UPA-1R) to study the regeneration and establishment of mahogany seedlings, before and after canopy opening (Figure 29).

Figure 29 Map of selection of trees for silvicultural treatments



The selection was based on the following criteria:

a) Five trees selected for harvesting where silvicultural treatment of canopy opening was conducted (Openings of at least 1,000 m^2);

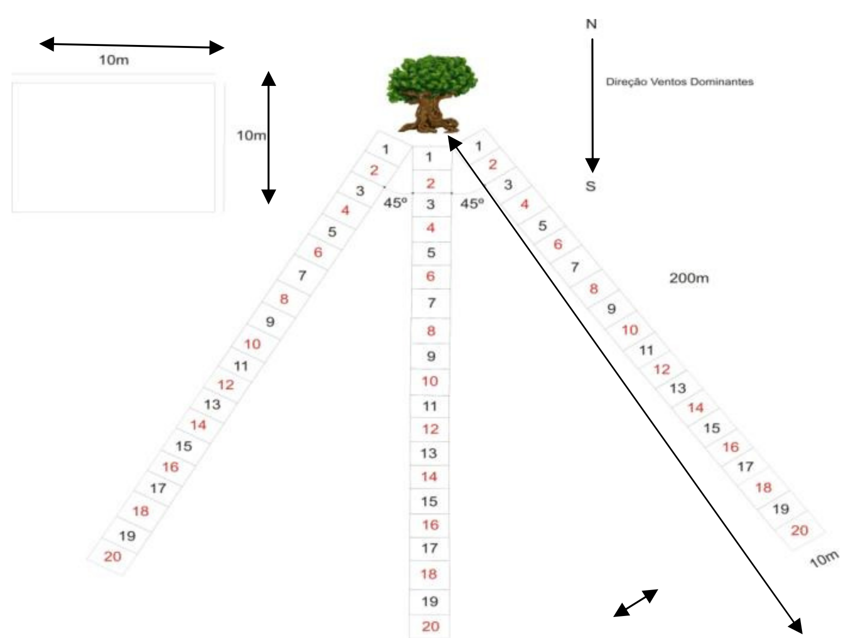
b) Five trees selected for harvesting where silvicultural treatment of canopy opening was conducted (Openings of at least 1,000 m^2) + taboca cutting;

c) Five remaining trees where silvicultural treatment of canopy openings were carried out (Openings of at least 1,000 m^2);

d) Five trees selected for harvesting, but without silvicultural treatment.

Three parcels of 10 m x 200 m were established in each of 20 selected trees. The parcels were long and narrow (10 m x 200 m), established in three directions, according to the direction of prevailing winds, in which two parcels of the end of each tree were placed from an angle of 45° starting from parcel located on the central axis of each tree. The central parcel starts at the base of tree (Figure 30).

Figure 30 Parcels of diagnosis of regeneration induction



3.3.4.4 Step 1 - Data Collection

Data were collected following the guidelines of this project, respecting its implementation phases, the first data collection was made before logging and second data collection will be made after logging.

Each parcel was divided into 20 sub-parcels of 10 m x 10 m to facilitate monitoring. In this parcel, all mahogany individuals with 2.4 cm ≤ DBH <10 cm were measured and tagged.

In even sub-parcels all mahogany individuals were counted, from seedlings to saplings with DBH <5.0 cm. To facilitate the location of seedlings in the subsequent measurements wooden stakes of approximately 50 cm tall were fixed next to each seedling (Figure 31).

Figure 31 Identification of mahogany seedlings in sub-parcels

Data were collected in 60 sampling parcels of natural regeneration of mahogany (10 m x 200 m) in twenty selected mahogany trees in the area. The circumference and height of mahogany individuals were measured in 600 sub-parcels of even numbers measuring 10 m x 10 m.

In these even sub-parcels seedlings from 30 cm of height to DBH 2.5 cm were measured. Also, in the same even sub-parcels, saplings with 2.5 cm <DBH ≤ 4.9 cm and young trees with 5.0 cm ≤ DBH ≤ 9.9 cm were measured.

Mahogany individuals with DBH ≥ 10 cm were considered trees in this survey; therefore, they were not included in the measurement of these regeneration parcels.

In addition, a survey (counting) of individuals in seedlings class smaller than 30 cm tall (newly germinated seedlings) was conducted.

The technical team was composed of 3 (three) forest engineers (UFRA graduate students), 10 (ten) local field workers were hired in the region, and 1 (one) forest technician sent by the Batisflor Company to assist in the field activities.

With the establishment of parcels in 20 selected mahogany trees in the area, a total of 60 parcels of 10 m x 200 m were obtained, which were subdivided into 1,200 sub-parcels of 10 m x 10 m.

In even sub-parcels, a survey of individuals according to aforementioned description was carried out, that is, plantlets, seedlings, saplings, young trees and trees, totaling 600 sub-parcels inventoried with these individuals.

In selected trees, the parcels were arranged in a wedge shape, a numbering was assigned in each tree and for parcels ranging from 1 to 3, from left to right of trails, based on the parcel that was located on the central axis of mahogany tree, receiving the numbering 2 in all trees.

The numbering from 1 to 20 of the sub-parcels of 10 m x 10 m was made on picket posts to limit the boundaries between sub-parcels of 10 m x 10 m inside of a parcel of 10 m x 200 m.

During the field survey, the following variables were collected: number of seedling count, diameter of mahogany seedlings with a caliper graduated in millimeters, and seedlings height using a centimeter ruler (Figure 32). Data were recorded on a field spreadsheet where seedling counting of *Swietenia macrophylla* King was registered, as well as observations concerning forest type, incidence of sunlight and the existence of tabocal in the area.

Figure 32 Measurement of diameter and height of a mahogany seedling within a 10 m x 10 m sub-parcel

The seedlings received aluminum tags that were fixed with nails in picket posts next to each seedling for easy identification within the sub-parcels.

4 RESULTS AND DISCUSSION

4.1 100% FOREST INVENTORY (CENSUS)

4.1.1 Distribution of Trees Surveyed at 100% Forest Inventory in Relation to Hydrographic Network in the Area

The forest inventory at 100% (census) surveyed all trees with minimum CAP equal to 100 cm for the species, except mahogany trees that were inventoried individuals with DBH ≥ 20 cm.

Thus, the first product was a preparation of map with the location of all trees in relation to the hydrographic network of the UPA-1R project area, shown in Figure 33. This mapping served as the basis for infrastructure planning, such as roads, forest trails and wood yards, as well as other forest operations activities.

Figure 33 Distribution of all species inventoried to 100% in relation to the hydrographic network of the project area

Figure 33 shows the areas with large concentration of individuals, while there are also areas where the intensity of trees occurrence is lower. In the areas of low occurrence, the occurrence of bamboos *Gadua* sp. is predominant; areas with high degree of bamboo or tabocas are known as Tabocal. Although there are adult mahogany trees in these areas, the occurrence is much lower compared to open areas, and the degree of dominance of bamboos is less, forming patches of occurrence of mahogany.

Another fact shown in Figure 33 is that the area of low trees concentration coincides with the area that presents high density of river network, unlike the high occurrence of individuals of mahogany that takes place in areas of low hydrographic density, but in ondulated topography with accentuated relief.

4.1.2 Distribution of Mahogany Trees in Relation to the Hydrographic Network and Topography of the Project Area

Figure 34 shows the distribution of mahogany trees only in relation to the hydrographic network of the inventoried area. This figure shows that mahogany trees tend to occur along the natural drainage area. This fact was also reported by other authors, Lamb (1966), Barros et al, (1992), Baima (2001), among others.

In UPA-1R with an area of 1,652.4 ha, 110 adult mahogany trees with DBH ≥ 20 cm were surveyed. Given their location in UPA-1R (Figure 34) and taking into consideration the permanent preservation areas and seasonal streams, mahogany trees were classified into three categories: (a) trees for harvesting, with 45 individuals; (b) trees kept for future harvesting, with 21 individuals; and (c) trees reserved as mother trees with 44 trees.

Figure 35 shows the distribution of mahogany individuals in relation to the hydrographic network and also in relation to the topography of the area. Thus, patches with high density of trees are determined not only by the drainage network of the area, but also mainly by ondulated topography; that is, high or low density of mahogany individuals in patches that are formed in the area is directly influenced by these two factors, the hydrographic network and rugged topography, which constitutes the characteristics of open ombrophyla forest with high intensity of sunlight reaching the forest ground.

Considering that the area of UPA-1R was divided into 19 Working Units (UT), and that management of forests with the occurrence of mahogany is regulated by MMA/IBAMA IN N° 7, the occurrence of mahogany trees with minimum cutting diameter (DBH ≥ 60 cm) is considered rare when occurs up to 5 trees of mahogany per UT, which occurs outside the permanent preservation area. For this reason, 110 mahogany trees (Figure 34) were classified according to four categories: i) harvesting; ii) future harvesting; iii) mother trees; and iv) rare trees (Table 4).

Table 4 Distribution of mahogany individuals by category

Distribution	Harvesting	Future harvest	Mother tree	Rare tree	Total
Number of trees	45	16	39	10	110
%	41	15	35	9	100

To comply with IN 07/2003 that sets out that five trees in each UT should be kept and only trees that exceed five individuals in each UT can be harvested. Thus, the classification of trees into four categories considering rare trees resulted in the data presented in Table 5.

Table 5 Number of trees, basal area and volume of mahogany trees with DBH ≥ 60 cm in UPA-1R

Variables	Harvesting	%	Remaining	%	Total	%
Number of trees	45	41	65	59	110	100
G (m²/ha)	0.049	61	0.031	39	0.080	100
V (m²/ha)	1120.182	61	702.046	39	1822.228	100

The logging operation of the area, will keep remaining stock in the area, 59% of mahogany trees with DBH ≥ 20 cm, corresponding to 39% of basal area and volume, respectively, contrary to the procedures before IN 07/2003, where an unplanned logging used to take place with the removal of 90% to 95% of existing trees in logged areas, including trees with DBH ≥ 45 cm.

Logging under sustainable forest management, according to current legal requirements, ensures the maintenance of approximately 60% of the stocks of remaining trees, but 40% of trees to be harvested represents a considerable volume, with more that 1,000 m³ of standing timber.

It is possible to obtain this volume because the management area provide a stock of trees selected for harvesting with DBH ranging from 60 cm to 180 cm, with an average volume of 25 m³ per tree.

Given the difficulties of conducting logging operations in open ombrophyla forest, considering rugged topography and clay soils that hinder the use of machineries, it is recommended to conduct economic feasibility study of species to be logged, according to the current legislation. Thus, it can be inferred that harvesting of only mahogany species without harvesting other species of lesser commercial value, the logging may not be economically viable.

In this case, even if it is premature, it is recommended to verify the possibility in future studies to include trees that remain in the area within UT in the quota of rare trees, but those trees located in permanent preservation areas.

Figure 34 Distribution of mahogany trees classified by categories in relation to the hydrographic network of UPA-1R area

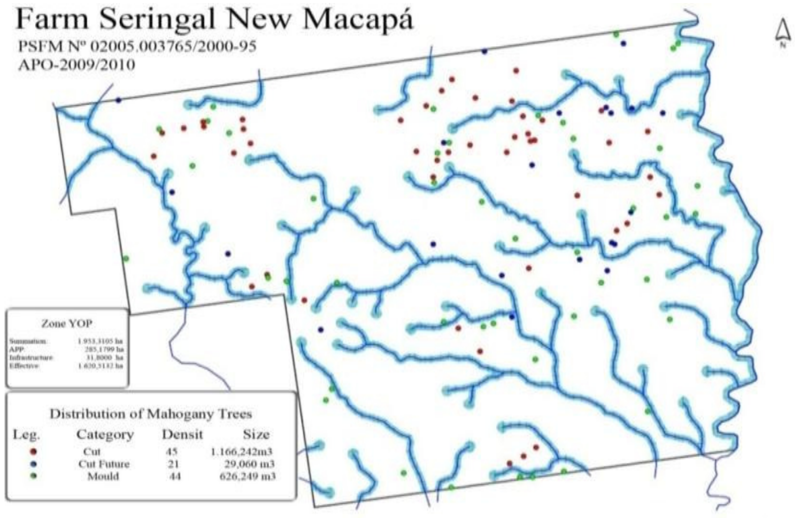
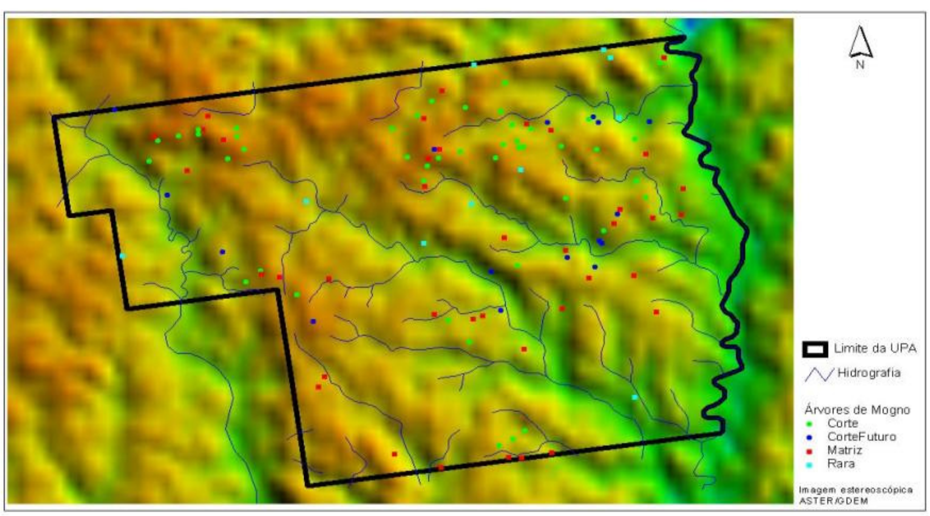


Figure 35 Distribution of mahogany trees in relation to the hydrographic network and topography of UPA-1R area



4.1.3 Floristic Composition of UPA-1R Area for Individuals Inventoried

The floristic composition of the tree stratum with mahogany trees with DBH ≥ 60 cm and ≥ CAP 100 cm of other species in the UPA-1R area consists of 8,333 individuals distributed among 76 genera, 85 species, 31 families and 2 individuals not identified (Table 6).

Table 6 List of floristic composition of tree stratum with mahogany trees with DBH ≥ 60 cm and CAP ≥ 100 cm of other species in UPA-1R area

Species	*Scientific Name*	*Family*
ABIU	*Pouteria sp*	Sapotaceae
ABIURANA	*Pouteria guianensis Aubl.*	Sapotaceae
AGUANO QUEROZENE	*Enterolobium sp.*	Mimosaceae
AMARELAO	*Euxylophora paraensis Huber*	Rutaceae
AMENDOIM TORRADO	*Pterogyne nitens Tul*	Leguminosae-Caesalpinioideae
AMESCLA	*Protium robustum (Sw.) D.M. Porter*	Burseraceae
AMOREIRA	*Maclura tinctoria (L.) D.Don ex Steud.*	Moraceae
ANDIROBA	*Carapa guianensis Aubl.*	Meliaceae
ANGELCA	*Guettarda argentea Lam*	Rubiaceae
ANGELIM AMARGOSO	*Vatairea sericea Ducke*	Leguminosae-Papilionoideae
ANGELIM/ANGICO	*Anadenanthera sp*	Leguminosae-Mimosoideae
BANDARRA	*Parkia paraensis Ducke*	Leguminosae-Mimosoideae
BRANQUILHO/CINZEIRO	*Terminalia tanibouca Rich*	Combretaceae
CABREUVA	*Myroxylon balsamum (L.) Harms*	Leguminosae-Papilionoideae
CAIXETA/MARUPA	*Simarouba amara Aubl.*	Simarubaceae
CAMBARA ROSA	*Erisma uncinatum Warm.*	Vochysiaceae
CANELA	*Ocotea spp*	Lauraceae
CARIPE	*Licania heteromorpha*	Chrysobalanaceae
CAROBA	*Jacaranda copaia (Aubl.) D. Don*	Bignoniaceae
CARRAPATEIRO	*Metrodorea stipularis. Mart*	Rutaceae
CASTANHA DE ARARA	*Joannesia heveoides Ducke*	Euphorbiaceae
CASTANHEIRA DO BRASIL	*Bertholletia excelsa Humb. & Bonpl.*	Lecythidaceae
CATUABA	*Qualea sp*	Vochysiaceae
CAUCHO	*Castilloa ulei Warb*	Moraceae
CEDRO CAJA	*Ni*	ni
CEDRO ROSA	*Cedrela odorata L.*	Meliaceae
CEREJEIRA	*Amburana acreana (Ducke) A.C.Sm.*	Leguminosae-Papilionoideae
CHICHA	*Sterculia pilosa Ducke*	Sterculiaceae
CINZEIRO PRETO	*Coussarea contracta*	Rubiaceae.
COPAIBA	*Copaifera sp*	Leguminosae-Caesalpinioideae
CUMARU	*Dipteryx odorata (Aubl.) Willd.*	Leguminosae-Papilionoideae
CURUPIXÁ	*Parahancornia amapa (Huber) Ducke*	Apocynaceae
EMBIRUCU	*Eriotheca longipedicellata (Ducke) A.*	Bombacaceae
ESPETEIRO	*Eperna falcata*	Leguminosae- Caesalpinioideae

Species	***Scientific Name***	***Family***
FARINHA SECA	*Albizia hasslerii (Chodat) Burkart*	Leguminosae-Mimosoideae
FAVEIRA	*Vataireopsis sp*	Leguminosae- Papilionoideae
FIGUEIRA BRANCA	*Ficus sp*	Moraceae
FREIJO	*Cordia goeldiana Huber*	Boraginaceae
GARAPEIRA	*Apuleia molaris Spruce ex Benth.*	Leguminosae-Caesalpinioideae
IPE	*Tabebuia spp*	Bignoniaceae
ITAUBA	*Mezilaurus itauba (Meisn.) Taub. Ex M*	Lauraceae
JATOBA	*Hymenaea coubaril L.*	Leguminosae-Caesalpinioideae
JEQUITIBA	*Cariniana micrantha Ducke*	Lecythidaceae
JITO/CEDRO MARINHEIRO	*Guarea macrophylla Vahl*	Meliaceae
LARANJINHA	*Guatteria citriodora Ducke*	Annonaceae
LEITEIRO	*Brosimum guianense (Aubl.) Huber*	Moraceae
LIMAOZINHO	*Randia arMata*	Rubiaceae
MACACAUBA	*Platymiscium sp*	Leguminosae-Papilionoideae
MANDIOCAO/MOROTOTO	*Schefflera morototoni (Aubl). Decne.*	Araliaceae
MARACATIARA	*Astronium lecointei Ducke*	Anacardiaceae
MARFIM/AZEITONA	*Agonandra sp*	Opileaceae
MAÇARANDUBA	*Manilkara huberi (Ducke) Chevalier*	Sapotaceae
MATAMATA	*Eschweilera grandiflora (Aubl.) Sandw*	Lecythidaceae
MIRINDIBA	*Terminalia amazonica (J.F.Gmel) Exell.*	Combretaceae
MAHOGANY	*Swietenia macrophylla King.*	Meliaceae
MULATEIRO	*Calycophyllum spruceanum Benth*	Rubiaceae
NAO IDENTIFICADA	*NI*	NI
OITICICA	*Clarisia racemosa Ruiz & Pav.*	Moraceae
PAINEIRA	*Chorisia sp*	Bombacaceae
PAMA	*Perebea mollis (Poepp. & Engl.) Huber*	Moraceae
PARAJU	*Manilkara sp*	Sapotaceae
PARIRI/FRUTAO	*Pouteria pariry (Ducke) Baehni*	Sapotaceae
PAU DE BALÇA	*Ochroma pyramidale (Cav. ex Lam.) Urb.*	Bombacaceae
PAU-ARARA	*Parkia sp*	Leguminosae-Mimosoideae
PEROBA AMAZONAS/PEROBA	*Aspidosperma pachypterum Müll.Arg*	Apocynaceae
PEROBA MICO	*Aspidosperma album (Vahl) R.Benoist e*	Apocynaceae
PEROBA ROSA	*Aspisdosperma polyneuron Müll. Arg.*	Apocynaceae
PIACA/ENVIRA	*Xylopia sp*	Annonaceae
PINHO CUIABANO	*Schizolobium amazonicum (Huber) Ducke*	Leguminosae-Caesalpinioideae
PINHO DO NORTE	*Hura crepitans L.*	Euphorbiaceae
PIQUIA	*Caryocar vilosum (Aubl.) Pers.*	Caricaraceae
SAPUCAIA	*Lecythis pisonis Cambess.*	Lecythidaceae
SERINGUEIRA	*Hevea brasiliensis Müll.Arg.*	Euphorbiaceae

Species	*Scientific Name*	*Family*
SORVEIRA	*Couma guianensis Aubl.*	Apocynaceae
SUCUPIRA	*Bowdichia nitida Spruce*	Leguminosae-Papilionoideae
SUMAUMA	*Ceiba pentandra (L.) Gaertn.*	Bombacaceae
TAUARI	*Couratari guianensis Aubl*	Lecythidaceae
TIMBURI	*Enterolobium maximum Ducke*	Leguminosae-Mimosoideae
TUCUPI DE ARARA	*Parkia decussata*	Leguminosae
UCUUBA	*Virola spp*	Myristicaceae
VIROLA	*Virola spp*	Myristicaceae

4.1.4 Phytosociological Structure of the UPA-1R Area Population

4.1.4.1 Number of sample units with the occurrence of species

Table 7 shows that among 84 species, only 14 (16%) species occurred in a single sample unit of a total of 195 units of 10 hectares each; all other species occurred in two or more sampling units. This shows that species are well distributed throughout the area, providing a good regeneration capable to support a forest succession in the project area. This distribution of species throughout the area could be because of high sunlight due to the characteristic of open ombrophyla forest, indicating the importance of microhabitats in the area.

In particular, mahogany species occurred in 110 (56%) of sample units of 10 ha, totaling 195 units in the area that was subdivided. This distribution in more than 50% of sample units also shows that despite mahogany species are distributed forming groups of individuals, within these groups individuals are distributed randomly, allowing the dissemination of their seeds in large areas.

Table 7 Number of sample units and species

#	*Species*	*Species Occurrence SU Number*	*#*	*Species*	*Species Occurrence SU Number*
1	**ABIU**	10	***43***	**JEQUITIBA**	23
2	**ABIURANA**	28	***44***	**JITO/CEDRO MARINHEIRO**	3
3	**AGUANO QUEROZENE**	122	***45***	**LARANJINHA**	1
4	**AMARELAO**	85	***46***	**LEITEIRO**	110
5	**AMENDOIM TORRADO**	3	***47***	**LIMAOZINHO**	1
6	**AMESCLA**	1	***48***	**MACACAUBA**	7
7	**AMOREIRA**	2	***49***	**MANDIOCAO/MOROTOTO**	4
8	**ANDIROBA**	1	***50***	**MARACATIARA**	142
9	**ANGELCA**	1	***51***	**MARFIM/AZEITONA**	105
10	**ANGELIM AMARGOSO**	30	***52***	**MASSARANDUBA**	25
11	**ANGELIM/ANGICO**	41	***53***	**MATAMATA**	71

12	**BANDARRA**	161	*54*	**MIRINDIBA**	32
13	**BRANQUILHO/CINZEIRO**	113	*55*	**MOGNO**	70
14	**CABREUVA**	119	*56*	**MULATEIRO**	34
15	**CAIXETA/MARUPA**	35	*57*	**NAO IDENTIFICADA**	7
16	**CAMBARA ROSA**	1	*58*	**OITICICA**	98
17	**CANELA**	65	*59*	**PAINEIRA**	1
18	**CARIPE**	1	*60*	**PAMA**	1
19	**CAROBA**	26	*61*	**PARAJU**	98
20	**CARRAPATEIRO**	1	*62*	**PARIRI/FRUTAO**	18
21	**CASTANHA DE ARARA**	6	*63*	**PAU DE BALÇA**	1
22	**CASTAN. DO BRASIL**	16	*64*	**PAU-ARARA**	38
23	**CATUABA**	39	*65*	**AMAZONAS/PEROBA**	1
24	**CAUCHO**	157	*66*	**PEROBA MICO**	5
25	**CEDRO CAJA**	23	*67*	**PEROBA ROSA**	1
26	**CEDRO ROSA**	134	*68*	**PIACA/ENVIRA**	3
27	**CEREJEIRA**	128	*69*	**PINHO CUIABANO**	128
28	**CHICHA**	42	*70*	**PINHO DO NORTE**	161
29	**CINZEIRO PRETO**	1	*71*	**PIQUIA**	115
30	**COPAIBA**	98	*72*	**QUARIQUARA**	1
31	**CUMARU**	153	*73*	**QUARUBA/CEDRILHO**	2
32	**CURUPIXÁ**	29	*74*	**SAPUCAIA**	26
33	**EMBIRUCU**	94	*75*	**SERINGUEIRA**	144
34	**ESPETEIRO**	40	*76*	**SORVEIRA**	49
35	**FARINHA SECA**	105	*77*	**SUCUPIRA**	29
36	**FAVEIRA**	19	*78*	**SUMAUMA**	84
37	**FIGUEIRA BRANCA**	87	*79*	**TAMARINDO**	94
38	**FREIJO**	61	*80*	**TAUARI**	13
39	**GARAPEIRA**	158	*81*	**TIMBURI**	2
40	**IPE**	38	*82*	**TUCUPI DE ARARA**	1
41	**ITAUBA**	54	*83*	**UCUUBA**	40
42	**JATOBA**	139	*84*	**VIROLA**	5

Note: SU = Sampling Unit

4.1.4.2 Abundance, Dominance and Frequency of Species

To complement the phytosociological structure analysis of the area, Table 8 presents data on abundance, dominance, frequency and importance value index of sampled species.

The absolute abundance data (Aabs) shows that several species are classified as "rare species" which according to the current legislation (IN 07/2003) is considered rare a species with Aabs = 0.03 trees/ha for each UT. Thus, it is possible that SFMP of the area does not take into consideration the species that although they are of commercial interest, they cannot be considered in the volume to be logged.

The horizontal structure of the inventoried area, expressed through the parameters of Abundance, Dominance, Frequency and forest Cover Value Index (CVI = Arel + Drel) and Importance Value Index (IVI = Arel + Drel + Frel) of species are presented in Table 8, which lists the species in decreasing order of values of IVI.

Considering the 26 most important species in the area, those species that present IVI up to 5.0%, these species correspond to 30% of the total species inventoried.

Table 8 Parameters of phytosociological structure for the species inventoried to 100% in UPA-1R area

Common Name	*Nºind.*	*Aabs (Nºind/ha)*	*Arel (%)*	*Dabs (m²/ha)*	*Drel (%)*	*Fabs (%)*	*Frel (%)*	*IVC (%)*	*IVI (%)*
PINHO DO NORTE	544	0,272	6,5283	3,1992	14,3821	161	3,778456	20,91	24,69
CUMARU	357	0,1785	4,2842	1,6707	7,510697	153	3,590706	11,79	15,39
GARAPEIRA	403	0,2015	4,8362	1,4895	6,696182	158	3,70805	11,53	15,24
BANDARRA	421	0,2105	5,0522	1,105	4,96748	161	3,778456	10,02	13,8
CAUCHO	451	0,2255	5,4122	0,7921	3,560688	157	3,684581	8,97	12,66
SERINGUEIRA	368	0,184	4,4162	0,7846	3,527038	144	3,379488	7,94	11,32
JATOBA	279	0,1395	3,3481	0,7582	3,408286	139	3,262145	6,76	10,02
SUMAUMA	133	0,0665	1,5961	1,2688	5,704083	84	1,971368	7,3	9,27
PINHO CUIABANO	327	0,1635	3,9242	0,4847	2,179119	128	3,00399	6,1	9,11
CEDRO ROSA	261	0,1305	3,1321	0,4844	2,177632	134	3,144802	5,31	8,45
MARACATIARA	266	0,133	3,1921	0,4032	1,812693	142	3,332551	5	8,34
CEREJEIRA	240	0,12	2,8801	0,527	2,369277	128	3,00399	5,25	8,25
PIQUIA	232	0,116	2,7841	0,5593	2,514428	115	2,698897	5,3	8
EMBIRUCU	254	0,127	3,0481	0,55	2,472436	94	2,206055	5,52	7,73
BRANQUILHO/CINZEIRO	244	0,122	2,9281	0,4649	2,08998	113	2,65196	5,02	7,67
AGUANO QUEROZENE	221	0,1105	2,6521	0,3868	1,739035	122	2,863178	4,39	7,25
CABREUVA	216	0,108	2,5921	0,2804	1,260491	119	2,792772	3,85	6,65
COPAIBA	143	0,0715	1,7161	0,5688	2,556961	98	2,29993	4,27	6,57
MARFIM/AZEITONA	193	0,0965	2,3161	0,3977	1,787718	105	2,46421	4,1	6,57
OITICICA	204	0,102	2,4481	0,3859	1,734709	98	2,29993	4,18	6,48
LEITEIRO	209	0,1045	2,5081	0,2666	1,198601	110	2,581554	3,71	6,29
FIGUEIRA BRANCA	129	0,0645	1,5481	0,5224	2,34831	87	2,041774	3,9	5,94
MAHOGANY	110	0,055	1,3201	0,647	2,908585	70	1,642807	4,23	5,87
PARAJU	147	0,0735	1,7641	0,3601	1,618714	98	2,29993	3,38	5,68
MATA-MATA	151	0,0755	1,8121	0,361	1,622778	71	1,666276	3,43	5,1
TAMARINDO	143	0,0715	1,7161	0,2099	0,943457	94	2,206055	2,66	4,87
FREIJO	92	0,046	1,104	0,0871	0,391421	61	1,431589	1,5	2,93
SORVEIRA	78	0,039	0,936	0,1404	0,631081	49	1,149965	1,57	2,72
ITAUBA	75	0,0375	0,9	0,0889	0,399617	54	1,267308	1,3	2,57
CHICHA	67	0,0335	0,804	0,1368	0,615027	42	0,985684	1,42	2,4
PAU-ARARA	60	0,03	0,72	0,1485	0,667798	38	0,891809	1,39	2,28
UCUUBA	75	0,0375	0,9	0,0884	0,397552	40	0,938747	1,3	2,24
CATUABA	50	0,025	0,6	0,1112	0,500076	39	0,915278	1,1	2,02
ANGELIM/ANGICO	54	0,027	0,648	0,086	0,386811	41	0,962215	1,03	2
CURUPIXÁ	39	0,0195	0,468	0,1843	0,828418	29	0,680591	1,3	1,98
MULATEIRO	43	0,0215	0,516	0,139	0,624685	34	0,797935	1,14	1,94
CASTANH. DO BRASIL	39	0,0195	0,468	0,242	1,087883	16	0,375499	1,56	1,93
ESPETEIRO	45	0,0225	0,54	0,0548	0,246183	40	0,938747	0,79	1,72
MIRINDIBA	35	0,0175	0,42	0,1218	0,547556	32	0,750997	0,97	1,72

IPE	42	0,021	0,504	0,0567	0,254929	38	0,891809	0,76	1,65
CAIXETA/MARUPA	43	0,0215	0,516	0,0694	0,312153	35	0,821403	0,83	1,65
SUCUPIRA	40	0,02	0,48	0,0748	0,336387	29	0,680591	0,82	1,5
ABIURANA	43	0,0215	0,516	0,0685	0,308097	28	0,657123	0,82	1,48
ANGELIM AMARGOSO	39	0,0195	0,468	0,0475	0,213653	30	0,70406	0,68	1,39
JEQUITIBA	25	0,0125	0,3	0,1103	0,495914	23	0,539779	0,8	1,34
SAPUCAIA	31	0,0155	0,372	0,0749	0,336518	26	0,610185	0,71	1,32
FAVEIRA	32	0,016	0,384	0,107	0,481179	19	0,445905	0,87	1,31
CAROBA	34	0,017	0,408	0,0523	0,235061	26	0,610185	0,64	1,25
MASSARANDUBA	29	0,0145	0,348	0,0704	0,316562	25	0,586717	0,66	1,25
CEDRO CAJA	25	0,0125	0,3	0,061	0,274196	23	0,539779	0,57	1,11
PARIRI/FRUTAO	19	0,0095	0,228	0,802166	0,180308	18	0,422436	0,40832	0,83075
TAUARI	19	0,0095	0,228	1,152888	0,259142	13	0,305093	0,48715	0,79224
ABIU	10	0,005	0,12	0,460009	0,103399	10	0,234687	0,2234	0,45809
NAO IDENTIFICADA	8	0,004	0,096	0,500739	0,112554	7	0,164281	0,20856	0,37284
CASTANHA DE ARARA	9	0,0045	0,108	0,415114	0,093308	6	0,140812	0,20131	0,34212
PEROBA MICO	9	0,0045	0,108	0,333782	0,075026	5	0,117343	0,18303	0,30037
MACACAUBA	7	0,0035	0,084	0,197374	0,044365	7	0,164281	0,12837	0,29265
VIROLA	6	0,003	0,072	0,202931	0,045614	5	0,117343	0,11762	0,23496
MANDIOCAO/MOROTOTO	4	0,002	0,048	0,075514	0,016974	4	0,093875	0,06498	0,15885
PIACA/ENVIRA	4	0,002	0,048	0,105087	0,023621	3	0,070406	0,07162	0,14203
AMENDOIM TORRADO	3	0,0015	0,036	0,15632	0,035137	3	0,070406	0,07114	0,14154
JITO/CEDRO MARINHEIRO	3	0,0015	0,036	0,10602	0,023831	3	0,070406	0,05983	0,13024
TIMBURI	2	0,001	0,024	0,153604	0,034526	2	0,046937	0,05853	0,10547
QUARUBA/CEDRILHO	2	0,001	0,024	0,07531	0,016928	2	0,046937	0,04093	0,08787
AMOREIRA	2	0,001	0,024	0,07298	0,016404	2	0,046937	0,04041	0,08734
TUCUPI DE ARARA	2	0,001	0,024	0,17665	0,039707	1	0,023469	0,06371	0,08718
PAU DE BALÇA	2	0,001	0,024	0,073202	0,016454	1	0,023469	0,04046	0,06392
PEROBA ROSA	1	0,0005	0,012	0,124161	0,027908	1	0,023469	0,03991	0,06338
PAINEIRA	1	0,0005	0,012	0,122282	0,027486	1	0,023469	0,03949	0,06296
PEROBA AMAZONAS/PEROBA	1	0,0005	0,012	0,096926	0,021787	1	0,023469	0,03379	0,05726
LIMAOZINHO	1	0,0005	0,012	0,081487	0,018316	1	0,023469	0,03032	0,05379
CARRAPATEIRO	1	0,0005	0,012	0,072578	0,016314	1	0,023469	0,02831	0,05178
ANDIROBA	1	0,0005	0,012	0,067851	0,015251	1	0,023469	0,02725	0,05072
CAMBARA ROSA	1	0,0005	0,012	0,05256	0,011814	1	0,023469	0,02382	0,04728
CARIPE	1	0,0005	0,012	0,050135	0,011269	1	0,023469	0,02327	0,04674
ANGELCA	1	0,0005	0,012	0,048943	0,011001	1	0,023469	0,023	0,04647
AMESCLA	1	0,0005	0,012	0,039219	0,008815	1	0,023469	0,02082	0,04429
QUARIQUARA	1	0,0005	0,012	0,024093	0,005416	1	0,023469	0,01742	0,04089
CINZEIRO PRETO	1	0,0005	0,012	0,023542	0,005292	1	0,023469	0,01729	0,04076
LARANJINHA	1	0,0005	0,012	0,021403	0,004811	1	0,023469	0,01681	0,04028
PAMA	1	0,0005	0,012	0,014719	0,003308	1	0,023469	0,01531	0,03878
Total	**8333**	**41,665**	**1,000,000**	**222,443**	**1,000,000**	**4261**	**100**	**200**	**300**

4.1.4.3 Pattern of spatial distribution of species in UPA-1R area

Another important aspect in the analysis of the phytosociological structure of the area is the way in which species are distributed spatially in the area. Thus, the dispersion of species was determined by the Morisita Index of Aggregation, as shown in Table.

Therefore, with 37 species of uniform or regular pattern (44%), 19 species with random pattern (22.6%) and 28 species being distributed in a gregarious form (33.4%), despite featuring an ecological structure of an area of primary rainforest, the typology is open ombrophyla forest, with 44% of the species presenting regular or uniform pattern; a large number of publications are found in the literature mentioning the works in Malaysia, Panama, Costa Rica and the Brazilian Amazon (Pires *et al* 1953; Barros, 1985; Barros, 1996, among others) show that in tropical forests, tree species are distributed mainly by gregarious or random patterns, rather than regular or uniform distributions, as the hypothesis of predators specific to the species.

Considering the distribution across the UPA-1R (1,953.31 ha) area, mahogany presented a gregarious pattern, that is, the occurrence of species patches in the inventoried area. However, the graphical analyses of spatial distribution of the species (Figure 36) in these patches, individuals are randomly distributed.

Table 9 Distribution of species pattern according to Morisita Index (MI)

#	*Common Name*	*Scientific Name*	*MI*	*Distribution Pattern*
1	ABIU	*Pouteria* sp	0,013	Uniform
2	ABIURANA	*Pouteria guianensis* Aubl.	0,261	Random
3	AGUANO QUEROZENE	*Enterolobium* sp.	7,015	Gregarious
4	AMARELAO	*Euxylophora paraensis* Huber	2,808	Gregarious
5	AMENDOIM TORRADO	*Pterogyne nitens* Tul	0,001	Uniform
6	AMESCLA	*Protium robustum* (Sw.) D.M. Porter	0	Uniform
7	AMOREIRA	*Maclura tinctoria* (L.) D.Don ex Steud.	0	Uniform
8	ANDIROBA	*Carapa guianensis* Aubl.	0	Uniform
9	ANGELCA	*Guettarda argentea* Lam	0	Uniform
10	ANGELIM AMARGOSO	*Vatairea sericea* Ducke	0,214	Random
11	ANGELIM/ANGICO	*Anadenanthera* sp	0,413	Random
12	BANDARRA	*Parkia paraensis* Ducke	25,513	Gregarious
13	BRANQUILHO/CINZEIRO	*Terminalia tanibouca* Rich	8,555	Gregarious
14	CABREUVA	*Myroxylon balsamum* (L.) Harms	6,701	Gregarious
15	CAIXETA/MARUPA	*Simarouba amara* Aubl.	0,261	Random
16	CAMBARA ROSA	*Erisma uncinatum* Warm.	0	Uniform
17	CANELA	*Ocotea* spp	1,316	Random
18	CARIPE	*Licania heteromorpha*	0	Uniform
19	CAROBA	*Jacaranda copaia* (Aubl.) D. Don	0,162	Uniform
20	CARRAPATEIRO	*Metrodorea stipularis* Mart.	0	Uniform
21	CASTANHA DE ARARA	*Joannesia heveoides* Ducke	0,01	Uniform
22	CASTANHEIRA DO BRASIL	*Bertholletia excelsa* Humb. & Bonpl.	0,214	Random
23	CATUABA	*Qualea* sp	0,354	Random
24	CAUCHO	*Castilloa ulei* Warb	29,283	Gregarious
25	CEDRO CAJA	ni	0,087	Uniform
26	CEDRO ROSA	*Cedrela odorata* L.	9,791	Gregarious
27	CEREJEIRA	*Amburana acreana* (Ducke) A.C.Sm.	8,276	Gregarious
28	CHICHA	*Sterculia pilosa* Ducke	0,638	Random
29	CINZEIRO PRETO	*Coussarea contracta*	0	Uniform
30	COPAIBA	*Copaifera* sp	2,93	Gregarious

				Distribution
31	CUMARU	*Dipteryx odorata* (Aubl.) Willd.	18,338	Gregarious
32	CURUPIXÁ	*Parahancornia amapa* (Huber) Ducke	0,214	Random
33	EMBIRUCU	*Eriotheca longipedicellata* (Ducke) A.	9,272	Gregarious
34	ESPETEIRO	*Eperna falcata*	0,286	Random
35	FARINHA SECA	*Albizia hasslerii* (Chodat) Burkart	5,236	Gregarious
36	FAVEIRA	*Vataireopsis* sp	0,143	Uniform
37	FIGUEIRA BRANCA	*Ficus* sp	2,382	Gregarious
38	FREIJO	*Cordia goeldiana* Huber	1,208	Random
39	GARAPEIRA	*Apuleia molaris* Spruce ex Benth.	23,376	Agregated
40	IPE	*Tabebuia* spp	0,248	Random
41	ITAUBA	*Mezilaurus itauba* (Meisn.) Taub. Ex M	0,801	Random
42	JATOBA	*Hymenaea coubaril* L.	11,191	Gregarious
43	JEQUITIBA	*Cariniana micrantha* Ducke	0,087	Uniform
44	JITO/CEDRO MARINHEIRO	*Guarea macrophylla* Vahl	0,001	Uniform
45	LARANJINHA	*Guatteria citriodora* Ducke	0	Uniform
46	LEITEIRO	*Brosimum guianense* (Aubl.) Huber	6,273	Gregarious
47	LIMAOZINHO	*Randia arMata*	0	Uniform
48	MACACAUBA	*Platymiscium* sp	0,006	Uniform
49	MANDIOCAO/MOROTOTO	*Schefflera morototoni* (Aubl). Decne.	0,002	Uniform
50	MARACATIARA	*Astronium lecointei* Ducke	10,171	Gregarious
51	MARFIM/AZEITONA	*Agonandra* sp	5,347	Gregarious
52	MASSARANDUBA	*Manilkara huberi* (Ducke) Chevalier	0,117	Uniform
53	MATAMATA	*Eschweilera grandiflora* (Aubl.) Sandw	3,268	Gregarious
54	MIRINDIBA	*Terminalia amazonica* (J.F.Gmel) Exell.	0,172	Random
55	MOGNO	*Swietenia macrophylla* King.	1,73	Gregarious
56	MULATEIRO	*Calycophyllum spruceanum* Benth	0,261	Uniform
57	NAO IDENTIFICADA	ni	0,008	Uniform
58	OITICICA	*Clarisia racemosa* Ruiz & Pav.	5,975	Gregarious
59	PAINEIRA	*Chorisia* sp	0	Uniform
60	PAMA	*Perebea mollis* (Poepp. & Engl.) Huber	0	Uniform
61	PARAJU	*Manilkara* sp	3,097	Agregated
62	PARIRI/FRUTAO	*Pouteria pariry* (Ducke) Baehni	0,049	Uniform
63	PAU DE BALÇA	*Ochroma pyramidale* (Cav. ex Lam.) Urb.	0	Uniform
64	PAU-ARARA	*Parkia* sp	0,511	Random
65	PEROBA AMAZONAS/PEROBA	*Aspidosperma pachypterum* Müll.Arg	0	Uniform
66	PEROBA MICO	*Aspidosperma album* (Vahl) R.Benoist e	0,01	Uniform
67	PEROBA ROSA	*Aspisdosperma polyneuron* Müll. Arg.	0	Uniform
68	PIACA/ENVIRA	*Xylopia* sp	0,002	Uniform
69	PINHO CUIABANO	*Schizolobium amazonicum* (Huber) Ducke	15,381	Gregarious
70	PINHO DO NORTE	*Hura crepitans* L.	42,622	Gregarious
71	PIQUIA	*Caryocar vilosum* (Aubl.) Pers.	7,733	Gregarious

				Distribution
72	QUARIQUARA	*Cenostigma tocantinum*	0	Uniform
73	QUARUBA/CEDRILHO	*Vochysia maxima* Ducke	0	Uniform
74	SAPUCAIA	*Lecythis pisonis* Cambess.	0,134	Random
75	SERINGUEIRA	*Hevea brasiliensis* Müll.Arg.	19,487	Agregated
76	SORVEIRA	*Couma guianensis* Aubl.	0,867	Random
77	SUCUPIRA	*Bowdichia nitida* Spruce	0,225	Random
78	SUMAUMA	*Ceiba pentandra* (L.) Gaertn.	2,533	Random
79	TAMARINDO	*Dialium guianense* (Aubl.) Sandwith	2,93	Random
80	TAUARI	*Couratari guianensis* Aubl	0,049	Uniform
81	TIMBURI	*Enterolobium maximum* Ducke	0	Uniform
82	TUCUPI DE ARARA	*Parkia decussata*	0	Uniform
83	UCUUBA	*Virola* spp	0,801	Random
84	VIROLA	*Virola* spp	0,004	Uniform

4.1.4.4 Species diversity in the UPA-1R area

The phytosociological structure concerning the species diversity in the area was determined by the Simpson's and Shannon-Weaver diversity index. Both Simpson's diversity Index (Ds = 0.970) and Shannon-Weaver diversity index (H '= 3.718) confirm the high diversity in the area, as originally foreseen by high floristic richness (n° of species = 84) for the tree stratum considered (Table 23). However, while noticing that some species with large numbers of sampled trees, these trees were not sufficient to characterize a concentration of dominance of this species in the area, as demonstrated by Simpson's concentration Cs = 0.030.

The equitability or uniformity index, in which individuals are distributed among species (Es = 0.031 and J '= 1.935) shown in Table 10, was also high, maintaining phytosociological characteristics typical of tropical forests. This fact shows that the forest of the project area, keep all original features of a typical open ombrophyla forest of the Amazon region, although the forest presents a high degree of bamboo infestation which completely dominate some parts of the project area, reflecting the occurrence of large numbers of shade tolerant and intolerant species living in harmony in this forest area, characterizing a diversity of microenvironments.

Table 10 Measures of phytosociological structure of the area, floristic richness, diversity and equitability

Measures of diversity and equitability		Value
Floristic richness	***# species=***	84
Simpson concentration of dominance	***Cs=***	0,030
Simpson's diversity	***Ds=***	0,97
Simpson maximum diversity	***H'máx=***	0,988
Simpson's equitability or uniformity	***Es=***	0,031
Shannon-Weaver diversity	***H'=***	3,718
Shannon-Weaver equitability or uniformity	***J'=***	1,935
Shannon-Weaver maximum diversity	***H'máx=***	1,919

The value of the Shannon-Weaver index (H') for the tree stratum of target population of the present study was H' = 3.718 nats, a value slightly lower compared to other studies: "The Open Forest with Bamboo in the Southwest Amazon: Patterns and Processes in Multiple Scales" and the "Phytosociological Structure on a Part of Open Ombrophyla Forest Located in the University Campus Jose Ribeiro Filho, Porto Velho - RO ", both conducted studies in open ombrophyla forest. The first study was conducted in the Chico Mendes Reserve, whose forests present a high occurrence of bamboo *Guadua*. The first study is located at 33 km from the capital Rio Branco (Acre state), with a value H '= 4.10 nats, and the second in Porto Velho (Rondonia State), with H' = 3.95 nats. This slight decrease in diversity in the studied areas may be due to the amplitude of the tree stratum considered.

4.1.4.5 Diametric structure

The diametric distribution of the stratum considered in the population, including all species inventoried in the area is shown in Table 11 and Figure 36.

Table 11 Diametric distribution of all species of the population

Class	*Range of class (cm)*	*Number of trees per class*	*Number of trees per ha*
I	30 – 40	164	0,10
II	40 – 50	1082	0,65
III	50 – 60	1431	087
IV	60 – 70	405	0,24
V	70 – 80	1529	0,92
VI	80 – 90	1159	0,70
VII	90 -100	876	0,53
VIII	100 – 110	687	042
IX	> 110	1000	0,60
TOTAL		8333	

Figure 36 Diametric distribution of tree stratum of mahogany trees with DBH ≥ 60 cm and CAP ≥ 100 cm of other species in UPA-1R area

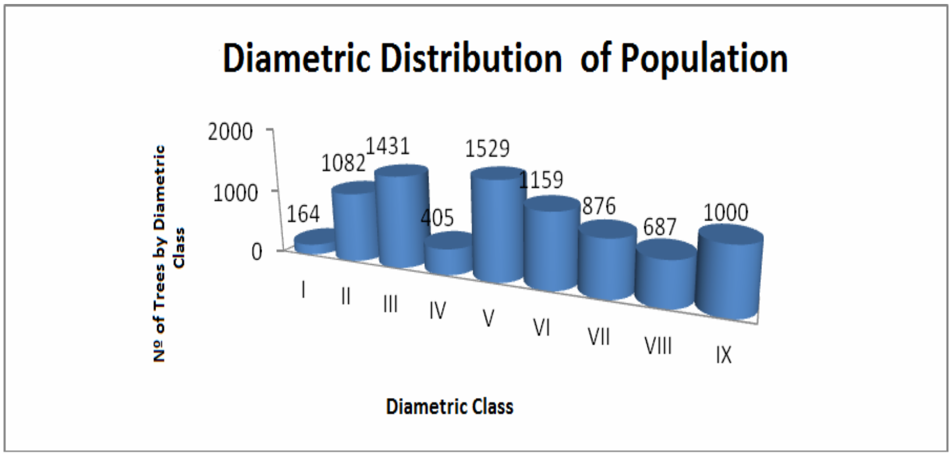


Figure 36 shows that the diametric structure of the tree stratum studied present randomly, that is, a distribution in that the class I (30-40 cm) present only 2% of individuals, while the last class considered, IX (DBH ≥ 110 cm) present 12% of the population of trees stratum considered.

This distribution reflects well the characteristics of typology of open ombrophyla forest, where there is occurrence of large trees, but it presents understory without much occurrence of these individuals, often dominated by lianas (vines) or bamboos, as it is the case of the project area.

Among 43 surveyed species (50%) of them occurred within the largest diametric class, in particular species such as Northern Pine (274 trees), Cumaru (128 trees), Sumaúma (106 trees), Garapeira (97 trees) and mahogany with 86 individuals equivalent to (78%) of 110 trees inventoried in the area with DBH ≥ 60 cm (Table 12).

Table 12 Diametric distribution by species of tree stratum of mahogany trees with DBH ≥ 60 cm and CAP ≥ 100 cm of other species

	Diametric Classes (m)									
	0,3 - 0,4	**0,4 - 0,5**	**0,5 - 0,6**	**0,6 - 0,7**	**0,7 - 0,8**	**0,8 - 0,9**	**0,9 - 1**	**1 - 1,1**	**>1,1**	
Species	**II**	**III**	**IV**	**IX**	**V**	**VI**	**VII**	**VIII**	**X**	**Total**
ABIU		4		1		1	2	2		10
ABIURANA	1	9	12	1	11	6	1	1	1	43
AGUANO QUEROZENE	3	33	46	2	64	40	21	12		221
AMARELAO	2	41	45	1	36	8	4	3		140
AMENDOIM TORRADO			1		1				1	3
AMESCLA						1				1
AMOREIRA					1	1				2
ANDIROBA								1		1
ANGELCA						1				1
ANGELIM AMARGOSO		12	17		9	1				39
ANGELIM/ANGICO		12	12		17	6	5	2		54
BANDARRA	3	34	39	36	83	76	59	56	35	421
BRANQUILHO/CINZEIRO	3	28	58	10	65	38	24	16	2	244
CABREUVA	9	68	73		35	18	12	1		216
CAIXETA/MARUPA	2	6	15		5	9	5	1		43
CAMBARA ROSA							1			1
CANELA	3	29	28	3	19	7	3	3	1	96
CARIPE						1				1
CAROBA		7	11		6	7	1	2		34
CARRAPATEIRO								1		1
CASTANHA DE ARARA			1	1	4		3			9
CASTANHEIRA DO BRASIL			2	4	1	3	3	6	20	39
CATUABA		7	9	3	14	7	6	1	3	50
CAUCHO	5	71	106	4	108	82	49	24	2	451
CEDRO CAJA	1	2	2	3	7	3	4	1	2	25
CEDRO ROSA	14	42	47	4	70	39	24	12	9	261
CEREJEIRA	4	19	32	6	54	53	36	30	6	240
CHICHA		4	15	3	21	13	7	2	2	67
CINZEIRO PRETO			1							1
COPAIBA	2	2	8	26	10	15	15	23	42	143
CUMARU	1	5	13	48	27	26	48	61	128	357
CURUPIXÁ		1	1	3	2	2	3	10	17	39
EMBIRUCU		18	37	5	60	62	42	27	3	254
ESPETEIRO	1	14	19		9	2				45
FARINHA SECA	4	36	61		60	25	3	2		191
FAVEIRA				4	2	6	9	8	3	32

FIGUEIRA BRANCA		4	11	14	14	12	17	23	34	129
FREIJO	10	45	31		5	1				92
GARAPEIRA	3	23	21	59	35	50	57	58	97	403
IPE	4	15	7		5	7	4			42
ITAUBA	17	11	9		16	3	5	3		75
JATOBA	2	21	35	18	47	46	40	40	30	279
JEQUITIBA	1	1	1	1	1	3	2	5	10	25
JITO/CEDRO MARINHEIRO			2					1		3
LARANJINHA			1							1
LEITEIRO	12	75	51		43	24	4			209
LIMAOZINHO				1						1
MACACAUBA		3	1		1	2				7
MANDIOCAO/MOROTOTO		2	2							4
MARACATIARA	3	59	81	2	69	31	14	5	2	266
MARFIM/AZEITONA	5	31	42	7	28	30	18	24	8	193
MAÇARANDUBA	1	2	4	1	7	2	7	3	2	29
MATAMATA		7	14	9	38	31	28	22	2	151
MIRINDIBA		1	2	2	4	5	7	4	10	35
MAHOGANY				6	9	3	3	3	86	110
MULATEIRO			3	3	4	6	10	9	8	43
NAO IDENTIFICADA		1			2	2	1		2	8
OITICICA	2	35	46	8	43	24	29	16	1	204
PAINEIRA									1	1
PAMA		1								1
PARAJU	2	11	25	5	33	22	18	15	16	147
PARIRI/FRUTAO			2		5	7	5			19
PAU DE BALÇA		1					1			2
PAU-ARARA		1	9	5	11	11	13	10		60
PEROBA AMAZONAS									1	1
PEROBA MICO	1		3		2	1	1	1		9
PEROBA ROSA									1	1
PIACA/ENVIRA		2	1			1				4
PINHO CUIABANO	6	72	94		83	45	22	5		327
PINHO DO NORTE	5	17	26	49	36	40	48	49	274	544
PIQUIA	2	14	28	11	37	64	35	29	12	232
QUARIQUARA			1							1
QUARUBA/CEDRILHO					1	1				2
SAPUCAIA	1	3	4	1	5	5	8	2	2	31
SERINGUEIRA	7	54	59	18	62	68	59	28	13	368
SORVEIRA	2	10	19	1	12	23	7	4		78
SUCUPIRA	1	5	7	1	15	4	4	2	1	40
SUMAUMA			1	10	3	3	3	7	106	133

TAMARINDO	1	28	51		40	12	9	2		143
TAUARI			2	5	5	1	1	3	2	19
TIMBURI						1			1	2
TUCUPI DE ARARA							1		1	2
UCUUBA	7	31	23		6	3	2	3		75
VIROLA		1	1		1	3				6
Grand total	**164**	**1082**	**1431**	**405**	**1529**	**1159**	**876**	**687**	**1000**	**8333**

Figure 37 shows the distribution of mahogany trees with DBH ≥ 60 cm that occurred in the area where the high incidence occurs in the largest diametric class (DBH> 110 cm) with 78% of individuals inventoried, with individuals reaching up to 180 cm in diameter with a volume estimated at 81 m³.

The occurrence of 78% of mahogany trees with DHB ≥ 110 cm is due to the fact that the study area is a primary forest, so these individuals are possibly over 100 years old, which guarantees a high timber volume within UPA-1R.

Figure 37 Diametric distribution of mahogany individuals in the UPA-R1 area

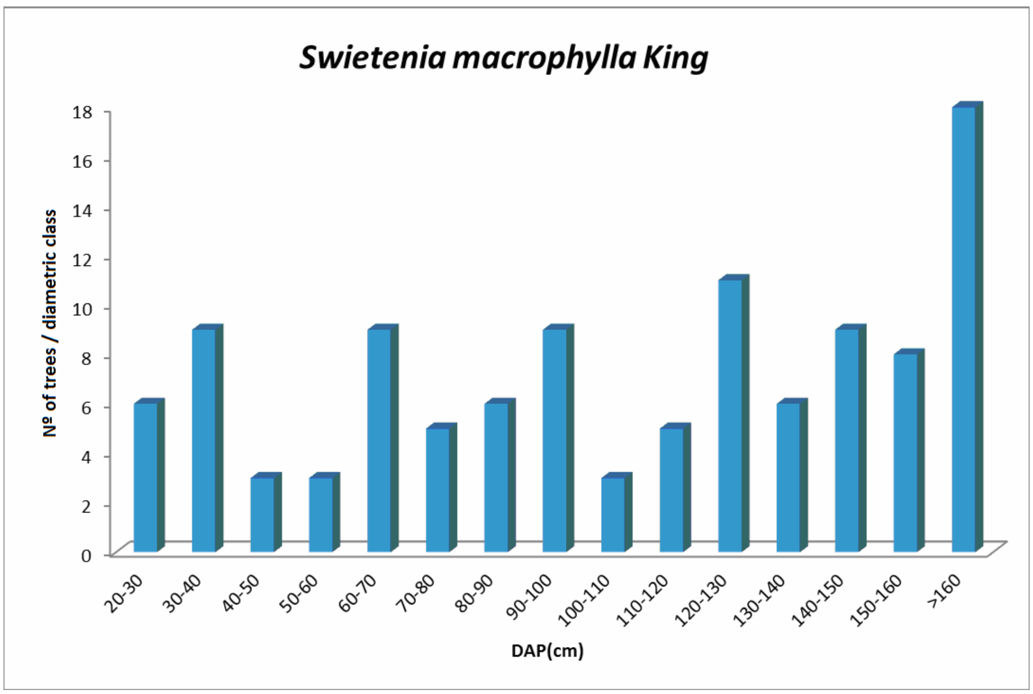
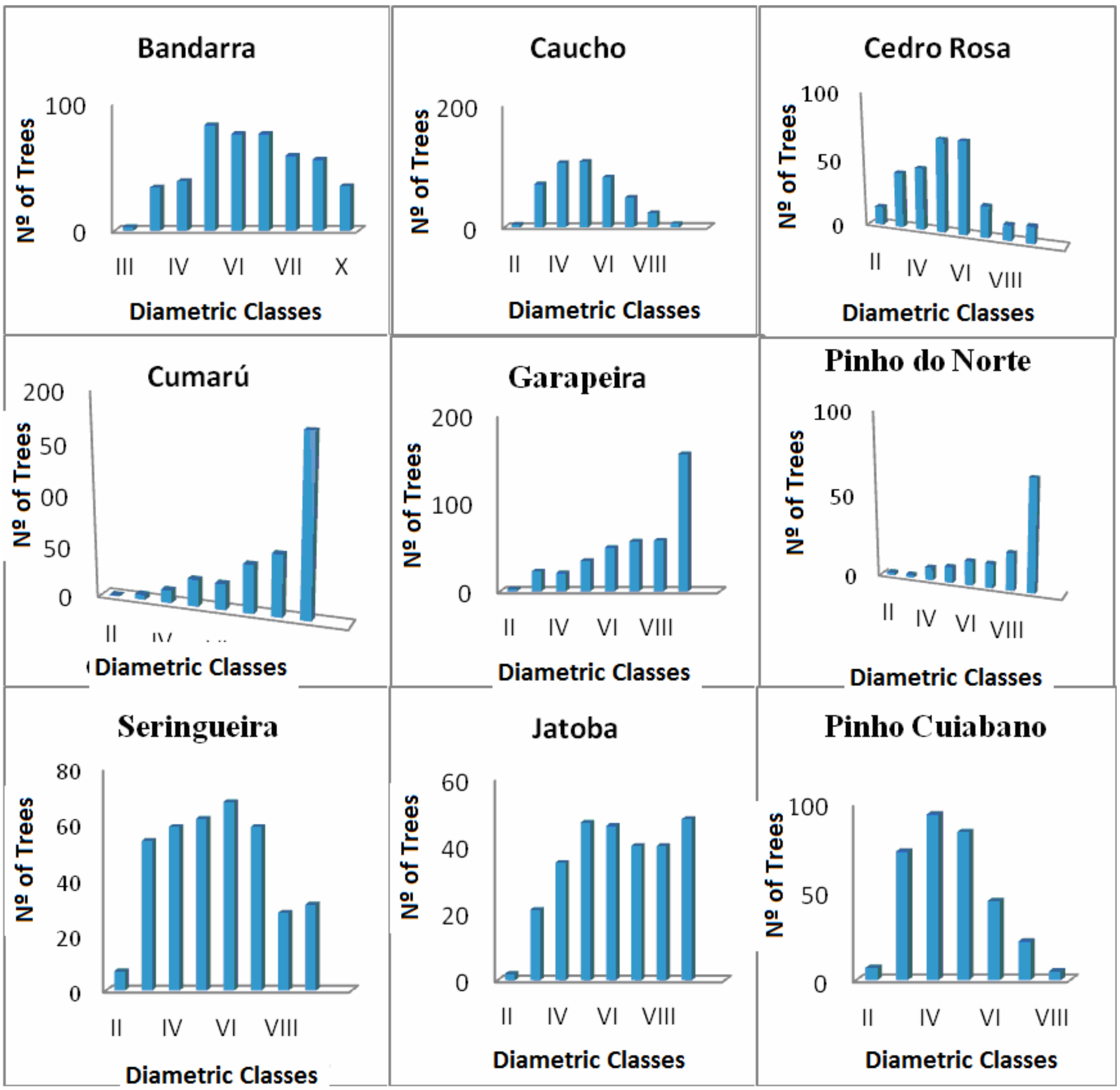


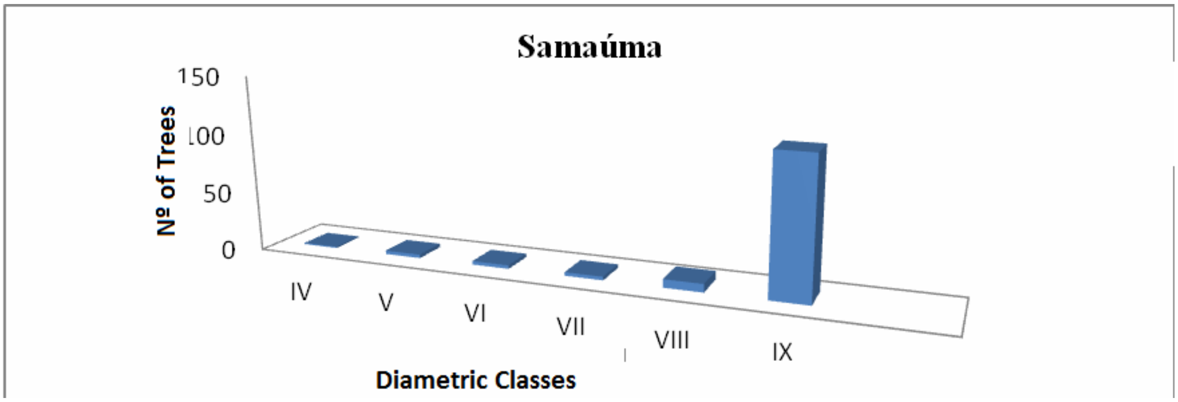
Figure 38 presents the diametric distributions of the most abundant 10 species in the the UPA-1R area, where the species such as Cumaru, Garapeira, North Pine and Sumauma presents distributions with the same trend, that is, as much as increases the diametric classes, also increase the occurrence of individuals. Although for mahogany, the field survey took place only individuals with DBH ≥ 110, it is possible to verify the same trend of these species.

This fact shows that although there are individuals in lower diametric classes, the abundance occurring is low, making the forester, or the regulations of environmental agencies, take into consideration and ensure the maintenance requirement of mother trees among trees that already reached the minimum cutting diameter.

On the contrary, other species maintain a high abundance of individuals in the intermediate diametric classes and also reach the upper classes in great abundance of its individuals.

Figure 38 Diametric distributions of the 10 most abundant species in the area of UPA-1R





4.2 CONTINUOUS FOREST INVENTORY (PERMANENT PARCELS)

4.2.1 Horizontal Structure

The data used for the horizontal structure analysis were obtained from field survey of eight permanent parcels (PP) of 0.25 hectares in a rectangle shape 10 x 20m, located in the UPA-1R area. This sampled area presented a total of 511 individuals distributed among 108 species, and of these only nine presented ten or more individuals, representing 47.75% of inventoried individuals: cacau, Canela, Cocão, freijó, ingá, joão mole, non-identified species, Pama, and 38 species presented only one individual responsible for only 7.44% of the total abundance of total inventoried.

Species not identified (N.I.) were considered in the calculations of the phytosociological parameters, due to its importance in the ecology of sustaining the forest, reaching higher values of Importance Value Index (IVI) in percentage, receiving a code numbering 1 for identification, for classes of trees, young trees and saplings.

4.2.1.1 Horizontal structure of the stratum: Tree (DBH ≥ 10 cm)

Table 13 shows the results of absolute and relative parameters of the horizontal structure, such as Abundance, Dominance, Frequency and Importance Value Index of plant species, with trees with DBH ≥ 10 cm, called Trees, classified by the values of codes of species in alphabetical order.

Table 13 Phytosociological Structure - Abundance, Dominance, frequency and IVI for the tree stratum (DBH ≥ 10 cm) of the project area

Code	Species	Fabs. (%)	Frel (%)	Aabs (ni/ha)	Arel (%)	Dabs. (m²/ha)	Drel. (%)	IVI (%)
1	Abiorana	2,50	1,04	2,50	0,98	0,11	0,69	2,72
2	Aguaninha	1,50	0,63	2,00	0,78	0,05	0,34	1,75
3	Amarelão	1,50	0,63	1,50	0,59	0,02	0,15	1,36
4	Angel	2,50	1,04	2,50	0,98	0,04	0,25	2,28
5	Angelca	3,50	1,46	3,50	1,37	0,01	0,09	2,92
6	Angelim Amargosa	2,50	1,04	2,50	0,98	0,05	0,30	2,33
7	Aratimpu	0,50	0,21	0,50	0,20	0,01	0,05	0,46
8	Bacuri	1,00	0,42	1,50	0,59	0,03	0,20	1,21

Code	Species	Fabs. (%)	Frel (%)	Aabs (ni/ha)	Arel (%)	Dabs. (m²/ha)	Drel. (%)	IVI (%)
9	Baginha	0,50	0,21	0,50	0,20	0,01	0,06	0,47
10	Bandarra	3,00	1,25	3,00	1,17	0,79	5,10	7,53
11	Barriguda	0,50	0,21	0,50	0,20	0,10	0,66	1,06
12	Bofe de Anta	3,50	1,46	3,50	1,37	0,25	1,59	4,43
13	Bolão	4,00	1,67	4,00	1,57	0,10	0,62	3,85
14	Breu	0,50	0,21	0,50	0,20	0,01	0,07	0,47
15	Cabriúva	1,00	0,42	1,00	0,39	0,05	0,34	1,15
16	Cacau	6,00	2,51	6,00	2,35	0,08	0,52	5,37
17	Cafezinho	1,00	0,42	1,50	0,59	0,01	0,09	1,09
18	Cajá	2,50	1,04	2,50	0,98	0,04	0,26	2,28
19	Cajarana	2,50	1,04	2,50	0,98	0,27	1,73	3,75
20	Cajuzinho	0,50	0,21	0,50	0,20	0,01	0,05	0,45
21	Calcho	3,50	1,46	3,50	1,37	0,39	2,50	5,33
22	Canela	6,00	2,51	6,00	2,35	0,20	1,29	6,14
23	Caneleira	1,00	0,42	1,00	0,39	0,01	0,06	0,87
24	Caripé	0,50	0,21	0,50	0,20	0,04	0,23	0,64
25	Carrapateiro	2,50	1,04	2,50	0,98	0,06	0,37	2,39
26	Castainha	1,00	0,42	1,00	0,39	0,02	0,11	0,92
27	Castanha	1,50	0,63	1,50	0,59	0,03	0,22	1,43
28	Castanharana	0,50	0,21	0,50	0,20	0,00	0,03	0,43
29	Cedro Marinheiro	2,00	0,84	2,00	0,78	0,05	0,31	1,93
30	Cedro Rosa	0,50	0,21	0,50	0,20	0,16	1,05	1,46
31	Cerejeira	1,00	0,42	1,00	0,39	0,36	2,32	3,13
32	Coaçu	3,00	1,25	3,50	1,37	0,20	1,30	3,92
33	Cocão	9,50	3,97	11,00	4,31	0,25	1,58	9,85
34	Coloral de Índio	1,00	0,42	1,50	0,59	0,03	0,18	1,19
35	Cumarú Ferro	0,50	0,21	0,50	0,20	0,41	2,65	3,06
36	Embaúba	1,00	0,42	1,00	0,39	0,06	0,41	1,22
37	Embaúba Tauaranha	0,50	0,21	0,50	0,20	0,01	0,08	0,48
38	Embaúba Tauren	0,50	0,21	0,50	0,20	0,01	0,04	0,44
39	Embiriba	1,50	0,63	2,00	0,78	0,03	0,19	1,60
40	Envira	0,50	0,21	0,50	0,20	0,00	0,03	0,43
41	Envira Beró	0,50	0,21	0,50	0,20	0,29	1,89	2,30
42	Envira Ferro	2,00	0,84	2,50	0,98	0,03	0,22	2,03
43	Espetero	1,00	0,42	1,00	0,39	0,05	0,34	1,15
44	Espinheiro	0,50	0,21	0,50	0,20	0,01	0,08	0,48
45	Faveira	0,50	0,21	0,50	0,20	0,10	0,65	1,05
46	Feijão Cru	0,50	0,21	0,50	0,20	0,01	0,08	0,49
47	Figueira Branca	1,00	0,42	1,00	0,39	0,01	0,10	0,90
48	Figueira Rosa	0,50	0,21	0,50	0,20	0,68	4,37	4,77
49	Freijó	6,00	2,51	6,00	2,35	0,44	2,85	7,71
50	Goiabão	1,50	0,63	2,00	0,78	0,02	0,14	1,55
51	Grão de galo	0,50	0,21	0,50	0,20	0,01	0,08	0,48
52	Guarantam	2,00	0,84	2,00	0,78	0,10	0,65	2,27
53	Ingá	13,00	5,43	13,00	5,09	0,86	5,53	16,04
54	Inharé	1,00	0,42	1,00	0,39	0,13	0,81	1,62
55	Ipê	1,00	0,42	1,00	0,39	0,02	0,15	0,96
56	Itaubão	0,50	0,21	0,50	0,20	0,05	0,31	0,71

Code	Species	Fabs. (%)	Frel (%)	Aabs (ni/ha)	Arel (%)	Dabs. (m²/ha)	Drel. (%)	IVI (%)
57	Jacaranda Cipó	0,50	0,21	0,50	0,20	0,06	0,41	0,82
58	Jacatiara	1,00	0,42	1,00	0,39	0,14	0,93	1,74
59	Jenipapim	0,50	0,21	0,50	0,20	0,04	0,25	0,66
60	Jerimunzinho	2,00	0,84	2,00	0,78	0,03	0,18	1,80
61	Jitó	0,50	0,21	0,50	0,20	0,01	0,04	0,44
62	João Mole	6,50	2,71	6,50	2,54	0,09	0,61	5,87
63	Leiteira	4,00	1,67	4,00	1,57	0,13	0,84	4,07
64	Leiteira Sucuba	1,00	0,42	1,00	0,39	0,02	0,11	0,92
65	Louro	1,00	0,42	1,00	0,39	0,01	0,07	0,88
66	Mamica de porca	1,50	0,63	2,00	0,78	0,32	2,03	3,44
67	Manga de Anta	1,00	0,42	1,00	0,39	0,10	0,65	1,46
68	Marfim Amarelo	2,50	1,04	3,00	1,17	0,21	1,36	3,57
69	Massaranduba	0,50	0,21	0,50	0,20	0,04	0,24	0,64
70	Mata-Matá	3,00	1,25	3,00	1,17	0,36	2,30	4,73
71	MataMata-preto	0,50	0,21	0,50	0,20	0,03	0,16	0,57
72	Mizoleira	0,50	0,21	0,50	0,20	0,07	0,43	0,84
73	Mahogany	1,50	0,63	1,50	0,59	1,66	10,67	11,88
74	Muiracatiara	0,50	0,21	0,50	0,20	0,09	0,61	1,01
75	Murungum	2,50	1,04	2,50	0,98	0,04	0,27	2,30
76	Mururu	0,50	0,21	0,50	0,20	0,02	0,12	0,53
77	N.I.	20,50	8,56	25,50	9,98	0,69	4,46	23,00
78	Oiticica	2,00	0,84	2,00	0,78	0,08	0,52	2,14
79	Ortiga	1,00	0,42	1,00	0,39	0,01	0,08	0,89
80	Paineira Barriguda	3,50	1,46	3,50	1,37	0,17	1,12	3,96
81	Pama	15,00	6,26	17,00	6,65	0,42	2,73	15,64
82	Parajú	0,50	0,21	0,50	0,20	0,00	0,03	0,44
83	Parajuba	0,50	0,21	0,50	0,20	0,07	0,45	0,86
84	Parneira Rosa	5,50	2,30	5,50	2,15	0,58	3,73	8,18
85	Pata de vaca	4,00	1,67	4,50	1,76	0,18	1,16	4,59
86	Pau Arara	1,00	0,42	1,00	0,39	0,50	3,20	4,01
87	Pau Brasil	0,50	0,21	0,50	0,20	0,01	0,04	0,45
88	Pérola d'água	0,50	0,21	0,50	0,20	0,00	0,03	0,44
89	Piaca	6,00	2,51	6,00	2,35	0,13	0,86	5,72
90	Pindaíba	1,00	0,42	1,00	0,39	0,04	0,27	1,08
91	Pinheiro do Norte	0,50	0,21	0,50	0,20	0,02	0,14	0,54
92	Piquiá	1,00	0,42	1,00	0,39	0,04	0,23	1,04
93	Quari-Quara	1,50	0,63	1,50	0,59	0,03	0,16	1,38
94	Sabia	0,50	0,21	0,50	0,20	0,02	0,16	0,56
95	Samaúma	1,00	0,42	1,00	0,39	0,62	3,97	4,78
96	Samaúma de Espinho	0,50	0,21	0,50	0,20	0,01	0,06	0,46
97	Sangrio	8,00	3,34	8,50	3,33	0,19	1,25	7,91
98	Sapota	2,50	1,04	2,50	0,98	0,21	1,38	3,40
99	Sapotinha	5,00	2,09	5,00	1,96	0,06	0,39	4,44
100	Seringueira	2,00	0,84	2,00	0,78	0,10	0,66	2,27
101	Seringuinha	3,00	1,25	3,50	1,37	0,26	1,64	4,26
102	Solveira	0,50	0,21	0,50	0,20	0,02	0,12	0,52
103	Sucupira	1,50	0,63	1,50	0,59	0,02	0,13	1,35
104	Tachi	1,50	0,63	1,50	0,59	0,08	0,51	1,73

Code	Species	Fabs. (%)	Frel (%)	Aabs (ni/ha)	Arel (%)	Dabs. (m²/ha)	Drel. (%)	IVI (%)
105	Tachirana	0,50	0,21	0,50	0,20	0,05	0,32	0,72
106	Tamarindo	0,50	0,21	0,50	0,20	0,00	0,03	0,43
107	Torrado	5,00	2,09	6,00	2,35	0,21	1,38	5,82
108	Unha de Vaca	0,50	0,21	0,50	0,20	0,02	0,12	0,52
	Total	**239,50**	**100**	**255,50**	**100**	**155,412**	**100**	**300**

The absolute abundance data (Aabs.) shows that none of the species were classified as "rare species" which according to the current legislation it is considered a rare species with Aabs = 0.03 trees/ha. From the ecological point of view, all species could be logged in the area once it also meets the legal requirement within each unit of Work Unit (UT).

The ten most abundant species in the area represent 41.3% of total species within this stratum (Table 14). The code 77 was assigned for all species that were not identified during the field survey that is why the species N.I. (not identified) appears among the species with high relative abundance in the stratum. Thus, it is noteworthy to mention that the species Pama with 6.65% of total individuals of the stratum, as the most frequent species.

Table 14 List of 10 species of the tree stratum with high Arel

#	Code	Species	Fabs. (%)	Frel (%)	Aabs (ni/ha)	Arel. (%)	Dabs. (m²/ha)	Drel. (%)	IVI (%)
1	77	N.I.	20.5	8.56	25.5	**9.98**	0.69	4.46	23
2	81	Pama	15	6.26	17	**6.65**	0.42	2.73	15.64
3	53	Inga	13	5.43	13	**5.09**	0.86	5.53	16.04
4	33	Cocão	9.5	3.97	11	**4.31**	0.25	1.58	9.85
5	97	Sangrio	8	3.34	8.5	**3.33**	0.19	1.25	7.91
6	62	João Mole	6.5	2.71	6.5	**2.54**	0.09	0.61	5.87
7	49	Freijo	6	2.51	6	**2.35**	0.44	2.85	7.71
8	22	Canela	6	2.51	6	**2.35**	0.2	1.29	6.14
9	107	Torrado	5	2.09	6	**2.35**	0.21	1.38	5.82
10	89	Piaca	6	2.51	6	**2.35**	0.13	0.86	5.72
	Sub total		**95.5**	**39.89**	**105.5**	**41.3**	**3.48**	**22.54**	**103.7**

The species mahogany, with a relative abundance Arel = 0.59%, it is positioned at the 44th position in relation to other species in the tree stratum.

For the relative dominance (Drel) the ten species with high values, that is, those with high percentage of basal area per hectare, representing 46.61% of land use in relation to other species in the stratum (Table 15).

Table 15 List of 10 species of trees stratum with high Drel

#	Code	Species	Fabs. (%)	Frel (%)	Aabs (ni/ha)	Arel. (%)	Dabs. (m²/ha)	Drel. (%)	IVI (%)
1	73	Mahogany	1.5	0.63	1.5	0.59	1.66	**10.67**	11.88
2	53	Inga	13	5.43	13	5.09	0.86	**5.53**	16.04
3	10	Bandarra	3	1.25	3	1.17	0.79	**5.1**	7.53
4	77	N.I.	20.5	8.56	25.5	9.98	0.69	**4.46**	23
5	48	Figueira Rosa	0.5	0.21	0.5	0.2	0.68	**4.37**	4.77
6	95	Samauma	1	0.42	1	0.39	0.62	**3.97**	4.78
7	84	Parneira Rosa	5.5	2.3	5.5	2.15	0.58	**3.73**	8.18
8	86	Pau Arara	1	0.42	1	0.39	0.5	**3.2**	4.01
9	49	Freijo	6	2.51	6	2.35	0.44	**2.85**	7.71
10	81	Pama	15	6.26	17	6.65	0.42	**2.73**	15.64
	Sub total		**67**	**27.99**	**74**	**28.96**	**7.24**	**46.61**	**103.54**

Mahogany, Inga, Bandarra, figueira rosa, Sumauma and Parneira rosa are species with large basal areas in the stratum, while mahogany with Drel of 1.66 m².ha^{-1} is positioned in the 1st place in the species ranking of the tree stratum.

As the most frequent, that is, the species presenting high dispersion in the area are Pama (6.26%), Inga (5.43%), Cocão (3.97%), Sangrio (3.34%), joão mole (2.71%), totaling 21.71% of the individuals inventoried (Table 16).

Mahogany species is in the 40th position in the ranking with a Frel 0.63% in relation to other species in the stratum.

Table 16 List of 10 species of the tree stratum with high Frel

#	Code	Species	Fabs. (%)	Frel (%)	Aabs (ni/ha)	Arel. (%)	Dabs. (m²/ha)	Drel. (%)	IVI (%)
1	77	N.I.	20.5	**8.56**	25.5	9.98	0.69	4.46	23
2	81	Pama	15	**6.26**	17	6.65	0.42	2.73	15.64
3	53	Inga	13	**5.43**	13	5.09	0.86	5.53	16.04
4	33	Cocão	9.5	**3.97**	11	4.31	0.25	1.58	9.85
5	97	Sangrio	8	**3.34**	8.5	3.33	0.19	1.25	7.91
6	62	João mole	6.5	**2.71**	6.5	2.54	0.09	0.61	5.87
7	49	Freijo	6	**2.51**	6	2.35	0.44	2.85	7.71
8	22	Canela	6	**2.51**	6	2.35	0.2	1.29	6.14
9	89	Piaca	6	**2.51**	6	2.35	0.13	0.86	5.72
10	16	Cocoa	6	**2.51**	6	2.35	0.08	0.52	5.37
	Sub total		96.5	40.31	105.5	41.3	3.35	21.68	103.3

In the evaluation of Importance Value Index, the main species identified is Inga with IVI 16.04%. In addition, other species are Pama, Mahogany, Cocão, Parneira rosa (Table 17).

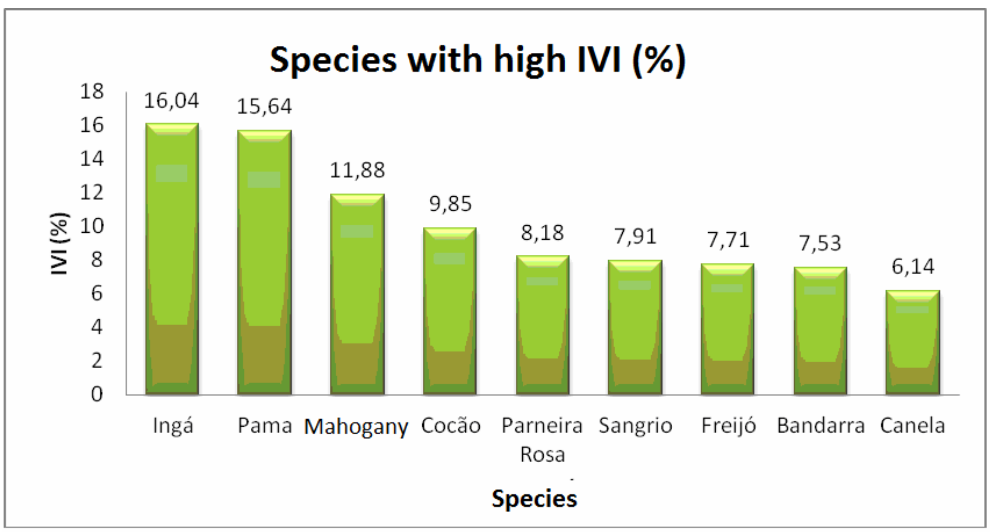
The result shows that although mahogany within the tree stratum is positioned the 44th, 1st and 40th for Abundance, Dominance and Frequency, respectively, with respect to IVI percentage of the species places in the 4th position in the ranking of other species within the stratum. This is because of the occurrence of a few trees (3 individuals), but with large diameters which placed it 1st in the ranking of dominance among the species.

Table 17 List of 10 species of the tree stratum with high IVI

#	Code	Species	Fabs. (%)	Frel (%)	Aabs (ni/ha)	Arel. (%)	Dabs. (m^2/ha)	Drel. (%)	IVI (%)
1	77	N.I.	20.5	8.56	25.5	9.98	0.69	4.46	**23**
2	53	Inga	13	5.43	13	5.09	0.86	5.53	**16.04**
3	81	Pama	15	6.26	17	6.65	0.42	2.73	**15.64**
4	73	Mahogany	1.5	0.63	1.5	0.59	1.66	10.67	**11.88**
5	33	Cocão	9.5	3.97	11	4.31	0.25	1.58	**9.85**
6	84	Parneira Rosa	5.5	2.3	5.5	2.15	0.58	3.73	**8.18**
7	97	Sangrio	8	3.34	8.5	3.33	0.19	1.25	**7.91**
8	49	Freijo	6	2.51	6	2.35	0.44	2.85	**7.71**
9	10	Bandarra	3	1.25	3	1.17	0.79	5.1	**7.53**
10	22	Canela	6	2.51	6	2.35	0.2	1.29	**6.14**
	Sub total		**88**	**36.76**	**97**	**37.97**	**6.08**	**39.19**	**113.88**

In sum, Figure 39 shows 10 species with high Importance Value Indexes with ecological importance in the tree stratum studied.

Figure 39 Distribution of IVI of main species of the tree stratum



The species Inga presented the highest IVI percentage because it ranked in second place in all phytosociological parameters. The species Pama got first place for abundance and relative frequency, however reached the 10th position for relative dominance; the high IVI reached by mahogany (*Swietenia macrophylla* King) was due to its basal area, resulting in high value of relative dominance, with only three individuals in the sampled area, providing 1.5 individuals/ha, being among the lowest values of frequency and abundance.

The species Cocão appears in the fourth position with respect to IVI percentage, while not ranked among the top ten species with high Drel percentage. The Parneira rosa species was not placed in the top 10 in the ranking of frequency and relative abundance, but it was among the top ten in terms of dominance, the same happened for the species Bandarra. But the opposite occurred with Sangrio species that was among the top five for high abundance and frequency, but it is not among the top ten in terms dominance. The Freijo species was placed among the top ten in the parameters, and Canela species was among the top ten in terms of abundance and frequency, however this did not happen for dominance.

4.2.1.2 Horizontal structure of the stratum: Young tree (5 cm ≤ DBH <10 cm)

Table 18 shows the results of absolute and relative parameters of the horizontal structure of the young tree stratum, such as Abundance, Dominance, Frequency and Importance Value Index of species with individuals of diameters 5 cm ≤ DBH <10 cm called young trees, classified by the code numberings and alphabetical order of species.

Table 18 Phytosociological Structure - Abundance, Dominance, Frequency and IVI for young trees (5 cm ≤ DBH <10 cm) of the studied area

Code	Species	Fabs. (%)	Frel. (%)	Aabs (ni/ha)	Arel. (%)	Dabs. (m²/ha)	Drel. (%)	IVI (%)
1	Três Folhas	10	1.99	10.02	1.53	0.05	1.95	5.46
2	Abiurana	32.5	6.47	47.49	7.25	0.16	6.53	20.25
3	Aguanhinha	2.5	0.5	2.49	0.38	0.01	0.4	1.28
4	Angel	2.5	0.5	2.49	0.38	0.01	0.22	1.1
5	Angelca	32.5	6.47	32.49	4.96	0.12	4.77	16.2
6	Angelim Amargosa	10	1.99	10.02	1.53	0.04	1.67	5.19
7	Bacuri	2.5	0.5	2.49	0.38	0.01	0.33	1.21
8	Breu	12.5	2.49	17.49	2.67	0.08	3.16	8.32
9	Cabriúva	2.5	0.5	2.49	0.38	0.01	0.47	1.35
10	Cacau	5	1	10.02	1.53	0.05	1.9	4.42
11	Cafezinho	15	2.99	17.49	2.67	0.04	1.68	7.34
12	Cajazeiro	2.5	0.5	2.49	0.38	0.01	0.26	1.14
13	Calcho	5	1	4.98	0.76	0.03	1.13	2.89
14	Caneleira	25	4.98	47.49	7.25	0.14	5.77	18
15	Caroba	2.5	0.5	2.49	0.38	0.01	0.38	1.26
16	Catanhinha	2.5	0.5	2.49	0.38	0.01	0.55	1.43
17	Catuaba	2.5	0.5	2.49	0.38	0.01	0.39	1.27
18	Coaçu	10	1.99	10.02	1.53	0.04	1.73	5.25
19	Cocão	2.5	0.5	2.49	0.38	0.01	0.51	1.39
20	Coloral	2.5	0.5	2.49	0.38	0.01	0.39	1.27
21	Envira	15	2.99	19.98	3.05	0.08	3.37	9.4
22	Enviveira	5	1	4.98	0.76	0.02	0.93	2.69
23	Escorrega Macaco	2.5	0.5	2.49	0.38	0.01	0.25	1.13
24	Espinheiro	2.5	0.5	2.49	0.38	0.01	0.29	1.17
25	Goiabão	5	1	7.53	1.15	0.04	1.76	3.9
26	Goiabinha	7.5	1.49	7.53	1.15	0.02	0.86	3.5
27	Grão de galo	2.5	0.5	2.49	0.38	0.01	0.49	1.37
28	Guarantam	5	1	4.98	0.76	0.02	0.85	2.61
29	Impateira	2.5	0.5	2.49	0.38	0.01	0.3	1.18

Code	Species	Fabs. (%)	Frel. (%)	Aabs (ni/ha)	Arel. (%)	Dabs. (m²/ha)	Drel. (%)	IVI (%)
30	Ingá	32.5	6.47	45.00	6.87	0.14	5.84	19.18
31	Inharé	5	1	7.53	1.15	0.03	1.32	3.46
32	Jerimunzinho	5	1	4.98	0.76	0.01	0.44	2.2
33	Jitó	10	1.99	10.02	1.53	0.05	2.05	5.57
34	João Mole	20	3.98	27.51	4.2	0.11	4.39	12.57
35	Laranjinha	2.5	0.5	2.49	0.38	0.01	0.36	1.24
36	Leiteira	2.5	0.5	2.49	0.38	0.01	0.22	1.1
37	Louro	5	1	4.98	0.76	0.02	0.72	2.47
38	Mamarú	2.5	0.5	2.49	0.38	0	0.2	1.08
39	Mamica de porca	5	1	7.53	1.15	0.02	0.97	3.11
40	Maparajuba	5	1	4.98	0.76	0.03	1.31	3.07
41	Mata-Matá	22.5	4.48	22.53	3.44	0.08	3.46	11.37
42	Muiracatiara	2.5	0.5	4.98	0.76	0.02	0.73	1.99
43	N.I.	57.5	11.44	97.53	14.89	0.38	15.72	42.05
44	Oiticica	2.5	0.5	4.98	0.76	0.01	0.41	1.67
45	Pama	22.5	4.48	37.53	5.73	0.15	6.02	16.22
46	Pata de Vaca	2.5	0.5	4.98	0.76	0.02	0.75	2.01
47	Pau Arara	2.5	0.5	2.49	0.38	0.01	0.26	1.14
48	Piaca	12.5	2.49	12.51	1.91	0.07	2.85	7.25
49	Pindaíba	7.5	1.49	7.53	1.15	0.02	0.86	3.5
50	Pinheiro	2.5	0.5	2.49	0.38	0.01	0.24	1.12
51	Pintadinho	2.5	0.5	2.49	0.38	0	0.19	1.07
52	Samaúma	5	1	4.98	0.76	0.03	1.22	2.98
53	Sapota	5	1	12.51	1.91	0.03	1.35	4.26
54	Seringueira	2.5	0.5	2.49	0.38	0.02	0.76	1.64
55	Sucupira	2.5	0.5	2.49	0.38	0.01	0.27	1.15
56	Tucumujú	2.5	0.5	2.49	0.38	0.01	0.25	1.13
57	Ucuúba	20	3.98	19.98	3.05	0.08	3.29	10.33
58	Virola Branca	2.5	0.5	2.49	0.38	0.01	0.21	1.09
	Total	**502.5**	**100.2**	**655**	**99.97**	**2.46**	**99.95**	**300**

The total number of individuals per hectare found in the area for the stratum was 655 young trees of 5 cm ≤ DBH <10 cm, and 58 species were identified in the sampled area.

Species not identified during the field survey were given the code numbering 43, while the species of common name "Três folhas" got a code number 1.

Among the ten species with high relative abundance, excluding species not identified (N.I.), found in the stratum were: Abiurana (7.25%), Caneleira (7.25%), Inga (6.87%), Pama (5.72%), Angelca (4.96%), totaling 32.06% of a hectare (Table 19).

Table 19 List of 10 species of the young tree stratum with high Arel

#	Code	Species	Fabs. (%)	Frel. (%)	Aabs (ni/ha)	Arel. (%)	Dabs. (m²/ha)	Drel. (%)	IVI (%)
1	43	N.I.	57.5	11.44	97.53	**14.89**	0.38	15.72	42.05
2	2	Abiurana	32.5	6.47	47.49	**7.25**	0.16	6.53	20.25
3	14	Caneleira	25	4.98	47.49	**7.25**	0.14	5.77	18
4	30	Inga	32.5	6.47	45.00	**6.87**	0.14	5.84	19.18
5	45	Pama	22.5	4.48	37.53	**5.73**	0.15	6.02	16.22
6	5	Angelca	32.5	6.47	32.49	**4.96**	0.12	4.77	16.2
7	34	João mole	20	3.98	27.51	**4.2**	0.11	4.39	12.57
8	41	Mata-Mata	22.5	4.48	22.53	**3.44**	0.08	3.46	11.37
9	21	Envira	15	2.99	19.98	**3.05**	0.08	3.37	9.4
10	57	Ucuúba	20	3.98	19.98	**3.05**	0.08	3.29	10.33
		Sub total	**280**	**55.74**	**398**	**60.69**	**1.44**	**59.16**	**175.6**

Relative dominance related to ten species with high values accounted for 59.16% of the area of one hectare by species of the stratum. On the other hand, the five most dominant species were the Abiurana, Pama, Inga, Caneleira, Angelca, which together account for 28.92% of the total for a hectare (Table 20).

Table 20 List of 10 species of the young tree stratum with high Drel

#	Code	Species	Fabs. (%)	Frel. (%)	Aabs (ni/ha)	Arel. (%)	Dabs. (m²/ha)	Drel. (%)	IVI (%)
1	43	N.I.	57.5	11.44	97.53	14.89	0.38	**15.72**	42.1
2	2	Abiurana	32.5	6.47	47.49	7.25	0.16	**6.53**	20.3
3	45	Pama	22.5	4.48	37.53	5.73	0.15	**6.02**	16.2
4	30	Inga	32.5	6.47	45.00	6.87	0.14	**5.84**	19.2
5	14	True Canela	25	4.98	47.49	7.25	0.14	**5.77**	18
6	5	Angelca	32.5	6.47	32.49	4.96	0.12	**4.77**	16.2
7	34	João mole	20	3.98	27.51	4.2	0.11	**4.39**	12.6
8	41	Mata-Matá	22.5	4.48	22.53	3.44	0.08	**3.46**	11.4
9	21	Envira	15	2.99	19.98	3.05	0.08	**3.37**	9.4
10	57	Ucuúba	20	3.98	19.98	3.05	0.08	**3.29**	10.3
	Sub total		**280**	**55.74**	**397.52**	**60.69**	**1.44**	**59.16**	**176**

Table 21 presents the list of ten species classified by Frel percentage, where six species with high frequencies are Abiurana, Angelca, Inga, Caneleira, Mata-Mata and Pama, all species ranging from 6.5% to 4.5%, showing that they are species that are better distributed in the area.

Table 21 List of 10 species of the young tree stratum with high Frel

#	Code	Species	Fabs. (%)	Frel. (%)	Aabs (ni/ha)	Arel. (%)	Dabs. (m²/ha)	Drel. (%)	IVI (%)
1	43	N.I.	57.5	**11.44**	97.53	14.89	0.38	15.72	42.05
2	2	Abiurana	32.5	**6.47**	47.49	7.25	0.16	6.53	20.25
3	5	Angelca	32.5	**6.47**	32.49	4.96	0.12	4.77	16.2
4	30	Inga	32.5	**6.47**	45.00	6.87	0.14	5.84	19.18
5	14	Caneleira	25	**4.98**	47.49	7.25	0.14	5.77	18
6	41	Mata-Mata	22.5	**4.48**	22.53	3.44	0.08	3.46	11.37
7	45	Pama	22.5	**4.48**	37.53	5.73	0.15	6.02	16.22
8	34	João mole	20	**3.98**	27.51	4.2	0.11	4.39	12.57
9	57	Ucuúba	20	**3.98**	19.98	3.05	0.08	3.29	10.33
10	11	Cafezinho	15	**2.99**	17.49	2.67	0.04	1.68	7.34
		Sub total	**280**	**55.74**	**395**	**60.31**	**1.4**	**57.47**	**173.5**

Concerning high IVI of 10 species, Table 22 shows that the value of sub total for Fabs percentage for other phytosociological parameters is constant, showing that these species remains present in almost all units of permanent parcels surveyed in the area, with the exception of Envira species, which is replaced by Cafezinho species when sorting by Frel percentage.

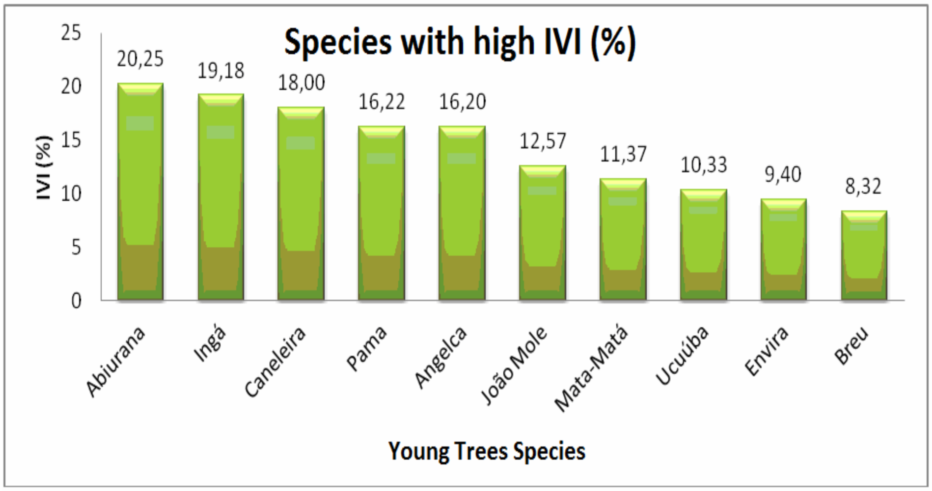
The species with high IVI such as Inga, Caneleira, Pama, Angelca where Abiurana reached the highest value (6.75%), totaling 29.95% of IVI percentage compared to other species in the young tree stratum.

Table 22 List of 10 species of the young tree stratum with high IVI

#	Code	Species	Fabs. (%)	Frel. (%)	Aabs (ni/ha)	Arel. (%)	Dabs. (m²/ha)	Drel. (%)	IVI (%)
1	43	N.I.	57.5	11.44	97.53	14.89	0.38	15.72	**42.05**
2	2	Abiurana	32.5	6.47	47.49	7.25	0.16	6.53	**20.25**
3	30	Inga	32.5	6.47	45.00	6.87	0.14	5.84	**19.18**
4	14	Caneleira	25	4.98	47.49	7.25	0.14	5.77	**18**
5	45	Pama	22.5	4.48	37.53	5.73	0.15	6.02	**16.22**
6	5	Angelca	32.5	6.47	32.49	4.96	0.12	4.77	**16.2**
7	34	João mole	20	3.98	27.51	4.2	0.11	4.39	**12.57**
8	41	Mata-Mata	22.5	4.48	22.53	3.44	0.08	3.46	**11.37**
9	57	Ucuúba	20	3.98	19.98	3.05	0.08	3.29	**10.33**
10	21	Envira	15	2.99	19.98	3.05	0.08	3.37	**9.4**
		Sub total	**280**	**55.74**	**397.52**	**60.69**	**1.44**	**59.16**	**175.6**

Figure 40 shows the 10 species ranked in order of decreasing IVI percentage. Considering that IVI percentage of species coded as non identified (N.I.) includes several species, therefore those species cannot be considered as high value of ecological importance in the area. Thus, the Abiurana is the species with most ecological importance of the young trees stratum, because it presented the highest Frel (6.47%), the highest Drel (6.53%) and the highest Arel with 7.25% and consequently, the highest IVI among species of the stratum considered.

Figure 40 Distribution of IVI of the main species of the young tree stratum



4.2.1.3 Horizontal structure of the stratum: Sapling (2.5 cm ≤ DBH <5 cm)

Table 23 shows the results of absolute and relative parameters of the horizontal structure of the sapling stratum, such as Abundance, Dominance, Frequency and Importance Value Index of individuals of species with diameters (2.5 cm ≤ DBH <5 cm), referred in this study as saplings, classified by the code values of species and in alphabetical order of species.

Table 23 Phytosociological Structure - Abundance, Dominance, Frequency and IVI for Saplings (2.5 cm ≤ DBH <5 cm) of the project area

Code	*Species*	*Fabs (%)*	*Frel (%)*	*Aabs (ni/ha)*	*Arel (%)*	*Dabs (m²/ha)*	*Drel (%)*	*IVI (%)*
1	Abiurana	0.28	9.65	120	8.89	0.58	9.35	27.88
2	Angelca	0.15	5.26	60	4.44	0.26	4.15	13.86
3	Bacuri	0.05	1.75	20	1.48	0.13	2.09	5.33
4	Bofe de Anta	0.05	1.75	20	1.48	0.1	1.63	4.87
5	Branquinho	0.03	0.88	10	0.74	0.08	1.3	2.92
6	Breu	0.13	4.39	50	3.7	0.21	3.37	11.46
7	Cabriúva	0.03	0.88	10	0.74	0.03	0.52	2.13
8	Cafezinho	0.03	0.88	10	0.74	0.02	0.4	2.02
9	Caneleira	0.33	11.4	220	16.3	1.01	16.2	43.93
10	*Cocão*	0.05	1.75	20	1.48	0.09	1.49	4.72
11	Cumujú	0.03	0.88	10	0.74	0.06	1	2.61
12	Envira	0.1	3.51	40	2.96	0.17	2.71	9.18
13	Escorrega Macaco	0.03	0.88	10	0.74	0.07	1.16	2.78
14	Espinheiro	0.03	0.88	10	0.74	0.04	0.72	2.33
15	Feijãozinho	0.03	0.88	10	0.74	0.04	0.72	2.33
16	Goiabinha	0.13	4.39	60	4.44	0.29	4.68	13.51
17	Grão de Galo	0.08	2.63	30	2.22	0.14	2.25	7.1
18	Guarantam	0.03	0.88	10	0.74	0.03	0.46	2.08
19	Inga	0.33	11.4	160	11.9	0.75	12	35.24
20	Jerimunzinho	0.05	1.75	20	1.48	0.12	1.94	5.18

Code	Species	Fabs (%)	Frel (%)	Aabs (ni/ha)	Arel (%)	Dabs (m²/ha)	Drel (%)	IVI (%)
21	Jitó	0.05	1.75	20	1.48	0.08	1.32	4.56
22	João mole	0.05	1.75	20	1.48	0.12	2	5.23
23	Louro	0.05	1.75	20	1.48	0.06	1.03	4.27
24	Maparajuba	0.05	1.75	20	1.48	0.09	1.49	4.73
25	Minjoleiro	0.03	0.88	10	0.74	0.07	1.08	2.69
26	N.I.	0.43	14.91	240	17.8	1	16	48.67
27	Pama	0.08	2.63	30	2.22	0.1	1.62	6.47
28	Pau Arara	0.03	0.88	10	0.74	0.09	1.49	3.11
29	Piaca	0.03	0.88	10	0.74	0.08	1.25	2.87
30	Pintadinho	0.03	0.88	10	0.74	0.03	0.46	2.08
31	Samaúma	0.08	2.63	30	2.22	0.13	2.01	6.86
32	Sapotinha	0.03	0.88	10	0.74	0.04	0.64	2.25
33	Rubber tree	0.03	0.88	10	0.74	0.03	0.46	2.08
34	Ucuúba	0.03	0.88	10	0.74	0.06	1.03	2.65
	Total	**2.85**	**100**	**1350**	**100**	**6.25**	**100**	**300**

In the sampled area, species richness of 34 species was observed, distributed among 1,350 individuals per hectare in the saplings class (2.5 cm ≤ DBH <5 cm).

The five most abundant species, Inga, Abiurana, Angelca, Goiabinha, with emphasis on Caneleira with 6.3%, these results in a relative abundance of 45.92%, while the ten species including those non identified (N.I.) are responsible for 74.8% of total abundance of individuals per hectare of the sapling stratum surveyed in the area (Table 24).

Table 24 List of 10 species of the sapling stratum with high Arel

#	Code	Species	Fabs (%)	Frel (%)	Aabs (ni/ha)	Arel (%)	Dabs (m²/ha)	Drel (%)	IVI (%)
1	26	N.I.	0.43	14.91	240	**17.78**	1	15.98	48.67
2	9	Caneleira	0.33	11.4	220	**16.3**	1.01	16.23	43.93
3	19	Inga	0.33	11.4	160	**11.85**	0.75	11.99	35.24
4	1	Abiurana	0.28	9.65	120	**8.89**	0.58	9.35	27.88
5	2	Angelca	0.15	5.26	60	**4.44**	0.26	4.15	13.86
6	16	Goiabinha	0.13	4.39	60	**4.44**	0.29	4.68	13.51
7	6	Breu	0.13	4.39	50	**3.7**	0.21	3.37	11.46
8	12	Envira	0.1	3.51	40	**2.96**	0.17	2.71	9.18
9	17	Grão de Galo	0.08	2.63	30	**2.22**	0.14	2.25	7.1
10	27	Pama	0.08	2.63	30	**2.22**	0.1	1.62	6.47
		Sub total	**2.04**	**70.17**	**1010**	**74.8**	**4.51**	**72.33**	**217.3**

The species Caneleira with a basal area of 1.014 m²/ha, corresponding to 16.23% of dominance, the most dominant species among the sapling stratum, followed by Inga, Abiurana, and Goiabinha, Angelca species, which showed higher values of relative dominance. These five species together amounted to 46.39% of the basal area of the stratum, and the ten most abundant, including the N.I. total 72.8%, corresponding to an area of 4.54 $m^2.ha^{-1}$ (Table 25).

Table 25 List of 10 species of the sapling stratum with high Drel

#	Code	Species	Fabs (%)	Frel (%)	Aabs (ni/ha)	Arel (%)	Dabs (m^2/ha)	Drel (%)	IVI (%)
1	9	Caneleira	0.33	11.4	220	16.3	1.01	**16.23**	43.93
2	26	N.I.	0.43	14.91	240	17.78	1	**15.98**	48.67
3	19	Inga	0.33	11.4	160	11.85	0.75	**11.99**	35.24
4	1	Abiurana	0.28	9.65	120	8.89	0.58	**9.35**	27.88
5	16	Goiabinha	0.13	4.39	60	4.44	0.29	**4.68**	13.51
6	2	Angelca	0.15	5.26	60	4.44	0.26	**4.15**	13.86
7	6	Breu	0.13	4.39	50	3.7	0.21	**3.37**	11.46
8	12	Envira	0.1	3.51	40	2.96	0.17	**2.71**	9.18
9	17	Grão de Galo	0.08	2.63	30	2.22	0.14	**2.25**	7.1
10	3	Bacuri	0.05	1.75	20	1.48	0.13	**2.09**	5.33
		Sub-total	**2.01**	**69.29**	**1000**	**74.06**	**4.54**	**72.8**	**216.16**

In the sapling stratum, the most dominant species are also those species that present a high rate of dispersion in the area, as confirmed by the Frel percentage shown in Table 26.

The species Caneleira stands out compared to other species occurring in 16.23% of sample units surveyed in the area.

Table 26 List of 10 species of the sapling stratum with high Frel

#	Code	Species	Fabs (%)	Frel (%)	Aabs (ni/ha)	Arel (%)	Dabs (m^2/ha)	Drel (%)	IVI (%)
1	26	N.I.	0.43	**14.91**	240	17.78	1	15.98	48.67
2	9	Caneleira	0.33	**11.4**	220	16.3	1.01	16.23	43.93
3	19	Inga	0.33	**11.4**	160	11.85	0.75	11.99	35.24
4	1	Abiurana	0.28	**9.65**	120	8.89	0.58	9.35	27.88
5	2	Angelca	0.15	**5.26**	60	4.44	0.26	4.15	13.86
6	6	Breu	0.13	**4.39**	50	3.7	0.21	3.37	11.46
7	16	Goiabinha	0.13	**4.39**	60	4.44	0.29	4.68	13.51
8	12	Envira	0.1	**3.51**	40	2.96	0.17	2.71	9.18
9	17	Grão de Galo	0.08	**2.63**	30	2.22	0.14	2.25	7.1
10	27	Pama	0.08	**2.63**	30	2.22	0.1	1.62	6.47
		Sub total	**2.04**	**70.17**	**1010**	**74.8**	**4.51**	**72.33**	**217.3**

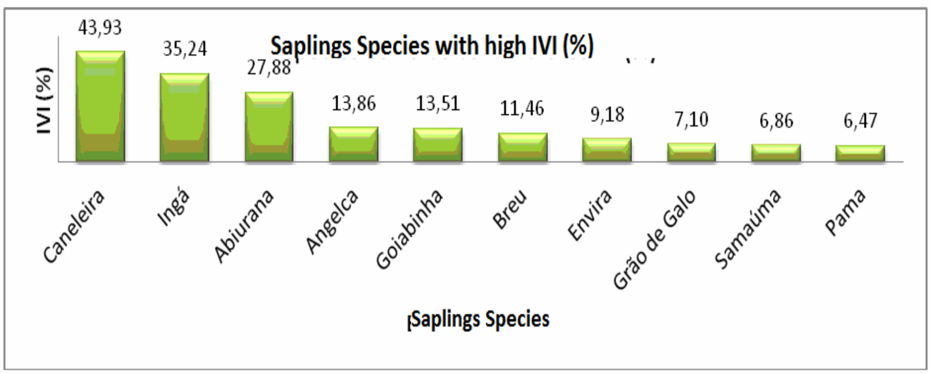
The species Caneleira, Inga and Abiurana remained in the top three positions in the ranking of the phytosociological parameter Arel, Drel and Frel percentage and also confirmed their ecological importance within the sapling stratum with IVI 43.93%, 35.24% and 27.88%, respectively (Table 27).

Table 27 List of 10 species of the sapling stratum with high IVI

#	Code	Species	Fabs (%)	Frel (%)	Aabs (ni/ha)	Arel (%)	Dabs (m²/ha)	Drel (%)	IVI (%)
1	26	N.I.	0.43	14.91	240	17.78	1	15.98	**48.67**
2	9	Caneleira	0.33	11.4	220	16.3	1.01	16.23	**43.93**
3	19	Inga	0.33	11.4	160	11.85	0.75	11.99	**35.24**
4	1	Abiurana	0.28	9.65	120	8.89	0.58	9.35	**27.88**
5	2	Angelca	0.15	5.26	60	4.44	0.26	4.15	**13.86**
6	16	Goiabinha	0.13	4.39	60	4.44	0.29	4.68	**13.51**
7	6	Breu	0.13	4.39	50	3.7	0.21	3.37	**11.46**
8	12	Envira	0.1	3.51	40	2.96	0.17	2.71	**9.18**
9	17	Grão de Galo	0.08	2.63	30	2.22	0.14	2.25	**7.1**
10	31	Samaúma	0.08	2.63	30	2.22	0.13	2.01	**6.86**
		Sub total	**2.04**	**70.17**	**1010**	**74.8**	**4.54**	**72.72**	**217.69**

Figure 41 illustrates the sequence of ten species with high ecological importance index within the sapling stratum. The species Caneleira with IVI = 43.93% ranks first in the species ranking, while the tenth position is Sumauma species with IVI = 6.86%.

Figure 41 Distribution of IVI of the main species of the sapling stratum



4.2.1.4 Horizontal structure of the stratum: Seedling (height less than 30 cm and DBH <2.5 cm)

The floristic composition of the seedling stratum, inventoried for 8 permanent parcels (PP), located in the UPA-1R area, which were measured in sub-parcels 5 m x 1 m, totaling a sample of 200 m², composed of 30 species distributed among 369 individuals counted, resulting in the estimate for the area of a density of 18,450 plants per hectare.

In the current survey, it was considered as seedlings all individuals ≥ 30 cm and DBH <2.5 cm, occurring in randomly selected sub-parcels with dimensions of 5m x 1m. The phytosociological analysis of this stratum was based on the parameters of horizontal structure of the stratum, such as Abundance, Frequency and IVI (Table 28), in addition to measures of species diversity and equitability.

Table 28 Phytosociological parameters of horizontal structure of the seedling stratum

#	*Species*	*Aabs. (ind.ha^{-1})*	*Arel (%).*	*Fabs.(%)*	*Frel.(%)*	*IVI (%) (Arel + Frel)*
1	Maria preta	6600	35.77	47.5	12.50	48.27
2	Inga	4200	22.76	75	19.74	42.50
3	Caneleira	1300	7.05	37.5	9.87	16.91
4	N.I.	1000	5.42	35	9.21	14.63
5	Pama	650	3.52	32.5	8.55	12.08
6	Louro	500	2.71	17.5	4.61	7.32
7	Goiabinha	500	2.71	15	3.95	6.66
8	Abiurana	450	2.44	15	3.95	6.39
9	Angelca	450	2.44	15	3.95	6.39
10	Sapotinha	750	4.07	2.5	0.66	4.72
11	Cafezinho	300	1.63	10	2.63	4.26
12	Envira	250	1.36	10	2.63	3.99
13	Jitó	200	1.08	10	2.63	3.72
14	Breu	200	1.08	7.5	1.97	3.06
15	Seringuinha	200	1.08	7.5	1.97	3.06
16	Canela de Jacamin	100	0.54	5	1.32	1.86
17	Seringueira	100	0.54	5	1.32	1.86
18	Cajuzinho	100	0.54	2.5	0.66	1.20
19	Angelim Amargoso	50	0.27	2.5	0.66	0.93
20	Bacuri	50	0.27	2.5	0.66	0.93
21	Bofe de Anta	50	0.27	2.5	0.66	0.93
22	***Cedro Marinheiro***	***50***	***0.27***	***2.5***	***0.66***	***0.93***
23	Ingazinho	50	0.27	2.5	0.66	0.93
24	Inharé	50	0.27	2.5	0.66	0.93
25	João mole	50	0.27	2.5	0.66	0.93
26	Leiteira	50	0.27	2.5	0.66	0.93
27	Maparajuba	50	0.27	2.5	0.66	0.93
28	Mahogany	50	0.27	2.5	0.66	0.93
29	Pintadinha	50	0.27	2.5	0.66	0.93
30	Tijí	50	0.27	2.5	0.66	0.93
	Total	**18450**	**100**	**380**	**100**	**200**

The total number of seedlings was found in 8 parcels of 369 individuals, where species with the largest number of individuals was Maria preta species with 132 individuals, representing approximately 36% of the abundance of the stratum, and it is the species with the highest IVI (24%), and 12 species presented only one individual each, contributing as a whole with 3.2% of the total, among which is Mahogany species.

Among species of seedlings surveyed, only 7 species do not match with those species found in the tree stratum, which are: Canela, Jacamin, Goiabinha, Ingazinho, Jito, Maparajuba, Maria preta , Pintadinha and Tijí.

For seedlings, Frequency and Abundance were calculated (Table 41), Maria preta species presented high importance with more than 48.27%, followed by Inga and Caneleira that both account for approximately 59.41%, the three together account for a total of 107.68% (1/3) on a scale of 300%.

4.2.2 Species Diversity of the Area

4.2.2.1 Species diversity and equitability of Tree, Young Tree, Sapling, and Seedling Strata

The diversity of species floristic richness (108 species) of trees stratum was determined by Simpson and Shannon-Weaver Diversity Index.

As Simpson's Diversity (Ds) index assumes a maximum value equal to 1 when the concentration of dominance is equal to zero, that is, in the extreme case in that all species present single individual in the stand, therefore being zero the probability that two individuals selected randomly in the population are the same species. Thus, Table 27 shows that when Simpson's Diversity equal to Ds = 0.9751, the tree stratum present a high diversity of tree species, maintaining the same diversity of tree stratum inventoried at IF (forest inventory) 100%.

On the other hand, the Shannon-Weaver H' diversity index measures species diversity of a population according to its equitability, that is, more or less equal in which individuals of the population are distributed among species. Thus, with the Shannon-Weaver diversity index equal to H'= 1.776 and an equitability J' = 0.78, the species diversity of the tree stratum is not so high compared with other populations, because some species present high abundance, while others present very few individuals.

The young tree stratum, defined by species that presented individuals with 5 cm ≤ DBH <10 cm in the study area presented a floristic richness of 58 species distributed in 655 individuals per hectare.

The diversity of species of the young tree stratum, and for the tree stratum was measured by Simpson (Ds) and Shannon-Weaver (H') index, as shown in Table 42.

With the diversity indices Ds = 0.948 and H'= 1.487, the tree and young tree strata present equally high diversity of species.

The sapling stratum consists of 34 species that presented individuals with 2.5 cm ≤ DBH <5 cm, distributed among 1,350 individuals per hectare in the sampled area.

The seedling stratum with a floristic richness of 30 species was the stratum with the largest Simpson's Dominance concentration (Cs), which shows that there is a 19.42% probability that two individuals of this stratum selected randomly belong to the same species. Therefore, with this concentration of dominance is that the three most abundant species are Maria preta 35.77%, with Inga with 22.76% and Caneleira with 7.05%, which together account for 65% of the total individuals of the seedlings stratum.

Based on the Ds and H' indices shown in Table 29, the seedling stratum also present a high diversity of species, but in turn is less diverse than the strata sapling, young tree and tree, respectively.

Table 29 Diversity and equitability index of species of the tree, young tree, sapling and seedling Strata

SPECIES DIVERSITY INDICES	*Strata*			
	Tree	***Young tree***	***Sapling***	***Seedling***
Floristic richness (nº species)	108	655	34	30
Simpson´s Concentration Cs =	0.0249	0.0514	0.0897	0.1942
Simpson´s Diversidade Ds =	0.9751	0.9486	0.9103	0.8058
Simpson´s Maximum Diversity Dmáx =	0.9946	0.9843	0.9713	0.9667
Simpson´s Equitability Es =	0.9804	0.9637	0.9372	0.8336
Shannon-Weaver´s Diversity H' =	1.776	1.4870	1.2472	0.9658
Shannon´s Equitability J' =	0.7791	1.4434	1.2350	0.6533
E (H') =	1.5842	1.7634	1.5315	0.9650
Shannon´s Maximum Diversity H'máx =	2.0334	0.8185	0.8064	1.4771

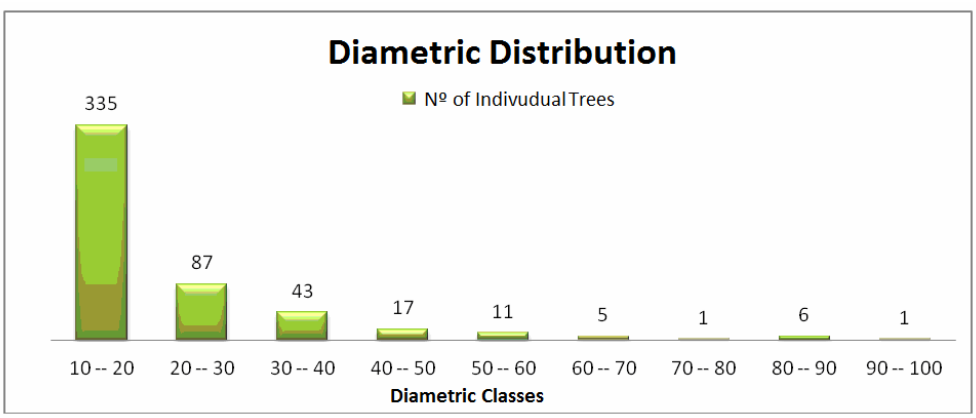
4.2.3 Diametric Structure

In the tree stratum, individuals were classified into nine classes with 10 cm diameter, and the lower limit of the first class equal to 10 cm and the upper limit of the last class equal to100 cm to include all inventoried individuals in that stratum.

The diametric structure of the tree stratum showed that over 65% of sampled individuals (335 trees, Figure 42) are found in the first class (DBH 10 cm to 20 cm). This finding is probably due to the natural dynamics of mortality and recruitment of new individuals to the population as a result of falling trees in this forest environment.

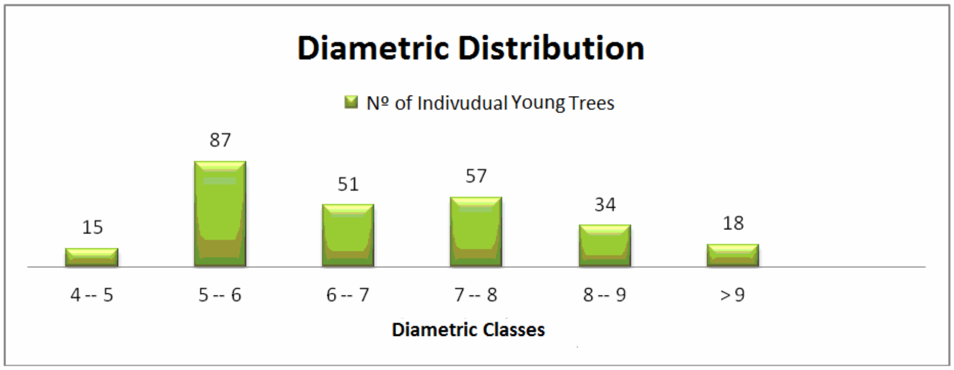
By analyzing the diameter structure of the plant community studied, there is a distribution pattern typical of primary forests where the highest density of individuals is smaller in diameter classes, characterizing the typical model of "reversed-J," according to a distribution negative exponential.

Figure 42 Diametric distribution of individuals in the tree stratum



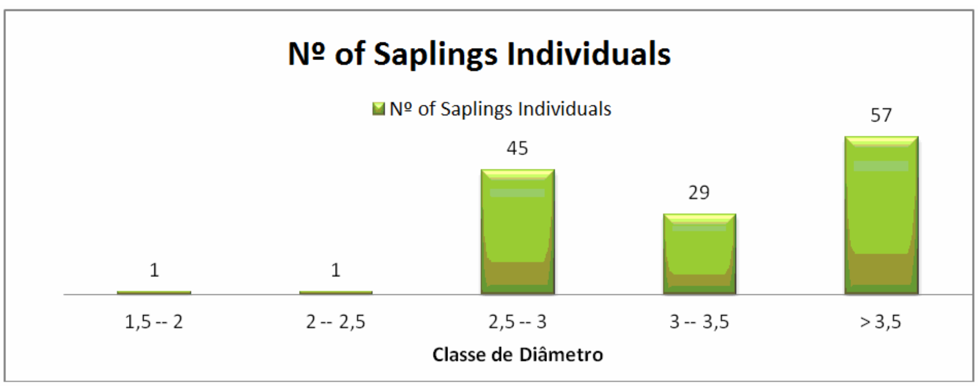
Note that the result of diametric distribution obtained for the young tree stratum is distinct from diametric distribution of individuals in the tree stratum, with the highest percentage in the second class (5 cm to 6 cm, Figure 43) with more than 33% of the total. The DBH considered was 1 cm for each of six classes in which 266 sampled individuals were ranked.

Figure 43 Diametric distribution of individuals in the young tree stratum



The inverse of distribution of individuals in the tree stratum was observed in diametric distribution of individuals of the stratum, where most of its sampled individuals were classified in the upper class (DBH> 3.5 cm), with approximately 43% of the total. With class interval equal to DBH 0.5 cm in five diametric classes considered, 133 individuals collected in the area within the seedling stratum (Figure 44) were all classified.

Figure 44 Diametric distributions of individuals in the sapling stratum



4.3 FOREST INVENTORY OF NATURAL REGENERATION OF *SWIETENIA MACROPHYLLA* KING (MAHOGANY)

4.3.1 Occurrence of plantlets and seedlings in various distances from mother tree

As presented in the section on material and methods, natural regeneration of the species *Swietenia macrophylla*, King was evaluated in terms of capability of dispersion and regeneration of mahogany seed in 20 trees previously selected, in which silvicultural treatments were applied.

Thus, Figure 45 to Figure 54 show the profile of the strata of plantlet and seedling in the sub-parcels of evaluation of mahogany regeneration in the sequence where the parcels established along mahogany trees were surveyed.

The figures shows the average number of plantlets and seedlings found in the sub-parcels of 10 m x 10 m in three parcels established in wedge-shaped in the direction of prevailing winds (East - West), in each of distances considered, that is, 10-20 m, 30-40 m, 50-60 m, 70-80 m, 90-100 m, 110-120 m, 130-140 m, 150-160 m, 170 to 180 m and 190-200 m, respectively. Also, the average number of plantlets and seedlings per hectare, obtained from 20 trees sampled, is shown.

Figure 45 Average occurrence of mahogany plantlets and seedlings in a distance 10 - 20 m from sub-parcel to mother tree

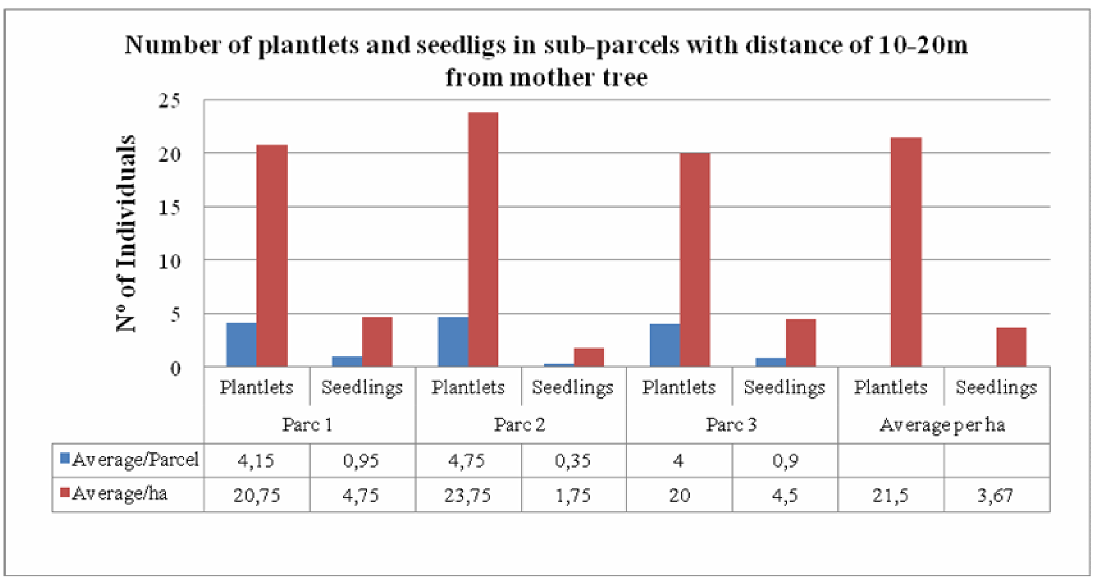
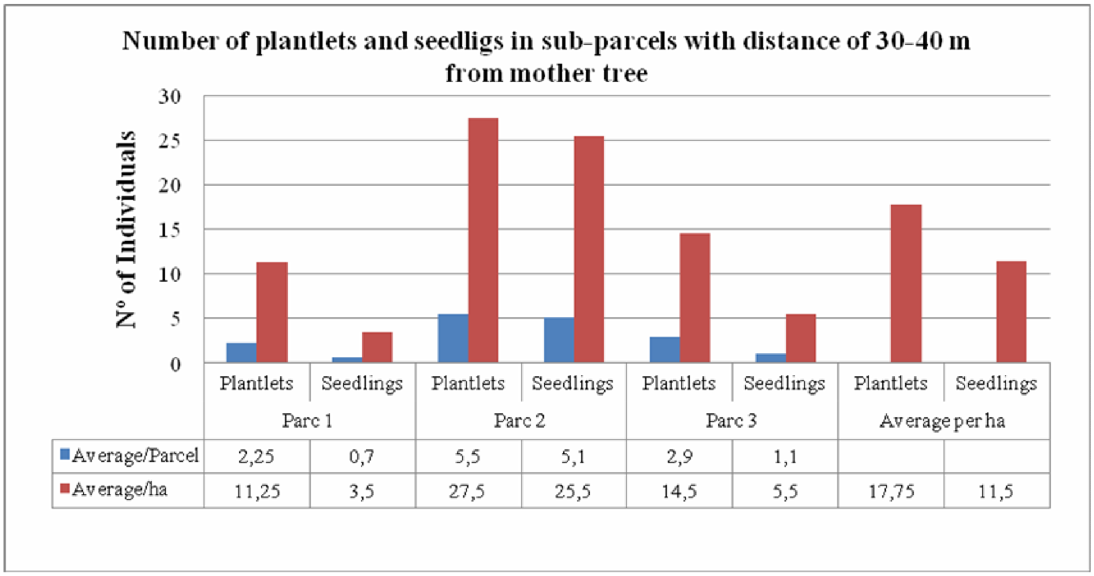
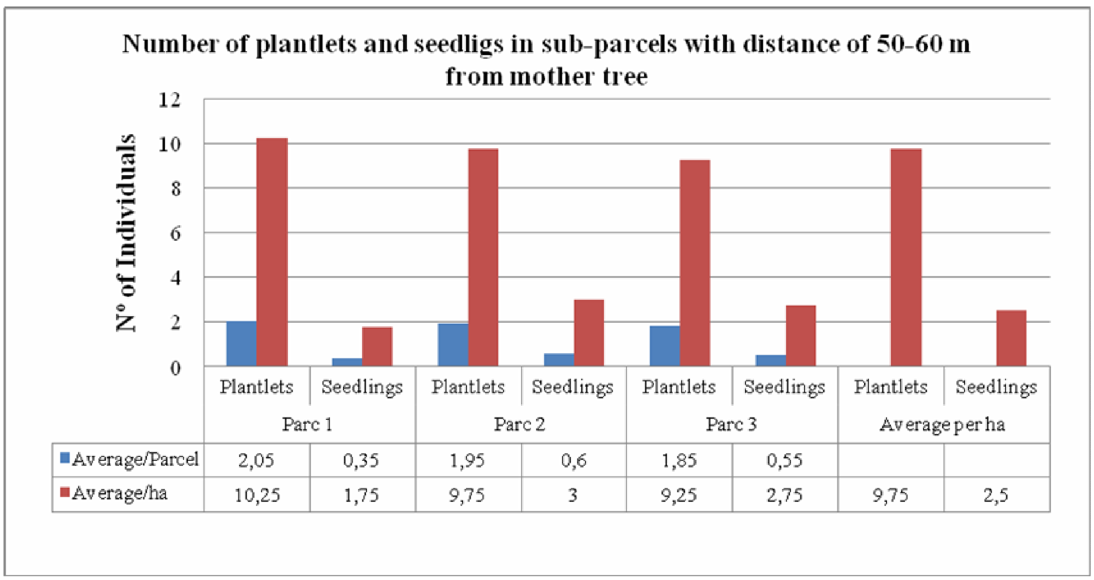


Figure 46 Average occurrence of mahogany plantlets and seedlings in a distance 30 - 40 meters from the sub-parcel to mother tree



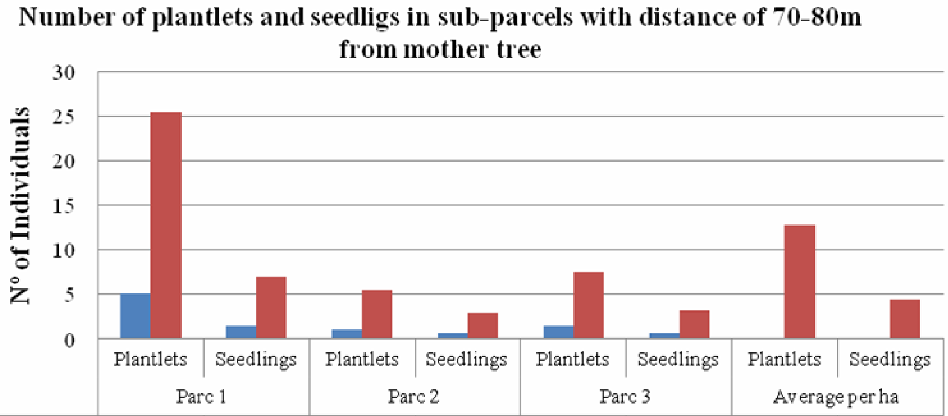
	Parc 1 Plantlets	Parc 1 Seedlings	Parc 2 Plantlets	Parc 2 Seedlings	Parc 3 Plantlets	Parc 3 Seedlings	Average per ha Plantlets	Average per ha Seedlings
Average/Parcel	2,25	0,7	5,5	5,1	2,9	1,1		
Average/ha	11,25	3,5	27,5	25,5	14,5	5,5	17,75	11,5

Figure 47 Average occurrence of mahogany plantlets and seedlings in a distance 50 - 60 meters from the sub-parcels to mother tree



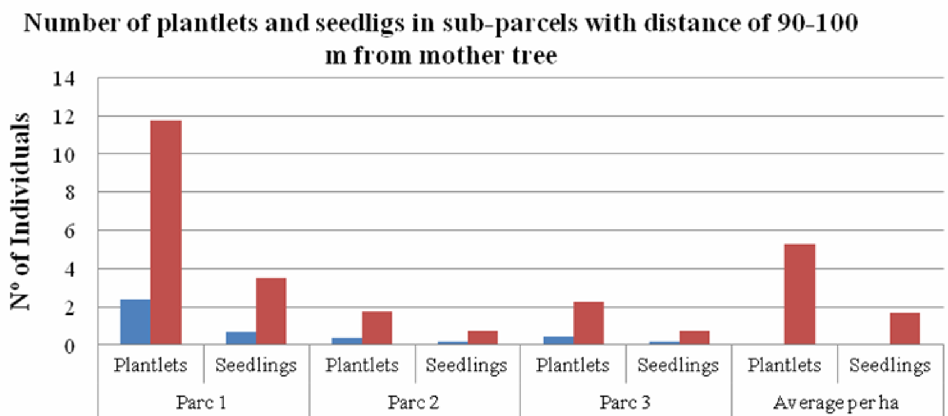
	Parc 1 Plantlets	Parc 1 Seedlings	Parc 2 Plantlets	Parc 2 Seedlings	Parc 3 Plantlets	Parc 3 Seedlings	Average per ha Plantlets	Average per ha Seedlings
Average/Parcel	2,05	0,35	1,95	0,6	1,85	0,55		
Average/ha	10,25	1,75	9,75	3	9,25	2,75	9,75	2,5

Figure 48 Average occurrence of mahogany plantlets and seedlings in a distance 70 - 80 meters from the sub-parcels to mother tree



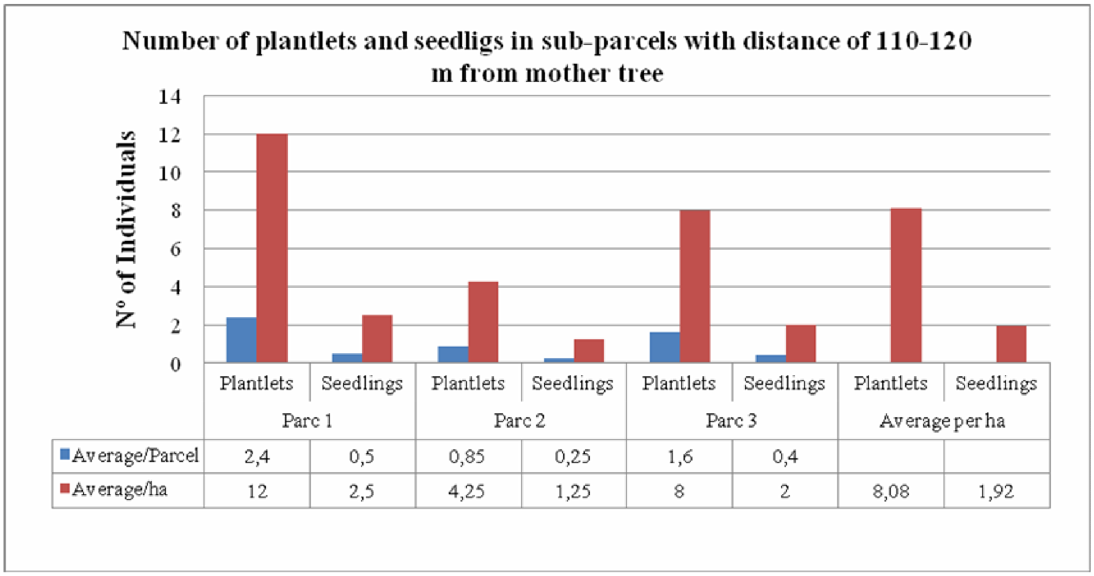
	Parc 1 Plantlets	Parc 1 Seedlings	Parc 2 Plantlets	Parc 2 Seedlings	Parc 3 Plantlets	Parc 3 Seedlings	Average per ha Plantlets	Average per ha Seedlings
Average/Parcel	5,1	1,4	1,1	0,6	1,5	0,65		
Average/ha	25,5	7	5,5	3	7,5	3,25	12,83	4,42

Figure 49 Average occurrence of mahogany plantlets and seedlings in a distance 90 - 100 meters from the sub-parcels to mother tree



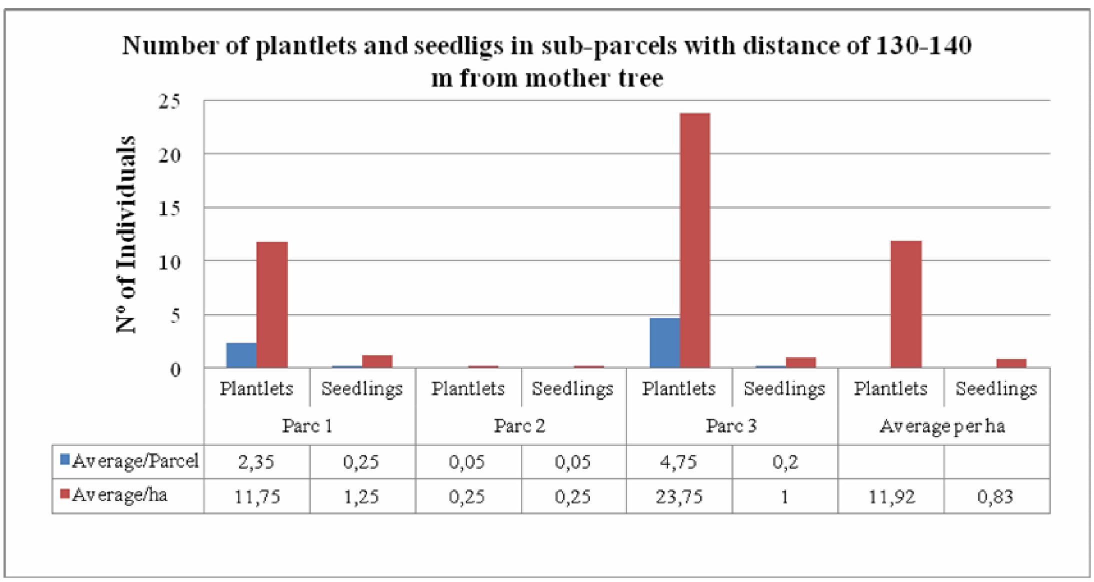
	Parc 1 Plantlets	Parc 1 Seedlings	Parc 2 Plantlets	Parc 2 Seedlings	Parc 3 Plantlets	Parc 3 Seedlings	Average per ha Plantlets	Average per ha Seedlings
Average/Parcel	2,35	0,7	0,35	0,15	0,45	0,15		
Average/ha	11,75	3,5	1,75	0,75	2,25	0,75	5,25	1,67

Figure 50 Average occurrence of mahogany plantlets and seedlings in a distance 110 - 120 meters from the sub-parcels to mother tree



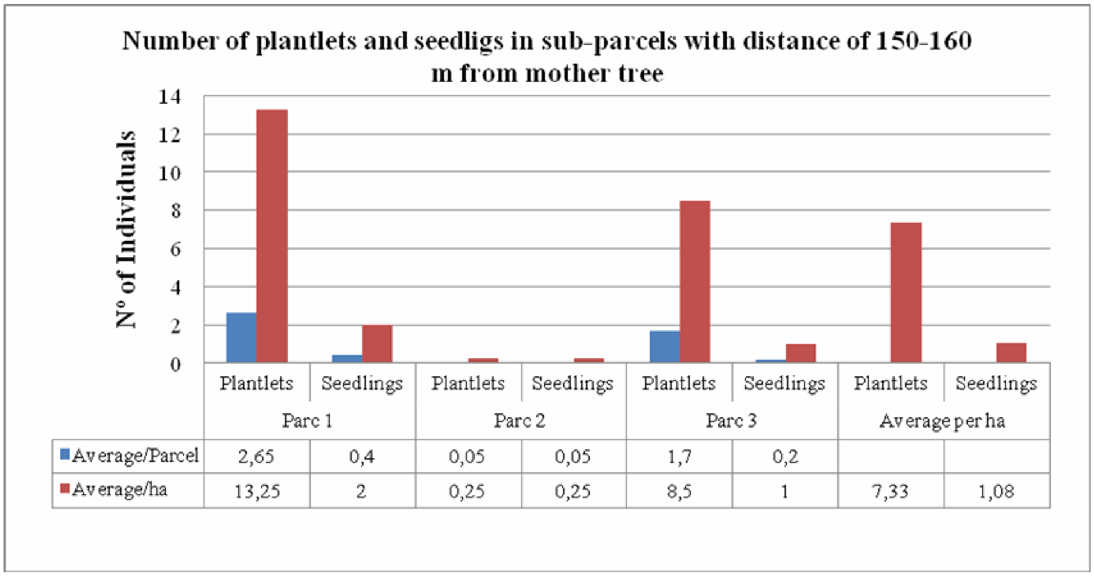
	Parc 1		Parc 2		Parc 3		Average per ha	
	Plantlets	Seedlings	Plantlets	Seedlings	Plantlets	Seedlings	Plantlets	Seedlings
Average/Parcel	2,4	0,5	0,85	0,25	1,6	0,4		
Average/ha	12	2,5	4,25	1,25	8	2	8,08	1,92

Figure 51 Average occurrence of mahogany plantlets and seedlings in a distance 130 - 140 meters from the sub-parcels to mother tree



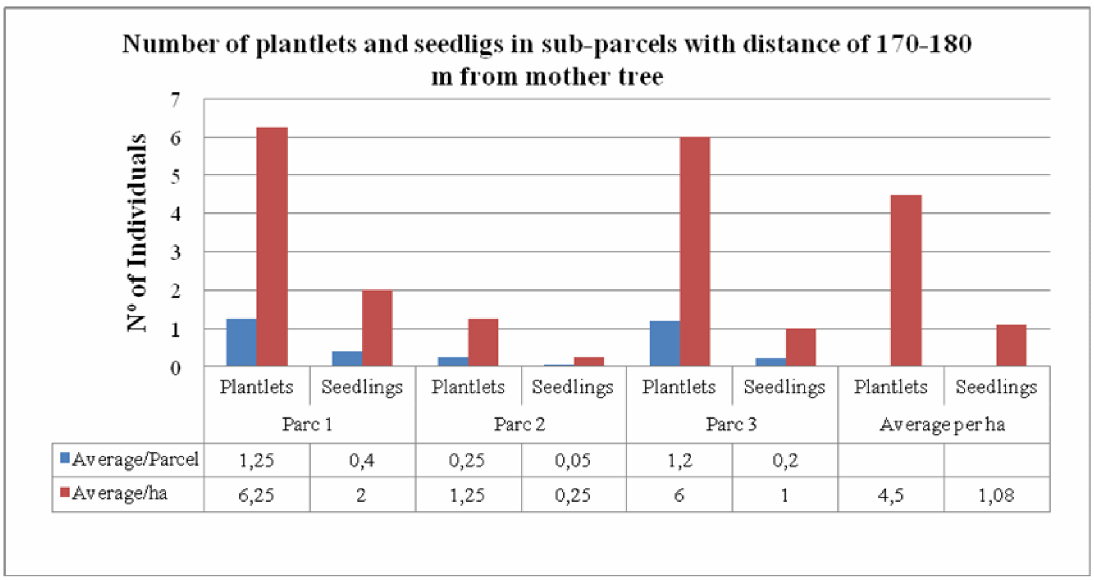
	Parc 1		Parc 2		Parc 3		Average per ha	
	Plantlets	Seedlings	Plantlets	Seedlings	Plantlets	Seedlings	Plantlets	Seedlings
Average/Parcel	2,35	0,25	0,05	0,05	4,75	0,2		
Average/ha	11,75	1,25	0,25	0,25	23,75	1	11,92	0,83

Figure 52 Average occurrence of mahogany plantlets and seedlings in a distance 150 - 160 meters from the sub-parcels to mother tree



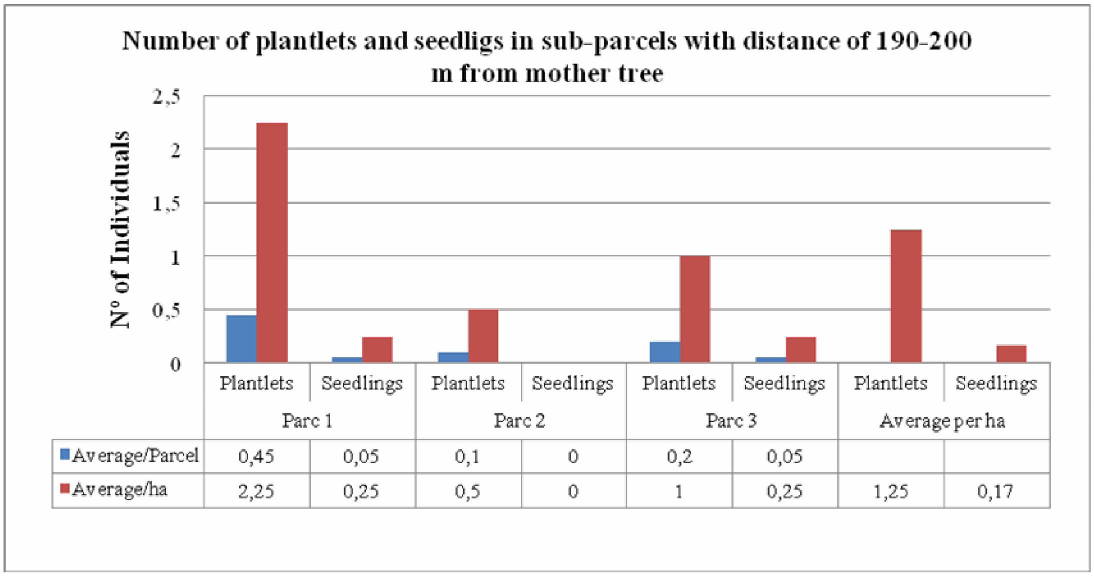
	Parc 1		Parc 2		Parc 3		Average per ha	
	Plantlets	Seedlings	Plantlets	Seedlings	Plantlets	Seedlings	Plantlets	Seedlings
Average/Parcel	2,65	0,4	0,05	0,05	1,7	0,2		
Average/ha	13,25	2	0,25	0,25	8,5	1	7,33	1,08

Figure 53 Average occurrence of mahogany plantlets and seedlings in a distance 170 - 180 meters from the sub-parcels to mother tree



	Parc 1		Parc 2		Parc 3		Average per ha	
	Plantlets	Seedlings	Plantlets	Seedlings	Plantlets	Seedlings	Plantlets	Seedlings
Average/Parcel	1,25	0,4	0,25	0,05	1,2	0,2		
Average/ha	6,25	2	1,25	0,25	6	1	4,5	1,08

Figure 54 Average occurrence of mahogany plantlets and seedlings in a distance 190 - 200 meters from the sub-parcels to mother tree



In all distances considered in the sub-parcels, individuals of plantlets and seedlings were registered. This occurrence varied on average from 1.25 individuals per ha to 21.5 individuals per hectare for plantlets and from 0.17 to 11.5 individuals per ha for seedlings.

In general, the trend is the decrease of occurrence of individuals of both plantlets and seedlings as the sub-parcels surveyed became more distant from mother tree, but with peaks of occurrence observed at a distance of 10-20 m, 70-80 m, and 130-140 m for plantlets and 30-40 m and 70-80 m for the seedlings stratum.

On the other hand, despite the proposed methodology for the field survey included young trees and saplings, in this study there was no occurrence of individuals in these strata in any of the 600 inventoried parcels.

In the sub-parcels of 10-20 m of distance from mother trees, the high concentration of number of plantlets was 21.5 individuals per ha, and the third largest concentration of seedlings per ha (3.67 ind./ha) have been registered. For distances from 30 to 40 m, a high occurrence of seedlings with 11.5 individuals per ha was registered, but from this distance there is a trend of reduction of occurrence.

At the distance from 50 to 60 m, the average number of plantlets per ha recorded was 9.75 individuals per ha showing a slight decrease of this stratum. The average number of seedlings in that sub-parcel was 2.50 individuals per ha, showing a significant decline of record of this stratum in relation to the previous sub-parcels.

In the sub-parcels of 70-80 m, there was an increase in number of plantlets per ha (12.83 ind./ha) and in number of seedlings per ha (4.42 ind./ha) compared to the previous sub-parcels.

At the distance from 90 to 100 m, there was a reduction in the registration of plantlets and seedlings, compared to the previous distance, the decrease was significant in more than half of the average of the total per ha, that is, 5.25 individuals per ha for plantlets, and 1,67 individuals per ha for seedlings.

In the sub-parcels from 110 to 120 m, there was an increase in number of seedlings per ha and also a slight increase in the average (8.08 ind./ha) of number of individuals of mahogany seedlings. However, there was no significant increase in the registration of the seedling stratum.

In the sub-parcels from 130 to 140 m, there was an increase (peak) in the average of plantlets (11.92/ha), this significant increase is due to the fact that it suffered the influence of dispersion of a mahogany tree located in the surrounding area of that sub-parcel. In the seedling stratum, there was a slight decrease in the average (0.83 ind./ha); from this sub-parcel to the last sub-parcel (190 - 200 m) is noted a certain stabilization in the total number of seedlings.

From distances of 150-160 m, the number of plantlets individuals per ha presented a decrease (7.33 ind./ha); on the other hand, the seedlings stratum remained practically stable (0,83 ind./ha) up to the distance of 170 - 180 m.

In the last sub-parcels (190 - 200 m), it was registered low rates of occurrence of plantlets and seedlings, which was 1.25 and 0.17 individuals per ha, respectively. Despite the distance is significant, there was the occurrence of two seedlings in this distance.

4.3.2 Evaluation of Occurrence of Plantlets and Seedling in Selected Trees for Silvicultural Treatments

The result of the occurrence of individuals of the plantlet and seedling strata in the 20 selected trees in the study area to receive silvicultural treatments in pre-logging measurement is shown in Table 28 and Figure 55.

Table 30 Total number of occurrence of individuals of the plantlet and seedling strata per hectare and per selected tree

Tree	*Total (individuals/ha)*			*Total (individuals /ha)*	
	Plantlets	*Seedlings*	*tree*	*Plantlets*	*Seedlings*
1	89.99	3.33	11	1579.84	46.66
2	909.91	166.65	12	89.99	0.00
3	0.00	0.00	13	209.98	3.33
4	179.98	10.00	14	2549.75	69.99
5	519.95	59.99	15	1009.90	129.99
6	50.00	0.00	16	89.99	0.00
7	289.97	46.66	17	359.96	26.66
8	30.00	6.67	18	89.99	3.33
9	1989.80	276.64	19	0.00	0.00
10	1579.84	303.30	20	309.97	0.00

Figure 55 Occurrence of total number of individuals per hectare of plantlets and seedlings in 20 selected trees for regeneration study

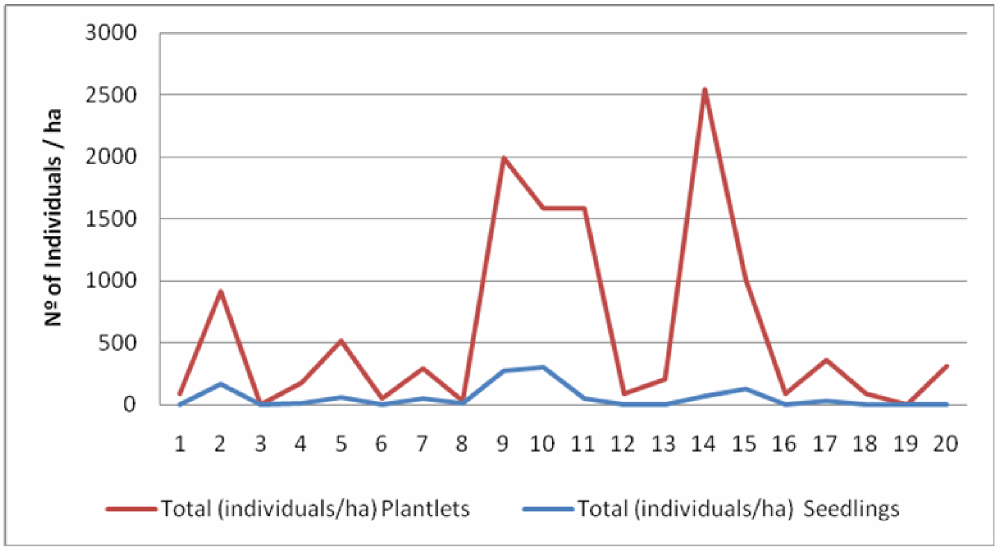


Figure 55 shows the variation of the occurrence of plantlets and seedlings in the UPA-1R area. The total number of plantlets per hectare varies greatly among 20 trees randomly selected from the population in order to represent their occurrence of these strata. The trees number 2, 9, 10, 11 and 14, registered the highest peaks of occurrence of plantlets, while the trees number 3 and 19 did not register individuals in this stratum.

In the seedling stratum, the trees number 2, 9 and 10, as for plantlets presented high occurrences of individuals of this stratum. However, the tree number 14 that presented high occurrence of plantlets did not maintain the same trend in the occurrence of individuals in the seedling stratum.

As stated above, despite the methodology of this project has foreseen measurement of the sapling (2.5 ≤ DBH <5.0 cm) and young tree (5.0 ≤ DBH ≤ 9.9 cm) strata, there was no occurrence of individuals in these strata in the 20 selected mahogany trees to evaluate regeneration. Due to the location of the study area which is in the border of Acre and Amazonas states, at the mouth of Acre, this region presents considerable presence of the genus *Guadua* bamboo that could be directly have influenced the mortality of plantlets and seedlings, as there is a large area with this species in the forest as a whole and in the sub-parcels as well.

In areas where there are large forest openings and, with the possibility of influence of seed dispersal by other large mahogany trees, the record of plantlets was expressive, which was numbered the tree number 14, which supposedly occurred in these conditions, in which seeds reached a distance from 130 to 140 m of the trunk, a density of 87 plantlets (2,550 plantlets/ha).

As to seedlings, the total number in the area is much less in comparison with plantlets, in which high concentration of this stratum is found in the mahogany tree number 10 (303.30 seedlings/ha); trees numbers 9, 2 and 15 present, respectively, high rates of seedlings in the area. There were no reports of seedlings in the trees numbers 3, 6, 12, 16, 19 and 20, equivalent to 30% of sampled trees (Table 30).

4.3.3 Occurrence of Plantlets and Seedlings in Relation to Distance from Mother Tree

In order to know the seed dispersal capacity of a mahogany mother tree in a surrounding area, particularly towards the direction of prevailing winds, sub-parcels of 10 m x 10 m were measured at different distances from tree trunk to evaluate the occurrence of mahogany individuals in different plantlets and seedlings strata, once the sapling and young tree strata were not recorded in the sampling, as shown in Table 29, Table 30 and Figure 56.

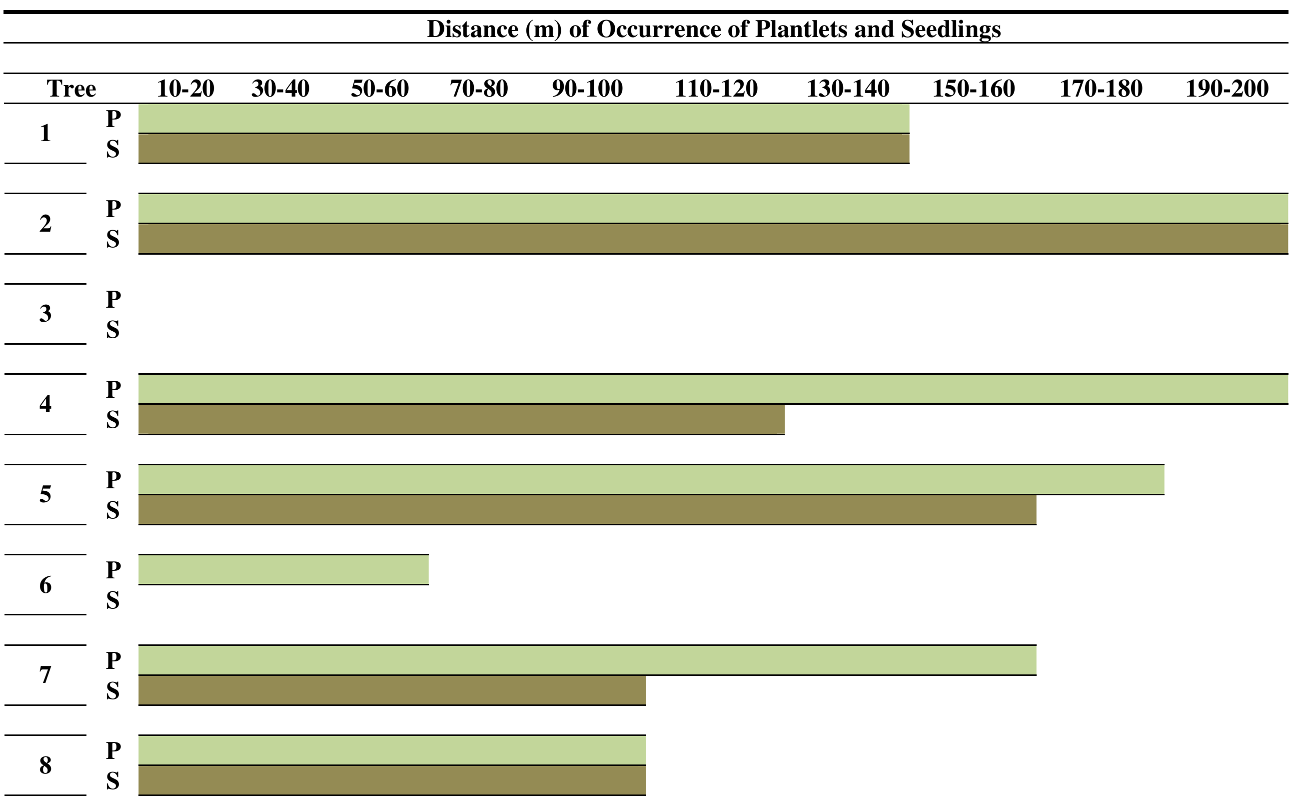
Table 31 Total seedlings per ha at distances from 10-20 m to 190-200 m of 20 mahogany trees

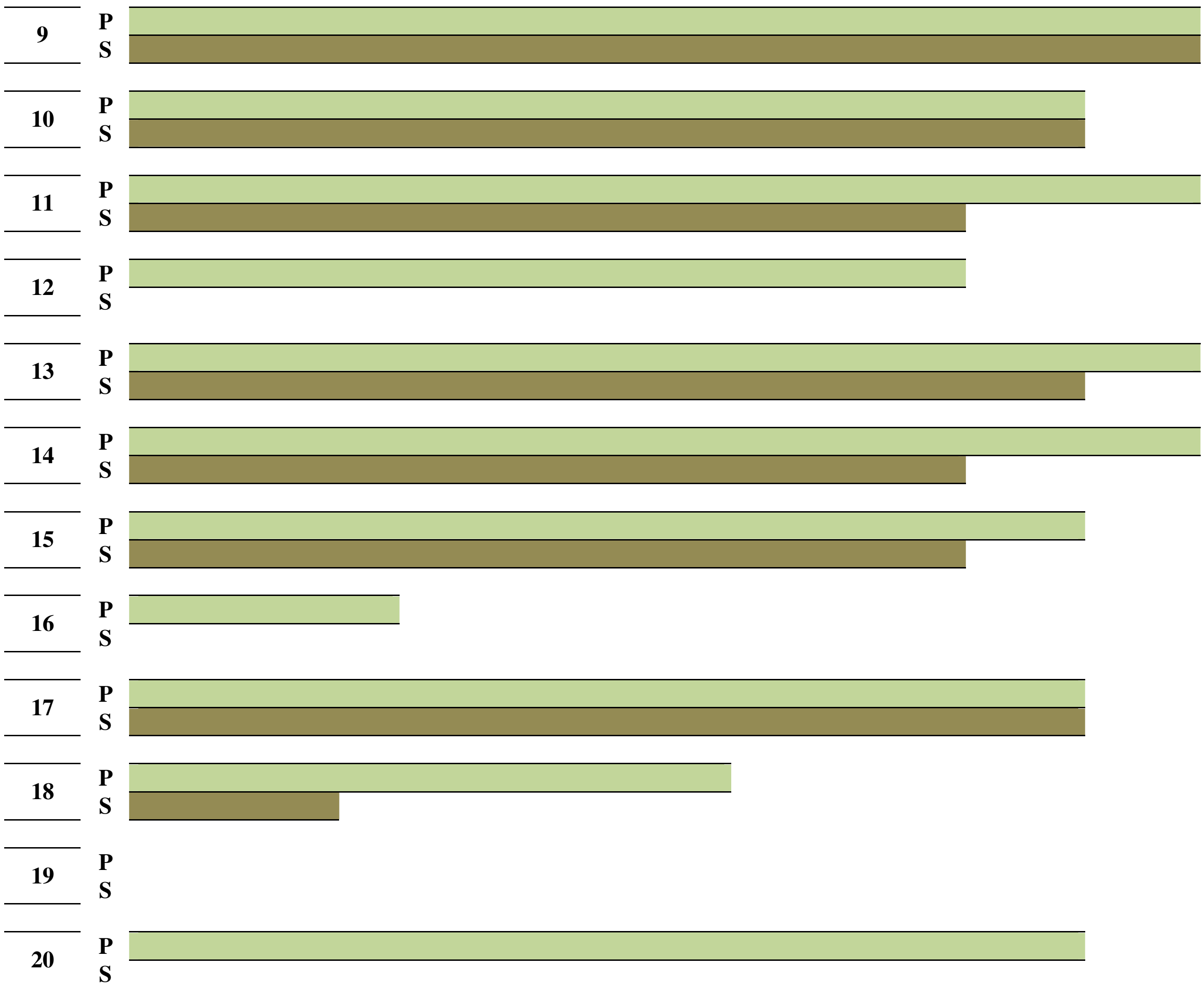
	PLANTLETS									
	Distances (m)									
Tree	**10 – 20**	**30 – 40**	**50 -60**	**70 - 80**	**90 - 100**	**110 - 120**	**130 - 140**	**150- 160**	**170 - 180**	**190 – 200**
1	99,99	0	0	0	0	0	199,98	0	0	0
2	1333,2	966,57	99,99	0	66,66	33,33	133,32	299,97	0	99,99
3	0	0	0	0	0	0	0	0	0	0
4	199,98	66,66	66,66	33,33	0	66,66	33,33	33,33	66,66	33,33
5	266,64	333,3	366,63	33,33	0	199,98	66,66	333,3	133,32	0
6	99,99	0	66,66	0	0	0	0	0	0	0
7	366,63	299,97	133,32	33,33	33,33	33,33	33,33	33,33	0	0
8	0	0	0	0	99,99	0	0	0	0	0
9	1733,16	1066,56	333,3	1433,19	599,94	599,94	333,3	133,32	233,31	166,65
10	1733,16	1599,84	699,93	366,63	533,28	199,98	0	399,96	33,33	0
11	433,29	1133,22	633,27	1933,14	233,31	33,33	433,29	299,97	99,99	33,33
12	33,33	0	0	133,32	0	66,66	0	66,66	0	0
13	0	133,32	33,33	33,33	0	99,99	0	199,98	166,65	33,33
14	899,91	833,25	399,96	366,63	299,97	1133,22	2899,71	766,59	766,59	133,32
15	599,94	566,61	633,27	466,62	199,98	499,95	266,64	99,99	33,33	0
16	166,65	66,66	66,66	0	0	0	0	0	0	0
17	133,32	33,33	166,65	66,66	0	133,32	366,63	199,98	99,99	0
18	66,66	0	99,99	0	0	133,32	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
20	433,29	0	99,99	233,31	33,33	0	0	66,66	166,65	0

Table 32 Total seedlings per ha at distances from 10-20 m to 190-200 m of 20 mahogany trees

SEEDLINGS										
	Distances (m)									
Tree	**10-20**	**30-40**	**50-60**	**70-80**	**90-100**	**110-120**	**130-140**	**150-160**	**170-180**	**190-200**
1	0	0	0	0	0	0	33,33	0	0	0
2	433,29	866,58	33,33	199,98	33,33	0	0	33,33	33,33	33,33
3	0	0	0	0	0	0	0	0	0	0
4	0	66,66	0	0	0	33,33	0	0	0	0
5	366,63	133,32	0	66,66	0	0	0	33,33	0	0
6	0	0	0	0	0	0	0	0	0	0
7	0	266,64	33,33	99,99	66,66	0	0	0	0	0
8	0	0	0	33,33	33,33	0	0	0	0	0
9	233,31	799,92	133,32	733,26	333,3	299,97	99,99	0	99,99	33,33
10	266,64	1633,17	199,98	333,3	66,66	66,66	99,99	166,65	199,98	0
11	33,33	99,99	33,33	199,98	33,33	33,33	0	33,33	0	0
12	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	33,33	0
14	33,33	233,31	233,31	33,33	0	66,66	33,33	66,66	0	0
15	99,99	433,29	333,3	66,66	33,33	199,98	33,33	99,99	0	0
16	0	0	0	0	0	0	0	0	0	0
17	0	33,33	0	0	66,66	66,66	33,33	0	66,66	0
18	0	33,33	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0

Figure 56 Distance of occurrence of plantlets and seedlings in relation to the tree





* P = plantlets; ** S = Seedlings

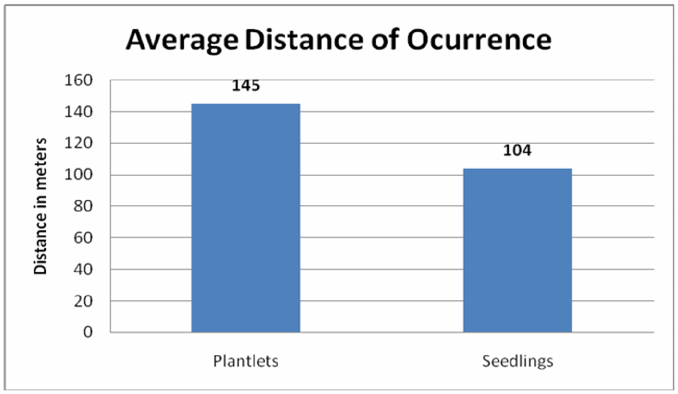
Figure 56 shows the variation in the occurrence of plantlets and seedlings of 20 mahogany trees related to distances, where the ranges of respective distances mentioned represent 600 even sub-parcels that were surveyed in the study area.

Gullison et al (1996) states that, "mahogany young trees require high sunlight and forest openings to grow rapidly in height." The absence of occurrence of plantlets and seedlings in the young tree stratum mentioned above show that these results corroborate data from the cited literature.

The occurrence of plantlets individuals although in some trees (2) have not occurred, in most other trees reached distances ranging from 160 to 200 m. Thus, on average individuals in the plantlet stratum are distributed to a radius of 145 meters from the trunk of mother tree.

For individuals of the seedling stratum, the number of trees with zero occurrence corresponded to 30%, and even though it occurred up to a distance of 200 meters as it occurred with mahogany tree number 2; on average, seedlings are distributed to 104 meters of distance from the trunk of mother tree (Figure 57).

Figure 57 Distance of occurrence of individuals of the plantlet and seedling strata in relation to the trunk of mother tree



Regarding the variation and trend of the occurrence in terms of distances is shown in Table 31 and Figure 58.

Table 33 Total number of plantlets and seedlings per ha in the dispersion distance of 60 parcels of regeneration induction

Distances (m)	***Nº plantlets/ha***	***Nº seedlings /ha***
10 - 20	21,50	3,67
30 - 40	17,75	11,5
50 – 60	9,75	2,5
70 – 80	12,83	4,42
90 – 100	5,25	1,67
110 - 120	8,08	1,92
130 - 140	11,92	0,83
150- 160	7,33	1,08
170 - 180	4,50	1,08
190 - 200	1,25	0,17

Figure 58 Average of individuals of plantlets and seedlings per ha at distances from 10 to 20 m to 190-200 m

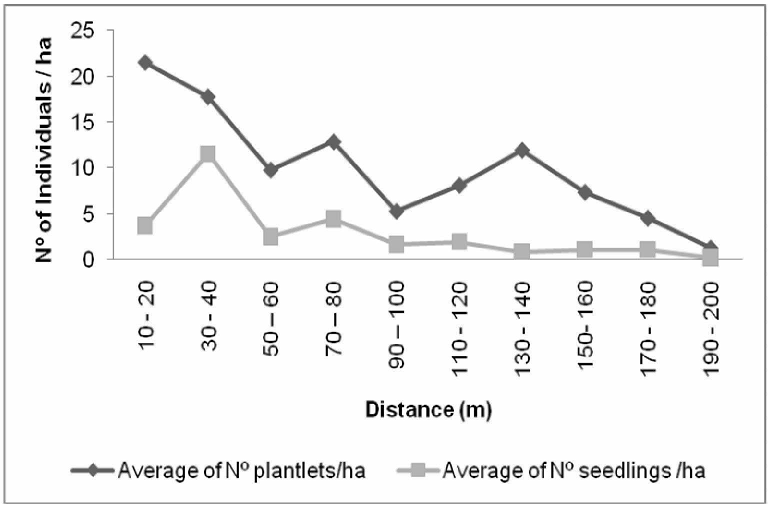


Table 58 and Figure 31 show the number of plantlets and seedlings per ha that occurred over the range of 200 m in parcels of mahogany regeneration. As mentioned before, both plantlets and seedlings individuals occur on average in all classes of distances studied; the number of plantlets (newly germinated seeds) always present in greater density (individuals/ha) over the distances in relation to seedlings; however, both strata follow the same trend of occurrence decreasing as distance from the trunk of mother tree increases.

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