CATIE Tropical Agricultural Research and Higher Education Center

Ecological and economic factors affecting the *sustainable* production of camedor palm (*Chamaedorea elegans* Mart) in Petén, Guatemala and Veracruz, Mexico.

By

Angel Sol-Sánchez

Turrialba, Costa Rica. December, 2007

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Thesis submitted to the consideration of the Graduate School to opt for the degree of Doctor Philosophy at the CATIE Ph.D. Program

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Declaration

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If my hands were filled with truths

I would keep it tightly closed

But if you need one

Remember that I have two hands.

Bernard Le Bouvier de Fontenelle

San Augustine

Dedication

To my family: Virginia, Angel, Cynthia Guadalupe because without them, my path would have been harder to follow. Likewise to Christopher **(†)**, my small son who came to bring us major joy to our family and life by a short time, but that the destiny fit us of our hands in December 2006. May he rest in peace (R.I.P.)

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Biography

Angel Sol-Sanchez was born in the state of Tabasco, Mexico, in August 2, 1966. There, he completed his academic formation. He attended Elementary School Benito Juarez Garcia and later on, High School Num 10. He completed his Bachelor studies in the Center for Industrial and Technological Bachelor Studies and Services Num 93.

His academic formation was carried out in Juarez Autonomous University of Tabasco, where he completed a career of Biology, focused on the taxonomy of plants, from 1985 to 1990.

In 1994-1995, he completed his master's degree studies in Tropical Agroecosystems at the Postgraduate College in Veracruz, Mexico. In 2001, he began his Ph.D. studies in CATIE, in the Department of Biodiversity and Forest.

He worked for two years as a researcher in Mexico's Federal Electricity Commission. From 1992 until know, he has been a researcher in the Graduate College of Tabasco in the Department of Genetic Resources and Productivity (IREGEP). At the same time, he has been a professor and has participated in courses regarding Tropical Fruits Production and Weeds Management in Plantations. Also, he has been in charge of the courses of Diversity Index Management, and Flora Management, in the Juarez Autonomous University of Tabasco, School of Biology. He has taught the course of Agroecology for veterinarians at the Popular University of Chontalpa.

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Chapter I.

Ecological factors that regulate the commercial production of *Chamaedorea elegans* palm leaves in natural conditions

Abstract

Ecological conditions where *Chamaedorea elegans* grows were studied in three locations in Guatemala and two in Mexico from July 2004 to July 2005. Shade, soil types, slope, primary or secondary forest, were the variables analyzed to group the sites. Shade trees and relative values of dominance, density, frequency, and importance value were estimated in order to group the type of trees found in the sampling plots. Diversity index dissimilarity and Sörensen indexes were applied.

Four types of sites and three groups of shade trees were obtained for Petén. For Mexico, three groups of sites and four groups of shade trees were also obtained. Shade tree numbers were 113 in 13,500 m^2 for Guatemala and 83 for Mexico in 9000 m^2. Shade was irregular, but 68 % was the percentage where most leaves were harvested. Seeds production was higher in areas that received greater sunlight percentages during the blossom season.

Leaf cut frequency was three times in Guatemala and five in Mexico per year. Harvests were done every 76 days on average in both countries. In Guatemala 7,523 leaves were evaluated, but only 21 % were commercialized, the rest lost their quality during their growth. In México, 32,133 leaves were evaluated and commercialized during the year.

Shannon's Index value was 2.51 for Carmelita, 2.58 for Oaxactúm and 2.55 from Suculté. The Duncan test did not show significant differences for this index. Pearson's correlation for commercial leaves and species showed a negative correlation of 70 % with a significance of 96 % and an alpha = 0.05 %.

For Mexico, the Shannon Index value was 2.69 for Pajápan and 2.28 for San Fernando, and had a positive correlation of 89 % with a significance of 98 % and alpha = 0.05 %. The Duncan test showed significant differences in species and fronds with an alpha = 0.05 %. The Dissimilarity index for Guatemala showed a very close relation in the number of species.

The Sörensen index showed that Carmelita and Suculté were the most similar communities because 40 % of the species were common in both locations. In Mexico the dissimilarity index showed that the number of species was 98.9 % common; The Sörensen index showed that 23 % were common species for both locations.

In Carmelita camedor palm plants grown in a wider rank of shade, but in Oaxactúm and Suculté this rank was narrower. In Pajápan, the highest production of leaves was reached in places from 66 % to 70 %, shade, while that in San Fernando the highest production of leaves was from 71 to 75 % shade. The total leaves evaluated in the sampling plots were in Guatemala 7,532 from which 17.7 % were for Carmelita, 20 % for Oaxactúm and 62.3 % for Suculté. In Mexico this volume was 32,133 from which 48 % for Pajápan and 52 % for San Fernando in Mexico. In most of the cases, the taller the plant, the higher the percentage of commercial leaves.

Fourteen companies in Guatemala and one in Mexico bought all the camedor palm leaves produced in both countries. In the productivity chain, it was estimated that at least 5 levels participate in the camedor palm commercialization, with different prices in each level. Finally, to establish a plantation of a hectare of this palm, a minimal initial inversion of US $2,390 for the two first years is required.

Resumen

De julio del 2004 a julio del 2005 se estudiaron las condiciones ecológicas en las cuales crece la palma camedor *Chamaedorea elegans* en tres localidades de Guatemala y dos de México. El estudio se llevo a cabo entre julio del 2004 y julio del 2005. En cada localidad se establecieron tres parcelas permanentes de monitoreo de 500 m^2 con 5 unidades de observación de 100 m^2 cada una y tres repeticiones. Las variables evaluadas para cada sitio fueron: porcentaje de sombra, pendiente, grado de conservación del bosque y se hizo un inventario de especies de árboles de sombra > a 5 cm. Calcularon los valores relativos de dominancia, densidad, frecuencia así como el valor de importancia para el análisis de cluster. En las comunidades de Carmelita y Oaxactúm en Guatemala, las parcelas permanentes de muestreo se establecieron dentro del bosque natural; y en Suculté, Guatemala, San Fernando y Pajápan en México, estas se establecieron en plantaciones comerciales.

Para la palma camedor, las variables evaluadas fueron: número de plantas de palma camedor por unidad de observación, altura, frondas totales, frondas comerciales, longitud de las frondas comerciales, plantas con flores y/o frutos, número de frutos por planta, presencia de meristemo apical y frecuencia de cosecha.

Se registró la presencia de 113 especies de árboles para Guatemala en 13500 m^2 y 83 para México en 9000 m^2. Para las comunidades del Petén se encontró que existen cuatro grupos de sitios donde crece la palma y tres grupos de árboles de sombra, y para México se registro la presencia de tres grupos de sitios donde se cultiva la especie y cuatro grupos de árboles de sombra.

Los porcentajes de sombra registrados fueron variables desde 25 % hasta 80 % en Guatemala, y de 66 % a 85 % en México; el porcentaje bajo el cual se evaluó y cosecho mayor volumen de frondas fue 68 %. La producción de semillas fue 4.5 veces mayor en áreas que recibieron mayores porcentajes de luz solar durante la floración. La frecuencia de cosecha anual fue tres veces en Guatemala y 5 veces en México. La cosechas se realizaron cada 76 días en promedió. En Guatemala se evaluaron 7,523 frondas, pero solo el 21 % mantuvieron su calidad para ser comercializadas, mientras que en México el total de hojas evaluadas y comercializadas fue de 32,133.

El índice de diversidad de Shannon para árboles de sombra obtenido para cada localidad fue de 2.51 para Carmelita, 2.58 para Oaxactúm y 2.53 para Suculté. Estadísticamente no hubo diferencias significativas para estos valores con un alpha al 0.05 %. El análisis de varianza para frondas, especies de árboles de sombra y porcentaje de sombra mostró diferencias significativas solo para frondas evaluadas en las comunidades (P<0.0001) y alpha = 0.05 %. La prueba de Duncan mostró diferencias estadísticas significativas para especies de árboles de sombra y frondas con un alpha = 0.05 %.

El análisis de correlación estadística de Pearson para árboles de sombra-frondas comerciales mostró una correlación negativa de 70 % con un nivel del significancia de 96 % y un alpha = 0.05 %

Para México el índice de diversidad de Shannon fue 2.69 para Pajápan y 2.28 para San Fernando y mostró una correlación positiva de 89 % con un nivel de significancia del 98 % y un alpha al 0.05 % para las variables árboles de sombra-frondas. El análisis de varianzas para estas localidades no mostró diferencias significativas entre especies de sombra, frondas y porcentaje de sombra (alpha = 0.05 %). La prueba estadística de Duncan no mostró diferencias significativas en especies de sombra, frondas, ni porcentaje de sombra

Para Guatemala el índice de disimilaridad de Sneath y Sokal mostró una relación muy estrecha en la estructura arbórea, siendo Carmelita y Suculté las comunidades más disimilares en sus componentes, pero un 40 % fueron especies comunes a ambos sitios de acuerdo al índice de similitud de Sörensen.

En México el índice de disimilaridad fue de 0.018, eso significa que son comunidades muy semejantes, en cuanto a estructura, asimismo el índice de similitud de Sörensen mostró que 23 % de las especies registradas son comunes para ambas comunidades.

Del total de hojas de palma camedor estudiadas en Guatemala, el 84.4 fueron cosechadas en su tamaño comercial mínimo (25 cm.). De ese total el 17.7 % fueron colectadas en Carmelita, 20 % en Oaxactúm y 62.3 % en Suculté. En México las frondas cosechadas tuvieron una distribución más homogénea entre las tallas comerciales, y el 48 % correspondió a Pajápan y 52 % a San Fernando.

Se encontró que existe una relación entre la altura de la planta y el número de hojas comerciales en 4 de las 5 comunidades estudiadas; a mayor altura, mayor numero de hojas comerciales. El precio de mercado local de las hojas fue variable, una gruesa de 100 hojas fue pagada en US $ 0.48 en Guatemala y en US $ 0.89 en México. La presencia de plagas fue registrada para las plantaciones de palma camedor en México, pero no en Guatemala. A su vez algunas enfermedades causadas por hongos principalmente se manifestaron en Guatemala, causando la muerte de algunas plantas, pero no en México.

Las compañías que comercian el producto son 14 para Petén Guatemala y una para México. En la cadena de custodia participan 5 niveles, cada uno agrega un proceso al comercio de la palma camedor e incrementa el precio. Finalmente se calculó la relación beneficio costo para establecer una hectárea de palma camedor en México y se estima que se requiere de una inversión inicial de 2,390 dólares para el año 1 y 2 en los cuales no hay ingresos por esta actividad. Sin embargo, la mayor parte del costo de establecimiento es absorbida por el gobierno Mexicano a través de paquetes tecnológicos y subsidios económicos para productores a través de organizaciones civiles sin fines de lucro.

1. Introduction

This dissertation is based on two papers and an integration of both, which are *included* as chapters 3, 4 and 5, but referred to as paper I and paper II in this document.

1.1 Problem statement

The distribution of the species *Chamaedorea elegans* Mart is restricted to the American continent, from Mexico to Guatemala (Hodel, 1992). However, due to its wide adaptation to different climates and temperatures as indoor plant this species has been distributed to all types of climates worldwide. Similarly, its leaves have been gathered for trade in the international market and its seeds have been used to cultivate indoor and outdoor potted plants (Eccardi, 2003). In addition to *C. elegans*, many species of this genus are cultivated in conservatories and greenhouses to meet the international demand as potted plants (CEC, 2003). Seeds of these species are in high demand by nurseries and florists in Mexico and the United States. In Mexico, seed collection takes place during the dry season (Hernandez, 2000). People usually go to the natural forest and collect the clusters of seeds; but as these species have irregular ripening of fruits, the cluster include mature fruits, partially mature fruits and developing fruits, this is due to inflorescences and flowers that open consecutively one after the other (Hodel, 1992.). For this reason, it is recommended to collect the mature fruits one by one or to wait until the cluster fruits are 75 % mature.

Although it is known that *Chamaedorea elegans* occurs in tropical areas, many aspects regarding plant management, harvest frequency, and ecological requirements as pollination, among others are unknown (Hodel, 1992). These aspects, combined with the overexploitation of leaves and the reduction of natural forests due to increased agriculture, cattle ranching, forest plantations and the establishments of new settlements have caused a progressive reduction of the natural populations of camedor palm (Hernández 2000; Ramón, 2001; Aguilar *et al.,* 2002. For example, in Tabasco, Mexico the greatest impact to this palm was caused in the 70`s with a project called “forced modernization of the tropics”, which eliminated 480,000 hectares of natural forest in order to build 22 *ejidos* (public lands) (Tudela, 1992). At the same time, similar projects were carried out in other locations in southern Mexico, with the consequent effects not only on camedor palm populations, but also on all plant species.

It is important to mention that there are currently information gaps concerning pollinator agents not only for this species but also for the genus in general (Hodel, 1992; Ramon 2001). Additionally, little is know about the biology of Chamaedorea species and isolated information is known about pests and diseases that attack these plants (Hodel, 1992; CEC, 2003). Projects like this one do not allow studying plants in their natural environment in some locations, and knowledge about them has been generated in forest fragments, nurseries, or greenhouses and inferences have been made about natural forest conditions. However, to obtain a sustainable camedor palm management, it is necessary to understand the factors linked to the success of the species in its natural environment (Aguilar *et al.,* 2002).

On the other hand, the combination of low production of seeds in natural populations, high demand for leaves, high percentage of waste and low local prices contribute to reduce the camedor palm populations. In addition, currently there are people who collect seeds of this palm in the natural populations, reducing the restoration of this species.

The commerce with middlemen is important because people in the communities look to obtain enough money to meet their needs; however the current tendencies are to commercialize directly their products (Aguilar *et al.,* 2002). The harvesters harvest the leaves whenever they can, but the income scarcely increases because the intermediary usually buys the product cheaper than the storage center or regional storage center. This forces the gatherers to increase harvest volumes. All of these interrelated factors constitute the main problem statement of *Chamaedorea elegans* in both countries where it was studied. Projects focused on conservation and rational use of camedor palm, could help to protect it and turn it into a more sustainable and profitable activity in the locations where it is exploited.

Although certification is being considered as a possibility, and Carmelita and Oaxactúm have begun to sell certified camedor palm leaves, it would take a long time to see the results, and to discern the impact on the restoration of wild populations of this species and the social benefits (CONAP, 2004).

Because this plant requires specific ecological conditions only grows in the tropical forest as small spots, so when gatherers find these spots of plants they harvest all leaves they can, it constitutes a disadvantage for the species if it taken in account that in the forest the camedor palm produce few leaves annually, and that also produce few seeds per plants. In addition, when some seeds are produced they take long time to germinate (Hernandez, 2000; Ramón, 2001; Eccardi, 2003; CEC, 2003; Quevedo, 2004). On the other hand, the excessive number of gatherers who are transported by companies from one location to another to gathers the palm leaves constitute a threat because they collect all types of leaves close to the camping site and then they move to other sites (Sanchez-Carrillo et al., 2003).

Until now, the gatherers' lack of training in camedor palm management in natural populations has resulted harmful to the species because gatherers do not know how to avoid resource deterioration and depletion of the camedor palm population. A similar effect has been seen in forest areas, because when local people cut wood from the forest, the cut trees crush many palm plants, as the area affected by a cut down tree varies from 213.28 m^2 to 926.62 m^2 on average (Monroy 1999, CEC 2003).

Finally, in general, because the government has not attended completely to the rural needs, people have survived by generating their income from the forest, depleting it in overexploited areas. However, socially these communities must be integrated with development programs to facilitate their way of living and to protect fragments of forest in all areas where natural forest currently occurs (Ramirez, 1999).

1.2 objectives

Paper I

The objectives of this study are to identify the different forms of camedor palm domestication and to determine its productivity and yield in comparison with the production obtained from wild populations, focusing on ecological, economic and social aspects

Paper II

1. To determine the yield of camedor palm leaves in wild populations and plantations considering ecological, economic and social aspects

2. To determine and compare the different harvest regimes in each type of production area

3. To identify the market requirements for camedor palm from Mexico and Guatemala based on an analysis of the production chains

1.3 Guiding research questions

Paper 1

1. Are the ecological conditions similar in all of the sites where this research was carried out?
2. Which is the importance of the shade trees in these sites?
3. How is the leaves production of camedor palm in the studied sites?
4. What is the importance of the shade type for camedor palm production?
5 Which is the importance of the ecological indexes for camedor palm production?
6. How ecologically are different the studied plots
7. What system of production is friendlier with the environment?
8. Which system of production is socially more benefit?

Paper II

1. Which is the leaves management?
2. What are the requirements of quality on the camedor palm leaves?
3. What is the volume of commercialization?
4. Which is the income?
5. What are the harvest months?
6. How many leaves are harvested annually per plant?
7. Which are the purchasers?
8. What are the distances from home to the natural populations?
9. What is the commercial size of the camedor palm leaves?
10. What is the cutting frequency?
11. How long time has the people been harvesting camedor palm leaves?
12. What is the percentage of rejected leaves?
13. What is the height of the plants?
14. What was percentage of death plants in each Sample during the research?
15. How is the plant response according the cutting frequency?
16. Which is the percentage of light inside the plots?
17. Which is the economical invest for establish a hectare of camedor palm

1.4 Study area

The study was carried out in three locations in northern Petén, Guatemala and two locations in Veracruz, Mexico (Fig. 1). The Mayan locations belonging to the Mayan Biosphere Reserve are located in northern Guatemala. The reserve shares territory with Mexico and Belize. Its territory covers an area of 2.1 million hectares, though only 1.5 million hectares are considered within the core zone and the zone of multiple uses; the rest of the area corresponds to the buffer zone. Geographic location of sampling plots is cited in annexes.

Location	Sample plots geographic location	
Carmelita	17º 39´ 57´´	89º 55´ 24´´
Oaxactúm	17º 19´ 36 33´´	90º 02´ 46´´
Suculté	250750 UTM	18-26350 UTM
San Fernando	18º 16´ 46.3´´	94º 53´ 40.7´´
Pajápan	18º 15´ 22´´	94º 41´ 50.4´´

Figure 1. Study area where the research was carried out. Guatemalan locations are marked with number 1 and Mexican with number 2

The landscape varies from gently undulating plains to karstic topography with rounded to steep hills and narrow valleys. The soil is dominated by thin soils of red and black or dark brown clay (rendzina); humic gleys, grumosols and red-yellow podzols are interspersed throughout the clay, and elevation ranges from 200-400 masl (Ferrusquia-Villafranca, 1993).

The soil structure is poor and infiltration rates are low; this heaviness of the soil leads to poor surface water drainage. These types of soil are of low to moderate fertility and the clay colloids have moderate cation exchange capacity. In an area with organic matter, leaching of nutrients is low but accelerated in drained slopes. The soil on these slopes is thinner and calcareous with outcroppings of parental material. Thirteen types of soil were reported in Petén (Golicher *et al.,* 1993).

The average annual precipitation is 1200-1500 mm, and the warmest period is from April to September with an average temperature of 32 ^{o}C. The coolest period is from November to January with an average minimum of 20 ^{o}C. Vegetation is semi-deciduous and 80 % of the Peten area is natural forest in good state of conservation, where at least 300 species of trees have been reported, some of which have important uses (Kukachka *et al.,* 1968; CONAP, 1990). Furthermore, swamps and marshes, riparian and aquatic ecosystems are present in the area (Leyden, 1984). Due to the low productivity of agricultural activities, Petén is mainly of forest vocation, and at least 15 communities participate in forest management (Mollinedo, 2000).

The Mexican communities studied are located in the plateau of the Santa Martha Mountain in Veracruz which covers four municipalities, Soteápan, Mecayápan, Pajápan and Tatahuicápan de Juárez. This region has 40,000 ha covered by forest of different sizes on the top of the mountains, but in the lowest sites, agricultural production is practiced (Ramirez, 1999). Cattle ranching are common and people cultivate grasses such as *Cynodon dactylon, Cynodon plectostachyus, Panicum maximum, Brachiaria mutica, Echinochloa polystachya, Hyparrhenia rufa* and others for feeding cattle. Agricultural activities in this area include the production of coffee, oranges, lemons, sugar cane, fine woods, bananas, pineapple, coconut, papaya and pepper (Ramirez, 1999). Fresh and salt-water fishing also takes place, along with raising pigs, sheep and poultry (INEGI-Veracruz, 2000). However, 85 % of the families in that area live in extreme poverty. Nahuatl and Popoluca Indigenous live in the area, and Chontal and Olmec Indigenous live in the border with the state of Tabasco (INEGI-Veracruz, 2000).

At least 30 communities are involved in the gathering and production of camedor palm leaves. Some of them are located in the natural forests of Catemaco, Santiago, San Andres Tuxtla, and other localities where people harvest the fronds from the natural vegetation. People began to cultivate this palm when the last fragments of natural forest were destroyed and the price of the agricultural products dropped. Currently, eight Mexican states cultivate camedor palm as their main activity (Aguilar *et al.,* 2002, Hernandez, 2000)

The second system of production identified in most of the communities is the adaptation of previous systems of production for the cultivation of camedor palm. This was a result of the coffee price crash of the last decade. The main production systems include secondary forest-camedor palm, coffee-camedor palm, rubber-camedor palm, and macadamia-banana-camedor palm (Sosa, 1997; Hernandez, 2000; Aguilar *et al.,* 2002). Locations where the study was carried out and the origin of camedor palm are listed in Table 1.

Table 1. Origin of the camedor palm in each community, cultivated variety and plantation age

Country	Location	Origin	Commercial Variety	Plantation age (years)
Guatemala	Carmelita	Natural populations	Petén	Unknown
Guatemala	Oaxactúm	Natural populations	Petén	Unknown
Guatemala	Suculté	Cultivated plants	Petén, San Luis	2.2
Mexico	San Fernando	Cultivated plants	San Luis Negrita de la Sierra	5 6.6
Mexico	Pajápan	Cultivated plants	San Luis	6.6

1.5 Methodology and Methods

1.5.1 Establishment of the sample plots

In order to evaluate the population size of the camedor palm, three permanent sample plots of 50 m x 10 m were established in each community. Following the method proposed by Cox, (1981), each sample plot was divided into five small 10 m x 10 m plots in order to facilitate the capture of information (Cox, 1981; Franco *et al.,* 1986; Comiskey *et al.,* 1999). All sub-plots were evaluated permanently every two months from July 2004 to July 2005 to obtain detailed ecological and economic information.

1.5.2. Spatial distribution of *Chamaedorea elegans* in the sample plots

Because the presence of *Chamaedorea elegans* Mart in the natural forest is affected by shade, plants in each sample plots were mapped in order to know their distribution and to relate shade and distribution. It was identified whether wild populations had uniform, random or clumped distribution according to Begon *et al.,* (1990).

1.5.3 Taxonomic identification of wood shade tree species located in each sample plot

Botanical samples with flowers or fruits of unknown shade trees were taken, processed and taxonomically identified in the herbarium using taxonomic keys for plants (Standley *et. a.,*1949; Miranda 1952; Miranda and Hernandez, 1963). No samples were taken of common shade tree species.

1.5.4 Light measurement in each sample plot

In each sample plot, light was measured with a densiometer, which works by using a concave Mirror. A sample point was established in each subplot and light percentage was measured throughout the year.

1.5.5. Variables evaluated regarding to camedor palm during the research period

The relation of variables evaluated during the research period is showed in the table 2.

Table 2. Field data collected in each sample plot regarding camedor palm

Variable	Procedure
- Number of camedor palm plants in each sample plot	All plants were numbered during the first measurement. Also, each new plant born throughout year was numbered
- Plant height (cm)	Each plant was measured from the soil to the last leaf using a wooden ruler throughout year
- Total leaves per plant	The leaves of each plant were counted
- Commercial leaves per plot ➢ Total length ➢ Number of leaflets	Four gatherers were hired in each community, who identified the commercial leaves in each sample plot during the measurements
- Harvested leaves per plot	The evidence of rachis were counted in each plant to know the commercial leaves and in each plant
- New leaves Per plot	New leaves per plant were counted during every measurement
- New plants Per plot	Each sample plot was carefully reviewed and every new plant numbered during every measurement
- Presence or absence of apical meristem per plant	The apical meristem was manually reviewed for each plant, as those damaged die after a few days
- Presence of flowers or fruits per plant	During each leaf measurement, a technician helped to identify blossoms or fruits in each plant and to count them.
- Harvest frequency	When it was not time to measure the plants, a local gatherer was paid to take charge of the sample plots and register when the gatherers cut leaves inside the sample plot, and the size and volume of the leaves
- Ecological characteristics of the vegetation in the sample plots	It was identified whether the vegetation in the sample was primary forest or secondary forest

1.5.6. Laboratory work

This section consisted of a direct evaluation of the quality of the commercial leaves. For this, a gross of fronds harvested for commerce was bought in each location and taken to the laboratory. The information collected locally was analyzed and considered as a support for the results. Similarly, taxonomic classification was corroborated in the herbarium, as this species presents geographic variants. The data evaluated were total length, body length, brightness, leaf health and number of leaflets.

1.5.7. Surveys

A survey with producers, gatherers and storage centers was conducted in order to understand the plant movements locally, volume of commercialization, price, wastes and other information, focusing on camedor palm commercialization. Two informal workshops were carried out in San Fernando México to gather information about camedor palm, such as natural distribution, prices, commercialization channel, and cultivated varieties.

In Guatemala, no workshops were carried out but informal meetings, first with people in charge of the local forest concession, to gather information about camedor palm. Some of the topics discussed were *C. elegans* distribution in the concession, methodology and program to gather this palm leaves, and palm prices, among others. The second meeting was with gatherers in general, who were interested in participating in this project. Natural distribution, cutting frequency, distances walked to obtain camedor palm leaves and other aspects were discussed.

Chapter II.

General ecological, economic and management features of the *Camedor palm*

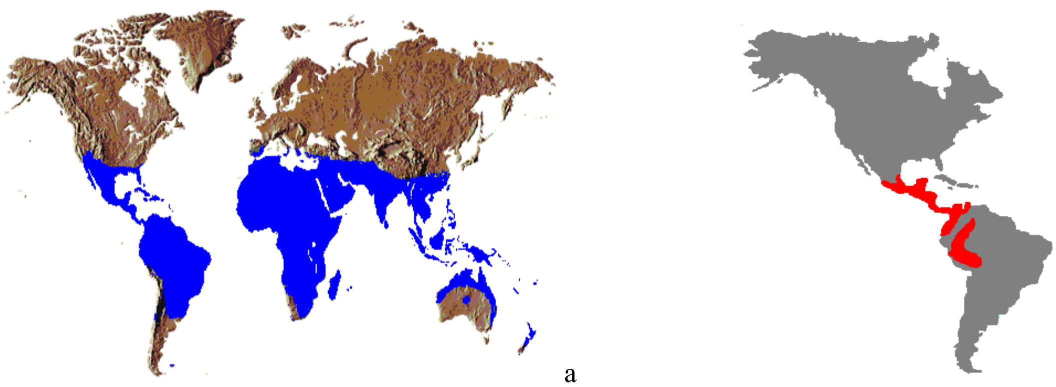
2.1 Ecology

2.1.1 Distribution and ecology of the Genus *Chamaedorea*

Family: Arecaceae
Genus: Chamaedorea
Species: *Chamaedorea elegans* Mart.
Common names: xate, and female xate in Guatemala, and Palma camedor or palmita in México

Chamaedorea is an understory palm restricted to Neotropical forests and cloud forests on the Atlantic and Pacific slopes, from western and eastern Mexico through Central America to Northwestern Ecuador and the Amazonian portions of Colombia, western Brazil, eastern Ecuador, eastern Peru and northern Bolivia. This genus includes more than 145 species, and a great number of species are concentrated in the mountains of Mexico and Guatemala. Other concentrations occur in the mountains of Costa Rica and Panama (Hoddel, 1992, Ramón, 2001). Few species are as ubiquitous and highly variable as *Chamaedorea pinnatifrons* and *C. tepejilote,* which occurs on both slopes Pacific and Atlantic in Mexico and Guatemala and extend throughout Central America, Colombia, Ecuador and Bolivia.

The palm family is distributed in the tropics and subtropics, and has 212 genus and 2,279 species (Fig. 1a). Specifically, the group of palms called *Chamaedoreoide* has six genus and 164 species out of which 133 belong to the *Chamaedorea* genus, are endemic to the American continent and are distributed from south-southeast Mexico to Bolivia and Brazil (Fig. 1b).



a b

Figure 1a, b. a) Natural distribution of palms in the world. b) Current distribution of the genus *Chamaedorea* in the American Continent. Created with information by Moore, (1973); Hodel (1992).

Guatemala and Mexico share some common species, with approximately 40 species recorded for each country. Veracruz, Oaxaca, Chiapas and Tabasco are the heart of Mexican Chamaedorea. The endemic species are *C. alternans, C. cataractarum, C. glaucifolia, C. hooperiana, C. klotzschiana, C. oreophylla, C. queroana, C. schiedeana, C. metallica, C. rigida and C. stolonifera.* Common species from Mexico, Guatemala, Belize, Honduras and Nicaragua are *C. neuroclamys, C. oblongata, C. sartorii and C. ernesti-augustii.*

The region of northern Guatemala, Belize, and the Yucatan Peninsula of Mexico supports several species of *Chamaedorea* found on limestone rocks, such as *C. seifrizii*. In southern Guatemala, El Salvador, Honduras and Nicaragua, *Chamaedorea* is not as common, perhaps due to the lack of high and large mountainous areas and deforestation.

On both the Atlantic and Pacific slopes, at an elevation of 800 to 1500 meters, the endemics to Costa Rica are *C. chazdoniae, C. crucensis, C. microspadix, C. parvifolia, C. pedunculata, C. undulatifolia, C. zamorae, C. minima, C. pumila* and *C. selvae*. The Panamanian endemics include *C. guntheriana, C. serpens, C. correae* and *C. verecunda*. In Peru, only a few species have been recorded such as *C. latisecta, C. linearis, C. smithii* and *C. fragans* (Hodel,1992)

Tropical and subtropical forests are the range of distribution of *Chamaedorea elegans;* these are mainly shaded sites, with low moisture, on mountain slopes with stony soils, from less than 40 masl up to 1400 masl (Aguilar, 1986). Phenology and management are the aspects less studied for this species (Hernandez, 1992; Ramirez and Velazquez, 1993). Even though it is a wild species, its cultivation is possible and is practiced in some countries.

2.1.2 Substrates where Chamaedorea grows

This genus of palms grows in a wide array of substrates, such as soils of volcanic origin, which have excellent structure enhancing their aeration, porosity and drainage. Soils in the tropics are often covered by an organic layer of humus composed of leaf litter, twigs, small branches, logs and mosses, lichens and other microflora in various states of decay. The leaf litter of the forest floor serves several functions such as to help maintain moisture, supply a low but constant stream of nutrients from the decaying materials and provide an appropriate medium for the germination of the seeds and establishment of seedlings and young plants. Another substrate where *Chamaedorea* usually occurs is calcareous soils or limestone rock. *C. pygmaea* has been reported to grow as an epiphyte in Panama. One species is a rheophyte, meaning that it grows along swiftly moving watercourses that are occasionally flooded. *Chamaedorea* are also considered as lithophytes because sometimes they grow on solid rock, usually limestone (Hodel, 1992)

2.1.3 Germination

Chamaedorea elegans is a palm used for indoor and outdoor decoration; it comes from seeds and is collected in its natural habitat in Mexico and Central America. The seeds are collected from summer to mid-winter, and are planted from September to November. Germination is uncertain and can take from two to nine months, depending on ecological factors and the degree of seed maturity (Poole et al., 1974).

However, depending on distance from the place of harvest, the seeds may suffer from some problems such as dehydration and fungi attacks on the surface, which penetrate and affect the embryo. It is recommendable for seeds to have three favorable conditions for good germinations: viability, no physical or chemical barriers and good conditions of humidity, temperate, light and oxygenation. Many problems in germination are due to failures in collection, management and seed storage.

Transplanting usually occurs when the plants have two leaves; however, a high percentage of the plants is affected and it takes a long time to be recovered. Therefore, it is better to wait until after 8 months have passed, when plants have six leaves and can resist pruning after planting. When pruning after planting, plants invest their energy in only a few leaves and in the new leaves.

2.1.4 Illumination and temperature required by *Chamaedorea elegans* Mart

Since *Chamaedorea elegans* grows in the understory, the light requirement is low because the forest cover impedes light from reaching the understory easily. Therefore, this species is good for indoors. Some studies refer to this palm as tolerant to low intensities of light. Photoperiod affects the plant’s appearance because the longer the photoperiod, the more the damage on the leaves, causing necrosis when light is very intense and long lasting (Conover *et al.,* 1982).

Several species of *Chamaedorea* can survive sub-freezing temperatures, but others die before reaching the freezing point; this resistance gives *Chamaedorea* a special value, as it can be cultivated in different places and temperatures. Clear examples are *Ch. arembergiana* and *Ch. costaricana,* which survive at -7 ^{o}C and - 4 ^{o}C, respectively, without affecting the plants or tissues. *Chamaedorea elegans*, inside a conservatory, can withstand temperatures of 44 ^{o}C for 3 months without affecting the leaves or roots (Barba and Romero, 1992). *C. elegans* resist very well to mechanical damages and survives and recuperates easily after management. For example, after a certain time of being abandoned it responds very well to watering and pruning of its older leaves.

2.1.5 Pollination and predators

It is uncertain how palms are pollinated in the understory. In open areas, wind is the main pollinator, but a theory is that the abundance of pollen and multiplicity of stamen or excess of staminate flowers produced in this species is an adaptation to insect predation rather than to wind pollination. Flies, bees and beetles have been reported as pollinators of understory species of palms such as *Asterogyne martiana* and *Bactris* sp, (Essig 1971). For the genus *Chamaedore*a, Henderson (1986) cited that bees, beetles and weevils collected pollen at staminate flowers and that they were attracted to the pistillate flowers of *Chamaedorea costaricana*. In general, most species of *Chamaedorea* have aromatic flowers, suggesting that they are indeed insect-pollinated. Similarly, many species have brightly colored flowers, such as yellow, red and orange, and sticky pollen, suggesting that insects participate in the pollination (Fisher and Moore, 1977).

Diverse species feed on *Chamaedorea* leaves or seeds, although this genus has developed some strategies for protection. Different insects bite the leaves and seeds and each species has a different pattern of chewing. However, the juice of the fruits is highly irritating to areas of tender skin, providing protection from predators (Hodel, 1992)

2.1.6 Flowering

Chamaedorea displays various floral variations, and the inflorescence can be interfoliar as in C. *oreophylla*, or infrafoliar as in *C. oblongata*. For some species such as *C. seifrizii,* the inflorescence is infrafoliar, but it emerges from among old persistent sheaths. The inflorescences are solitary at a node, but other species have several staminate inflorescences. The multiplicity of inflorescences extends the anthesis and increases the opportunities for pollination, since individual inflorescences open consecutively one after the other (Hodel, 1992)

Inflorescences are erect for spreading and droop when laden with fruits. They are branched to one order, although some species have branched staminate inflorescences. The peduncles are short as in *C. fragans* or long, slender and robust as in *C. macrospadix*. Usually they emerge erect or spreading. They are somewhat flattened basally and cylindrical apically.

The rachises may be short as in *C. stolonifera* or long as in *C. woodsoniana*. They are round, or longitudinally angled and are usually greenish. The rachis usually becomes red-orange, orange in mature fruit, or rarely green as in *C. radicalis.*

In general *Chamaedorea* have small or minute flowers that are no more than 5 mm in diameter and symmetrical. Staminate or pistillate flowers are densely or remotely arranged in a spiral and are sessile or partly sunken in elliptic or round pits in the axis. Most species have flowers arranged in a solitary manner, although some have staminate flowers paired or in short lines. Other species, such as *C. adscendens,* have staminate flowers that are densely arranged. Some species have aromatic flowers. The calyx is usually low and ring-like or cup-shaped. Less frequently, it is well developed and prominent in the bud, as in *C. crecensis*, with the three sepals being united basally or distinct and imbricates (Hodel, 1992).

2.1.7 Fruits

The fruits are small and vary in shape, even among individuals of the same species. In general, they are globose to oblong. Rarely, fruits are angled from mutual pressure, as in *C. arenbergiana, C. deckeriana* and *C. allenii*; this depends on the percentage of pollinated flowers. When few flowers are fertilized, the fruits have sufficient space to develop and become more or less globose. However, where a high rate of fertilization has occurred, swelling fruits will be angled by mutual pressure with adjacent fruits as they develop.

Rarely, the fruits are curved, as in *C. angustisecta*, *C. neuroclamys* and *C. oblongata*, whose fruits acquire several colorations; sometimes they are black, orange, red or yellow. Usually they are green when growing and black when reaching maturity (Hodel, 1992).

2.2 Economic

2.2.1. Economic importance of *Chamaedorea elegans*

The importance of *Chamaedorea elegans* can be described from three points of view. The first is the social focus, since many people in the communities where this species grows participate in its collection, so it constitutes a source of income for these people, and because it involves many people outside the community for processing and transportation. The economic point of view is the second focus, because when there is no other productive activity camedor palm constitutes a source of income coming from the natural forests. In some locations in Guatemala, people usually gather camedor palm leaves in the same area every year because they know where it grows in big populations. The third important aspect that deserves to be mentioned is the ecological; camedor palm is a resource gathered by everyone in locations where it is present. All negative effects caused to the natural forest directly affect the C*hamaedorea elegans* populations (Ramón, 2001). Forests destined for agriculture, ranch lands or any other activity reduces the *Chamaedorea* populations.

2.3 Silvicultural aspects

2.3.1 Palm response to shade intensity

One of the most important environmental factors in plant growth is sunlight. It is essential for plants to carry out photosynthesis, as it is the source of chemical energy required by plants. Leaf orientation and pigmentation such as carotene, phytochrome and flavonoids regulate the volume of absorbed light. The *Chamaedorea* genus grows well in sites with 70-80 % shade (Hoddel, 1992). When light intensity has been manipulated under laboratory conditions, *C. elegans* has shown different responses, the highest growth has been obtained in greenhouses with 70 % shade, as well as a significant increase in the number of leaves was also observed under this percent of shade (Badaway *e. al.,* 1987; Ramón, 2001).

2.3.2. Propagation and fertilization

This species (*Chamaedorea elegans*), can only be propagated by seed, but in the genus *Chamaedorea*, there are several species, like *C. cataractarum* and *C. seifrizii,* that can be propagated by buds. Currently, it is possible to produce *C. elegans* plants and other species *in vitro* from seeds, organs, embryos, tissues or protoplasts. However, the more common problems are obtaining a sterile culture media, and a low response of the tissues.

When the soil is poor in nitrogen, new *Chamaedorea elegans* plants show symptoms at four months. The symptoms are, older leaves turning yellowish, plants growing low, and leaves being smaller than the normal size. However, if nitrogen is applied, the plants take four months to return to their normal state (Borschat, 1984). Phosphorous deficiency stops plant growth and potassium deficiency causes necrotic spots on the leaves, and when it is severe, plants cannot recover. Calcium deficiency provokes squatty plants and deformation in the new leaves, which die a little while later. Magnesium deficiency attacks the older leaves first, causing a yellow color and progresses from the border toward the center of the leaves. Sulfur deficiency appears after a year, provoking a yellow color in all the new leaves followed by necrotic spots. Other deficiencies such as iron, boron, copper, and molybdenum can provoke irreversible damage and plant death, depending on the severity (Chase *et al.,* 1993).

2.3.3. Pests and diseases

Acari can severely attack leaves, changing the leaves from green to brown, in only three days. When acari are detected, it is recommendable to apply insecticide soap (Safer Agro-Chem's). This soap has the same efficiency against acari as synthetic products, which have a longer residual effect. The acari that attack the *Chamaedorea elegans* palm the most are *Tetranychus tumidus* Banks, *Tetranychus urticae* Kotch, and *Tetranychus cinnabarinus* Banks. The most destructive is *Tetranychus tumidus*, because it attacks the palms in greenhouses and plantations. Its damage is so severe that it is considered a limiting factor in plant quality. *Tenuipalpus chamaedorea* also attacks the leaves of *Chamaedorea* although to a lesser degree (Salas *et al.,* 1985).

Similarly, nymphs of cochinilla cottony, *(Rhizoecus americanus,* Hambleton), attack *Chamaedorea elegans* roots. This species is so aggressive that the soil can contain eggs, nymphs, and adult females at the same time. Other pathogens that attack *Chamaedorea* are nematodes of the species *Pratylenchus coffeae* (Kaplan and MacGowan 1982). *Phytophtora palmivora*, on the other hand, produces necrotic spots on *Ch. elegans* leaves (Chase and Broschat, 1993).

Adult plants are attacked by *Gliocladium vermoesen* and *Fusarium oxysporum*, which cause their death. *G. vermoesen* causes a disease called bud putrefaction. It attacks several species such as *C. erumpens, C. elegans C. metallica* and *C. tepejilote* (Atilano *e. al.,* 1980) and can be avoided by ventilating the plantation, regulating shade and reducing humidity.

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Chapter III. Paper one

Ecological factors that regulate the commercial production of *Chamaedorea elegans* leaves in Petén Guatemala and Veracruz México.

Sol-Sánchez, Ángel; Campos, A. J. J.; Current D.; Stoian D.

Key words: *Chamaedorea elegans,* Petén, shade trees, cluster, diversity indexes.

Abstract

From July 2004 to July 2005, the ecological conditions under which Chamaedorea elegans grows were studied in three locations in Guatemala and two in Mexico. Each location had three permanent sample plots of 500 m^2 with three replications in each one. Percentage of shade, slope, type of environment, shade trees and relative values of dominance, density, frequency, and importance were estimated in order to group the closely related variables and find the number of possible groups of sites where camedor palm grows. Similar methodology was followed for shade trees. Four types of sites and three groups of shade trees were obtained for Petén. For Mexico, three groups of sites and four groups of shade trees were obtained. Number of shade trees was 113 for Guatemala and 83 for Mexico.

Shade was irregular, but 68 % shade was the percentage under which most leaves were harvested. Seed production was 4.5 times better in areas that received greater sunlight percentages during the blossom season. Annual harvest frequency was 3 times in Guatemala, and 5 times in Mexico. Harvests were conducted every 76 days on average. In Guatemala, 7,523 leaves were evaluated, but only 21 % were commercialized. In Mexico, 32,133 leaves were evaluated and all resulted in commercial leaves.

Shannon's Index for shade trees was obtained for all studied locations, with 2.51 in Carmelita, 2.58 in Oaxactúm and 2.55 in Suculté. The Duncan test did not show significant differences for this index. Pearson's correlation for commercial leaves and number of shade trees species showed a negative correlation of 70 % with a significance of 96 % and alpha = 0.05 %.

For Mexico, the Shannon's Index for shade trees was 2.69 for Pajápan and 2.28 for San Fernando, and had a positive correlation of 89 % with a significance of 98 % and alpha = 0.05 %. The Duncan

test showed significant differences in number of shade tree species and fronds with alpha = 0.05 %. The Dissimilarity index for Guatemala showed a very close relation in number of species. The Sörensen's index showed that Carmelita and Suculté were the most similar communities, since 40 % of the species were common in both locations. In Mexico, the dissimilarity index showed 98.9 % of number of species in common; The Sörensen's index showed that 23 % were common species for both locations in Mexico.

1. Introduction

Among non-wood forest products, the species most exploited in southern Mexico, Belize and Guatemala is camedor palm, known locally as xate in Guatemala and Belize, and camedor palm in México, which includes several species of palms of the *Chamaedorea* genus, such as *Chamaedorea elegans* Mart., *C. seifrizii* Burret, *C. oblongata* Mart., *C. neurochlamys* Burret, *C. pinnatifrons* Burret and *C. ernesti-augustii* (Merman, 2004).

The leaves of these species are collected in the natural forests for commercialization. Intermediaries buy the leaves and sell them to companies that export them to the United States and Europe. The main producing countries are Mexico, Guatemala and Costa Rica (Hodel, 1992; Ramirez, 1999; Ramón, 2001).

Although the Mayan Biosphere Reserve in Petén, Guatemala has more than 2.1 million hectares, this species only grows in 25 % of these lands, avoiding open areas, flood zones and areas affected by forest and agricultural activities. Likewise, Belize has wide land extensions covered with natural forest where this species occurs; however, it is considered a protected species when in wild natural populations (Radachowsky *et al.,* 2004).

In Mexico, camedor palm populations have been reduced to small and fragmented subpopulations and 8 states where this species was common have begun to cultivate it in agroforestry systems or secondary forest (Costa Rica also has begun to cultivated *C. elegans* under shade cloth. (CEC, 2003; Aguilar *et al.,* 2005).

Currently, due to the overexploitation and demand of this species in the international market, many communities in Mexico cultivate it with positive results. Currently in Veracruz there are 395 hectares planted, out of which 91 hectares are in Catemaco-Coyame, 50 ha in San Fernando, 84 in Santa Martha, 76 in San Pedro Soteápan and Santa Rosa Cintepec, 25 in Chaparral Municipality of Juchique de Ferrer and 70 ha distributed among San Fernando, Mazumiapan Chico and Santa Martha. The Regional Sustainable Development Programs and the Secretary of Environment and Natural Resources (PRODERS-SEMARNAT) financed these plantations (Ramirez and Velazquez, 1993; Ramirez 1999, Aguilar *et al.,* 2002; Castro, 1992; Dorantes *et al.,* 2005).

In Petén, Guatemala, several local communities are cultivating this species in the understory of natural forests. Seedlings for restoration and establishment of plantations are produced in a greenhouse with capacity for 4 million located in Suculté. However, though most of the communities extract commercial leaves from the natural forest (Rosado, 2004).

In Mexico, three big storage centers receive camedor palm locally, prior to export to the United States or Europe. These storage centers are located in Veracruz, Oaxaca, and Mexico City (COLEACP, *et al.,* 1998). Similarly, the United States has several important sites where this foliage is imported before being distributed to wholesalers and retailers throughout the country. Also, camedor palm is selected and exported to Canada and to the European Union, where consumers demand this product (CEC, 2003) (Fig. 1).

According to the Homma model (1992), this species is currently in the declining phase in the natural ecosystem and is entering the cultivation phase (Rosado, 2004). Nowadays, plantations are being established to supply the demand for camedor palm as it has become more difficult to find it in natural forest areas. Some reasons are: 1) loss of natural forest areas to agriculture and other uses; 2) over harvesting of the natural forest populations, and 3) fires that escape from agricultural and pasture areas, destroying natural populations, which require many years to recover from fire**.** This is a similar process to what has occurred with other non-wood forest products in the Amazon. Furthermore, because of the camedor palm plants produce few seeds annually, it had showed a tendency to decrease in its natural environment (Radachowsky *et al.,* 2004; Current[1], 2005).

[1] 2005. Camedor palm commerce (interview). CATIE, Turrialba Costa Rica. University of Minnesota. Center for integrated natural resources and agricultural management

In Petén, non-wood forest products in general, have not been studied completely. For example, of the 728 species of plants cited from Petén, 300 are trees that could potentially be profitable for the communities, although there are not enough studies to show that (CATIE 1993; CONAP, 1990; Mollinedo, 2000).

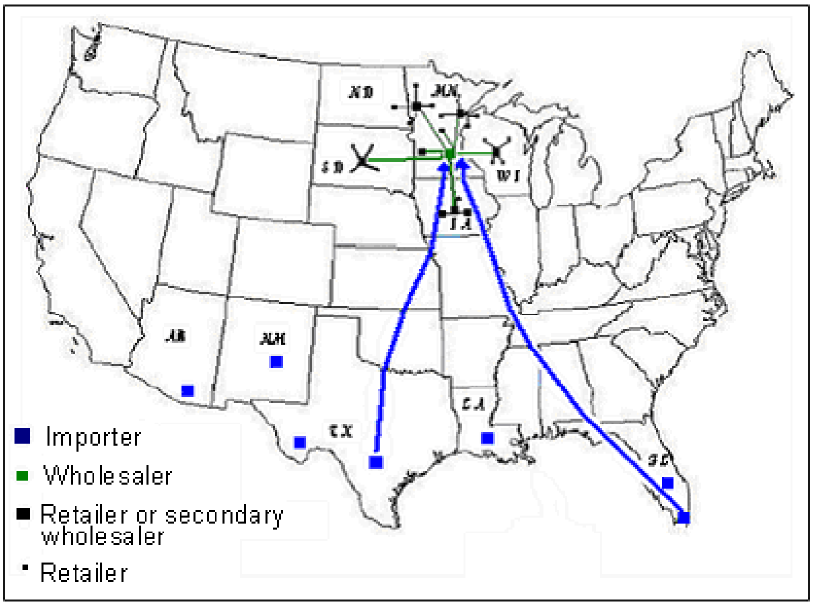

Figure 1. Sites of import from México and sale of *Chamaedorea elegans* leaves in the United States. (Galvez *et al.,* 1990; Ramirez, 1999; CCA, 2002). Minneapolis-St Paul wholesalers are used as an example.

In general, in Guatemalan camedor palm leaves are harvested from the natural forests with no special training and in an unrestrained fashion. In other words, still developing fronds, fronds with physical deteriorations by fungi or insect attacks, and fronds affected by climatic conditions are harvested, increasing the percentage of wasted leaves than can not be commercialized (Radachowsky *et al.,* 2004).

Not all harvested leaves in the Guatemalan forest are acceptable for commerce. A low percentage of them are of high quality, a high percentage is of secondary quality, and a similar percentage is not apt for commerce. This percentage varies, Sol (1992) and Radachowsky *et al.,* (2004) reported values of 35 % and 70 % respectively of *Chamaedorea elegans* leaves rejected in storage centers in Mexico and Guatemala. Currently, at least four million leaves are sold on the international market for Easter Day. A portion of these leaves is cultivated, although a high percentage comes from natural populations from México and Guatemala. Therefore, it is necessary to find a way to use this resource in a sustainable manner in order to conserve the natural populations (Hoddel, 1992).

Palm leaves are sold at a high price in the market; nevertheless, good quality is required, so, adequate principles, criteria and indicators need to be developed focusing on quality, price and protection of the ecosystem, as has been done for other forest activities (McGinley and Finegan 2000; Mollinedo, 2000).

Chamaedorea elegans plays an important role in the international market for non-wood forest products; however, humans have brought about the extinction of this species in some natural areas because a sustained yield principle has not being established and enforced. So, currently, many people are growing this plant in natural forests and in plantations (Ramirez and Velasquez, 1993). In Mexican communities, camedor palm commerce is controlled by middlemen. The locals sell camedor palm by gross, which equals 144 fronds or 12 dozen fronds. The harvesters deliver their product to a local middleman. The camedor palm buyers select the leaves by quality and pays according to their quality (Castro, 1992). For example, based in this study[2], during 2005 price per gross of 144 fronds was US $1.2, in San Fernando and US $1.4 in Pajápan. Particularly in Guatemala, it is important to collect only those leaves apt for the international market. This implies cutting leaves with no mechanical damages, of minimum size and acceptable color. The highest percentage of waste reported has been for Guatemala (Ammour *et al.,* 1994; Radachowsky *e. al.,* 2004).

In Mexico, The Mexican Official Standard NOM-007-RECNAT-1997 establishes the guidelines to harvest, to transport, to storage, and to protect the palms. However, *Chamaedorea elegans* has not been neither protected nor restored successfully by the excessive number of gatherers. In addition, there are several factors involved in the process that restrict *Chamaedorea elegans* Mart restoration in natural areas. What is more critical is that those middlemen hire day laborers who walk through the natural forest and gather all type of leaves, including those that will not be accepted for commercialization (CEC, 2003; Sanchez-Carrillo and Valtierra-Pacheco, 2003).

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[2] Field data got from July 2004 to July 2005.

In a survey with 60 indigenous Lacandon and Chol people, the inhabitants showed interest in protecting the natural populations of camedor palm. One problem that they identified is that many foreign gatherers come to their lands to gather this product. Frequently the middlemen hire local people and demand a large amount of product to be gathered in a small amount of time, and so the gatherers cut all type of leaves invading the indigenous lands, having no training whatsoever for harvesting, and fires are caused by foreigners or camping. In order to reduce these problems, the surveyed people suggested restoring the wild populations of camedor palm, establishing periods of prohibition, not hiring day laborers and providing training courses to gatherers (Sanchez-Carrillo and Valtierra-Pacheco, 2003).

The loss of forest cover in the Mayan area is seen as undesirable, and the need to conserve the biodiversity of these areas has been recognized as a global issue, resulting in international action for rescuing the value of the forests of Petén. Cattle grazing lands often have low productivity, and agriculture provides the farmers with a limited income, which is supplemented by products collected from the forest (Golicher *et al.,* 1993; Oliveira, 1996).

In order to avoid the loss of the natural camedor palm populations, a permanent monitoring system should be implemented. Biological monitoring describes the natural dynamics of biological communities, the consequences of human influences, and it predicts or prevents unwanted changes. Two types of monitoring have been suggested for conservation and for project development; the first is biodiversity monitoring, which involves changes in biological diversity using indicator groups. The second type is impact monitoring, which periodically assesses human activity in some important commercial species such as *Cedrela odorata, Swietenia macrophylla, Chamaedorea ssp, Sabal spp, Manilkara zapota* that are under management (Galindo-Leal, 1999).

The dimensions for monitoring biodiversity and species vary according to several factors. Vasquez-Torres (1991) suggested drawing 50 m x 50 m North-South plots for studying biodiversity. These plots may include trees, shrubs, herbs, palms, epiphytes, rattans and lianas. However, Cox (1981) and Franco *et al.,* (1986) suggest 50 m x 10 m plots, subdivided into 10 x 10 m plots making sure to cover all types of vegetation in the area. Particularly for camedor palm, in Guatemala, several studies have been carried out, and every researcher used different plot sizes (CATIE, 1993; Galvez, 1996; Ceballos, 1995; Marmillod *et al.,* 1997; Galvez, 1996; Carrera, 1996). Ceballos (1995) and

Pineda (1996) studied the camedor palm population in San Miguel la Palotada by using 320 plots of 25 m^2 and 35 plots of 50 m^2 in order to estimate the number of commercial leaves. The results showed 327 and 272 commercial leaves per hectare, respectively.

Galvez (1996) conducted similar research in that location using five sample plots of 5 m x 5 m and concluded that more sample plots were necessary. Marmillod, *et al.,* (1997) suggested that 20 plots of 5 m x 10 m could give reliable information regarding the camedor palm population. However, ecological studies suggest that the best size for plots is 10 m x 10 m because this plot size enables complete studies of herb populations (Cox, 1981; Franco *et al.,* 1986; Begon *et al.,* 1990).

Local communities in Petén are highly dependant on camedor palm; however, between 30 % and 50 % of the harvested leaves are rejected by the market due to lack of organization, low-value given to camedor palm, lack of infrastructure, irregular sizes, rustic transportation, little knowledge of the species, bad leaf quality and difficultly for accessing camedor palm (Bianco, 1997; Radachowsky *et al.,* 2004). In other cases, only 35 % of the leaves are purchased as export palms (Gálvez *et al.,* 1990).

In addition to camedor palm, other non-wood forest products (NWFP) are commercially exploited. These are *Desmoncus anomalus* Bartlett, *D. leiorhachis* Burret, *D. schippii* Burret, *D. quasillarius* Bartlett, *D. oaxactunensis* Bartlett and *D. ferox* Bartlett, used for manufacturing baskets, hats, handbags and furniture (Chinchilla, 1993).

Currently, the only NWFP species that have a legal framework for concession in the Mayan Biosphere Reserve is *Manilkara zapota* L.V. Royen; nevertheless, *Chamaedorea elegans* and other similar local foliage should have a similar legal framework in order to avoid further degradation of their populations (Colom, 1996).

In general, before exploiting a product, Gretzinger (1996) suggests studying both, qualitative and quantitative aspects as well as identifying needs and objectives, proposing actions, performing biological and ecological studies in the affected areas, identifying selected topics, and identifying alternatives and mitigations. The goal is to create an evaluation policy and a systematic operation plan for using these resources.

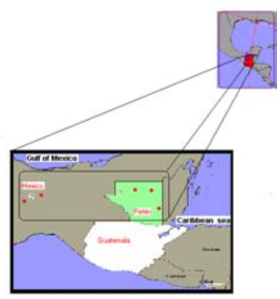
1.1 Study area

1.1.1 Guatemala

The study was carried out in three locations in northern Petén, Guatemala and two locations in Veracruz, Mexico (Fig. 2). The communities from Petén, Guatemala belonging to the Mayan Biosphere Reserve and are located in northern Guatemala. The reserve shares territory with Mexico and Belize. Its territory covers an area of 2.1 million hectares, though only 1.5 million hectares are considered within the core zone and the zone of multiple uses; the rest of the area corresponds to the buffer zone.

The landscape varies from gently undulating plains to karstic topography with rounded to steep hills and narrow valleys. The soil is dominated by thin soils of red and black or dark brown clay (rendzina); humic gleys, grumosols and red-yellow podzols are interspersed throughout the clay, and elevation ranges from 200-400 masl (Ferrusquia-Villafranca, 1993).

The soil structure is poor and infiltration rates are low; this heaviness of the soil leads to poor surface water drainage. These types of soil are of low to moderate fertility and the clay colloids have moderate cation exchange capacity. In an area with organic matter, leaching of nutrients is low but accelerated in drained slopes. The soil on these slopes is thinner and calcareous with outcroppings of parental material. Thirteen types of soil were reported in Petén (Golicher *et al.,* 1993).



Location	Sample plots geographic location	
Carmelita	17º 39´ 57´´	89º 55´ 24´´
Oaxactúm	17º 19´ 36 33´´	90º 02´ 46´´
Suculté	250750 UTM	18-26350 UTM
San Fernando	18º 16´ 46.3´´	94º 53´ 40.7´´
Pajápan	18º 15´ 22´´	94º 41´ 50.4´´

Figure 2. Geographic location of the study area in Guatemala and Mexico.

The average precipitation is 1200-1500 mm annually, and the warmest period is from April to September with an average temperature of 32 ^{o}C. The coolest period is from November to January with an average minimum of 20 ^{o}C. Vegetation is semi-deciduous and 80% of the territory is covered by forest, and at least 300 species of trees have been reported in Petén, some of which have important uses (Kukachka *et al.,* 1968; CONAP, 1990). Similarly, swamps or marshes, riparian and aquatic ecosystems are present in the area (Leyden, 1984). Due to the low productivity of agricultural activities, Petén is mainly of forest vocation, and at least 15 communities participate in forest management (Mollinedo, 2000).

1.1.2. Veracruz

The Mexican communities studied are located in the plateau of the Santa Martha Mountain in Veracruz, which covers the four municipalities of Soteápan, Mecayápan, Pajápan and Tatahuicápan de Juarez, where people collect this palm from the natural forest. This region has 40,000 ha covered by fragment of forest of different sizes on the top of the mountains, but in the lowest sites, agricultural production is practiced (Ramirez, 1999). Cattle ranching are common and people cultivate grasses such as *Cynodon dactylon, Cynodon* sp*, Panicum maximum, Brachiaria mutica, Echinochloa polystachya, Hyparrhenia rufa* and others for feeding cattle. Agricultural activities in this area include the production of coffee, oranges, lemons, sugar cane, fine woods, bananas, pineapple, coconut, papaya and pepper (Ramirez, 1999).

Fresh and salt-water fishing also takes place, along with raising pigs, sheep and poultry (Censo Agropecuario, Veracruz 2000). Many of the communities live in extreme poverty. Nahuatl and Popoluca Indians live in the area, and Chontal and Olmec Indians live in the border with the state of Tabasco (Censo Nacional de Poblacion y Vivienda, Veracruz, 2000).

At least 30 communities are involved in the gathering and production of this palm. Some of them are located in the natural forests of Catemaco, Santiago, San Andres Tuxtla, and other localities where people harvest the fronds from the natural vegetation. People began to cultivate camedor palm when the last fragments of natural forest were destroyed and the price of the agricultural products dropped. Currently, eight Mexican states cultivate the camedor palm as their main economic activity.

The second system of production identified in most of the communities is the adaptation of previous systems of production for the cultivation of camedor palm. This was a result of the coffee price crash of the last decade. The main production systems include secondary forest-camedor palm, coffee-camedor palm, rubber-camedor palm, and macadamia-banana-camedor palm. Locations where the study was carried out and the origin of camedor palm are listed in Table 2.

Table 1. Origin of the camedor palm in each community, cultivated variety and plantation age

Country	Location	Origin	Commercial Variety	Plantation age (years)
Guatemala	Carmelita	Natural populations	Petén	Natural populations
Guatemala	Oaxactúm	Natural populations	Petén	Natural populations
Guatemala	Suculté	Cultivated plants	Petén, San Luis	2.2
Mexico	San Fernando	Cultivated plants	San Luis Negrita de la Sierra	5 6.6
Mexico	Pajápan	Cultivated plants	San Luis	6.6

The objectives of this study are to identify the different forms of camedor palm domestication and to determine its productivity and yield in comparison with the production obtained from wild populations, focusing on ecological, economic and social aspects.

2. Materials and methods

A mathematics model in a randomized design with measurements on the time was used in order to analyze the field data.

2.1 Stistical Model

$Y_{ij} = \mu + Ci + EiJ$

Y_{ij} = Response variable

μ = General media

C_i = Effect of the i-t community

E_{iJ} = error

2.2 Methods

2.2.1. Establishment of the permanent sample plots

Three sample plots of 50 m x 10 m with three replications were drawn in each location. In each replication five monitoring units were drawn. Each monitoring unit was 10m x 10m. Each sample plot was delimited by a wood stake hammered into the ground in each corner. The geographic location was taken using the GPS. In addition, in each sampling plot, soil characteristics, slope, and humus were recorded.

2.2.2. Spatial distribution of *Chamaedorea elegans* into the sample plots

The position of each camedor palm was mapped in white paper to relate shade percentage and palm distribution. This served to identify whether wild populations had uniform, random or clumped distribution, according to Begon *et al.,* (1990).

2.2.3. Taxonomic identification of shade tree species located in each sample plot

Each tree inside the plot was numbered with a permanent ink on a galvanized steel label. Then, botanical samples were brought down from unknown shade trees by using a long reach cutter and botanical scissors. The botanical samples were taken to the herbarium of Universidad Juarez Autónoma de Tabasco to be processed and identified. These samples were dried in an electrical dryer. Finally, the botanical samples were identified by using taxonomic keys.

2.2.4 Light measurement into each sample plot

In each sample plot, light was measured with a densiometer, which works by using a concave Mirror. A sample point was established in each subplot and light percentage was measured throughout the year.

2.2.5. Laboratory work

In the herbarium, the samples of unknown shade trees were dried, processed and identified using botanical taxonomic keys. The samples of camedor palm leaves taken to the herbarium were reviewed to corroborate their commercial characteristics.

2.2.6. Surveys

A set of surveys was conducted with producers, gatherers and storage centers in order to learn about the local movements of plants, volume of commercialization, price, wastes and other information, focusing on camedor palm commercialization. To help in the capture of information, two workshops were carried out in San Fernando and Pajápan. At first, a pre-sampling was conducted to determine the population size to be surveyed, employing the formula displayed below. As there are not many producers in each locality, the interviews were applied to nearly all the population involved in camedor palm gathering during the period of the research. Table 2 shows the number of surveyed people by location, and sites where workshops were carried out.

$$n = (N * S^2 / N-1)\ (B^2/4) + S^2$$

n = Number of samples
N = Population size
S^2 = Variance
B = Limit of the sampling error

In Guatemala, no workshops were carried out, but informal meetings, first with people in charge of the local forest concession, to gather information about camedor palm. Some topics discussed were, *Chamaedorea elegans* distribution in the concession, methodology and program to gather this palm, and palm prices, among others. The second meeting was with gatherers in general, who were interested in participate in this project. In addition, information on natural distribution, harvesting frequency, and distances walked to get camedor palm leaves and other aspects were boarded.

Table 2. Number of people involved in camedor palm gathering by location, number of surveyed gatherers in each location, and procedure to obtain the field information.

Location	Gatherers	Surveyed gatherers	Procedure to obtain information
Carmelita, Guat.	51	47	Meetings
Oaxactúm, Guat.	70	63	Meetings
Suculté, Guat.	155	Only project leaders	Meetings
Pajápan, Mex.	55	45	1 Workshop and meetings
San Fdo. Mex.	32	29	2 workshops and meetings

2.2.7. Shade tree richness by using the Shannon's Index

Species richness of shade trees was calculated in each community in both Mexico and Guatemala to determine the percentage of plants that are common among the communities. The Shannon Index formula is as follows:

$$H' = -\sum_{i=1}^{s} P_i . \ln . P_i$$

H′ = Shannon's Index

p_i = ni/N (proportion of individuals in the i species)

n = number of individuals of the i species

N = all individuals of all species

2.2.8. Differences in the communities by using Sneath and Sokal's dissimilarity Index

The dissimilarity index was obtained. This information allowed us to determine how different the study sites are regarding the number species of shade trees in each site (Cox, 1981) and how different each site is from another, in general.

$$I_1 = \sqrt{\frac{\sum \left(\frac{X_i - Y_i}{X_i + Y_i} \right)^2}{S}}$$

I_i = Dissimilarity Index
X_i = Species in sample 1
Y_i = Species in sample 2
S = total species

2.2.9. Similitude of species percent by using the Sörensen's Index

This index was calculated in order to determine how similar the studied communities are regarding the number of common shade tree species.

$$S = \frac{2C}{A + B}$$

S = Sorensen's similarity Index

A = Number of species in sample A

B = Number of species in sample B

C = Number of common species in both samples

3. Results

The results are analyzed grouping the study sites and shade trees species located in each sample plot. In addition, field data for shade, sunlight and fruits production, rain and sprouted leaves, commercial leaves production and price are discussed. Also, Shannon Index, Sneath and Sokal dissimilarity index, and Sorensen index are used. The cluster analysis allowed grouping sites with similar ecological characteristics. The variables considered for this cluster were shade percentage, slope, soil and type of environment.

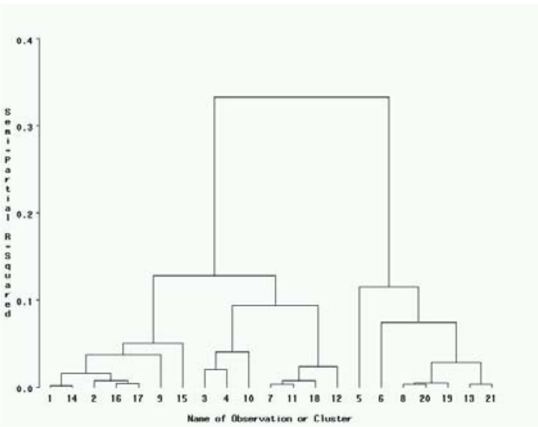
3.1 Grouping of the studied communities and shade trees

In the cluster analysis for Guatemala, four groups of sample plots with ecological similitude were found. The variables used for this grouping were shade percentage, slope, soil, and forest conservation rate. The group one included seven plots with shade from 68.5 % to 77.3 %; flat slope; flooded, non-flooded and dry-rocky soils. Camedor palm plants were found in nearly all plots, though with a clearly defined pattern. Plants were more abundant in flat, shallow clay soil, slightly wavy, with a layer of litter, followed by slope soils and less commonly rocky soils. There were not camedor palm plants in areas with limestone outcrops.

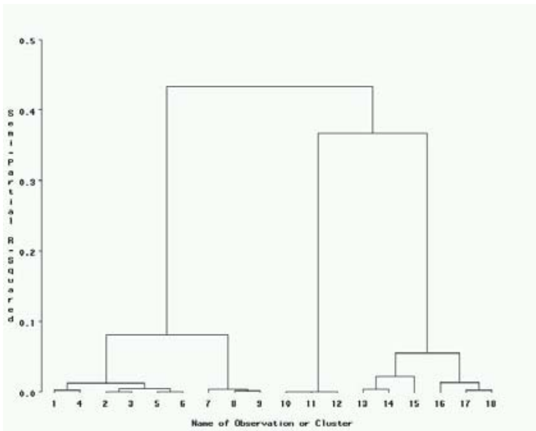
The second group included also seven plots with flat and no flooding or partially flooding soil and with a percentage of shade variable between 29.2 % to 59 %. These soils were not good for camedor palm for two main reasons, they were heavy soils (clays) that remain flooded for a long time, shade was lower than what camedor palm needs, and the forest was secondary. The next group included only one plot, which had wavy clay-rocky soil, and was different from the rest of the plots. The last group was made of six plots which presented abrupt and wavy slopes, clay-rocky soil and 54.8 % to 65.2 % shade (Graph 1).

For the Mexican locations, the dendogram showed three grouping of plots. Group one included nine plots with shade from 77.8 % to 85.2 %, light slope, rocky outcrops and well drained. Shade is managed and regulated once a year and the shade trees are species selected by the producers. In these locations, people manage the secondary forest to create propitious conditions for camedor palm cultivation.

The second group, grouping three locations, had plots with 72 % shade, abrupt slope, and clay/muddy soil. The particular characteristic was that most shade trees were *Belotia campbellii*, with lots of moisture and the camedor palm plantations without a management. The last group included five plots with 72% to 79.2% shade, abrupt slope and clay soil (Graph 2).



Graph 1. Cluster analysis for Carmelita, Oaxactúm and Suculté. Gatherers communities of camedor palm in the Mayan Biosphere Reserve. N=27



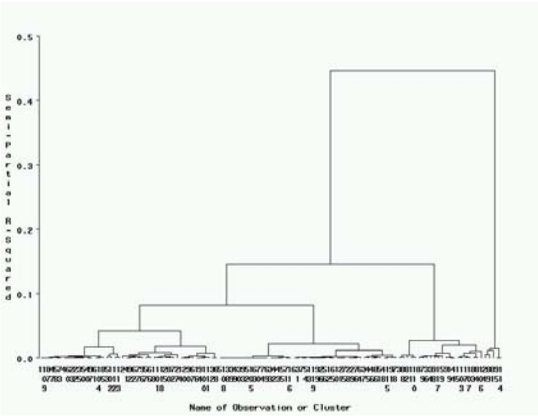
Graph 2. Cluster analysis for San Fernando and Pajápan, Mexico. Producer communities of camedor palm in plantation. N=18

Likewise, in order to complete the understanding of the relationship between variables, another cluster analysis was conducted for tree species. Relative values of dominance, density, frequency and importance were the variables considered for this analysis. For Guatemala, three big groups were found that share similar ecological conditions. In the first one, all tree species were closely related; this group included the most common and less demanding (in relation to their ecological characteristic) species. Both flooding and no flooding were included. The second group included species that are more demanding in their requirements. Some of the species were *Talisia sp, Spondias mombin, Calophyllum brasiliensis, Wimmeria bartlettii, Topobea standley, Pouteria* *amygdalina*, among many others. The last group included only four tree species; *Zuelania guidonia, Rollinia microcephala, Pouteria durlandii* and *Pseudolmedia oxiphyllaria.* These were the less common and most different from the rest of the species, which means that their ecological characteristics are not as common as the others (Graph 3).

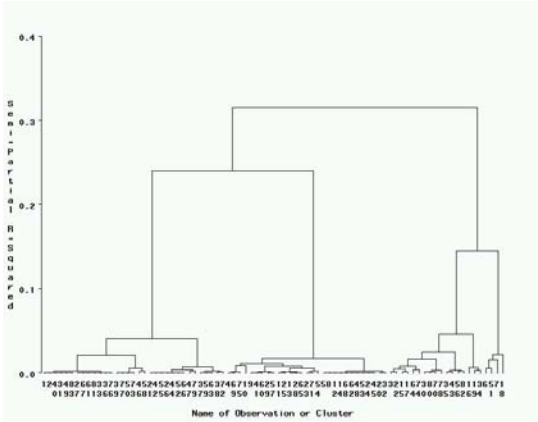
This tree grouping is linked to the ecological conditions of the area which confer particularities developed there, but disfavor those that are not native of the ecosystem. Species of fast growth generally grow in open areas but their growth is reduced when they are in forest areas. For example, *Zuelania guidonia* usually emerge and grows well in open areas and sandy soils as well as in savannas, but in the forest it appears grouped only with other three species which have few common characteristics with the rest of trees. Similarly *Pseudolmedia oxyphillaria* grows well in humid and shaded soils; however here is a principal component on all sampled sites and their canopy is variable, being greater in those covered by forest (Miranda y Hernández 1963; Rzedowsky, 1978)

For Mexico, the cluster analysis turned out four groups. The first one, grouped most of the species present in the plots with similar characteristics, including everything from cultivated species to wild and uncommon. A second group included similar species from the fragment of the natural forest, cultivated and others. The third group included species from the secondary forest and forest, this group was smaller than the previous. The last group included four species, *Coffea arabiga, Belotia mexicana, Coccoloba barbedensis* and *B. campbelli.* These differ from the rest of the species in that they are the less suitable for shade (Graph 4).

Similarly, four species were the lesser commons, first coffee shrubs were cultivated as a main product and is present in almost all of the studied areas. Likewise *Belotia campelli* was favored when the natural forest was eliminated. Because is a species of secondary forest, although it does not have any commercial value it was used to shade the camedor palm plantation. *Coccoloba* genus group species of savanna, as in Pajápan, but here also is used to shade the camedor palm plantation. For that reason all of them make a separate group of the rest of the species found for Pajápan and San Fernando (Ramirez 1999; Pennington *et al.,* 1968).



Graph 3. Cluster analysis for studied tree species registered in the permanent sample plot in the Mayan Biosphere Reserve; 119 species were registered.



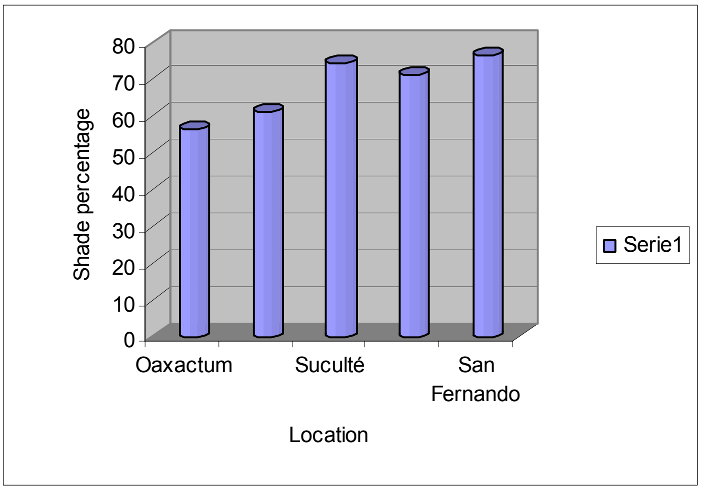
Graph 4. Cluster analysis for studied tree species registered in the permanent sample plot in Mexico; 83 species were registered.

3.2. Shade variation in the study sites

Shade varied from location to location in a general way. A Duncan test showed significant differences in shade percentage at 0.05%. This occurred because forest concessions have suffered negative effects such as unintentional fires, tree cutting programs, road openings for the transportation of wood and other non-wood forest products. All the communities were significantly different from each other and the number of species and canopy were important for shade percentages (Graph 5).

The National Council of Protected Areas (CONAP) in Guatemala regulates forests in Suculté and does not allow opening roads or cutting trees because this area - which belongs to the Mayan Mountains and Landscape Conservation Area, is in ecological restoration.

Currently, these forests are in a good conservation condition and are reaching their ecological stability, if presence of tree fern (*Dicksonia gigantea*) is considered an indicator of the ecosystem maturity (Luna *et al.,* 2001). Consequently, the main problem in Suculté for camedor palm cultivation is the excess of shade, which does not favor camedor palm fronds production during the rainy season, because the litter layer is very tight, and as it took a long time for the sample plot to dry, this favored fungi growth and some plants died by rotting. Shade percentage was a bit heterogeneous; however, the constant management given to shade trees allowed cultivating quality fronds for the international market. Shade measured along the year varied from 56.5 % to 74.1 % in Guatemalan communities and from 71.2 % to 76.36 % in Mexican communities.



Graph 5. Shade percentages registered in each location.

3.3. Effect of sunlight over the camedor palm fruit production

Light percentages were determinant for the volume of new leaves after the rain began. In areas where shade was higher than 80 %, only a few leaves sprouted, on the other hand, the number of leaves was highest in sample plots where shade was between 55 % and 70 % at the beginning of the rainy season.

During the dry season, new leaves were not abundant; some plants did not have any leaves in this period, and some lost their old leaves, or they turned yellowish. In addition, during this season, many shade trees dropped their leaves and sunlight in the understory was greater.

On the other hand, for the Guatemalan communities, almost all mature camedor palm plants that received 47 % sunlight on average during the dry period bloomed and produced seeds; however, each plant had one cluster with a few fruits. For the Mexican communities, all plants that received 32 % sunlight on average during the dry period had an average of three big clusters. The number of seeds produced per plant varied from 27 to 131. The lowest value corresponds to the natural population in Guatemala and the other (131) corresponds to plantations in Mexico.

Similarly, fruit maturation was more regular in the Mexican communities where shade was regulated, but it was also more delayed. In Guatemala, seed size was smaller and the sunlight burned some before they could not mature. Gatherers in Guatemala did not gather seeds because it takes too long, plant produce few seeds, the prices were not attractive and not all the plants produced seeds.

On the other hand, in Mexico, people harvested the seeds of camedor palm in their plantation because they have a good price, are easy to pick up, have a place in the market, and are easy to sell. Field data showed that approximately two hundred kilos were harvested per hectare during the period of this study. A local pest called reel coffee (*Hypothenemus hampei* Ferrari) affected the camedor palm fruits when they were developing.

3.4. Effect of rain on camedor leaves production

The first measurement of plants was in July 2004, at the end of the dry season. In Guatemala, during this period, gatherers did not gather leaves or gathered small amounts because the possibilities of finding camedor palm leaves were scarce**.** Rain began in September, and the first harvest of camedor palm leaves took place 22 days after the first rain. In both locations, Oaxactúm and Carmelita, at the end of September and October, the local storage centers received camedor palm every day. The regional intermediaries came two days a week to pick up the product. In conclusion, 76 days passed between the last harvest in the dry season and the first harvest in the rainy season.

During this research, rain was essential for sprouting leaves. In Guatemala (Oaxactúm and Carmelita), new leaves appeared seven days after the first rain; their average size at the time of opening was 33.4 cm, and they were harvested 22 days after sprouting. On the other hand, in Suculté, the excessive shade did not favor sprouting of leaves, and some plants died from fungal attacks.

Because the plants are dispersed in the forest, there was no specific plan for collecting leaves, and the collection was performed every two to two and half months, depending on a previous inspection. Some factors that promoted irregularity in harvested plants were the collection of all types of leaves, including the apical meristem, broken leaves and withered plants. In Carmelita and Suculté, excess water exerted negative effects on camedor palm plants, as 32 % (9 plants) of the new and old plants died due to flooding in Carmelita, and 0.22 % (99 plants) in Suculté. The excess water was due to the soil having too much litter, which retained water, and excess shade. New leaves per sample were few after rain.

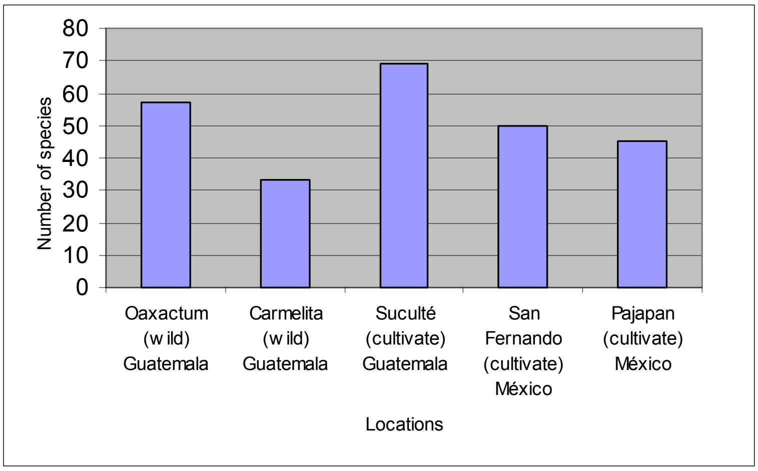
In Mexico, the dry season is different from Guatemala; it is from February to July, but the driest months are May and June. Therefore, during this time, the producers did not harvest palm leaves. On the contrary, during the dry season they pruned their plantation, eliminating all unwanted leaves. When the sample plots were established at the end of July, plants had been pruned and had two or tree leaves. This way, the plant retained water and could resist the dry period. In Pajápan, producers were usually not pressured regarding when to harvest because they had a previous contract with intermediaries to deliver their product. They usually delivered their product all year round. They work and commercialize their products together. They work using a rotation system every two months. San Fernando did not have the same management, and were irregular in the harvest. They delivered their product to a local intermediary who bought the product irregularly; therefore, even through the producers had a rural production society, they could not sell their entire product. In addition, foreign intermediaries did not buy the product during the rainy season because of the inaccessibility to the town and plantations.

3.5 Effect of shade tree species on camedor palm leaves production

Chamaedorea elegans frond quality depends on the type of shade tree. In Guatemala, tree families such as Tiliacea, Lauracea, Sapotacea and Moracea are avoided as shade for *Ch. elegans* because their leaves are big, do not allow light diffusion in the understory, and take much time for decomposition, and so *Ch. elegans* plants do not receive enough light and their leaves are opaque and stained. People usually know where to harvest camedor palm leaves and avoid those site dominated by those tree species. Therefore, it was important to evaluate the effects of shade trees on the production of leaves of *Chamedorea*.

The number of species per community was variable; Oaxactúm, Carmelita and Suculté had 57, 33 and 69 species, respectively. In Mexico, the species number was 49 for San Fernando and 45 for Pajápan (Graph 6). Even though some species were common, most were different from each other. As was expected, Suculté had the highest number of shade tree species because the camedor palm plantations are located in a protected forest named (Mayan Mountains Landscape Conservation

Zone), where tree richness was the highest. In the Mexican sample plots, the highest number of shade trees was found in San Fernando, because the camedor palm plantations are planted in secondary forests and fragments of natural forests.



Graph 6. Number of shade tree species per location in Mexican and Guatemalan locations

In Mexico, one sample was established in an area where nearly all shade trees were *Belotia campbelli*. This tree grows fast and has a heavy bark because it absorbs water and decomposes fast. During the year, many palm plants were crushed due to branches of this species falling down on the *C. elegans* plantations. In addition, palms also rotted due to contact with wet tree barks.

In Pajápan, an insect perforated a tree species *Coccoloba barbadensis* used as shade tree during the dry season. The sap that fell from the tree holes stained many *C. elegans* leaves, which were rejected for commerce. During rainy season, we noticed that tree litter from trees such as *Coccoloba barbadensis, Persea americana, Manilkara zapota, Pouteria zapota, Belotia campbelli* and *Ficus sp* were in a very slow process of decomposition. This was because the leaves of these trees are very thick, coriaceous, and have calcium oxalate. On the other hand, they retained water and moisture was higher than in sites where litter was composed by leaves of other species.

In Guatemala, all species were wild; however, in Mexico we were able to identify four groups according to their precedence, management and use. There were tolerant[3] species such as *Apeiba*

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[3] Common name given to wild plants that grows in camedor palm plantations. Farmer allows them to regenerate and grow there as they can benefit the plantation.

tibourbou, selected species like *Cordia alliodora*, species under management such as *Coccoloba barbadensi*s, and planted or cultivated like *Persea americana*.

3.6 Commercial leaf production and price in the studied sites during 2004-2005

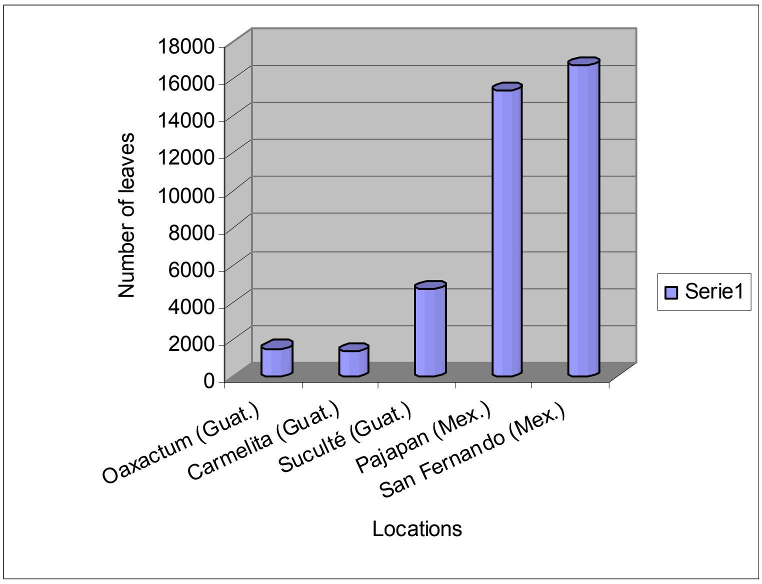
In Guatemala, the study evaluated 7,523 plants during the study period. 6576 of these plants were harvested at minimum commercial size (12 inches) (Graph 7). Suculté did not harvest leaves because of their relatively young age of the plantations and because the plants did not have commercial leaves in regular volume.

During this research, only 21 % (1580) of the leaves registered for all plants in Oaxactúm and Carmelita were acceptable for the market, the rest were not commercially important. This is due to several factors such as bad presentation, broken plants, and plants burned by sunlight, bitten by insects or affected by fungal attacks. The local price during the year was US $ 0.38 per 80 fronds in both Guatemalan locations, Carmelita and Oaxactúm

In Mexico, Pajápan showed constant production of leaves in all sites. In each case, the number of fronds depended on plant density and age. In Pajápan, one of the studied plantations was young, with 30,000 plants per hectare, and the leaves were not completely commercial because the excess shade delayed leaf production. The other two sites were productive plantations and all evaluated leaves had commercial quality. Pajápan remained at a stable price during the year at US $1.43 per gross (144 fronds), which reflects better price compared to Guatemala

Leaf production in cultivated sites in Mexico was higher than in Guatemalan natural populations. Production was 32,133 fronds for commerce in all the sampling plots. The producers made the first selection of leaves; they harvested only the commercial leaves, and leaves that were commercially not viable were eliminated from the plant. However, during the process of selection and boxing, only 1 % was rejected because the leaves were not of commercial quality due to problems such as withering leaves, broken leaves or missing leaflets. The producers obtained better prices than those obtained from the natural forest in Guatemala because of good management and selection (Graph 7).

San Fernando was an irregular site for leaf production. During the rainy season, people cannot gather their leaves due to inaccessibility to their plantations and because transportation from the plantation to the town is not available. Therefore, they move their product by hanging it on their backs and walking for more than two and half hours, and then taking a bus to the city to commercialize the camedor palm leaves. Particularly in San Fernando, during the rainy season, many problems occurred with the leaves, such as necrosis, bud rot, leaf spots and seedling blights. A high percentage of the leaves were not apt for commerce. Prices during the year remained stable at US $ 1.16 per gross (144 fronds) which is lower to the price paid for Pajápan leaves.



Graph 7. Number of leaves evaluated during the research in each locations.

3.7 Shade tree richness by using the Shannon's Index

The Shannon index was included in the evaluation to determine the variation of the shade trees in the natural forest and plantation. Determining the shade tree species is important because there are tree species that are no apt for shade to *C. elegans*. Trees that are not recommended are, for example, those that lose branches frequently, those with very big leaves or trees whose leaves take too long to break down.

Diversity measures for a specific area are not isolate values, but values that consider species richness and the evenness of present organisms (Peet, 1974; Magurran, 1988). However, these values are not stable in time and change with the effort of inspection, because the number of species tends to grow (Kirby *et al.* 1986). For the Guatemalan communities, the index values were 2.51, 2.58 and 2.55 for Carmelita, Oaxactúm and Suculté respectively, with standard deviation of 0.0458, 0.471 and 0.135

respectively The most homogeneous in relation to the worked plots was Carmelita with a standard deviation of (+ 0.0458), with relation to the other communities. In Carmelita, the dominant species were *Pouteria durlandii, Pouteria reticulata,* and both *Trichilia havanensis* and *Brosimum alicastrum*, which represented 41 %, 39.13 %, and 46.2 % in plot 1; *Pseudolmedia oxiphyllaria, Pouteria durlandii,* and *Chrysophylla argentea* in plot 2; and *Chrysophylla argentea* with 45 % in plot 3, this palm grows in big populations in places not suitable for *Chamaedorea elegans*, like places with water excess or water retention. These conditions provoke root putrefaction of *C. elegans* and death of the plant in short time. Other species grew in places free of flooding, which are appropriate places for most of the species of the *Chamaedorea* genus. In general, the results of this Index were similar, which means that the diversity of tree species in the three Guatemalan locations is similar.

In Oaxactúm, the Shannon diversity index was 2.58, with a standard deviation of +0.471. The most common species were *Sebastiana longicuspis, Bursera simarouba, Chrysophylla argentea, Pseudolmedia oxiphyllaria*, and *Pouteria unilocuris*. Suculté was the third studied site and the diversity index was 2.55 with a standard deviation of + 0.135. In this location, species were very different from the other two sites. The common species here were *Virola koschnyi, Pouteria reticulata, Rollinia microcephala, Topobea standley* and *Cupania guatemalensis.*

The ANOVA did not show significant differences (P>8847) for the studied locations in Guatemala, therefore, the Shannon's diversity Index was equal for the three study locations. According to this information, in Petén, tree richness is similar throughout the region, probably due to the management given to the natural forest throughout a rotational system for sustainable management, and so the null hypothesis is not rejected. Mean was 2.55 and variation coefficient 7.1.

For Carmelita, isolated trees were common because the area remained flooded for several months and camedor palm plants located in valleys or lowlands died; nevertheless higher elevation places promoted the development of isolated camedor palm plants. Oaxactúm had a higher value regarding number of leaves since they came from the unaltered vegetation. Data for a correlation analysis for the Guatemalan communities are shown in table 3.

Table 3. Data on species, shade percentages and number of fronds registered in the studied locations in Guatemala.

	Locations								
Variable	Oaxactúm			Carmelita			Suculté		
Plots	1	2	3	1	2	3	1	2	3
Species	39	33	58	39	46	35	21	19	33
Shade %	59.33	53.07	57.07	61.37	76.49	45.27	70.33	72.73	79.43
Fronds	415	462	630	502	260	570	1735	1450	1499

The values of this Index showed that the three locations are similar, although some species were dominant in relation to others. This is because the ecological conditions benefit some species more than others. In particular, tree richness registered for these communities can be considered a good estimator for camedor palm development, because light intensity reaches the understory at different intensities. The index values calculated represent a good estimator to make a relationship between shade tree function and the understory, where *Chamaedorea elegans* grows. These values are ranked from 1.5 to 3, and are rarely greater (Magurran, 1989).

Pearson's correlation between the number of species, shade percentages and number of fronds from Guatemala, showed a negative correlation of 70 % with a significance of 96 % and alpha = 0.05 % (Table 4); this means that the larger the number of species of shade trees, the smaller the number of camedor palm leaves produced. More specifically, there was more shade than the plants needed to carry out their physiologic functions completely and their way to avoid loss of energy is by not producing useful organs, in this case leaves. In other words, the plants were alive but shade excess was a limiting factor. The other variable did not show correlation.

Table 4. Pearson's correlation coefficient/probabilities for all studied Guatemalan locations (n = 27)

	Species	Fronds	Shade
Species	1.00	0.04	0.49
Fronds	-0.70	1.00	0.14
Shade	- 0.26	0.54	1.00

A factor related to these results is that camedor palm leaves were found to sprout in places where sunlight ranged between 64 % and 72 %. Places over or under this range were not appropriate for camedor palm plants.

Carmelita and Oaxactúm are communities forest concessions where every 25 years some commercial wood species such as *Cedrela, odorata, Swietenia macrophylla* and *Bucida buceras* are expected to be harvested. The ecosystem is altered during this process because, when trees fall, younger trees, shrubs, and plants in the understory are broken, or killed. There is constant dynamism in the ecosystem since, in these cleared areas, new light demanding species frequently appear, suddenly raising the diversity index (Kirby *et al.,* 1986). Under this point of view, the structure of the forest in Petén is not as complex as that of older forest because the stability is broken and restarted gradually (Martinez, 1995).

The studied communities are not in a critical state, nor are they in risk of collapsing because the seed bank constantly provides new individuals to the ecosystem. Suculté forests are also in a restoration state with better conservation state because it is a protected area that could be indicated by the presence of arboreal ferns (Luna, *et al.,* 2001).

Regarding the importance value index, the species with the highest values were *Brosimum alicastrum, Chrysophylla argentea* and *Pouteria durlandii* in Carmelita*, Pseudolmedia oxiphyllaria, Pouteria sp* and *Pouteria reticulata* in Oaxactúm*; Rollinia microcephala, Virola koschnyi* and *Cupania guatemalensis* in Suculté.

For the Mexican communities, the diversity indexes were 2.69 for Pajápan and 2.28 for San Fernando, with a standard deviation of 0.028 and 0.6, respectively. Statistically, they had a coefficient of variation of 21.15, a mean of 2.4884 and Pr>F=0.3997, the mean was the same for both communities, so the diversity index was the same for both studied locations. The Duncan test showed no significant differences between the communities with P=0.05.

The variation in the standard deviation is due to the fact that camedor palm plantations in Pajápan receive good management, mainly tree shade regulation twice a year, while people in San Fernando do not implement any type of management and so the shade trees are made up of wild species.

Common shade tree species were *Cordia alliodora, Coccoloba hondurensis, Trichilia hirta, Tabernaemontana arborea, Cochlospermum vitifolium* and *Gliricidia sepium.*

The Pearson correlation coefficient between variables such as number of species, shade percentage and leaf production, found a direct relationship between the number of shade trees and number of leaves, though it was not similar for shade percentages, which was very independent. Data for the correlation analyses for the Mexican communities is shown in Table 5. The Pearson correlation coefficient showed a positive correlation of 89 % with a significance of 98 % and alpha = 0.05 %. Statistically, this correlation was high (table 6).

Table 5. Data for correlation analyses for the Mexican communities

	Plots (Pajápan)			Plots (San Fernando)		
Variable	1	2	3	1	2	3
Species	21	21	27	26	10	23
Shade %	71.51	70.83	71.21	75.84	77.93	69.30
Fronds	4770	4804	5835	7641	1828	7255

Table 6. Pearson's correlation for coefficient/probabilities from the Mexican communities (n=18)

	Species	Fronds	Shade
Species	1.00	0.02	0.24
Fronds	0.89	1.00	0.34
Shade	- 0.57	- 0.48	1.00

3.8 Analyses of variance

For the studied Guatemalan communities, regarding the analysis of variance for the species of shade trees, the Fisher's LSD test did not show differences between the locations (P>0.0947). This means that, statistically, the numbers of shade tree species are equal in the studied locations. It also suggests that tree species could have a homogenous distribution in the forest in Petén. Under this focus, the statistical value does not allow rejecting the H_o, which means that there is no significant difference for the variable species of shade trees with $\alpha = 0.05$ (Table 7).

For the number of fronds evaluated during the year, the analysis of variance show significant differences between the studied locations (P≤0.0001). Therefore, statistically, the number of evaluated leaves is different with α=0.05. This value is directly related with shade percent and sunlight during the rainy season. Therefore, H_o is rejected.

Similarly, for shade percentage, Fisher's LSD test did not present significant differences between the locations (P>0.1413). Therefore, statistically, shade percentage was the same for the three locations with α = 0.05. This information does not allow rejecting the null hypothesis.

Table 7. Fisher's LSD test for ANOVA and Duncan Test for the studied communities in Guatemala (N=9).

Variable	R^2	R^2 Aj	CV %	P-value	α	Locality	Mean	N	Duncan Test
Species	0.54	0.39	25.87	0.0947	0.05	Suculté	24.33	3	A
						Carmelita	40.00	3	A B
						Oaxactúm	43.33	3	B
Fronds	0.95	0.93	17.27	0.0001	0.05	Suculté	444.00	3	A
						Carmelita	502.33	3	A
						Oaxactúm	1561.33	3	B
Shade	0.48	0.31	14.97	0.1413	0.05	Suculté	56.50	3	A
						Carmelita	61.01	3	A
						Oaxactúm	74.16	3	A

For the species in the Mexican communities, the variance analysis presented a variation coefficient of 30.44 with P=0.5633. Due to this statistical evidence H_o was not rejected; in other words, there is no significant difference in this variable for communities with α = 0.05 (Table 8).

Regarding fronds, the Fisher test showed a variation coefficient of 43.65 with P = 0.8296. Statically, this value does not allow to reject H_o; this means that there is no difference in the number of fronds for the communities with α = 0.05. Similarly, for shade percentage, the Fisher test indicated a variation coefficient of 4.39, with a P= 0.2904; in other words, this value does not allow to reject H_o, so there is no significant difference in this variable for communities with α = 0.05.

Table 8. Fisher's LSD test for ANOVA and Duncan Test for the studied communities in Mexico (N=9).

Variable	R^2	R^2 Aj	CV	P-value	α	Location	Mean	N	Duncan test
Species	0.09	0.00	30.44	0.5637	0.05	San Fernando Pajápan	19.67 23.00	3 3	A A
Fronds	0.01	0.00	43.65	0.8296	0.05	San Fernando Pajápan	5136.33 574.67	3 3	A A
Shade	0.27	0.09	4.39	0.2904	0.05	San Fernando Pajápan	71.18 74.36	3 3	A A

Specifically for San Fernando, during the initial management of camedor palm plantations in one area, the forest was eliminated and only a few tree species, such as *Belotia mexicana* and *Mortoniodendrum guatemalensis* were allowed to grow, representing 79 % of the individuals present in the sample plot. On the other sites, the dominant species were *Coffea arabiga, Sloanea medusula, Cornutia grandifolia* and *Pseudolmedia oxiphyllaria*.

Ecologically, this region had two types of environments for camedor palm production. The first type of environment is in Pajápan and refers to plantations with shade trees that are under technical management in order to cultivate quality leaves. The second one is located in San Fernando and refers to secondary forest with isolated old trees that do not receive any kind of management and where many camedor palm leaves are not suitable for commerce. The number of species registered was 45 for Pajápan, where there was a management process; these species are useful for the producer and have commercial value. In San Fernando, there were 49 tree species, though the majorities are wild species. These species do not represent a market value, but they are used locally as fuel and for rustic construction**.** Regarding the importance value index, the dominant species were *Belotia mexicana, Coccoloba hondurensis, Tabernaemontana arborea, Gliricidia sepium* and *Coffea arabiga* (annex 1)

3.9 Dissimilarity in the shade tree structure by using the Sneath and Sokal's Dissimilarity Index

The dissimilarity index establishes that the value for comparison between two or more communities fluctuates between 0 and 1; the closer it is to zero the more similarities there are between the communities, and as the value approaches 1, the communities are more different (Sneath and Sokal, 1973).

In Guatemala, Suculté and Carmelita were the communities less dissimilar in their components with a dissimilarity index value of 0.001 (Table 9). This means that the number of species for both communities was similar in 99%, but only 9.8% were common species for both communities, according to Sorensen's similarity index.

Table 9. Values for the Sneath and Sokal dissimilarity index for the Guatemalan communities

Guatemala	Carmelita	Oaxactúm	Suculté
Carmelita	-	0.027	0.001
Oaxactúm	0.027	-	0.033
Suculté	0.001	0.033	-

For Carmelita-Oaxactúm, this value was 0.027 and the Sorensen similarity index was 40%. This is a high value since Carmelita is a flooding lowland and Oaxactúm is a high site with areas with slight slopes where flooding does not occur. However, the main importance is that ecological and climatic conditions favor the common species growing in both sites.

For Oaxactúm-Suculté, the dissimilarity index was 0.033. It was the highest dissimilarity index value for the Guatemalan communities; this means that these communities were the most dissimilar among themselves. Sorensen's Similarity Index showed that only 17% of the registered species are common for both communities. The Duncan test for the dissimilarity index for communities did not show significant differences ($P=0.05$).

From an ecological point of view, each community is different from the other two. In Carmelita, flooding is prolonged for several months where species such as *Chrysophylla argentea, Bravaisia sp* and *Scheelea liebmanii* are present. Oaxactúm is a region with small hills and limestone outcrops, and Suculté is located on a mountain range with steep slopes.

In general, the dissimilarity index for the three communities was 0.020, with a standard error of 0.0108, which means that they had a similitude of 98% with relation to the number of species registered in the sites (Table 10).

Table 10. Dissimilarity index descriptive statistics for the Guatemala and Mexico communities

Country	N	Mean	S.D	S.E.	Minimum	Maximum
Guatemala	9	0.0248	0.0325	0.0108	0.0026	0.0850
Mexico	6	0.0331	0.0311	0.0127	0.0038	0.0760

In Mexico, Pajápan showed an average dissimilarity index of 0.0143 for its three sample plots, and San Fernando 0.052. This means that 98.57 % and 94.8 % of the species were present in the replication for each community; however, between Pajápan and San Fernando the Sneath and Sokal's Dissimilarity index was 0.018 and only 23.3 % of the species were registered for both communities, according to the Sörensen's Diversity Index.

In San Fernando, winds influenced one plot because it was established in a isolated spot of secondary forest, the other plot did not suffer wind effects and was protected because it is was established on a slope. A third plot was drawn in a place where few trees grew because the owner deforested the area; species such as *Belotia mexicana* and *Pleurantodendrum mexicanum* were the most common species. However, the first species represents a risk factor for camedor palm leaves production because it is a soft wood, with fast growth; long fibers and the oldest branches die by suppression and fall onto the plantation, killing many individuals. Between both communities, the dissimilarity index was 0.018 with a standard error of 0.0127 and, statically, it did not show significant differences for this variable with α=0.05.

Due to irregularity in the management factors, it was not possible to have equal number of commercial leaves of *Chamaedorea elegans* in both Mexican communities; however, the number of leaves evaluated was higher than those values registered for Guatemala in which the number of fronds evaluated was 7,523 for Guatemala and 32,133 for Mexico.

4. Discussion and Conclusion

In the cluster analysis used, several groups appeared that shared similarities and that could be taken as a reference for inferring the best sites for camedor palm production or plantations. Although the

Mayan Biosphere Reserve has 2 million hectares, only 25% is suitable for *Chamaedorea elegans* growth (Radachowsky *et al.,* 2004).

Particularly for Mexico, the cluster analysis also grouped several sites where camedor palm is cultivated, with similar characteristics. The use of local varieties of *Ch. elegans* has made this cultivation more successful. Unlike Pajápan, where the entire collected commercial volume was commercialized, in San Fernando, in Mexico, the production was not gathered completely due to the inaccessibility to the plantation during the rainy season.

Like other non-wood forest products, pre and post-harvest management of camedor palm is essential for establishing the sale price. US $0.38 was paid per gross in Guatemala, from July 2004 to July 2005, whereas three times this amount was paid per gross in the Mexican communities. Under this context, frond size did not represent any aggregate value for gatherers because the price is established by the middlemen and it does not consider frond size. However, in the international market, leaves are commercialized according to their size, the bigger the frond the better the price.

A disadvantage of camedor palm identified in this work in Guatemala was that this foliage is locally purchased by quantity, not by quality. Therefore, the harvesters do not gather only healthy leaves, but also those that appear to be in good condition. This situation limits an increase in price, because harvesters deliver a high percentage of non-commercial leaves, which are later rejected. Radachowsky *et al.,* (2004) cited that over 70 % of the camedor palm leaves from Petén are rejected for commerce. This waste seriously affects the gatherers because their work looking for camedor palm leaves in the forest is not compensated. Plants are also affected in their natural populations because they lose the option of functioning properly physiologically.

The number of shade species was variable in each plot. Most were tree species, but also some palms such as *Chrysophylla argentea* were present. This palm represents a good indicator of absence of camedor palm in some plots in Carmelita because the ecological requirements are quite different for each species. The best shade for camedor palm growth was from high trees because it allowed light diffusion to the understory. Small trees and shrubs blocked camedor palm development and enhanced pests and diseases during the rainy season. Similarly, trees with coriaceous leaves were not suitable for shade, because they did not allow light penetration to the understory and the camedor palm plants experienced problems such as limited number of new leaves, spotted leaves, and water retention in the litter.

Therefore, if it were necessary to create a camedor palm plantation in the communities, it is recommended to avoid tree species of the Lauraceae, Polygonaceae, Sapotaceae, and Tiliacea families for shade. Field data showed that shade should be regulated periodically. For example, during the rainy season, light penetration must be allowed as new leaves grow during this season and require photosynthesis. On the other hand, during the dry period, more shade will work better because the camedor palm leaves will need protection against sunlight. This means that management practices such as pruning and thinning of shade tree should be carried out in the beginning of the rainy season.

Although camedor palm grows in the understory, it requires approximately 30% sunlight on average for developing properly physiologically. Negative tendencies in camedor palm leaf production were noticed in sites with little or too much shade. Therefore, in order to manage this species it is necessary to find an equilibrium that allows commercial camedor palm leaf production throughout the year without affecting the plants. On the other hand, plants that received 50% sun on average showed enhanced flowering and fruiting. In short, it is recommended to designate an area for seed production and to avoid using the same area for leaves and seeds at the same time.

According to the results of this study, Oaxactúm and Suculté would be appropriate sites for seed production following an annual program linked to the tree harvest since the cleared sites allow more sunlight than non-intervened sites. However, no gatherers showed a culture of collecting seeds neither during the camedor palm collection nor during the survey application.

In natural conditions like in the Petén forest, it is not possible to manage camedor palm plants that germinate by them in the forest, yet it is possible to generate a plan that allows collecting only commercial quality leaves and helps avoid the current unnecessary negative effects on the plants. Only camedor palm leaves from Mexico are managed before harvesting; consequently, they receive a better price than those from Guatemala. However, in both countries frond size did not represent an advantage for the producer, and so most fronds were commercialized at their minimum size, (30 cm). From an economical point of view, it is necessary to create a policy that allows producers and gatherers to receive a payment according to frond size and to allow camedor palm populations to remain in the ecosystem.

The promotions of markets and other incentives practices as well as the development of standards and regulations that encourage good management practices should be instruments used to contribute to the conservation of wild populations of *Ch. elegans*.

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Chapter IV. Paper two

Productivity, harvest regimes and commercialization of camedor palm *Chamaedorea elegans* Mart in Guatemalan and Mexican communities

Key Words: xate, camedor palm, *Chamaedorea elegans,* NTFP, Non-timber forest products, Petén.

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Abstract

Camedor palm yield was studied in three locations in Guatemala and two in Mexico during 2004-2005. Each location had three permanent sample plots of 500 m^2 with three replications. Each sample plot was divided into 5 smaller subplots of 100 m^2. Number of camedor palm plants, height, total leaves, commercial leaves, commercial leaf length, harvested leaves and presence of apical meristem were the variables evaluated in order to estimate the volume of production, frequency of harvests, and leaf size.

Petén traded 4,085,492 gross annually on average from 1996 to 2004, with the highest production in 1996 and 2000. Likewise, Mexico gathered on average 2024.5 ton/$year^{-1}$ from 1994 to 1999, and the highest harvest was 1997. Leaf extraction from Petén was studied from January 2004 to January 2005. January was the month with the highest yield. It was found that in Carmelita, plants were grown under a wider range of shade, but in Oaxactúm and Suculté, the range was smaller. In Pajápan, highest leaf production was reached in a shade percentage of 66 to 70%, while in San Fernando it was 71 to 75%. The number of total leaves evaluated in the sample plots in Guatemala was 7,532 and 32,133 in Mexico.

In Guatemala, 84.4% of the evaluated leaves were harvested at the minimum commercial size (25 cm), while in Mexico the percentages of commercial leaves had a homogeneous distribution in the four established categories. In most of the cases, it was found that the taller the plant the higher the percentage of commercial leaves. Price varied from location to location, a gross of 100 leaves was paid US$ 0.48 in Guatemala and US$ 0.89 in Mexico, on average. Pests and diseases were present in the camedor palm plantations in Mexico.

Fourteen companies in Guatemala and one in Mexico bought all the camedor palm leaves produced in both countries. In the productivity chain, it was estimated that at least five levels participate in camedor palm commercialization, with different prices at each level. Finally, to establish a plantation of camedor palm of one hectare, a minimal initial investment of US$ 2,390 for the first two years is required. Harvesting frequency was three times per year in Guatemala and five times per year in Mexico.

I. Introduction

The commerce of non-timber forest products (NTFPs) is a growing activity around the world and includes a diversity of products such as flowers, fruits, seeds, leaves, gum or rubber, medicinal plants, furniture, Christmas ornaments, mushrooms and many others, which are commercialized in rural areas. These forest products have played an important role in the rural economy of developing countries (FAO, 1997; Johnson, 1998). Although NTFP commerce is a small fraction of wood commerce, it represents a considerable amount of money. Each country has a different income according to the product that commercializes. For example, medicinal plants generate an annual income of 10 billion dollars in the world market. In Indonesia, the rattan trade produces 134 million dollars annually, whereas in India it generates 1 billion dollars annually. Similarly, the trade of Christmas ornaments, mushrooms, and other edible products, generate an annual income of 200 million dollars (Taylor, 1999; Padoch and Pinedo-Vasquez, 1996). However, currently a high percentage of these NTFPs are extracted from natural areas and requires policies and legislations for valuing the NTFP importance in all levels of the trade chain, considering volume, prices, employment, benefits, conservation and others (*Wong et al.,* 2001, Ciesla, 1998; Lawrence 1985; Johnson, 1992). These NTFPs constitute an important safety net in most of the cases for remote regions where the environmental risk is high, income is low, and a high dependence on these resources exists. Nowadays, approximately 11 million people who inhabit the tropical and subtropical forest have a direct relation with the forest products and their use or trade (McSweeney, 2003).

The production and use of NTFPs involves a large number of people for harvesting, collecting, processing, marketing and exporting. The informal nature of NTFP transactions often result in the rural producer not receiving an equitable share of the benefits, especially in situations where exploitive trade relationships exist (FAO, 1995).

A high percentage of the production and trade of NTFPs is done at the local and rural level, and markets do not grow if they only supply local demand. Generally, the growth of NTFPs in rural markets depends on the growth in urban demand, which often tends to grow faster than the rural markets. Urban NTFP markets tend to cover a narrower range, which reflects competition from alternative products, changing the consumption pattern (Marshall *et al.,* 2003).

Non-timber forest products are an extremely heterogeneous group; the harvesting tools and techniques vary considerably and harvesting methods are specific for each NTFP. Most of the harvesters are unskilled, untrained in modern NTFPs gathering methods and processes. As a result, the harvesting methods for many NTFPs are rudimentary, and sometimes wasteful, destructive and unsustainable. In some cases, traditional knowledge has allowed the successful use and management of these resources over time. For example, in the Mayan civilization in southern Mexico, the gum tree *Manilkara zapota* was used for hundreds of years and is still in use, with a natural production of 600 to 1000 ton/year^{-1} (FAO, 2005). Usually, efforts for a better integration of the harvesting of wood and non-timber products have not been considered, but the tendency is for people who use these resources to use and manage them in a sustainable manner.

Trade transactions are influenced by policy incentives, regulations, legal restrictions, control and standards. Tariff and non-tariff barriers, quality specifications, terms of import, and exchange mechanisms affect the international trade (Taylor *et al.,* 1996). Around the world, 180 million rural households depend on NTFPs as their main source of income (Simon, 1996; FAO, 1997; Emerton, 1997).

Non-timber forest products are usually gathered in natural forests; however, agroforestry systems have also become good systems for producing NTFPs, since they contribute to the conservation of natural habitats. For example, siricote fruits (*Cordia alliodora)* and guaya *(Talisia floresii)* in Campeche, and pepper (*Pimenta dioica*) in Tabasco, were usually harvested by cutting the tree's secondary branches, a destructive method with which the tree requires a long time to recover its foliage and produce fruit again. Under this system, the gatherers usually cleaned the understory, cutting herbs, shrubs and small trees in order to pick up the fruit. However, since these species were integrated and managed in agroforestry systems or in home gardens, locally called "solar", people only take off the fruit cluster and the fruits are harvested manually one by one. So, establishment of these NTFPs in agroforestry systems results in employing people while reducing pressure on wild populations and recovering the product from bad management. Other advantages of cultivating these species in agroforestry systems are a more reliable production, relieving pressure on forests, income generation, harvesting ease, improving growth rates, increasing crop value and obtaining regular product size (FAO, 1995).

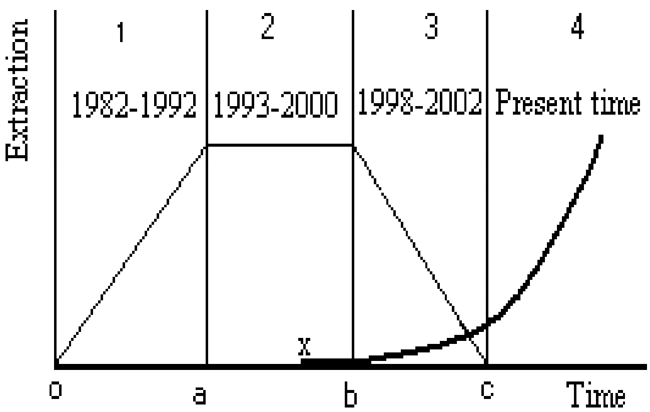
As each community in the world has a different number of undomesticated species used for daily diet and commerce, it is complicated to estimate the number of species that are sources of NTFP. However, in tropical areas the number of species could be larger than in temperate or dry areas, as reported for a community in Chiapas, Mexico (Sol, 1992). On the other hand, some communities, such as Cote d´Ivoire, depend on few species to survive (Ruiz, 1996; Herzog *et al.,* 1996).

Due to the demand and increasing use of some of these products, diverse NTFP species have been threatened and their populations reduced, disappearing from their natural habitat without the possibility to recover their populations. This is true for palms, orchids, begonias and others. Non-timber forest products have been targeted as key elements to consider in development and conservation initiatives, and new attention is given to policy options to encourage NTFP development. Ongoing methodologies also look to focus on most of the possible aspects of extraction or production and commerce to reach sustainable production for the long term (Belcher *et al.,* 2000). Currently, a NTFP typology for national accountability and easy commercialization, groups four types with 16 types of products coming form NTFP. Likewise, according to final use, a classification system of the NTFPs groups seven categories (Chandrasekharan, 1995; Wyatt, 1991)

Camedor palm (leaves of the genus *Chamaedorea* Mart), has been a highly exploited NTFP in southern Mexico, Belize and Guatemala for the last 50 years; it includes at least four species of palms: *Chamaedorea elegans, Chamaedorea ernesti-augusti, Chamaedorea oblongata, Chamaedorea sp (*CCA, 2002; Merman, 2004). This NTFP generates millions of dollars annually for wholesalers and retailers in the United States; in rural communities, it generates employment for 15,000 families involved in this activity. In Guatemala, 7,000 families earn 25% of their salary and living expenses harvesting camedor palm. Furthermore, more than 60% of men in Petén acquire most of their income through camedor palm harvesting (Ramirez, 2002; Radachowsky *et al.,* 2004).

Guatemala and Belize have large wild populations of this palm due to the existence of large natural forest extensions, but in Mexico, these leaves come from plantations established in agroforestry systems, as well as from plantations. Costa Rica produces this type of foliage in greenhouses. In Petén, Guatemala, several local communities are cultivating this species in the understory (Rosado, 2004, Sol *et al.,* 2005). In the last decades, camedor palm populations have been decreasing in their natural environments, and will continue to decrease due to overexploitation (Radachowsky *et al.,* 2004). According to Homma (1992), it is a natural tendency in those NTFP gathered from the forest.

Camedor palm extraction in Mexico and Guatemala has followed the tendency of Homma's model, which is explained in four steps. The oldest record of camedor palm leaves trade is from 1946 in Mexico. In that period, began the growth of the expansion phase. During that time, all commercialized leaves were completely wild, and the market for these leaves was growing on an international level (Figure 1). The second step is a stable phase; the market did not require more camedor palm leaves and demand did not grown either. But that did not prevent camedor palm populations from decreasing; activities such as forest exploitation, opening of agricultural areas, ranch lands and economical development projects, among others, reduced the forest surface during this period, fragmenting the camedor palm population into small subpopulations. This period covers 1993 to 2000.



1 = Expansion phase

2 = Stabilization phase

3 = Declining phase

4 = Cultivated plantations phase

a = Technology available for the cultivation

b = Possible substitutes

c = High price stability

x = Beginning of plantations

Figure 1. Historical cycle of the extraction of camedor palm leaves in Mexico and Guatemala. Adapted from Homma, (1992).

The next step is a declining phase, due to increasing activities that affected the natural populations of camedor palm and the fact that the natural forest could not supply enough leaves for the international market. This period can be recorded from 1998 to 2002. In this period, production declined, and the demand could not be covered completely. In that time, in Mexico, appeared the first small projects focused on camedor palm cultivation to cover the international demand for leaves. In addition, the government program included funding for rural communities to cultivate this species as a source of income.

The last step is the current situation and response of the established plantations; those plantations are producing leaves in a more intense manner than the natural areas and have helped to cover the international demand. However, a high percentage of camedor leaves still comes from natural forests in Guatemala and Mexico.

Step three did not completely follow the Homma model, since camedor palm gathering was never completely exhausted, as the small subpopulations were an important part of the production chain as well as suppliers of seeds for establishing plantations.

Camedor palm from these three countries is exported to the United States, Canada and the European Union (COLEACP and Bougault, 1998; Castro, 1992; Ramirez and Velazquez, 1993; CEC, 2003). Like other NTFPs, not all of the camedor palm leaves gathered can be commercialized; consequently, great volumes are rejected. This percentage varies from 22.5 to 70 % because camedor palm gathering requires trained people in all the sectors of the trade chain, focusing on the conservation of this resource. A disadvantage nowadays is that in some cases camedor palm is paid for volume rather than quality (Sol, 1992; Radachowsky *et al.,* 2004). However, some locations have begun to consider certification as a possible solution to overexploitation, high waste and low prices. With this certification, people seek to increase the price of camedor palm and gather only commercial leaves (Rainforest Alliance, 2005)

Palm leaves prices are high in the market, though good quality is required. In order to obtain good prices, harvesting methods, processing, and laws in general must change and adapt to sustainable forest management. Currently, camedor palm trade follows a chain from the harvester to the user, passing through several intermediaries who increase the palm price (Castro, 1992).

Loss of forest cover is a global issue that needs to be focused in Petén in order to conserve the values of the forest's goods and services, such as palms, fibers, fruits, leaves, medicine and others, and to generate constant income. Currently, ranch lands and agricultural activities in this region only provide the farmers with a limited income, not enough for sustainable livelihood (Golicher *et al.,* 1993; Oliveira, 1996).

In general, camedor palm has been widely studied, with studies focusing on plot sizes, plant inventories, plant density, commercial leaves, local markets and others issues; nevertheless, further studies regarding its production chain and a long-term evaluation through permanent sample plots are required in order to determine its growth and yield (Ceballos, 1995; Marmillod *et al.,* 1997; Galvez, 1996; Carrera, 1996).

In Mexico and Petén, rural people are highly dependent on camedor palm; therefore, they need to reduce the percentage of rejected leaves that do not pass the quality standard into the local storing center by improving their gathering techniques, infrastructure, transportation, knowledge of the species, leaf quality and distribution. Currently over 70 % of the leaves gathered in the forest are discarded because they do not pass the first selection in the local sorting and storage centers (Bianco, 1997; Radachowsky *et al.,* 2004). However, with training in camedor palm gathering carried out by the Rainforest Alliance in some locations in Petén, waste has been reduced to an average of 10 % and is expected to continue decreasing. This way, the natural forest can recover its natural population of camedor palm (Current[4], 2005)

Considering these needs as a baseline, this research was proposed with the following specific objectives:

1. To determine the yield of camedor palm leaves in wild populations and plantations, considering ecological, economical and social aspects.
2. To determine and compare the different harvesting regimes in each type of production area.

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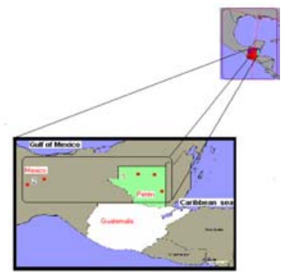
[4] 2005. Camedor palm commerce (interview). CATIE, Turrialba Costa Rica. University of Minnesota. Center for integrated natural resources and agricultural management

3. To identify the market requirements for camedor palm from Mexico and Guatemala based on an analysis of the production chains.

In order to guide this research, we argue that the current process of harvesting camedor palm in natural populations in Petén, Guatemala is not sustainable environmentally, unviable economically and unjust socially.

1.1. Study area

The study was carried out in three locations in northern Petén, Guatemala and two locations in Veracruz, Mexico (Fig. 2). The Mayan locations belonging to the Mayan Biosphere Reserve are located in northern Guatemala. The reserve shares territory with Mexico and Belize. Its territory covers an area of 2.1 million hectares, though only 1.5 million hectares are considered within the core zone and the zone of multiple uses; the rest of the area corresponds to the buffer zone.



Location	Sample plots geographic location	
Carmelita	17º 39´ 57´´	89º 55´ 24´´
Oaxactúm	17º 19´ 36 33´´	90º 02´ 46´´
Suculté	250750 UTM	18-26350 UTM
San Fernando	18º 16´ 46.3´´	94º 53´ 40.7´´
Pajápan	18º 15´ 22´´	94º 41´ 50.4´´

Figure 2. Study area where the research was carried out and geographic location.

The landscape varies from gently undulating plains to karstic topography with rounded to steep hills and narrow valleys. The soil is dominated by thin soils of red and black or dark brown clay (rendzina); humic gleys, grumosols and red-yellow podzols are interspersed throughout the clay, and elevation ranges from 200-400 masl (Ferrusquia-Villafranca, 1993).

The soil structure is poor and infiltration rates are low; this heaviness of the soil leads to poor surface water drainage. These types of soil are of low to moderate fertility and the clay colloids have moderate cation exchange capacity. In an area with organic matter, leaching of nutrients is low but accelerated in drained slopes. The soil on these slopes is thinner and calcareous with outcroppings of parental material. Thirteen types of soil were reported in Petén (Golicher *et al.,* 1993).

The average precipitation is 1200-1500 mm annually, and the warmest period is from April to September with an average temperature of 32 ^{o}C. The coolest period is from November to January with an average minimum of 20 ^{o}C. Vegetation is semi-deciduous and 80% of the territory is covered by forest, and at least 300 species of trees have been reported in Petén, some of which have important uses (Kukachka *et al.,* 1968; CONAP, 1990). Similarly, swamps or marshes, riparian and aquatic ecosystems are present in the area (Leyden, 1984). Due to the low productivity of agricultural activities, Petén is mainly of forest vocation, and at least 15 communities participate in forest management (Mollinedo, 2000).

The Mexican communities studied are located in the plateau of the Santa Martha Mountain in Veracruz which covers four municipalities, Soteápan, Mecayápan, Pajápan and Tatahuicápan de Juarez where people collect this palm from the natural forest. This region has 40,000 covered by forest of different sizes on the top of the mountains, but in the lowest sites, agricultural production is practiced (Ramirez, 1999). Cattle ranching are common and people cultivate grasses such as *Cynodon dactylon, Cynodon plectostachyus, Panicum maximum, Brachiaria mutica, Echinochloa polystachya, Hyparrhenia rufa* and others for feeding cattle. Agricultural activities in this area include the production of coffee, oranges, lemons, sugar cane, fine woods, bananas, pineapple, coconut, papaya and pepper (Ramirez, 1999).

Fresh and salt-water fishing also takes place, along with raising pigs, sheep and poultry (Censo Agropecuario, Veracruz 2000). Many of the communities live in extreme poverty. Nahuatl and Popoluca Indians live in the area, and Chontal and Olmec Indians live in the border with the state of Tabasco (Censo Nacional de Poblacion y Vivienda, Veracruz, 2000).

At least 30 communities are involved in the gathering and production of camedor palm. Some of them are located in the natural forests of Catemaco, Santiago, San Andres Tuxtla, and other localities where people harvest the fronds from the natural vegetation. People began to cultivate camedor palm when the last fragments of natural forest were destroyed and the price of the agricultural products dropped. Currently, eight Mexican states cultivate camedor palm as their main activity.

The second system of production identified in most of the communities is the adaptation of previous systems of production for the cultivation of camedor palm. This was a result of the coffee price crash of the last decade. The main production systems include secondary forest-camedor palm, coffee-camedor palm, rubber-camedor palm, and macadamia-banana-camedor palm. Locations where the study was carried out and the origin of camedor palm are listed in Table 1.

Table 1. Origin of the camedor palm in each community, cultivated variety and plantation age

Country	Location	Origin	Commercial Variety	Plantation age (years)
Guatemala	Carmelita	Natural populations	Petén	Long time
Guatemala	Oaxactúm	Natural populations	Petén	Long time
Guatemala	Suculté	Cultivated plants	Petén, San Luis	2.2
Mexico	San Fernando	Cultivated plants	San Luis Negrita de la sierra	5 6.6
Mexico	Pajápan	Cultivated plants	San Luis	6.6

2. Material and methods

2.1 Statistical Model

A mathematics model in a randomized design with measurements on the time was used in order to analyze the field data.

$Y_{ij} = \mu + Ci + EiJ$

Y_{ij} = Response variable

μ = General media

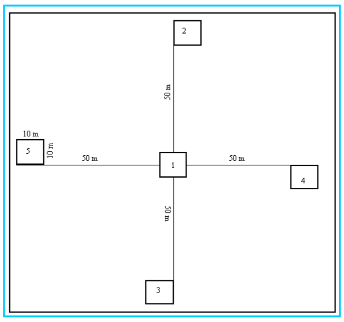
C_i = Effect of the i. t community

E_{iJ} = error

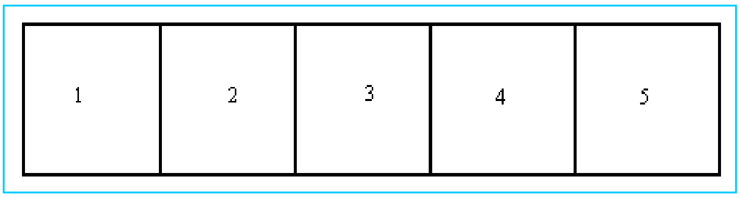
2.2 Methods

2.2.1 Establishment of the sample plots

In order to evaluate the population size of the camedor palm, three permanent sample plots of 50 m x 10 m were established in each community. Following the method proposed by Cox, (1981), each sample plot was divided into five small 10 m x 10 m plots in order to facilitate the capture of information (Cox, 1981; Franco *et., al,* 1986; Comiskey *et al.,* 1999). All sub-plots were evaluated permanently from July 2004 to July 2005 to obtain detailed ecological and economic information. In Guatemala the sampling plot consisted of 5 monitoring plots distributed one at center, and one drawn at North, South, East and West at 50 meters of distance from de central sample plot. In this way, there were more possibilities to find camedor plants (Fig. 3a). In México the sampling plot designs were drawn one behind the other, because plants are together (Fig. 3b).



3a



3b

Figure 3a). Sample plots establishment (Carmelita and Oaxactúm) in Guatemala. **Figure 3b).** Sample plots establishment in San Fernando and Pajápan in Mexico and Suculté in Guatemala

2.2.2. Spatial distribution of *Chamaedorea elegans* into the sample plots

Because the presence of *Chamaedorea elegans* Mart in the natural forest is affected by shade, plants in each sample plots were mapped in order to relate shade and their distribution and know their distribution. It was identified whether wild populations had uniform, random or clumped distribution according to the Begon *et al.,* (1990).

2.2.3. Evaluated variables regarding to camedor palm during the research period

In each sample plot, all camedor palms were numbered using indelible ink and permanent labels. A number was assigned to each newborn plant. Plant height was measured every two and a half months with a wooden ruler. Commercial leaves per plant were counted during each measurement. Total length and number of leaflets per commercial leaf was recorded. Evidence of rachis of harvested leaves was counted to determine yield per plant. New leaves per plant were counted during every measurement. Each sample plot was carefully reviewed and every new plant numbered during every measurement. The apical meristem was manually reviewed for each plant to check damages during harvest. During flowering period, flowered plants and number of clusters was counted for every plant. During fruit production, mature clusters of fruit were harvested, placed in a paper bag and, subsequently, fruits per cluster were counted one by one. Frequency of leaf harvesting was recorded to determine how many times the plants are harvested per year. The description of variable evaluated, and measurement procedure during the research period is showed in the table 2.

Table 2. Field data collected in each sample plot in Petén Guatemala and Mexico.

Variable	Measuring procedure
- Number of camedor palm plants in each sample plot	All plants were numbered during the first measurement. Also, each new plant born throughout year was numbered
- Plant height (cm)	Each plan was measured from the soil to the last leaf using a wooden ruler throughout year
- Total leaves per plant	The leaves of each plant were counted
- Commercial leaves Total length and number of leaflets	Four gatherers were hired in each community, who identified the commercial leaves in each sample plot during the measurements
- Harvested leaves per plot	The evidence of rachis were counted in each plant to know the commercial leaves and in each plant
- New leaves per plot	New leaves per plant were counted during every measurement
- New plants per plot	Each sample plot was carefully reviewed and every new plant numbered during every measurement
- Presence or absence of apical meristem	The apical meristem was manually reviewed for each plant, as those damaged die after a few days
- Presence of flowers or fruits	During each leaf measurement, a technician helped to identify blossoms or fruits in each plant and to count them
- Harvest frequency	When it was not time to measure the plants, a local gatherer was paid to take charge of the sample plots and register when the gatherers cut leaves inside the sample plot, and the size and volume of the leaves
- Ecological characteristics of the vegetation in the sample plots	It was identified whether the vegetation in the sample was primary forest or secondary forest

2.2.4 Database consultation.

The National Council of Protected Areas (CONAP) database was consulted to obtain primary information about commerce volumes, issued licenses, purchaser companies, prices, taxes paid for issued licenses, and extraction sites, among others

2.2.5 Financial indicators

In order to determine the income tendencies per hectare of camedor palm, financial indicators such as net income and net present value were estimated using the following formulae:

Net Income
NI = IB- TC
IB = Gross Income
TC = Total Costs

Net Present Value = NPV
NPV = ∑ (Bn-Cn)/1+i)n
Bn = Benefit each year
Cn = Cost each year
i = Real interest rate interest
n = Year update

3. Results

3.1 Camedor palm yield and harvest regimes in the studied sites in Guatemala and Mexico

In Guatemala, generally in Petén, forest concessions that have forests in their lands gather and deliver camedor palm leaves monthly to export companies. Production is constant during the year, although it is lower during the dry season. During this period of the year people walk greater distances to sites that have not been harvested during that year. Furthermore, in order to cover the demand during the dry season, people gather camedor palm leaves in sites that have more shade and are close to rivers.

During this research, information was obtained regarding the last nine years of extraction[5] of camedor palm leaves in Petén, finding an annual average of 4,085,492.00 gross. However, 1996 and

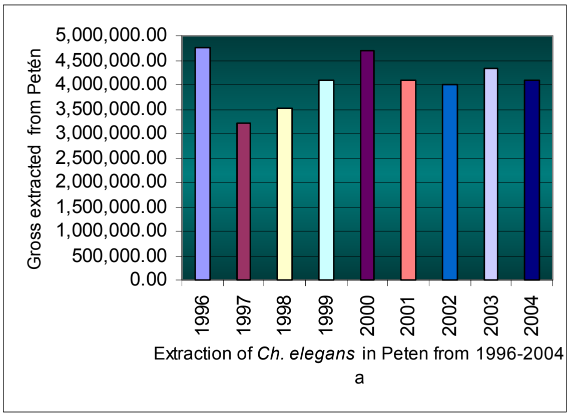
[5] It refers to camedor palm that was harvested and extracted from forests in Petén. Waste is not considered.

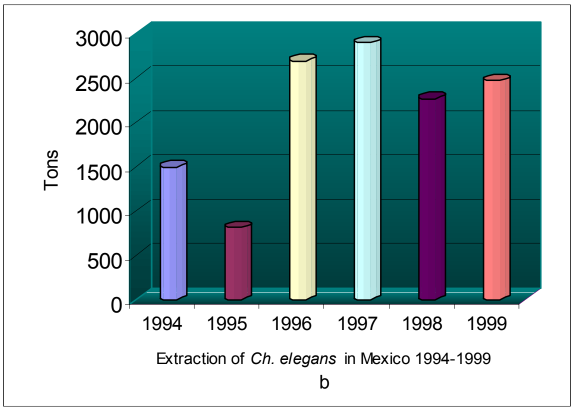
2000 were the highest years of extraction with 4,750, 000 and 4,682,050 gross, respectively (Graph 1a). Extraction has been high, and the tendency following one year of high production is two or three years of lower production.

In Mexico, extraction of *C. elegans* leaves has been more irregular and there is no continuous record of its trade, mostly because this product is gathered from fragments of natural forests and is licensed by SEMARNAT. The average during this period was 2024.5 tons of leaves. However, the highest trade volume was during 1996 and 1997. No records are available for the following years (Graph 1b).

Likewise, the monthly volume of camedor palm leaves gathered from January 2004 to January 2005 was evaluated during this research. The result shows that 4,623,389 gross of this palm were extracted from Petén and traded by 14 enterprises, which transported this product from Petén to Guatemala where it was once again selected, processed, boxed and exported.

The highest extraction month was January in both 1994 and 1995, with 455,699 and 542,200 gross[6], respectively, as well as March with 446,400 and May with 406,950 gross, respectively, although each month had a different extraction volume (Graph 2a).



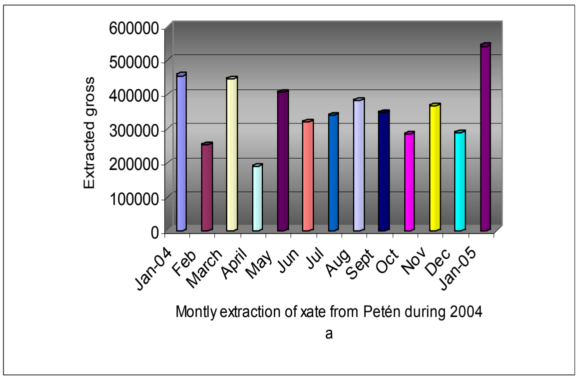


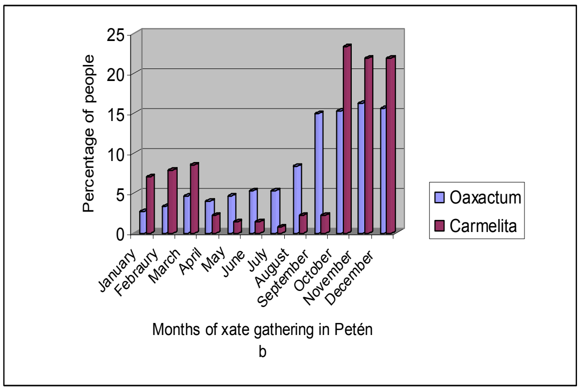
Graph 1a. Volume of extraction of *C. elegans* leaves from Petén from 1996 to 2004, expressed in gross. **Graph 1b.** Volume of extraction of camedor palm leaves in Mexico from 1994 to 1999, expressed in tons.

Source: CONAP, database consultation, Petén 2005. (Licenses issued)

[6] A gross is equal to 80 camedor palm leaves in Guatemala, and 144 camedor palm leaves in México.

Although the dry season is from January to July, its effects were only marked in February and April, when production was the lowest of the year. The rains in December 2003 and January 2004 promoted the sprouting and growing of leaves, which were gathered in March 2004. Areas where camedor palm was not gathered during April were harvested in May. People surveyed in the studied locations said that the highest volume of leaves gathered is from September to December and the less volume is gathered during the rest of the year (Graph 2b).





Graph 2a. Extraction volume of camedor palm leaves in Petén in 2004. **Graph** 2b) Percentage of people surveyed regarding when they gather camedor palm leaves from the study locations.

In the permanent sample plots, production volume was variable for each measuring and depended on several ecological factors, such as plant age, regeneration capacity, percentage of sunlight and water availability. In addition, during the harvest, the gatherers' skill was a positive aspect regarding yield because, in plants with no damaged meristem, leaf production continued, whereas plants that were affected during the gathering died. Younger plants - one and two years, the leaf production was low and produced on average 1.3 leaves every 75 days(Sample plot 3 from Pajápan); on the other hand, physiologically mature plants produced 3.24 leaves every 75 days.

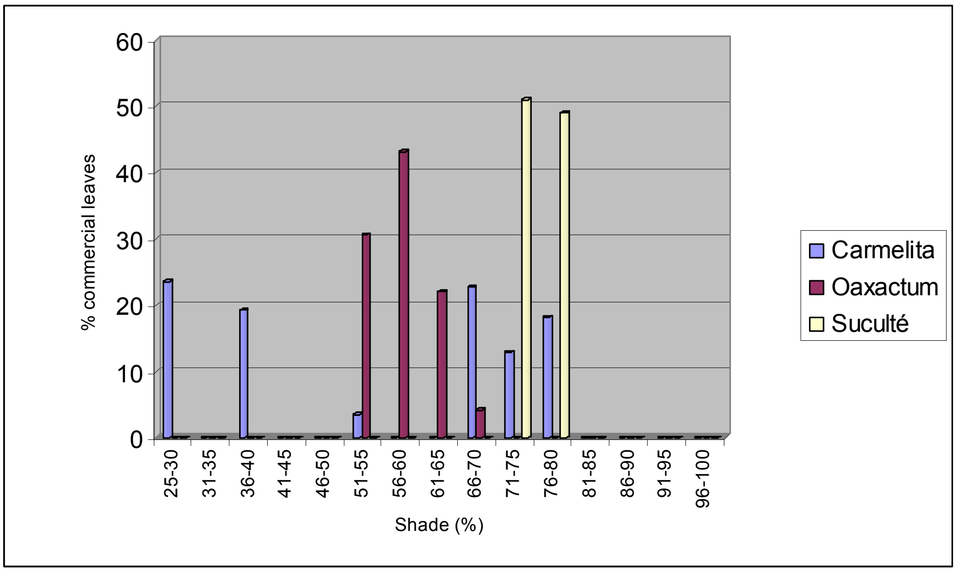
Biologically, young plants distribute their energy equally among their physiological functions, such as growth, absorption, leaf production, excretion and others. Therefore, it is expected that commercial leaf production would be lower.

So, contrarily, in adult plants, higher leaf and fruit production is expected because the plants are already established in the environment; many producers usually leave only potentially commercial leaves on the plant and so the plants only grow commercial leaves. In that way specifically in

Mexico, it was noticed that harvested plants produced greater number of leaves and more frequently than young plants that have not been harvested or have been though only few harvests.

Shade was a decisive factor for leaf production. In Carmelita, leaves were distributed irregularly in relation to the percentage of shade. Therefore, 43% were found in places with less than 40% shade, and 53% were located in areas between 66% and 70% shade. This irregularity in distribution was directly related to soil moisture after rain, because plants were able to grow and sprout leaves in open sites provided that they have enough moisture (Graph 3).

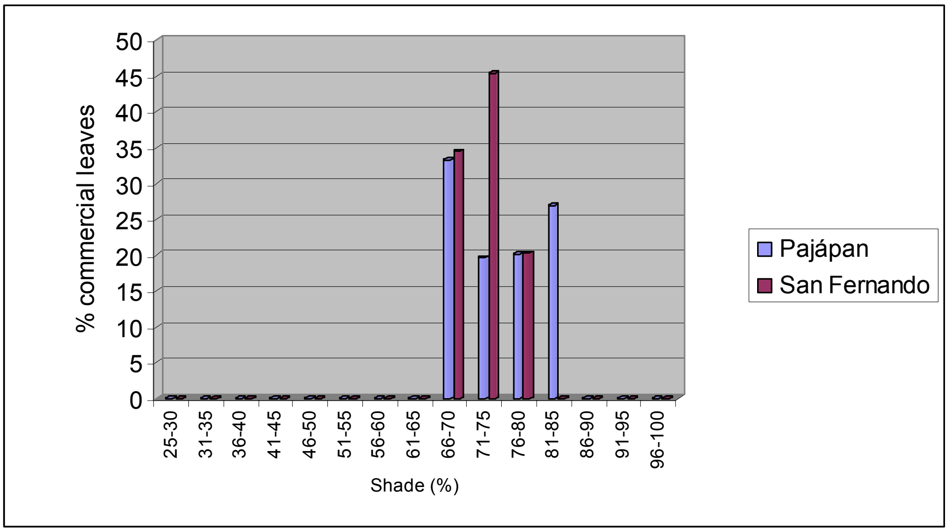
Oaxactúm had a more specific range of shade for leaf production, ranging from 51 to 70%, and shade was more homogeneous because the natural forests have not been affected as frequently as in Carmelita. For example, in Carmelita, fires were frequent and severe during 2000 and 2002. These fires affected the natural distribution of *Chamaedorea elegans* because they burned camedor palm plants and damaged the natural population. Consequently, people began to harvest in places used for timber harvesting for commerce and construction, and other sites where camedor palm plants were not common (Graph 3).



Graph 3. Shade percentage and percentage of commercial leaves found in the Guatemalan locations between July 2004 and July 2005.

Suculté was the location where plants were found under the highest percentages of shade, between 70 % and 80 %. However, these percentages were not favorable to camedor palm plants because the thick layer of litter on the soil retained moisture and many plants were affected by fungi; in some cases, only some leaves were affected although usually entire plants died of fungi (Graph 3).

In Mexico, the locations studied had a more homogeneous percentage of shade. In Pajápan, although shade in sample plots was between 66 % and 85 %, the best percentage of shade was from 66 % to 70 %. The second best percentage for leaf production was 81 % to 85 %. In San Fernando, shade in the sample plots ranged between 66 % and 80 %, although commercial leaves were more common in 71 %-75 % shade (Graph 4). However, shade percentage was frequently reduced in Pajápan by prunning the secondary branches of the shade trees or entire trees when they are too close together, in order to produce leaves of commercial quality and acceptable size.



Graph 4. Shade percentage and percentage of commercial leaves found in the Mexican locations between July 2004 and July 2005.

Due to each sample plot having different sunlight percentages, each site had different percentages of leaves. In Petén, four measurements were taken from July 2004 to July 2005. The total number of evaluated leaves was 7,532, out of which 17.7 % were from Carmelita, 20 % from Oaxactúm and the rest from Sucultè (Table 4 and Graph 5).

The largest percentage of leaves barely reached minimum commercial size, (25 cm), because gatherers cut leaves on average every 75 days, after leaves sprouted. Not all of the plants had new commercial leaves, for several reasons: excess sun exposure burned those in open areas; excess water rotted whole plants in some cases; a few plants died when the apical meristem or stem was damaged during the gathering.

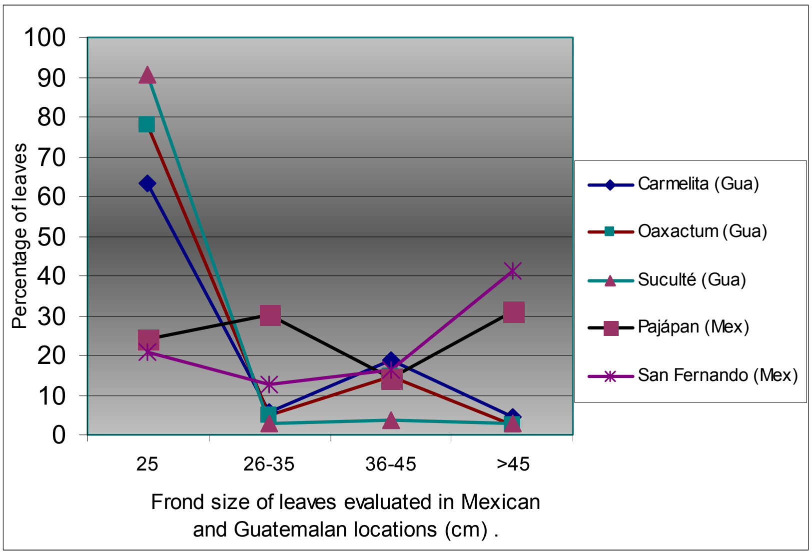
In Mexico during the study period, five measurements were taken. In dry periods, there was no harvest because many plants could die due to reduction of foliar surface. In both locations, 32,133 commercial fronds were evaluated. From this total, 63.7 % were evenly distributed between 25 and 45 cm, and 36.3 % were > 46 cm (Table 3).

Table 3. Percentage of leaves evaluated per location in Guatemala and Mexico from July 2004 to July 2005.

	Percentage per size and location				
Size (cm)	Guatemala			Mexico	
	Carmelita %	Oaxactúm %	Suculté %	Pajápan %	San Fernando %
25	71	77.5	90.7	24	21
26-35	6	5	3.1	30	13.5
36-45	18.5	15	3.2	15	25
>45	4.5	2.5	3	31	40.5
Total	100	100	100	100	100

The percentage of evaluated fronds was similar in both locations, with 48 % in Pajápan and 52 % in San Fernando. However, plant density was greater in Pajápan than in San Fernando. The percentages of leaves harvested were variable in each location. In Guatemala, all locations had the highest percentages of small leaves, but in México, leaves were more regularly distributed by size (Graph 5).

Most of the leaves from Carmelita and Oaxactúm were not of the best quality. Fronds had fungal damage, insect bites, resin, and spots from trees, broken leaves and opaque green color. The result obtained in the Mexican communities is an excellent indicator of yield, which could be suitably managed in order to become a sustainable resource generator of income in the short-term. Likewise, if the percentages of non commercial leaves were reduced, it could contribute even more t the role that *chamaedorea* plays as a safety net to these rural communities. In the surveys from Pajápan, less than 10% of the people considered that camedor palm has a low price and does not allow saving money for urgent needs; nevertheless, people in general consider that camedor palm leaves are like a green safety net since they can harvest leaves and sell them in order to cover their needs.



Graph 5. Distribution by size of camedor palm leaves evaluated in the studied Guatemalan (n=27) and Mexican (n=18) communities from July 2004 to July 2005.

In August 2005, the three study locations in Guatemala began to harvest camedor palm leaves under a certification scheme. Only Suculté is producing it in plantations with advanced management techniques; nevertheless, Carmelita and Oaxactúm continue gathering it from the natural forest. However, with the participation of the Rain Forest Alliance, the Non-traditional Product Exporter Association, Counterpart, The Wildlife Conservation Society, the Forest Community Association of Petén, Guatemala's National Council for Protected Areas and the University of Minnesota (Center for Integrated Natural Resource and Agricultural Management), Carmelita and Oaxactúm have begun to sell certified camedor palm. This certification will generate an annual profit of US$ 104,000. In addition to this achievement, they have employed more women for the selection and boxing of camedor palm leaves (CONAP, 2004).

Suculté had the highest percentage of leaves during the study year; however, these leaves were not traded because this community is aiming to produce high volumes for certified markets. As this plantation is young, it does not yet produce commercial leaves in a consistent manner.

For the Mexican communities, the percentage of leaves under 45 cm was distributed similarly and 22.6% corresponded to 25-cm fronds, 20.3% to leaves between 26-35 cm, 20.3% to leaves measuring 36 to 45 cm, and the rest, 36.7%, to leaves larger than 45 cm.

The main reasons for this similar distribution of leaves by size were: first, because during the rainy season people could not harvest all their leaves, therefore, many leaves were left for the next harvesting period and therefore grew from minimum size to the next size. The second reason is a technical one; in Pajápan, people usually left three or four potentially commercial leaves on each plant at all times. When it was cutting period, they harvest only two leaves per plant and two leaves remain the plants, and generally each plant sprouted two more. The following cutting period, harvesters would cut the oldest two leaves and the new ones would remain for the next season. In this manner, the harvested leaves are in fact three and half months old. This technique allows the plant to remain with leaves all the time, and many of them reach larger sizes.

3.2 Relationship between plant height and commercial leaves

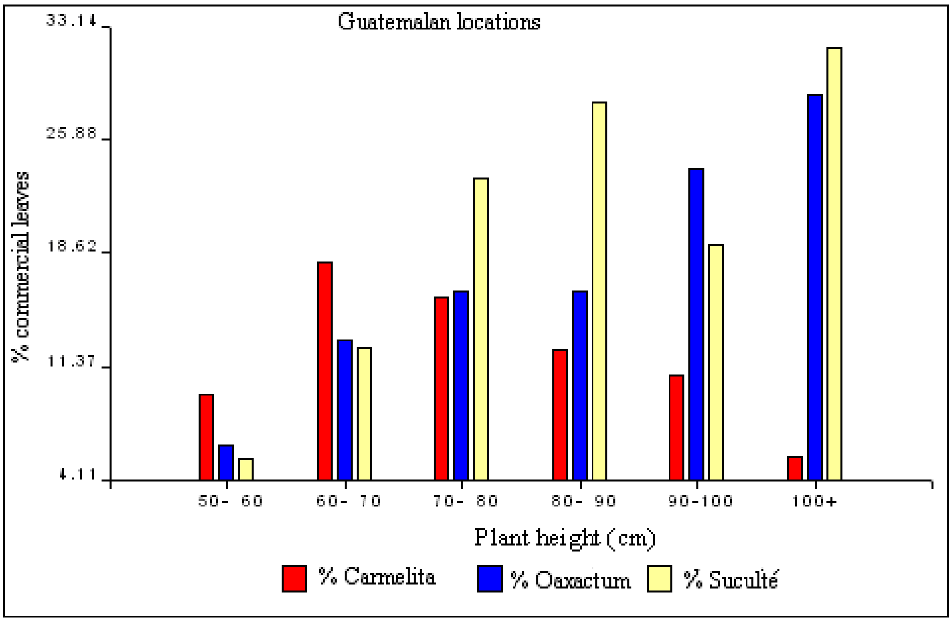
Plant height and percentage of commercial leaves were related in both countries. In general, in Carmelita, the highest percentage of commercial leaves was found in plants from 60 to 70 cm height, but putting together all the measurements, a tendency to decrease according to plant height was observed. This could occur because many sites were located in areas with under 60% shade, and plants under these conditions usually do not produce commercial leaves but remain with their older leaves and tend to produce seeds.

On the contrary, Oaxactúm showed a tendency toward more commercial leaves, according to plant height. As seen in Graph 2, plants between 50 and 60 cm had a lower percentage of leaves, which increased as plant height increased. Plants over 100 cm had the highest percentage of commercial leaves, but these plants were not frequent found. This could be a response to the frequency of harvest, as it was noticed that in Oaxactúm, people gathered leaves from the same plants more frequently than in Carmelita.

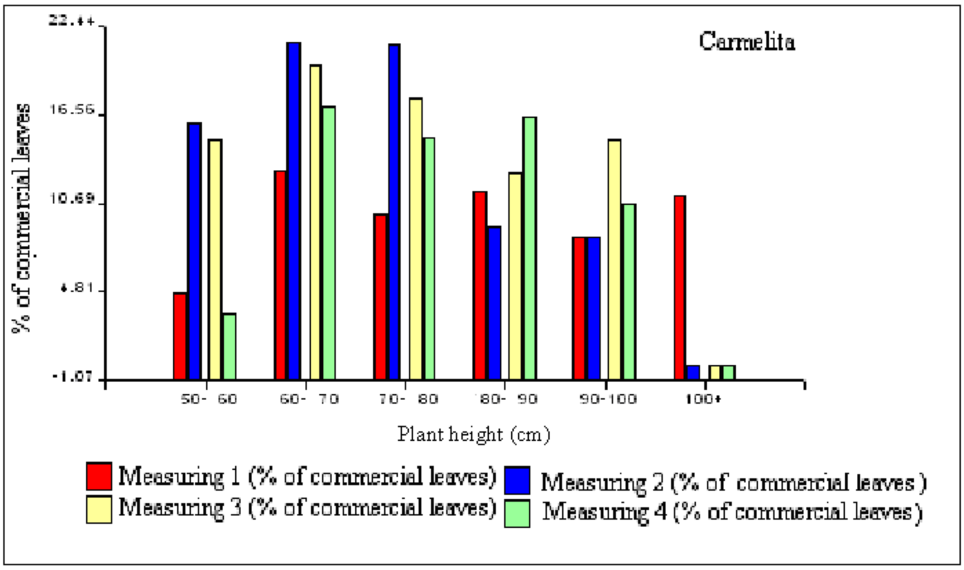
In Suculté, a plantation with two varieties of camedor palm (JumboMex and Petén) showed that the higher the plant, the higher the percentage of commercial leaves. The JumboMex variety was the most common because the first plantations were planted with this variety, though it did not grow as the Petén variety did. The Petén variety is shown in graph 2 with height over 70 cm. It is important to explain that this variety was planted in more open areas, with 55% shade, but the soil's humidity helped the plants to grow well and constantly developed leaves (Graph 6).

In Carmelita, from the measurement carried out in October, the largest volume of commercial leaves was obtained from plants over 100 cm tall. This first measurement was conducted during the rainy season. The second measurement was also conducted during the rainy season, although this time plants between 50 and 80 cm tall had the highest percentage of commercial leaves. In the third measurement, all heights contributed with an average of 10.7 to 22.4% commercial leaves (Graph 7). The last measurement taken in July 2005, showed that the highest percentage of commercial leaves was obtained from plants over 60 cm tall (Graph 7).

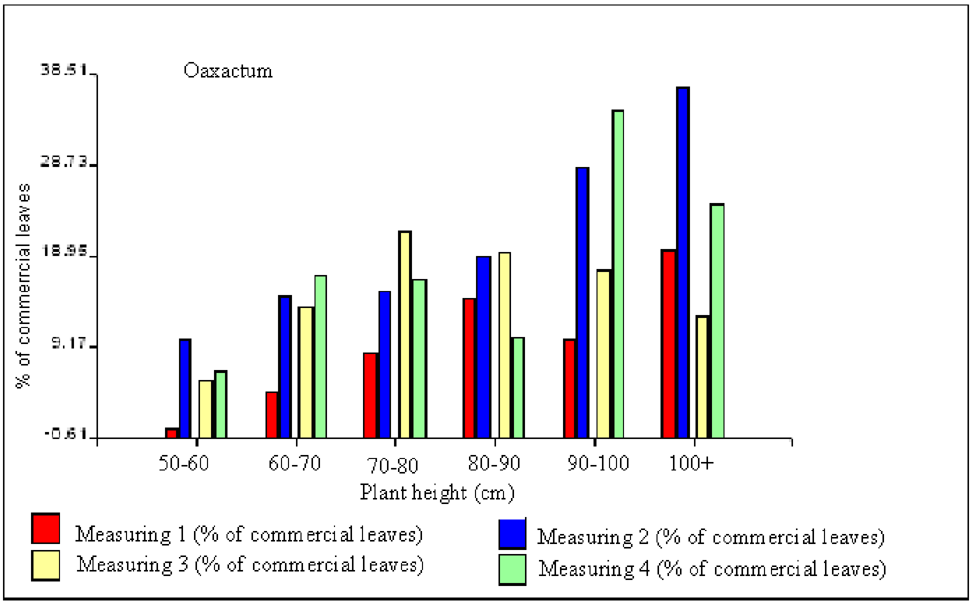
On the other hand, in Oaxactúm, measurements one and two showed that plants over 90 cm contributed with the highest volume of commercial leaves. Measurement three, carried out in March, showed more than 20% commercial leaves over the rest of sizes. Finally, the last measurement, taken July 2005, once again showed that the taller the plant the higher the volume of commercial leaves (Graph 8).



Graph 6. Relationship between plant height and percentage of commercial leaves in Guatemalan locations. Measurements were taken from July 2004 to July 2005.

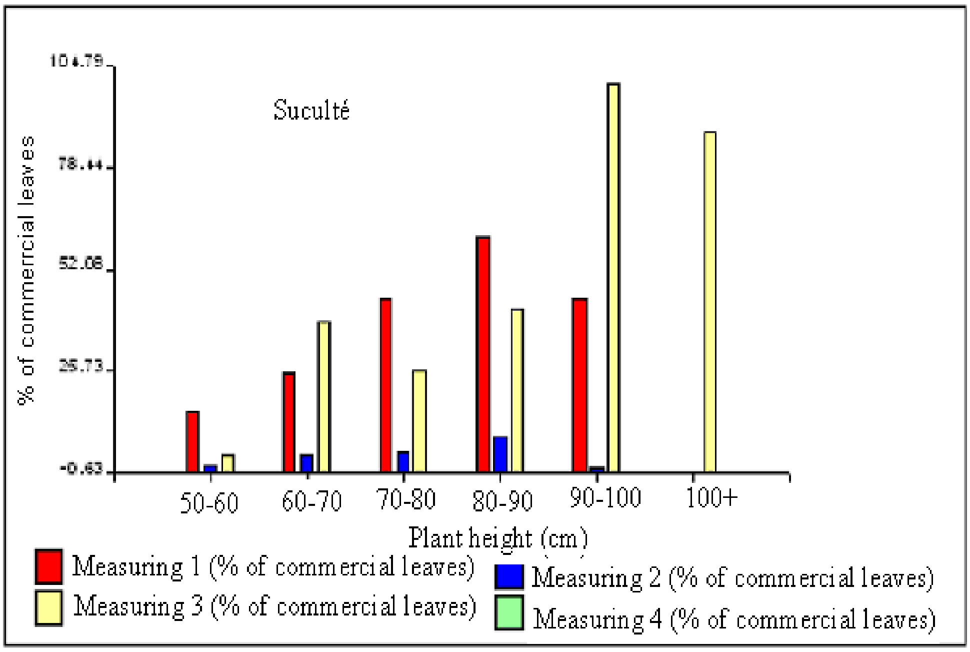


Graph 7. Relationship between plant height and percentage of commercial leaves in Carmelita. Measurements were taken between July 2004 and July 2005.



Graph 8. Relationship between plant height and percentage of commercial leaves in Oaxactúm. Measurements were taken from July 2004 to July 2005.

Suculté showed a different pattern because, even though it is a plantation, during the research year, no commercial leaves weres harvested because the people involved in camedor palm cultivation were looking to get the highest volume for exportation. Nevertheless, the first measurement showed that plants between 80 and 90 cm tall had the highest volume of commercial leaves. The third measurement, on the other hand, showed that plants over 100 cm tall presented the highest value of commercial leaves. The last measurement was not graphed because, as there was not harvest, leaves from measurement three were the same as the last measurement (Graph 9).



Graph 9. Relationship between plant height and percentage of commercial leaves in Suculté. Measurements were taken from July 2004 to July 2005.

3.3 Relationship between evaluated variables

For the Guatemalan locations, a linear discriminative analysis was conducted for the study variables in order to determine the variable that most discriminates the locations. The first canonical ax explains 99.79% of the variability of the study locations in the conjoint of all variables (Table 4).

Table 4. Self-values of Inv (E) H

Self value	%	% accumulative
152.45	99.79	99.79
0.33	0.21	100.00

According to the canonical discriminative function, the number of individuals (2.55) is the variable with most weight in the discrimination of the study locations. Harvested leaves were the next most important variable with -1.15, and the rest showed lower values (Table 5).

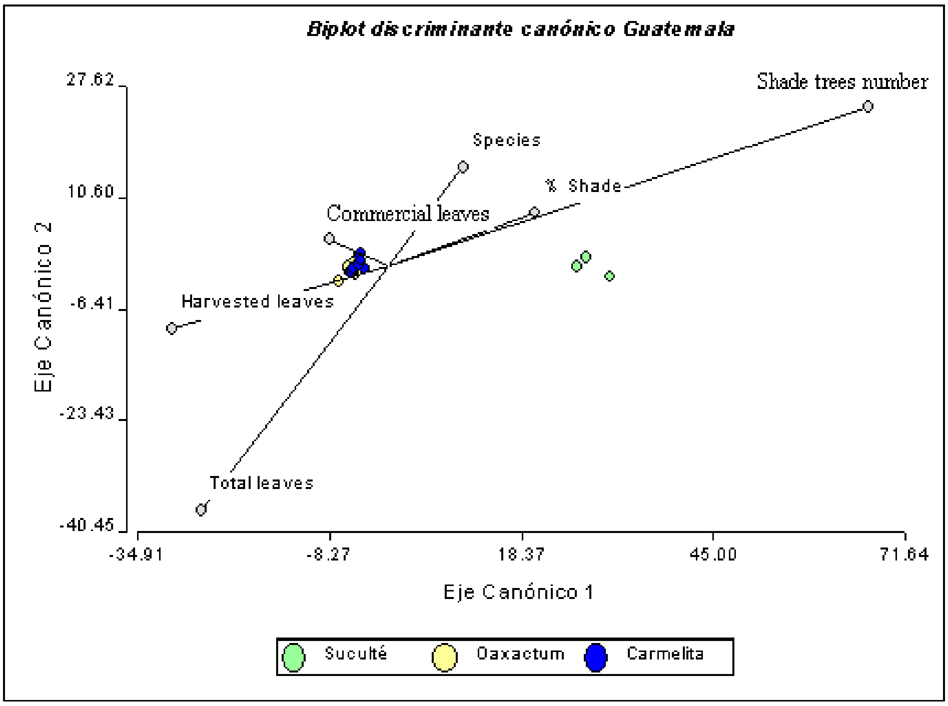
Table 5. Discriminative functions of standardized data with common variances

	1	2
Shade %	0.77	0.32
Species	0.39	0.58
Shade trees number	2.55	0.94
Total leaves	-0.99	-1.42
Commercial leaves	-0.31	0.16
Harvested leaves	-1.15	-0.36

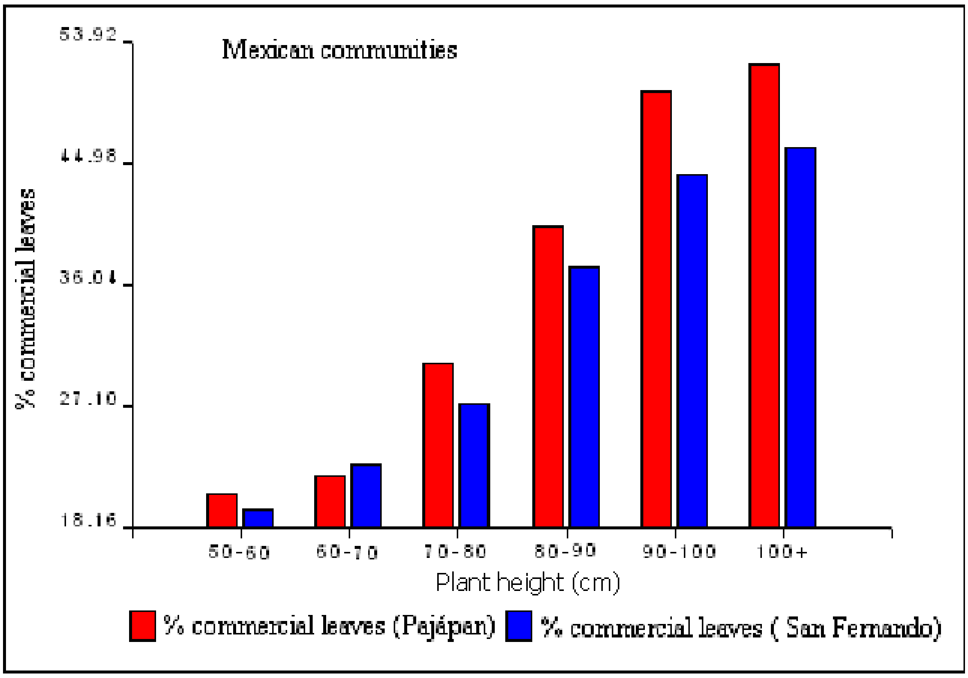
Considering data from table 2, graph 10 was generated, showing a discriminative canonical biplot analysis for Guatemalan locations. Suculté tends to have a greater number of evaluated plants, but less total and harvested leaves. Contrarily, Oaxactúm and Carmelita tend to have more harvested leaves and less evaluated plants (canonic axis 1). On canonical axis 2, the three locations are located at the same height, and so all variations are explained in axis 1.

Suculté differed from Oaxactúm and Carmelita in shade percentages, but Carmelita and Oaxactúm are highly similar in commercial leaves and harvested leaves. The number of plants and shade percentage show a very close relationship between these locations because the angle is very close between both lines. Shade percentage and species are the following closely related variables, followed by commercial leaves and harvested leaves (Graph 10).

In general, for the Mexican locations, putting together all of the measurements, a clear pattern shows that the taller the plant the higher the percentage of commercial leaves. A logical response could be that these plants are under constant pressure because their leaves are harvested every two or two and half months and so they respond by producing more leaves to cover the lost ones. It seems that the number of leaves is greater according to plant growth. This is because usually the producer does not harvest leaves I plants younger than two or two and half years (Graph 11). San Fernando also showed a similar pattern to Pajápan, the taller the plant the higher the percentage of commercial leaves. In both cases, it would be interesting to know the response with taller plants (Graph 11).



Graph 10. Discriminative canonical Biplot analyses for the Guatemalan locations showing the relationship between each variable.

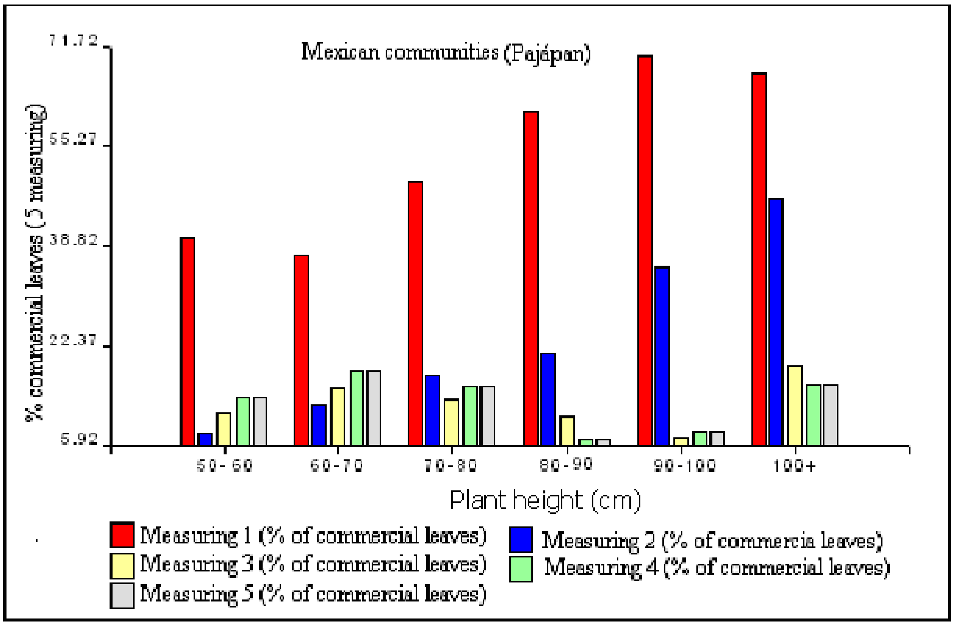


Graph 11. Relationship between plant height and percentage of commercial leaves in Mexican locations. Plants measurements taken from July 2004 to July 2005.

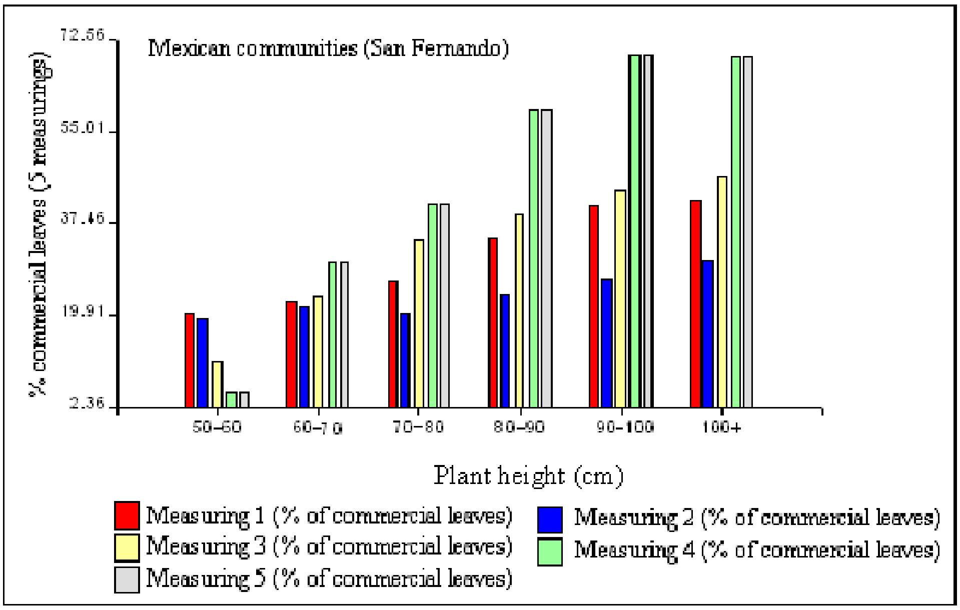
In Pajápan, the pattern is similar for measurement one and two with a small difference in the first and last measurement. The long bars indicate the first measurement, which was taken at the beginning of the research when no leaves have been harvested before in the sample plot, and so the percentages of commercial leaves are higher than in the following measurement. The second measurement also had the highest percentages of commercial leaves in the taller plants, but the third, fourth and fifth measurements showed an irregular pattern of commercial leaves. We suppose that this response was due to producers in Pajápan making three deliveries very close together and not allowing the plants to recover and produce more leaves (Graph 12).

In San Fernando, the pattern is very similar to Pajápan, the taller the plant the higher the percentage of commercial leaves. In this location, the tendency was more marked than in Pajápan. In all ranges of height, it is possible to see that the volume of commercial leaves is higher if the plant is taller (Graph 13). The two equal bars in measurement four and five show similar percentages because, between measurement four and five, the producers did not harvest their leaves, and so in measurement five the volume of commercial leaves was the same as in four. People did not harvest their product during this time for two reasons: first, because between the two measurements they spent their time on other agricultural activities of subsistence, such as maize, beans and squash and, second, because local people were expecting the middlemen to agree to better prices.

For Mexico, as there were only two locations, it was not possible to conduct a discriminative canonical analysis, and so the MANOVA test was applied. Because in this analysis the tests for F are approximate and not exact, there are several approximations to for conducting it. There is a consensus among several authors in that if three of the four tests are significant, the null hypothesis can be rejected. Therefore, according to the results obtained, the four tests were significant with $p \leq 0.05$ and so, the null hypothesis is rejected. This means that the communities studied in Mexico are different in all the evaluated variables (Table 6).



Graph 12. Relationship between plant height and percentage of commercial leaves in Pajápan. Leaves measurements taken from July 2004 to July 2005.



Graph 13. Relationship between plant height and percentage of commercial leaves in San Fernando. Plants measurements taken from July 2004 to July 2005.

Table 6. Multivariate analysis of variance fro the communities studied in Mexico.

Table of multivariate variance (Wilks)

F.V.	Statistics	F	gl(num)	gl(den)	P
Locations	0.04	48.93	6	11	<0.0001

Table of multivariate variance (Pillai)

F.V.	Statistics	F	gl(num)	gl(den)	P
Locations	0.96	48.93	6	11	<0.0001

Table of multivariate variance (Lawley-Hotelling)

F.V.	Statistics	F	gl(num)	gl(den)	P
Locations	26.69	48.93	6	11	<0.0001

Table of multivariate variance (Roy)

F.V.	Statistics	F	gl(num)	gl(den)	P
Locations	26.69	48.93	6	11	<0.0001

Hotelling's test Alpha:0.05

Error: Common covariance matrix gl: 16

Location	% shade	Species	# plants	Total leaves	Commercial leaves	Harvested leaves	N	
Pajápan	74.41	21.67	6,919	13,653	15,409	15,905	9	A
San Fernando	73.63	17.78	6,223	16,685	16,724	4,721	9	B

Different letters indicate significant differences (p<= 0.05)

3.4 Price by gross of Camedor palm leaves in Guatemala and Mexico during this research

In Guatemala, all sizes of leaves were sold at the same price, US $ 0.48 per gross of 100 leaves during the field research. Unfortunate for the gatherers, frond size did not play a role in the income for this activity. Therefore, gatherers harvest the fronds when they reached approximately 25 cm; occasionally, when they obtained larger leaves, they could not sell them for a better price. However, in a survey and interviews carried out in some storage centers in San Benito and Santa Elena, Petén, women laborers separated fronds by size because they have an agreement with companies to deliver them by size, and the price offered to the storage center is variable according to frond size.

In Mexico, during the study period, a bundle of 100 palm leaves was paid in US $ 0.99 in Pajápan and US $ 0.80 in San Fernando. This variation in prices is because leaves from Pajápan were of regular size, healthy, of clear color, not broken, and the driver could access the plantation. Contrarily, the roads to San Fernando are not paved; the leaves were usually mistreated because people hang them on their backs, harvests were irregular and the leaves not very healthy. In both locations, the cultivated variety is *Chamaedorea elegans* from San Luis.

Economically, these fronds could be traded according to their size. However, locally, size is not a guarantee for a better price. Pajápan usually harvested their leaves with a previous contract, and sometimes the purchasing enterprises took a long time to ask for leaves, so the fronds grew on the plant, but the price did not change. Some harvesters said that they preferred to sell fronds at the minimum size because they could have six delivery periods per year, and selling larger sizes represents a financial loss for them.

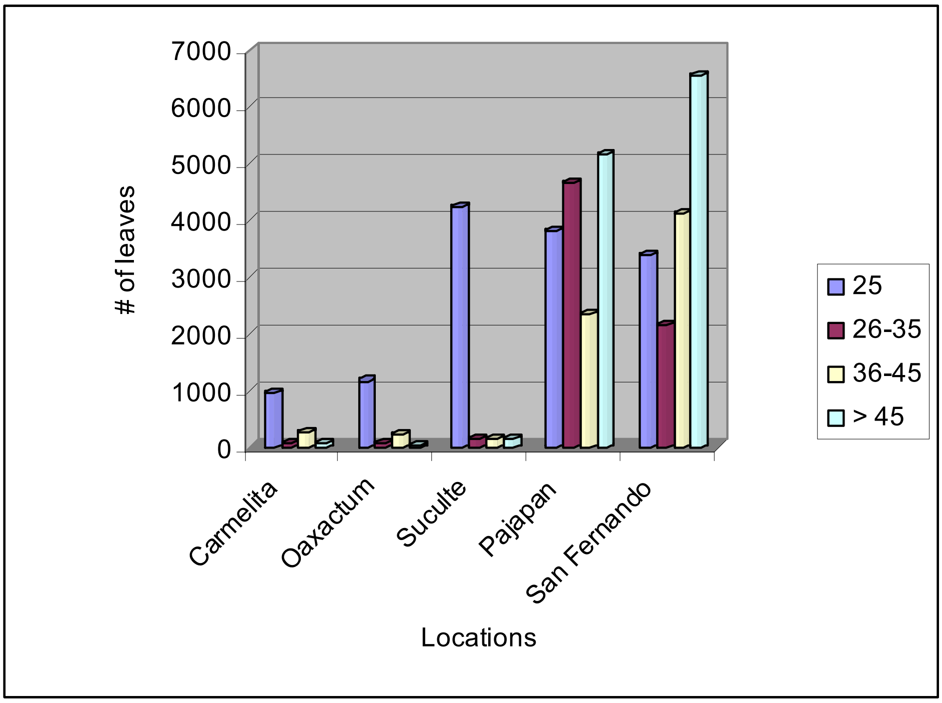
3.5 Main pests and diseases registered in the studied sites

Only in Mexico, some species of fauna such as small deer (*Mazama americana*), wild rabbits (*Sylvilagus* sp), grasshoppers (*Orthoptera* sp) and squirrels (*Sciurus* sp), that feed from seeds, stems and leaves were identified. Underground, the main problem was caused by the juvenile larvae of *Phyllophaga* sp, a beetle with the common name of May beetle or June beetle; this larvae feeds on the roots of new plants, causing these camedor palm plants to die. In addition, a rodent (*Geomys* sp) with the common name of tuza, which also feeds on palm roots, was identified. These problems occurred in sites without management, mainly San Fernando, where all types of weeds grew. However, further detailed studies are required in order to estimate the severity of damage. Pajápan was almost completely pest and disease-free because, since the camedor palm cultivation is their main source of income, they usually apply agrochemical products. However, there was a severe grasshopper attack in 2004 and the combat was manually. In Guatemala, these problems were not identified, reflecting probably the role natural ecosystems play in biologically controlling pest and diseases.

From the productivity point of view, there was a great difference between values obtained for the Mexican and the Guatemalan communities (Graph 14). Based on this result, the Guatemalan communities could obtain a better income from their camedor palm in a plantation because the density is greater and plants grow together, and so all types of management can be applied in time to obtain commercial volume. Similarly, from a practical point of view, the distances walked in order to gather camedor palm are much shorter than in the natural forest.

Leaf distribution by size was more regular in the Mexican locations because people can manage the plantation. This is mainly true for Pajápan; where harvesters take into account all the factors that could affect leaf production (Graph 14).

In two sample plots from Pajápan and three from San Fernando, densities were 20,000 plants per hectare, because the people began to establish camedor palm density according to a government project by which this density was recommended. However, after the first production, producers noticed that it was possible to increase the density to 30,000, then 43,000 and finally 71,400 plants per hectare, so one sample plot in Pajápan left a plantation established with 30,000 plants per hectare (Aguilar *et al.,* 2002, Aguilar, 2005). In the conducted survey, most of the people said that they increased the palms density in all plantations to 67,000 plants per hectare, although they need to apply fertilization annually with a formula of 17-17-17 of Nitrogen–Phosphorous-Potassium.



Graph 14. Leaves and sizes evaluated for each location from July 2004 to July 2005.

Contrarily, in Guatemala, plant densities were lower, an average of 792 leaves per hectare, although other authors have reported 272 leaves per hectare in the same locations but in different places. In general, from an ecological point of view, plant populations were variable in the forest and depended on favorable ecological factors (Pinelo, 2000; CONAP, 2004).

Regarding varieties, San Fernando and Pajápan are growing camedor palm variety "San Luis", although it is being replaced by "Negrita de la Sierra". In Carmelita and Oaxactúm, people are gathering a local variety from Petén, and Suculté is growing the JumboMex and Petén varieties. The JumboMex variety is a commercial variety widely known in the world, but the Petén variety is at a disadvantage because its shape is not round like the JumboMex, but sharp, and most of the florists in the world prefer to use the round variety because floral arrangements are usually arranged symmetrically. Additionally, leaves in the JumboMex variety are greener and the leaflets are closer together. However, the JumboMex variety planted in Suculté has not given satisfactory results because it is a very rainy location and this species grows well in places with no water excess and no more than 68% shade. On the other hand, CONAP does not allow openings in the forest for camedor palm cultivation or pruning the trees. The only activity allowed is to clean the soil gathering litter, branches, trunks and other organic material and moving it out of the plantation. Even though Suculté registered the largest fronds from the Petén variety which was more resistant to sunlight, grew more quickly and had more regeneration power than the JumboMex variety; its acceptance in the international market is currently more restricted (Grant[7], 2005).

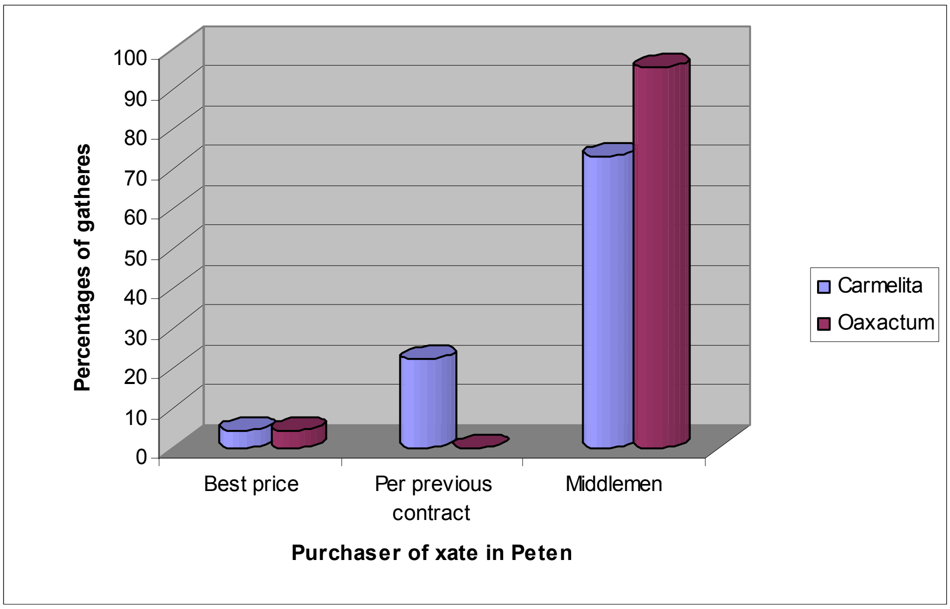
3.6 Commerce enterprises of camedor palm leaves in Petén Guatemala, and Veracruz, México

In Guatemala, gatherers did not have many options for commercializing their camedor palm leaves. They sold their product to local and foreign intermediaries who have been purchasing it for the last 30 years in both locations. Intermediaries stored the camedor palm leaves for two days in a rustic storeroom until a bigger intermediary came to take it.

The process is simple, the foreign intermediaries called the local middlemen to say when they would come to the location to ship camedor palm, so the local middlemen informed the gatherers and they went ahead and gathered it in the forest. In Carmelita, 73.3 % of the population who gathered camedor palm sold it to middlemen, 22.2 % had a previous contract and 4.4 % did not have a specific buyer and sold it to whoever offered a better price. Contrarily, in Oaxactúm, 95.5 % of the

[7] 2005. Camedor palm commerce in the European Union (Interview). "Camedor palm project" Manage. Founding from United Kingdom. San Benito, Petén. Guatemala. Association Alliance for a World Just.

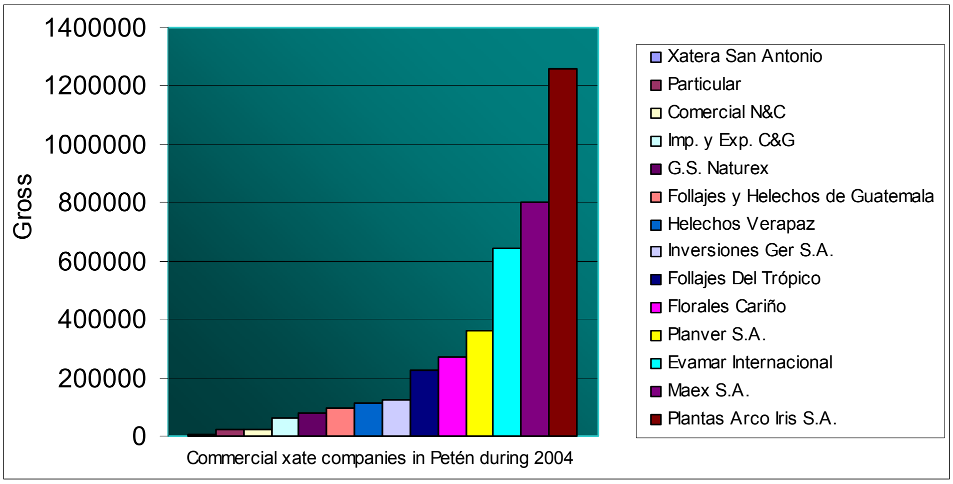
gatherers delivered their product to middlemen; 4.5 % did not have specific middlemen and usually sold it to the purchaser who offered the best price (Graph 15).



Graph 15. Ways in which gatherers sell their camedor palm leaves in Petén, Guatemala

Although gatherers can sell their product directly in San Benito or Santa Elena, they prefer to sell it to the intermediaries. Some reasons they gave were that the intermediaries have maintained a stronghold on the market scene for a long time, they are able to provide farmers with money and resources for their work, and they provide quick credit. They also pay quickly for the product, they pay daily, always in cash, even when there is not enough product; they have a good local weekly organization system and gatherers sometimes obtain free rides to the city (Pswarayi-Riddihough and Jones, 1995). When camedor palm leaves availability was low, in the dry season, some intermediaries came to the locations to buy this NTFP and paid better prices; hence people decided to sell camedor palm leaves to them even though the purchased volume was not high.

In general, in Petén, Guatemala, 14 companies traded camedor palm regularly during 2004. Evamar Internacional, Maex S.A, and Planta Arco Iris are the companies with the largest market share. The latter moved 1,257,170 gross in that year. These three companies moved more camedor palm than the other 11 put together (Graph 16).



Graph 16. Grosses of camedor palm leaves moved from Petén to Guatemala, for export during 2004.

During that year, the company "Planta Arco Iris" was given 215 licenses for moving camedor palm leaves in Petén; Maex S.A. was given 134 licenses and Evamar Internacional received 114. Taxes paid by these companies were equivalent to US $7.75 per license (Table 10). These taxes were for *Chamaedorea elegans C. Oblongata, C. ernesti-augusti,* and *C. erumpens* because the camedor palm included these species (Table 10).

In Mexico, Flor de Catemaco purchased most of the product. This company sent buyers to the study locations to buy the product, generally not during rainy season. Therefore, the product was traded directly by this company. Some particulars came to the area to buy leaves, but this product was also sold to Flor de Catemaco. On the other hand, some local flower shops bought camedor palm leaves weekly but the volume was low and was not recorded.

Table 7. Camedor palm leaves extraction companies, gathered volume, licenses issued and taxes paid in Petén during 2004.

Company	Gross traded	Total leaves	Licenses issued	Taxes paid (US $)
Comercial N&C	22,580	2,709,600	4	31.01
Evamar Internacional	642,099	77,051,880	114	883.81
Florales Cariño	271,300	32,556,000	36	279.1
Follajes Del Tropico	225,400	27,048,000	34	263.59

Follajes y Helechos de Guatemala	96,500	11,580.000	12	93.03
G.S. Naturex	81,200	9,744,000	12	93.03
Helechos Verapaz	112,500	13,500,000	18	139.55
Imp. y Exp. C&G	60,600	7,272,000	12	93.03
Inversiones Ger S.A.	122,640	14,716,800	25	193.82
Maex S.A.	802,800	96,336,000	134	1,038.87
Particular	20,000	2,400,000	2	15.51
Plantas Arco Iris S.A.	1,257,170	150,860,400	211	1,635.83
Planver S.A.	361,300	43,356,000	73	565.95
Camedor palma San Antonio	5,100	612,000	1	7.75
Total	1,257,170	150,860,400	691	5,333

Source: CONAP database, Petén, 2004-2005

3.7. Supply chain

Camedor palm generally goes through several stages and processes before reaching the consumer. During this process, the price varies according to the stage in which it is, as well as management, size and quality. In each stage, a management practice is usually added and the price increases, but the last actors in the chain obtain the best benefits (Table 8).

Table 8. Trade chain and income per camedor palm gross in each stage

		Mexico ($ US) 100 leaves		Guatemala ($ US) 100 leaves	
	Chain level	2004-2005	%	2004-2005	%
1	Producer or gatherer [1]	0.90	4.38	0.827	3.10
2	Local collector [1]	1.18	5.74	0.86	3.23
3	Regional collector [1]	1.73	8.42	5.2+1.02	19.54
4	Wholesaler [2]	3.54	17.23	7.22	27.13
5	Local Retailer and US wholesaler [2]	13.19+2	64.21	12.5+ 2.88	46.98

[1] Own data obtained from July 2004 to July 2005.
[2] Based on CEC, 2003.

In the supply chain the process is relatively simple; in México it is not complicated because not many companies participate in the processing and export of this palm. However in Guatemala the process is more complicated. The gatherers usually sell their product to a local intermediary, who stores the product two or tree days on the ground, which is of ground, and walls of wood. During this time, palm leaves are covered with a sisal sack to avoid the dehydration. The local buyer after the first day waters the leaves because they begin to lose the brightness, so they usually receive leaves only two days before is shipped.

The regional collector could be a particular who buys and sells leaves or a buyer sent by any company to collect the product. In the first case, after collecting the product they go their store center where women classify the leaves by quality and make bundles of 25 leaves which are sold to export companies. Depending of the volume of commercial leaves by local gross, they perceive 5.2+ 2 dollars per bundle of 100 commercial leaves. Usually to get 100 commercial leaves, 208 are waste. On the other hand if the regional collector works for a company, then only receive a salary. The next steps are realized for export companies. Table 11 show the supply chain and incomes for México and Guatemala.

3.8 Cost-benefit ratio for camedor palm leaves production in México

3.8.1 Investment costs

For planting a hectare of camedor palm, each community spends different amounts because each uses different methods for cultivating it. Information in Table 10 was calculated based on seven plots of different ages evaluated during 2004 in Pajápan and San Fernando. Considering management, harvest frequency, volume and leave size, it was calculated that a camedor palm plantation has a productive life of 12 years after the first production in the 3rd year; although some authors think that it can be productive for more than 14 years (Rosado, 2004; Grant, 2005[8]).

A well managed plantation can produce good quality leaves for 12 years, but if it is over-pruned, its productive life period will be reduced to 7-9 years and it will produce small leaves. When a plantation begins to produce many seeds and small leaves, it is better to replant the plantation. In the plantation, the farmer must plant the younger plants before eliminating the older ones. In this

[8] 2005. Camedor palm production (Interview). “Camedor palm” Manager. United Kingdom Founding. San Benito, Petén. Guatemala. Association Alliance for a Just World.

manner, in the 13th year, plants will be growing but there will also be leaves for harvesting. In the 14th year, older plants will need to be cut in order to allow the new plantation to grow. Consequently, the farmer will not have a lag in income (Table 10).

In Petén, the establishment of a hectare of camedor palm had a variable cost; Ramirez (2002) reported a cost of US$ 565.1 from the first year to the third year when harvest begins. However, Association Alliance for a Just World (2004) reported a cost of US$ 3041.15 per hectare for two years, and for Mexico, CCA (2002) reported a cost of US$ 252. For Guatemala, the costs contrast sharply; Alianza por un Mundo Justo found a cost-benefit ratio of 1:1.7 after 12 years of production, but this research found a ratio of 1:2.67. On the other hand, as the forest concessions in Petén, are regulated by CONAP laws, they can not destroy the natural forest to plant camedor palm, so Carmelita developed a management plan for collecting wild population of camedor palm and estimated an income of US$ 57,778.967 annually, or US$ 10,110.40 for fees if foreigners collect this palm in their forests.

The financial costs for a hectare of camedor palm in Pajápan was based on information from several plantations of several years in production, however, no one had 12 years of age because camedor palm plantations in Mexico are relatively new. However being constant the income, it was calculated the financial indicators for 14 years taking as true that in the twelfth year in the plantation must be replanted and that in the fourteenth year old plants must be eliminated to allow the new plants to grow. Results are shown in Table 9.

In a comparative analysis, a great difference in the productivity of camedor palm leaves was found between natural forest and a plantation. Plant density per hectare is the main factor for obtaining a better income in plantation. In a hectare of camedor palm plantation, it is possible to obtain 360,000 commercial leaves annually, but in the forest, only 3,511 were available during 2004-2005. An advantage for Petén is that each community has several thousands of hectares of forest, although not all of them are apt for camedor palm growth (Table 10).

Table 9. Cost-benefit ratio per hectare of camedor palm plantation in Mexico.

Years	Costs	Revenue	Gross income	Discounting Factor	VAN
1	*1,851.26*	*0.00*	*-1,851.26*	*0.955110*	-1,768.15664
2	435.40	0.00	-435.40	0.912235	-397.19150
3	235.35	2,989.76	2,754.41	0.871284	2,399.87207
4	529.07	2,989.76	2,460.69	0.832172	2,047.72065
5	522.37	2,989.76	2,467.39	0.794816	1,961.12107
6	529.07	2,989.76	2,460.69	0.759137	1,868.00204
7	522.37	2,989.76	2,467.39	0.725059	1,789.00289
8	529.07	2,989.76	2,460.69	0.692511	1,704.05647
9	522.37	2,989.76	2,467.39	0.661424	1,631.99070
10	529.07	2,989.76	2,460.69	0.631732	1,554.49962
11	522.37	2,989.76	2,467.39	0.603374	1,488.75871
12	486.97	2,989.76	2,502.79	0.576288	1,442.32799
13	480.28	2,989.76	2,509.49	0.550419	1,381.26784
14	486.97	2,989.76	2,502.79	0.525710	1,315.74179
Total	6,882.00	35,877.13	28,995.13		18,419.01369
		TIR	72%		
		B/C R	1:2.67		

Table 10. Comparative analysis of productivity in Mexican and Guatemalan communities in a planted hectare of camedor palm and a hectare of natural forest after the third year.

Country	Plants per hectare	Total Leaves	Commercial Leaves	Commercial Gross	Price US$	Annual Harvests	Annual Income US $
Mexico plantation	30,000	420,000	360,000	2291.5 + 208	1.3	5-6	$3032.3
Guatemala (Natural forest)	791 + 88	16,738	3511	29.25	0.34	3-4	10

Field data from July 2004 to July 2005[9]

A disadvantage, however, for gatherers in Guatemala was the distances that needed to be walked to reach the camedor palm and back home, with the camedor palm hanging on their backs or on mules. More than 65 % of the surveyed people walked between 6 and 10 km in Carmelita and more than 50

[9] Information calculated taken as a reference that effectively in one hectare there are 30,000 camedor palms. If the number of plants grows or decreases the annual income varies.

% in Oaxactúm walked the same distance. A camedor palm gatherer in Guatemala usually receives an irregular annual income, which depends on the amount gathered. Generally, this income varies from US$ 134 to US$ 227[10] on average.

Likewise, 30 % and 40 % of the gatherers from Carmelita and Oaxactúm walked an average of 15 kilometers everyday to reach camedor palm leaves. People in Carmelita said that the fires in 2000 and 2002 destroyed the nearby populations of camedor palm, and currently no plants have germinated in these areas. The day laborers usually made camps in the forest and lived there for short terms. They collected all types of camedor palm and when production declined, they moved to other places. They needed to walk less than local people did.

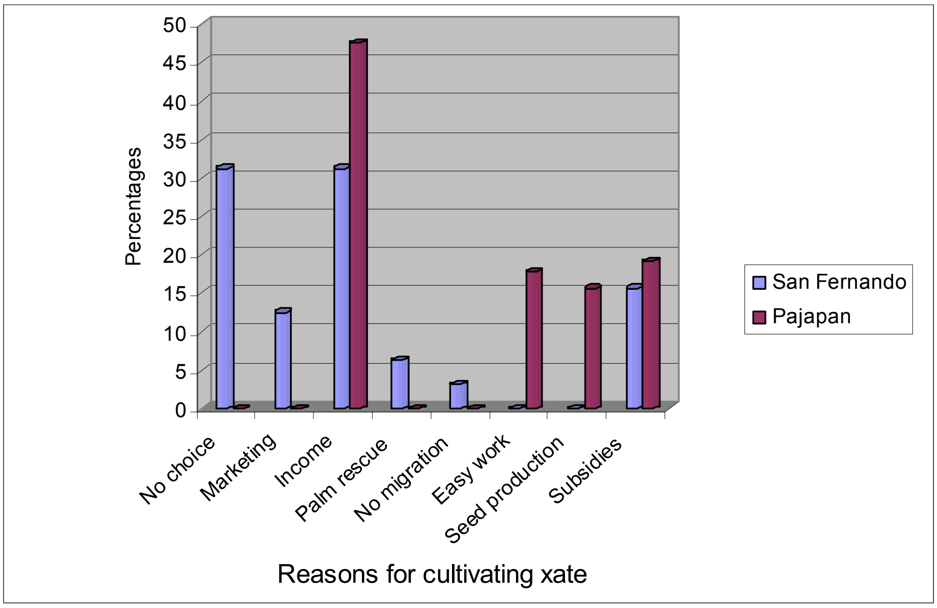
In both locations, gatherers were not selective during the gathering process because when they were in camp, they collected other species from the *Chamaedorea* genus. In Carmelita, three species were registered; *C. ernesti-augusti, C. oblongata* and *C. elegans,* but in Oaxactúm people gathered five species during the year; *C. ernesti-augusti, C. oblongata* and *C. elegans C. tepejilote* and *C. erumpens*.

In Carmelita, people have been gathering camedor palm for 45 years; nowadays there are people over 85 years old who are still working, gathering camedor palm leaves. On the other hand, in Oaxactúm, according to the interviews, people are relatively new to this activity. The oldest gatherers have been cutting camedor palm leaves for no more than 15 years, and they are no more than 45 years old. This is because Oaxactúm has more tourist activities, more opportunities to attend school, to work off-farm, and to help the family. Therefore, less than 50% of people of working age gather camedor palm. In Suculté, more than 100 men and 35 women participated in camedor palm activities throughout year. In addition, in storage centers in San Benito and Santa Elena, more women worked in the manual selection of camedor palm during 2004-2005 than men did.

In Mexico, camedor palm cultivation began with the coffee crisis and the government implemented a program for cultivating camedor palm. Many people participated in the beginning, but they were new to producing camedor palm under management. Camedor palm cultivation began eight years ago in Pajápan and 4 years later in San Fernando.

[10] Field data information gotten from surveys conducted from July to August 2004.

The size of plantations is small, in Pajápan, 90 % of the interviewees had less than one hectare; in San Fernando 50 % of the plantations are of less than one hectare, and in both locations the rest of the interviewees cultivated between one and three hectares. People have different reason for cultivating camedor palm. For example, in San Fernando, 31 % of the surveyed people said that they did not have another choice because not many commercial products grow in the region. They had survived on coffee production but nowadays, coffee prices are very low and so it is not a profitable activity. A similar percentage said that they cultivated it because camedor palm production generates income. Additionally, 15.5 % said that the government pays to cultivate this product and 12.5 % said that the leaves are easily traded. On the other hand, in Pajápan, 47.5 % said that they are growing this product because it is the only species that can be traded five or six times during the year and generate enough income to make a living if it is well managed. Likewise, 17.7 % consider that producing camedor palm is easy work and, finally, 15.5 % said they could sell their seeds for a good price (Graph 17).



Graph 17. Reasons that surveyed people gave in San Fernando and Pajápan for cultivating camedor palm (n = 87).

In Carmelita, 70 % of the people surveyed have been transporting their product on their backs their whole life, and 30 % rode on mules or horse. Contrarily, in Oaxactúm, more than 60 % of the gatherers rode on mules, 30 % walked, and a few used trucks or carts.

During the dry season, gatherers could use the concession trucks for transportation if they were on the same road, but this was not frequent. During the rainy season, only the mules could walk through the flooded roads in Carmelita. During this period, purchaser did not come to Carmelita for camedor palm because the main road was flooded for more than two months.

In Guatemala, all harvesters have some basic knowledge of camedor palm management as they have been in direct contact with the forest. This is different in Mexico, in San Fernando, approximately 70 % of the people said are not knowledgeable in camedor palm management and the rest have minimum knowledge. Contrarily, in Pajápan, 55 % of the people have worked with camedor palm, are familiar with its management, and harvest it every two months, while 20 % prefer to do it every three months, and the rest harvest once a year (Table 11).

Table 11. Number of camedor palm harvests per year and percentages

Locations	Times per year					
	1	2	3	4	5	Total
San Fernando	-	17.0	6.5	6.5	70	100
Pajápan	-	-	21	25	53	100
Oaxactúm	-	29	66	5	-	100
Carmelita	10.2	71.8	18	-	-	100

4. Discussion and Conclusions

Camedor palm leaves gathering has been an important economical activity in Petén and in Mexico for many years, although, in Petén, this has been more marked because camedor palm is an understory species and this zone has approximately 2 million hectares of potential habitat for this species. Nevertheless, it seems that only 500,000 hectares are good sites for *Chamaedorea elegans (*Radachowsky *et. al.,* 2004). In Mexico, this species is very important for the local economy of rural communities; however, several important agricultural and forestry activities have caused a reduction of the species natural habitat, thus decreasing its populations. Currently, this species is being promoted in plantations, with improved varieties. Due to loss of habitat and seed shortage during 1995 in Mexico, the production of *Ch. elegans* leaves was the lowest during this year.

Although this foliage is generally harvested and commercialized throughout the year, in Guatemala, people harvest it during the rainy season because they cannot realize any other productive activity. On the other hand, in Mexico, according to the producers, there is no specific season for gathering camedor palm in the forest because plantations are close to their houses and so, whenever they need some money, they can harvest 15 or 20 gross and sell them to florist shops in the city. However, this system is neither profitable nor recommended.

In almost all the locations height was directly linked with number of commercial leaves. Even though we did not find any work that mentioned that pruning favors camedor palm plant growth and sprouting of leaves, it was noticed that pruned plants (not affecting the apical meristem) produced leaves more frequently than plants that are not pruned, and also favored plant growth.

In the natural forest, the number of plants and number of leaves per sample plot was variable. Although in the natural forest camedor palm plants were harvested every 75 days on average, it would also be viable to harvest every 90 days because the leaves would have enough time to completely mature into commercial leaves. Additionally, during this time the plant would be able to recover the energy spent during the production of the harvested leaves.

In relation to plant height and percentage of commercial leaves, it was found that height is an important factor when considering volume of commercial leaves because the taller the plant the larger the volume of commercial leaves. In Guatemala, this pattern was clearly demonstrated in Oaxactúm and partially in Suculté, but in Carmelita, the opposite was observed, as people usually did not harvest the same plant. Therefore, although the plants were tall, they actually had a few commercial leaves. For the Mexican communities, in both cases the percentage of commercial leaves was greater if plants were more than one meter tall.

In a comparative analysis, there are more advantages when harvesting camedor palm leaves is realized under management in a plantation rather than gathering it in natural conditions, because the harvested volume is greater, people do not walk long distances looking for plants, and all of the plants are close together. However, plantations also have some disadvantages, like in San Fernando, where producers only commercialized part of their product. Economically, it represents a loss for the people because if they are producing camedor palm leaves in large amounts, they would commercialize all of the production. Therefore, producers in this community need a commercialization system that allows selling their product regardless of climatic conditions. On the other hand plantations have an investment cost that cold be a limitation to most rural people

From an economic point of view, it is proposed that camedor palm be commercialized by size and that a fair price is agreed upon with the importers. However, recently, both Carmelita and Oaxactúm have established an agreement with companies in the United States to sell certified camedor palm leaves from the forest. People will adopt conventional technologies for producing this palm in regular volumes, quality, and delivery frequency. Contrarily, even though Mexico has been producing camedor palm for several years, it is clear that training is necessary, focusing mainly on three aspects: shade management, disease and pest control, and quality control.

It has also been argued that the harvest of camedor palm leaves from natural forests helps protect the forest because gatherers protect the forest in order to protect their source of income. In addition, the presence of members of the community in the forest serves to protect the forest from invasion (CEC, 2003). However, in Guatemala, from an ecological point of view, it is better to combine the natural recollection of camedor palm with camedor palm from plantations for several reasons, such as to protect and restore the natural population, delimitate the production area and regulate the local income for this activity. In order for this to be a profitable activity, people could work in groups establishing plantations in secondary forests and planting 30,000 plants per hectare. This density is acceptable under natural forest, due to the trees, a higher density will not be allowed. Ecological factors cited in Sol *et al.,* (2005a) should be taken into account.

In Carmelita, people should choose the best places to establish a plantation. The Petén variety is the best option for them. While the plantations reach a productive level, CONAP should conduct a population study for camedor palm in areas where camedor palm gathering is solicited and estimate the volume that could be gathered in each location. Because populations are dynamic, it would be recommended to conduct this study every four years. Companies that trade camedor palm leaves could contribute the money required for this study because they benefit directly from camedor palm production. This population study would determine the volume that these companies can extract from the forest without affecting the camedor palm populations in the natural forest. If CONAP establishes and justifies this type of study, it will assure long-term sustainable production.

Currently, the international market is favoring camedor palm from Guatemala because it is cheaper to purchase in Guatemala than Mexico. The aforementioned is a way to develop that type of market. Currently, local gatherers in Guatemala sell their product to intermediaries and receive only 1.43 % of the final price, but they could increase their income if they deliver their products outside their towns. For example, the last achievement by Carmelita and Oaxactúm is that they have begun to sell their camedor palm directly to San Antonio, Texas in the United States, assuring an annual income of approximately US$ 104,000. It has been argued that more than 50 % of this income will be paid to camedor palm gatherers, and the rest will be paid to women selectors. This is the first step in the harvest control and sustainability of camedor palm in the Mayan Biosphere Reserve (Rain Forest Alliance, 2005), resulting in an increased in the income of the local population.

This certified commerce of camedor palm leaves has provided the opportunity for women in the community to be involved in the selection and processing of the camedor palm leaves. They are participating and adding value to camedor palm, which goes a step beyond the middlemen and provides additional income and employment opportunities to the community.

For Mexican towns, avoiding the presence of unwanted fauna in the plantation is a high-priority because it is the enemy of leaf quality. Although there are several cultivars in Mexico and Guatemala, each location would cultivate what is appropriate to their ecological conditions, seeing as, in the international market, all varieties of *Chamaedorea elegans* are highly accepted.

Producers must look for better options for selling camedor palm leaves. In Guatemala, this situation can only change if people get organized to commercialize their products as societies of rural production inside the forest concession. Economically, the income is low because most gatherers harvest the same plant two or three times per year, but in a plantation, the income is greater because people harvest five times on average. From a physiological point of view, it is recommended to harvest a camedor palm plant no more than four times in a plantation and no more than three times in natural populations annually in order to obtain a longer productive life.

Putting together all of the variables, the conclusions for Guatemala are divided into two parts, the first focusing on the period up to July 2005, in which the people had no relation with certification o exportation on their own, and the second one after July 2005. Regarding the first period, is possible to conclude that up until July 2005, the process of gathering and commercialization could be considered as environmentally unsustainable because the people had been pressuring the natural population of camedor palm in order to obtain enough leaves for commerce thus producing a high percentage of waste. However, since July 2005, the panorama has changed because people have begun to harvest only potentially commercial camedor palm leaves, following advice from national and international institutions. This has given place to the training of people in harvesting and greatly reduced waste from 70 % to 10 %, with possibilities of further reducing it. As a result, in general, the people and institutions involved expect to change the old opinion that camedor palm is not environmentally acceptable. Linked to this new achievement, although the first steps to commercialize certified camedor palm leaves have been taken, it is possible to conclude that, economically, it has not been viable for the lack of correct distribution of the economic benefits to the people involved. However, it is expected that camedor palm leaves can be sold at a better price, changing the expectations of people selling directly to the United State. Likewise, socially speaking, if we look back, participation in camedor palm-related activities was socially unfair as only men took part in these activities; recently, though, women play an important role in camedor palm production, in nurseries, in manual selection and in boxing for exportation.

Taking as a reference the first conclusion, and thinking always of improving the local economy, we expect camedor palm leaves gathering to become an economic activity for all the locations involved. It will also become environmentally acceptable, since people have been training in camedor palm gathering, and socially fair as women have begun to occupy and important role in the leaves selection and boxing for exportation.

For Mexico, putting together all of the variables, camedor palm production has not been an economically viable activity, because people are required to sell great volumes of camedor palm leaves in order to obtain enough money to cover their needs. It is possible to say that it is an environmentally acceptable activity because people do not need to deforest in order to establish their plantations; they have planted camedor palm in agroforestry systems where coffee was previously planted. On the other hand, it is not socially fair because only men receive money, even though women participate in the selection of camedor palm leaves.

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Chapter V.
General overview of results, Discussion and Conclusions

5.1. Distribution features of Chamaedorea elegans

Chamaedorea is a genus restricted to the American Continent, from Mexico to Colombia, Ecuador and Peru, mainly restricted by climate and soil. This genus grows in moist areas, avoiding dry areas, such as Nicaragua, where the number of species is reduced. Likewise, in the region of the Andes, it is not represented because of the cold temperatures. The *Chamaedorea* genus includes small and tall species which are appreciated for their ornamental value.

The studied species, *Chamaedorea elegans*, is endemic to Mexico and Guatemala. In Mexico, its exploitation as an ornamental plant began several decades ago in the Northern border on well drained volcanic soils. In the South, it grows on different types of soil such as clay, muddy clay, and rocky outcrop, all of which have high relative moisture. In Tabasco, this species was common in flat areas but now it only grows in the mountains in fragments of tropical forest. In Chiapas, it grows in nearly the entire state because of the high precipitation. In the pacific zone, it grows well in Oaxaca and Guerrero - mainly mountainous areas where precipitation is high. In Guatemala, it grows in soils from light to abrupt slopes, with variable shade that ranges from 25 %, like in Carmelita, to 85 %, as in Suculte. Similarly, in Belize this species is present in the forest as well as in archeological ruins where soil is moist but not flooded.

Currently, Mexico has no protection areas for this species as in Peten, where the national parks are considered protection areas for the *Chamaedorea* genus, especially the commercial species. In the natural distribution area, *C. elegans* flowers in open sites where shade is under 55 %, but does not produce commercial leaves, as they are burned by the excess of sun.

5.2 Silvicultural aspects of *Chamaedorea elegans* palm

Due to *Chamaedorea elegans* being a species undergoing a process of domestication, many aspects of its silviculture are unknown; although there is an isolate progress in plant densities - which vary from 30,000 to 67,000 plants/ha, substrate, germination, scarifications methods and others.

However, it is necessary to further investigation on population management in natural forests because, up until know, this activity has been extractive.

On a general level, under low shade densities, seed production is increased and the plants can produce from 2 to 8 inflorescences when flowering takes place under 50 % shade. Likewise, the number of seeds per plant is higher compared with plants growing in the forest (higher shade), where fructification occurs sporadically.

Regarding germination, the time required varies between 6 to 12 months. Factors that regulate germination generally come from the condition in which seeds are harvested to post-harvest management. Seeds collected at 75 % maturation or more have a high chance of germinating in less time than those harvested at the beginning of the maturation process. Likewise, water availability, seed health and absence of pathogens and predators also favor early germination.

In the study area, in Mexico, after seed collection took place, people washed the seeds to eliminate the external cover, and then the seeds were dried in a shaded room for three days. Subsequently, the seeds were placed in sealed plastic bags, with enough space between the seeds and the bag's knot, and hanged close to the ceiling or in a warm area. The seeds then begin to transpire and, after a month, the first evidence of germination, "the radicle", appeared. A disadvantage observed in this method is that the seeds need to be separated manually one by one before the roots reach 3 mm, because their roots break easily; then the seeds were planted in a germination bed. In Suculté, people preferred to use any chemical scarification method and immediately buried the seeds, because this method does not require more management after germination.

Before transplanting, it is recommended that the plants remain in germination beds for 18 months or until plants have 8 leaves. This way, the plants are not affected when moved to the final site. Transplanting must be done in the rainiest period to avoid harm to the leaves and roots.

In the study area, in Mexico, producers used two transplanting methods. The first is the most common and consists of transplanting into pots; however, it takes a long time because the producer can only plant a number of plants daily if the final site is far from the germination bed. The second method consists of transplanting with naked-root. This method is more convenient because it allows the transport and transplant of more plants daily than the first method, and the plants do no suffer any harm.

On the other hand, the planting method is variable; some people have established their plantations in rows, one plant followed by another. However, in order to protect the plants, it is recommended to plant them in a triangular way, trying to fit 30,000 plants per hectare in order to avoid fertilization during the production period.

Regarding shade management, in this research it was verified that 68 % shade on average was the best percentage required to produce commercial quality leaves. In Mexico, this is possible because the producers are owners of their lands and can regulate them by harvesting branches or eliminating undesirable trees that generate problems, like *Acacia cornigera* or *Cecropia peltata*, which live in symbiosis with ants, or *Pithecelobium* sp, which develops too many thorns, endangering product. Taking as an example the results in this research, it is recommended to avoid the following species for shade: *Belotia campbellii*, the genus *Coccoloba* spp, *Pouteria zapota*, *Manilkara zapota*, among other species; some species of fauna feed from these species and the leftovers fall down on the camedor palms damaging the leaves

Regarding pruning, no work has cited that the pruning of young plants favors the production of commercial leaves. However, in this research, it was verified that young plants with many potentially non-commercial leaves (stained, bitten by insects, broken or attacked by fungi) that were pruned, recovered soon and grew totally new healthy leaves. In addition, the plants formed a stem and the new leaves were not in contact with the ground.

5.3 Grouping of the studied communities and shade trees

The groups of sites obtained in the cluster analysis are product of the similitude among the evaluated variables for the sites as well as for shade trees. Due to different soil types - the volcanic origin of the soil in the Santa Martha Mountain in Mexico, the alluvial soil in Guatemala and the rocky soil in some parts -, there are different types of vegetation in which C*hamaedorea elegans* distributes.

In Guatemala, four groups of sites and three groups of trees were found; in Mexico, there were three groups of sites and four groups of trees, given mainly by interaction between climate and soil.

However, a detailed zoning is necessary in order to evaluate all the ecological factors involved in camedor palm distribution

Due to the good conservation condition in the Guatemalan forest, there were more shade trees species over 5 cm in diameter than in Mexico. In Mexico, the number of species was lower because these are managed species and the plantations are established in secondary forests under management, where lianas, herbs and unwanted palms of different genera are eliminated in order to increase the number of camedor palm plants per hectare and to facilitate their growth.

In Guatemala, a wild palm that was abundant in the sample plots was the *Cryosophila argentea* broom palm. This indicates that this area is not suitable for camedor palm, because *Cryosophila argentea* is an indicator excess of shade or flood zone, and so the camedor palm was scarce or absent in these plots, as the ecological conditions between *C. argentea* and *Chamaedorea elegans* are completely different. Another common species was *Pseuldomedia oxiphyllaria*, which is a good indicator of *C. elegans* presence because it grows on high, well drained soils and produces good shade for *C. elegans*

5.4 Effect of sunlight on camedor palm fruit production

As previously cited, *Chamaedorea elegans* bloom and produce fruits in open sites. Plants located in sample plots under 50 % shade produced flowers and fruits, while plants in plots with higher shade percentage did not. In Mexico, sites with less than 65 % shade produced flowers and fruits, but sites with over 70 % shade did not go through the flowering process. Sites that spent more than four weeks without canopy during the dry season the sunlight penetrated well to the understory and the plant of palms produced much more fruits. The same phenomenon was observed in plants situated in the borders of the plantations.

The producers recollected the camedor palm seeds in July because it has an established market; price during the research period was US $10. In the studied areas, it was verified that no consensus exists regarding seed production per hectare. Some authors cite a production of 70 kg/ ha^{-1}, while others cite 200 kg/ ha^{-1}. This volume is directly related to the plantation's objective. High production of seeds is expected in areas specifically designated for seeds, whereas in areas where the main objective is leaf production, a lower volume of seeds is expected, as the required percentage of sunlight is different in each case. It is proposed that producers establish a different area for seed production in order to obtain seeds for replanting or for new plantations.

Although seed production was an objective to evaluate, in Pajápan, producers collected 100 kg on average per hectare during the research, which represents an income of US $1000. Usually, the seeds are commercialized by order in order to assure their sale.

5.5 The effect of rain on camedor leaf production

In both countries after the dry season, new leaves appeared which were harvested 22 days after opening. In sites where fructification took place, the first leaves took longer to develop. These leaves were harvested in the second harvest, which was carried out at 2 and half months intervals. This is due to the plants going through a process of recovery after the fructification period. In sites where shade was 68 %-70 % leaf production was faster (for more details see chapter 3).

In the plantations where the sample plots were established, the producers performed pruning at the beginning of the dry season leaving only two or three leaves per plant. These plants produced abundant seeds, and leaves once the rainy season began. It seems that this management practice reduces the presence of pests and diseases.

A different situation was observed in the plantations located in Suculté, Guatemala. Due to shade and organic matter excess the plants did not produced new leaves as was expected, on the contrary, many of them died by fungi attacks because the leaves were in contact with the ground. Economically, it is recommended to prune the entire JumboMex variety plantation in order to eliminate all the older leaves, favoring the emission of new leaves, and to clean the organic matter in the plantation, or to change the JumboMex variety by the Petén variety, which is local and grows well under those ecological conditions.

The same location had high production in greenhouses at 80 % shade, in sloped sites, which were managed by the Fair Trade Association, but the investment cost is high and most producers cannot adopt this technology. In this area in Petén, this is the best way to cultivate JumboMex variety. No pests or diseases were identified in the breeding grounds or in the production area in the greenhouse.

In this case, it is necessary to evaluate the volume that can be produced under this system, the recovery period, commercial sizes and productive period because plant density is very high.

5.6 Biological Indexes application

5.6.1. Shannon Diversity Index

The diversity index being a mathematical measure of species diversity in a community provided accurate information about the community composition taking into account the number of species present and relative values. Likewise, it allowed us to identify rare species in the sample plots based on the importance value index (Annex 1).

Statistically, there were no differences among the Petén communities regarding their diversity index, thus there is homogeneity between the number of these species and individuals for the three studied communities in Petén. The diversity index also allowed us to determine which are the most common though not necessarily the most important shade trees species. Some common species were *Pouteria durlandii*, *Pouteria reticulate*, *Trichilia havanensis* and *Brosimum alicastrum.* In the Guatemalan locations, an inverse relation between species-commercial leaves was found. This occurs because in some sites many shade trees could generate more shade than that required by the species to grow.

For Mexico, there were statically significant differences in values of the diversity index. This is because San Fernando has its plantations in fragments of natural forest and Pajápan in secondary forest under shade tree management. In Mexico, the species-commercial leaves relation was positive. The higher the number of shade trees, the greater the volume of commercial leaves, because the people regulated the shade trees. At the starting of the plantations all shade tree species are allowed to grow, but when shade is sufficient, only trees that are beneficial for shade are managed.

5.6.2 Sneath and Sokal Dissimilarity Index and Sörensen Similitude Index application

In the Petén communities, the values obtained varied from 0.001 to 0.033. This suggests that, from a general point of view, the three communities studied in Petén are very similar in their species number, because the values are close to cero. Statistically, all the communities were equal with alpha=0.05. In Mexico, this value was 0.018, if we consider that the plantation in San Fernando was established in fragments of forest, while people in Pajápan have used the secondary forest to establish their plantation.

For the common species among the studied sites, according to the Sorensen Similitude Index, Carmelita and Oaxactúm share 40 % of common species, which is a high value if we consider that their ecological conditions are different, although this explains the wide adaptation of the species to several ecological conditions. Uaxactun and Suculte only share 17 % of their species. Suculte has species such as *Dicksonia gigantea, Virola koschny* and *Coussapoa oligocephala*, which only grow in well conserved sites. *Dicksonia gigantea* is listed in appendices II of CITES. Because the plantation in Suculte is located in a protected area, many shade tree species are different from the other two locations. Suculte and Carmelita only share 9.8 % of their species, because the conditions of precipitation, soil, temperature and floristic composition are different. In Mexico, only 23 % of the species were common to San Fernando and Pajapan, mainly due to the type of environment in which the plantations were established.

5.7 Prices by gross of Camedor palm in Guatemala and Mexico during the research period

The leaf price in Guatemala was stable for the communities, but in Mexico, it was variable between the communities. As explained in chapter III, quality is the main factor that regulates the price in the communities. From the organizational point of view, San Fernando can improve their camedor palm leaves commerce if they organize as producers to sell their product. Currently, the monopolized market is a local problem, because it does not allow other buyers to come to the community. Consequently, when the only buyer decides not to purchase more products, the producers cannot sell their production.

A bundle of 100 leaves was paid at US $0.48 in Guatemala and US $0.89 in Mexico, although in Guatemala, in the gathering locations, a bundle of 100 leaves had only 26 commercial leaves on average, the rest is waste, whereas in Mexico, 100 % of the leaves were of commercial quality.

Particularly, I consider that the Guatemalan locations can work with a more organized system for trading their product and improving their earnings by taking training courses on species management, processes and delivery, supported by the Rainforest Alliance, which recently has trained people on these aspects. This will allow them to trade their product under a certification system, which could be useful for carrying out a more sustainable harvesting of their natural plantations. No middlemen participate in this process.

Likewise, the Center for Integrated Natural Resources and Agricultural Management (CINRAM), Minnesota, conducted a research with Catholic churches that use this palm during Easter. Those churches began to buy it directly from gatherers in Guatemala or Mexico, in order increase the local earnings and protect the natural population of the natural forest.

5.8 Commercial yield of *Chamaedorea elegans* leaves palm

During the last 50 years, Mexico has been the first exporter of camedor palm, followed by Guatemala; however, information regarding the volume of commerce has only recently become available. The extraction volume has been 326,839 400 leaves on average annually from Petén and 2024.5 tons/year from Mexico; due to the different measure unit, it is not possible to make a comparison of number of commercialized leaves between both countries.

During the research year in Guatemala, January 2004 and January 2005 were the months with highest extraction volume of between 420,000 and 510,000 gross of 80 leaves. September through December had the most intense harvest activity. Graph 2b shows the harvest months, and graphs 3, 4 and 5, in chapter 3, show the distribution percentage of commercial leaves regarding shade percentage (chapter IV). Carmelita was an irregular site for leaf production because commercial leaves recorded had between 25 % and 80 % shade; the other communities had more regularity in shade percentage where leaves were present. Because the plantations in Suculte are established in natural shade, the percentage of shade is higher than what camedor palm requires in order to grow satisfactorily without being affected.

Among the Mexican locations, Pajapan can be considered a model to follow for new plantations, because shade is distributed homogeneously between 66 % and 80 %, though the higher percentage of commercial leaves was obtained between 66 % and 70 %. San Fernando presented values between 66 % and 80 % shade, but the highest volume of commercial leaves was obtained with 71 % to 75 % shade. Shade management throughout the year allowed the production of homogenous leaves regarding commercial quality and size.

5.9 Height commercial leaves production ratio of *Chamaedorea elegans* Mart.

Nearly in all the locations, a direct relationship was observed between height and number of commercial leaves. This occurs due to a response to stem development because, as the plant grows, the leaves lose contact with the ground and, consequently, no pests or diseases are present and so all the developed leaves are potentially commercial. At the time of the last measurement, older plants in Pajápan and San Fernando were 6.6 years old and the maximum height registered was 135 cm for both sites. In Guatemala, one plant was 256 cm high, another was 205 cm high, and the rest were less than 148 cm.

Carmelita was the only location that showed an inverse relationship between height and number of commercial leaves, because many of the plots were drawn in intervened zones and only 60-70 cm high plants with shade covering them produced commercial leaves; the rest were exposed to sunlight and were burned.

Making a direct relationship between the studied variables and studied sites, the Biplot of the linear discriminative analysis show that Suculte differ in the axes 1 from the other two communities in shade tree number, total leaves and harvested leaves, while the other communities show high values of total leaves and harvested leaves, and low values of number of shade tree species.

5.10 Pests and diseases in camedor palm plantations

Pests are directly related to predators. Since the plantations in Pajápan and San Fernando have fewer predators, a high incidence of pests was registered during the study period. Some authors (Chase *et. al,* 1991; Rosado, 2004) report pests in breeding grounds but not in plantations, thus, further research is required in this field as pests are opportunists and take advantage of the plantation's conditions. In regards to disease, only *Phytophthora palmivora* affected some of the leaves in Carmelita.

Regarding diseases, the situation was overall more severe in Sucult\u00e9, because the disease known as damping-off affected many plants, due to an excess in moisture. This disease is caused by fungi present in the growing medium; it is a mixture of species of *Rhizoctonia*, *Pythium*, *Fusarium*, *Phytophthora*, *Sclerotinia, Sclerotium*, *Botrytis*, and others and can attack germinating seeds, seedlings and weak plants. It occurs in most soils as in greenhouses. In Suculte, it was present in the plantation. The other locations were not affected by diseases.

5.11 Supply chain and cost / benefit ratio for a hectare of Chamaedorea elegans plantation

The supply chain was represented by five levels: the gatherers, the local middlemen, the regional middlemen, the wholesaler, and the local and US wholesaler, in both Mexico and Guatemala. To find out the product's origin, each level in the supply chain has information about where the camedor palm comes from, its processes and distribution.

Although currently only a few communities have certification, it is expected that all locations that trade camedor palm will participate in the certification process and the creation of the trade standards. In many of the cases, each level is independent of the others.

In the trade chain, the first two middlemen only receive and deliver the product, they do not perform any extra labor, and they do not participate in the product's classification or cleaning process. However, when the regional collector works for an enterprise, he moves the product to a storage center where women select and classify the commercial leaves, prior to being sent to export.

Because there are commercial plantations only in Mexico, the investment needed to establish a hectare of camedor palm was calculated for locations where the government has previously supported projects related to this palm. It was found that the producers required a little more than US $2,000 per hectare for the first two years. Currently, producers in the study area do no spend that amount because the government programs provide seeds, agricultural tools and an economic incentive during the two years of plantation maintenance (for details see table 12, second paper).

5.12 General Recommendations

Guatemala

Management

The first step is to stop collecting leaves by quantity, collecting only commercial leaves.

Avoid fires caused by camping of foreign people inside the forest.

For each community, it is suggested that the camedor palm be collected by sector to allow the rest of the palms to recover their leaves. Pruning is suggested for all productive plants eliminating non-commercial leaves so that the plant will produce commercial leaves.

Productive

Pruning is recommended to increase the number of commercial leaves. This can be done when gatherers are colleting leaves in each sector, this way pruning will be carried out in a short amount of time.

In order to avoid more pressure on the natural population of camedor palms, it is suggested to establish a 10-hectare plantation in two parts, 5 hectares the first years and 5 the second year. Seeds can be purchased in Belize, as the varieties are the same and it is a nearby country.

Social

With a good internal organization for commercializing the camedor palm, it is recommended that both men and women participate in the process of selection and boxing in order to help the family economy.

Political

It is suggested that CONAP perform a study every 4 to 5 years regarding population size, in order to know the volume that can be authorized in sites where people collect camedor palm.

Organizational

The current organization through the forest concession is a good system to regulate camedor palm harvest for commerce avoiding the collection of non-commercial leaves.

From an ecological point of view, a restoration of the Petén areas where fires extinguished natural populations in 2000 and 2002 is suggested. Also suggested is the establishing of areas exclusively for seeds and then restoring the affected areas. The same variety must be considered for restoration.

Policies

Regulation should be establish in order to protect the camedor palm, the natural forest and the local fauna

Supervision in each concession is needed in order to avoid gathering more palms than the permission establish and for avoiding to gather palms in protected areas

Incentives for those communities that gather only commercial leaves is necessary as are doing currently Carmelita and Oaxactúm, who are commencing certificates camedor Palms to the Unit States

Market

The best market that Petén could reach is the certified ones because the price increases highly, moreover protects the natural forest and avoids the overexploitation of leaves

Mexico

Management

It is suggested that the communities involved in camedor palm production perform all management-related activities such as weed elimination, pest combat, shade regulation and an annual pruning, to favor the production of new leaves.

Local varieties are recommended for cultivation in order to assure good leaf quality.

Productive

It is recommended to not exceed 30,000 plants per hectare of camedor palm, because the farmers will need to apply fertilizer, for which the price is high. If a producer considers that he could apply fertilizer during the productive period, then he should plant no more than 60,000 per hectare because the leaves reduce in size.

Social

Although each producer has a family organization, it is suggested that women who participate in leaves selection receive a salary in order to motivate participation in family activities.

Political

It is suggested that the locations that are receiving government support also receive technical legal advice in order to have a competitive plantation.

Organizational

The study locations need internal organization in order to commercialize their product throughout the year. This is of high-priority in San Fernando.

Technological

Technological transference from location to location is recommended in order to avoid repeating mistakes. Pajápan is a good example for reference.

Policies

Mexico needs to apply those laws regarding to the protection on flora and fauna. Some areas have extinguished the natural population of this palm and currently people is cultivating it

The government has incentives for people who is growing this palm, however needs to supervise the good use of the money

Market

The best market for México could be also the certified ones because the price increases highly, moreover protects the natural forest and people could avoids the overexploitation of leaves.
Also this type of market could contribute to increase the areas planted with this palm

Annexes

Annex 1. Geographic location of the studied area in both Guatemala and Mexico

Location	Samples plot geographic location	
Carmelita	17º 39´ 57´´	89º 55´ 24´´
	17º 40´ 09´´	90º 02´ 46´´
	17º 31´ 45´´	90º 12´ 09´´
	17º 26´ 17´´	90º 05´ 05´´
Oaxactúm	17º 19´ 36 33´´	89º 30´ 55.33´´
	17º 39´ 59.51´´	89º 26´ 3.30´´
	17º 40´ 0.39´´	89º 41´ 53.05´´
	17º 19´ 34.30´´	89º 41´ 46.15´´
Suculté	250750 UTM	18-26350 UTM
San Fernando	18º 16´ 46.3´´	94º 53´ 40.7´´
	18º 18´ 57.6´´	94º 53´ 26.1´´
	18º 18´ 34.8´´	94º 53´ 05´´
Pajápan	18º 15´ 22´´	94º 41´ 50.4´´
	18ºº 14´ 59.7´´	94º 41´ 37.0´´
	18º 14´ 51.6´´	94º 41´ 32.8´´

ANNEX 2. Shade tree species and index value for each location

Peten, Guatemala.

CARMELITA	Sibalito 4							
Scientific name	**Dominance**	**Relative Dominance**	**Density**	**Relative Density**	**Frequency**	**Relative Frequency**	**V.I.**	**Pi*Ln Pi**
Allophylus cominia	2	0,0029	1	0,0105	1	0,0227	0,0362	0,0479
Aspidosperma megalocarpum	5	0,0073	1	0,0105	1	0,0227	0,0405	0,0479
Brosimun alicastrum	28,5	0,0414	4	0,0421	2	0,0455	0,1290	0,1334
Celtis trinervia	3	0,0044	1	0,0105	1	0,0227	0,0376	0,0479
Chryosophylla argentea	40,97	0,0596	6	0,0632	3	0,0682	0,1909	0,1744
Chrysophyllum caimito	59,46	0,0864	2	0,0211	1	0,0227	0,1302	0,0813
Cupania guatemalensis	13,62	0,0198	1	0,0105	1	0,0227	0,0531	0,0479
Gymnanthes lucida	20,15	0,0293	7	0,0737	3	0,0682	0,1712	0,1922
Laetia thamnia	16,75	0,0244	10	0,1053	3	0,0682	0,1978	0,2370
Lonchocarpus sp	4	0,0058	1	0,0105	1	0,0227	0,0391	0,0479
Manilkara zapota	38	0,0552	5	0,0526	3	0,0682	0,1761	0,1550
Pimenta dioica	6	0,0087	1	0,0105	1	0,0227	0,0420	0,0479
Pouteria campechiana	19,26	0,0280	4	0,0421	2	0,0455	0,1156	0,1334
Pouteria durlandii	83,76	0,1218	22	0,2316	5	0,1136	0,4670	0,3388
Pouteria zapota	25,03	0,0364	2	0,0211	2	0,0455	0,1029	0,0813
Protium copal	14,5	0,0211	2	0,0211	2	0,0455	0,0876	0,0813
Pseuldomedia oxiphyllaria	127,29	0,1851	11	0,1158	3	0,0682	0,3690	0,2496
Sabal mauritiformis	6	0,0087	1	0,0105	1	0,0227	0,0420	0,0479
Sideroxylon tempisque	30	0,0436	1	0,0105	1	0,0227	0,0769	0,0479
Spondias mombin	90,8	0,1320	1	0,0105	1	0,0227	0,1653	0,0479
Talisia floresii	35,56	0,0517	4	0,0421	3	0,0682	0,1620	0,1334
Trichilia havanensis	18,21	0,0265	7	0,0737	3	0,0682	0,1683	0,1922
	687,86	1,0000	95	1,0000	44	1,0000	3,0000	2,6145

CARMELITA	Aguacatillo 1							
Scientific name	**Dominance**	**Relative Dominance**	**Density**	**Relative Density**	**Relative Frequency**	**Relative Frequency**	**V.I.**	**Pi*Ln Pi**
Acacia cornigera	1,5000	1,5000	0,0018	1,0000	1,0000	0,0088	0,0227	0,0415
Aspidosperma megalocarpum	24,0000	39,5000	0,0476	4,0000	3,0000	0,0351	0,0682	0,1175
Brosimun alicastrum	20,4500	22,4500	0,0271	2,0000	2,0000	0,0175	0,0455	0,0709
Tabebuia Chrysantha	30,0000	30,0000	0,0362	1,0000	1,0000	0,0088	0,0227	0,0415
Bursera simarouba	20,4300	20,4300	0,0246	1,0000	1,0000	0,0088	0,0227	0,0415
Cedrela odorata	81,7200	8,7200	0,0105	1,0000	1,0000	0,0088	0,0227	0,0415
Chryosophylla argentea	1,0000	200,7000	0,2420	41,0000	5,0000	0,3596	0,1136	0,3678
Cupania guatemalensis	2,2700	2,2700	0,0027	1,0000	1,0000	0,0088	0,0227	0,0415
Cupania maccrophylla	3,7500	3,7500	0,0045	1,0000	1,0000	0,0088	0,0227	0,0415
Laetia thamnia	7,0000	7,0000	0,0084	1,0000	1,0000	0,0088	0,0227	0,0415
Lycaria sp	24,6000	24,6000	0,0297	1,0000	1,0000	0,0088	0,0227	0,0415
Manilkara zapota	3,0000	8,0000	0,0096	3,0000	2,0000	0,0263	0,0455	0,0957
Matayba opositifolia	1,0000	1,0000	0,0012	1,0000	1,0000	0,0088	0,0227	0,0415
Nectandra membranacea	9,0800	9,0800	0,0109	1,0000	1,0000	0,0088	0,0227	0,0415
Pimenta dioica	1,0000	7,0000	0,0084	1,0000	1,0000	0,0088	0,0227	0,0415
Pouteria campechiana	12,0000	23,0500	0,0278	3,0000	3,0000	0,0263	0,0682	0,0957
Protium copal	20,0000	20,0000	0,0241	1,0000	1,0000	0,0088	0,0227	0,0415
Pseuldomedia oxiphyllaria	2,0000	100,4200	0,1211	12,0000	3,0000	0,1053	0,0682	0,2370
Sabal mauritiformis	4,0000	10,2500	0,0124	2,0000	2,0000	0,0175	0,0455	0,0709
Pouteria durlandii	3,5000	137,6300	0,1659	27,0000	5,0000	0,2368	0,1136	0,3411
Sideroxylon tempisque	9,0800	9,0000	0,0109	1,0000	1,0000	0,0088	0,0227	0,0415
Simarouba glauca	9,0000	9,0000	0,0109	1,0000	1,0000	0,0088	0,0227	0,0415
Simira salvadorensis	11,0000	28,0800	0,0339	2,0000	1,0000	0,0175	0,0227	0,0709
Trema micrantha	21,0000	21,0000	0,0253	1,0000	1,0000	0,0088	0,0227	0,0415
Trichilia havanensis	1,5000	4,5000	0,0054	2,0000	2,0000	0,0175	0,0455	0,0709
Zanthoxylon microcarpum	7,5000	7,5000	0,0090	1,0000	1,0000	0,0088	0,0227	0,0415
	331,3800	829,3700	1,0000	114,0000	44,0000	1,0000	1,0000	2,2033

CARMELITA **Aguacatillo 3**

Scientific name	Dominance	Relative Dominance	Density	Relative Density	Frequency	Relative Frecuency	V.I.	Pi*Ln Pi
Acacia cornigera	4	0,0056	3	0,0216	3	0,0526	0,0798	0,0289
Aspidosperma megalocarpum	10	0,0139	2	0,0144	2	0,0351	0,0634	0,0595
Bravaisia tubiflora	3,54	0,0049	2	0,0144	1	0,0175	0,0369	0,0262
Brosimun alicastrum	12	0,0167	1	0,0072	1	0,0175	0,0415	0,0684
Bursera simarouba	2	0,0028	1	0,0072	1	0,0175	0,0275	0,0164
Casearia sp	4	0,0056	1	0,0072	1	0,0175	0,0303	0,0289
Chryosophylla argentea	26	0,0362	9	0,0647	3	0,0526	0,1536	0,1202
Chrysophyllum mexicanum	2	0,0028	1	0,0072	1	0,0175	0,0275	0,0164
Colubrina reclinata	23,65	0,0330	9	0,0647	4	0,0702	0,1679	0,1125
Dendropanax arboreus	4	0,0056	1	0,0072	1	0,0175	0,0303	0,0289
Faramea occodentalis	6	0,0084	2	0,0144	1	0,0175	0,0403	0,0400
Gymnanthes lucida	33,9	0,0472	10	0,0719	3	0,0526	0,1718	0,1442
Laetia thamnia	39	0,0543	12	0,0863	3	0,0526	0,1933	0,1583
Lonchocarpus castilloi	110	0,1533	1	0,0072	1	0,0175	0,1780	0,2875
Lysiloma desmontachys	4	0,0056	1	0,0072	1	0,0175	0,0303	0,0289
Manilkara zapota	59,4	0,0828	8	0,0576	3	0,0526	0,1930	0,2062
Matayba opositiflora	2	0,0028	1	0,0072	1	0,0175	0,0275	0,0164
Nectandra membranacea	39	0,0543	16	0,1151	4	0,0702	0,2396	0,1583
Pimenta dioica	6,5	0,0091	3	0,0216	3	0,0526	0,0833	0,0426
Pouteria campechiana	14	0,0195	3	0,0216	2	0,0351	0,0762	0,0768
Pouteria durlandii	47,15	0,0657	11	0,0791	2	0,0351	0,1799	0,1789
Pseuldomedia oxiphyllaria	108	0,1505	5	0,0360	2	0,0351	0,2215	0,2850
Pterocarpus oficinalis	5	0,0070	1	0,0072	1	0,0175	0,0317	0,0346
Sabal mauritiformis	38,7	0,0539	6	0,0432	3	0,0526	0,1497	0,1575
Pouteria durlandii	46,15	0,0643	14	0,1007	3	0,0526	0,2177	0,1765
Talisia floresii	2,4	0,0033	1	0,0072	1	0,0175	0,0281	0,0191
Trema micrantha	5	0,0070	1	0,0072	1	0,0175	0,0317	0,0346
Trichilia havanensis	21,8	0,0304	8	0,0576	2	0,0351	0,1230	0,1061
Zanthoxylon microcarpum	16,5	0,0230	2	0,0144	1	0,0175	0,0549	0,0867
	22	0,0307	3	0,0216	1	0,0175	0,0698	0,1068
	717,69	1,0000	139	1,0000	57	1,0000	3,0000	2,8513

CARMELITA	Bajillal							
Scientific name	**Dominance**	**Relative Dominance**	**Density**	**Relative density**	**Frequency**	**Relative Freqency**	**V.I.**	**Pi*Ln Pi**
Acacia cornigera	7	0,0114	3	0,0330	3	0,0638	0,1082	0,1125
Aspidosperma megalocarpum	56,5	0,0917	4	0,0440	2	0,0426	0,1782	0,1373
Bucida buceras	19	0,0308	1	0,0110	1	0,0213	0,0631	0,0496
Bursera simarouba	13	0,0211	2	0,0220	2	0,0426	0,0856	0,0839
Chryosophylla argentea	132,62	0,2151	29	0,3187	5	0,1064	0,6402	0,3644
Chrysophyllum caimito	6	0,0097	1	0,0110	1	0,0213	0,0420	0,0496
Colubrina reclinata	72,14	0,1170	9	0,0989	3	0,0638	0,2798	0,2288
Cordia sp	4	0,0065	1	0,0110	1	0,0213	0,0388	0,0496
Cupania guatemalensis	12,95	0,0210	2	0,0220	2	0,0426	0,0855	0,0839
Laetia thamnia	24	0,0389	1	0,0110	1	0,0213	0,0712	0,0496
Manilkara zapota	16,81	0,0273	3	0,0330	2	0,0426	0,1028	0,1125
Matayba opositifolia	6	0,0097	1	0,0110	1	0,0213	0,0420	0,0496
Metopium brownei	12,1	0,0196	2	0,0220	2	0,0426	0,0842	0,0839
Nectandra membranacea	1,8	0,0029	2	0,0220	2	0,0426	0,0675	0,0839
Pimenta dioica	0,56	0,0009	1	0,0110	1	0,0213	0,0332	0,0496
Pouteria amigdalina	46,26	0,0750	2	0,0220	2	0,0426	0,1396	0,0839
Pouteria campechiana	12	0,0195	2	0,0220	1	0,0213	0,0627	0,0839
Pouteria zapota	12,6	0,0204	2	0,0220	1	0,0213	0,0637	0,0839
Pseuldomedia oxiphyllaria	24,5	0,0397	3	0,0330	1	0,0213	0,0940	0,1125
Rollinia jimenezii	5	0,0081	1	0,0110	1	0,0213	0,0404	0,0496
Sabal mauritiformis	9	0,0146	1	0,0110	1	0,0213	0,0469	0,0496
Pouteria lundelii	32,7	0,0530	8	0,0879	4	0,0851	0,2261	0,2138
Sideroxylon tempisque	8,5	0,0138	1	0,0110	1	0,0213	0,0461	0,0496
Simarouba glauca	47,5	0,0771	5	0,0549	2	0,0426	0,1746	0,1594
Trema micrantha	6	0,0097	1	0,0110	1	0,0213	0,0420	0,0496
Zanthoxylon microcarpum	15,9	0,0258	3	0,0330	3	0,0638	0,1226	0,1125
	616,44	1,0000	91	1,0000	47	1,0000	2,9805	2,6368

CARMELITA **Sibalito 1**

Scientific name	Dominance	Relative Dominance	Density	Relative Density	Frequency	Relative Frequency	V.I.	Pi*Ln Pi
Acacia cornigera	2,5	0,0061	2	0,0303	2	0,0513	0,0877	0,1060
Astronium graveolens	0,25	0,0006	1	0,0152	1	0,0256	0,0414	0,0635
Brosimun alicastrum	59	0,1434	4	0,0606	4	0,1026	0,3066	0,1699
Bursera graveolens	45,89	0,1115	3	0,0455	3	0,0769	0,2339	0,1405
Bursera simarouba	18	0,0437	1	0,0152	1	0,0256	0,0845	0,0635
Celtis trinervia	1	0,0024	1	0,0152	1	0,0256	0,0432	0,0635
Eugenia capuli	7,5	0,0182	1	0,0152	1	0,0256	0,0590	0,0635
Eugenia xalapensis	10	0,0243	1	0,0152	1	0,0256	0,0651	0,0635
Guarea chichon	6,25	0,0152	1	0,0152	1	0,0256	0,0560	0,0635
Guarea chichon	0,25	0,0006	1	0,0152	1	0,0256	0,0414	0,0635
Guarea excelsa	3	0,0073	1	0,0152	1	0,0256	0,0481	0,0635
Gymnanthes lucida	4	0,0097	1	0,0152	1	0,0256	0,0505	0,0635
Manilkara zapota	9,33	0,0227	1	0,0152	1	0,0256	0,0635	0,0635
Nectandra membranacea	3,5	0,0085	1	0,0152	1	0,0256	0,0493	0,0635
Oreopanax sp	3	0,0073	1	0,0152	1	0,0256	0,0481	0,0635
Pimenta dioica	1	0,0024	1	0,0152	1	0,0256	0,0432	0,0635
Pouteria durlandii	66,39	0,1613	15	0,2273	5	0,1282	0,5168	0,3367
Pouteria sp	17,1	0,0416	2	0,0303	2	0,0513	0,1231	0,1060
Pouteria zapota	0,25	0,0006	1	0,0152	1	0,0256	0,0414	0,0635
Rollinia jimenezii	1	0,0024	1	0,0152	1	0,0256	0,0432	0,0635
Sabal mauritiformis	9	0,0219	1	0,0152	1	0,0256	0,0627	0,0635
Simira salvadorensis	0,25	0,0006	1	0,0152	1	0,0256	0,0414	0,0635
Talisia floresii	91	0,2211	7	0,1061	3	0,0769	0,4041	0,2380
Trichilia havanensis	38,07	0,0925	12	0,1818	2	0,0513	0,3256	0,3100
Trichilia minuflora	14	0,0340	4	0,0606	1	0,0256	0,1203	0,1699
	411,49	1,0001	66	1,0000	39	1,0000	3,0001	2,6560

CARMELITA	Aguacatillo 2							
Scientific name	**Dominance**	**Relative Dominance**	**Density**	**Relative density**	**Frequency**	**Relative Frequency**	**V.I.**	**Pi*Ln Pi**
Aspidosperma megalocarpum	68,58	0,0841	7	0,0556	3	0,0652	0,2049	0,1606
Brosimun alicastrum	6,00	0,0074	1	0,0079	1	0,0217	0,0370	0,0384
Chryosophylla argentea	166,07	0,2037	36	0,2857	5	0,1087	0,5981	0,3579
Colubrina reclinata	28,06	0,0344	3	0,0238	2	0,0435	0,1017	0,0890
Descnocida	5,00	0,0061	1	0,0079	1	0,0217	0,0358	0,0384
Eugenia capuli	2,70	0,0033	1	0,0079	1	0,0217	0,0330	0,0384
Guarea excelsa	6,80	0,0083	1	0,0079	1	0,0217	0,0380	0,0384
Laetia thamnia	8,50	0,0104	3	0,0238	2	0,0435	0,0777	0,0890
Litsea glaucens	14,00	0,0172	1	0,0079	1	0,0217	0,0468	0,0384
Manilkara zapota	6,50	0,0080	3	0,0238	1	0,0217	0,0535	0,0890
Nectandra sp	12,00	0,0147	1	0,0079	1	0,0217	0,0444	0,0384
Nectandra membranacea	43,68	0,0536	6	0,0476	2	0,0435	0,1447	0,1450
Platymiscium dimorphandrum	47,60	0,0584	2	0,0159	2	0,0435	0,1177	0,0658
Pouteria campechiana	61,00	0,0748	5	0,0397	2	0,0435	0,1580	0,1280
Pouteria durlandii	133,65	0,1640	30	0,2381	5	0,1087	0,5107	0,3417
Pouteria zapota	22,33	0,0274	2	0,0159	1	0,0217	0,0650	0,0658
Protium copal	25,80	0,0316	2	0,0159	1	0,0217	0,0693	0,0658
Pseuldomedia oxiphyllaria	80,51	0,0988	9	0,0714	5	0,1087	0,2789	0,1885
Sabal mauritiformis	40,50	0,0497	7	0,0556	4	0,0870	0,1922	0,1606
Sideroxylon tempisque	13,00	0,0159	1	0,0079	1	0,0217	0,0456	0,0384
Simira salvadorensis	9,80	0,0120	1	0,0079	1	0,0217	0,0417	0,0384
Trichilia havanensis	1,00	0,0012	1	0,0079	1	0,0217	0,0309	0,0384
Zanthoxylon microcarpum	12,10	0,0148	2	0,0159	2	0,0435	0,0742	0,0658
	815,18	1,0000	126	1,0000	46	1,0000	3,0000	2,3578

CARMELITA	**Sibalito 2**							
Scientific name	**Dominance**	**Relative Dominance**	**Density**	**Relative density**	**Frequency**	**Relative Frequency**	**V.I.**	**Pi*Ln Pi**
Brosimun alicastrum	88,02	0,2205	12	0,1739	5	0,1471	0,5415	0,3042
Celtis trinervia	7,5	0,0188	1	0,0145	1	0,0294	0,0627	0,0614
Dendropanax arboreus	36	0,0902	1	0,0145	1	0,0294	0,1341	0,0614
Eugenia xalapensis	1	0,0025	1	0,0145	1	0,0294	0,0464	0,0614
Ficus sp	4	0,0100	1	0,0145	1	0,0294	0,0539	0,0614
Gymnanthes lucida	2,5	0,0063	1	0,0145	1	0,0294	0,0502	0,0614
Laetia thamnia	10	0,0251	5	0,0725	3	0,0882	0,1857	0,1902
Manilkara zapota	9,04	0,0226	1	0,0145	1	0,0294	0,0666	0,0614
Pouteria amigdalin	4,8	0,0120	1	0,0145	1	0,0294	0,0559	0,0614
Pouteria durlandii	22,75	0,0570	7	0,1014	2	0,0588	0,2173	0,2321
Pouteria zapota	3	0,0075	1	0,0145	1	0,0294	0,0514	0,0614
Poutetia sp	4,8	0,0120	1	0,0145	1	0,0294	0,0559	0,0614
Protium copal	0,5	0,0013	1	0,0145	1	0,0294	0,0452	0,0614
Pouteria durlandii	55,4	0,1388	15	0,2174	5	0,1471	0,5032	0,3318
Simira salvadorensis	1,5	0,0038	2	0,0290	1	0,0294	0,0622	0,1026
Talisia floresii	77,25	0,1935	5	0,0725	4	0,1176	0,3836	0,1902
Trichilia havanensis	39,41	0,0987	9	0,1304	2	0,0588	0,2880	0,2657
Wimmeria bartletii	31,72	0,0795	4	0,0580	2	0,0588	0,1963	0,1651
	399,19	1,0000	69	1,0000	34	1,0000	3,0000	2,3955

CARMELITA	Sibalito 3							
Scientific name	Dominance	Relative Dominane	Density	Relative Density	Frequency	Relative Frecuency	V.I.	Pi*Ln Pi
Brosimun alicastrum	206,46	0,3337	6	0,0750	4	0,1026	0,5112	0,1943
Chryosophylla argentea	3	0,0048	2	0,0250	1	0,0256	0,0555	0,0922
Eugenia xalapensis	1	0,0016	1	0,0125	1	0,0256	0,0398	0,0548
Faramea occidentalis	7,5	0,0121	1	0,0125	1	0,0256	0,0503	0,0548
Guarea excelsa	27,6	0,0446	5	0,0625	3	0,0769	0,1840	0,1733
Laetia thamnia	4	0,0065	1	0,0125	1	0,0256	0,0446	0,0548
Malmea depressa	1	0,0016	1	0,0125	1	0,0256	0,0398	0,0548
Manilkara zapota	9,4	0,0152	3	0,0375	3	0,0769	0,1296	0,1231
Nectandra membranacea	2	0,0032	2	0,0250	1	0,0256	0,0539	0,0922
Pouteria campechiana	89,6	0,1448	5	0,0625	2	0,0513	0,2586	0,1733
Pouteria durlandii	40,5	0,0655	9	0,1125	2	0,0513	0,2292	0,2458
Pouteria zapota	26	0,0420	3	0,0375	1	0,0256	0,1052	0,1231
Pseuldomedia oxiphyllaria	7,5	0,0121	1	0,0125	1	0,0256	0,0503	0,0548
Rollinia jimenezii	2,4	0,0039	1	0,0125	1	0,0256	0,0420	0,0548
Sapindus saponaria	2	0,0032	1	0,0125	1	0,0256	0,0414	0,0548
Pouteria durlandii	68,66	0,1110	17	0,2125	4	0,1026	0,4260	0,3291
Simira salvadorensis	5	0,0081	2	0,0250	2	0,0513	0,0844	0,0922
Talisia floresii	66,75	0,1079	4	0,0500	3	0,0769	0,2348	0,1498
Trema micrantha	2,64	0,0043	1	0,0125	1	0,0256	0,0424	0,0548
Trichilia havanensis	31,15	0,0503	11	0,1375	3	0,0769	0,2648	0,2728
Vitex gaumeri	12	0,0194	1	0,0125	1	0,0256	0,0575	0,0548
	2,6	0,0042	2	0,0250	1	0,0256	0,0548	0,0922
	618,76	1,0000	80	1,0000	39	1,0000	3,0000	2,6465

CARMELITA	Jolubal 2							
Scientific name	Dominance	Relative Dominance	Density	Relative Density	Frequency	Relative Frequency	V.I.	Pi*Ln Pi
Acacia cornigera	3	0,0075	2	0,0290	2	0,0571	0,0937	0,1026
Aspidosperma megalocarpum	13,5	0,0339	1	0,0145	1	0,0286	0,0769	0,0614
Bursera simarouba	2	0,0050	1	0,0145	1	0,0286	0,0481	0,0614
Chryosophylla argentea	157,66	0,3957	31	0,4493	5	0,1429	0,9878	0,3595
Colubrina reclinata	31,3	0,0786	3	0,0435	2	0,0571	0,1792	0,1363
Cordia sp	8	0,0201	2	0,0290	2	0,0571	0,1062	0,1026
Cupania guatemalensis	13	0,0326	2	0,0290	1	0,0286	0,0902	0,1026
Laetia thamnia	5,6	0,0141	1	0,0145	1	0,0286	0,0571	0,0614
Manilkara zapota	16,81	0,0422	3	0,0435	2	0,0571	0,1428	0,1363
Matayba opositifolia	6	0,0151	1	0,0145	1	0,0286	0,0581	0,0614
Nectandra membranacea	4	0,0100	1	0,0145	1	0,0286	0,0531	0,0614
Pouteria amigdalina	16	0,0402	1	0,0145	1	0,0286	0,0832	0,0614
Pouteria campechiana	12	0,0301	2	0,0290	1	0,0286	0,0877	0,1026
Pouteria lundelii	18,1	0,0454	5	0,0725	4	0,1143	0,2322	0,1902
Pouteria zapota	7	0,0176	1	0,0145	1	0,0286	0,0606	0,0614
Pseuldomedia oxiphyllaria	24,5	0,0615	3	0,0435	1	0,0286	0,1335	0,1363
Rollinia jimenezii	3,5	0,0088	1	0,0145	1	0,0286	0,0518	0,0614
Sabal mauritiformis	9	0,0226	1	0,0145	1	0,0286	0,0657	0,0614
Sideroxylon tempisque	8	0,0201	1	0,0145	1	0,0286	0,0631	0,0614
Simarouba glauca	20,5	0,0514	3	0,0435	2	0,0571	0,1521	0,1363
Zanthoxylon microcarpum	19	0,0477	3	0,0435	3	0,0857	0,1769	0,1363
	398,47	1,0000	69	1,0000	35	1,0000	3,0000	2,2555

Oaxactúm **Cerro Jengibre**

Scientific name	Dominance	Relative Dominance	Density	Relative Density	Frequency	Relative Frequency	V.I.	Pi*Ln Pi
Sebastiana longicuspis	116,5	0,1402	12	0,1395	2	0,0377	0,3175	0,2748
Chryosophyla argentea	82	0,0987	10	0,1163	3	0,0566	0,2716	0,2502
Bursera simarouba	152,6	0,1836	8	0,0930	4	0,0755	0,3521	0,2209
Cordia dentata	37,5	0,0451	5	0,0581	3	0,0566	0,1599	0,1654
Spondias mombin	106,95	0,1287	5	0,0581	3	0,0566	0,2434	0,1654
Pseudolmedia oxiphyllaria	68	0,0818	5	0,0581	3	0,0566	0,1966	0,1654
Cordia alliodora	30	0,0361	4	0,0465	2	0,0377	0,1203	0,1427
Laetia thamnia	102	0,1227	3	0,0349	2	0,0377	0,1954	0,1171
Vitex gaumeri	85	0,1023	3	0,0349	3	0,0566	0,1938	0,1171
Wimmeria bartleti	24	0,0289	3	0,0349	2	0,0377	0,1015	0,1171
Pseudobombax ellipticum	13,98	0,0168	2	0,0233	1	0,0189	0,0589	0,0875
Pimenta dioica	13,5	0,0162	2	0,0233	2	0,0377	0,0772	0,0875
Pouteria amigdalina	68	0,0818	2	0,0233	2	0,0377	0,1428	0,0875
Pouteria sp	52	0,0626	2	0,0233	1	0,0189	0,1047	0,0875
Pouteria reticulata	48	0,0578	2	0,0233	2	0,0377	0,1188	0,0875
Simarouba glauca	21	0,0253	2	0,0233	2	0,0377	0,0863	0,0875
Astronium graveolens	27,23	0,0328	1	0,0116	1	0,0189	0,0633	0,0518
Manilkara zapota	49	0,0590	1	0,0116	1	0,0189	0,0895	0,0518
Oreopanax lachnocephala	49	0,0590	1	0,0116	1	0,0189	0,0895	0,0518
Pouteria zapota	49	0,0590	1	0,0116	1	0,0189	0,0895	0,0518
Cupania guatemalensis	16	0,0193	1	0,0116	1	0,0189	0,0497	0,0518
Lysiloma desmontachys	16	0,0193	1	0,0116	1	0,0189	0,0497	0,0518
Ficus sp	14	0,0168	1	0,0116	1	0,0189	0,0473	0,0518
Brosimun alicastrum	12	0,0144	1	0,0116	1	0,0189	0,0449	0,0518
Nectandra sp	12	0,0144	1	0,0116	1	0,0189	0,0449	0,0518
Protium copal	12	0,0144	1	0,0116	1	0,0189	0,0449	0,0518
Bucida buceras	6	0,0072	1	0,0116	1	0,0189	0,0377	0,0518
Eugenia xalapensis	5	0,0060	1	0,0116	1	0,0189	0,0365	0,0518
Acacia farnesiana	4	0,0048	1	0,0116	1	0,0189	0,0353	0,0518
Eugenia capuli	4	0,0048	1	0,0116	1	0,0189	0,0353	0,0518
Quercus sp	2	0,0024	1	0,0116	1	0,0189	0,0329	0,0518

Thropis racemosa	1	0,0012	1	0,0116	1	0,0189	0,0317	0,0518
	705,71	1,0000	86	1,0000	53	0,8492	3,0000	3,0896

Oaxactúm, La pita

Scientific name	Dominance	Relative Density	Density	Relative Density	Frequency	Relative Frequency	V.I.	Pi*Ln Pi
Chryosophya argentea	54,5	0,0570	13	0,1857	4	0,0930	0,3358	0,3127
Sebastiana longicuspis	127	0,1329	9	0,1286	2	0,0465	0,3079	0,2637
Pseudolmedia oxiphyllaria	78,9	0,0825	7	0,1000	4	0,0930	0,2756	0,2303
Cupania guatemalensis	81,5	0,0853	6	0,0857	4	0,0930	0,2640	0,2106
Pouteria amigdalina	126	0,1318	6	0,0857	4	0,0930	0,3106	0,2106
Aspidosperma stegomeris	60,5	0,0633	4	0,0571	3	0,0698	0,1902	0,1636
Pouteria reticulata	54	0,0565	4	0,0571	3	0,0698	0,1834	0,1636
Protium copal	68,5	0,0717	3	0,0429	2	0,0465	0,1610	0,1350
Brosimun alicastrum	45	0,0471	2	0,0286	2	0,0465	0,1222	0,1016
Eugenia xalapensis	19,5	0,0204	2	0,0286	1	0,0233	0,0722	0,1016
Spondias mombin	47	0,0492	2	0,0286	2	0,0465	0,1243	0,1016
Aspidosperma megalocarpum	4	0,0042	1	0,0143	1	0,0233	0,0417	0,0607
Astronium graveolens	27	0,0282	1	0,0143	1	0,0233	0,0658	0,0607
Cordia alliodora	8	0,0084	1	0,0143	1	0,0233	0,0459	0,0607
Cordia dentata	10,5	0,0110	1	0,0143	1	0,0233	0,0485	0,0607
Guarea excelsa	16	0,0167	1	0,0143	1	0,0233	0,0543	0,0607
Laetia thamnia	6	0,0063	1	0,0143	1	0,0233	0,0438	0,0607
Oreopanax lachnocephala	4	0,0042	1	0,0143	1	0,0233	0,0417	0,0607
Pimenta dioica	16	0,0167	1	0,0143	1	0,0233	0,0543	0,0607
Pouteria sp	9	0,0094	1	0,0143	1	0,0233	0,0470	0,0607
Pouteria unilocularis	4	0,0042	1	0,0143	1	0,0233	0,0417	0,0607
Sabal mauritiformis	8	0,0084	1	0,0143	1	0,0233	0,0459	0,0607
Vitex gaumeri	81	0,0847	1	0,0143	1	0,0233	0,1223	0,0607
	955,9	1,0000	70	1,0000	43	1,0000	3,0000	2,7230

Oaxactúm, Camino a la llorona

Scientific name	Dominance	Relative Dominance	Density	Relative Density	Frequency	Relative Frequency	V.I.	Pi*Ln Pi
Acacia cornigera	9,5	0,0186	3	0,0370	3	0,0588	0,1145	0,1221
Amphelocera hottlei	24	0,0471	1	0,0123	1	0,0196	0,0790	0,0543
Aspidosperma megalocarpum	138	0,2706	3	0,0370	2	0,0392	0,3468	0,1221
Aspidosperma stegomeris	16	0,0314	1	0,0123	1	0,0196	0,0633	0,0543
Brosimun alicastrum	7,75	0,0152	3	0,0370	3	0,0588	0,1111	0,1221
Calophyllum brasiliensis	21	0,0412	1	0,0123	1	0,0196	0,0731	0,0543
Chryosophya argentea	47,15	0,0925	12	0,1481	4	0,0784	0,3190	0,2829
Cordia dentata	5	0,0098	1	0,0123	1	0,0196	0,0418	0,0543
Cupania guatemalensis	6,4	0,0125	1	0,0123	1	0,0196	0,0445	0,0543
Erytrhina sp	76	0,1490	3	0,0370	3	0,0588	0,2449	0,1221
Eugenia xalapensis	15,75	0,0309	2	0,0247	2	0,0392	0,0948	0,0914
Ficus sp	40,5	0,0794	1	0,0123	1	0,0196	0,1114	0,0543
Hampea sp	6	0,0118	1	0,0123	1	0,0196	0,0437	0,0543
Laetia tamnia	6	0,0118	1	0,0123	1	0,0196	0,0437	0,0543
Lysiloma desmontachys	66	0,1294	1	0,0123	1	0,0196	0,1614	0,0543
Manilkara zapota	12	0,0235	1	0,0123	1	0,0196	0,0555	0,0543
Pouteria amigdalina	12	0,0235	4	0,0494	3	0,0588	0,1317	0,1486
Pouteria sp	160,2	0,3141	6	0,0741	5	0,0980	0,4862	0,1928
Pouteria unilocularis	100,3	0,1967	9	0,1111	4	0,0784	0,3862	0,2441
Protium copal	30,25	0,0593	4	0,0494	3	0,0588	0,1675	0,1486
Pseudolmedia oxiphyllaria	205	0,4020	11	0,1358	3	0,0588	0,5966	0,2711
Sebastiana longicuspis	4,52	0,0089	1	0,0123	1	0,0196	0,0408	0,0543
Sideroxylon capiri	11,8	0,0231	1	0,0123	1	0,0196	0,0551	0,0543
Wimmeria bartleti	112	0,2196	5	0,0617	1	0,0196	0,3009	0,1719
Zantoxilon microcarpum	55	0,1078	3	0,0370	2	0,0392	0,1841	0,1221
Zuelania guidonea	4	0,0078	1	0,0123	1	0,0196	0,0398	0,0543
	510	1,0000	81	1,0000	51	1,0000	3,0000	2,8670

Oaxactúm, Sitio cacao

Scientific name	Dominance	Relative Dominance	Density	Relative Density	Frequency	Relative Frequency	V.I.	Pi*Ln Pi
Pseudolmedia oxiphyllaria	194	0,1868	17	0,2394	5	0,1136	0,5399	0,1476
Chryosophylla argentea	14	0,0135	5	0,0704	2	0,0455	0,1294	0,1440
Spondias mombin	42	0,0404	5	0,0704	3	0,0682	0,1790	0,1211
Acacia cornigera	16,5	0,0159	4	0,0563	3	0,0682	0,1404	0,1106
Pouteria unilocularis	101,8	0,0980	5	0,0704	2	0,0455	0,2139	0,1086
Sebastiana longicuspis	52	0,0501	4	0,0563	3	0,0682	0,1746	0,0983
Pimenta dioica	40	0,0385	3	0,0423	1	0,0227	0,1035	0,0958
Pouteria reticulata	6,5	0,0063	2	0,0282	1	0,0227	0,0572	0,0806
Pouteria amigdalina	21	0,0202	2	0,0282	1	0,0227	0,0711	0,0745
Oreopanax sp	24,4	0,0235	2	0,0282	1	0,0227	0,0744	0,0732
Dendropanax arboreus	194	0,1868	5	0,0704	5	0,1136	0,3709	0,0699
Sabal mauritiformis	29	0,0279	2	0,0282	2	0,0455	0,1015	0,0644
Pouteria sp	43	0,0414	2	0,0282	2	0,0455	0,1150	0,0609
Calophyllum brasiliensis	75	0,0722	2	0,0282	2	0,0455	0,1458	0,0542
Guarea excelsa	4	0,0039	1	0,0141	1	0,0227	0,0407	0,0451
Protium copal	4	0,0039	1	0,0141	1	0,0227	0,0407	0,0451
Bursera simarouba	6	0,0058	1	0,0141	1	0,0227	0,0426	0,0445
Laetia sp	6	0,0058	1	0,0141	1	0,0227	0,0426	0,0445
Sideroxylon capiri	6,25	0,0060	1	0,0141	1	0,0227	0,0428	0,0444
Erytrhina sp	8	0,0077	1	0,0141	1	0,0227	0,0445	0,0438
Malmmea depressa	10	0,0096	1	0,0141	1	0,0227	0,0464	0,0432
Cordia alliodora	14	0,0135	1	0,0141	1	0,0227	0,0503	0,0421
Zantoxilon microcarpum	24	0,0231	1	0,0141	1	0,0227	0,0599	0,0396
Cordia megalantha	49	0,0472	1	0,0141	1	0,0227	0,0840	0,0349
Quina schippi	54	0,0520	1	0,0141	1	0,0227	0,0888	0,0341
	1038,45	1,0000	71	1,0000	44	1,0000	3,0000	1,7651

Oaxactúm, La Sarteneja

Scientific name	Dominance	Relative Dominance	Density	Relative Density	Frequency	Relative Frequency	V.I.	Pi*Ln Pi
Annona sp	4,8	0,0079	1	0,0161	1	0,0263	0,0503	0,0666
Aspidosperma megalocarpum	5,6	0,0092	1	0,0161	1	0,0263	0,0516	0,0666
Aspidosperma stegomeris	8,61	0,0141	1	0,0161	1	0,0263	0,0566	0,0666
Astronium graveolens	42	0,0690	1	0,0161	1	0,0263	0,1114	0,0666
Belotia mexicana	6,76	0,0111	1	0,0161	1	0,0263	0,0535	0,0666
Dendropanax arboreus	12,24	0,0201	1	0,0161	1	0,0263	0,0626	0,0666
Ficus sp	58,8	0,0966	1	0,0161	1	0,0263	0,1390	0,0666
Oreopanax sp	5	0,0082	1	0,0161	1	0,0263	0,0507	0,0666
Pouteria amigdalina	2	0,0033	1	0,0161	1	0,0263	0,0457	0,0666
Sebastiana longicuspis	58,3	0,0958	1	0,0161	1	0,0263	0,1382	0,0666
Amphelocera hottlei	15,18	0,0249	2	0,0323	1	0,0263	0,0835	0,1108
Malvaviscus sp	15,48	0,0254	2	0,0323	1	0,0263	0,0840	0,1108
Manilkara zapota	4,86	0,0080	2	0,0323	2	0,0526	0,0929	0,1108
Brosimun alicastrum	105,13	0,1727	3	0,0484	2	0,0526	0,2737	0,1465
Laetia thammia	18,96	0,0311	3	0,0484	3	0,0789	0,1585	0,1465
Eugenia xalapensis	24,06	0,0395	4	0,0645	3	0,0789	0,1830	0,1768
Chryosophya argentea	21,32	0,0350	8	0,1290	3	0,0789	0,2430	0,2642
Pouteria reticulata	38,59	0,0634	8	0,1290	4	0,1053	0,2977	0,2642
Pouteria sp	129,04	0,2120	9	0,1452	4	0,1053	0,4624	0,2801
Pseudolmedia oxiphyllaria	32,05	0,0526	11	0,1774	5	0,1316	0,3616	0,3068
	608,78		62	1,0000	38	1,0000	3,0000	2,5833

Oaxactúm, Rastrojo de Don Urbano

Scientific name	Dominance	Relative Dominance	Density	Relative Density	Frequency	Relative Frequency	V.I.	Pi*Ln Pi
Pseudolmedia oxiphyllaria	35,88	0,1215	13	0,1711	4	0,0976	0,3901	0,3020
Pouteria reticulata	29,62	0,1003	11	0,1447	5	0,1220	0,3669	0,2798
Aspidosperma megalocarpum	23,15	0,0784	8	0,1053	3	0,0732	0,2568	0,2370
Laetia thamnia	57,34	0,1941	7	0,0921	4	0,0976	0,3838	0,2197
Eugenia xalapensis	20,67	0,0700	6	0,0789	2	0,0488	0,1977	0,2004
Chryosophya argentea	12,5	0,0423	4	0,0526	3	0,0732	0,1681	0,1550
Pouteria sp	27,78	0,0940	4	0,0526	2	0,0488	0,1954	0,1550
Cordia alliodora	6,83	0,0231	3	0,0395	1	0,0244	0,0870	0,1276
Oreopanax sp	12,14	0,0411	3	0,0395	2	0,0488	0,1293	0,1276
Aspidosperma stegomeris	5,25	0,0178	2	0,0263	1	0,0244	0,0685	0,0957
Malmmea depressa	3,46	0,0117	2	0,0263	2	0,0488	0,0868	0,0957
Pouteria amigdalina	12,3	0,0416	2	0,0263	2	0,0488	0,1167	0,0957
Sebastiana longicuspis	22,25	0,0753	2	0,0263	1	0,0244	0,1260	0,0957
Acacia cornigera	1	0,0034	1	0,0132	1	0,0244	0,0409	0,0570
Amphelocera hottlei	2,5	0,0085	1	0,0132	1	0,0244	0,0460	0,0570
Astronium graveolens	2,64	0,0089	1	0,0132	1	0,0244	0,0465	0,0570
Brosimun alicastrum	4,32	0,0146	1	0,0132	1	0,0244	0,0522	0,0570
Cordia megalantha	4,5	0,0152	1	0,0132	1	0,0244	0,0528	0,0570
Hampea sp	4	0,0135	1	0,0132	1	0,0244	0,0511	0,0570
Manilkara zapota	1,8	0,0061	1	0,0132	1	0,0244	0,0436	0,0570
Sabal mauritiformis	4	0,0135	1	0,0132	1	0,0244	0,0511	0,0570
Wimmeria bartleti	1,5	0,0051	1	0,0132	1	0,0244	0,0426	0,0570
	295,43	1,0000	76	1,0000	41	1,0000	3,0000	2,6997

Oaxactúm, Camino a la pita 2

Scientific name	Dominance	Relative Dominance	Density	Relative Density	Frequency	Relative Frequency	V.I.	Pi*Ln Pi
Pseudolmedia oxiphyllaria	105,78	0,2291	17	0,2361	4	0,0851	0,5503	0,3408
Chrysophyllum caimito	6,45	0,0140	7	0,0972	4	0,0851	0,1963	0,2266
Pouteria amigdalina	36,80	0,0797	6	0,0833	3	0,0638	0,2268	0,2071
Aspidosperma megalocarpum	45,75	0,0991	5	0,0694	4	0,0851	0,2536	0,1852
Pouteria sp	45,45	0,0984	5	0,0694	4	0,0851	0,2530	0,1852
Sabal mauritiformis	31,34	0,0679	4	0,0556	3	0,0638	0,1872	0,1606
Sebastiana longicuspis	11,79	0,0255	4	0,0556	3	0,0638	0,1449	0,1606
Acacia cornigera	4,26	0,0092	2	0,0278	2	0,0426	0,0796	0,0995
Aspidosperma stegomeris	8,05	0,0174	2	0,0278	2	0,0426	0,0878	0,0995
Erytrhina sp	17,80	0,0385	2	0,0278	2	0,0426	0,1089	0,0995
Ficus sp	26,30	0,0569	2	0,0278	1	0,0213	0,1060	0,0995
Pouteria reticulata	10,70	0,0232	2	0,0278	2	0,0426	0,0935	0,0995
Protium copal	5,96	0,0129	2	0,0278	1	0,0213	0,0620	0,0995
Astronium graveolens	1,20	0,0026	1	0,0139	1	0,0213	0,0378	0,0594
Bernarda interrupta	5,98	0,0129	1	0,0139	1	0,0213	0,0481	0,0594
Calophyllum brasiliensis	3,38	0,0073	1	0,0139	1	0,0213	0,0425	0,0594
Chryosophylla argentea	27,07	0,0586	1	0,0139	1	0,0213	0,0938	0,0594
Cordia dentata	2,30	0,0050	1	0,0139	1	0,0213	0,0401	0,0594
Dendropanax arboreus	31,79	0,0688	1	0,0139	1	0,0213	0,1040	0,0594
Eugenia xalapensis	3,00	0,0065	1	0,0139	1	0,0213	0,0417	0,0594
Laetia sp	5,00	0,0108	1	0,0139	1	0,0213	0,0460	0,0594
Malmmea depressa	3,00	0,0065	1	0,0139	1	0,0213	0,0417	0,0594
Pimenta dioica	5,50	0,0119	1	0,0139	1	0,0213	0,0471	0,0594
Vitex gaumeri	7,80	0,0169	1	0,0139	1	0,0213	0,0521	0,0594
Zuelania guidonea	9,00	0,0195	1	0,0139	1	0,0213	0,0547	0,0594
	461,83	1,0000	72	1,0000	47	1,0000	3,0000	2,7761

Oaxactúm, Camino a la pita 1

Scientific name	Dominance	Relative Dominance	Density	Relative Density	Frequency	Relative Frequency	V.I.	Pi*Ln Pi
Pseudolmedia oxiphyllaria	84,80	0,1229	20	0,2198	5	0,1136	0,4563	0,3330
Chryosophya argentea	38,36	0,0556	14	0,1538	4	0,0909	0,3004	0,2880
Pouteria reticulata	115,37	0,1672	12	0,1319	4	0,0909	0,3900	0,2672
Pouteria amigdalina	150,60	0,2183	11	0,1209	5	0,1136	0,4528	0,2554
Pouteria sp	53,31	0,0773	6	0,0659	4	0,0909	0,2341	0,1793
Aspidosperma megalocarpum	23,43	0,0340	4	0,0440	2	0,0455	0,1234	0,1373
Aspidosperma stegomeris	65,68	0,0952	4	0,0440	3	0,0682	0,2073	0,1373
Erytrhina sp	32,17	0,0466	3	0,0330	2	0,0455	0,1251	0,1125
Oreopanax sp	56,01	0,0812	3	0,0330	2	0,0455	0,1596	0,1125
Protium copal	10,60	0,0154	3	0,0330	2	0,0455	0,0938	0,1125
Calophyllum brasiliensis	33,50	0,0486	2	0,0220	2	0,0455	0,1160	0,0839
Dendropanax arboreus	9,15	0,0133	2	0,0220	2	0,0455	0,0807	0,0839
Guarea excelsa	4,50	0,0065	2	0,0220	2	0,0455	0,0740	0,0839
Laetia sp	5,80	0,0084	2	0,0220	2	0,0455	0,0758	0,0839
Astronium graveolens	1,80	0,0026	1	0,0110	1	0,0227	0,0363	0,0496
Cecropia peltata	3,00	0,0043	1	0,0110	1	0,0227	0,0381	0,0496
Sebastiana longicuspis	1,80	0,0026	1	0,0110	1	0,0227	0,0363	0,0496
	689,880	1,0000	91	1,0000	44	1,0000	3,0000	2,4193

Oaxactúm, Camino a la pita 3

Scientific name	Dominance	Relative Dominance	Density	Relative Density	Frequency	Relative Frequency	V.I.	Pi*Ln Pi
Pseudolmedia oxiphyllaria	188,321	0,3012	28	0,3146	5	0,1111	0,7270	0,3638
Chryosophya argentea	38,3	0,0613	10	0,1124	5	0,1111	0,2847	0,2456
Pouteria amigdalina	82,63	0,1322	10	0,1124	4	0,0889	0,3334	0,2456
Pouteria reticulata	16,07	0,0257	8	0,0899	5	0,1111	0,2267	0,2166
Pouteria sp	102,38	0,1638	7	0,0787	5	0,1111	0,3535	0,2000
Protium copal	16,09	0,0257	4	0,0449	3	0,0667	0,1373	0,1394
Aspidosperma megalocarpum	26	0,0416	3	0,0337	2	0,0444	0,1197	0,1143
Brosimun alicastrum	7	0,0112	3	0,0337	2	0,0444	0,0893	0,1143
Oreopanax sp	10,4	0,0166	3	0,0337	2	0,0444	0,0948	0,1143
Pimenta dioica	55,688	0,0891	3	0,0337	2	0,0444	0,1672	0,1143
Aspidosperma stegomeris	20,52	0,0328	2	0,0225	2	0,0444	0,0997	0,0853
Calophyllum brasiliensis	12,8	0,0205	1	0,0112	1	0,0222	0,0539	0,0504
Cordia dentata	28	0,0448	1	0,0112	1	0,0222	0,0782	0,0504
Cupania guatemalensis	3	0,0048	1	0,0112	1	0,0222	0,0383	0,0504
Guarea excelsa	2,4	0,0038	1	0,0112	1	0,0222	0,0373	0,0504
Laetia thamnia	1	0,0016	1	0,0112	1	0,0222	0,0351	0,0504
Malmmea depressa	5,04	0,0081	1	0,0112	1	0,0222	0,0415	0,0504
Sabal mauritiformis	9	0,0144	1	0,0112	1	0,0222	0,0479	0,0504
Wimmeria bartletii	0,5	0,0008	1	0,0112	1	0,0222	0,0343	0,0504
	625,14	1,0000	89	1,0000	45	1,0000	3,0000	2,3569

SUCULTÉ 1

Scientific name	Dominance	Relative Dominance	Density	Relative Density	Frequency	Relative Frequency	V.I.	Pi*Ln Pi
Allophyllus campstostachys	44	0,0842	8	0,1231	3	0,0857	0,2930	0,2578
Bactris sp	5	0,0096	2	0,0308	2	0,0571	0,0975	0,1071
Cordia geroscathus	8	0,0153	1	0,0154	1	0,0286	0,0593	0,0642
Coussapoa oligocephala	13,5	0,0258	2	0,0308	2	0,0571	0,1137	0,1071
Cupania guatemalensis	164	0,3137	8	0,1231	2	0,0571	0,4939	0,2578
Unknown	3	0,0057	1	0,0154	1	0,0286	0,0497	0,0642
Dicksonia gigantea	16,5	0,0316	2	0,0308	2	0,0571	0,1195	0,1071
Virola koschnyi	78,75	0,1506	13	0,2000	5	0,1429	0,4935	0,3219
Eugenia capuli	11	0,0210	2	0,0308	1	0,0286	0,0804	0,1071
Malcote o papelillo	7,5	0,0143	2	0,0308	1	0,0286	0,0737	0,1071
Miconia hondurensis	6	0,0115	1	0,0154	1	0,0286	0,0554	0,0642
Miconia o Senecio	2	0,0038	1	0,0154	1	0,0286	0,0478	0,0642
Orbygnia sp	4	0,0077	1	0,0154	1	0,0286	0,0516	0,0642
Pseudolmedia spuria	15	0,0287	4	0,0615	3	0,0857	0,1759	0,1716
Rheedia Sp	5	0,0096	1	0,0154	1	0,0286	0,0535	0,0642
Rollinia microcephala	94,5	0,1808	13	0,2000	5	0,1429	0,5236	0,3219
Topobea standleyl	15	0,0287	2	0,0308	2	0,0571	0,1166	0,1071
Vochysia hondurensis	30	0,0574	1	0,0154	1	0,0286	0,1013	0,0642
	522,75	1,0000	65	1,0000	35	1,0000	3,0000	2,4233

SUCULTÉ 2

Scientific name	Dominance	Relative Dominance	Density	Relative density	Frecuency	Relative Frequency	V.I.	Pi*Ln Pi
Allophyllus campstostachys	83	0,1039	7	0,0753	3	0,0714	0,2506	0,1947
Annona sp	2	0,0025	1	0,0108	1	0,0238	0,0371	0,0487
Bactris	16,5	0,0207	6	0,0645	4	0,0952	0,1804	0,1768
Cordia geroscathus	16	0,0200	1	0,0108	1	0,0238	0,0546	0,0487
Coussapoa oligocephala	6	0,0075	2	0,0215	2	0,0476	0,0766	0,0826
Cupania guatemalensis	176,25	0,2207	9	0,0968	4	0,0952	0,4127	0,2260
Desconocido	1	0,0013	1	0,0108	1	0,0238	0,0358	0,0487
Dicksonia gigantea	12	0,0150	1	0,0108	1	0,0238	0,0496	0,0487
Virola koschnyi	160	0,2004	16	0,1720	5	0,1190	0,4915	0,3028
Eugenia capuli	14	0,0175	4	0,0430	2	0,0476	0,1082	0,1353
Guazuma ulmifolia	0,5	0,0006	1	0,0108	1	0,0238	0,0352	0,0487
Malmea depressa	18,25	0,0229	5	0,0538	1	0,0238	0,1004	0,1572
Miconia hondurensis	4	0,0050	1	0,0108	1	0,0238	0,0396	0,0487
Nectandra	44	0,0551	1	0,0108	1	0,0238	0,0897	0,0487
Pouteria reticulata	2,75	0,0034	3	0,0323	1	0,0238	0,0595	0,1108
Pseudolmedia spuria	40,75	0,0510	16	0,1720	5	0,1190	0,3421	0,3028
Quercus sp	99	0,1240	1	0,0108	1	0,0238	0,1585	0,0487
Rollinia microcephala	32,5	0,0407	8	0,0860	2	0,0476	0,1743	0,2110
Tabernaemontana sp	8	0,0100	1	0,0108	1	0,0238	0,0446	0,0487
Topobea standley	62	0,0776	8	0,0860	4	0,0952	0,2589	0,2110
	798,5	1,0000	93	1,0000	42	1,0000	3,0000	2,5496

SUCULTÉ 3

Scientific name	Dominance	Relative Dominante	Density	Relative Density	Frecuency	Relative Frequency	V.I.	Pi*Ln Pi
Calophyllum brasiliensis	72	0,1403	5	0,0735	3	0,0698	0,2836	0,1919
Chrysophyllum mexicanum	4	0,0078	1	0,0147	1	0,0233	0,0458	0,0621
Terminalia amazonia	6	0,0117	1	0,0147	1	0,0233	0,0497	0,0621
Bactris sp	4	0,0078	2	0,0294	2	0,0465	0,0837	0,1037
Unknown 1	2	0,0039	1	0,0147	1	0,0233	0,0419	0,0621
Unknown 2	12	0,0234	1	0,0147	1	0,0233	0,0613	0,0621
Inga spectabilis	30	0,0584	2	0,0294	2	0,0465	0,1344	0,1037
Dicksonia gigantea	18	0,0351	2	0,0294	2	0,0465	0,1110	0,1037
Coussapoa oligocephala	29	0,0565	3	0,0441	2	0,0465	0,1471	0,1377
Miconia hondurensis	7	0,0136	2	0,0294	2	0,0465	0,0896	0,1037
Reedia sp	6	0,0117	1	0,0147	1	0,0233	0,0497	0,0621
Pseudolmedia spuria	13	0,0253	5	0,0735	3	0,0698	0,1686	0,1919
Godmania aescuifolia	9	0,0175	1	0,0147	1	0,0233	0,0555	0,0621
Engelhardtia guatemalensis	8	0,0156	2	0,0294	2	0,0465	0,0915	0,1037
Virola koschnyi	10	0,0195	5	0,0735	3	0,0698	0,1628	0,1919
Malmmea depressa	4	0,0078	1	0,0147	1	0,0233	0,0458	0,0621
Papelillo o Malcota	6	0,0117	1	0,0147	1	0,0233	0,0497	0,0621
Vochysia hondurensis	22	0,0429	2	0,0294	1	0,0233	0,0955	0,1037
Topobea standleyl	12,25	0,0239	5	0,0735	3	0,0698	0,1672	0,1919
Cordia geroscathus	1	0,0019	1	0,0147	1	0,0233	0,0399	0,0621
Cupania guatemalensis	114	0,2221	11	0,1618	4	0,0930	0,4769	0,2947
Rollinia microcephala	52,55	0,1024	13	0,1912	5	0,1163	0,4098	0,3163
	513,3	1,0000	68	1,0000	43	1,0000	3,0000	2,6971

Veracruz, México.

San Fernando (sites 1-3)	Antonio							
Scientific name	**Dominance**	**Relative Dominance**	**Density**	**Relative density**	**Frecuency**	**Relative Frequency**	**V.I.**	**Pi*Ln Pi**
Belotia campelli	199	0,6032	23	0,5349	3	0,2308	1,3689	0,3347
Guazuma ulmifolia	2	0,0061	1	0,0233	1	0,0769	0,1062	0,0875
Hirtella triandra	8	0,0242	1	0,0233	1	0,0769	0,1244	0,0875
Ilex belizenzis	2	0,0061	1	0,0233	1	0,0769	0,1062	0,0875
Mirica cerifera	5	0,0152	1	0,0233	1	0,0769	0,1153	0,0875
Mortoniodendrum guatemalensis	95,4	0,2892	11	0,2558	2	0,1538	0,6988	0,3488
Nectandra sp	9	0,0273	1	0,0233	1	0,0769	0,1275	0,0875
Simira salvadorensis	2	0,0061	1	0,0233	1	0,0769	0,1062	0,0875
Siparuna guianensis	6,5	0,0197	2	0,0465	1	0,0769	0,1431	0,1427
Tabebuia chrysantha	1	0,0030	1	0,0233	1	0,0769	0,1032	0,0875
	329,9	1,0000	43	1,0000	13	1,0000	3,0000	1,4384

San Fernando (sites 1-3)	Brigido							
Scientific name	**Dominance**	**Relative Dominance**	**Density**	**Relative Density**	**Frecuency**	**Relative Frequency**	**V.I.**	**Pi*Ln Pi**
Terminalia amazonia	25,4	0,0183	1	0,0139	1	0,0244	0,0566	0,0594
Tabernaemontana arborea	14	0,0101	1	0,0139	1	0,0244	0,0484	0,0594
Sikingia salvadorensis	14	0,0101	1	0,0139	1	0,0244	0,0484	0,0594
Sebastiana longicuspis	45	0,0324	1	0,0139	1	0,0244	0,0707	0,0594
Nectandra angusta	7,87	0,0057	1	0,0139	1	0,0244	0,0439	0,0594
Nectandra ambiguens	9,7	0,0070	1	0,0139	1	0,0244	0,0453	0,0594
Luhea speciosa	4	0,0029	1	0,0139	1	0,0244	0,0412	0,0594
Inga vera	15,42	0,0111	1	0,0139	1	0,0244	0,0494	0,0594
Inga quaternata	9,25	0,0067	1	0,0139	1	0,0244	0,0449	0,0594
Hirtella triandra	3,25	0,0023	1	0,0139	1	0,0244	0,0406	0,0594
Desconocida	12	0,0086	1	0,0139	1	0,0244	0,0469	0,0594
Cordia sp	6	0,0043	1	0,0139	1	0,0244	0,0426	0,0594
Psychotria sp	16	0,0115	2	0,0278	1	0,0244	0,0637	0,0995
Mortoniodendrum paliocosii	6,5	0,0047	2	0,0278	1	0,0244	0,0568	0,0995
Pouteria sapota	1,25	0,0009	2	0,0278	2	0,0488	0,0775	0,0995
Piper sp	4,72	0,0034	2	0,0278	2	0,0488	0,0800	0,0995
Cupania dentata	3,77	0,0027	2	0,0278	2	0,0488	0,0793	0,0995
Coffea arabiga	7,92	0,0057	2	0,0278	2	0,0488	0,0823	0,0995
Heliocarpus americanus	17,76	0,0128	3	0,0417	2	0,0488	0,1032	0,1324
Cordia alliodora	74,74	0,0538	3	0,0417	2	0,0488	0,1443	0,1324
Annona sp	65,18	0,0469	3	0,0417	3	0,0732	0,1618	0,1324
Mortoniodendrum guatemalensis	16,82	0,0121	4	0,0556	2	0,0488	0,1164	0,1606
Pseudolmedia oxyphyllaria	205,5	0,1480	5	0,0694	1	0,0244	0,2418	0,1852
Sloanea medusula	225,9	0,1627	6	0,0833	3	0,0732	0,3192	0,2071
Cornutia grandifolia	104,87	0,0755	6	0,0833	3	0,0732	0,2320	0,2071
Belotia mexicana	467,4	0,3366	18	0,2500	3	0,0732	0,6598	0,3466
	1388,62	1,0000	72	1,0000	41	1,0000	3,0000	2,8138

San Fernando (sites 1-3)	Dionisia							
Scientific name	**Dominance**	**Relative Dominance**	**Density**	**Relative density**	**Frecuency**	**Relative Frequency**	**V.I.**	**Pi*Ln Pi**
Albizzia guachepele	42	0,0640	1	0,0238	1	0,0357	0,1235	0,0890
Alfaroa costaricensis	31	0,0472	1	0,0238	1	0,0357	0,1067	0,0890
Belotia campelli	23	0,0350	1	0,0238	1	0,0357	0,0946	0,0890
Coccoloba barbedensis	96	0,1462	3	0,0714	2	0,0714	0,2891	0,1885
Cochlospermum vtifolium	15	0,0228	1	0,0238	1	0,0357	0,0824	0,0890
Coffea arabiga	66,6	0,1014	15	0,3571	3	0,1071	0,5657	0,3677
Desconocida 1	16	0,0244	1	0,0238	1	0,0357	0,0839	0,0890
Eugenia sp	36	0,0548	1	0,0238	1	0,0357	0,1144	0,0890
Garcia parviflora	12	0,0183	1	0,0238	1	0,0357	0,0778	0,0890
Hampea integerrima	6	0,0091	1	0,0238	1	0,0357	0,0687	0,0890
Ilex panamensis	32	0,0487	1	0,0238	1	0,0357	0,1083	0,0890
Lonchocarpus hondurensis	66	0,1005	2	0,0476	2	0,0714	0,2196	0,1450
Luhea speciosa	33	0,0503	1	0,0238	1	0,0357	0,1098	0,0890
Matayba oppositifolia	25	0,0381	1	0,0238	1	0,0357	0,0976	0,0890
Picramnia antidesma	14	0,0213	2	0,0476	2	0,0714	0,1404	0,1450
Platimiscium yucatanum	18	0,0274	1	0,0238	1	0,0357	0,0869	0,0890
Quercus peduncularis	16	0,0244	1	0,0238	1	0,0357	0,0839	0,0890
Simira salvadorensis	4	0,0061	1	0,0238	1	0,0357	0,0656	0,0890
Stemmadenia sp	4	0,0061	1	0,0238	1	0,0357	0,0656	0,0890
Terminalia amazonia	22	0,0335	1	0,0238	1	0,0357	0,0930	0,0890
Vochysia guatemalensis	19	0,0289	1	0,0238	1	0,0357	0,0885	0,0890
Xilosma flexucosum	32	0,0487	2	0,0476	1	0,0357	0,1321	0,1450
Zuelania guidonia	28	0,0426	1	0,0238	1	0,0357	0,1022	0,0890
	656,6	1,0000	42	1,0000	28	1,0000	3,0000	2,5930

Pajapan (sites 1-3) **4-1**

Scientific name	**Dominance**	**Relative Dominance**	**Density**	**Relative Density**	**Frecuency**	**Relative Frequency**	**V.I.**	**Pi*Ln Pi**
Trichilia hirta	94,5	0,1072	3	0,0385	2	0,0444	0,1901	0,1253
Tabernaemontana arborea	33	0,0374	2	0,0256	2	0,0444	0,1075	0,0939
Sebastiana Longicuspis	0,5	0,0006	1	0,0128	1	0,0222	0,0356	0,0559
Sapindus saponaria	96,15	0,1091	4	0,0513	2	0,0444	0,2048	0,1523
Psidium juajaba	14	0,0159	1	0,0128	1	0,0222	0,0509	0,0559
Pithecelobium lanceolatum	12	0,0136	2	0,0256	2	0,0444	0,0837	0,0939
Persea americana	11	0,0125	3	0,0385	2	0,0444	0,0954	0,1253
Nectandra sp	15,5	0,0176	1	0,0128	1	0,0222	0,0526	0,0559
Inga sp	18	0,0204	3	0,0385	3	0,0667	0,1255	0,1253
Guazuma ulmifolia	70	0,0794	3	0,0385	2	0,0444	0,1623	0,1253
Gliricidia sepium	71,5	0,0811	13	0,1667	5	0,1111	0,3589	0,2986
Eugenia capuli	43	0,0488	7	0,0897	2	0,0444	0,1830	0,2164
Xilosma flexuosum	23,5	0,0267	2	0,0256	2	0,0444	0,0967	0,0939
Erythrina americana	15	0,0170	5	0,0641	3	0,0667	0,1478	0,1761
Cupania dentata	36	0,0408	1	0,0128	1	0,0222	0,0759	0,0559
Cordia alliodora	101,1	0,1147	13	0,1667	5	0,1111	0,3924	0,2986
Coccoloba barbedensis	103,95	0,1179	9	0,1154	4	0,0889	0,3222	0,2492
Callophyllum brasiliensi	6	0,0068	1	0,0128	1	0,0222	0,0418	0,0559
Bursera simarouba	2,5	0,0028	2	0,0256	2	0,0444	0,0729	0,0939
Apeiba tibourbou	104	0,1180	1	0,0128	1	0,0222	0,1530	0,0559
Tepioltbault	10,5	0,0119	1	0,0128	1	0,0222	0,0470	0,0559
	881,7	1,0000	78	1,0000	45	1,0000	3,0000	2,6592

Pajápan (sites 1-3)	4-2							
Scientific name	**Dominance**	**Relative Dominance**	**Density**	**Relative density**	**Frecuency**	**Relative Frequency**	**V.I.**	**Pi*Ln Pi**
Bursera simarouba	20,73	0,0173	2	0,0215	2	0,0426	0,0814	0,0826
Cecropia obtussifolia	12	0,0100	1	0,0108	1	0,0213	0,0421	0,0487
Coccoloba honduresis	228,83	0,1915	14	0,1505	5	0,1064	0,4484	0,2850
Cordia alliodora	135,8	0,1136	15	0,1613	5	0,1064	0,3813	0,2943
Cordia megalantha	16	0,0134	3	0,0323	2	0,0426	0,0882	0,1108
Cupania detata	24	0,0201	1	0,0108	1	0,0213	0,0521	0,0487
Desconocida1	24,66	0,0206	1	0,0108	1	0,0213	0,0527	0,0487
Erythrina americana	5,54	0,0046	3	0,0323	1	0,0213	0,0582	0,1108
Gliricidia sepium	11,6	0,0097	2	0,0215	2	0,0426	0,0738	0,0826
Guazuma ulmifolia	14,76	0,0124	3	0,0323	3	0,0638	0,1084	0,1108
Inga chelele	17	0,0142	2	0,0215	2	0,0426	0,0783	0,0826
Luhea speciosa	99	0,0828	1	0,0108	1	0,0213	0,1149	0,0487
Persea americana	11,67	0,0098	2	0,0215	2	0,0426	0,0738	0,0826
Rubiaceae	60,6	0,0507	4	0,0430	1	0,0213	0,1150	0,1353
Sapindus saponaria	83,2	0,0696	4	0,0430	3	0,0638	0,1765	0,1353
Sebastiana longicuspis	34,5	0,0289	4	0,0430	2	0,0426	0,1144	0,1353
Squizolobium parahybum	145	0,1213	2	0,0215	2	0,0426	0,1854	0,0826
Tabernaemontana arborea	109,4	0,0916	10	0,1075	4	0,0851	0,2842	0,2398
Trichilia hirta	94,43	0,0790	12	0,1290	3	0,0638	0,2719	0,2642
Xilosma flexuosum	46,24	0,0387	7	0,0753	4	0,0851	0,1991	0,1947
	1194,96	1,0000	93	1,0000	47	1,0000	3,0000	2,6241

Pajapan (sites 1-3) Scientific name	Juan Dominance	Relative Dominance	Density	Relative Density	Frecuency	Relative Frequency	V.I.	Pi*Ln Pi
Tabernaemontana arborea	139,78	0,1635	12	0,1500	5	0,1064	0,4198	0,2846
Squizolobium parahybum	48	0,0561	1	0,0125	1	0,0213	0,0899	0,0548
Sickingia salvadorensis	4,2	0,0049	2	0,0250	2	0,0426	0,0725	0,0922
Randia sp	3	0,0035	1	0,0125	1	0,0213	0,0373	0,0548
Psidium guajaba	0,25	0,0003	1	0,0125	1	0,0213	0,0341	0,0548
Poulsenia armata	2,25	0,0026	1	0,0125	1	0,0213	0,0364	0,0548
Pithecelobium lanceolatum	13,9	0,0163	3	0,0375	2	0,0426	0,0963	0,1231
Nectandra ambiguens	6	0,0070	2	0,0250	2	0,0426	0,0746	0,0922
Myrcia sp	4	0,0047	1	0,0125	1	0,0213	0,0385	0,0548
Manilkara zapota	4	0,0047	1	0,0125	1	0,0213	0,0385	0,0548
Lonchocarpus cruentus	12	0,0140	1	0,0125	1	0,0213	0,0478	0,0548
Guazuma ulmifolia	11,2	0,0131	1	0,0125	1	0,0213	0,0469	0,0548
Gliricidia sepium	253,16	0,2960	6	0,0750	4	0,0851	0,4561	0,1943
Eugenia xalapensis	5,6	0,0065	2	0,0250	2	0,0426	0,0741	0,0922
Dendropanax arboreus	1	0,0012	1	0,0125	1	0,0213	0,0349	0,0548
Cordia megalantha	6	0,0070	1	0,0125	1	0,0213	0,0408	0,0548
Cordia alliodora	103,7	0,1213	8	0,1000	4	0,0851	0,3064	0,2303
Cochlospermun vitifolium	114,19	0,1335	12	0,1500	5	0,1064	0,3899	0,2846
Coccoloba barbedensis	21	0,0246	2	0,0250	2	0,0426	0,0921	0,0922
Cedrela odorata	3	0,0035	1	0,0125	1	0,0213	0,0373	0,0548
Castilla elastica	3	0,0035	1	0,0125	1	0,0213	0,0373	0,0548
Byrsonima crassifolia	11,4	0,0133	11	0,1375	1	0,0213	0,1721	0,2728
Bursera simaruba	44,55	0,0521	2	0,0250	2	0,0426	0,1196	0,0922
Brosimun alicastrum	3	0,0035	1	0,0125	1	0,0213	0,0373	0,0548
Belotia campelli	3	0,0035	1	0,0125	1	0,0213	0,0373	0,0548
Araliaceae	6	0,0070	2	0,0250	1	0,0213	0,0533	0,0922
Apeiba tibourbou	28	0,0327	2	0,0250	1	0,0213	0,0790	0,0922
	855,18		80	1,0000	47	1,0000	3,0000	2,8020

Annex 3. Shade tree species registered in the sample plot for each location

	Species	Carmelita	Oaxactum	Suculté	San Fernando	Pajápan
1	*Acacia cornigera* L. Willd.		x			
2	*Acacia farnesiana* (Mill) Kuntze		x			
3	*Acacia* sp		x			
4	*Albizzia guachepele* (Kunt) Harman				x	
5	*Alfaroa costaricensis* Standl.				x	
6	*Allophyllus campstostachys* Bicbach			x		
7	*Allophylus cominia* Bicbach	x				
8	*Alseis yucatanensis* Standl.			x		
9	*Ampelocera hottlei* (Standl) Standl.		x			
10	*Annona* sp		x	x	x	
11	*Apeiba tibourbou* Aubl.					x
12	*Aspidosperma megalocarpum* (Muell) Arg	x	x			
13	*Aspidosperma stegomeris* Woodson		x			
14	*Astronium graveolens* Jacq.	x	x			
15	*Bactris sp*			x		
16	*Belotia mexicana (*Dc) Schaum.		x	x	x	x
17	*Bernarda interrupta* Kuntze		x			
18	*Bravaisia tubiflora* Hemsley et Hook	x				
19	*Brosimun alicastrum* Sw.					x
20	*Bucida buceras* L.	x				
21	*Bursera graveolens* (Kunth) Triana & Planch.	x				x
22	*Bursera simarouba* (L.) Sarg.	x	x			x
23	*Byrsonima crassifolia* H.B.K.					x
24	*Calophyllum brasiliensis* Cambes		x	x		x
25	*Casearia* sp	x				
26	*Castilla elastica* Cerv.					x
27	*Cecropia obtussifolia* Bertol					x
28	*Cecropia peltata* L.		x			

29	*Cedrela odorata* L.	x				x
30	*Celtis trinervia* Lam.	x				
31	*Chryosophya argentea* Bartlet	x	x			
32	*Chrysophyllum cainito* L.	x	x			
33	*Chrysophyllum mexicanum* Brandegee ex Standl	x		x		
34	*Coccoloba barbedensis* Jacq.				x	x
35	*Coccoloba* sp					x
36	*Cochlospermum vtifolium* Spreng.				x	x
37	*Coffea arabiga* L.				x	
38	*Colubrina reclinata* Mill.	x				
39	*Cordia alliodora* Ruiz et Pavon				x	x
40	*Cordia dentata* Poir		x			
41	*Cordia geroscathus* Ruiz &Pavon			x		
42	*Cordia megalantha* Blake		x			x
43	*Cordia sp*	x			x	
44	*Cornutia grandifoli* (Schltdl. & Cham.) Schauer				x	
45	*Coussapoa oligocephala* Donn Smithii			x		
46	*Cupania dentata* Poir				x	x
47	*Cupania guatemalensis* (Turcz.) Radlk.	x	x	x		
48	*Cupania maccrophylla* A. Rich.	x				
49	*Dendropanax arboreus* (L.) Decne.	x	x			x
50	*Dicksonia gigantea* Karst.			x		
51	*Didimopanax* sp					x
52	*Engelhardtia guatemalensis* Standl.			x		
53	*Erythrina americana* Miller					x
54	*Erytrhina sp*		x			
55	*Eugenia capuli* (Cham & Schelecht.) Bergius	x	x	x		x
56	*Eugenia sp*				x	
57	*Eugenia xalapensis* (Kunth) DC.	x	x			x
58	*Faramea occidentalis* (L.) Rich.	x				
59	*Ficus sp*	x	x			
60	*Garcia parviflora* (Swartz) Poiret				x	
61	*Gliricidia sepium* (Jacq) Steud.					x

62	*Godmania aescuifolia*(Kunth) Standl.			x		
63	*Guarea chichon* Vahl.	x				
64	*Guarea excelsa* H. B. K.	x	x			
65	*Guazuma ulmifolia* Lam.			x	x	x
66	*Gymnanthes lucida* Sw.	x			x	
67	*Hampea integerrima* Schlecht.					
68	*Hampea* sp		x			
69	*Heliocarpus americanus* L.				x	
70	*Hirtella triandra* Sw.				x	
71	*Ilex belizenzis* Standl.				x	
72	*Ilex panamensis* Standl.				x	
73	*Inga chelele* Willd.					x
74	*Inga quaternata* Willd.				x	
75	*Inga* sp					x
76	*Inga spectabilis* (Vahl) Willd.			x		
77	*Inga vera* Willd.				x	
78	*Laetia* sp		x			
79	*Laetia thamnia* L.	x	x			
80	*Litsea glaucescens* H.B.K.	x				
81	*Lonchocarpus castilloi* Standl.	x				
82	*Lonchocarpus cruentus* Lundell					x
83	*Lonchocarpus hondurensis* Benth				x	
84	*Lonchocarpus* sp	x				
85	*Luhea speciosa* Willd.				x	x
86	*Lycaria* sp	x				
87	*Lysiloma desmontachis* Benth.	x	x			
88	*Malmmea depressa* Willd.	x	x			
89	*Malvaviscus* sp		x			
90	*Manilkara zapota* L. Van Royen		x			x
91	*Matayba oppositifolia* (A. Rich) Benth.				x	
92	*Metopium brownei* (Jacq) Urban	x				
93	*Miconia hondurensis* Sw.			x		
94	*Mirica cerifera* L.				x	

95	*Mortoniodendrum guatemalensis* Standl and Steyerm.				x	
96	*Mortoniodendrum paliocosii* Standl and Steyerm.				x	
97	*Myrcia* sp					x
98	*Nectandra ambiguens* Sw.				x	x
99	*Nectandra angusta* Sw.				x	
100	*Nectandra membranacea* Sw.	x				
101	*Nectandra* sp	x	x	x	x	x
102	*Orbygnia* sp			x		
103	*Oreopanax lachnocephala* Standley		x			
104	*Oreopanax* sp	x	x			
105	*Persea americana* Mill.					x
106	*Picramnia antidesma* Sw.				x	
107	*Pimenta dioica* (L). Merril	x	x			
108	*Piper sp*				x	
109	*Pithecelobium lanceolatum* Humb & Bompl					x
110	*Platimiscium yucatanum* Standl				x	
111	*Platymiscium dimorphandrum* Donn-Smithii	x				
112	*Poulsenia armata* (Miq) Standl					x
113	*Pouteria amigdalina* (Standl.) Baehni	x	x			
114	*Pouteria campechiana* Baehni	x				
115	*Pouteria durlandii* (Standl.) Baehni	x				
116	*Pouteria reticulata* (Engl.) Eyma		x	x		
117	*Pouteria zapota* (Jacq.) H.E.Moore & Stearn	x	x		x	
118	*Protium copal* (Schltdl. & Cham.) Engler	x	x			
119	*Pseudobombax ellipticum* H.B.K. Dugald		x			
120	*Pseudolmedia oxiphyllaria* A.R. P.		x		x	
121	*Pseudolmedia spuria* (Sw.) Griseb.			x		
122	*Psidium guajaba* L.					x
123	*Psychotria* sp				x	
124	*Pterocarpus oficinalis* Jacq	x				
125	*Quercus peduncularis* Née An.				x	
126	*Quercus* sp		x	x		
127	*Quina schippi* (Sagot) Benth.		x			

128	*Randia* sp					x
129	*Rheedia* sp			x		
130	*Rollinia jimenezii* Saff.	x				
131	*Rollinia microcephala* Rosse			x		
132	*Rubiaceae* (plant family)					x
133	*Sabal mauritiformis* (Karsten) Gris.	x	x			
134	*Sapindus saponaria* L.	x				x
135	*Sebastiana longicuspis* Standley		x		x	x
136	*Sideroxylon capiri* (A. DC.) Pittier		x			
137	*Sideroxylon tempisque* (Pittier) Pennington	x				
138	*Simarouba glauca* DC.	x	x			
139	*Simira salvadorensis* (Standl.) Steyerm	x			x	x
140	*Sloanea medusula* Schumann.				x	x
141	*Spondias mombin* L. C.	x	x			
142	*Squizolobium parahybum* (Vill) Blake					x
143	*Stemmadenia* sp				x	
144	*Tabebuia Chrysantha* (Jacq.) Nichols	x			x	
145	*Tabebuia chrysantha* Hemsl.					
146	*Tabernaemontana arborea* Mill				x	x
147	*Tabernaemontana* sp			x		
148	*Talisia floresii* Standley	x				
149	*Talisia* sp	x				
150	*Terminalia amazonia* (Gmeil) Exell.			x	x	x
151	*Thropis racemosa* (L.) Urban.		x			
152	*Topobea standleyl* Standley			x		
153	*Trema micrantha* (L). Blume	x				
154	*Trichilia havanensis* (Jacq)	x				
155	*Trichilia hirta* L.					x
156	*Trichilia minuflora* Standley	x				
157	Unknown					x
158	Unknown					x
159	Unknown	x	x	x		
160	Unknown	x		x		

161	Unknown	x		x		
162	*Virola koschnyi* Warb.			x		
163	*Vitex gaumeri* Greeeman	x	x			
164	*Vochysia guatemalensis* Donn-Smith.				x	
165	*Vochysia hondurensis* Sprague			x		
166	*Wimmeria bartleti* Bartleti	x	x			
167	*Xilosma flexuosum* (H. B. K.) Hemsl.				x	x
168	*Zanthoxylon microcarpum* O. Cf	x	x			
169	*Zuelania guidonea (*Sw.) Britt. et Millsp.		x		x	