FLORISTIC COMPOSITION, STRUCTURE AND DIVERSITY OF THE FOREST IN THE BAHÍA HONDA REGION (VERAGUAS, PANAMA)

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Quantitative floristic and structural studies are fundamental to understand the ecology of tropical forests. This type of inventory is scarce in Central America except in sites with a long standing tradition in tropical research such as La Selva in Costa Rica and Barro Colorado Island (BCI) in the center of the Panama Canal (Knight, 1975; Hartshorn, 1983; Foster *& al.*, 1992; Thorington *& al.*, 1992) or recently, the studies all over the Canal region (Pyke *& al.*, 2001).

Close to our study area, in the S of Veraguas, the only known studies are quantitative descriptions of the forests of the island of Coiba, in the works of Pérez *& al.*, (1996) and more recently of Ibáñez (2001). These kind of studies, using permanent plots, in addition to being essential to get to know the floristic composition of an unknown wooded area, allow us to evaluate the dynamics of the forest (growth, turnover, etc.), to study the ecology of the species and at the same time they serve as a frame of reference for any research in the area.

This is the first quantitative floristic inventory, using one hectare plots, in two sites of the Bahía Honda region. We intend to describe the floristic composition, diversity and structure of its forests, that is, the abundance and identity of the families and species of trees in each of the sites represented by a plot.

Permanent Plots

For a first study of the floristic composition, structure and diversity of the

forests of the Bahía Honda region, we have chosen a method of demarcation of two permanent plots, each one covering 1 hectare (10,000 m_). Numerous studies of mixed tropical forests are based on this type of sampling as it provides an adequate measure of the diversity and structure of the forest (Boom, 1986; Gentry, 1988; Faber-Langendoen *& al*., 1991). The fact they are permanent makes it possible to carry on long-term studies, very convenient and appropriate in this case, as they are located in areas destined to be the object of future scientific research.

Two plots of 1 hectare each have been set up, following the methodology proposed by the SI/MAB Program (Smithsonian Institution/Man and the Biosphere Biological Diversity Program) (Alder *& al*., 1992; Dallmeier *& al*., 1992; Dallmeier *& al*., 1996).

One of the plots was established in the north of the island of Canales de Tierra (ICT) (P1) and another one on the mainland, in the so called "El Edén Forest" (P2) (Fig. 2. Vegetacion chapter). The marking and numbering of all trees was carried out in March (ICT) and August of 2002 (El Edén).

Methodology

The methodology used in this study is the same one described in Ibáñez (2001), which we summarize here. The 1 hectare plots form a square of 100 m x 100 m which have been divided into twenty five 20 m x 20 m quadrats. These, in turn, are divided into 100 sub-quadrats measuring 10 m x 10 m and forming a grid that remains permanently marked with PVC tubes every 10 m. Between the tubes, polyester string was tied so that the quadrats remain well marked.

Within each hectare all the individuals with diameters at breast height (DBH) (1.30 m from the ground) equal to or greater than 10 cm were tagged. Aluminum tags were used and each individual was assigned a unique number.

The DBH of the trunk of each individual was measured (and all stems in the case it had more than one). This parameter is used in calculations of basal area, dominance and growth studies (Campbell, 1989). The following information was also recorded: a) presence of buttresses (and height), in which case the DBH was measured above, b) any irregularity of the trunk, c) phenologic

condition of each individual, d) any information that could be helpful for later identification, such as characteristics of the bark, exudation, presence of latex, (e) common name given by the field assistants, etc.

Collection of Samples and Identification

In each plot, botanical samples were collected of every species or morpho-species (taxa thought to be a different species but without a given scientific name). Most of them were in sterile condition, as fertile samples could not be found. All botanical specimens were later determined in the herbarium. The field identification was used only in the cases where the species was well known to the author, as it was very common in one plot and had been collected repeatedly (Campbell, 1989; Condit, 1998). Very large trees that were impossible to collect samples from, remained undetermined, provided they had not been recognized by studying their bark, wood, leaves, etc.

We obtained three sets of botanical collections. The first one was deposited at the herbarium of the University of Panama (PMA), the second at the herbarium of the Royal Botanical Gardens of Madrid (MA) and the third one will remain at the future herbarium of the Liquid Jungle Lab (LJL), in Canales de Tierra island.

The determination of all botanical samples was done at the herbarium of the University of Panama using floras and existing monographs, and by comparing them with herbarium specimens, which for the most part had been determined by specialists of the different families or genera.

Databases

The information obtained from the sampling of the plots has been stored in EXCELL program. A copy of this file is included to be used at the Biological Station (LJL). Any researcher wanting to use this information for their own publications, they first must contact the person responsible for the data, Alicia Ibáñez (aliciapanama@yahoo.com)

Plot 1 - Canales de Tierra Island

Plot 1 is located in the N side of Canales de Tierra Island, on the hillside facing Bejucosa Cove. Its UTM coordinates are: 17NMU 3657. This is the most dense forest section, with trees of greater height than those of any other site on the island. It seems that the area has remained scarcely disturbed for a long time and the appearance of the forest is that of an old and mature one. Probably only large trunks of "níspero" trees, *Manilkara staminodella* (*Sapotaceae*) have been extracted from the area, judging from the remains of the cut stumps still visible and according to the testimony of the most recent inhabitants. In nearby areas, along the ridge that runs along the island, one can still see large numbers of big holes on the ground, remnants of recent excavations or "huacas", which are graves of Pre-Columbian Indians. This points to the dense habitation of the island in those times and our lack of knowledge about the impact of these populations on its forests.

Our plot is situated in the middle of the slope that goes from the ridge to the sea. One half of it lies on terrain with a slight slope while the other half is located on a steep slope (+30%), almost to the edge of the N coast of the island.

Plot 2 - El Edén

Plot 2 is located at approximately 1.000 m from the small laboratory of El Edén, in the so called "El Edén forest". The UTM coordinates are: 17NMU 3958. This is the only wooded spot in this area, making it a small forest island in a sea of early succesional scrub vegetation (rastrojo). This seems to be an area that has been continuously disturbed by fire and logging on numerous occasions. Undisturbed for at least 50 years, the trees for the most part are not too high, which points to a secondary forest in an advanced state of recovery, though there are also some big specimens of fast growing species. The plot is located in a basin, or small valley, through which a creek flows; its boundary is a trail - connecting El Edén to Limón- that runs around the forest. The topography is

irregular and its whole surface has a moderate slope.

Floristic and Structural Descriptions

Methods

To characterize the floristic composition and structure of the forest in the two plots, for each species of DBH ≥ 10 cm, the following parameters were calculated: basal area, relative dominance, relative frequency, relative density and an index of value of importance (IVI) (cf. Boom, 1986; Balslev *& al*., 1987; Dallmeier *& al*., 1992).

- The *basal area* of an individual is the area occupied by the section of the trunk at breast height (1.3 meters from the ground) and it can be calculated according to the formula (Cintron & Schaeffer Novelli, 1984):

*basal area/individual=0.00007854 x DAP^2 (m^2/ha)

-The basal area/species is the sum of the basal area of all the individuals of that species. A parameter commonly used to compare different forests is the *basal area per hectare*, which is the sum of the basal areas of all the individuals of each species. To calculate this parameter we used the DBH of each stem, in the case there was more than one individual.

- *Relative dominance*: basal area of one species in relation to the basal area of all species. It is equal to the basal area in relative terms:

$$\text{Rel. dom.} = \frac{\text{basal area / species}}{\text{total basal area}} \times 100$$

- *Relative density*. The absolute density is the total number of individuals of one species per area unit. The relative density is the absolute density in relative terms.

$$\frac{\text{No. individuals / species}}{}$$

$$\text{Rel. den.} = \frac{\text{}}{\text{total No. individuals}} \times 100$$

- *Relative frequency*. The absolute frequency is the number of units of the sample units (in this case, quadrats) in which a species is present. The relative frequency was calculated using the twenty five units of 20 m x 20 m in the 1 hectare plots, using the formula:

$$\text{Rel. frec.} = \frac{\text{Absolute frequency / species}}{\text{Sum of absolute frequencies}} \times 100$$

- *Index of value of importance* (IVI). This index combines the previous measures, relative density, dominance and frequency (Curtis *& al*., 1951). The IVI varies between 0 and 300 and is defined in the following formula:

IVI for each species = rel.dom.+ rel.den.+ rel.freq.

Results

107 species and morphospecies of trees with a DBH equal to or greater than 10 cm, out of a total of 923 marked trees, were identified (Table 1). Of the 107 species, 6 were assigned to morphospecies, belonging to the following genera and families: 1 *Ficus* (*Moraceae*), 1 *Pouteria* (*Sapotaceae*), 1 *Melastomataceae*, 3 *Moraceae*. These specimens have not been yet identified due to the lack of fertile material, of recent taxonomic revisions or material with which to compare.

Nine individuals of more than 1 meter in diameter were found. All except one, *Hyeronima alchorneoides* (*Euphorbiaceae*), are in plot P1. Four of these trees are very large specimens of "algarrobo" trees, *Hymenaea courbaril* (*Fabaceae*), one individual of *Luhea seemanii* (*Tiliaceae*), and the others *Hyeronima alchorneoides* (*Euphorbiaceae*), *Parinari chocoensis* (*Chrysobalanaceae*) o *Ficus obtusifolia* (*Moraceae*).

There are big differences between the two plots with respect to the

species present and most abundant. In the first place we describe the floristic composition of each plot with reference to the trees most abundant in the forest, that is, those that represent approximately 50% of the individuals of the plot.

Plot 1 – ICT

In this plot located on the island of Canales de Tierra we counted 460 trees with a DBH ≥ 10 cm, corresponding to at least 59 species and morphospecies until now identified (Table 2). This forest is relatively mature, probably in an area that was never completely deforested, however as we pointed out before, we do not know the impact of former inhabitants. The forest in this part of the island is dominated by two species of *Burseraceae*, *Tetragastris panamensis* and *Protium tenuifolium* ssp. *mcleodii*. There are also several very large specimens of "algarrobo" trees, *Hymenaea courbaril*, (*Fabaceae*), and some other common species are "tangaré", *Calophyllum longifolium* (*Clusiaceae*), and "chonta", *Astrocaryum standleyanum* (*Arecaceae*). The "níspero" tree, *Manilkara staminodella* (*Meliaceae*), a timber-yielding species very much exploited in other times, is present in the plot, though the individuals are still very young. This means that the stock of this species is now recovering on the island. There are some large "maría" trees, *Calophyllum longifolium* (*Clusiaceae*), also a timber tree very much used in all of Central America. Of the species with the most interesting distribution found in the plot, we can point out *Erblichia odorata* (*Turneraceae*), a very uncommon tree in Panama and relatively abundant in the area of Bahía Honda. We can also remark the coexistence of typical species of the humid forests characteristic of this region, with others from drier environments such as *Sterculia apetala* (*Sterculiaceae*) or *Astronium graveolens* (*Anacardiaceae*). Part of the plot, on the area with a very steep slope close to the sea, there grow sun-loving species such as *Ochroma pyramidale* (*Bombacaceae*), *Trema micrantha* (*Ulmaceae*), etc. together with arborescent ferns of *Cyathea multiflora.* The forest in plot 1 is mostly a mature one, with a large diversity of species, however to a lesser

degree than the forest of El Edén, on the mainland.

Plot 2 - EL Edén

In the 1 hectare plot of El Eden we counted 463 trees of a DBH ≥ 10 cm, corresponding to at least 72 species and morphospecies identified until now (Table 3). The forest is dominated by the tree species, *Trichospermum galeotti* (*Tiliaceae*) and *Apeiba tibourbou* (*Tiliaceae*), most of the individuals are of great size; while the palm *Atrocaryum standleyanum* is also very abundant. The two species of *Tiliaceae* are typical of disturbed and secondary forests and both have a great ecological range, growing in dry forests as well as in the humid and very humid ones. *Hyeronima alchorneoides* (*Euphorbiaceae*) and *Vochysia ferruginea* (*Vochysiaceae*), are also very common species in this plot, characteristic of humid and very humid forests, both abundant in mature secondary forests.

The understorey of this plot is very dense, with great abundance of large-leaved herbaceous species, indicating an environment with high light intensity, such as *Cyclanthus bipartitus* (*Cyclanthaceae*), *Cardudovica palmata* (*Cyclanthaceae*) *Calathaea inocephala* (*Marantaceae*), *Costus pulverulentus* (*Costaceae*), *Heliconia imbricata* (*Heliconiaceae*) and palms such as *Geonoma sp.1*. The large number of terrestrial *Araceae* that cover the ground such as *Dieffenbachia sp*., *Syngonium sp*., etc. also indicates a high edaphic humidity.

This is a secondary forest in an advanced state of recovery and with a high diversity of species. It is dominated by fast-growing species that drop large numbers of leaves, contributing to improve the edaphic conditions and would be very appropriate for use in mixed plantations, for the recovery of areas with degraded soils (Perez & Condit, 2002). We also observe in the understorey tree species characteristic of mature forests that are regenerating such as *Licania hypoleuca* (*Chrysobalanaceae*), *Parinari chocoensis* (*Chrysobalanaceae*), etc.

There are many interesting species in this area such as *Tetrorchidium rotundatum* (*Euphorbiaceae*), a large tree only recorded before in Panama in the area of Cerro Hoya (Deago, 2001). Some others that are abundant in this area,

but little collected in Panama, are *Oxandra venezuelana* (*Anonnaceae*), *Gloeospermum eneidense* (*Violaceae*), *Chimarrhis parviflora* (*Rubiaceae*) and *Sloanea ternifolia* (*Elaeocarpaceae*).

The flora catalogue describes the ecologic characteristics and uses of the tree species of the plots.

Discussion

In the forests of Bahía Honda the dominant families are the same as those found in the forests of the lowlands of Panama and the Neotropics. *Fabaceae* and *Moraceae* are the ones represented by the greater number of species. The *Fabaceae* family (*Leguminosae*) is the most diverse in almost all the humid Neotropical and African forests (Gentry, 1988) and it is also so in Bahía Honda. *Moraceae* is the second most represented family on the mainland forests, in Central America as well as in the Amazon (Gentry, 1988; Gentry, 1990) and we see it is very diverse and abundant in the region of Bahía Honda. This family is, on the contrary, not diverse on Coiba island, where only the genus *Ficus* (Ibáñez, 2001) has been found. It has also been previously recorded as dominant over areas with soils rich in nutrients (Gentry, 1988), same as *Arecaceae* or *Palmae*. The palm family has a low diversity in the area, if we compare it to its representation on continental forests in El Chocó (Gentry, 1986; Galeano *& al*., 1998) Costa Rica (Janzen, 1983) and the Amazon (Balslev *& al*., 1987; Henderson, 1995). Only one species, "chonta" (*Astrocaryum standleyanum*) is very abundant in the area.

We must point out that the tree species composition is basically different in the two plots. They both share 24 species, which represents 33.3% of the total found on Plot P2 (El Edén) and 40.6% of those on plot P1 (ICT). This is a very low level of floristic similarity between two sites that are so close, attributable in this case to the different degree of maturity of the forest -much less mature in El Edén-, to differences in habitat -much drier on Island Canales de Tierra- and maybe to the so called "island effect", that implies the dominance of certain species and the disappearance of many others on islands. However in this case, due to the proximity of the island to the mainland, this effect has been

subdued. Comparing the floristic similarity of the forests of Bahía Honda with the ones at Coiba Island, we can say that plot P2 (El Edén) shares 50% of its species with the species of the Coiba plots (Ibáñez, 2001), while P1 (ICT) does so with 66%.

The density of trees per hectare (460-463) found on Bahía Honda is similar to that of the humid and very humid tropical forests of both basins in Central America, as in the Panama Canal area and Costa Rica, and also to other more distant forests in Mexico and El Chocó (Colombia), whose values vary approximately between 300-600 trees/hectare (Hartshorn, 1983; Lieberman *& al*., 1985; Bongers *& al*., 1988; Lieberman *& al*., 1996; Galeano *& al*., 1998; Valverde, 1998; Leigh, 1999).

The values of basal area, 32,37 (P1) and 35,18 (P2) in Bahía Honda, are also similar to those cited in other comparable studies in the Neotropics, for Central America as well as for the Amazon (Mori *& al*., 1983; Balslev *& al*., 1987; Galeano *& al*., 1998).

Diversity

One of the most important aspects in the characterization of plant communities is that deriving from the study of its diversity. The humid tropical forests are characterized by a high diversity of tree species with low relative densities of most of them. Diversity patterns of any area are determined by historic, geographic and ecological processes (Ricklefs *& al*., 1993). On a regional scale, for tropical forests, gradients of diversity associated to latitude, altitude, precipitation, seasonality, soil fertility, etc., have been reported (Gentry *& al*., 1987; Gentry, 1998; Valencia *& al*., 1994). On a local scale, environmental heterogeneity caused by the variation of environmental factors, such as soil properties, fertility, humidity or light conditions inside the forest, create different diversity patterns (Gentry, 1982; Gentry & Emmons, 1987; Condit *& al*., 1996).

Comparing the tree diversity of the two Bahía Honda plots, we see that the one at El Edén is notably more diverse than the one on Canales de Tierra (72 species to 59). This is an expected result due to several causes: in the first place at El Edén plot we have a mixture of pioneer, early succesional and late

secondary species -this gives us an indication of previous human disturbances- together with others typical of the humid primary forests of the region. This forest dynamics (disturbance-recovering) has been frequently considered as one of the factors in the maintenance of high levels of diversity (Denslow, 1987; Denslow, 1995; Duivenvoorden, 1996). However, the forest where plot P1 is located, on Canales de Tierra Island, does not show this kind of signs of forest disturbance. Secondly, the environmental conditions on both sites are probably quite different, with greater air and edaphic dryness in the case of P1, due to its proximity to the coastal fringe and also to the likely lesser precipitation on the island than on the continent. Lastly, despite the fact that the distance between the Island Canales de Tierra and the continent is quite small (c. 350 meters), it is probable that a certain "island effect" exists, causing a decrease in the number of species.

While in Bahía Honda we find a mean number of 65 species of trees (DBH $\geq$ 10 cm) per hectare, the studies carried out on Coiba Island show us a mean number of 46 (Ibáñez, 2001) and on the island of Barro Colorado 93 (CTFS, 2000). Although these results are only tentative, due to the small number of samples, we can conclude that in the region of Bahía Honda the forests have an intermediate level of diversity between the more diverse forests of the Panama Canal area and the Panamanian Atlantic side, and the poorest ones on Coiba Island (Ibáñez, 2001).

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39- 60.

Table 1. List of families and species identified in the plots

plot	FAMILY	SPECIES
1-2	*Anacardiaceae*	***Anacardium excelsum*** (Bertero & Balb. ex Kunth) Skeels (1725 Al, 2249 Al)
1	*Anacardiaceae*	***Astronium graveolens*** Jacq. (1762 Al)
1	*Anacardiaceae*	***Spondias mombin*** L.
2	*Annonaceae*	***Oxandra venezuelana*** R.E. Fr. (2181 Al)
2	*Annonaceae*	***Rollinia mucosa*** (Jacq.) Baill. (2237 Al)
2	*Annonaceae*	***Xylopia frutescens*** Aubl. (2205 Al)
1-2	*Apocynaceae*	***Lacmellea panamensis*** (Woodson) Markgr. (2184 Al)
2	*Apocynaceae*	***Tabernaemontana arborea*** Rose (2197 Al)
1-2	*Araliaceae*	***Dendropanax arboreus*** (L.) Decne. & Planch. (1727 Al, 2195 Al)
1-2	*Araliaceae*	***Schefflera morototoni*** (Aubl.) Maguire, Steyerm. & Frodin (2192 Al)
1-2	*Arecaceae*	***Astrocaryum standleyanum*** L.H. Bailey
1	*Arecaceae*	***Oenocarpus minor*** Mart.
1	*Bombacaceae*	***Ochroma pyramidale*** (Cav. ex Lam.) Urb.
2	*Bombacaceae*	***Pachira sessilis*** Benth. (2279 Al)
2	*Boraginaceae*	***Cordia bicolor*** A. DC. (2190 Al)
1-2	*Burseraceae*	***Protium tenuifolium*** ssp. ***mcleodii*** (I.M. Johnst.) D.M. Porter (1732 Al, 2226 Al)
1-2	*Burseraceae*	***Tetragastris panamensis*** (Engl.) Kuntze (1726 Al, 2220 Al)
1	*Cecropiaceae*	***Cecropia insignis*** Liebm. (1751 Al)
2	*Cecropiaceae*	***Cecropia peltata*** L. (2218 Al)
2	*Cecropiaceae*	***Pourouma bicolor*** ssp. ***scobina*** (Benoist) C.C. Berg & van Heusden (2212 Al)
1	*Celastraceae*	***Maytenus schippii*** Lundell (1870 Al)
1	*Chrysobalanaceae*	***Hirtella racemosa*** var. ***hexandra*** (Willd. Roem. & Schult.) Prance (1736 Al)
2	*Chrysobalanaceae*	***Hirtella triandra*** Sw. (2225 Al)
1	*Chrysobalanaceae*	***Parinari chocoensis*** Prance (1719 Al)
1	*Clethraceae*	***Clethra lanata*** M. Martens & Galeotti (1858 Al)
1	*Clusiaceae*	***Calophyllum brasiliensis*** Cambess. (1748 Al)
1-2	*Clusiaceae*	***Calophyllum longifolium*** Willd. (1854 Al, 2268 Al)

1	*Clusiaceae*	***Garcinia intermedia*** (Pittier) Hammel
2	*Clusiaceae*	***Marila laxiflora*** Rusby (2174 AI)
2	*Elaeocarpaceae*	***Sloanea terniflora*** (Moç. & Sessé ex DC.) Standl. (2242 AI)
2	*Euphorbiaceae*	***Alchornea costaricensis*** Pax & K. Hoffm. (2317 AI)
1-2	*Euphorbiaceae*	***Alchornea grandis*** Benth. (1770 AI, 2193 AI)
1-2	*Euphorbiaceae*	***Hyeronima alchorneoides*** Allemão (2194 AI)
1	*Euphorbiaceae*	***Sapium glandulosum*** (L.) Morong
2	*Euphorbiaceae*	***Tetrorchidium rotundatum*** Standl. (2267 AI)
1	*Fabaceae-Caesalpinoideae*	***Copaifera aromatica*** Dwyer (1765 AI)
1-2	*Fabaceae-Caesalpinoideae*	***Hymenaea courbaril*** L.
1	*Fabaceae-Caesalpinoideae*	***Prioria copaifera*** Griseb. (1744 AI)
1	*Fabaceae-Mimosoideae*	***Cojoba tubulifera*** (Benth.) Britton & Rose (1865 AI)
2	*Fabaceae-Mimosoideae*	***Enterolobium schomburgkii*** Benth.
2	*Fabaceae-Mimosoideae*	***Inga acuminata*** Benth. (2285 AI)
1-2	*Fabaceae-Mimosoideae*	***Inga densiflora*** Benth. (1772 AI, 2185 AI)
2	*Fabaceae-Mimosoideae*	***Inga mucuna*** Walp. & Duchass. (2264 AI)
2	*Fabaceae-Mimosoideae*	***Inga nobilis*** ssp. ***quaternata*** (Poepp. & Endl.) T.D. Penn. (2209 AI)
1	*Fabaceae-Mimosoideae*	***Inga punctata*** Willd. (1758 AI)
2	*Fabaceae-Mimosoideae*	***Inga spectabilis*** (Vahl) Willd. (2207 AI)
2	*Fabaceae-Mimosoideae*	***Inga thibaudiana*** ssp. ***thibaudiana*** (2238 AI)
1	*Fabaceae-Papilionoideae*	***Lonchocarpus heptaphyllus*** (Poir.) DC. (1722 AI)
2	*Fabaceae-Papilionoideae*	***Ormosia coccinea*** var. ***subsimplex*** (Spruce ex Benth.) Rudd (2170 AI)
1	*Flacourtiaceae*	***Casearia commersoniana*** Cambess. (1869 AI)
1-2	*Flacourtiaceae*	***Lacistema aggregatum*** (P.J. Bergius) Rusby (1738 AI, 2213 AI)
1	*Lauraceae*	***Nectandra lineata*** (Kunth) Rohwer (1749 AI)
2	*Lauraceae*	***Ocotea cernua*** (Nees) Mez (2219 AI)
1	*Lauraceae*	***Ocotea rubrinervis*** Mez (1768 AI)

2	*Lecythidaceae*	***Couratari guianensis*** Aubl.
2	*Lecythidaceae*	***Gustavia superba*** (Kunth) O. Berg. (2239 AI)
1-2	*Leguminosae*	***Swartzia simplex*** var. ***continentalis*** Urb. (1724 AI, 2274 AI)
2	*Melastomataceae*	***Melas sp.1*** (2236 AI)
1-2	*Melastomataceae*	***Miconia argentea*** (Sw.) DC. (1747 AI, 2286 AI)
2	*Melastomataceae*	***Miconia poeppigii*** Triana (2183 AI)
1	*Melastomataceae*	***Mouriri gleasoniana*** Standl. (1866 AI)
1	*Melastomataceae*	***Mouriri myrtilloides*** ssp. ***parvifolia*** (Benth.) Morley (1766 AI)
1-2	*Meliaceae*	***Carapa guianensis*** Aubl. (1720 AI, 2254 AI)
2	*Meliaceae*	***Guarea grandifolia*** DC. (2244 AI)
2	*Meliaceae*	***Guarea pterorhachis*** Harms. (2214 AI)
2	*Meliaceae*	***Trichilia tuberculata*** (Triana & Planch.) C. DC. (2229 AI)
1	*Monimiaceae*	***Siparuna pauciflora*** (Beurl.) A. DC. (1717 AI)
1	*Moraceae*	***Brosimum alicastrum*** ssp. ***bolivarense*** (Pittier) C.C. Berg (1730 AI)
2	*Moraceae*	***Castilla elastica*** var. ***costaricanum*** (Liebm.) C. Berg (2177 AI)
2	*Moraceae*	***Ficus insipida*** Willd. (2167 AI)
2	*Moraceae*	***Ficus maxima*** Mill. (2245 AI)
1	*Moraceae*	***Ficus obtusifolia*** Kunth (1715 AI)
1	*Moraceae*	***Ficus sp.3*** (1878 AI)
2	*Moraceae*	***Maquira guianensis*** ssp. ***costaricana*** (Standley) (2252 AI)
1	*Moraceae*	***Mora sp.4*** (1731 AI)
2	*Moraceae*	***Mora sp.5*** (2286 AI)
1-2	*Moraceae*	***Mora sp.7*** (1857 AI, 2224 AI)
2	*Moraceae*	***Perebea guianensis*** Aubl. (2222 AI)
2	*Myristicaceae*	***Virola koschnyi*** Warb. (2255 AI)
1-2	*Myristicaceae*	***Virola sebifera*** Aubl. (2171 AI)
2	*Myrtaceae*	***Myrcia splendens*** (Sw.) DC. (2314 AI)
2	*Nyctaginaceae*	***Guapira costaricana*** (Standl.) Woodson (2235 AI)
1-2	*Olacaceae*	***Heisteria concinna*** Standl. (1728 AI, 2199 AI)
1-2	*Rhizophoraceae*	***Cassipourea elliptica*** (Sw.) Poir. (1769 AI, 2179 AI)
1-2	*Rubiaceae*	***Amaioua corymbosa*** Kunth (2227 AI)
1	*Rubiaceae*	***Calycophyllum candidissimum*** (Vahl) DC. (1729 AI)
2	*Rubiaceae*	***Chimarrhis parviflora*** Standl. (2204 AI, 2231 AI)
1	*Rubiaceae*	***Faramea occidentalis*** (L.) A. Rich. (1723 AI)
1-2	*Rubiaceae*	***Macrocnemum roseum*** (Ruiz & Pav.) Wedd.

		(1718 Al, 2215 Al)
1	*Rubiaceae*	***Posoqueria latifolia*** (Rudge) Roem. & Schult. (1746 Al)
1	*Sapotaceae*	***Manilkara staminodella*** Gilly (1743 Al)
1	*Sapotaceae*	***Pouteria foveolata*** T.D. Penn. (1742 Al)
2	*Sapotaceae*	***Pouteria glomerata*** (Miq.) Radlk. (2221 Al)
2	*Sapotaceae*	***Pouteria sp.2*** (2234 Al)
2	*Simaroubaceae*	***Simaba cedron*** Planch. (2233 Al)
2	*Simaroubaceae*	***Simarouba amara*** Aubl.
2	*Staphyleaceae*	***Turpinia occidentalis*** (Sw.) G. Don (2169 Al)
1	*Sterculiaceae*	***Sterculia apetala*** (Jacq.) H. Karst. (1737 Al)
2	*Sterculiaceae*	***Theobroma angustifolium*** Sessé & Moc. ex DC. (2202 Al)
2	*Tiliaceae*	***Apeiba tibourbou*** Aubl. (2188 Al)
1-2	*Tiliaceae*	***Luehea seemannii*** Triana & Planch. (1735 Al)
2	*Tiliaceae*	***Trichospermum galeottii*** (Turcz.) Kosterm. (2168 Al)
1	*Turneraceae*	***Erblichia odorata*** Seem. (1739 Al)
1	*Ulmaceae*	***Trema micrantha*** (L.) Blume (1875 Al)
2	*Verbenaceae*	***Vitex cooperi*** Standl.
2	*Violaceae*	***Gloeospermum eneidense*** Hekking (2211 Al)
1-2	*Vochysiaceae*	***Vochysia ferruginea*** Mart. (1860 Al, 2196 Al)

Table 2. P1 - ICT. Tree species (DBH ≥ 10 cm) and their abundance indexes.

FAMILY	SPECIES	No stems	No ind.	Basal area	Rel. dom.	Rel. den.	Rel. frec.	ivi
Burseraceae	***Tetragastris panamensis***	67	67	2.63	8.14	14.57	6.32	29.02
Burseraceae	***Protium tenuifolium***	64	64	1.83	5.66	13.91	7.43	27.01
Fabaceae	***Hymenaea courbaril***	8	8	5.57	17.20	1.74	2.23	21.17
Meliaceae	***Carapa guianensis***	33	33	1.87	5.78	7.17	6.32	19.27
Arecaceae	***Astrocaryum standleyanum***	37	37	0.71	2.19	8.04	5.58	15.81
Myristicaceae	***Virola sebifera***	22	22	1.23	3.80	4.78	6.69	15.27
Sapotaceae	***Manilkara staminodella***	19	19	0.39	1.20	4.13	4.83	10.17
Rubiaceae	***Macrocnemum roseum***	16	14	0.84	2.59	3.04	3.35	8.98
Araliaceae	***Dendropanax arboreus***	14	14	0.79	2.44	3.04	3.35	8.83
Clusiaceae	***Calophyllum longifolium***	11	11	1.09	3.37	2.39	2.97	8.74
Chrysobalanaceae	***Parinari chocoensis***	5	5	1.78	5.50	1.09	1.86	8.44
Moraceae	***Brosimum alicastrum***	11	11	1.11	3.43	2.39	2.60	8.42
Rhizophoraceae	***Cassipourea elliptica***	15	15	0.53	1.63	3.26	2.97	7.87
Melastomataceae	***Miconia argentea***	15	14	0.37	1.15	3.04	2.97	7.16
Olacaceae	***Heisteria concinna***	11	11	0.34	1.04	2.39	3.72	7.15
Fabaceae	***Swartzia simplex***	11	11	0.43	1.33	2.39	3.35	7.07
Moraceae	***Ficus obtusifolia***	3	2	1.79	5.53	0.43	0.74	6.71
Vochysiaceae	***Vochysia ferruginea***	5	5	1.07	3.31	1.09	1.49	5.88
Sapotaceae	***Pouteria foveolata***	4	4	0.93	2.87	0.87	1.49	5.23
Euphorbiaceae	***Hyeronima alchorneoides***	2	2	1.25	3.86	0.43	0.74	5.04
Fabaceae	***Prioria copaifera***	6	6	0.56	1.73	1.30	1.49	4.52
Rubiaceae	***Faramea occidentalis***	7	7	0.08	0.26	1.52	2.23	4.01
Cecropiaceae	***Cecropia insignis***	4	4	0.30	0.93	0.87	1.49	3.28
Tiliaceae	***Luehea seemannii***	1	1	0.79	2.43	0.22	0.37	3.02
	indet	5	5	0.23	0.70	1.09	1.12	2.90
Moraceae	***Ficus sp.***	4	4	0.30	0.92	0.87	1.12	2.90
Clusiaceae	***Calophyllum brasiliensis***	3	3	0.46	1.42	0.65	0.74	2.82
Araliaceae	***Schefflera morototoni***	3	3	0.24	0.75	0.65	1.12	2.52
Lauraceae	***Nectandra lineata***	2	2	0.37	1.13	0.43	0.74	2.31
Fabaceae	***Copaifera aromatica***	3	3	0.15	0.46	0.65	1.12	2.23
Arecaceae	***Oenocarpus mapora***	4	4	0.03	0.10	0.87	1.12	2.09
Lecythidaceae	***Couratari guianensis***	2	2	0.28	0.87	0.43	0.74	2.05
Fabaceae	***Inga sp.***	3	3	0.07	0.23	0.65	1.12	2.00
Clethraceae	***Clethra lanata***	3	3	0.16	0.51	0.65	0.74	1.90
Rubiaceae	***Calycophyllum candidissimum***	3	2	0.17	0.52	0.43	0.74	1.70
Anacardiaceae	***Spondias mombin***	2	2	0.13	0.40	0.43	0.74	1.58
Sterculiaceae	***Sterculia apetala***	2	2	0.12	0.37	0.43	0.74	1.55
Lacistemataceae	***Lacistema aggregatum***	3	3	0.03	0.10	0.65	0.74	1.50
Lauraceae	***Ocotea rubrinervis***	3	2	0.06	0.17	0.43	0.74	1.35

Euphorbiaceae	***Sapium glandulosum***	1	1	0.24	0.73	0.22	0.37	1.32
Fabaceae	***Inga densiflora***	1	1	0.21	0.64	0.22	0.37	1.23
Turneraceae	***Erblichia odorata***	1	1	0.19	0.59	0.22	0.37	1.18
Celastraceae	***Maytenus schippii***	2	2	0.05	0.15	0.43	0.37	0.95
Bombacaceae	***Ochroma pyramidale***	2	2	0.03	0.10	0.43	0.37	0.91
Rubiaceae	***Amaioua corymbosa***	2	2	0.02	0.06	0.43	0.37	0.86
Fabaceae	***Inga punctata***	1	1	0.09	0.26	0.22	0.37	0.85
Anacardiaceae	***Anacardium excelsum***	1	1	0.07	0.21	0.22	0.37	0.79
Euphorbiaceae	***Alchornea grandis***	1	1	0.06	0.18	0.22	0.37	0.77
Myrtaceae	***Myrcia splendens***	1	1	0.06	0.18	0.22	0.37	0.77
Sapotaceae	***Pouteria glomerata***	1	1	0.04	0.12	0.22	0.37	0.71
Apocynaceae	***Lacmellea panamensis***	1	1	0.04	0.11	0.22	0.37	0.70
Moraceae	***Mora sp.7***	1	1	0.03	0.09	0.22	0.37	0.68
Fabaceae	***Cojoba tubulifera***	1	1	0.02	0.07	0.22	0.37	0.66
Anacardiaceae	***Astronium graveolens***	1	1	0.02	0.06	0.22	0.37	0.65
Monimiaceae	***Siparuna pauciflora***	1	1	0.02	0.05	0.22	0.37	0.64
Clusiaceae	***Garcinia intermedia***	1	1	0.02	0.05	0.22	0.37	0.64
Lauraceae	***Nectandra sp.***	1	1	0.01	0.04	0.22	0.37	0.63
Moraceae	***Ficus sp.3***	1	1	0.01	0.04	0.22	0.37	0.63
Ulmaceae	***Trema micrantha***	1	1	0.01	0.04	0.22	0.37	0.63
Melastomataceae	***Mouriri myrtilloides***	1	1	0.01	0.04	0.22	0.37	0.62
Rubiaceae	***Posoqueria latifolia***	1	1	0.01	0.03	0.22	0.37	0.62
Moraceae	***Mora sp.4***	1	1	0.01	0.03	0.22	0.37	0.62
Flacourtiaceae	***Casearia commersoniana***	1	1	0.01	0.03	0.22	0.37	0.62
Chrysobalanaceae	***Hirtella racemosa***	1	1	0.01	0.03	0.22	0.37	0.62
Melastomataceae	***Mouriri gleasoniana***	1	1	0.01	0.03	0.22	0.37	0.62
Fabaceae	***Lonchocarpus pentaphyllus***	1	1	0.01	0.02	0.22	0.37	0.61
TOTAL		**466**	**460**	**32.37**	**100**	**100**	**100**	**300**

Table 3. P2 – El Edén. Tree species (DBH _ 10 cm) and their abundance indexes.

FAMILY	SPECIES	No stems	No ind.	Basal area	Rel. dom.	Rel. den.	Rel. frec.	ivi
Tiliaceae	***Trichospermum galeottii***	56	56	8.00	22.73	12.10	6.36	41.18
Tiliaceae	***Apeiba tibourbou***	73	73	5.41	15.37	15.77	8.13	39.27
Arecaceae	***Astrocaryum standleyanum***	66	66	0.97	2.74	14.25	7.77	24.77
Euphorbiaceae	***Hyeronima alchorneoides***	12	12	2.55	7.26	2.59	3.53	13.39
Vochysiaceae	***Vochysia ferruginea***	18	18	1.37	3.88	3.89	4.24	12.01
Clusiaceae	***Marila laxiflora***	14	14	0.67	1.91	3.02	3.53	8.47
Lecythidaceae	***Couratari guianensis***	7	7	1.39	3.94	1.51	2.12	7.57
Fabaceae	***Inga densiflora***	11	10	0.50	1.43	2.16	3.18	6.77
Euphorbiaceae	***Tetrorchidium rotundatum***	7	7	0.81	2.30	1.51	2.12	5.93
Melastomataceae	***Miconia argentea***	14	14	0.23	0.67	3.02	1.77	5.46
Myristicaceae	***Virola sp.***	7	7	0.60	1.71	1.51	2.12	5.34
Rubiaceae	***Macrocnemum roseum***	7	7	0.58	1.66	1.51	2.12	5.29
Sapotaceae	***Pouteria glomerata***	8	8	0.59	1.67	1.73	1.77	5.16
Burseraceae	***Tetragastris panamensis***	5	5	0.71	2.00	1.08	1.41	4.50
Staphyleaceae	***Turpinia occidentalis***	7	7	0.16	0.47	1.51	2.47	4.45
	indet	7	7	0.29	0.82	1.51	1.77	4.10
Moraceae	***Maquira guianensis***	10	8	0.18	0.51	1.73	1.77	4.01
Meliaceae	***Guarea pterorhachis***	5	5	0.38	1.08	1.08	1.77	3.93
Cecropiaceae	***Pourouma bicolor***	5	5	0.46	1.30	1.08	1.41	3.79
Apocynaceae	***Lacmellea panamensis***	7	7	0.12	0.34	1.51	1.77	3.62
Apocynaceae	***Tabernaemontana arborea***	5	5	0.24	0.67	1.08	1.77	3.52
Fabaceae	***Inga thibaudiana***	5	5	0.31	0.88	1.08	1.06	3.02
Araliaceae	***Schefflera morototoni***	3	3	0.45	1.29	0.65	1.06	3.00
Fabaceae	***Inga sp.***	5	5	0.14	0.39	1.08	1.41	2.89
Melastomataceae	***Miconia poeppigii***	3	3	0.38	1.08	0.65	0.71	2.43
Meliaceae	***Carapa guianensis***	3	3	0.38	1.07	0.65	0.71	2.43
Meliaceae	***Guarea grandifolia***	2	2	0.45	1.28	0.43	0.71	2.42
Anacardiaceae	***Anacardium excelsum***	4	4	0.12	0.33	0.86	1.06	2.26
Olacaceae	***Heisteria concinna***	4	4	0.11	0.31	0.86	1.06	2.23
Fabaceae	***Enterolobium schomburgkii***	1	1	0.58	1.65	0.22	0.35	2.22
Moraceae	***Ficus sp.***	1	1	0.57	1.61	0.22	0.35	2.18
Meliaceae	***Trichilia tuberculata***	3	3	0.15	0.42	0.65	1.06	2.13
Moraceae	***Perebea guianensis***	4	4	0.07	0.19	0.86	1.06	2.12
Melastomataceae	***Melas sp.1***	1	1	0.54	1.54	0.22	0.35	2.11
Sapotaceae	***Pouteria sp.2***	1	1	0.54	1.54	0.22	0.35	2.11
Cecropiaceae	***Cecropia peltata***	3	3	0.11	0.30	0.65	1.06	2.01
Tiliaceae	***Luhea seemanni***	1	1	0.50	1.43	0.22	0.35	2.00
Rhizophoraceae	***Cassipourea elliptica***	3	3	0.10	0.28	0.65	1.06	1.99
Simaroubaceae	***Simaba cedron***	3	3	0.10	0.28	0.65	1.06	1.99
Myristicaceae	***Virola sebifera***	3	3	0.08	0.24	0.65	1.06	1.95

Fabaceae	***Inga acuminata***	3	3	0.06	0.18	0.65	1.06	1.89
Clusiaceae	***Calophyllum longifolium***	2	2	0.26	0.74	0.43	0.71	1.87
Euphorbiaceae	***Alchornea grandis***	3	3	0.06	0.16	0.65	1.06	1.87
Myristicaceae	***Virola koschnyi***	1	1	0.45	1.27	0.22	0.35	1.84
Araliaceae	***Dendropanax arboreus***	2	2	0.23	0.66	0.43	0.71	1.80
Annonaceae	***Xylopia frutescens***	3	3	0.03	0.08	0.65	1.06	1.79
Fabaceae	***Swartzia simplex***	3	3	0.03	0.08	0.65	1.06	1.79
Fabaceae	***Hymenaea courbaril***	1	1	0.33	0.95	0.22	0.35	1.52
Moraceae	***Mora sp.7***	2	2	0.13	0.37	0.43	0.71	1.51
Verbenaceae	***Vitex cooperi***	1	1	0.30	0.86	0.22	0.35	1.43
Annonaceae	***Oxandra venezuelana***	2	2	0.09	0.26	0.43	0.71	1.39
Moraceae	***Ficus maxima***	2	2	0.07	0.19	0.43	0.71	1.33
Violaceae	***Gloeospermum eneidense***	2	2	0.07	0.19	0.43	0.71	1.32
Rubiaceae	***Chimarrhis parviflora***	2	2	0.06	0.16	0.43	0.71	1.30
Nyctaginaceae	***Guapira costaricana***	2	2	0.06	0.16	0.43	0.71	1.30
Moraceae	***Ficus insipida***	2	2	0.05	0.14	0.43	0.71	1.28
Annonaceae	***Rollinia mucosa***	2	2	0.04	0.10	0.43	0.71	1.24
Lacistemataceae	***Lacistema aggregatum***	2	2	0.03	0.09	0.43	0.71	1.23
Myrtaceae	***Myrcia splendens***	2	2	0.03	0.09	0.43	0.71	1.22
Sterculiaceae	***Theobroma angustifolium***	2	2	0.02	0.06	0.43	0.71	1.20
Lauraceae	***Ocotea cernua***	2	2	0.02	0.06	0.43	0.71	1.20
Bombacaceae	***Pachira sessilis***	2	2	0.12	0.33	0.43	0.35	1.11
Boraginaceae	***Cordia bicolor***	2	2	0.10	0.29	0.43	0.35	1.07
Fabaceae	***Ormosia coccinea***	1	1	0.15	0.42	0.22	0.35	0.99
Fabaceae	***Legu sp.***	1	1	0.08	0.22	0.22	0.35	0.79
Moraceae	***Castilla elastica***	1	1	0.07	0.21	0.22	0.35	0.78
Euphorbiaceae	***Alchornea costaricensis***	1	1	0.06	0.18	0.22	0.35	0.75
Fabaceae	***Inga spectabilis***	1	1	0.06	0.16	0.22	0.35	0.73
Elaeocarpaceae	***Sloanea terniflora***	1	1	0.05	0.14	0.22	0.35	0.70
Rubiaceae	***Amaioua corymbosa***	1	1	0.05	0.13	0.22	0.35	0.70
Chrysobalanaceae	***Hirtella triandra***	1	1	0.04	0.11	0.22	0.35	0.68
Burseraceae	***Protium tenuifolium***	1	1	0.04	0.11	0.22	0.35	0.68
Lauraceae	***Laur sp.***	1	1	0.02	0.07	0.22	0.35	0.64
Fabaceae	***Inga nobilis***	1	1	0.02	0.07	0.22	0.35	0.64
Simaroubaceae	***Simarouba amara***	1	1	0.01	0.04	0.22	0.35	0.61
Fabaceae	***Inga mucuna***	1	1	0.01	0.03	0.22	0.35	0.60
Lecythidaceae	***Gustavia superba***	1	1	0.01	0.03	0.22	0.35	0.60
Moraceae	***Mora sp.5***	1	1	0.01	0.02	0.22	0.35	0.59
TOTAL		**466**	**463**	**35.18**	**100**	**100**	**100**	**300**