Internship 145-631-VA

A Plant Species Inventory of a One-hectare Forested Plot Using ACER Sampling Methodologies at The Caño Palma Biological Station in Tortuguero, Costa Rica

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ABSTRACT

Tropical forest ecosystems are incredibly diverse, providing extensive resources that sustain and support a wide variety of organisms. In particular, these environments contain unique habitats that are home to distinct communities of plant species. However, the exceptional biodiversity found in the tropics is now being threatened by changing environment conditions resulting from anthropogenic activities. Because of the challenging nature inherent in tropical forest studies, many of these regions have been overlooked and consequently, there is a dire need for additional research. In this study, a forest monitoring program developed by ACER was applied to a Neotropical rainforest setting at the Caño Palma Biological Station in Tortuguero, Costa Rica. It was determined that, in order to provide significant data used to identify ecological trends in the forest community, it would be necessary to carry out this project on an annual basis.

INTRODUCTION

The forests surrounding Tortuguero, Limon make up one of the most biologically diverse regions in Costa Rica. Several protected areas, including Tortuguero National Park and the Barra del Colorado Wildlife Refuge, combine with forests in Nicaragua to form the largest expanse of Atlantic and Caribbean lowland tropical wet rainforest in Central America (Lewis et al., 2010). Largely undisturbed, these remote areas often remain understudied. With 400 known species of trees and over 2200 species of plants, 58 of which are endemic to the region, this vast forest supports a rich and thriving ecosystem (SINAC, 2013). However, the area has recently been subject to the impacts of anthropogenic pressures due to a substantial increase in ecotourism throughout the region. In addition, changing environmental conditions causing frequent droughts and decreased biodiversity in tropical regions have been directly linked to global climate change

(Fonty et al., 2009). Due to a lack of knowledge regarding Neotropical rainforests, it is difficult to formulate accurate predictions as to how these ecosystems will respond to mounting environmental changes (Bonal et. al, 2008). As such, further knowledge is needed to understand the complex interactions that take place within these unique habitats.

While numerous botanical inventories have been performed throughout the region, there are few studies in place that are capable of monitoring changes in forest succession over time. ACER, or the Association for Canadian Educational Resources, is a non-profit organization developed to monitor forest biodiversity. Working in association with Environment Canada and the Smithsonian Institution, ACER focuses on the involvement of students and the community in order to carry out projects that monitor and measure the effects of human impacts on the environment and how forests respond to climate change (ACER, 2010). Through the adaptation of Smithsonian research protocols, these long-term studies allow for comparison with similar projects around the world (ACER, 2010). For example, a number of one-hectare forest biodiversity research plots were set up in Canada in the late 1990s by ACER to assess changes in forest biodiversity through time and have provided significant results (Butt, 2010). Since ACER is a Canadian- based organization, the sampling techniques have been developed for northern temperate forests; however, the application of these protocols could provide crucial baseline data on largely understudied ecosystems, including Neotropical rainforests.

In 2012, an ongoing project was initiated at the Caño Palma Biological Station in collaboration with The Canadian Organization for Tropical Education and Rainforest Conservation (COTERC) and Vanier College in Quebec, Canada to apply ACER sampling methodologies in a Neotropical rainforest setting.

METHODOLOGIES

Study Area:

The Caño Palma Biological Station is located 7 km North of Tortuguero Village, Limon, Costa Rica (17T 0223431 mE 1172152 mN) within the confines of the Barra del Colorado Wildlife Refuge. The property consists of approximately 40 hectares of Caribbean Lowland Wet Rainforest, characterized by swampy conditions and a dominance of palm species. The region has an average annual temperature of 26 ˚C and receives between 4500 and 6000 mm of precipitation per annum (SINAC, 2013). A 1-hectare sample plot was chosen at the southern section of the property in an attempt to increase the diversity of species included in the sample plot based on the transitional nature of this location (refer to Appendix I Figure 1).

Sampling Techniques:

The perimeter of the 1-hectare (100 X 100 meters) plot was delineated using a compass and a 50-meter measuring tape. The four corners were marked using flagging tape. The plot was then further divided into 25 sub-plots, each measuring 20 x 20 meters.

A white ring of paint was applied to the four corner trees of each sub-plot in order to define the boundaries of the sub-plots. Flagging tape was also applied to each of the four corners, with the sub-plot number and corner number written on the tape (see Appendix 1 Figure 2).

Starting at side 1 and proceeding at 2 meter intervals in a spiral fashion towards the center of the each sub-plot (see Appendix 1 Figure 3), all trees with a diameter at breast height (DBH=1.37m) of over 4 centimeters were tagged, with the plot number and tree number written on each label as per ACER protocol (ACER, 2010).

Trees with a DBH over 4 cm but below 10 cm were tagged using a piece of rope and tape. All trees with a DBH of 10 cm or greater were marked with a metal tag on the south side of the tree as a standardization. The DBH of all tagged trees was measured using a DBH measuring tape or a caliper (for trees smaller than 10 centimeters) and recorded. All measurements were taken from the south side of the tree to ensure consistency in future studies.

The trees were then identified to species with the help of local ethnobotanist Mario Garcia Quesada. Within each sub-plot, three representative trees were chosen based on species and size. The heights of the selected trees were measured using a compass equipped with a clinometer at a distance of 20 m. Any dead or dying trees were noted. The data was recorded in a field notebook and later compiled into an archive for future interpretation.

RESULTS

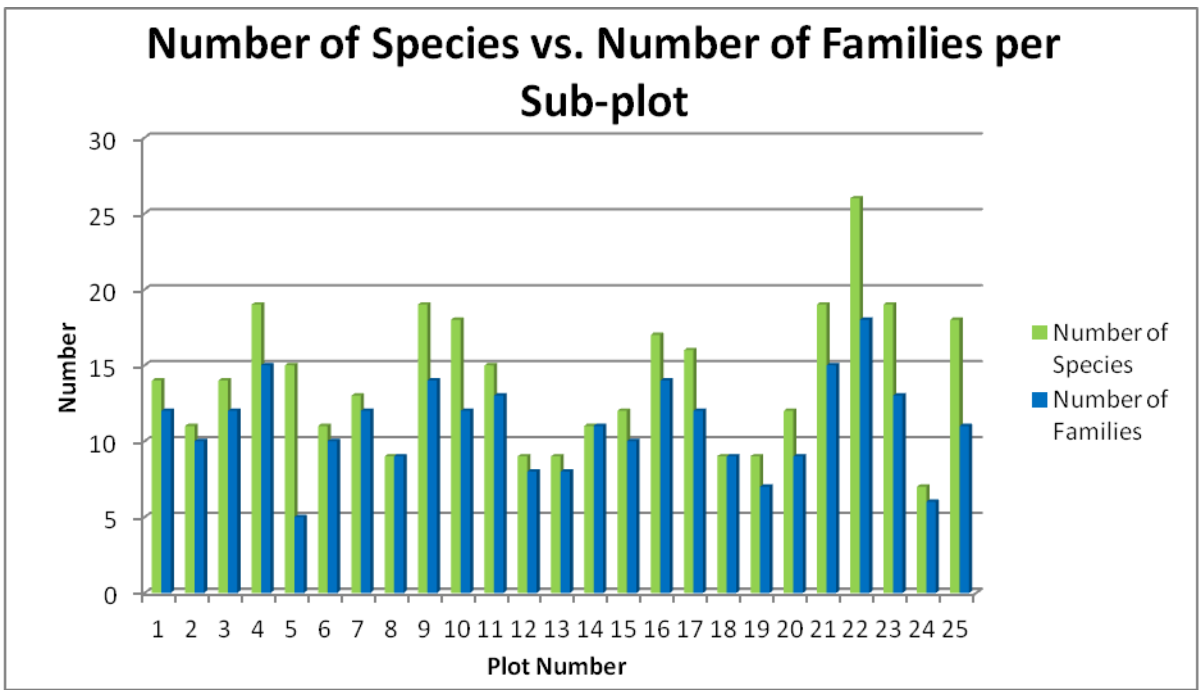

Figure 1. A representation of the plant species diversity found within each of the 25 sub-plots through a comparison of the number of species and number of families. The results are based on data obtained at the Caño Palma Biological Station during February 2013.

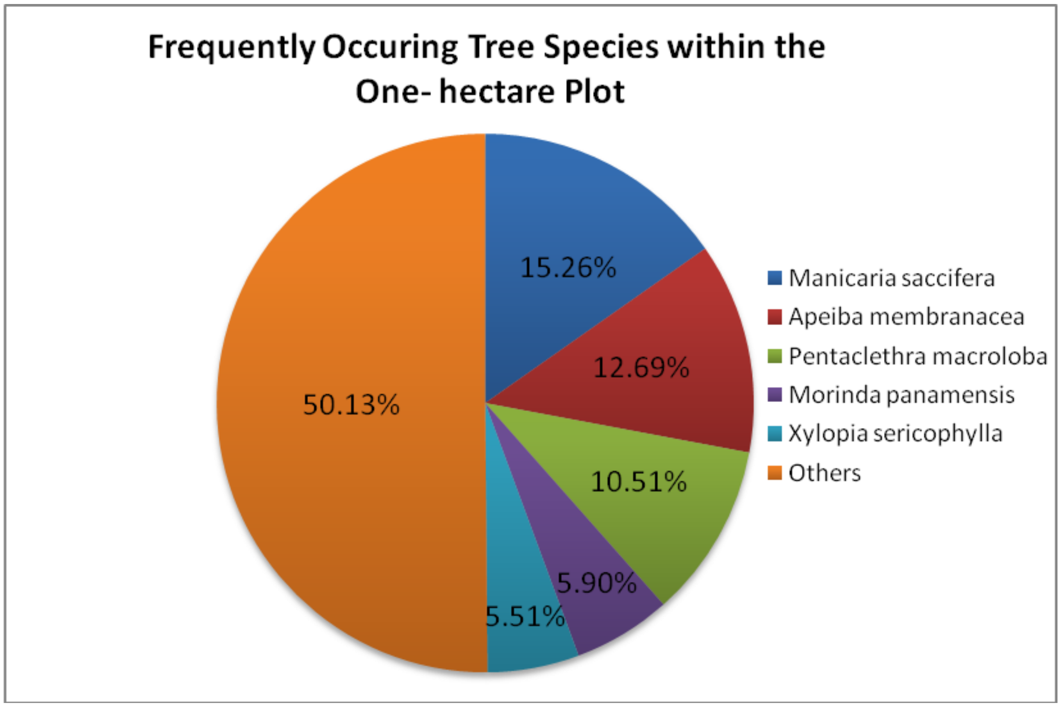

Figure 2. Depiction of the 5 most frequently occurring tree species (%) found within a one-hectare forested plot at the Caño Palma Biological Station from an inventory performed during February 2013.

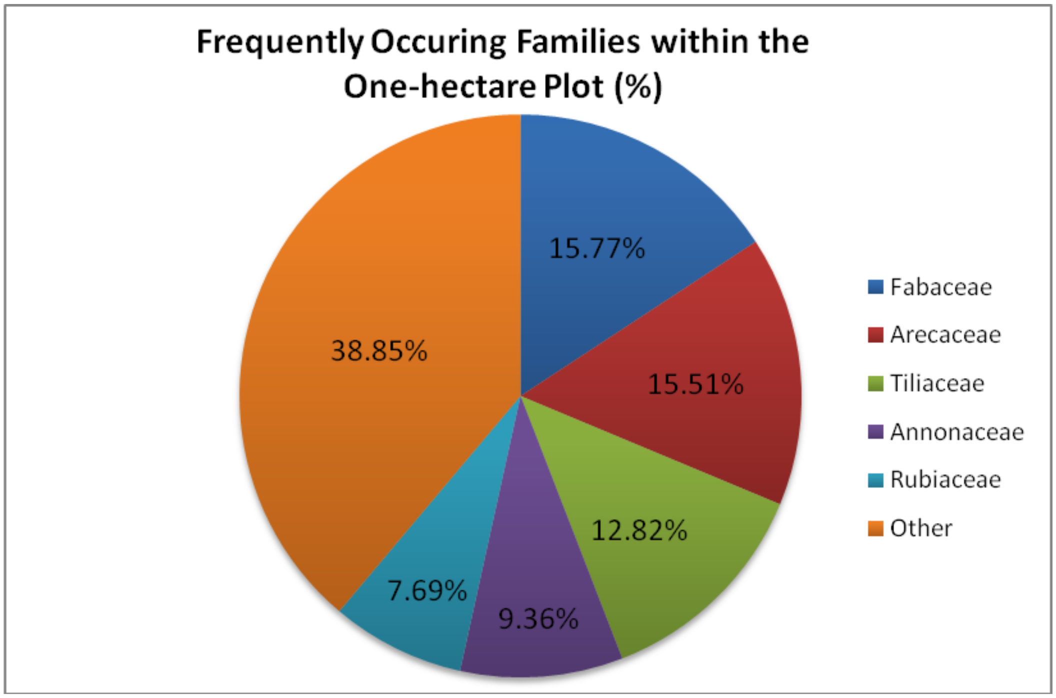

Figure 3. Depiction of the 5 most frequently occurring tree families (in %) found within a one-hectare forested plot at the Caño Palma Biological Station from an inventory performed during February 2013.

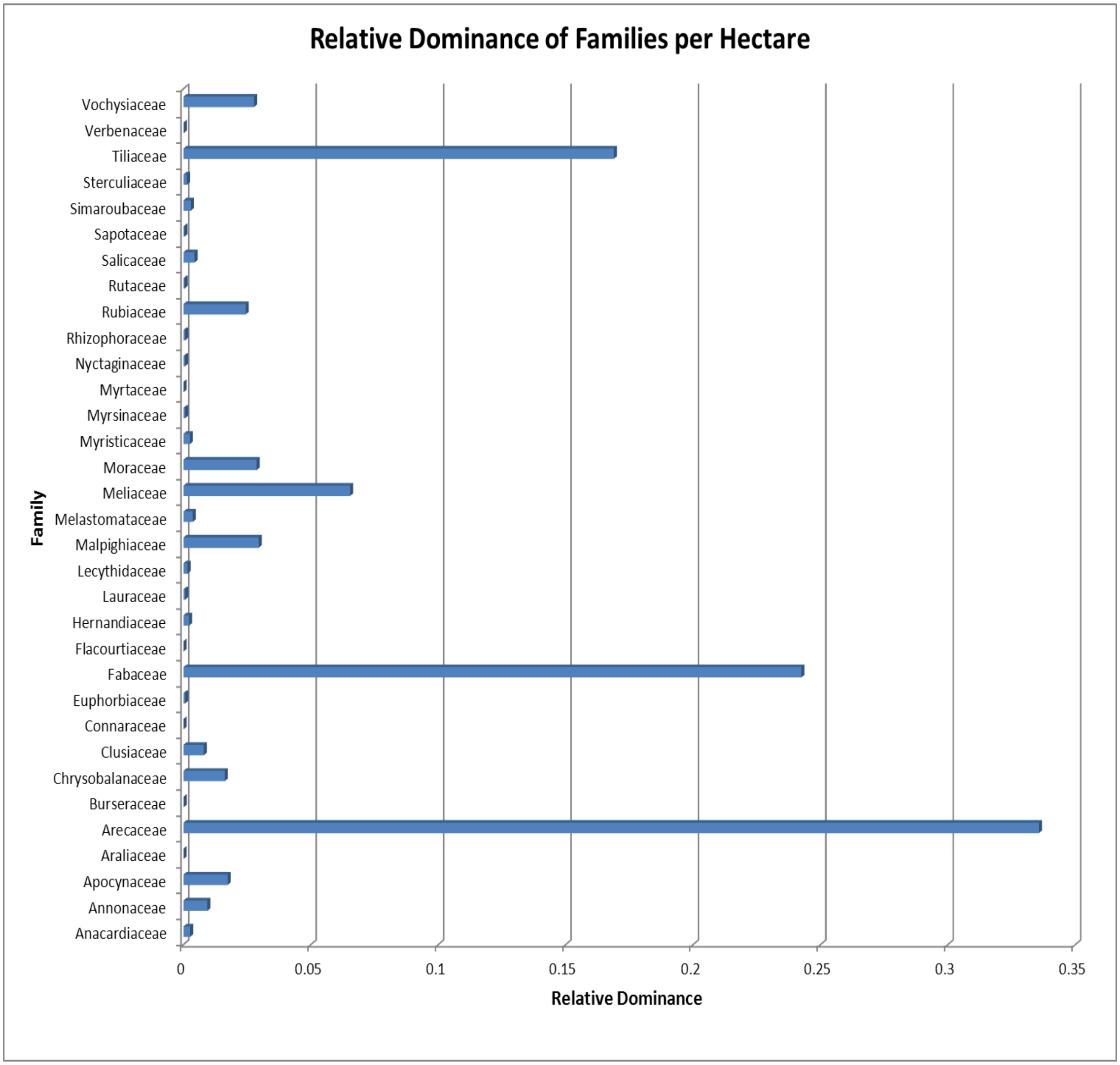

Figure 4. Relative dominance of families found within a one-hectare plot located at the Caño Palma Biological Station during February 2013. Dominant families include Aracaceae (0.3357), Fabaceae (0.2425) and Tiliaceae (0.1689).

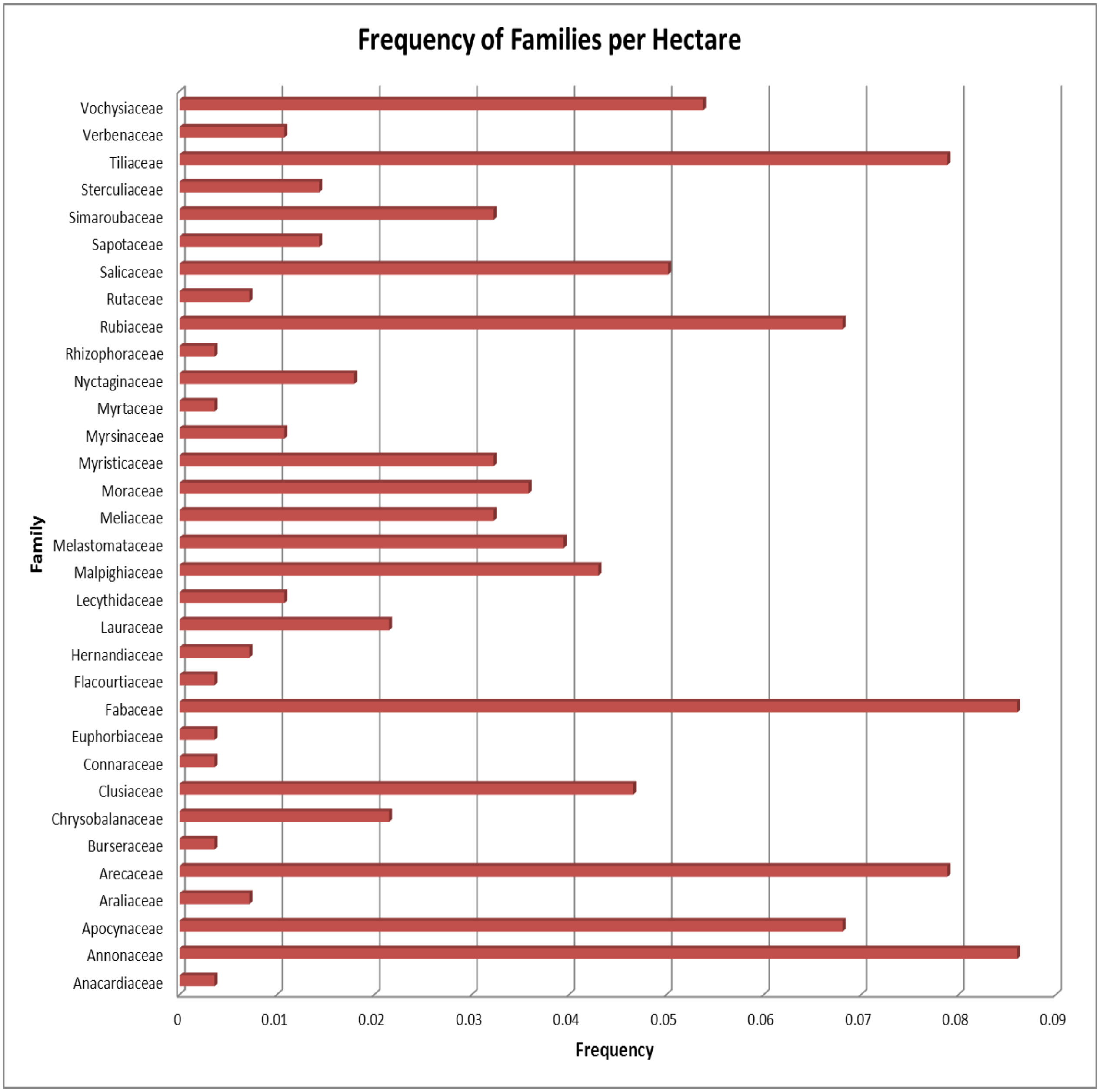

Figure 5. Frequency of families found within the one- hectare plot at the Caño Palma Biological station during February 2013. The families with the highest frequency include Annonaceae and Fabaceae (0.0860), followed by Tiliaceae (0.0788).

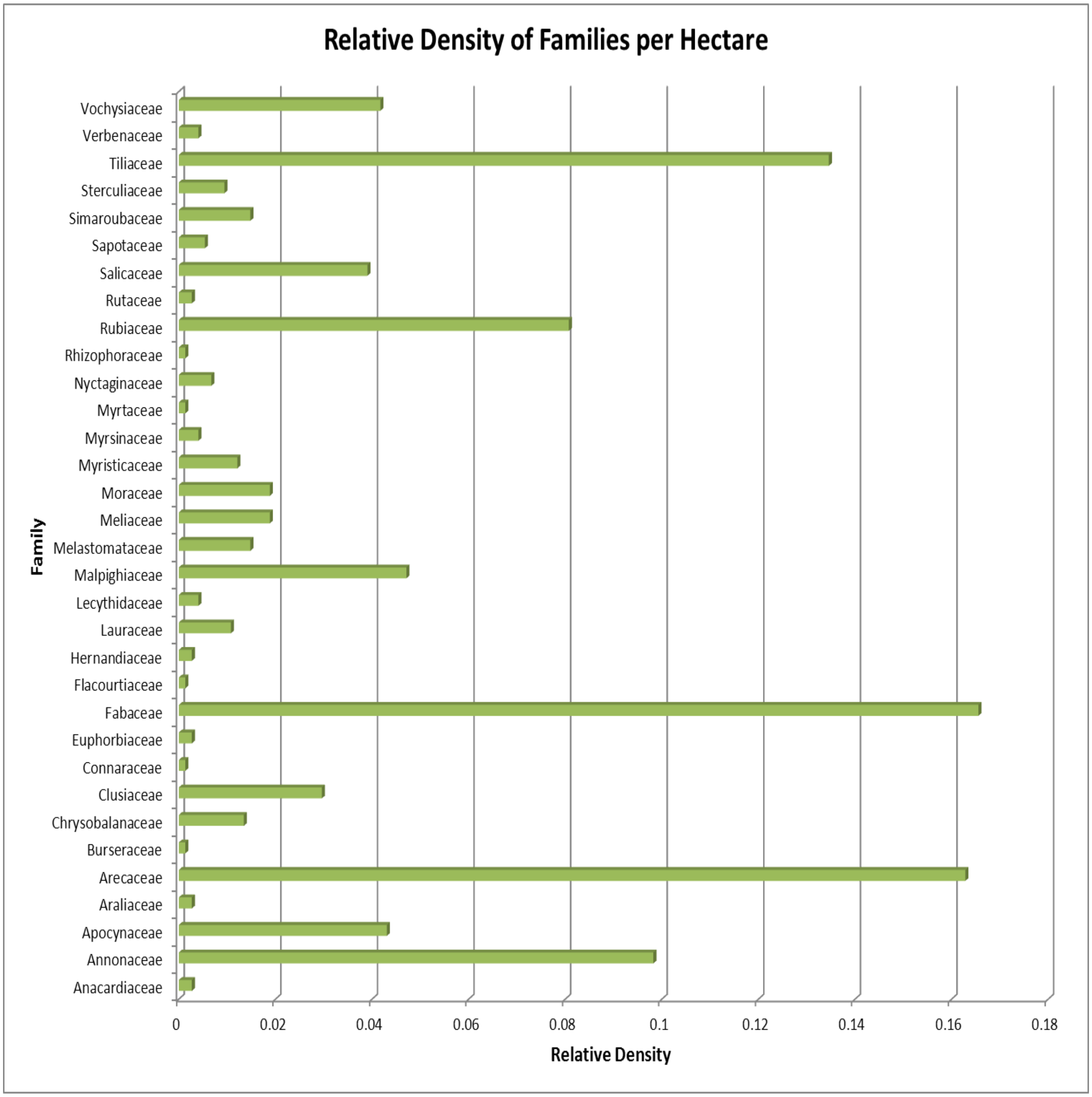

Figure 6. Relative density of families found within the one- hectare plot at the Caño Palma Biological station during February 2013. The families with the highest relative densities within the plot include Fabaceae (0.1654), Arecaceae (0.1628), and Tiliaceae (0.1345).

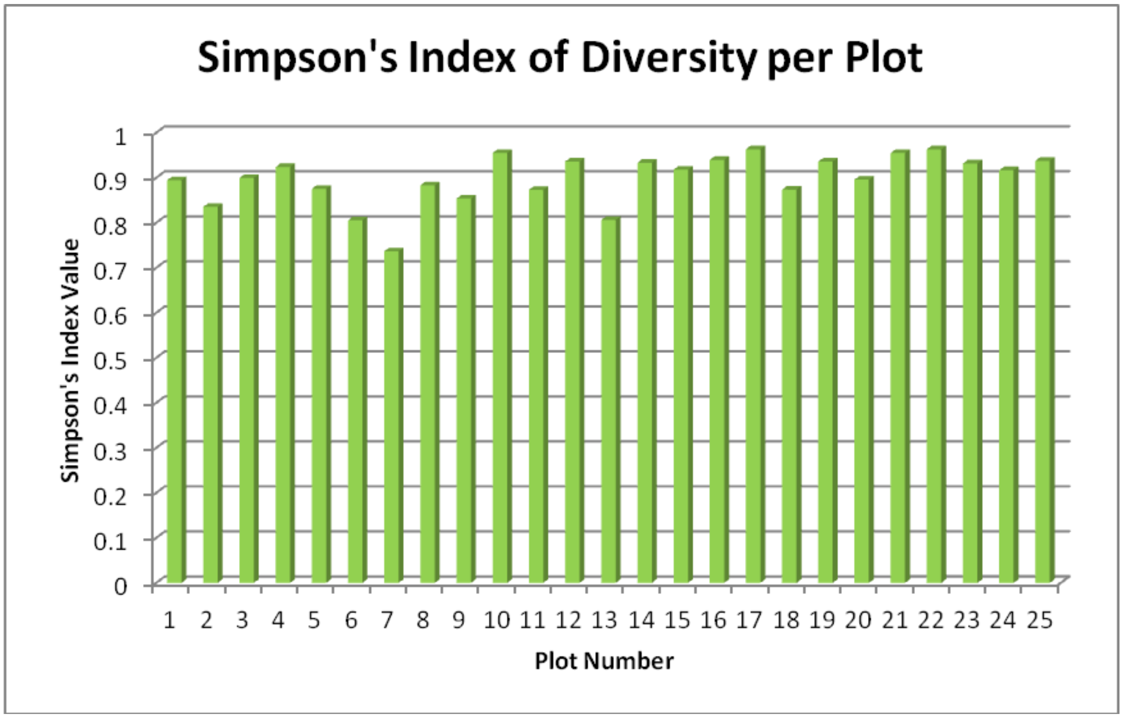

Figure 7. Simpson's Index of Diversity values for each of the 25 subplots within the one-hectare sample plot at the Caño Palma Biological Station. Values were calculated based on the following equation: SID= 1-D, where $D=\sum n(n-1)/N(N-1)$, n= the total number of individuals of a particular species and N= the total number of individuals of all species. The Simpson's Index of Diversity calculated for the entire 1-hectare plot was found to be 0.9301.

DISCUSSION

Due to the astounding diversity of flora and fauna found throughout the Neotropics, studies pertaining to the ecology of such regions are vital to the preservation and protection of these pristine environments. In recent years, these habitats have experienced drastic alterations as a result of human activities (Maslin et. al., 2005). According to various climate change models, researchers predict that forests will experience an increase in the frequency of droughts, insect infestations, forest diseases, and unpredictable precipitation patterns (Dale et.al., 2001). The likelihood of these occurrences poses a significant threat to the prevalence of forest ecosystems, particularly in the tropics.

As a result, there is a desperate need to establish monitoring programs in these areas in order to identify alterations of habitat resulting from anthropogenic influences. However, because of the difficulties involved in studies of the tropics, such as dense vegetation and remoteness of location as well as variations in sampling methodologies, a basic protocol would be advisable in order to establish significant long-term studies. ACER has developed a simple and efficient methodology to sample a given forest stand. These sampling methods were applied in a Caribbean lowland rainforest at the Caño Palma Biological Station in Tortuguero in order to implement a long-term plant species inventory with which to gather benchmark data such as tree species composition, DBH, and height that can be analyzed and compared with past and future findings.

The survey performed in 2013 showed a total of 780 individual trees with a DBH of over 4 cm within the one-hectare plot. Further identification revealed a total of 81 different species representing 33 families within the one-hectare plot. When compared with a similar study performed by Vanier College in a northern temperate forest in Lachute, Quebec, Canada, only 25 different species were recorded within a one-hectare plot, attesting to the elevated biodiversity in these regions. Plot 22 had the highest number of tree species (26) and families (18) with a total of 50 trees (refer to Figure 1). Plot 24 had the lowest number of species (7), while plot 5 had the fewest families (5), with a total of 10 and 46 individual trees, respectively. The most frequently occurring tree species found within the one-hectare plot include *Manicaria saccifera* (15.26%), *Apeiba membranacea* (12.69%), *Pentaclethra macroloba* (10.51%), *Morinda panamensis* (5.90%) and *Xylopia sericophylla* (5.51%), representing 49.87% of all trees found within the plot (see Figure 2). Reflecting these results, the most frequently occurring families within the plot were Fabaceae (15.77%), Aracaceae (15.51%), Tiliaceae (12.82%), Annonaceae (9.36%), and Rubiaceae (7.69%) representing 61.15% of all trees recorded (see Figure 3).

Table 1 in Appendix II is a summary of data based on different tree species found within the one-hectare forested plot at the Caño Palma Biological Station. All individual trees found within the plot were grouped according to species and any unidentified or dead individuals were omitted from the calculations. The relative dominance of each species was calculated using basal area measurements to assess the dominant species within the plot. Determining the relative dominance of a species is essential in understanding the interactions that take place within the plant community. It allows for an insight into the viability of a habitat by examining which species occupies the most area relative to the area covered by all of the species in the site (Dash et. al., 2001). In this study, the species with the highest relative dominance values were found to be *Manicaria saccifera* (0.3331), *Pentaclethra macroloba* (0.2084), and *Apeiba membranacea* (0.1687), respectively. The species were then grouped into families as shown in Figure 4 and those with the highest values were Aracaceae (0.3357), Fabaceae (0.2425) and Tiliaceae (0.1689).

The frequency at which each species occurred within the 25 sub-plots was also calculated. When calculated for each species, these values can give an indication of several habitat parameters such as forest type, soil drainage, the amount of available light, competition, and recent disturbances. The more suited a tree is to the habitat, the more likely it is to grow in abundance in that area. For example, *Manicaria saccifera* has been shown to prefer wet, swampy habitats with poor drainage (Snarr et. al., 2010). These conditions are characteristic of the property surrounding the Caño Palma Biological Station. The species with the highest frequencies in this study were *Pentaclethra macroloba* (0.96), *Manicaria saccifera* (0.88) and *Apeiba membranacea* (0.88).

Frequency values for each family were also calculated and Figure 5 shows Annonaceae (0.0860), Fabaceae (0.0860), and Tiliaceae (0.0788) to have the highest frequencies.

Relative density values for each species within the one-hectare plot were then calculated, as shown in Figure 6. The results show that the species with the highest relative density values were *Manicaria saccifera* (0.1599), *Apeiba membranacea* (0.1330), and *Pentaclethra macroloba* (0.1102). When grouped into families, those with the highest relative densities were Fabaceae (0.1654), Arecaceae (0.1628) and Tiliaceae (0.1345).

Simpson's Index of Diversity values were calculated for each of the 25 sub-plots, as well as for all of the species in the one-hectare plot (see Figure 7). The Simpson's Index of Diversity is one of the most commonly used measures of ecological diversity (Gorelick et.al., 2006). The index is widely used to demonstrate species richness and abundance within a given community. The model is based on the probability that two randomly chosen individuals within the sample area will be of a different species (Kempton et.al., 1978). While variations of this model exist, the calculations used in this study operate on the principle that species diversity increases as the value approaches 1. The index values ranged from 0.7365 as seen in Plot 7 to 0.9633 in Plot 17. The Simpson's Index of Diversity calculated for the entire 1-hectare plot was found to be 0.9301. These values indicate particularly high plant species diversity within the forest community. When compared to a study performed in a primary lowland rainforest at the Nouragues and Paracou Research Stations in French Guiana, in which the species and phylogenetic diversity of tree communities were compared, the Simpson's Index of Diversity values ranged from 0.96-0.98 (Gonzalez et. al., 2010). While these values are higher than the results obtained in this study, it should be noted that the forests surrounding the Nouragues and Paracou Research Stations are virtually untouched by human impacts (Nouragues Research Station, 2013). In a study conducted in a northern temperate forest in New Hampshire, USA at a sample site within a Certified Audubon Cooperative Sanctuary, the average Simpson's Index of Diversity was found to be 0.77 (Smith et. al, 2010). These findings show that rainforest communities contain increased levels of biodiversity when compared to ecosystems in other parts of the world.

While the ACER sampling protocols provided adequate data with reasonable ease of sampling, the application of these methodologies in a Neotropical rainforest setting could benefit from various modifications. The major sources of error in the study stemmed mostly from inconsistencies in data collection and a lack of implementation of standardizations. Although a list of standardizations for all procedures has been produced by ACER, the difficulties involved in sampling in the Neotropics at times hindered the efficiency of the sampling techniques. For example, when measuring the DBH of a species such as *Pentaclethra macroloba*, which characteristically have large buttress roots sometimes reaching a height well above 1.37 m, these measurements were often inaccurate. In addition, when measuring the DBH of *Manicaria saccifera*, which exhibit various growth forms, the lack of a defined trunk in certain individuals often makes the standard measuring technique ineffective. Because the measurement is often taken around the outgrowth of leaves instead of the actual trunk, which is frequently found at heights lower than 1.37 m, the results are not always representative. Furthermore, when measuring tree height with a clinometer, the dense canopy makes visibility particularly difficult and as a result it is believed that measurements were not always exact.

In order to improve the ease of sampling and the accuracy of data gathering, it is suggested that future surveys employ the use of additional standardizations to ensure reliable results. One such standardization would involve the determination of what constitutes a multi-stemmed tree.

Before conducting a plant inventory, the criteria that separate multi-stemmed trees from individual trees must first be established, as there were inconsistencies regarding this aspect in the previous year's study. This also affects the DBH measurements, as individual stems can be measured separately and combined to give an overall DBH value, or contrastingly, the circumference around the multiple stems can be measured as the DBH. As a result, there can be significant differences in results depending on the technique chosen. In addition, the application of permanent tree identification tags was found to be crucial to the success of the study. Other methods of identification, such as the use of flagging tape markers and rope, failed to withstand the annual rigors of wind, rain, and insect damage.

CONCLUSION

Forest communities are continuously changing as a result of environmental processes. This includes forest succession due to both natural and anthropogenic impacts on forest communities. While many of the changes observed in forest ecosystems are expected and self-regulating, recent disturbances, such as forest fragmentation and logging pressures, have resulted in an altered landscape from which forests may or may not recover. Additionally, various studies show that climate change will affect species distribution as well as the ability of many plant communities to adapt to the changes (Fonty et. al., 2009). The uncertainties regarding the future of these forests illustrate the need for further research that will advance the understanding of how forests will respond to increasing environmental modifications.

The rainforests surrounding Tortuguero are no exception to the far-reaching effects of habitat alterations. Though large expanses of these forests are protected by the Costa Rican government, the area is nonetheless affected by an increase in both tourists and residents (Snarr et. al., 2010). Mounting environmental issues, such as habitat disturbances, noise and water pollution, illegal deforestation and declining wildlife, have been observed throughout this region (Meletis et. al., 2009). Furthermore, the area's geographic isolation necessitates the need for increased efforts to conserve the biological processes responsible for the regions elevated diversity (Valencia et. al., 2004).

By performing a plant species inventory, it is possible to obtain baseline data and draw conclusions founded on changes in the vegetative community over time. Looking at various parameters and comparing these measurements to past data, ecological trends in forest succession and species biodiversity changes can be identified. The study conducted at Caño Palma can provide the necessary data to monitor these changes. However, in order to recognize any significant change and the resulting implications, it would be advisable to continue the study on an annual basis.

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APPENDIX I

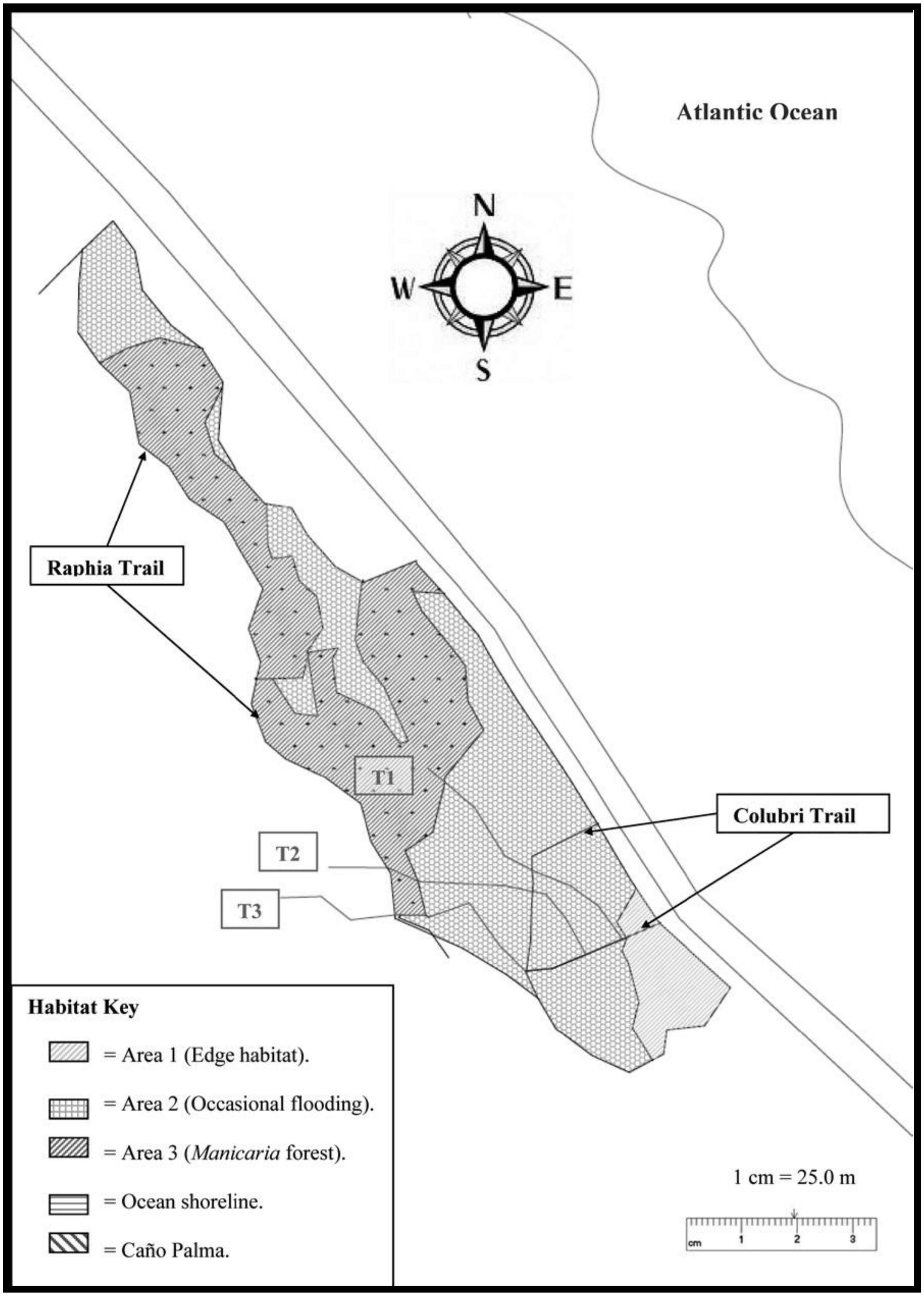

Figure 1. Map of the 40-hectare property surrounding the Caño Palma Biological Station (Lewis et. al., 2010).

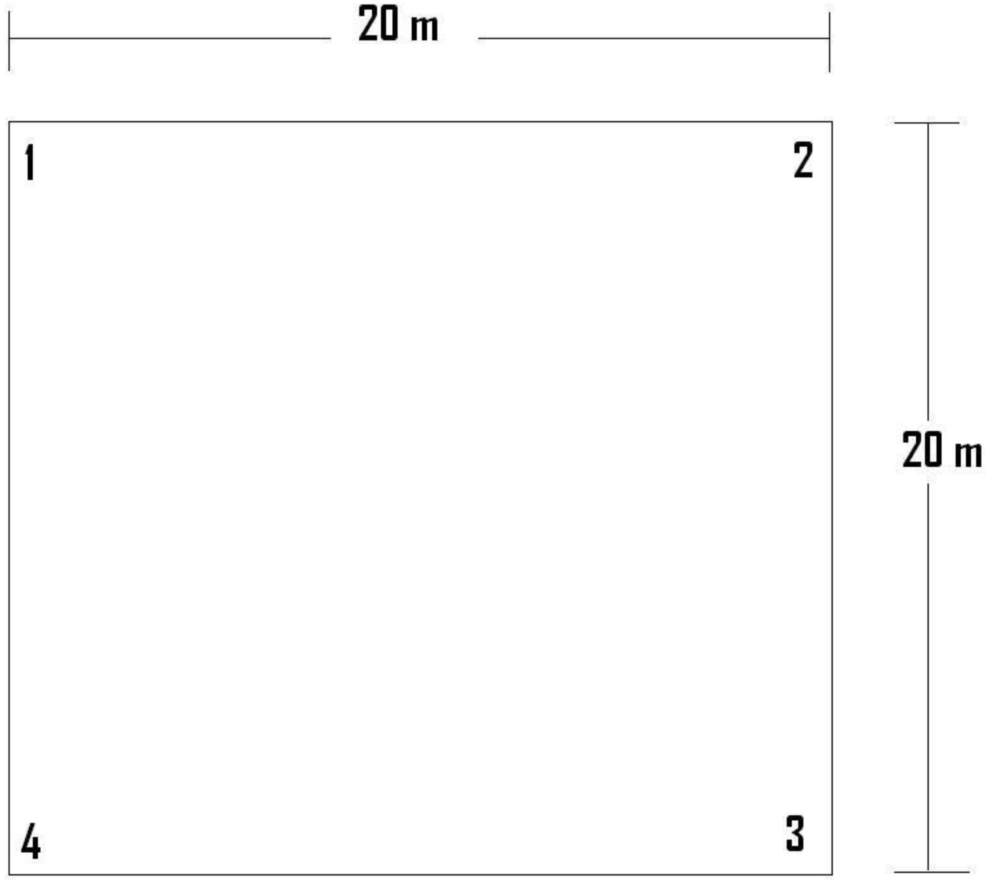

Figure 2. Diagram illustrating the corner numbering scheme in each sub-plot.

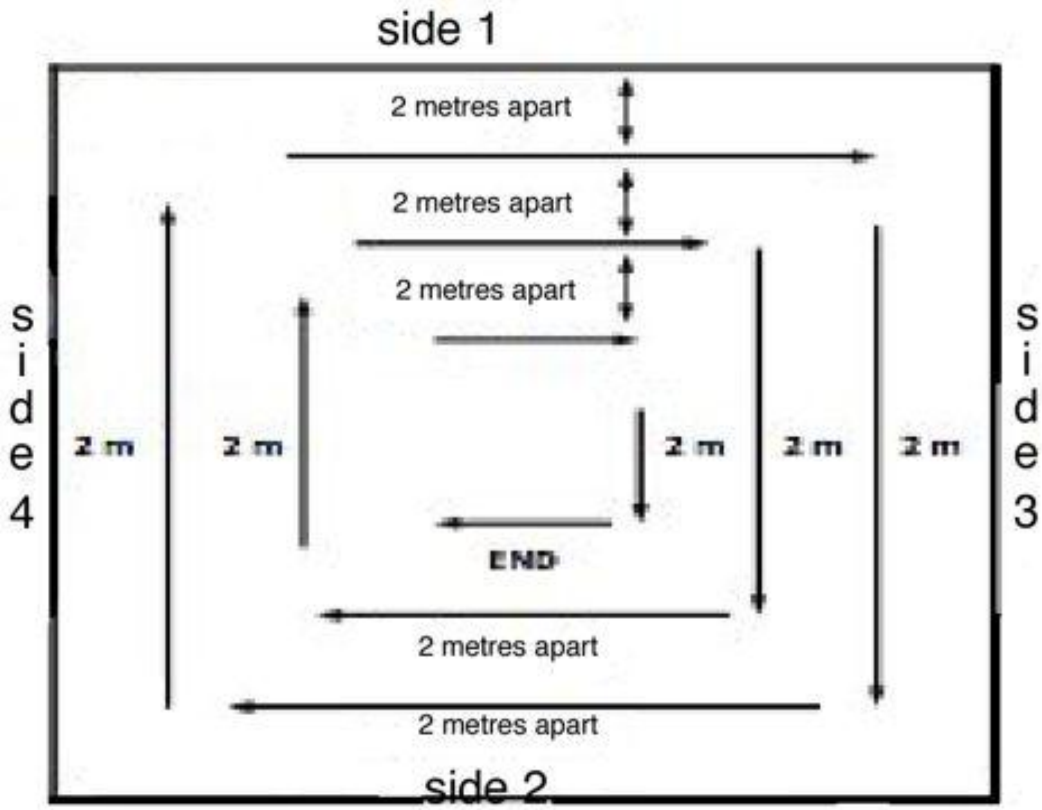

Figure 3. Diagram illustrating the sampling protocol used in each sub-plot (ACER, 2010).

APPENDIX II

Table 1. The relative dominance of each species was calculated using the sum of the basal area ($BA = \pi r^2$) per species divided by the sum of the total basal area of all species combined ($\sum \pi r^2$). Relative density was calculated based on the total number of individuals belonging to each species divided by the total number of individuals found within the one-hectare plot. Frequency values were obtained by dividing the number of sub-plots in which each species was found by the total number of sub-plots (25) within the one-hectare plot.

Family	Species	Sum of Basal Area (cm²)	Relative Dominance	# of Individuals per Hectare	Relative Density	# of Plots Present	Frequency
Fabaceae	*Abarema macradenia*	1011.99845	0.0014123	2	0.002688172	2	0.08
Euphorbiaceae	*Alchornea latifolia*	478.92065	0.0006683	2	0.002688172	1	0.04
Annonaceae	*Annonaceae sp.*	93.26585	0.0001302	1	0.001344086	1	0.04
Tiliaceae	*Apeiba membranacea*	120936.706	0.1687696	99	0.133064516	22	0.88
Myrsinaceae	*Ardisia sp.*	495.28005	0.0006912	3	0.004032258	3	0.12
Arecaceae	*Bactris gasipaes*	0	0	1	0.001344086	1	0.04
Moraceae	*Brosimum guianense*	379.14715	0.0005291	5	0.00672043	4	0.16
Malpighiaceae	*Byrsonima arthropoda*	20683.1329	0.0288637	35	0.047043011	12	0.48
Myrtaceae	*Calyptranthes chytraculia*	31.6531625	4.417E-05	1	0.001344086	1	0.04
Meliaceae	*Carapa nicaraguensis*	46478.1309	0.0648612	11	0.014784946	8	0.32
Salicaceae	*Casearia sylvestris*	1859.76705	0.0025953	19	0.025537634	11	0.44
Rhizophoraceae	*Cassipourea elliptica*	486.70785	0.0006792	1	0.001344086	1	0.04
Myristicaceae	*Compsoneura mexicana*	67.2274	9.382E-05	3	0.004032258	3	0.12
Araliaceae	*Dendropanax arboreus*	53.5841	7.478E-05	2	0.002688172	2	0.08
Annonaceae	*Desmopsis bibracteata*	123.44125	0.0001723	2	0.002688172	2	0.08
Fabaceae	*Fabaceae sp.*	243.1616	0.0003393	1	0.001344086	1	0.04
Moraceae	*Ficus popenoei*	19103.76	0.0266597	1	0.001344086	1	0.04
Moraceae	*Ficus sp.*	102.0186	0.0001424	1	0.001344086	1	0.04
Clusiaceae	*Garcinia madruno*	141.70035	0.0001977	4	0.005376344	4	0.16
Lecythidaceae	*Grias cauliflora*	1176.4481	0.0016418	3	0.004032258	3	0.12
Meliaceae	*Guarea ropalocarpa*	281.4853	0.0003928	2	0.002688172	1	0.04
Meliaceae	*Guarea sp.*	143.06625	0.0001997	1	0.001344086	1	0.04
Annonaceae	*Guatteria amplifolia*	176.625	0.0002465	1	0.001344086	1	0.04
Annonaceae	*Guatteria diospyroides*	1388.1155	0.0019371	18	0.024193548	9	0.36
Hernandiaceae	*Hernandia stenura*	1593.7541	0.0022241	2	0.002688172	2	0.08
Chrysobalanaceae	*Hirtella media*	3727.7138	0.0052021	2	0.002688172	1	0.04
Chrysobalanaceae	*Hirtella triandra*	2060.61715	0.0028756	3	0.004032258	2	0.08
Salicaceae	*Homalium guianense*	169.63065	0.0002367	1	0.001344086	1	0.04
Fabaceae	*Inga cocleensis*	10551.4617	0.0147248	13	0.017473118	8	0.32
Fabaceae	*Inga sp.*	404.12585	0.000564	2	0.002688172	2	0.08
Fabaceae	*Inga thibaudiana*	576.51185	0.0008045	2	0.002688172	2	0.08
Rubiaceae	*Ixora sp.*	32.1536	4.487E-05	1	0.001344086	1	0.04

Flacourtiaceae	*Lacistema aggregatum*	36.2984	5.066E-05	1	0.001344086	1	0.04
Apocynaceae	*Lacmellea panamensis*	289.3824	0.0004038	1	0.001344086	1	0.04
Salicaceae	*Laetia procera*	378.23655	0.0005278	4	0.005376344	3	0.12
Salicaceae	*Laetia thamnia*	711.28065	0.0009926	5	0.00672043	3	0.12
Lauraceae	*Lauraceae sp.*	453.18835	0.0006324	7	0.009408602	6	0.24
Chrysobalanaceae	*Licania platypus*	2863.8056	0.0039965	1	0.001344086	1	0.04
Tiliaceae	*Luehea seemannii*	162.7776	0.0002272	1	0.001344086	1	0.04
Apocynaceae	*Malouetia guatemalensis*	12004.3677	0.0167523	29	0.038978495	18	0.72
Arecaceae	*Manicaria saccifera*	238704.982	0.3331176	119	0.159946237	22	0.88
Melastomataceae	*Miconia tomentosa*	2632.37975	0.0036735	11	0.014784946	11	0.44
Rubiaceae	*Morinda panamensis*	16652.3856	0.0232387	46	0.061827957	15	0.6
Nyctaginaceae	*Neea amplifolia*	116.83155	0.000163	3	0.004032258	3	0.12
Nyctaginaceae	*Neea laetevirens*	311.7706	0.0004351	2	0.002688172	2	0.08
Lauraceae	*Ocotea atirrensis*	22.05065	3.077E-05	1	0.001344086	1	0.04
Myristicaceae	*Otoba novogranatensis*	38.465	5.368E-05	1	0.001344086	1	0.04
Fabaceae	*Pentaclethra macroloba*	149367.39	0.2084452	82	0.110215054	24	0.96
Moraceae	*Perebea sp.*	334.9124	0.0004674	2	0.002688172	1	0.04
Rubiaceae	*Posoqueria latifolia*	130.53765	0.0001822	6	0.008064516	5	0.2
Sapotaceae	*Pouteria sp.*	300.00345	0.0004187	4	0.005376344	4	0.16
Chrysobalanaceae	*Prioria copaifera*	14531.1056	0.0202784	21	0.028225806	9	0.36
Burseraceae	*Protium panamense*	103.81625	0.0001449	1	0.001344086	1	0.04
-	*Protiuma glabarum*	37.37385	5.216E-05	1	0.001344086	1	0.04
Rubiaceae	*Psychotria calidicola*	120.7016	0.0001684	1	0.001344086	1	0.04
Rubiaceae	*Psychotria grandis*	512.0555	0.0007146	4	0.005376344	4	0.16
Rubiaceae	*Psychotria sp.*	46.54265	6.495E-05	1	0.001344086	1	0.04
Fabaceae	*Ptherocarpus sp.*	23.74625	3.314E-05	1	0.001344086	1	0.04
Connaraceae	*Rourea sp.*	44.15625	6.162E-05	1	0.001344086	1	0.04
Rubiaceae	*Rudgea cornifolia*	23.74625	3.314E-05	1	0.001344086	1	0.04
Simaroubaceae	*Simarouba amara*	2077.24345	0.0028988	11	0.014784946	9	0.36
Arecaceae	*Simpsonia sp.*	2001.94625	0.0027938	1	0.001344086	1	0.04
Moraceae	*Sorocea pubivena*	718.11015	0.0010021	5	0.00672043	5	0.2
Anacardiaceae	*Spondias mombin*	1908.18585	0.0026629	2	0.002688172	1	0.04
Sterculiaceae	*Sterculia recordiana*	596.68635	0.0008327	5	0.00672043	4	0.16
Clusiaceae	*Symphonia globulifera*	662.1318	0.000924	9	0.012096774	5	0.2
Apocynaceae	*Tabernamontana alba*	140.579763	0.0001962	2	0.002688172	2	0.08
Sterculiaceae	*Theobroma simiarum*	400.9466	0.0005595	2	0.002688172	1	0.04
Annonaceae	*Thevetia ahouai*	349.75675	0.0004881	6	0.008064516	4	0.16
Myristicaceae	*Virola cebifera*	125.1133	0.0001746	2	0.002688172	2	0.08
Myristicaceae	*Virola koschnyi*	1588.369	0.0022166	3	0.004032258	3	0.12
Clusiaceae	*Vismia macrophylla*	4924.65825	0.0068725	9	0.012096774	7	0.28
Verbenaceae	*Vitex kuylenii*	154.71565	0.0002159	3	0.004032258	3	0.12

Vochysiaceae	*Vochysia allenii*	983.4637	0.0013724	6	0.008064516	6	0.24
Vochysiaceae	*Vochysia ferruginea*	8513.5291	0.0118808	16	0.021505376	7	0.28
Vochysiaceae	*Vochysia sp.*	10383.4619	0.0144903	9	0.012096774	5	0.2
Annonaceae	*Xylopia ferruginea*	83.28065	0.0001162	1	0.001344086	1	0.04
Annonaceae	*Xylopia sericophylla*	4453.12445	0.0062144	43	0.057795699	21	0.84
Annonaceae	*Xylopia sp.*	59.41665	8.292E-05	1	0.001344086	1	0.04
Rutaceae	*Zanthoxylum panamense*	330.68125	0.0004615	2	0.002688172	2	0.08
Fabaceae	*Zyggia latifolia*	117.78925	0.0001644	3	0.004032258	3	0.12
Grand Total	**-**	**716578.792**	**1**	**744**	**1**	**-**	**-**