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Assessment of Vegetation Structural Diversity And Similarity Index of IITA Forest Reserve in Ibadan, Oyo State, Nigeria

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ABSTRACT

The analysis of vegetation structural diversity and similarity index of International Institute of Tropical Agriculture (IITA) forest reserve was carried out by vegetation survey using transects and plot sampling techniques. Forty plots of 10m by 10m each were laid equally along four transect (A, B, C, at 90^{0}E and D at 0^{0}N). Data were analysed using descriptive statistics, relative density, diversity and similarity indices. The result showed that the forest reserve has one hundred and ninety species of plants belonging to sixty three families. The dominant plant families recorded in the forest are Leguminosae (12.63%), Rubiaceae (8.42%), Euphorbiaceae (7.89%), Apocynaceae (5.26%) and Sterculiaceae (3.68%). The most abundant plant species in the forest are mostly secondary colonizers climbers, shrubs and trees such as Culcasia saxatilis (4.46%), Icacina trichantha (4.10%), Shrub: Alchornea laxiflora (3.86%), Sphenocentrum jollyanum (3.50%), followed by tree: Newbouldia laevis (3.23%), and Funtumia elastica (2.63%) respectively. Transect D had the highest Simpson's diversity index of 0.01184 while the lowest is with C 0.02091. The Simpson similarities indices (Beta diversity) of transects varied from 50.75% to 42.76% for transects B and C, A and C, and C and D respectively. The forest reserve of IITA shows a high diversity (alpha, gamma and beta diversity) of plants and have multiplicity of species, therefore, adequate protection of the reserve should be a priority to maintain and prevent loss of plant biodiversity.

Keywords: Vegetation, structural diversity, IITA forest reserve, plant biodiversity, Simpson's diversity index

INTRODUCTION

Tropical forests are among the richest and most complex terrestrial ecosystems supporting a variety of life forms of not less than half of all species on earth (Phillips, 1996) and a tremendous intrinsic ability for self-regeneration if properly maintained. The rate of deforestation has been estimated variously for different parts of the world. It has been postulated that forests have been recently affected by large scale anthropogenic and natural changes (Philips, 1996) and better understanding of the ecological changes in

natural forest depends on progress in monitoring network of tropical forest plots.
Nigeria embraces a very wide range of habitat and ecosystem with varying degrees of species diversity within them. Some ecosystems are impoverished relative to their recent past and the diversity of species is greatly depleted in certain areas. Species' diversities within habitats vary greatly and they are higher in low land equatorial rain forest. In general, species' diversity is well correlated with the annual amount of rainfall with the wetter areas tending to be richer in species diversity in the southern parts of Nigeria (Ayodele and Lameed 1999). “Biodiversity is the totality of heritable variations or differences in characteristics that exist in all living things, individuals and their species in various ecosystems in different parts of the earth” (Ayodele and Lameed, 1999). “Biodiversity includes genetic diversity, species richness and ecosystem diversity, and assumes that these are interdependent” (Groombridge and Jenkins, 2002) “and quantified through taxonomy inventories within specified areas” (Fox and Rowntree, 2000). “The number of different species within a geographical area depends on migration and adaptation to environmental conditions and how they in turn modify the environment” (Groves, 2002).

Saye and Wegge (1992) reported that the loss and fragmentation of tropical moist forest is the single threat to the world's biological diversity. According to Kokwaro (1994), seventeen million hectares of tropical forest are being cleared annually, and scientists therefore believe that about sixty thousand of the world's two hundred and forty thousand plant species and even higher proportions of vertebrates and insects species could become extinct during the next three decades unless deforestation trend is slowed down immediately. Increased human population led to forest clearings for agriculture, firewood collection and charcoal production and hence posed a threat to sustainable biodiversity conservation (Mogaka, 2002). In Nigeria, the situation is worse as biodiversity is adversely under serious threat because of lack of implementation of policies and law of conservation, economic instability, poverty and low standard of living of the people.

Measurement of structural diversity appears a good indicator of forest management (Lindgren and Sullivan, 2001). In fact, structural diversity has been reported to be a major factor determining forest vegetation (Koop, 1989). Generally, biodiversity measurement typically focuses on the species' level and species' diversity is one of the most important indices which are used for the evaluation of ecosystems at different scales (Ardakani, 2004). Diversity is always measured in units of the number of species (Jost, 2006). Beta diversity is generally thought of as the change in diversity among various Alpha diversities (variation in species composition among geographic regions) (Magurran, 2004). There exists a wide variety of methods for measuring Beta diversity, among which similarity measures are the simplest and the most commonly used for calculating Beta diversity from abundance or presence/absence data (Koleff *et al*., 2003). Both diversity and similarity indices can be used to compare differences between communities or samples from communities (Koleff *et al*., 2003, Magurran, 2004). Sorensen (1948) index was based on both the number of species present in samples and the numbers only seen in each of them (Koleff *et al*., 2003). Sorenson's measure is regarded as one of the most effective presence/absence similarity

measures (Sorensen, 1948). Lennon *et al*. (2001) noted that if samples differ greatly in terms of their species richness, Sorenson measures will always be large.

The International Institute of Tropical Agriculture (IITA) forest reserve is a mosaic of abandoned villages and farmland at various stages of forest re-growth. The plots that were under cultivation before the acquisition forty years ago are now mainly a thicket of *Chromolaena odorata*. It is interesting that although some tree saplings are now emerging through this undergrowth, there is so far little sign of the structure and diversity of the original primary forest. On the other hand, it is remarkable to note that many of the forest species of plants and animals have managed to survive or even flourish in this extended "bush fallow". The natural vegetation in this area could be classified as tropical semi-deciduous forest with various pockets of vegetation types ranging from derived savanna, secondary forest and riparian types. According to Ezealor (2002), the area resembles mature Guinea-Congo lowland rainforest with scattered emergence of trees which include *Ceiba, Milicia* and *Terminalia* species. Large clumps of bamboo (*Bambusa vulgaris)* are common; stands of *Raphia vinifera* are found along watercourses while scattered oil-palms *Elaeis guineensis* grow in both low-lying and the relatively better-drained upland areas. The reserve had been under active protection as an informal forest and nature reserve for forty years, therefore, it is important to assess the vegetation structural diversity and similarity index in order to know species composition and structure of the forest reserve.

METHODOLOGY

The study area: The study area is International Institute of Tropical Agriculture (IITA) reserve forest, Ibadan, Oyo State, Nigeria. IITA is located at longitude 7^0 30' 8"N, latitude 3^0 54' 37"E and 243m above sea level (Tenkouano and Baiyeri, 2007). The site falls within humid tropical lowland region with two distinct seasons: the longer wet season and shorter dry season. The wet season lasts for eight months and it extends from March to October while the dry season lasts for four months from November to February. The rainfall pattern is bimodal with an annual total which ranges from 1,300-1,500mm most of which falls between May and September. The average daily temperature ranges between 21^0C and 23^0C while the maximum is between 28^0C and 34^0C. Radiation is about 5285MJ/m^2/year. Mean relative humidity is in the range of 64% to 83% ((Tenkouano and Baiyeri, 2007).

Methods of data collection

The method of data collection for this study was based on vegetation survey using transects and plot sampling techniques (Wolda, 1983).

Vegetation Transect: The vegetation transects was established to obtain a representative sample of the woody vegetation of the study area as well as to understand the species assemblage of trees, shrubs and climbers in their various habitats (forest composition) at the beginning of the study (base line data). Transects were established with minimal disruption to the environment and marked with flagging tape at every 10m.

Transects and plots designs: Four transects (A, B, C 90^0E and D 0^0N) were constructed with the aid of prismatic compass within the reserved area. Each transect is 500m long. Ten sampling plots of 10m by 10m each were demarcated along each of the transect (using ranging poles, compass and red flag tape) making a total number of 40 sampling plots (4 transects by 10 plots). A distance of 40m was left between each of the plot to minimize repetition of plant species while 20m was left at the beginning and at the end of each transect as the border row to minimize edge effects. Complete enumeration and identification of herbs, climbers, shrubs and trees was carried out in each of the plot with their proper scientific names and vernacular names. Scientific names are important in ecological studies while vernacular names were useful for ethno botanical studies. Samples of plants that cannot be identified on the field were taken to the Arboretum of Forestry Research Institute of Nigeria, Ibadan for proper identification.

Data analysis

The data were analyzed using descriptive statistics. Diversity indices and similarities indices were also used.

Diversity indices: Diversity indices used by ecologists have been applied in quantitative ethnobotany (Begossi 1996; Figueiredo, *et al*., 1993, 1997). It is the variety and variability among living organism, it measures both species' richness (measure of abundance) and the equitability with which individuals are distributed among the species (Isichei, 1996; Badejo, 1996). Three levels of diversities have been distinguished. These are alpha, beta and gamma diversities (Ojo, 1996; Gauch, 1986). Community studies vary in the number of species encountered in a sample (alpha diversity), and in the total number of species encountered in a study (gamma diversity)- (Gauch, 1986). For the measurement of diversity, the Alpha (Simpson diversity index), and Beta (Sorensen similarities indices) diversity were used to determine and compare the plant diversity of each transect.

Alpha Diversity: - Two common approaches for measuring alpha diversity are species' richness (number of species in the community) and evenness and heterogeneity (distribution of individual among the species). The common index for Simpson diversity index was used (Simpson, 1949).

Simpson's diversity index (D) = $\sum n_i (n_i-1)/ N (N-1)$

Where

N= Total frequency of all the species

n= Total number of each species

Similarity indices (Beta Diversity): - The measurement can either be in terms of comparing differences or similarity between samples or location. Wolda (1983) suggested the use of similarity indices for measuring beta diversity. Sorensen similarities index was therefore used to determine and compare the similarities of plant species in transect A&B, A&C, A&D, B&C, B&D, and C&D because the plots and transects are of equal sizes (Sorensen, 1948)

Sorensen similarity index = a/a+b+c *100

a= number of species common to both sites (e.g. transect A & B)

b= number of species in site A not in site B (e.g. species in transect A not in transect B).

c= number of species in site B not in site A (e.g. species in transect B not in transect A).

RESULTS

Vegetation Survey

One hundred and ninety species of plants belonging to sixty three families were identified in all the transects (Table 2).

The dominant plant families recorded in the area are: Leguminosae, Rubiaceae, Euphorbiaceae, Apocynaceae, Sterculiaceae with the following percentages 12.63%, 8.42%, 7.89%, 5.26% and 3.68% respectively. Sapindaceae and Moraceae have the same percentage of 3.16%. However, other families accounted for between 0.53% to 2.11% (Table 2).

Among the sixty-three families, climbers have the highest family of 26, followed by tree 24, shrub 23 and herb 20. Also, of the entire plant form tree has the highest number of species 67, climber 50, shrub 45, and herb 28 respectively. In terms of the relative abundance of the plant form, tree and shrub are the most abundant 1060 (31.74%) and 1057 (31.63%) while climber and herb have 833 (24.94%) and 390 (11.68%) abundant respectively (Table 3).

Ten plant species are the most abundant species in all transects. These are *Culcasia saxatilis* (4.46%), *Icacina trichantha* (4.10%), *Alchornea laxiflora* (3.86%), *Sphenocentrum jollyanum* (3.50%), *Chassalia kolly* (3.38%), *Microdesmis puberula* (3.23%), *Newbouldia laevis* (3.23%), *Deinbolla pinnata* (2.69%), *Funtumia elastica* (2.63%) and *Combretum zenkeri* (2.28%) respectively (Table 4).

Simpson Diversity and Similarity Indices of Plant Species

Table 5 shows the species' richness (diversity of plant in the transects). Transect D has the highest plant diversity index of 0.01184, transect A and B have a high diversity indices of 0.01638 and 0.01675 respectively, while transect C has the least diversity index of 0.02091 respectively. It could therefore be deducted that transect D is richer in plant species than all other transects, followed by transect A, B, and lastly transect C. When data from all transects were added together, the result showed a much higher plant diversity of 0.00322 in the forest.

In table 6, the Simpson similarities indices of transects varied from 50.75% to 42.76% for transects B and C, A and C, and C and D respectively. Transect B and C have a high similarities index of 50.75% followed by transect A and B with 45.45%. Transect B and D, and A and D has a moderate value of 43.36%, and 43.14% respectively. Transect A and C, and C and D had the same but low similarities index of 42.76% when compared with other transects. Transect B and C, which have the highest percentage of similarities index (50.75%) are similar to each other in terms of plant species between the two transects. The result

generally showed that the similarity indices of plant between transect apart from transects B and C is low, less than 50%.

DISCUSSION

The result of the study showed a high diversity of plant species (190 species) from 63 families despite the disturbance that had occurred in the area such as hunting, land clearing for experiment, construction of physical structure, firewood, poles and stakes collection and occasional but illegal felling of timber. Poaching of bats in the forest reserve is also associated with cutting down of young trees. Isichei (1996) observed that succession restores and increase diversity of life in an area after disturbance. Also according to Ayodele and Lameed (1999), species' diversity is well correlated with the annual amount of rainfall with the water areas tending to be rich in species diversity in the southern parts of Nigeria. The abundance of plant species in the forest reserved may be due to the combined effects of favourable climatic conditions and protection over many years which enhance regeneration.

The most abundant plant species in the forest are mostly secondary colonizers climbers, shrubs and trees such as *Culcasia saxatilis*, *Icacina trichantha*, Shrub: *Alchornea laxiflora*, *Sphenocentrum jollyanum*, *Chassalia kolly*, *Microdesmis puberula*, Deinbolla pinnata, followed by tree: *Newbouldia laevis*, and *Funtumia elastica* respectively. All these with other plants grow in association with each other to form large thickets in the forest. This is supported by Bourgeron, 1983 and Brunig, 1983 that thickets commonly occur in tropical forests in response to disturbance. Their pervasiveness and persistence are noted by Grieg-Smith (1952), that the secondary forest occurring even 30 years after cultivation resulted in a tangle of vegetation much less regularly layered in structure than non-cultivated secondary forest. It has been suggested that thickets are an aggregation of individuals which, while they may have competed with each other in the past, essentially coexist without detriment to one another and may even proffer some protective advantages to constituent individuals (Grieg-Smith, 1952; Brunig, 1983).

In terms of plant diversity, transect D showed the highest plant diversity index of 0.01184, followed by transects A and B (0.01638 and 0.01675) while transect C showed a relatively low diversity indices of 0.02091 respectively. In terms of intra species (alpha diversity), transect D also has the highest diversity (111 species), followed by transect A (109 species), transect C (106 species) and transect B (97 species). In term of Gamma diversity (individual species), transect D recorded the highest diversity of 1016 plants followed by transect A (848) while transect B and C recorded 746 and 730 plants respectively. It follows that transect D is richer in plant species and individual species (alpha and gamma) than all other transects. When data from all transects were added together; the result shows a much higher alpha and gamma diversity of (190 and 3340) and Simpson diversity index of 0.00322. The Simpson diversity index is however low when compared with the value of over 0.90 obtained for the species-rich evergreen forests of the Western Ghats (Pascal, 1988).

Beta diversity which compares the similarity between transects as suggested by Wolda (1983) shows that transect B and C are highly similar with the value of 50.75%, this is followed by transect A and B 45.45%. Transect A and D and B and D are similar with each other with 43.14% and 43.36% while transect A and C and C and D are equally similar, but having the lowest similarities' indices of 42.76%. Transect B and C, which have the highest percentage of similarities indices (50.75%) are similar to each other in terms of plant species and composition between the two transects. Transect B and C have 68 plant species in common, transect B has 28 plant species that were not found in transect C while transect C has 38 plant species that were not found in transect B. The result generally shows that the similarities indices of plant between transect apart from transect B and C were low, less than 50%.

CONCLUSION

The study shows high diversity of plants from sixty three families. The dominant plant families are Leguminosae, Rubiaceae, Euphorbiaceae, Apocynaceae and Sterculiaceae. The reserve is also reasonably well- stocked with multiplicity of species with tree having the highest number of species followed by shrubs, climber and herbs respectively. Though open areas with large gaps without trees were noticed in the reserve. Thus, the forest reserve of IITA is more diverse in plant species and serves as reservoir of plants that could be useful as timber and non timber forest products. Adequate protection of the site should be a priority to prevent loss of diversity of plants from the Reserve.

RECOMMENDATIONS

Based on the outcome of the study, the following recommendations were made.

1. Adequate protection and conservation of the forest reserve to prevent illegal felling of trees and removal of poles, firewood, stakes or any other forest products that may lead to loss of plants diversity should be given priority.
2. Enrichment planting of trees should be carried out in open areas or areas with large gaps to enhance the development of the forest reserve towards a mature succession stage. This should be done systematically by first locating and mapping out such areas.
3. Environmental education and enlightenment of IITA staff and villagers living around the perimeter fence on the need to conserve and protect the forest. This will reduce illegal felling of trees and poaching;
4. Development of buffer zone as presently obtained in IITA where villagers would be allowed to collect firewood, palm products, vegetables, medicinal plants and other forest products for their immediate needs. However, they should be restricted to such reserve and not allow encroaching into protected areas.

Table 1: Vegetation Survey: List of Plant Species found in IITA Forest Transects

S/n	Scientific Name	Family name	Form	TA	TB	TC	TD	Total	%Total
1	*Abrus precatorius* Linn	Leguminosae	Climber	9	2	1	-	12	0.36
2	*Acacia ataxacantha* DC	Leguminosae	Climber	11	13	-	1	25	0.75
3	*Acacia kamerunensis* Gandoger	Leguminosae	Climber	2	-	-	-	2	0.06
4	*Acalypha racemosa* Wall. Ex Bail	Euphorbiaceae	Herb	2	-	1	-	3	0.09
5	*Adenia cissampeloides* (Planch. Ex Benth) Harms	Passifloraceae	Climber	-	1	-	-	1	0.03
6	*Adenia lobata* (Jacq.) Engl.	Passifloraceae	Climber	2	-	3	1	6	0.18
7	*Afzelia Africana* Smith	Leguminosae	Tree	-	-	-	1	1	0.03
8	*Ageratum conyzoides* Linn	Asteraceae	Herb	4	-	-	-	4	0.12
9	*Alafia barteri* Oliv.	Apocynaceae	Climber	-	-	1	1	2	0.06
10	*Albizia ferruginea* Benth	Leguminosae	Tree	5	2	-	8	15	0.45
11	*Albizia zygia* (DC) J. F. Macbr.	Mimisoideae	Tree	16	6	14	14	50	1.50
12	*Alchornea cordifolia* (Schum. & Thonn.) Muell. Arg.	Euphorbiaceae	Shrub	-	-	2	-	2	0.06
13	*Alchornea laxifora* (Benth) Pax & K. Hoffm.	Euphorbiaceae	Shrub	34	71	10	14	129	3.86
14	*Allophyllus africanus* P. Beauv.	Sapindaceae	Shrub	3	-	1	-	4	0.12
15	*Alstonia boonei* De Wild	Apocynaceae	Tree	-	4	1	-	5	0.15
16	*Ananas comosus* (Linn.) Merrill	Bromeliaceae	Herb	2	-	-	-	2	0.06
17	*Anchomanes difformis* Engl.	Araceae	Herb	8	4	1	5	18	0.54
18	*Angelaea oblique* (P. Beauv.) Baill.	Connaraceae	Herb	-	-	-	6	6	0.18

19	*Angylocalyx oligophyllus* (Bak.) Bak. f.	Leguminosae	Climber	-	-	-	4	4	0.12
20	*Aningeria robusta* (A. Chev.) Aubrev. & Pellegr.	Sapotaceae	Tree	-	-	-	1	1	0.03
21	*Anthocleista vogelii* Planch.	Longaniaceae	Tree	1	-	-	-	1	0.03
22	*Antiaris toxicaria* Lesechnault	Moraceae	Tree	24	9	8	10	51	1.53
23	*Antidesma laciniatum* Muell. Arg.	Euphorbiaceae	Shrub	-	-	1	-	1	0.03
24	*Asystasia gangentica* (Linn.) T. Anders	Acantaceae	Climber	-	-	9	1	10	0.30
25	*Baissea axillaris* (Benth.) Hua.	Apocynaceae	Climber	-	2	3	14	19	0.57
26	*Baphia nitida* Lodd.	Leguminosae	Shrub	2	20	6	-	28	0.84
27	*Blighia sapida* Konig	Sapindaceae	Tree	11	3	6	10	30	0.90
28	*Blighia unijugata* Bak.	Sapindaceae	Tree	2	5	1	3	11	0.33
29	*Bombax buonopozense* P. Beauv.	Bombacaceae	Tree	-	-	3	1	4	0.12
30	*Spermacoce globosa* Schum. & Thonn.	Rubiaceae	Climber	-	18	-	-	18	0.54
31	*Bridelia micrantha* (Hochst.) Bail.	Euphorbiaceae	Shrub	3	-	-	-	3	0.09
32	*Byrsocarpus coccineus* Schum. & Thonn.	Connaraceae	Climber	11	22	5	3	41	1.23
33	*Caesalpinia bonduc* Roxb	Leguminosae	Climber	-	-	-	10	10	0.30
34	*Canthium venosum* Oliv.	Rubiaceae	Shrub	2	3	2	1	8	0.24
35	*Carpolobia lutea* G. Don	Polygalaceae	Shrub	3	21	11	20	55	1.65
36	*Ceiba pentandra* (Linn.) Gaertn.	Bombacaceae	Tree	-	1	1	-	2	0.06
37	*Celtis philipensis* Blanco	Ulmaceae	Tree	2	2	1	17	22	0.66
38	*Celtis zenkeri* Engl.	Ulmaceae	Tree	5	10	4	-	19	0.57

39	*Chasmanthera dependens* Hochst	Menispermaceae	Climber	-	5	1	5	11	0.33
40	*Chassalia Kolly* (Schumach.) Hepper	Rubiaceae	Shrub	33	32	26	22	113	3.38
41	*Chromolaena odorata* (L.) R. M. King & Robinson	Asteraceae	Herb	-	-	6	16	22	0.66
42	*Chrysophyllum albidum* G. Don.	Sapotaceae	Tree	20	2	5	9	36	1.08
43	*Cissampelos owariensis* P. Beauv. Ex DC.	Menispermaceae	Climber	3	-	-	1	4	0.12
44	*Cissus arguta* Hook. f.	Vitaceae	Climber	8	1	-	-	9	0.27
45	*Cissus vogelii* Hook. f.	Vitaceae	Climber	15	15	6	13	49	1.47
46	*Citrus sinesis* Osbeck	Rutaceae	Tree	1	-	-	-	1	0.03
47	*Clausena anisata* (Wild.) Hook. f. ex Benth.	Rutaceae	Shrub	23	8	15	2	48	1.44
48	*Cleistopholis patens* (Benth.) Engl. & Diels	Annonaceae	Tree	-	1	-	-	1	0.03
49	*Clerodenderon capitatum* Hook. Bot. Mag. T.	Verbenaceae	Shrub	1	-	-	7	8	0.24
50	*Cnestis ferruginea* DC.	Connaraceae	Shrub	23	6	15	12	56	1.68
51	*Cola caricaefolia* (G. Don) K. Schum.	Rubiaceae	Shrub	-	-	-	9	9	0.27
52	*Coffea togoensis*	Rubiaceae	Shrub	1	2	-	-	3	0.09
53	*Cola acuminate* (P. Beauv.) Schott & Endl.	Sterculiaceae	Tree	-	-	-	1	1	0.03
54	*Cola gigantean* A. Chev.	Sterculiaceae	Tree	-	2	1	-	3	0.09
55	*Cola millenii* K. Schum.	Sterculiaceae	Tree	2	11	9	25	47	1.41
56	*Cola nitida* (Vent.) Schott & Endl.	Sterculiaceae	Tree	1	-	1	1	3	0.09
57	*Combretum racemosum* P. Beauv.	Combretaceae	Shrub	-	-	-	2	2	0.06
58	*Combretum zenkeri* Engl. Diels	Combretaceae	Climber	47	12	7	10	76	2.28

59	*Cremaspora triflora* (Thonn.) K. Schum.	Rubiaceae	Climber	7	3	12	3	25	0.75
60	*Croton lobata* Linn.	Euphorbiaceae	Herb	-	-	-	5	5	0.15
61	*Culcasia saxatilis* A. Chev.	Araceae	Climber	-	10	54	85	149	4.46
62	*Cyathula prostrate* (L.) Blume	Amaranthaceae	Herb	2	27	-	15	44	1.32
63	*Dalbergiella welwitschii* (Bak.) Bak.f.	Leguminosae	Climber	1	4	6	9	20	0.60
64	*Daniellia ogea* (Harms) Rolfe ex Holl	Leguminosae	Tree	-	1	-	-	1	0.03
65	*Deinbollia pinnata* Schums. & Thonn.	Sapindaceae	Shrub	6	26	29	29	90	2.69
66	*Delonix regia* (Boj. Ex Hook.) Rafin.	Leguminosae	Tree	-	-	-	1	1	0.03
67	*Dichapetalum madagascariense* Poir	Dichapetalaceae	Shrub	10	6	12	-	28	0.84
68	*Dioscorea bulbifera* Harms	Dioscoreaceae	Climber	6	1	1	-	8	0.24
69	*Dioscorea mangenotiana* J. Miege	Dioscoreaceae	Climber	6	-	3	-	9	0.27
70	*Dioscorea minutiflora* Pax. Engl.	Dioscoreaceae	Climber	-	-	-	3	3	0.09
71	*Dioscoreophyllum cumminsii* (Stapf) Diets	Menispermaceae	Climber	29	-	7	13	49	1.47
72	*Diospyros mespiliformis* Hochst. Ex A. DC	Ebenaceae	Tree	-	-	1	-	1	0.03
73	*Diospyros monbuttensis* Gurke	Ebenaceae	Tree	1	11	9	9	30	0.90
74	*Dissotis rotundifolia* (Sm.) Triana	Melastomataceae	Climber	1	-	-	-	1	0.03
75	*Dracaena manni* Baker	Agavaceae	Shrub	-	18	3	-	21	0.63
76	*Dracaena phrynioibes* Hook	Agavaceae	Herb	-	-	-	4	4	0.12
77	*Drypetes gilgiana* (Pax) Pax & K. Hoffm.	Euphorbiaceae	Shrub	-	-	-	1	1	0.03
78	*Drypetes molunduana* Pax & K. Hoffm.	Euphorbiaceae	Tree	2	14	1	-	17	0.51

79	*Elaeis guineensis* Jacq.	Palmae	Tree	3	14	19	9	45	1.35
80	*Entada pursoaetha* DC	Leguminosae	Climber	1	-	-	4	5	0.15
81	*Entandrophragma cylindricum* (Sprague) Sprague	Meliaceae	Tree	2	-	-	-	2	0.06
82	*Erythrococca anomala* (Juss. Ex Poir) Oliv.	Euphorbiaceae	Shrub	-	3	3	1	7	0.21
83	*Euadenia trifoliolata* (Schum. & Thonn.) Oliv.	Capparidaceae	Shrub	-	-	-	3	3	0.09
84	*Euclina longiflora*	Rubiaceae	Shrub	-	3	-	1	4	0.12
85	*Eulophia quartiniana* A. Rich.	Orchidaceae	Herb	6	-	-	8	14	0.42
86	*Ficus exasperate* Vahl.	Moraceae	Tree	3	3	4	3	13	0.39
87	*Ficus vogeliana* Miq.	Moraceae	Tree	1	-	3	-	4	0.12
88	*Funtumia elastica* (Preuss) Stapf.	Apocynaceae	Tree	26	10	22	30	88	2.63
89	*Garcinia kola* Heckel	Guttiferaceae	Tree	2	-	-	-	2	0.06
90	*Glyphaea brevis* (Spreng.) Monachino	Tilliaceae	Shrub	-	17	-	-	17	0.51
91	*Gongronema latifolium* Decne	Asclepiadaceae	Climber	3	2	3	4	12	0.36
92	*Grewia carpinifolia* Juss.	Tilliaceae	Tree	-	-	16	-	16	0.48
93	*Grewia pubescens* P. Beauv.	Tilliaceae	Tree	9	-	-	12	21	0.63
94	*Habenaria barrina* Ridl.	Orchidaceae	Herb	4	-	-	-	4	0.12
95	*Hedranthera barteri* (Hook. f.) Pichon	Apocynaceae	Shrub	-	4	2	3	9	0.27
96	*Hilleria latifolia* (Lam.) H. Walt.	Phytolaccaceae	Herb	-	-	-	8	8	0.24
97	*Reissantia indica* (Wild.) Halle	Celastraceae	Climber	-	-	1	-	1	0.03
98	*Holarrhena floribunda* (G. Don) Dur. & Schinz.	Apocynaceae	Tree	6	7	4	2	19	0.57

99	*Hoslundia opposite* Hahl.	Lamiaceae	Shrub	-	9	-	-	9	0.27
100	*Hypselodelphys violacea* (Ridl.) Milne-Redh.	Marantaceae	Herb	-	1	-	-	1	0.03
101	*Icacina trichantha* Oliv.	Icacinaceae	Climber	23	7	19	88	137	4.10
102	*Indigofera hirsuta* Linn. var. Hirsuta	Leguminosae	Herb	4	-	-	-	4	0.12
103	*Khaya grandifoliola* C. DC.	Meliaceae	Tree	5	-	-	2	7	0.21
104	*Landolphia owariensis* P. Beauv.	Apocynaceae	Climber	-	-	-	1	1	0.03
105	*Lannea welwitchii* (Heirn) Engl.	Anacardiaceae	Tree	4	-	-	-	4	0.12
106	*Lantana camara* Linn.	Fabanaceae	Climber	-	-	1	-	1	0.03
107	*Lecaniodiscus cupanioides* planch. ex Benth.	Sapindaceae	Tree	22	17	20	9	68	2.04
108	*Leptoderris micrantha* Dunn I.C.	Leguminosae	Climber	-	-	-	4	4	0.12
109	*Leucaena leucocephala* (Lamk.) de Wit.	Leguminosae	Tree	1	-	-	17	18	0.54
110	*Lonchocarpus cyanescens*Benth.	Leguminosae	Tree	1	6	-	1	8	0.24
111	*Lonchocarpus sericeus* (Poir.) H.B.K.	Papilonaceae	Tree	-	1	5	1	7	0.21
112	*Macaranga bateri* Muell. Arg.	Euphorbiaceae	Tree	-	-	-	2	2	0.06
113	*Maesopsis eminii* Engl.	Rhamnaceae	Tree	3	-	1	-	4	0.12
114	*Malacantha alnifolia* (Baker) Pierre	Sapotaceae	Tree	2	16	5	-	23	0.69
115	*Mallotus oppositifolius* (Geisel) Muell.Arg.	Euphorbiaceae	Shrub	8	-	6	16	30	0.90
116	*Manihot esculenta* Crantz.	Euphorbiaceae	Shrub	-	7	-	-	7	0.21
117	*Marantochloa cuspidate* (Rosc.) Milne-Redh.	Marantaceae	Herb	-	10	-	-	-	0.30
118	*Megaphrynium macrostachyum* (Benth.) Milne-Redh.	Marantaceae	Herb	-	-	-	20	20	0.60

119	*Melanthera scadens* (Schum. & Thonn.) Roberty	Asteraceae	Climber	8	-	-	4	12	0.36
120	*Mezoneuron benthamianum* Bail.	Ceasalpinoideae	Climber	-	-	2	2	4	0.12
121	*Microdesmis puberula* Hook. f. ex Planch.	Pandaceae	Shrub	57	6	26	19	108	3.23
122	*Milcia excels* (Welw.) C.C. Berg	Moraceae	Tree	2	-	1	1	4	0.12
123	*Milletia thonningii* (Schum. & Thonn.) Bak.	Leguminosae	Tree	2	9	-	-	11	0.33
124	*Mondia whitei* (Hook. f.) Skeels	Periclocaceae	Climber	4	-	-	-	4	0.12
125	*Monodora tenuifolia* Benth.	Annonaceae	Tree	6	7	4	4	21	0.63
126	*Morinda lucida* Benth.	Rubiaceae	Tree	2	-	1	-	3	0.09
127	*Morus mesozygia Stapf.*	Moraceae	Tree	13	1	1	3	18	0.54
128	*Mucuna pruriens* DC	Leguminosae	Climber	2	-	-	-	2	0.06
129	*Napoleona vogelii* Hook. & Planch.	Lecythidaceae	Shrub	-	3	1	4	8	0.24
130	*Newbouldia laevis* (P. Beauv.) Seemann ex Bureav	Bignoniaceae	Tree	29	22	14	43	108	3.23
131	*Ochna afzelii* R.Br. ex Oliv.	Ochnaceae	Tree	4	-	3	-	7	0.21
132	*Olax gambecola* Bail.	Olacaceae	Shrub	4	-	-	-	4	0.12
133	*Olax subscorpioidea* Oliv.	Olacaceae	Shrub	-	-	7	-	7	0.21
134	*Oplismenus hirtellus* (Linn.) P. Beauv.	Poaceae	Herb	-	10	5	6	21	0.63
135	*Palisota hirsute* (Thunb.) K. Schum	Commelanaceae	Herb	-	1	-	-	1	0.03
136	*Pararistolochia goldieana* (Hook.f.) Hutch. & Dalz.	Aristolocaceae	Climber	-	-	-	3	3	0.09
137	*Parquetina nigrescens* Bail.	Periclocaceae	Climber	11	2	6	2	21	0.63
138	*Paullinia pinnata* Linn.	Sapindaceae	Climber	-	3	1	-	4	0.12

139	*Pavetta corymbosa* Houtt.	Rubiaceae	Shrub	5	1	-	1	7	0.21
140	*Petiveria alliaceae* Linn	Phytolaccaceae	Herb	1	-	-	61	62	1.86
141	*Phaulopsis falcisepala* C. B. Clarke	Acantaceae	Herb	5	-	1	6	12	0.36
142	*Phyllanthus muellerianus* O. Ktze.	Euphorbiaceae	Climber	-	-	-	1	1	0.03
143	*Piper guineense* Schum. & Thonn.	Piperaceae	Climber	3	-	6	4	13	0.39
144	*Piper umbellatum* Linn.	Piperaceae	Herb	-	-	-	2	2	0.06
145	*Pouzolzia guineensis* Benth.	Urticaceae	Herb	-	-	1	-	1	0.03
146	*Psychotria psychcnoides* Linn.	Rubiaceae	Shrub	-	3	4	-	7	0.21
147	*Pteris togoensis* Hiern	Adantaceae	Herb	-	20	34	17	71	0.13
148	*Pterocarpus osun* Craib	Leguminosae	Tree	-	2	-	1	3	0.09
149	*Pterocarpus santalinoides* L Herit. ex DC.	Leguminosae	Tree	-	-	1	-	1	0.03
150	*Pycnanthus angolensis* (Welw.) Warb.	Myristicaceae	Tree	1	1	-	1	3	0.09
151	*Pyrenacantha staudtii* (Engl.) Engl.	Icacinaceae	Climber	2	1	-	4	7	0.21
152	*Rauvolfia vomitoria* Afzel.	Apocynaceae	Shrub	2	1	-	4	7	0.21
153	*Ricinodendron heudelotii* (Baill.) Pierre ex Pax	Euphorbiaceae	Tree	-	2	-	2	4	0.12
154	*Rothmannia hispida* (K. Schum.) Fagerlind	Rubiaceae	Shrub	8	1	-	-	9	0.27
155	*Rothmannia longiflora* Salisb	Rubiaceae	Shrub	-	-	2	-	2	0.06
156	*Rytigynia nigerica* (S. Moore) Robyns	Rubiaceae	Shrub	2	4	3	-	9	0.27
157	*Rytigynia umbellulata* Robyns	Rubiaceae	Shrub	27	6	9	6	48	1.44
158	*Sabicea calycina* Benth.	Rubicaeae	Climber	-	-	-	1	1	0.03

159	*Salacia pallescens* Oliv.	Celastraceae	Shrub	7	5	2	-	14	0.42
160	*Sanseviera liberica* Ger. & Labr.	Agavaceae	Shrub	-	5	4	-	9	0.27
161	*Secamone afzelii* (Schultes) K. Schum.	Asclepidaceae	Climber	1	-	4	-	5	0.15
162	*Senacio biafrae* O. & H.	Asteraceae	Climber	5	-	-	-	5	0.15
163	*Sherbournia bignoniflora* G. Don.	Rubiaceae	Shrub	-	1	1	-	2	0.06
164	*Smilax kraussiana* Meisn.	Smilacaceae	Climber	1	1	3	6	11	0.33
165	*Solanum erianthum* Linn.	Solanaceae	Shrub	1	-	-	-	1	0.03
166	*Solenostemon monostachyus* (P. Beauv.) Brig. Subsp.	Lamiaceae	Herb	2	-	-	-	2	0.06
167	*Sorindeia grandifolia* Engl.	Anacardiaceae	Tree	-	2	-	-	2	0.06
168	*Sphenocentrum jollyanum* Pierre	Menispermaceae	Shrub	40	7	28	42	117	3.50
169	*Spigelia anthelmia* Linn.	Longanaceae	Herb	-	1	-	-	1	0.03
170	*Spondias mombin* Linn.	Anacardiaceae	Tree	-	1	8	8	21	0.63
171	*Sterculia oblonga* Mast	Sterculiaceae	Tree	-	-	-	1	1	0.03
172	*Sterculiar tragacantha* Lindl.	Sterculiaceae	Tree	6	10	11	2	29	0.87
173	*Stereospermum acuminatissmum* K. Schum.	Bignoniaceae	Tree	1	-	2	-	3	0.09
174	*Strombosia pustulata* Oliv.	Olacaceae	Tree	1	-	-	-	1	0.03
175	*Strophanthus hispidus* A. DC.	Apocynaceae	Climber	-	1	3	1	5	0.15
176	*Tacca leontopetaloides* (Linn.) O. Ktze.	Taccaceae	Herb	-	4	-	-	4	0.12
177	*Tetracera podotricha* Afzel. ex G. Don	Dilleniceae	Climber	-	-	2	-	2	0.06
178	*Thaumatococcus daniellii* (Benn.) Benth.	Marantaceae	Herb	-	-	40	-	40	1.20

179	*Tragia tenuifolia* Benth.	Euphorbiaceae	Climber	-	-	-	2	2	0.06
180	*Trichilla monadelpha* (Thonn.) J.J. de Wilde	Meliaceae	Tree	12	8	13	11	44	1.32
181	*Trichilla prieuriana* A. Juss.	Meliaceae	Tree	5	3	3	20	31	0.93
182	*Trilepsium madagascariense*	Moraceae	Tree	1	8	7	11	27	0.81
183	*Triplochiton scleroxylon* K. Schum.	Sterculiaceae	Tree	-	-	1	4	5	0.15
184	*Urena lobata* Linn.	Malvaceae	Shrub	-	-	1	-	1	0.03
185	*Urera cordifolia* Engl.	Urticaceae	Climber	7	-	-	-	7	0.21
186	*Uvaria chamae* P. Beauv.	Annonaceae	Shrub	-	-	2	-	2	0.06
187	*Uvaria picta* Linn.	Leguminosae	Herb	2	-	-	2	4	0.12
188	*Voacanga Africana* Stapf	Apocynaceae	Tree	3	2	-	-	5	0.15
189	*Xanthoxylum zanthoxylloides* Lam.	Rutaceae	Tree	-	-	1	1	2	0.06
190	*Xylopia aethiopica* (Dunal) A. Rich.	Annonaceae	Tree	-	-	1	-	1	0.03
	Total			848	746	730	1016	3340	

Table 2: Vegetation Survey: List of Plant Families, Frequency and their Percentages in all the Forest Transects

s/n	Family Name	Frequency	Percentage
1	Acantaceae	2	1.05
2	Adantaceae	1	0.53
3	Agavaceae	3	1.58
4	Amaranthaceae	1	0.53
5	Anacardiaceae	3	1.58
6	Annonaceae	4	2.11
7	Apocynaceae	10	5.26
8	Araceae	2	1.05
9	Aristolocaceae	1	0.53
10	Asclepiadaceae	2	1.05
11	Asteraceae	4	2.11
12	Bignoniaceae	2	1.05
13	Bombacaceae	2	1.05
14	Bromeliaceae	1	0.53
15	Capparidaceae	1	0.53
16	Celastraceae	2	1.05
17	Combretaceae	2	1.05
18	Commelanaceae	1	0.53
19	Connaraceae	3	1.58
20	Delleniceae	1	0.53
21	Dichapetalaceae	1	0.53
22	Dioscoreaceae	3	1.58
23	Ebenaceae	2	1.05

24	Euphorbiaceae	15	7.89
25	Fabanaceae	1	0.53
26	Guttiferaceae	1	0.53
27	Icacinaceae	2	1.05
28	Lamiaceae	2	1.05
29	Lecythidaceae	1	0.53
30	Leguminosae	24	12.63
31	Longaniaceae	2	1.05
32	Malvaceae	1	0.53
33	Maranthaceae	4	2.11
34	Melastomataceae	1	0.53
35	Meliaceae	4	2.11
36	Menispermaceae	4	2.11
37	Moraceae	6	3.16
38	Myristicaceae	1	0.53
39	Ochnaceae	1	0.53
40	Olacaceae	3	1.58
41	Orchidaceae	2	1.05
42	Palmae	1	0.53
43	Pandaceae	1	0.53
44	Passifloraceae	2	1.05
45	Periclocaceae	2	1.05
46	Phytolaccaceae	2	1.05
47	Piperaceae	2	1.05
48	Poaceae	1	0.53
49	Polygalaceae	1	0.53

50	Rhamnaceae	1	0.53
51	Rubiaceae	16	8.42
52	Rutaceae	3	1.58
53	Sapindaceae	6	3.16
54	Sapotaceae	3	1.58
55	Smilacaceae	1	0.53
56	Solanaceae	1	0.53
57	Sterculiaceae	7	3.68
58	Taccaceae	1	0.53
59	Tilliaceae	3	1.58
60	Ulmaceae	2	1.05
61	Urticaceae	2	1.05
62	Verbenaceae	1	0.53
63	Vitaceae	2	1.05

Table 3: Vegetation Survey: Total Number, Frequency, Percentages and Family of Climber, herb, shrub and tree found in all the forest transects

Plant Form	Species no/0.4ha	Percentage Species	Species Frequency	Percentage of Total Freq.	Plant Family	Percentage of Plant Family
Climber	50	26.32	833	24.94	26	27.96
Herb	28	14.74	390	11.68	20	21.51
Shrub	45	23.68	1057	31.65	23	24.73
Tree	67	35.26	1060	31.74	24	25.81
Total	190		3340		93	

Table 4: Most Abundant Plant Species in all the Transects

S/n	Plant species	Family	Form	Frequency	Percentage of Total Species
1	*Culcasia saxatilis*	Araceae	Climber	149	4.46
2	*Icacina trichantha*	Icacinaceae	Climber	137	4.10
3	*Alchornea laxiflora*	Euphorbiaceae	Shrub	129	3.86
4	*Sphenocentrum jollyanum*	Menispermaceae	Shrub	117	3.50
5	*Chassalia kolly*	Rubiaceae	Shrub	113	3.38
6	*Microdesmis puberula*	Pandaceae	Shrub	108	3.23
7	*Newbouldia laevis*	Bignoniaceae	Tree	108	3.23
8	*Deinbolla pinnata*	Sapindaceae	Shrub	90	2.69
9	*Funtumia elastica*	Apocynaceae	Tree	88	2.63
10	*Combretum zenkeri*	Combretaceae	Climber	76	2.28

Table 5: Simpson Diversity Index of plant species in the forest

Transect	n	N	Diversity	Inversed diversity
A	109	848	0.01638	61.01
B	97	746	0.01675	59.70
C	106	730	0.02091	47.82
D	111	1016	0.01184	84.46
All transect	190	3340	0.00322	310.56

Table 6: Simpson Similarities Index of plant species in the forest

Transect	A	B	C	D
A	*	45.45%	42.76%	43.14%
B		*	50.75%	43.36%
C			*	42.76%
D				*

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