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Structure and floristic composition of flood plain forests in the Peruvian Amazon II. The understorey of restinga forests

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Abstract

Structure and floristic composition of small trees and shrubs (1.5 m height to 10 cm diameter at breast height was described in two flood plain forests of the lower Ucayali river, Peruvian Amazon. The forests were of the high and low restinga type, on an annual average flooded around 1 and 2 months, respectively. The soils were nutrient rich entisols, and the vegetation forms closed high canopy forests with presence of emergents. A total of 25 permanent sample plots covering 0.64 ha were established. They were nested within six quadratic 1 ha permanent sample plots where large individuals (≥10 cm DBH) were inventoried. Overall average density and basal area of the understorey were 4458 ha and 5.0 m^2 /ha, respectively. The families of Moraceae, Leguminosae, Annonaceae, Euphorbiaceae, and Lauraceae were among the most important tree families, while important shrub and small tree families were Violaceae, Rubiaceae, Melastomataceae, and Olacaceae. Two hundred eight and 204 tree species were registered in the restinga forest overstories and understories, respectively. Fifty-six percent of the species were shared between the two forest strata, while around 22% were confined to each of them. Species present only in the understorey were predominantly shrubs or treelets, while some of the species with a presence only in the overstorey were probably early succession species about to disappear from the forests.

Keywords: Wetlands; Family importance value; Species importance value; Biodiversity; Species richness; Species evenness

1. Introduction

The understorey of a forest warrants special attention because it often contains more plant species and constitutes more to the food chain than other strata. Species may be restricted to this forest compartment, and these small individuals may provide shelter and food for many animals (Foster, 1982; Gentry and Emmons, 1987; Hubbell and Foster, 1992). Forest rejuvenation takes place through presence of seedlings, saplings and poles in understories, gaps or on bare land according to the species in question (e.g. Denslow, 1980; Whitmore et al., 1983; Swaine and Whitmore, 1988; Clark and Clark, 1992). Furthermore, within their niche, the small individuals may be important in processes such as recycling of nutrients (e.g. Jordan, 1985). This implies that knowledge on the structure, floristic composition, and dynamics of the small individuals is needed to develop silvicultural systems (e.g. Lamprecht, 1989; Gomez-Pompa and Burley, 1991; Hubbell and Foster, 1992; Whitmore, 1995).

Most quantitative botanical inventories in Amazonian rain forests have focused on large rather than small individuals (e.g. Uhl and Murphy, 1981; Boom, 1986; Campbell et al., 1986; Balslev et al., 1987; Rankin-de-Merona et al., 1992; Ayres, 1995; Valencia et al., 1994).

However, some workers have included small individuals in their inventories (Worbes, 1983, 1986; Gentry and Emmons, 1987; Colonnello, 1990; Worbes et al., 1992; Freitas, 1996a). Many of these studies dealt with non-inundated forests, while the studies of Worbes (1983, 1986), Gentry and Emmons (1987), Colonnello (1990), Worbes et al. (1992) and Freitas (1996b) concerned Amazonian flood plain forests.

The present study provides a quantitative description of the structure and floristic composition of smaller sized tree and shrub individuals in two Amazonian flood plain forests on the lower Rio Ucayali in Peru. Comparisons were made with trees >_ 10 cm DBH (diameter at breast height) on the same site. Furthermore, species with sufficient densities were classified according to maximum size attained. The terms small individuals or understorey were used to signify individuals ranging in size from 1.5 m height to 10 cm DBH, while the terms large individuals or overstorey refer to individuals over 10 cm DBH.

2. **Study area**

The study was completed in the Loreto Department of Peru located in the tropical wet lowlands of the Amazon. Plots were established in high and low restinga flood plain forests in the Braga-Supay zone of the lower Ucayali river, approximately 10 km south-west of Jenaro Herrera (4°55'S, 73°44'W). General aspects of the study site were described by Kvist and Nebel (2001), while the location, growth conditions, and overstorey floristic composition and structure in the two restinga forests were described by Nebel et al. (2001a).

Both restinga forests were characterised by relatively fertile entisols classified as Typic Hydraquents (Andersen, 1995). During September 1987 to February 1997 the average inundation was around 1 and 2 months per year, respectively, for high and low restinga. Both types can support high forest with a canopy height of approximately 30 m, plus scattered emergents above the main canopy. The forests appeared to be undisturbed by humans, but individuals of the most valuable commercial species may have been felled.

3. Materials and methods

Permanent sample plots were established during September-November 1993 to study the small trees and shrubs in the restinga forests. A total of 25 subplots measuring 16 m x 16 m were established within six square 1 ha permanent sample plots. Four 16 m x 16 m sub-plots were established in each of six 1 ha plots, and in one of these an additional 16 m x 16 m sub-plot was established, thus, sampling 1024 and 1280 m^2, respectively. The sub-plots were systematically distributed throughout the 1 ha plots.

Tree and shrub individuals from 1.5 m height up to 10 cm DBH were permanently marked with numbered aluminum tags, and their coordinates, DBH and total height were measured. A vernier caliper was used for diameter measurement in the case of individuals with DBH less than 5 cm, while a diameter tape was used for individuals with 5-10 cm DBH. Individuals with total heights up to 15 m were measured with a telescopic pole, while the height of other individuals was estimated. Crown position and crown form were evaluated according to Dawkins classification (Alder and Synnott, 1992).

In connection to the establishment of the sub-plots all individuals were identified in the field. Voucher specimens were collected when field identification could not be properly made, which was the case for 63% of the individuals. Identification of these specimens was carried out at the Herbarium at University of Aarhus (AAU) in Denmark, and for most of the families and genera specimens were sent to taxonomic specialists for identification. Individuals were recorded as unidentified in the case that the voucher specimen was lost, if the individual had died in the period from plot establishment until collection, or if it has not yet been identified.

Calculations of family importance value (FIV) accorded to Mori et al. (1983), while species importance value (SIV) was calculated according to Curtis and McIntosh (1950, 1951).

Relative frequency was estimated using sample units of 8 m x 8 m. Calculations assumed that unidentified specimens were already represented, and consequently they did not count in the frequency calculations. Jaccard and Sorensen coefficients of similarity were calculated according to Greig-Smith (1983) and Sorensen (1948). Formulae for FIV, SIV and similarity coefficients were given by Nebel et al. (2001a).

4. **Results**

The density of understorey individuals was around 4400 ha in both forests, and the basal area was close to 5 m^2/ha (Table 1). The size distribution of individuals is shown in Figs. 1 and 2.

A total of 47 families were present on the 0.64 ha covered by the study, while in each of the 1 ha plots 35-43 families were represented. Of a total of 204 tree species recorded, 87-109 occurred in single 1 ha plots where four 16 m x 16 m sub-plots were established, while 120 were present in the 1 ha plot with five 16 m x 16 m sub-plots (Table 1). Approximately 10% of the species accounted for around 50% of the individuals (Fig. 3). A similar pattern was observed when basal area was used instead of density.

Many of the species were found on more than one plot, both within and between the two different forest types (Table 2).

Nineteen percent of the species were only found in high restinga, while 21% were unique to the low restinga. These forest types had high similarity coefficients (Table 3).

The number of species encountered increased rapidly as the sample increased to -0.1 ha, after which a gradual but constant increase in new species per area unit was observed in Fig. 4.

The relative densities, diversities, and dominances together with the resulting FIVs are shown in Table 4 for high and low restinga forests. SIVs and their components are given in Appendix A. Many of the understorey tree species also occurred in the overstorey (Table 5). Of the 264 tree species present in the under and overstories of the restinga forests, 148 (56%) were shared between the two forest compartments, while 56 (21%) and 60 (23%) species were restricted to the small and large individuals, respectively. In the restinga forests, 226 species (86%) were comparatively small and were not observed with maximum DBH exceeding 50 cm (Fig. 5).

Table 1. Number of families, number of species, number of individuals and basal areas for understorey trees in six 1 ha plots[a]

	Number of families	Number of species	Individuals (per hectare)	Basal area (m^2 /ha)
High restinga	45	160	4585	5.1
Plot 1	43	121	4609	5.1
Plot 2	35	87	4268	5.0
Plot 3	39	109	4873	5.2
Low restinga	45	166	4320	5.0
Plot 4	38	97	5049	5.7
Plot 5	41	107	3740	4.3
Plot 6	38	99	4170	4.9
All plots	47	204	4458	5.0

[a] In plot 1, five sub-plots of 16 m x 16 m were inventoried (1280 m^2), while four 16 m x 16 m sub-plots were sampled in the other plots (1024 m^2). Plots 1, 2, and 3 belong to the high restinga forest, while plots numbered 4 through 6 are located in low restinga forest.

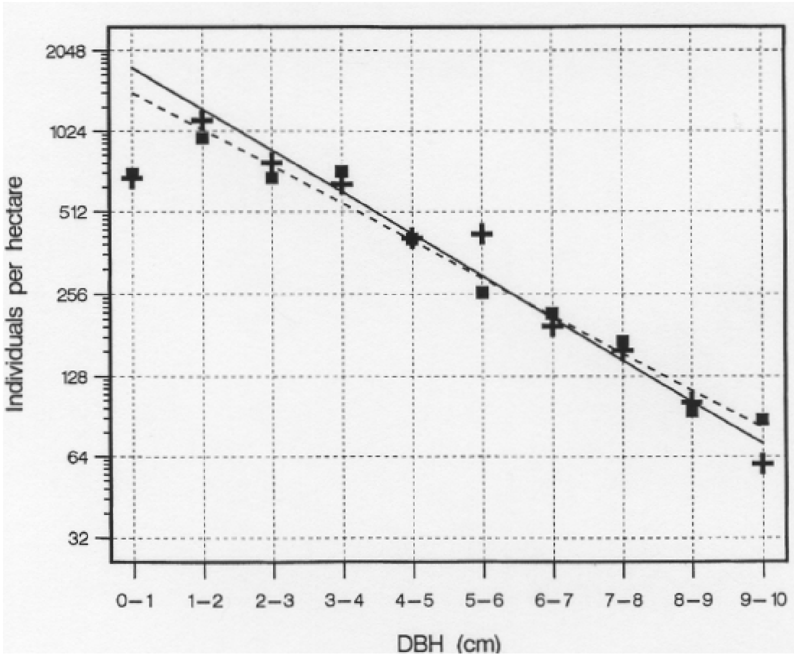

Fig. 1. Diameter class distribution of individuals in high restinga (pluses) and low restinga (squares). Regression lines calculated for density in DBH classes (excluding the diameter class 0-1 cm). High restinga is represented by the solid line (N = exp (7.657408 -0.356018 -midpoint), R^2 =0.98) and low restinga by the short dashes (N = exp (7.421199 - 0.316765 -midpoint), R^2 = 0.98). Midpoints for formulae are DBH in cm.

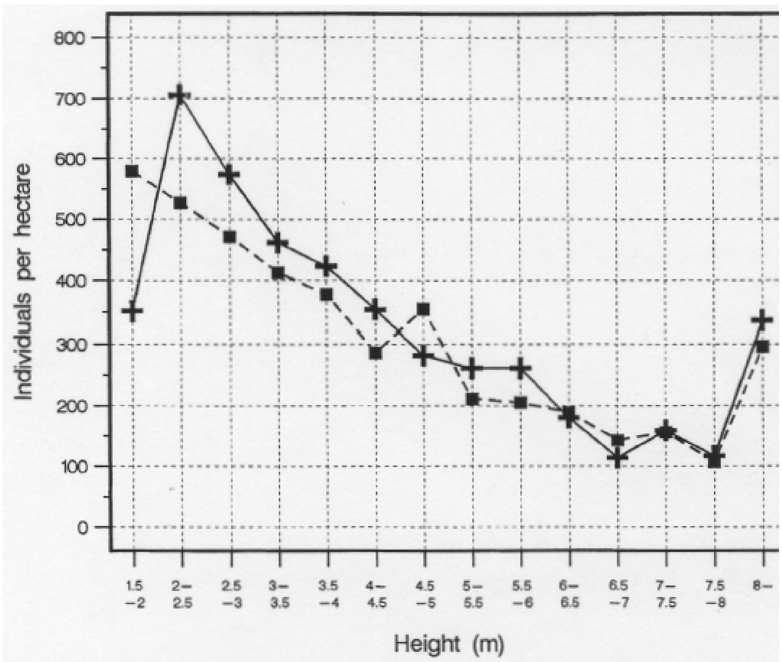

Fig. 2. Height class distribution of individuals in high restinga (+, solid line) and low restinga (■, short dashes).

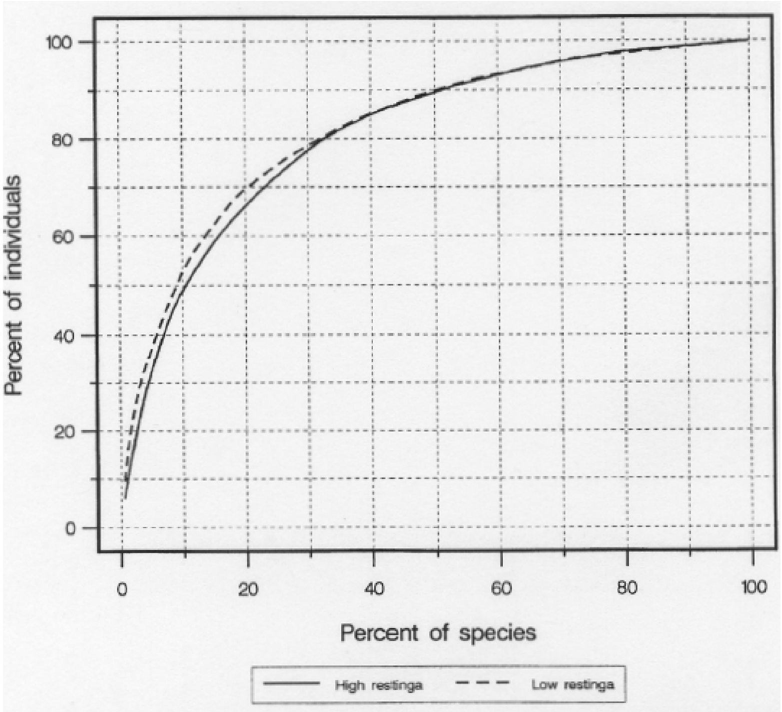

Fig. 3. The cumulative percentage of individuals as a function of the cumulative percentage of species in the understorey of high and low restinga forests, when the species were arranged in descending order according to the number of individuals with which they were represented.

Table 2. Numbers (top right) and percentages (bottom left) of species shared between pairs of plots'

		High restinga			Low restinga		
	Plot	1	2	3	4	5	6
High restinga	1	(121)	71	78	65	72	52
	2	47%	(87)	59	51	54	42
	3	54%	46%	(109)	69	70	59
Low restinga	4	36%	31%	41%	(97)	64	54
	5	38%	31%	39%	37%	(107)	62
	6	25%	23%	32%	30%	34%	(99)

° Actual species numbers in plots in parentheses.

Table 3. Number and percentage of species occurring in either low or high restinga forests, or in both forests'

	High restinga only	Low restinga only	Both forests	Total
Number of species	38	44	122	204
Percentage of total species	19	21	60	100
Jaccard coefficient	-	-	0.60	-
Sorensen coefficient	-	-	0.75	-

[a] Jaccard and Sorensen coefficients of similarity.

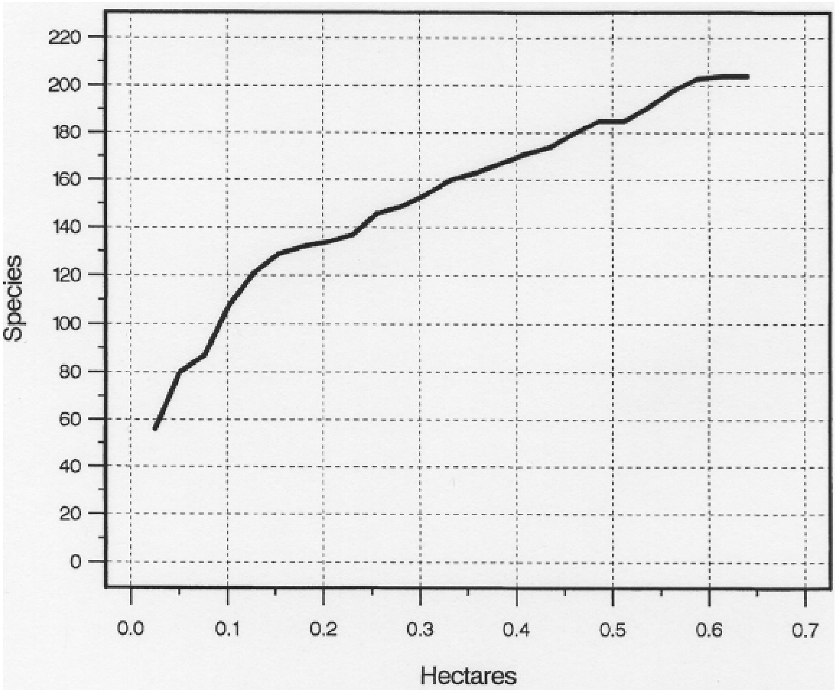

Fig. 4. Number of new species recorded in the understorey of restinga forests as sampling progressed from plot 1 through 6.

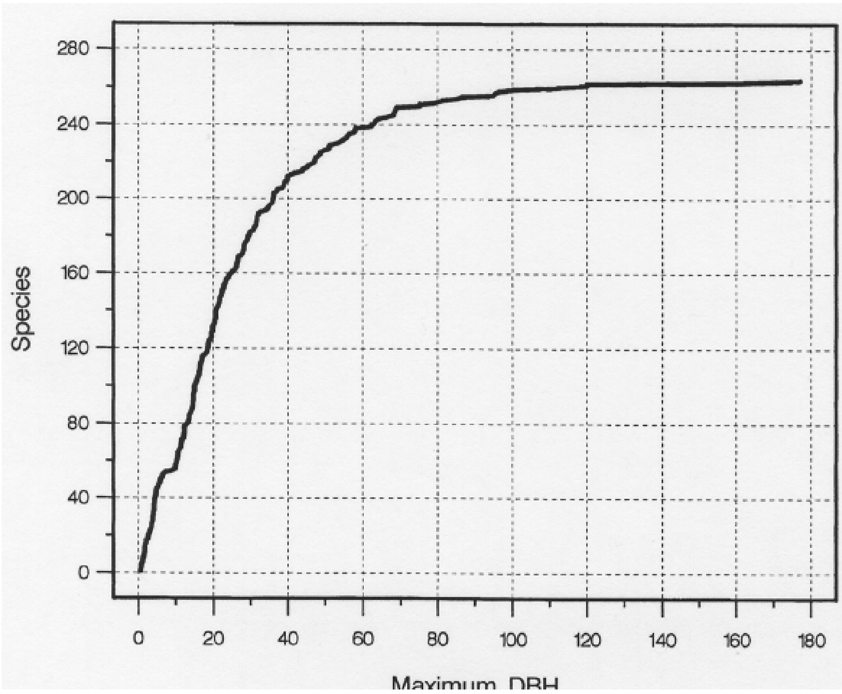

Fig. 5. Number of species recorded in restinga forests as a function of the maximum DBH attained by the individuals of the species.

Table 4. Family importance value (FIV) of families present in the understorey of high and low restinga forests

	High restinga				Low restinga			
	Rel. den.	Rel. div.	Rel. dom.	FIV	Rel. den.	Rel. div.	Rel. dom.	FIV
Anacardiaceae	0.26	1.24	0.46	1.96	0.15	1.2	0.01	1.36
Annonaceae	7.4	7.45	6.81	21.67	4.75	7.19	8.01	19.94
Apocynaceae	0.66	1.24	0.49	2.39	0.3	1.2	0.43	1.93
Arecaceae	6.88	2.48	8.56	17.92	4.3	1.2	2.78	8.27
Bombacaceae	2.16	1.86	3.49	7.52	0.6	0.6	1.17	2.38
Boraginaceae	0.92	1.24	1.37	3.53	0.53	1.2	1.14	2.86
Burseraceae	2.03	0.62	2.35	5.01	0.45	0.6	0.34	1.39
Caesalpiniaceae	0.26	L24	0.37	1.88	0.53	1.2	0.57	2.29
Capparaceae	0.92	0.62	1.33	2.87	0.53	0.6	0.9	2.03
Cecropiaceae	0.66	1.86	1.8	4.32	0.98	0.6	0.63	2.21
Celastraceae	0.13	0.62	0.13	0.88	0.53	1.2	0.16	1.88
Chrysobalanaceae	1.11	2.48	0.48	4.08	0.9	4.19	1.55	6.65
Clusiaceae	3.67	1.86	2.18	7.71	2.79	1.8	1.42	6
Combretaceae	0.2	0.62	0.67	1.48	0.6	1.8	0.79	3.19
Dichapetalaceae	0.13	0.62	0.03	0.78	0.08	0.6	0.01	0.68
Ebenaceae	0.13	1.24	0.19	1.56	0.38	0.6	0.48	1.46
Elaeocarpaceae	0.52	0.62	1.02	2.16	0.68	1.2	1.39	3.27
Euphorbiaceae	6.09	5.59	6.57	18.26	9.8	5.99	11.33	27.12
Fabaceae	1.51	4.97	1.66	8.13	1.73	4.19	1.53	7.45
Flacourtiaceae	1.51	2.48	1.13	5.12	3.69	4.19	3.66	11.54
Icacinaceae	-		-	-	0.23	0.6	0.74	1.57
Lauraceae	4.06	4.97	3.72	12.75	3.54	5.39	5.6	14.53
Lecythidaceae	1.38	2.48	1.75	5.62	2.19	2.4	2	6.58
Malpighiaceae	0.07	0.62	0.04	0.73	0.6	0.6	0.3	1.5
Melastomataceae	5.05	3.73	2.04	10.81	5.65	2.4	4.77	12.82
Meliaceae	1.05	2.48	1.75	5.28	0.9	2.99	2	5.9
Mimosaceae	3.8	5.59	5.14	14.53	3.99	5.39	8.37	17.76
Moraceae	11.14	6.83	11.87	29.84	2.56	4.19	3.62	10.37
Myristicaceae	1.31	1.86	1.34	4.51	3.09	1.8	4.36	9.24
Myrsinaceae	0.26	0.62	0.28	1.16	0.98	0.6	0.72	2.3
Myrtaceae	1.97	4.97	2.48	9.42	5.88	7.19	6.75	19.81
Nyctaginaceae	1.38	0.62	1.33	3.33	1.88	1.2	1.93	5.01
Ochnaceae	0.13	0.62	0.02	0.77	0.3	0.6	0.11	1.01
Olacaceae	6.62	1.86	1.66	10.14	10.1	2.4	2.78	15.28
Passifloraceae	0.07	0.62	0.01	0.69	-	-	-	-
Polygonaceae	1.18	2.48	1.46	5.12	2.11	2.4	2.4	6.91
Quiinaceae	0.13	0.62	0.01	0.77	0.15	0.6	0.1	0.85
Rubiaceae	7.34	6.83	3.27	17.44	10.4	8.38	4.35	23.13
Sapindaceae	1.25	1.24	1.1	3.59	1.28	2.4	0.85	4.53
Sapotaceae	2.56	3.11	2.28	7.94	2.56	1.8	3.95	8.31
Simaroubaceae	0.46	1.24	0.02	1.72	0.23	1.2	0.12	1.55
Solanaceae	1.05	1.86	0.24	3.15	3.24	1.2	0.75	5.18
Sterculiaceae	0.72	1.86	0.9	3.49	0.15	0.6	0.07	0.82
Theophrastaceae	0.33	0.62	0.04	0.99	-	-	-	-
Tiliaceae	-		-	-	0.6	1.2	1.22	3.02
Violaceae	8.85	1.24	15.61	25.7	0.98	1.2	1.97	4.15
Unidentified	0.72	0	0.54	1.26	2.11	0	1.87	3.98

Table 5. Number of species identified in the overstorey (individuals above 10 cm DBH), in the understorey (individuals higher than 1.5 m and up to 10 cm DBH), and common for understorey and overstorey of restinga forests (high and low).

	Total	Overstorey total	Understorey total	Overstorey only	Understorey only	Common
High restinga	205	139 (68%)	160 (78%)	45 (22%)	66 (32%)	94(46%)
Plot 1	149	86 (58%)	120 (81%)	29 (20%)	63 (42%)	57 (38%)
Plot 2	134	98 (73%)	87 (65%)	47 (35%)	36 (27%)	51 (38%)
Plot 3	150	97 (65%)	109 (73%)	41 (28%)	53 (35%)	56 (37%)
Low restinga	228	181 (79%)	166 (73%)	62 (27%)	47 (21%)	119 (52%)
Plot 4	156	120(77%)	97 (81%)	59 (38%)	36 (23%)	61 (39%)
Plot 5	173	131 (76%)	107 (82%)	66 (38%)	42(24%)	65 (38%)
Plot 6	171	129 (75%)	99 (58%)	72(42%)	42(25%)	57 (33%)
All plots	264	208 (79%)	204(76%)	60 (23%)	56 (21%)	148 (56%)

Appendix B classifies restinga forest tree species represented by 10 or more individuals according to the maximum diameter attained (DBHmax). The size classes used were based on the classification of other workers (e.g. Campbell et al., 1986; Swaine et al., 1987; Hubbell and Foster, 1992; Richards, 1996).

5. Discussion

Brunig (1983) found a considerable variation in tropical rain forest density in the DBH range of around 1-10 cm (2000-20,000/ha), though the mean value was at the low end. For the same diameter range Bongers et al. (1988) reported comparable densities (2250-5000 ha) in lowland tropical rain forests. Gentry and Terborgh (1990) recorded 203 individuals (2.5-10 cm DBH) on a 0.1 ha plot in a Peruvian flood plain forest at Cocha Cashu, and commented that the forest had an open understorey due largely to lack of individuals in the size class 2.5-10 cm DBH. Comparing results from the Braga-Supay restinga forests (Table 1, Fig. 1) with figures mentioned above we found that they were within the common range for lowland tropical rain forests, and data did not suggest a restriction in understorey development, as might have been suspected as a consequence of the annual flooding. The longest inundation occurred in the low restinga forest, which had the highest proportion of individuals in the smallest height class (Fig. 2). However, it appeared that adjacent forests exposed to longer flooding had fewer understorey individuals.

Eight out of the ten most important families in each forest were shared. In the high restinga Violaceae and Arecaceae were ranked two and ten, while in the low restinga they were ranked number 21 and 17, respectively. Furthermore, the Moraceae was much more important in the high than in the low restinga. In the low restinga, the families Euphorbiaceae, Myrtaceae, Olacaceae, and Flacourtiaceae attained considerably higher values than in high restinga. Overall the tree families Moraceae, Leguminosae, Annonaceae, Euphorbiaceae and Lauraceae were among the most important. Families containing relatively many shrub and smaller tree species like Violaceae, Rubiaceae, Melastomataceae, and Olacaceae were also among the most important.

In both restinga forests the mid-canopy species *Oxandra sphaerocarpa, Drypetes amazonica,* and *Perebea longipedunculata* were important. Several important shrub species also occurred in both forests: *Tococa sp., Neea floribunda, Heisteria acuminata,* and *Coussarea brevicaulus.* Of species growing to larger sizes especially the palm *Scheelea brachyclada* as well as *Guatteria sp. 1, Protium nodulosum, Inga cinnamomea, Maquira coriacea, Sorocea steinbachii,* and *Leonia glycicarpa* were representative for the high restinga. Similarly among the species of smaller stature *Naucleopsis glabra, Rondeletia sp.,* and *Gloeospermum equatoriense* were indicative for the high restinga plots. In the low restinga the larger growing *Zygia juruana* and the smaller stature *Laetia corymbulosa, Myrcia* sp. 5, and *Rudgea sessiliflora* were important. Some of these species are distinctive and may be useful in distinguishing between the forest types (Appendix A).

Gentry and Emmons (1987) studied understories in neotropical rain forests, including the regularly flooded Peruvian Cocha Cashu flood plain forest. They found that more shrubs tended to be present on fertile than on infertile sites, where tree saplings dominated the understorey. Accordingly, we observed many shrub and midcanopy species (Table 5, Appendix B) in the fertile Braga-Supay restinga forests. In adjacent closed high forests exposed to longer flooding, fewer shrub species tended to be present.

In the Braga-Supay forests, many species were present only as small individuals with diameters less than 10 cm DBH (Fig. 5, Table 5), which was in accordance with the findings of Gentry and Dodson (1987). Likewise, various species were present only as individuals exceeding 10 cm DBH (Table 5). However, in these proportions there may be species which by chance happened to be represented by small or large individuals only. Of these species represented by more than 10 individuals, 15 were restricted to presence in the understorey, while 9 occurred in the overstorey only (cf. 60 and 56, respectively, when all species were considered, Table 5, Appendix B). Under the environmental conditions represented by the sample, and assuming that observations were not by chance only, a species present in both the overstorey and the understorey (1) indicates that the species grows to larger sizes and rejuvenates. A species present only in the understorey (2) suggests that it is a shrub/treelet, or an invader thriving under the current environmental conditions, e.g. due to succession development. A species present only in the overstorey (3) denotes that the species rejuvenates under other environmental conditions, e.g. in a previous succession stage. The species in the Braga-Supay restinga forests belonging to (2) were mainly shrubs or treelets. Contrary, several species of (3) were large growing trees with no individuals in the sapling and pole sizes, and may be disappearing from the forests. Some of the species belonging to this group included *Anaxagorea sp., Apeiba aspera, Calycophyllum spruceanum, Ceiba pentandra, Cordia lutea, Inga edulis* and *Pseudobombax munguba.* Most of these are known to be confined to early succession stages. This indicates that the Braga-Supay restinga forests were in a succession development, which is probably most progressed for the high restinga, where large trees of *Calycophyllum spruceanum* were no longer present. This was in agreement with Foster et al. (1986), Salo et al. (1986), Worbes et al. (1992), and Worbes (1997) who observed that floristic composition and structure of flood plain forests are highly influenced by succession stage. It also gives further evidence to the observations of Nebel et al. (2001a), that the high restinga was in a later succession stage than the low restinga.

If large samples are available a further impression of how single species thrive may be obtained from studying in more detail their diameter distribution pattern (e.g. Denslow, 1980; Whitmore et al., 1983; Bongers et al., 1988; Swaine and Whitmore, 1988; Nebel et al., 2001b).

6. Conclusion

We found that patterns of understorey floristic composition and structure, and their relation to similar figures for the overstorey, may successfully be described using sub-sampling within plots where overstorey individuals are under study. This helps to complete the description of biodiversity and forest structure, and may be used to interpret aspects of forest and population dynamics. If remeasurements are carried out, data for modelling may also be provided. However, inventories of the abundant understorey individuals are time consuming, and for forest management purposes it may make more sense to focus sampling on the species to be managed, as specific knowledge on their ecology will probably be more desirable in a forest management context.

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References

Alder, D., Synnott, T.J., 1992. Permanent sample plot techniques for mixed tropical forest. Oxford Forestry Institute, Oxford, Tropical Forestry Papers, No. 25, 124 pp.

Andersen, M.K., 1995. Jorde i peruviansk Amazonas. Thesis, Royal Veterinary and Agricultural University, 46 pp.

Ayres, J.M., 1995. As matas de varzea do Mamiraua. MCT CNPq Sociedade Civil Mamiraua, 123 pp.

Balslev, H., Luteyn, J., 0llgaard, B., Holm-Nielsen, L.B., 1987. Composition and structure of adjacent unflooded and floodplain forest in Amazonian Ecuador. Opera Botanica 92, 37-57.

Bongers, F., Popma, J., del Castillo, J.M., Carabias, J., 1988. Structure and floristic composition of the lowland rain forest of Los Tuxtlas, Mexico. Vegetatio 74, 55-80.

Boom, B.M., 1986. A forest inventory in Amazonian Bolivia. Biotropica 18 (4), 287-294.

Brunig, E.F., 1983. Vegetation structure and growth. In: Golley, F.B. (Ed.), Tropical Rain Forest Ecosystems. Structure and Function. Elsevier, Amsterdam, pp. 49-75.

Campbell, D.G., Douglas, C.D., Prance, G.T., Maciel, U.N., 1986. Quantitative ecological inventory of terra firme and varzea tropical forest on the Rio Xingu, Brazilian Amazon. Brittonia 38 (4), 369-393.

Clark, D.A., Clark, D.B., 1992. Life history diversity of canopy and emergent trees in a neotropical rain forest. Ecol. Monogr. 62 (3), 315-344.

Colonnello, G., 1990. A Venezuelan floodplain study on the Orinoco River. Forest Ecol. Manage. 33/34, 103-124.

Curtis, J.T., McIntosh, R.P., 1950. The interrelations of certain analytic and synthetic phytosociological characters. Ecology 31 (3), 435-455.

Curtis, J.T., McIntosh, R.P., 1951. An upland forest continuum in the prairie-forest border region of Wisconsin. Ecology 32 (3), 476-496.

Denslow, J.S., 1980. Gap partitioning among tropical rainforest trees. Biotropica 12 (Suppl.), 47-55.

Foster, R.B., Arce, J.B., Wachter, T.S., 1986. Dispersal and the sequential plant communities in Amazonian Peru floodplain. In: Estrada, A., Fleming, T.H. (Eds.), Frugivores and Seed Dispersal. Dr W. Junk Publishers, Dordrecht, pp. 357-370.

Freitas, L.A., 1996a. Caracterizacion floristica y estructural de cuatro comunidades boscosas de la llanura aluvial inundable en la zona Jenaro Herrera, Amazonia Peruana. Instituto de Investigaciones de la Amazonia Peruana, Iquitos, Documento Tecnico, No. 21, 73 pp.

Freitas, L.A., 1996b. Caracterizacion floristica y estructural de cuatro comunidades boscosas de terraza baja en la zona de Jenaro Herrera, Amazonia Peruana. Instituto de Investigaciones de la Amazonia Peruana, Iquitos, Documento Tecnico, No. 26, 77 pp.

Gentry, A.H., Dodson, C., 1987. Contribution of nontrees to species richness of a tropical rain forest. Biotropica 19 (2), 149-156.

Gentry, A.H., Emmons, L.H., 1987. Geographical variation in fertility, phenology, and composition of the understorey of neotropical forests. Biotropica 19 (3), 216-227.

Gentry, A.H., Terborgh, J., 1990. Composition and dynamics of the Cocha Cashu "mature" floodplain forest. In: Gentry, A.H. (Ed.), Four Neotropical Rainforests. Yale University Press, New Haven, London, pp. 542-563.

Gomez-Pompa, A., Burley, F.W., 1991. The management of natural tropical forests. In: Gomez-Pompa, A., Whitmore, T.C., Hadley, M. (Eds.), Rain Forest Regeneration and Management. UNESCO, Paris, pp. 3-18.

Greig-Smith, P., 1983. Quantitative Plant Ecology. Blackwell Scientific Publications, Oxford, 359 pp.

Hubbell, S.P., Foster, R.B., 1992. Short-term dynamics of a neotropical forest: why ecological

research matters to tropical conservation and management. OIKOS 63, 48-61.
Jordan, C.F., 1985. Nutrient Cycling in Tropical Forest Ecosystems. Wiley, Chichester, 190 pp.
Kvist, L.P., Nebel, G., 2001. A review of Peruvian flood plain forests: ecosystems. inhabitants and resource use. For. Ecol. Manage. 150, 3-26.
Lamprecht, H., 1989. Silviculture in the tropics. Tropical forest ecosystems and their tree species - possibilities and methods for their long-term utilization. GTZ, Eschborn, 296 pp.
Mori, S.A., Boom, B.M., de Carvalho, A.M., dos Santos, T.S., 1983. Southern Bahian moist forests. Bot. Rev. 49 (2), 155-232.
Nebel, G., Kvist, L.P., Vanclay, J.K., Christensen, H., Freitas, L., Ruiz, J., 2001a. Structure and floristic composition of flood plain forests in the Peruvian Amazon. I. Overstorey. For. Ecol. Manage. 150, 27-57.
Nebel, G., Dragsted, J., Simonsen, T.R., Vanclay, J.K., 2001b. The Amazon flood plain forest tree *Maquira coriacea* (Karsten) C.C. Berg: aspects of ecology and management. For. Ecol. Manage. 150, 103-113
Rankin-de-Merona, J.M., Prance, G.T., Hutchings, R.W., Silva, M.F., Rodrigues, W.A., Uehling, M.E., 1992. Preliminary results of a large-scale tree inventory of upland rain forest in the central Amazon. Acta Amazonica 22 (4), 493-534.
Richards, P.W., 1996. The Tropical Rain Forest. Cambridge University Press, Cambridge, 575 pp.
Salo, J., Kalliola, R., Hakkinen, I., Makinen, Y., Niemela, P., Puhakka, M., Coley, P.D., 1986. River dynamics and the diversity of Amazon lowland forest. Nature 322, 254-258.
Swaine, M.D., Hall, J.B., Alexander, I.J., 1987. Tree population dynamics at Khade, Ghana (1968-1982). J. Trop. Ecol. 3, 331-345.
Swaine, M.D., Whitmore, T.C., 1988. On the definition of ecological species groups in tropical rain forests. Vegetatio 75, 81-86.
Sorensen, T., 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analyses of the vegetation on Danish commons. Det Kongelige Danske Videnskabers Selskab Biologiske Skrifter 5 (4), 1-34.
Uhl, C., Murphy, P .G., 1981. Composition, structure, and regeneration of a tierra firme forest in the Amazon basin of Venezuela. Tropi. Ecol. 22 (2), 219-237.
Valencia, R., Balslev, H., Paz y Mino, G.C., 1994. High tree alphadiversity in Amazonian Ecuador. Biodiv. Conserv. 3, 21-28.
Whitmore, T.C., 1995. Perspectives in tropical rain forest research. In: Lugo, A.E., Lowe, C. (Eds.), Tropical Forests: Ecology and Management. Springer, Berlin, pp. 397-407.
Whitmore, T.C., Brown, N.D., Swaine, M.D., Kennedy, D., Goodwin-Bailey, C.L, Gong, W.K., 1983. Secondary succession from seed in tropical rain forests. For. Abstr. 44 (12), 767-779.
Worbes, M., 1983. Vegetationskundliche Untersuchungen zweier Uberschwemmungswalder in Zentralamazonien - vorlaufige Ergebnisse. Amazonia 8 (1), 47-65.
Worbes, M., 1986. Lebensbedingungen und Holzwachstum in zentralamazonischen Uberschwemmungswaldern. Scripta Geobotanica 17, 7-112.
Worbes, M., Klinge, H., Revilla, J.D., Martius, C., 1992. On the dynamics, floristic subdivision and geographical distribution of varzea forests in Central Amazonia. J. Veg. Sci. 3, 553-564.

Appendix A.

Species importance value (SIV) for species present in high and low restinga as well as in both forests. SIV is the sum of relative density (rel. den), relative frequency (rel. fre), and relative dominance (rel. dom) of each species. Characteristic species of both restinga forests (R), of high restinga (H) and low restinga (L). Absolute totals in the bottom of columns allow calculation of absolute values for each species. Numbers after species names are collection numbers of J. Ruiz et al. (number only) and Nebel (with "N") as registered at University of Aarhus (AAU), Denmark.

	Charateristic species	High restinga				Low restinga			
		Relative density	Relative frequency	Relative dominance	SIV	Rel. den	Rel. fre	Rel. dom	SIV
Anacardiaceae									
Spondias mombin L. 2278		0.26	0.6	0.46	1.32	–	–	–	–
Tapirira guianensis Aublet 1659		–	–	–	–	0.15	0.34	0.01	0.5
Annonaceae									
Crematosperma sp. 8712	L	0.72	1.2	0.65	2.57	1.06	1.87	1.8	4.72
Duguetia spixiana C. Martius 5508		0.26	0.6	0.39	1.25	0.15	0.34	0.23	0.72
Duguetia sp. N307038		0.07	0.15	0.02	0.23	–	–	–	–
Guatteria sp. 1 2006	H	1.44	1.2	0.65	3.3	0.15	0.34	0.22	0.71
Guatteria sp. 3 5202		–	–	–	–	0.08	0.17	0.47	0.72
Guatteria sp. 4 N807332		0.39	0.75	0.35	1.5	0.08	0.17	0.1	0.34
Malmea sp. 6013		0.2	0.45	0.49	1.14	0.15	0.34	0.31	0.8
Oxandra sphaerocarpa R. E. Fries 1579	R	1.18	1.35	1.19	3.72	0.9	1.36	2.43	4.69
Pseudoxandra polyphleba (Diels) R. E. Fries 4085		0.26	0.45	0.07	0.78	0.08	0.17	0.27	0.52
Rollinia cuspidata C. Martius 9266	L	0.85	1.2	0.65	2.7	0.98	1.36	0.98	3.32
Unonopsis floribunda Diels 1266		0.66	1.2	0.72	2.58	0.3	0.68	0.4	1.38
Xylopia micans R. E. Fries 1165		0.72	1.05	0.85	2.62	0.6	1.19	0.55	2.34
Xylopia sp. 1 2024		0.66	1.2	0.78	2.63	0.23	0.51	0.25	0.98
Apocynaceae									
Himatanthus bracteatus (A. DC.) Woodson 2048		0.07	0.15	0.08	0.3	0.23	0.34	0.35	0.91
Tabernaemontana markgrafiana J. F. Macbride N209199		0.59	0.75	0.4	1.74	0.08	0.17	0.08	0.33
Arecaceae									
Astrocaryum jauari C. Martius		0.07	0.15	0.12	0.33	–	–	–	–
Bactris sp.	R	3.28	1.35	2.01	6.63	4.14	1.02	2.5	7.67
Euterpe precatoria C. Martius		0.07	0.15	0.26	0.48	0.15	0.17	0.27	0.6
Scheelea brachyclada Burret	H	3.47	1.8	6.17	11.44	–	–	–	–
Bombacaceae									
Ceiba samauma (C. Martius & Zuccarini) Schumann 5345		0.13	0.3	0.18	0.61	–	–	–	–
Matisia bracteolosa Ducke 2277	H	1.9	1.5	3.01	6.41	0.6	0.68	1.17	2.46
Pachira aquatica Aublet 4535		0.13	0.3	0.3	0.73	–	–	–	–
Boraginaceae									
Cordia nodosa Lamarck 3049	H	0.85	1.35	1.37	3.57	0.45	0.85	1.13	2.43
Unidentified		0.07	0.15	0	0.22	0.08	0.17	0	0.25
Burseraceae									
Protium nodulosum Swart 1090	H	2.03	1.65	2.35	6.04	0.45	0.85	0.34	1.64
Caesalpiniaceae									
Cynometra sp. 9060		0.13	0.3	0.08	0.51	0.08	0.17	0.13	0.37
Senna bacillaris var. *benthamiana* (J. F. Macbride) H. Irwin & Barneby 1439		0.13	0.3	0.29	0.72	0.45	0.68	0.44	1.57
Capparaceae									
Capparis sola J. F. Macbride 3013	H	0.92	1.05	1.33	3.3	0.53	1.02	0.9	2.45
Cecropiaceae									
Cecropia ficifolia Warburg ex Snethlage N907037		–	–	–	–	0.98	0.85	0.63	2.46
Cecropia unidentified		0.13	0	0.12	0.25	–	–	–	–
Pourouma acuminata C. Martius ex Miquel 1356		0.07	0.15	0.37	0.58	–	–	–	–
Pourouma cecropiifolia C. Martius 2014		0.39	0.75	1.31	2.45	–	–	–	–
Pourouma cucura Standley and Quatrecasas		0.07	0.15	0	0.22	–	–	–	–
Celastraceae									
Maytenus macrocarpa (R. and P.) Briquet 2408		0.13	0.3	0.13	0.56	0.15	0.34	0.14	0.63
Maytenus sp. N907022		–	–	–	–	0.38	0.51	0.02	0.91
Chrysobalanaceae									
Couepia subcordata Bentham 9400		–	–	–	–	0.08	0.17	0.1	0.35
Couepia sp. 6389		0.13	0.3	0.01	0.44	0.15	0.34	0.22	0.71
Hirtella triandra ssp. *triandra* Swartz 3243		0.46	0.6	0.06	1.11	0.15	0.34	0.04	0.53
Licania britteniana Fritsch 3088		0.26	0.6	0.25	1.12	0.3	0.51	0.7	1.51
Licania macrocarpa Cuatrecasas 2581		–	–	–	–	0.08	0.17	0.25	0.5
Licania micrantha Miquel 5558		–	–	–	–	0.08	0.17	0.06	0.31
Parinari parilis J. F. Macbride 1170		0.26	0.6	0.17	1.03	0.08	0.17	0.17	0.42
Clusiaceae									
Garcinia macrophylla C. Martius 7349	L	1.18	0.6	0.65	2.43	2.34	2.04	1.27	5.65
Garcinia madruno (Kunth) Hammel 8113	H	2.42	1.8	1.51	5.73	0.38	0.68	0.14	1.2
Tovomita sp. 6173		–	–	–	–	0.08	0.17	0	0.25
Vismia angusta Miquel 1298		0.07	0.15	0.02	0.23	–	–	–	–
Combretaceae									
Buchenavia amazonia Al-Mayah and Stace 6316		–	–	–	–	0.08	0.17	0.07	0.32
Terminalia dichotoma G. Meyer 5598		–	–	–	–	0.08	0.17	0.01	0.26
Terminalia oblonga (Ruiz Lopez & Pavon) Steudel 2196		0.2	0.45	0.67	1.31	0.45	0.85	0.71	2.01
Dichapetalaceae									
Tapura sp. 5440		0.13	0.3	0.03	0.46	0.08	0.17	0.01	0.25
Ebenaceae									
Diospyros sp. 1 8716		0.07	0.15	0.05	0.27	0.38	0.85	0.48	1.71
Diospyros sp. 5		0.07	0.15	0.14	0.35	–	–	–	–
Elaeocarpaceae									
Sloanea guianensis (Aublet) Bentham 6443		0.52	0.9	1.02	2.44	0.6	0.85	1.36	2.81
Sloanea sp. 2 7201		–	–	–	–	0.08	0.17	0.03	0.28

	Charateristic species	High restinga				Low restinga			
		Relative density	Relative frequency	Relative dominance	SIV	Rel. den	Rel. fre	Rel. dom	SIV
Euphorbiaceae									
Alchornea schomburgkii Klotzsch 6577		0.2	0.45	0.12	0.76	0.45	1.02	0.86	2.33
Cleidion sp.		–	–	–	–	0.08	0.17	0.09	0.34
Croton cuneatus Klotzsch 3553		0.66	0.45	0.63	1.74	1.51	1.19	0.84	3.53
Drypetes amazonica var. *peruviana* J. F. Macbride 2228	R	3.93	1.8	4.69	10.42	6.78	1.7	8.19	16.67
Glycydendron amazonicum Ducke 7625		0.2	0.3	0.17	0.67	0.08	0.17	0.07	0.32
Hura crepitans L. 2137		0.13	0.3	0.19	0.62	–	–	–	–
Jablonskia congesta (Bentham ex Muell. Arg.) Webster N407513		0.07	0.15	0.01	0.23	0.15	0.34	0.01	0.5
Mabea nitida Spruce ex Bentham 5327		–	–	–	–	0.08	0.17	0.1	0.35
Margaritaria nobilis L. f. N909168		–	–	–	–	0.23	0.34	0.03	0.59
Podocalyx sp. 9484		0.13	0.15	0.12	0.4	0.3	0.34	0.37	1.01
Sapium glandulosum (L.) Morong 5342		0.66	0.6	0.57	1.83	0.15	0.34	0.77	1.26
Sapium marmierii Huber 2211		0.13	0.15	0.07	0.35	–	–	–	–
Fabaceae									
Andira inermis (W. Wright) H. B. K. ex DC. 5239		0.2	0.3	0.15	0.65	0.15	0.17	0.04	0.36
Ormosia sp. 1 3404		0.13	0.3	0.34	0.77	–	–	–	–
Platymiscium stipulare Benth. 3382		0.07	0.15	0.46	0.67	0.08	0.17	0.17	0.42
Pterocarpus amazonum (C. Martius ex Bentham) Amshoff 7003		–	–	–	–	0.23	0.34	0.05	0.61
Pterocarpus sp. 1 3172		0.13	0.3	0.25	0.68	0.15	0.34	0.44	0.93
Pterocarpus sp. 2 8465		0.07	0.15	0.01	0.22	0.23	0.51	0.03	0.76
Swartzia cardiosperma Spruce ex Bentham 1152		0.07	0.15	0.02	0.24	0.53	1.02	0.41	1.95
Swartzia simplex (Swartz) Sprengel 1258		0.79	0.9	0.35	2.03	0.38	0.85	0.39	1.61
Swartzia sp. 6121		0.07	0.15	0.08	0.3	–	–	–	–
Flacourtiaceae									
Casearia aculeata Jacquin 1187	L	0.66	0.45	0.27	1.37	1.06	1.19	0.92	3.16
Casearia arborea (Richard) Urban 8431		0.26	0.6	0.34	1.2	0.08	0.17	0.33	0.57
Casearia sylvestris Swartz 8320		0.2	0.3	0.04	0.54	0.6	0.51	0.85	1.96
Hasseltia floribunda H. B. K. N209184		0.39	0.75	0.48	1.62	0.08	0.17	0.06	0.3
Laetia corymbulosa Spruce ex Bentham 9289	L	–	–	–	–	1.73	1.02	1.2	3.96
Xylosma sp. 1 8569		–	–	–	–	0.08	0.17	0.3	0.54
Xylosma sp. 2		–	–	–	–	0.08	0.17	0	0.25
Icacinaceae									
Calatola venezuelana Pittier 4328		–	–	–	–	0.23	0.34	0.74	1.31
Lauraceae									
Aniba guianensis Aublet 9172		–	–	–	–	0.08	0.17	0.01	0.26
Aniba sp. 1 1138	H	1.11	1.35	1.23	3.69	0.6	0.68	1.23	2.51
Endlicheria formosa A. C. Smith 2207		–	–	–	–	0.08	0.17	0.13	0.38
Endlicheria sp. 7477		0.13	0.3	0.06	0.49	0.45	0.51	0.16	1.12
Endlicheria verticillata Mez 9737		0.07	0.15	0.01	0.22	0.23	0.51	0.4	1.13
Nectandra cuneato-cordata Mez 6537		0.59	0.6	0.77	1.96	0.38	0.68	0.29	1.35
Ocotea cernua (Nees) Mez 8437		1.11	1.2	0.56	2.87	0.38	0.85	0.61	1.83
Ocotea javitensis 9056		0.13	0.3	0.25	0.68	0.3	0.68	0.65	1.64
Pleurothyrium parviflorum Ducke 1278	L	0.59	1.05	0.61	2.25	0.98	1.36	1.95	4.29
unidentified sp. 4		0.26	0.45	0.22	0.93	–	–	–	–
Unidentified		0.07	0	0.01	0.08	0.08	0	0.17	0.24
Lecythidaceae									
Couroupita guianensis Aublet 7369		0.07	0.15	0.08	0.3	0.15	0.34	0.18	0.67
Couroutari oligantha A. C. Smith 6337		0.2	0.3	0.17	0.67	0.3	0.51	0.14	0.95
Eschweilera parvifolia C. Martius ex A. DC. 5031	L	0.33	0.75	0.19	1.26	1.36	1.87	1.18	4.4
Eschweilera turbinata (Berg) Niedenzu 5019	H	0.79	1.05	1.31	3.15	0.38	0.51	0.5	1.39
Malpighiaceae									
Byrsonima densa (Poiret) DC. 9104		0.07	0.15	0.04	0.25	0.6	0.68	0.3	1.58
Melastomataceae									
Miconia centrodesma Wurdack 8097		0.2	0.3	0.17	0.67	0.08	0.17	0.24	0.49
Miconia sp. 1 3061		0.39	0.75	0.6	1.74	–	–	–	–
Mouriri grandiflora A. DC. 9273	L	1.31	0.75	0.69	2.75	1.73	1.87	3.57	7.17
Mouriri sp.		0.07	0.15	0.02	0.24	–	–	–	–
Tococa coronata Bentham N307114	L	0.85	0.9	0.19	1.94	1.81	1.7	0.71	4.21
Tococa sp. N109148	R	2.23	1.2	0.37	3.79	2.03	1.36	0.25	3.64
Meliaceae									
Cedrela odorata L. 2066		0.2	0.45	0.54	1.19	0.08	0.17	0.16	0.41
Guarea macrophylla Vahl 3230		0.46	0.6	0.69	1.75	0.38	0.85	0.96	2.19
Trichilia inaequilatea Pennington 7021		–	–	–	–	0.08	0.17	0.1	0.35
Trichilia pallida Swartz 3449		0.13	0.3	0.43	0.86	0.08	0.17	0.07	0.31
Trichilia pleeana (Adr. Jussieu) C. DC. 6037		0.26	0.45	0.08	0.79	–	–	–	–
Trichilia rubra C. DC. 7191		–	–	–	–	0.3	0.51	0.71	1.52
Mimosaceae									
Inga bourgonii (Aublet) DC. 5569		0.07	0.15	0.02	0.23	0.15	0.34	0.29	0.78
Inga cinnamomea Spruce ex Bentham 1097	H	0.92	1.35	2.13	4.4	0.08	0.17	0.23	0.47
Inga nobilis Willdenow 1180		0.26	0.45	0.6	1.31	0.08	0.17	0.4	0.64
Inga pavoniana G. Don 4264		0.46	0.3	0.19	0.95	–	–	–	–
Inga psittacorum L. Uribe 1515		–	–	–	–	0.15	0.34	0.04	0.53
Inga semialata (Vell. Conc.) C. Martius 1002		0.13	0.3	0.43	0.86	–	–	–	–
Inga stenoptera Bentham 1381		0.26	0.6	0.06	0.92	0.15	0.34	0.24	0.73
Inga tessmannii Harms 1551		0.39	0.6	0.38	1.37	0.23	0.51	0.07	0.81
Inga vismiifolia Poeppig 5242	L	1.11	1.2	0.44	2.76	0.98	1.53	1.85	4.35

	Charateristic species	High restinga				Low restinga			
		Relative density	Relative frequency	Relative dominance	SIV	Rel. den	Rel. fre	Rel. dom	SIV
Inga unidentified		0.07	0	0.4	0.47	–	–	–	–
Zygia inaequalis (H. and B. ex Willd.) Pittier 8148		–	–	–	–	0.23	0.34	0.48	1.05
Zygia juruana (Harms) L. Rico 1467	L	0.13	0.3	0.48	0.91	1.96	1.7	4.79	8.45
Moraceae									
Brosimum guianense (Aublet) Huber 1333		0.13	0.3	0.03	0.46	0.15	0.17	0.02	0.34
Brosimum lactescens S. Moore 4097		0.07	0.15	0.28	0.49	–	–	–	–
Clarisia biflora R. & P. 1049		0.26	0.45	0.22	0.93	–	–	–	–
Ficus maxima Miller N217296		0.59	0.75	0.63	1.97	0.08	0.17	0.01	0.25
Ficus paraensis (Miquel) Miquel 1364		0.07	0.15	0.07	0.28	–	–	–	–
Maclura tinctoria ssp. *tinctoria* (L.) Steudel N407489		0.07	0.15	0.03	0.25	–	–	–	–
Maquira coriacea (Karsten) C. C. Berg 2018	H	3.28	1.5	2.62	7.4	0.3	0.51	0.41	1.23
Naucleopsis glabra Spruce ex Pittier N307160	H	1.25	1.2	0.53	2.98	0.08	0.17	0.11	0.36
Perebea longipedunculata C. C. Berg 1217	R	2.56	1.5	3.11	7.17	0.98	1.19	1.37	3.54
Sorocea steinbachii C. C. Berg 1141	H	2.62	1.5	3.7	7.82	0.75	1.36	0.8	2.91
Trophis racemosa (L.) Urban 2106		0.26	0.6	0.65	1.51	0.23	0.34	0.9	1.46
Myristicaceae									
Iryanthera juruensis Warburg 7467	L	0.26	0.45	0.13	0.84	2.41	1.02	3.58	7.01
Virola elongata (Bentham) Warburg 6500		0.2	0.3	0.47	0.97	0.23	0.51	0.26	1
Virola pavonis (A. DC.) A. C. Smith 8454		0.79	1.05	0.53	2.37	0.45	0.68	0.52	1.65
Virola unidentified		0.07	0	0.21	0.27	–	–	–	–
Myrsinaceae									
Stylogyne sp. 3463		0.26	0.3	0.28	0.84	0.98	1.19	0.72	2.89
Myrtaceae									
Calyptranthes sp. 9388		0.39	0.6	0.49	1.48	0.3	0.68	0.7	1.68
Calyptranthes sp. 2 N219309		0.13	0.3	0.46	0.89	–	–	–	–
Eugenia marowijensis Miquel 2351		0.26	0.6	0.37	1.23	0.3	0.68	0.34	1.32
Eugenia muricata DC. 1091		0.2	0.45	0.32	0.97	0.3	0.51	0.13	0.94
Eugenia ochrophloea Diels 4347	L	0.66	0.9	0.71	2.26	2.03	1.7	2.53	6.27
Eugenia patens Poiret N109216		0.07	0.15	0.05	0.27	0.23	0.51	0.16	0.9
Eugenia sp. 2 1190		0.07	0.15	0.01	0.22	0.15	0.34	0.42	0.91
Eugenia sp. 4 9045		0.2	0.3	0.08	0.58	0.68	1.02	0.24	1.94
Eugenia sp. 6 5503		–	–	–	–	0.23	0.51	0.01	0.75
Eugenia unidentified		–	–	–	–	0.08	0	0.42	0.5
Marlierea subulata McVaugh 7519		–	–	–	–	0.08	0.17	0	0.25
Myrcia sp. 5 7347	L	–	–	–	–	0.9	1.19	1.03	3.12
Myrcia sp. 7 8299		–	–	–	–	0.53	0.51	0.67	1.7
Myrciaria floribunda (West ex Willdenow) O. Berg 7045		–	–	–	–	0.08	0.17	0.09	0.34
Nyctaginaceae									
Neea floribunda Diels 8667	R	1.38	1.65	1.33	4.36	1.66	1.53	1.34	4.52
Neea sp. 9089		–	–	–	–	0.23	0.34	0.59	1.16
Ochnaceae									
Ouratea sp. 5256		0.13	0.3	0.02	0.45	0.3	0.51	0.11	0.92
Olacaceae									
Cathedra acuminata (Bentham) Miers 7397		0.07	0.15	0.03	0.24	0.08	0.17	0.34	0.59
Heisteria acuminata (Humboldt and Bonpland) Engler N807283		6.16	1.8	0.93	8.89	9.5	2.04	2.29	13.82
Heisteria spruceana Engler 5599		–	–	–	–	0.45	0.51	0.06	1.03
Minquartia guianensis Aublet 2223		0.39	0.75	0.69	1.84	0.08	0.17	0.09	0.33
Passifloraceae									
Dilkea sp.		0.07	0.15	0.01	0.22	–	–	–	–
Polygonaceae									
Coccoloba densifrons C. Martius ex Meissner 5274	L	0.72	1.05	0.73	2.5	1.66	1.19	1.83	4.68
Coccoloba lehmannii Lindau 9006		–	–	–	–	0.08	0.17	0.12	0.36
Coccoloba mollis Casaretto 2019		0.07	0.15	0.45	0.66	0.08	0.17	0.01	0.25
Coccoloba sp. 3 9042		0.2	0.45	0.21	0.86	0.3	0.34	0.45	1.09
Triplaris amaricana L. 2122		0.2	0.45	0.07	0.72	–	–	–	–
Quiinaceae									
Quiina sp. 8398		0.13	0.3	0.01	0.45	0.15	0.34	0.1	0.59
Rubiaceae									
Alibertia edulis (Richard) A. Richard ex DC. 9166		0.07	0.15	0.02	0.24	0.45	0.68	0.15	1.28
Alibertia sp. N407523		0.2	0.3	0.04	0.53	–	–	–	–
Borojoa sp. 1 1552		–	–	–	–	0.3	0.51	0.31	1.12
Chomelia barbellata Standley 1416		0.13	0.3	0.21	0.64	0.23	0.51	0.21	0.94
Coussarea brevicaulis Krause 9385	R	1.64	1.65	1.2	4.48	2.79	1.36	2.12	6.26
Faramea sp. 1		–	–	–	–	0.15	0.17	0.02	0.34
Faramea sp. 2		–	–	–	–	0.15	0.17	0.03	0.35
Posoqueria sp. 1 N219479		0.66	0.75	0.22	1.63	0.08	0.17	0.06	0.3
Posoqueria sp. 2		0.07	0.15	0.03	0.25	–	–	–	–
Psychotria marginata Swartz 1246		0.85	1.2	0.32	2.37	0.15	0.34	0.35	0.84
Psychotria mathewsii P.C. Standley		–	–	–	–	0.08	0.17	0.11	0.36
Psychotria remota Bentham 1365		0.2	0.45	0.34	0.98	0.53	0.85	0.11	1.49
Psychotria stenostachya Standley N417200		0.72	0.75	0.04	1.51	–	–	–	–
Randia armata (Swartz) DC. 8457		0.33	0.6	0.12	1.05	0.15	0.34	0.36	0.85
Rondeletia sp. N309246	H	2.49	1.65	0.73	4.87	0.3	0.68	0.03	1.01
Rudgea sessiliflora Standley N821419	L	–	–	–	–	4.9	1.87	0.43	7.19
Simira sp. 9731		–	–	–	–	0.15	0.34	0.07	0.56
Sapindaceae									
Cupania latifolia H. B. K. 1507		–	–	–	–	0.08	0.17	0.1	0.35
Talisia sp. 1 N317266	H	0.92	1.05	0.8	2.77	0.53	0.85	0.53	1.91

	Charateristic species	High restinga				Low restinga			
		Relative density	Relative frequency	Relative dominance	SIV	Rel. den	Rel. fre	Rel. dom	SIV
Talisia sp. 2 N317267		0.33	0.6	0.3	1.23	0.23	0.51	0.08	0.82
Unidentified sp. 5548		–	–	–	–	0.45	0.51	0.14	1.1
Sapotaceae									
Chrysophyllum argenteum ssp. *auratum* (Miquel) Pennington 5295		0.26	0.45	0.14	0.85	0.3	0.68	0.16	1.14
Chrysophyllum sp. 1 3282		0.26	0.6	0.68	1.54	–	–	–	–
Pouteria cuspidata ssp. Dura (Eyma) Pennington 5128		0.2	0.3	0.12	0.61	–	–	–	–
Pouteria reticulata (Engler) Eyma 2004	L	0.66	1.2	0.49	2.34	1.21	1.36	2.21	4.77
Pouteria unidentified		–	–	–	–	0.15	0	0.4	0.55
Sarcaulus brasiliensis ssp. *brasiliensis* (A. DC.) Eyma 2336		1.18	1.2	0.86	3.24	0.9	0.68	1.18	2.76
Simaroubaceae									
Picramnia magnifolia J.F. Macbr. N909191		–	–	–	–	0.08	0.17	0.08	0.33
Picramnia sellowii ssp. *spruceana* (Engler) Pirani N819372		0.39	0.6	0.02	1.01	0.15	0.34	0.04	0.53
Simaba orinocensis H.B.K. N409099		0.07	0.15	0	0.22	–	–	–	–
Solanaceae									
Cyphomandra sp.		0.07	0.15	0.08	0.3	–	–	–	–
Solanum sp. 4	L	0.79	0.75	0.14	1.68	3.17	1.87	0.74	5.78
Solanum sp. 8		0.2	0.45	0.02	0.67	0.08	0.17	0	0.25
Sterculiaceae									
Herrania sp.		0.2	0.45	0.04	0.69	0.15	0.34	0.07	0.56
Sterculia sp. 3492		0.33	0.15	0.05	0.53	–	–	–	–
Theobroma cacao L. 2016		0.2	0.45	0.8	1.45	–	–	–	–
Theophrastaceae									
Clavija sp. N219467		0.33	0.6	0.04	0.96	–	–	–	–
Tiliaceae									
Luehea cymulosa Spruce ex Bentham 7084		–	–	–	–	0.53	0.51	1.1	2.13
Vasivaea sp. 6556		–	–	–	–	0.08	0.17	0.12	0.37
Violaceae									
Gloeospermum equatoriense Hekking 2168	H	4.06	1.8	5.5	11.37	0.45	0.68	1.3	2.43
Leonia glycycarpa Ruiz Lúpez & Pavún 2027	H	4.78	1.8	10.1	16.69	0.53	0.68	0.67	1.88
Unidentified									
Unidentified		0.72	0	0.54	1.26	2.11	0	1.87	3.98
Total absolute values		1526	667	1.69		1327	589	1.53	

Appendix B.

Classification of species according to maximum DBH $_{(\mathrm{DBHmax})}$ recorded in restinga. Only species present with more than 10 individuals are considered. Species within groups are ordered alphabetically.

DBHmax < 10 cm

Bactris sp.
Coussarea brevicaulis Garcinia madruno Heisteria acuminata Naucleopsis glabra
Picramnia sellowii ssp. spruceana *Posoqueria sp. 1*
Psychotria stenostachya Rondeletia sp. Rudgea sessiliflora Solanum sp. 4 Tabernaemontana markgrafiana Talisia sp. 1
Tococa coronata Tococa sp.

10 cm < $_{\mathrm{DBHmax}}$ < 25 cm

Anaxagorea sp.
Astrocaryum murimuri Borojoa sp. Byrsonima densa Capparis sola Casearia aculeata Casearia sylvestris Cecropia ficifolia Chomelia barbellata
Chrysophyllum argenteum ssp. auratum *Coccoloba densifrons Cordia nodosa*
Couroutari oligantha Crematosperma sp. Diospyros sp. 1 Eugenia marowijensis
Eugenia muricata Eugenia sp. 4 Euterpe precatoria Ficus maxima
Gloeospermum equatoriense Hirtella triandra ssp. triandra *Inga cinnamomea*
Inga tessmannii Iryanthera juruensis Laetia corymbulosa Leonia glycycarpa Malmea sp. Matisia bracteolosa Myrcia sp. 5 *Neea floribunda Ocotea javitensis Parinari parilis*
Perebea longipedunculata Pleurothyrium parviflorum Pseudoxandra polyphleba Psychotria marginata Psychotria remota Pterocarpus amazonum Pterocarpus sp. 1 Randia armata Rollinia cuspidata
Socratea exorhiza Sorocea steinbachii Stylogyne sp.
Swartzia cardiosperma Swartzia simplex Theobroma cacao Trichilia rubra Triplaris amaricana Trophis racemosa Zygia juruana

25 cm < DBHmaX < 125 cm

Alchornea schomburgkii Andira inermis Aniba sp. 1
Astrocaryum jauari Calatola venezuelana Calyptranthes sp. 1 Casearia arborea
Cathedra acuminata Cecropia membranacea Cedrela odorata Clarisia biflora Cordia lutea Croton cuneatus Cupania latifolia
Drypetes amazonica var. *peruviana Duguetia spixiana Eschweilera parvifolia Eschweilera turbinata*
Eugenia ochrophloea aff. Ficus killipii Garcinia macrophylla Guatteria sp. 1
Himatanthus bracteatus Inga edulis
Inga nobilis Inga semialata Inga stenoptera Inga vismiifolia Luehea cymulosa Maytenus macrocarpa Minquartia guianensis Mouriri grandiflora Nectandra cuneato-cordata
Ocotea cernua Oxandra sphaerocarpa Platymiscium stipulare Pourouma acuminata
Pourouma cecropiifolia Pouteria reticulata Protium nodulosum Sapium glandulosum Sapium marmierii
Sarcaulus brasiliensis ssp. brasiliensis Scheelea cephatotis Sloanea guianensis Spondias mombin sens. *lat. Sterculia sp.*
Trichilia pleeana Unonopsis floribunda Virola elongata Virola pavonis Xylopia micans Xylopia sp. 1
Zygia cauliflora

75 cm DBHmax > 125 cm

Brosimum lactescens Calycophyllum spruceanum Ceiba samauma Coccoloba sp. 3
Guarea macrophylla Hura crepitans Licania britteniana Maquira coriacea Terminalia oblonga