CHAPTER 5

Floristic Composition and Growth Habits of Plants in Understory, Natural, Treefall Gaps and Fire-Disturbed Areas of a Tropical Forest in Southern Bahia, Brazil

Adriana Maria Zanforlin Martini, Jomar Gomes Jardim,
and Flavio Antonio Maës dos Santos

Abstract

Martini, A. M. Z. (Departamento de Ciências Biológicas, Universidade Estadual de Santa Cruz, Ilhéus, BA, Brazil. Current Address: Universidade Federal de São Paulo – Campus Diadema, Rua Prof. Artur Riedel, 275, Bairro Eldorado, 09972-270 Diadema, SP, Brazil. E-mail: amzmartini@uol.com.br); J. G. Jardim (Programa de Pós-Graduação em Botânica, Departamento de Ciências Biológicas, Universidade Estadual de Feira de Santana, Av. Universitária s/n - Km 03 da BR 116, Campus Universitário, 44031-460 Feira de Santana, BA, Brazil. E-mail: j.jardim@yahoo.com.br) and F. A. M. dos Santos (Departamento de Botânica, Universidade Estadual de Campinas, C.P.

6109, 13083-970 Campinas, SP, Brazil, fsantos@ unicamp.br). Floristic Composition and Growth Habits of Plants in Understory, Natural, Treefall Gaps and Fire-Disturbed Areas of a Tropical Forest in Southern Bahia, Brazil. Mem. New York Bot. Gard. 100: 147–192. 2008.—In spite of the increasing number of studies on nonarboreal as well as arboreal species in tropical forests, few have analyzed all of the various growth habits encountered at disturbed sites. This chapter presents a floristic survey of six natural treefall gaps, six understory areas adjacent to these gaps, six plots in a burned area (5 yrs old), and six plots in the understory of an intact forest near the burned area. The study was conducted at the Una Biological Reserve, southern Bahia, Brazil. Six 1-m^2 subplots were laid out randomly, and all vascular plants between 0.2 and 5 m tall were surveyed. A total of 1288 individuals were identified, distributed among 291 species, 165 genera, and 69 families. Myrtaceae, Rubiaceae, and Fabaceae were the richest families in the treefall gaps and the understory areas, whereas Melastomataceae and Asteraceae showed the greatest species richness in the burned areas. *Psychotria purpurascens*, *Evodianthus funifer*, and *Philodendron surinamense* were among the most abundant species in treefall gaps and understory areas. In the burnt area, 50.5% of the species observed were exclusive to that habitat, and the three most abundant species (*Scleria secans*, *Pteridium aquilinum*, and *Miconia mirabilis*) were observed only in that habitat. Among the 10 growth habits analyzed, trees constituted the predominant form, both in terms of individuals (27%) and species (33.6%). For each arboreal individual surveyed in a given area, 2.7 individuals of other growth habits were also present. Likewise, for every tree species, 2 nontree species were observed. These relationships were similar among the four habitats, although the burnt area showed a distribution of growth habits that was quite distinct. It had more individuals of scandent plants and vines and fewer individuals of hemiepiphytes than expected by chance. Moreover, in terms of number of species, the burnt habitat showed lower numbers of trees, vines, scandent plants, and herbs. Hemiepiphytes were very abundant in the treefall gaps and the adjacent understory. These results confirm extremely high species richness in the study area, and highlight the need to include more growth habits in floristic surveys in order to better understand the floristic composition and the successional patterns of disturbed habitats.

Resumo

Martini, A. M. Z. (Departamento de Ciências Biológicas, Universidade Estadual de Santa Cruz, Ilhéus, BA, Brazil. Current Address: Universidade Federal de São Paulo—

Campus Diadema, Rua Prof. Artur Riedel, 275, Bairro Eldorado, 09972-270 Diadema, SP, Brazil. E-mail: amzmartini@uol.com.br); J. G. Jardim (Programa de Pós-Graduação em Botânica, Departamento de Ciências Biológicas, Universidade Estadual de Feira de Santana, Av. Universitária s/n—Km 03 da BR 116, Campus Universitário, 44031-460 Feira de Santana, BA, Brazil, j.jardim@yahoo.com.br); e F. A. M. dos Santos (Departamento de Botânica, Universidade Estadual de Campinas, C.P. 6109, 13083-970 Campinas, SP, Brazil, fsantos@unicamp.br). Floristic Composition and Growth Habits of Plants in Understory, Natural, Treefall Gaps and Fire-Disturbed Areas of a Tropical Forest in Southern Bahia, Brazil. Mem. New York Bot. Gard. 100: 147–192. 2008.— Apesar do crescente número de trabalhos realizados com toda a comunidade de plantas incluindo todos os hábitos de crescimento, em florestas tropicais, poucos estudos têm considerado os diferentes hábitos de crescimento em ambientes com diferentes graus de perturbação. No presente estudo foram amostradas seis clareiras naturais, seis áreas de sub-bosque adjacentes a estas clareiras, seis parcelas em uma área queimada há cerca de cinco anos e seis parcelas no sub-bosque de uma área de floresta próxima à área queimada, na Reserva Biológica de Una, região Sul do estado da Bahia, Brasil. Em cada parcela, todos os indivíduos de plantas vasculares entre 20 cm e 5 m de altura foram amostrados em 6 subparcelas de 1 m^2. Estes indivíduos foram identificados e classificados quanto ao hábito de crescimento. Foram classificados 1288 indivíduos, pertencentes a 291 espécies, 165 gêneros, e 69 famílias. Nas áreas de clareiras e nos sub-bosques as famílias mais ricas foram Myrtaceae, Rubiaceae, e Fabaceae. Na área queimada, as famílias Melastomataceae e Asteraceae apresentaram maior número de espécies. *Psychotria purpurascens*, *Evodianthus funifer*, e *Philodendron surinamense* estiveram entre as espécies mais abundantes nas áreas de clareiras e sub-bosque. Na área queimada 50,5% das espécies observadas foram exclusivas daquele ambiente, indicando uma composição florística bastante diferenciada neste ambiente. Além disso, as três espécies mais abundantes na área queimada, *Scleria secans*, *Pteridium aquilinum*, e *Miconia mirabilis*, ocorreram apenas neste ambiente. Em relação aos 10 hábitos de crescimento analisados, as espécies arbóreas representaram 27% dos indivíduos e 33,6% das espécies amostradas. Foi observado que para cada indivíduo de espécie arbórea amostrado, outros 2,7 indivíduos dos outros hábitos de crescimento estavam presente e para cada espécie arbórea amostrada, 2 espécies não-arbóreas foram observadas. Estas relações foram aparentemente similares nos quatro ambientes analisados. Entretanto, a área queimada apresentou uma distribuição de indivíduos e espécies por hábito de crescimento bastante diferenciada dos demais ambientes, tendo sido observado neste ambiente um número significativamente menor de

indivíduos de hemiepífitas e significativamente maior de indivíduos de plantas escandentes e trepadeiras herbáceas. Em relação ao número de espécies, foi observado na área queimada um número significativamente menor de espécies arbóreas, trepadeiras herbáceas, plantas escandentes e herbáceas, do que seria esperado ao acaso. Por outro lado, as hemiepífitas foram muito abundantes nas áreas de clareiras e de sub-bosque adjacente a estas. Os resultados apresentados confirmam a altíssima riqueza de espécies na região estudada e destacam a importância de incluir espécies de hábitos não-arbóreos na caracterização florística de uma região e na compreensão do processo de sucessão em ambientes perturbados.

Introduction

In general, tropical rain forests do not show sharp discontinuities in their vertical structure (Richards, 1996) due to the presence of tree species in every size class, as well as to the dynamic structure of the forests with contiguous areas in different stages of development (Whitmore, 1998). The division of the forest into horizontal layers, although representing a certain simplification or abstraction (Whitmore, 1998), can be useful to describe and analyze the forest structure or to compare different habitats, if the limits of layers are clearly and unequivocally defined.

In practice, the lower stratum of a forest is defined as the assemblage of plants found in the lowest 5 m, including young individuals of arboreal species as well as individuals of all the other growth habits of vascular plants. The upper stratum represents the assemblage of plants more than 5 m above the forest floor.

The assemblage of plants in the lower stratum has received more attention in recent decades due to specific surveys of the herbaceous/shrub vegetation (Gentry & Dodson, 1987; Poulsen & Balslev, 1991; Dirzo et al., 1992; Poulsen, 1996; Laska, 1997); studies on plant interactions within this stratum (Davis et al., 1998; Becker et al., 1999); and studies relating plants in the lower stratum with those in upper stratum (Gilliam et al., 1995; Galeano et al., 1998; Webb & Peart, 2000).

A large number of growth habits are found within the lower stratum, and according to Gilliam et al. (1995) these plants can be classified into two groups. The first group is formed by "resident" species, which are herbs, creepers, or shrubs whose entire lives are spent in the lower stratum. The second group is formed by "transient" species, such as trees, lianas, and hemiepiphytes that initiate their lives on the forest floor but have the potential to reach the upper stratum. Studies directed specifically towards resident plants have revealed that this herbaceous/shrub vegetation may account for up to 50% of the total number of species present in a given area of tropical forest (Gentry & Dodson, 1987; Schnitzer & Carson, 2000). Some regions already known for their high richness of arboreal species have also demonstrated a similar richness in the lower stratum, to the point of doubling the number of species previously registered (Gentry & Dodson, 1987; Galeano et al., 1998).

Besides their contribution to the structure and composition of the forests, herbaceous and shrub species are also extremely important to the fauna that live in the forest understory (Gentry & Emmons, 1987). Nonetheless, the biology and ecology of these plant species are little known, except for a few studies that have focused on their reproduction (Greig, 1993; Nicotra, 1999; Villegas, 2001); root architecture (Poulsen, 1996; Becker et al., 1999); or herbivory (Marquis, 1992; Marquis et al., 1997).

Past studies have usually been conducted in environments that have suffered little or no disturbance. Studies of the responses of resident plant communities to natural (Denslow et al., 1990; Dirzo et al., 1992) or anthropic disturbances (Rico-Gray & García-Franco, 1992) are relatively rare. Natural disturbances may more directly affect the transient species because they can rapidly respond to the formation of treefall gaps and grow to reach the upper canopy. Resident understory plants may pass their entire lives in the shade and, therefore, are less dependent on gap formation. The relationships between resident and transient species in disturbance situations may be quite distinct from their relationships in undisturbed habitats, although researchers have generally ignored this area of research.

The transient species in the lower forest stratum (as defined by Gilliam et al., 1995) interact strongly with the resident species in terms of their competition for both aboveground and root space (Becker et al., 1999) and for light and nutrients (Bigelow, 1993; Davis et al., 1998). These interactions have presumably shaped the characteristics of these groups, allowing the coexistence of extremely large assemblages of species in tropical forests.

The interactions that occur within the lower stratum are fundamental in determining which of the transient species will replenish the natural stock of arboreal species in the upper and lower canopies. In events of natural disturbances in the forest canopy, the species present in the transient group are most likely to occupy the space opened by the fallen tree(s). Uhl et al. (1988) observed that the plants with the greatest chance of occupying the canopy openings are those more than 1 m tall or those that resprout immediately after the tree fall.

Studies that considered only the arboreal flora, specifically the young individuals, encountered a basically similar floristic composition in both the treefall gaps and the understory (Barton, 1984; Brokaw & Busing, 2000a), with the exception of some pioneer tree species (Brokaw & Busing, 2000b).

Discussions concerning the influence of treefall gaps on the composition and diversity of tropical forests have been based largely on arboreal surveys. Schnitzer & Carson (2000) found these conclusions to be premature, because studies characterizing the herbaceous plant/shrub strata and other life-forms present in gaps are relatively rare. For some groups, such as the lianas, there is strong evidence of a differential utilization of the gap habitat (Putz, 1984; Schnitzer et al., 2000).

Disturbances of greater intensity, such as fire, can profoundly modify the structure and composition of the vegetation (Kennard et al., 2002), principally of the lower stratum, which is generally eliminated by the flames. It is important to consider that fire is not a natural component of humid forest environments, in contrast to other vegetation types such as the cerrado (Brazilian savanna). In humid forests, the combustion potential is normally quite low, because the microclimate in the lower stratum provides a high relative humidity and mild temperatures (Uhl et al., 1990). As a consequence, very few humid forest species would be expected to retain characteristics that allowed them to resist burning.

A fire results in the liberation of physical space as well as a great increase in the availability of essential nutrients in the ash. Both of these factors can greatly benefit the first wave of colonizing species (Vinha et al., 1983; Uhl & Jordan, 198; Kennard et al., 2002). Characteristics such as the capacity for vegetative propagation or stump-sprouting, as well as the breaking of seed dormancy by heat, tend to favor the colonization of fire-disturbed areas by certain groups of plants. Thus, the dominant species in burned habitats would be expected to differ from those encountered in undisturbed areas.

Besides the alterations in the floristic composition as a result of burning, there is also an accumulation of dead woody material (fallen bark, branches, and trunks). This material serves as a physical support that may favor the establishment of groups of support-dependent plants such as lianas, scandent plants, and hemiepiphytes that would be expected to occur in large numbers in these habitats.

Similarly, the predominance of herbaceous species during the initial stages of secondary succession after intense disturbances in tropical regions and their gradual replacement by woody plants and lianas have been well documented (Stroomgaard, 1986; Rico-Gray & García-Franco, 1992; Guariguata & Ostertag, 2001).

An important factor to be considered in modeling succession after the passage of fire is the matrix of landscapes in which the altered area is found (Rico-Gray & García Franco, 1992). The proximity of intact natural areas can significantly accelerate regeneration by serving as a source of diaspores (Guariguata & Ostertag, 2001). On the other hand, the absence of diaspore sources can result in a stagnation of the successional processes, so the first colonizing plants continue to dominate the site.

In the southern region of the state of Bahia, northeastern Brazil, it is a common practice to use fire for managing agricultural areas. The complex environmental mosaic in this region often aligns areas of intense agricultural activities with forest fragments, and the accidental passage of fire to these forested areas represents a serious risk to their conservation.

The arboreal component of this southern Bahian vegetation has been studied in detail (Gouvêa et al., 1976; Martini et al., 2007; Mori et al., 1983b; Thomas et al., 1998, Chap. 3; Veloso, 1946 a, 1946b, 1946c), but only rarely have the herbaceous/shrub components or support-dependent plants been examined (Amorim et al., Chap. 4). Quantitative studies concerning the effects of natural or anthropic disturbances on this vegetation type are also rare (Vinha et al., 1983).

Our study sought to better understand the structure of tropical forests by quantifying the vegetational characteristics of their lower stratum. It also sought to determine the effects of natural disturbances (treefall gaps) as well as anthropic disturbances (fire) on the floristic composition and the distribution of growth forms in this stratum.

Study Area

This study was undertaken in the Una Biological Reserve, located in the municipality of Una, Bahia, Brazil (15° 10' S and 39° 03' W). The Reserve occupies approximately 11,400 ha, and 78% of its area is considered well-conserved forest (Marques et al., 2002). The remaining areas were recently disturbed or are undergoing regeneration. The climate is classified as type Af in the system of Köppen (1936) and is characterized by the absence of a definite dry period (Figure 5-1) and a yearly total rainfall greater than 1300 mm (Mori et al., 1983b).

The soils in the study area are predominately red/yellow latosols, variation Colônia (Typic Haplortox). They are nutrient poor, although exhibiting a good physical structure (IBAMA/MMA, 1998).

The Reserve is situated within the Mata Atlântica domain and is composed predominately of Floresta Ombrófila Densa de Terras Baixas (IBGE, 1992). It was classi-

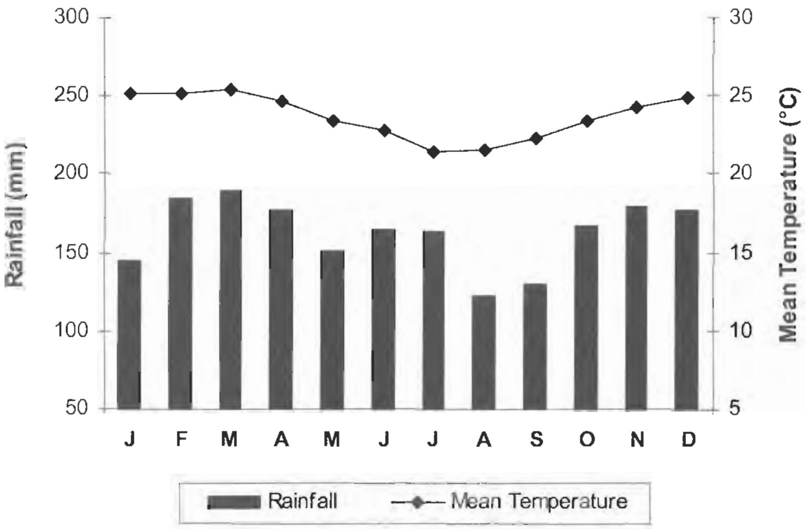

Fig. 5-1. Historical series of rainfall amounts and mean temperatures, Una, Bahia, Brazil (1968–2002). Data from CEPLAC/CEPEC/Climatologia.

fied by Gouvêa et al. (1976) as Mata Higrófila Sul-Baiana (Southern Bahian Humid Forest).

Materials and Methods

All natural gaps within a 3-ha area of forest (Figure 5-2, Area 1) in the Una Biological Reserve were mapped. Gaps were defined as open areas in the canopy that represented a discontinuity in the vertical gradient of the forest. They are generally associated with fallen trees. Only gaps where the vegetation was up to 5 m tall and/or where the trees had a maximum diameter of 8 cm at ground level were considered.

Among these gaps, six of the largest and most recent (determined by the presence of thin twigs, or sometimes even dry leaves, on the terminal branches of the principal fallen tree) were chosen for study. In order to calculate the area of the gaps, their centers were determined visually, and the distance between the two trees (diameter at ground level greater than 8 cm) at the furthest opposite edges were measured. The distance between the two trees in an axis perpendicular to the first one was then measured. In order to make comparisons with the literature, the area of the gap was estimated using the formula for an ellipse, but the sample area was a lozenge. The area of the treefall gaps in this study varied from 65.4 to 260.9 m^2. Adjacent to each of the

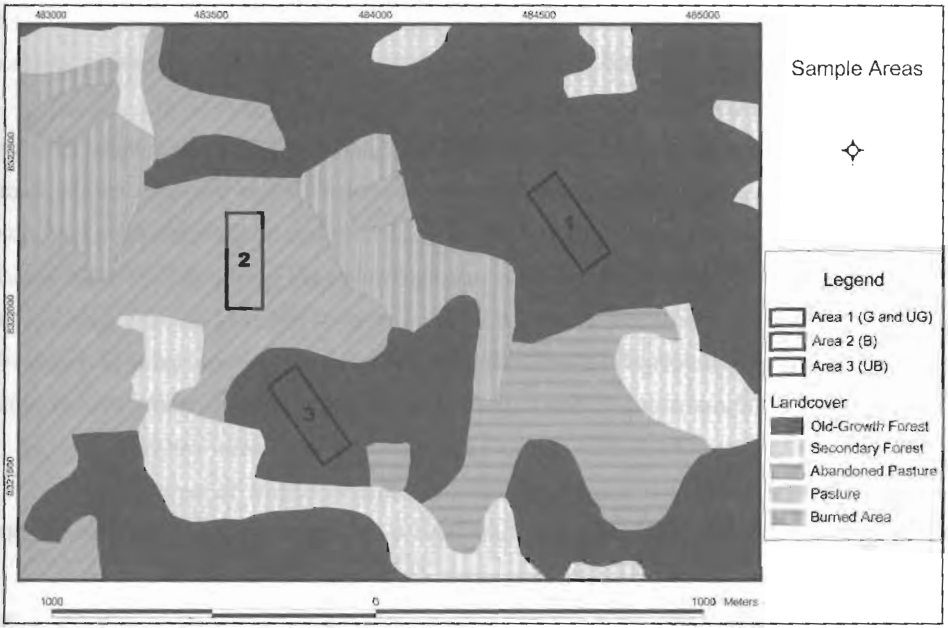

Fig. 5-2. Diagram of landcover and sample areas within Una Biological Reserve, Bahia, Brazil. The treefall gap (G) and understory near gap (UG) plots are located in Area 1, the burned area (B) plot in Area 2, and the understory near burned area (UB) plots in Area 3.

six gaps, a sample plot of equal area was established in the forest understory at a minimum distance equivalent to the larger diameter of that respective gap.

Six sample plots were also established within an area of forest that was burned during an accidental fire in February 1995 (Figure 5-2, Area 2) and was located approximately 1 km from Area 1 described above. Additionally, six other sample plots were established in the understory of a forest area approximately 200 m from the burned area (Figure 5-2, Area 3). The sample plots at the burned area and the forest understory near burned area were laid out following the same spatial distribution and with the same areas as the six gaps of Area 1.

The sampling habitats thus defined will be referred to as follows: treefall gaps (G), understory near gaps (UG), burned area (B), understory near burned area (UB).

Within each sample plot, six 1-m^2 subplots were randomly selected (total of 36 in each habitat), and all plants between 0.2 and 5 m tall were surveyed. Because, by definition, there were no plants taller than 5 m or with a diameter greater than 8 cm to be found within the treefall gaps, any randomly located 1-m^2 subplot that contained plants exceeding these limits in the other three habitats was eliminated. In these cases, another randomized 1-m^2 location was surveyed in its place. Likewise, any randomly located 1-m^2 subplot that had more than 10% of its area occupied by fallen trunks or branches was eliminated, and another randomized location was surveyed in its place. The total sampled area was 144 m^2.

All surveys were undertaken between January and May 2000. Plants were identified by comparisons to herbarium specimens stored at the Centro de Pesquisas do Cacao (CEPEC) herbarium, according to the classification system elaborated by Cronquist (1981), with modifications by the Angiosperm Phylogeny Group (1998). All botanical material collected was deposited in the CEPEC herbarium. The growth habits of the plants were classified according to the definitions adopted by Amorim et al. (Chap. 4), based on field observations in the region. Ten different growth habits were encountered in this study:

Trees (TR). Woody plants whose adults have a dbh greater than 15 cm and heights greater than 6 m.

Treelets (TL). Woody plants whose adults have a dbh no greater than 15 cm and heights between 4 and 10 m.

Shrubs (SH). Woody plants of medium size with branches near the base of the trunk.

Subshrubs (SS). Small woody plants with branches at the base of the trunk (soil level).

Herbs (HE). Small, terrestrial, nonwoody plants.

Woody vines (WV). Large climbing plants with woody stems, often with anomalous structures.

Vines (VI). Climbing plants without a woody stem, always fixed in the ground and with most of the aboveground structure formed by the stem.

Hemiepiphytes (HP). Climbing herbaceous plants usually fixed in the ground and with many clinging roots and most of the aboveground structure formed by aerial roots.

Scandent plants (SC). Shrub-like plants with long branches lacking sufficient support to remain erect.

Epiphytes (EP). Plants dependent on external support and without any connection to the soil.

DATA ANALYSIS

The number of individuals within each major taxonomic group (monocotyledons, dicotyledons, and pteridophytes) was compared among the four habitats studied. The chi-square test was used to determine if there was an equal distribution of individuals in each group.

The chi-square test was also used to verify differences in the proportion of individuals of each growth form among the four habitats studied. The differences between the values expected and the values observed for each value of the contingency table (habitat×growth habit) were classified in decreasing order. The 10 largest deviations are presented, indicating the most important differences in abundance in each habitat.

To verify if the number of species of each growth habit varied among the habitats, a mean species accumulation curve was elaborated, based on the total number of species observed in each habitat and their respective abundances. This curve was constructed using the mean number of species obtained in 1000 repetitions for a predetermined number of individuals (10, 20, 30, etc.) using the "independent sampling" method of the EcoSim program Version 6.0 (Gotelli & Entsminger, 2001).

Using this method, it is possible to estimate how many species would be expected for a given number of individuals, and what would be the variation expected (confidence intervals, CIs) by chance. If the actual number of species observed for a given number of individuals in any of the habitats is less than the CI value, it would indicate that habitat was imposing limitations on the establishment of some species of a particular growth habit. In this way, it is possible to evaluate if the number of species of any particular growth habit encountered in any given habitat differs significantly from the number of species expected at random and independent of the number of individuals sampled.

The growth habits of the plants were aggregated into two groups, as suggested by Gilliam et al. (1995): a resident group composed of herbs, shrubs, subshrubs, and scandent plants and a transient group composed of trees, treelets, vines, woody vines, hemiepiphytes, and epiphytes. The numbers of individuals and species in each of these two groups were compared using the chi-square test with Yates correction (Zar, 1999).

Likewise, the arboreal species were separated from the other growth habits, and the numbers of individuals and species in these two groups were compared in each of the different habitats using the chi-square test with Yates correction (Zar 1999).

Results

Our survey recorded a total of 1312 individuals. Of these, 24 could not be identified or separated into morphospecies due to the condition of the plants when collected.

These plants were treated as "incertae sedis" (12 individuals) or "ni" (12 individuals), indicating that a preliminary identification at the family or genus level was possible, but they could be either a new species or a species already described but in another growth stage (see Appendix 5-1). The results presented here, therefore, will refer only to the 1288 positively identified individuals encountered.

Of the total number of individuals, 755 (58.6%) were dicotyledons, 474 (36.8%) were monocotyledons, and 59 (4.6%) were pteridophytes. Their proportions were similar among the four habitats studied ($\chi^2=6.726$, df=6, p=0.347).

Considering the four habitats together, 291 species were encountered, distributed among 165 genera and 69 families (Table 5-1). Among these species, 238 (81.8%) were dicotyledons, 44 (15.1%) were monocotyledons, and 9 (5.1%) were pteridophytes. These proportions were maintained in the four different habitats. These results indicate that the monocotyledons, although representing a relatively small proportion of the species present in the area, were responsible for a large number of individuals, probably due to high abundance of a few species. The opposite is true for the dicotyledons.

Among the 291 species encountered, 186 (64%) were identified to the species level, 86 (30%) only to the genus level, and 19 (6%) to the family level (see Appendix 5-1).

The numbers of families varied little among the four habitats, although the numbers of genera and species were larger in the treefall gaps and smaller in the burned areas. However, these differences may reflect only the differences in the absolute number of individuals encountered in these habitats (Table 5-1).

TABLE 5-1

Numbers of individuals at different taxonomic levels observed in the habitats sampled within the Una Biological Reserve, Bahia, Brazil. Habitats: G=Treefall gaps, UG=Understory near gaps, B=Burned area, UB=Understory near burned area.

HABITAT	INDIVIDULS	INDIV. NOT IDENTIFIED	FAMILIES	GENERA	SPECIES
G	353	8	52	100	138
UG	330	6	49	92	129
B	293	2	46	75	103
UB	312	8	49	80	113
TOTAL	1288	24	69	165	291

TABLE 5-2

Numbers of species of the richest families in the four habitats studied in the Una Biological Reserve, Bahia, Brazil with the ranking of the family within each habitat in parentheses.

FAMILY	TOTAL	TREEFALL GAPS	UNDERSTORY NEAR GAPS	BURNED AREA	UNDERSTORY NEAR BURNED AREA
MYRTACEAE	31 (1)	12 (1)	12 (2)	6 (3)	17 (1)
RUBIACEAE	21 (2)	10 (2)	13 (1)	6 (3)	11 (2)
FABACEAE	14 (3)	8 (3)	6 (3)	2 (7)	4 (3)
MELASTOMATACEAE	13 (4)	3 (7)	1 (8)	11 (1)	3 (4)
ASTERACEAE	10 (5)	0	2 (7)	9 (2)	0
EUPHORBIACEAE	9 (6)	5 (5)	2 (7)	4 (5)	2 (5)
BROMELIACEAE	9 (6)	3 (7)	4 (5)	1 (8)	4 (3)
ARACEAE	8 (7)	5 (5)	5 (4)	2 (7)	4 (3)
SAPOTACEAE	8 (7)	5 (5)	6 (3)	1 (8)	4 (3)
APOCYNACEAE	8 (7)	2 (8)	2 (7)	4 (5)	2 (5)
CHRYSOBALANACEAE	7 (8)	6 (4)	4 (5)	1 (8)	3 (4)
POACEAE	7 (8)	5 (5)	1 (8)	2 (7)	4 (3)
CLUSIACEAE	5 (10)	1 (9)	1 (8)	5 (4)	2 (5)

The most species-rich families were Myrtaceae (31 species), Rubiaceae (21), Fabaceae (14), Melastomataceae (13), and Asteraceae (10). However, the principal families and the number of species observed differed significantly in the four different habitats studied. For example, the families Melastomataceae and Asteraceae predominated in the burned areas, but were absent or poorly represented in the other habitats (Table 5-2). Likewise, the family Clusiaceae showed a greater number of species in the burned area than elsewhere, whereas the family Fabaceae was represented there by only two species. In the other areas, the three most species-rich families were Myrtaceae, Rubiaceae, and Fabaceae, though their orders would differ.

Of the total number of species analyzed, only 11 (3.8%) were sampled in all habitats. These species must have wide tolerance limits that allow them to colonize habitats as diverse as treefall gaps and burned areas. Some of these species, such as *Psychotria purpurascens*, *Euterpe edulis*, and *Becquerelia cymosa*, were among the most abundant encountered (Table 5-3).

TABLE 5-3

Numbers of individuals of the most abundant species in the four habitats studied within the Una Biological Reserve, Bahia, Brazil.

SPECIES	TOTAL	TREEFALL GAPS	UNDERSTORY NEAR GAPS	BURNED AREA	UNDERSTORY NEAR BURNED AREA
Psychotria purpurascens	73	23	6	7	37
Evodianthus funifer	57	35	15	—	7
Scleria secans	46	—	—	46	—
Euterpe edulis	42	16	11	3	12
Merostachys sp	42	17	2	—	23
Philodendron surinamense	40	6	20	—	14
Rhodospatha latifolia	31	11	19	1	—
Becquerelia cymosa	29	4	7	12	6
Calathea sp1	24	—	2	12	10
Paypayrola blanchetiana	23	9	11	—	3
Calathea sciurioides	20	3	10	—	7
Geonoma pauciflora	19	—	6	1	12
Philodendron fragantissimum	17	9	7	—	1
Psychotria minutiflora	16	4	3	7	2
Miconia mirabilis	16	—	—	16	—
Pteridium aquilinum	15	—	—	15	—
Lomagramma guianensis	14	1	7	—	6
Ecclinusa ramiflora	13	3	4	3	3
Becquerelia clarkei	13	—	—	9	4
Protium aracouchini	13	2	9	—	2

On the other hand, the number of species specific to each habitat was relatively high, representing 33.3%, 27.1%, and 26.5% of the species sampled in the treefall gaps, understory adjacent to treefall gaps, and forest adjacent to the burned area, respectively. A large number of these species, however, were represented by only a single individual, a situation that does not allow analyses concerning preferences.

In the burned area, 50.5% of the species observed were exclusive to that habitat. Among these, *Scleria secans*, *Pteridium aquilinum*, and *Miconia mirabilis* were the most abundant and represented 26.3% of all individuals surveyed in the burned area. These three species showed a distinct preference for this habitat and possess characteristics that permit them to dominate it.

In the other three areas, a large fraction of the most abundant species (Table 5-3) was sampled in two or three different habitats, e.g., *Evodianthus funifer* and *Philodendron surinamense*. Two species, *Euterpe edulis* and *Psychotria purpurascens*, were sampled in all four habitats, although in small numbers in the burned area. *Merostachys* sp., a bamboo with a scandent habit, was extremely abundant in the forest understory near the burned area and abundant in the treefall gaps, although few individuals were observed in the forest understory near the gaps.

Growth habits were determined for only 1220 (93%) of the 1288 individuals surveyed due to the lack of information concerning some species. Trees constituted the predominant growth habit (27%), followed by the hemiepiphytes, subshrubs, herbs, and scandent plants. These latter habits all showed equivalent numbers of individuals. Epiphytes and woody vines were poorly represented (Figure 5-3).

Distribution of the number of individuals of each growth habit differed significantly among the four habitats studied ($\chi^2=205.01$, df=27, $p<0.0001$). The largest differences in relation to the expected values were observed in the burned area. This

TABLE 5-4

Principal deviations calculated from a contingency table for the number of individuals in each habitat in the Una Biological Reserve, Bahia, Brazil and for each growth habit. Only the 10 largest deviations are presented. Habitats: G=Treefall gaps, UG=Understory near gaps, B=Burned area, UB=Understory near burned area. Growth Habits: TL=Treelets, SS=Subshrubs, VI=Vines, HP=Hemiepiphytes, SC=Scandent plants.

GROWTH HABIT	HABITAT	OBSERVED VALUES	EXPECTED VALUES	DEVIATION	% DEVIATION*	% ACCUMULATED
HP	B	1	42.45	40.470	19.74	19.74
SC	B	59	30.06	27.871	13.59	33.33
VI	B	38	16.98	26.027	12.69	46.03
HP	UG	82	48.08	23.939	11.68	57.71
SS	UB	62	38.54	14.287	6.97	64.67
SS	UG	22	42.88	10.166	4.96	69.63
HP	G	71	51.27	7.592	3.70	73.34
SC	UG	19	34.04	6.647	3.24	76.58
VI	G	9	20.51	6.458	3.15	79.73
TL	UG	31	21.05	4.704	2.29	82.02

*Percentage contribution of the deviation to the total value of χ^2.

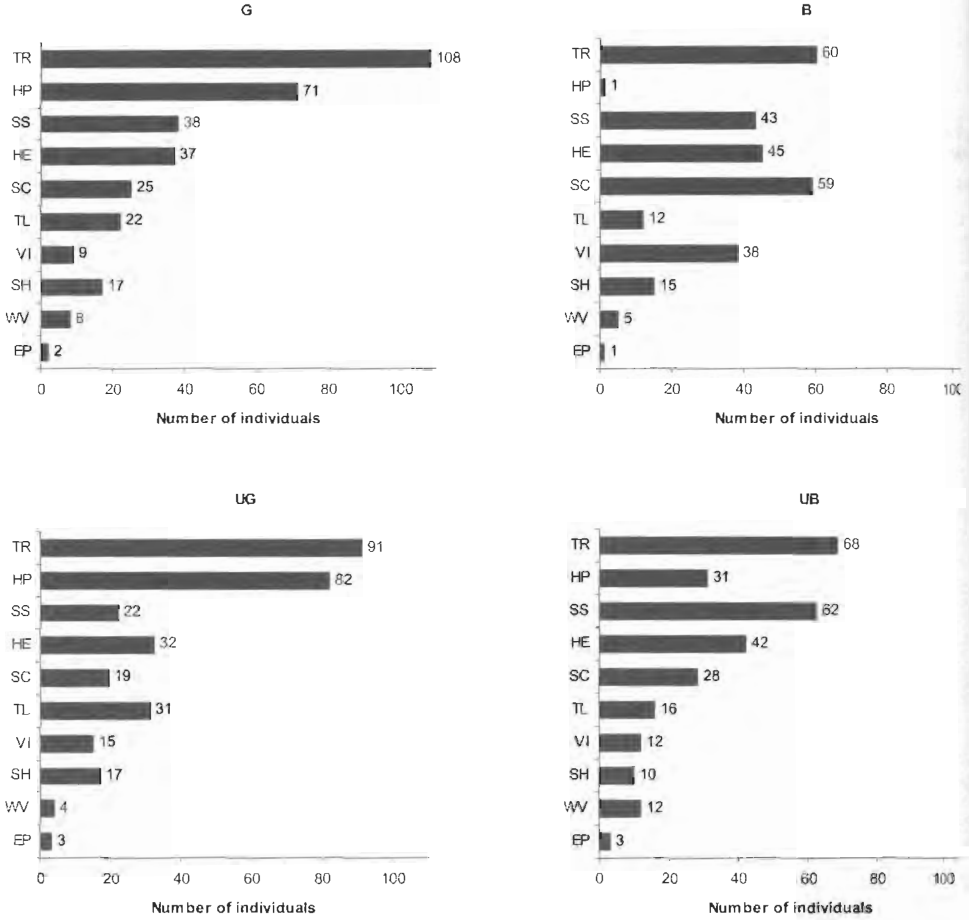

Fig. 5-3. Distribution of the numbers of individuals of each of the different growth habits within the four habitats analyzed in the Una Biological Reserve, Bahia, Brazil. Habitats: G = Treefall gaps, UG = Understory near gaps, B = Burned area, UB = Understory near burned area; Growth Habits: TR = Trees, TL = Treelets, SH = Shrubs, SS = Subshrubs, HE = Herbs, WV = Woody vines, VI = Vines, HP = Hemiepiphytes, SC = Scandent plants, EP = Epiphytes.

habitat showed smaller numbers of hemiepiphytes and larger numbers of scandent plants and vines than expected (Table 5-4; Figure 5-3). The understory adjacent to the treefall gaps showed greater number of hemiepiphytes and fewer subshrubs and scandent plants. The understory adjacent to the burned area showed a greater abundance of subshrubs. In the treefall gaps, there was a slight increase in the number of hemiepiphytes and a lesser number of vines.

In general, the distribution of the number of individuals among the different growth habits was similar between the treefall gaps and the adjacent understory (Figure 5-3). However, the understory of the forest area near to the burned area (UB) differed as much from the treefall gaps as from the understory adjacent to those gaps. The burned area showed a distribution distinct from the other habitats.

In relation to the number of species within each of the growth habit classes, we observed a significantly smaller number of tree species in the burned area and in the understory adjacent to it, as well as fewer scandent plants and herbs. The burned area also showed significantly fewer species of vines, and the understory near the burned area showed reduced numbers of subshrubs (Table 5-5).

In the treefall gaps, only the number of subshrubs was less than expected, whereas in the adjacent understory, only the herbs showed a significantly reduced number of species. Epiphytes and woody vines were not analyzed due to their small numbers.

The number of species observed in any of the habitats studied was never superior to the values estimated for the different growth habit classes. This suggests that none of the habitats favor any of these growth habits.

Analyzing the entire set of species (Figure 5-4) and individuals (Figure 5-3) within each growth habit showed only small numbers of vines, although the number of species (31) was quite high. On the other hand, the hemiepiphytes included a large number of individuals (it was the second most abundant class of growth forms), but only 10 species. Some species of hemiepiphytes were among the most abundant species sampled in this study, such as *Evodianthus funifer*, *Philodendron surinamense*, and *Rhodospatha latifolia* (Table 5-3).

We classified 511 individuals representing 89 species as resident and 705 individuals belonging to 161 species as transient. The absolute number of transient species was always greater than the number of resident species in all of the four habitats surveyed (Figure 5-5). However, in the burned habitat, the number of individuals of resident species was greater than the number of individuals of transient species. This difference was due to the great abundance of individuals of the resident species *Scleria secans*, *Pteridium aquilinum*, and *Becquerelia cymosa*. In the forest near the burned area, the great abundance of *Psychotria purpurascens*, a subshrub of the Rubiaceae and a small number of hemiepiphytes resulted in similar numbers of individuals of resident and transient species.

When the arboreal species are compared separate from the other growth habits, it becomes evident that if the surveys had considered only tree species, even including the younger individuals, the density and richness of the forest habitats would have been greatly underestimated. For every individual tree surveyed, another 2.7 nontree

TABLE 5-5

Randomized results (1000 repetitions), indicating the number of species expected by chance for a predetermined number of individuals among the different growth habits in the Una Biological Reserve, Bahia, Brazil and their respective confidence intervals (CI), emphasizing (shaded rows) situations where the observed number of species is significantly less than the values within the CIs. Habitats: G=Treefall gaps, UG=Understory near gaps, B=Burned area, UB=Understory near burned area; Growth Habits: TR=Trees, TL=Treelets, SH=Shrubs, SS=Subshrubs, HE=Herbs, VI=Vines, HP=Hemiepiphytes, SC=Scandent plants.

GROWTH HABITS	HABITATS	N INDIVIDUALS OBSERVED	N SPECIES OBSERVED	N SPECIES ESTIMATED	LOWER CI	HIGHEST CI	
TR	G	108	48	51.3	45.2	57.4	
TR	UG	91	41	46.79	40.53	53.05	
TR	B	60	26	36.41	31.03	41.79	(-)
TR	UB	68	32	39.25	33.75	44.75	(-)
TL	G	22	11	12.31	9.18	15.44	
TL	UG	31	15	15.21	12.12	18.31	
TL	B	12	6	8.12	5.35	10.89	
TL	UB	16	9	9.95	7.01	12.88	
SH	G	17	13	11.46	8.67	14.24	
SH	UG	17	11	11.46	8.67	14.24	
SH	B	15	9	10.6	7.75	13.44	
SH	UB	10	6	7.78	5.5	10.05	
SS	G	38	7	10.44	7.65	13.22	(-)
SS	UG	22	7	8.12	5.29	10.94	
SS	B	43	10	10.96	8.11	13.81	
SS	UB	62	9	12.52	9.96	15.08	(-)
HE	G	37	16	15.26	11.64	18.88	
HE	UG	32	10	14.12	10.46	17.77	(-)
HE	B	45	11	16.86	13.23	20.49	(-)
HE	UB	42	10	16.23	12.62	19.84	(-)
VI	G	9	8	7.86	6.09	9.63	
VI	UG	15	11	11.85	9.27	14.43	
VI	B	38	18	22.15	18.83	25.48	(-)
VI	UB	12	9	9.98	7.83	12.12	
HP	G	71	9	8.53	7.44	9.62	

(continued)

TABLE 5-5 (*continued*)

GROWTH HABITS	HABITATS	N INDIVIDUALS OBSERVED	N SPECIES OBSERVED	N SPECIES ESTIMATED	LOWER CI	HIGHEST CI	
HP	UG	82	8	8.67	7.72	9.63	
HP	B	1	1	1	1	1	
HP	UB	31	6	7.52	5.79	9.26	
SC	G	25	7	8.35	5.13	11.58	
SC	UG	19	10	7.15	4.18	10.12	
SC	B	59	9	**13.56**	**10.31**	**16.81**	(-)
SC	UB	28	5	8.99	5.77	12.21	(-)

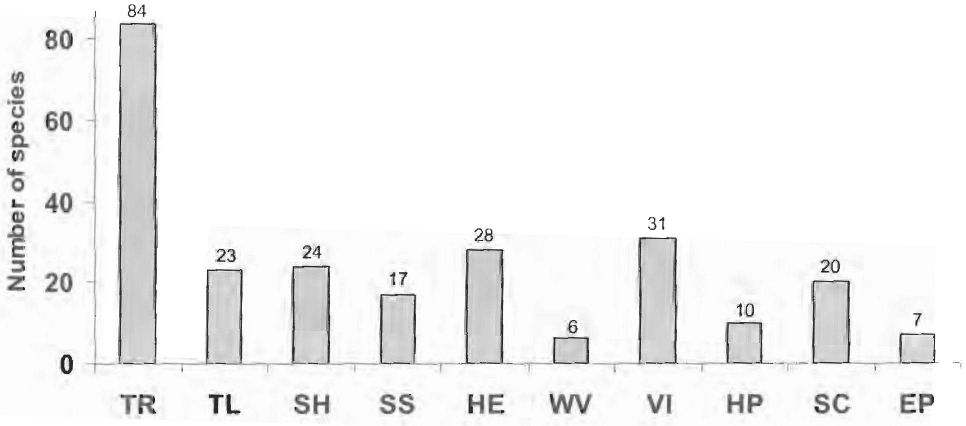

Fig. 5-4. Total number of species of each growth habit in the Una Biological Reserve, Bahia, Brazil. Growth Habits: TR=Trees, TL=Treelets, SH=Shrubs, SS=Subshrubs, HE=Herbs, WV=Woody vines, VI=Vines, HP=Hemiepiphytes, SC=Scandent plants, EP=Epiphytes.

individuals were found in the lower stratum of the forest. Additionally, for every tree species surveyed, 2 nontree species were encountered.

The greatest number of individual trees was observed in the treefall gaps, whereas the least number was found in the burned area. The total number of individuals of the other growth habits did not differ significantly among the other habitats (Figure 5-6). The distributions of the number of species and of the number of individuals were similar in all four habitats.

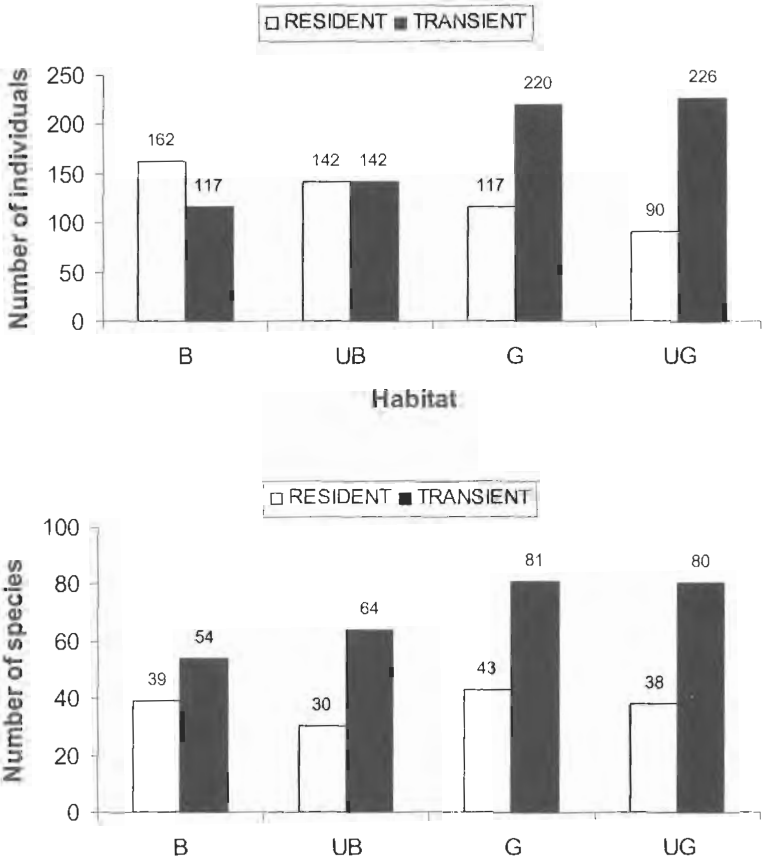

Fig. 5-5. Numbers of individuals and numbers of species of resident and transient plants within the four habitats analyzed in the Una Biological Reserve, Bahia, Brazil. Habitats: G=Treefall gaps, UG=Understory near gaps, B=Burned area, UB=Understory near burned area.

Discussion

The proportions of species in the major taxonomic groups in this study were similar to those observed by Galeano et al. (1998), where 70% of the species were dicotyledons, and by Gentry & Dodson (1987), where 69.6% were dicotyledons, 21.1% were monocotyledons, and 9% were pteridophytes. This distribution of species may simply reflect the total distribution of vascular plants in the world. According to Tiffney & Mazer (1995), there are 170,149 (73.6%) species of dicotyledons; 50,862 (22%) species of monocotyledons; and 10,000 (4.3%) species of pteridophytes. It would be interest-

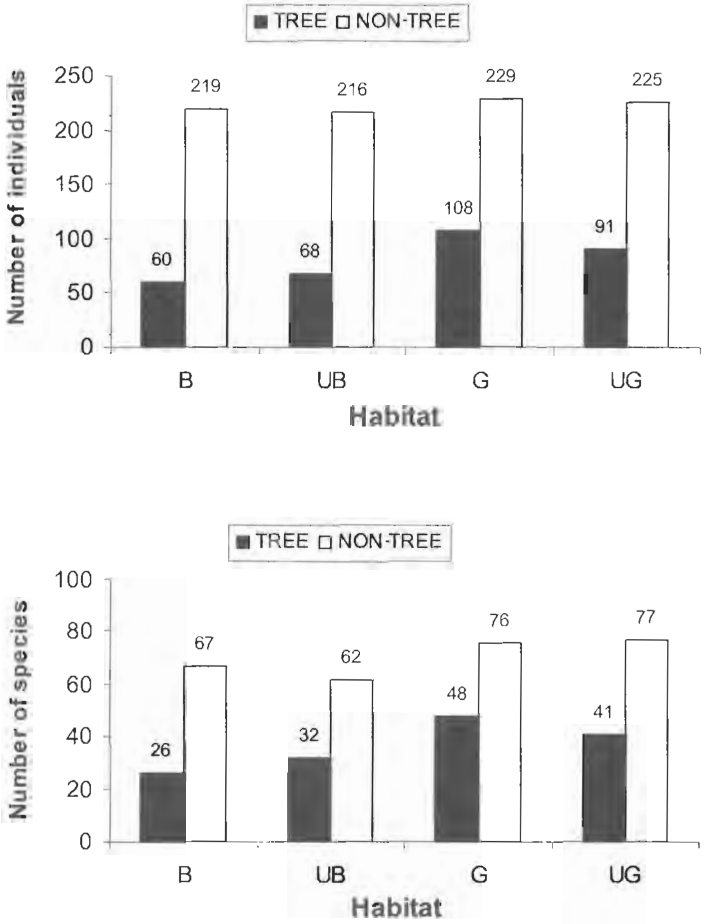

Fig. 5-6. Numbers of individuals and numbers of species of trees within the four habitats analyzed in the Una Biological Reserve, Bahia, Brazil compared with the other growth habit classes grouped as "nontree." Habitats: G=Treefall gaps, UG=Understory near gaps, B=Burned area, UB=Understory near burned area.

ing to verify if these proportions are maintained in other vegetation types throughout the world.

Considering that some studies have indicated an increase in the number of herbaceous species in the initial stages of secondary succession in tropical forests (Guariguata & Ostertag, 2001) and that a large part of the monocotyledonous species are herbaceous (Kremer & Van Andel, 1995; Tiffney & Mazer, 1995), the number of monocots might be expected to increase in burned areas. Nonetheless, even the disturbed habitats in this study maintained similar distributions among the major taxonomic groups. Again, it would be interesting to investigate if this regular distribution is maintained during the whole of the successional process in different vegetation formations or after different types of disturbances.

The Myrtaceae showed a notable species richness in this study. This finding is in agreement with Mori et al. (1983a), who identified Myrtaceae as one of the most important families in the Brazilian Atlantic coastal forest area, a region that is probably also the center of diversity for this group. A large fraction of the species of Myrtaceae encountered in this study were young individuals of arboreal or treelet species.

The Rubiaceae appeared as an important family in this study, probably due to the number of shrub and subshrub species, a result similar to that obtained by Salis et al. (1996) upon analyzing the understory of a semideciduous forest in southeastern Brazil. Nebel et al. (2001) and Laska (1997) also pointed out the importance of the Rubiaceae in terms of the shrubs and small trees in tropical forests. Many species within this family apparently find favorable conditions for establishment and growth in the limited light environment of the forest understory. On the other hand, *Psychotria purpurascens*, the most important species of this family in this study, was found in disturbed areas as well as in the understory. According to Canham (1989), one serious difficulty for plants occupying the understory is establishing a balance between maintaining low metabolic rates in that shady environment and being able to respond rapidly and efficiently to the appearance of well-illuminated environments. Perhaps for this reason, only a small number of species (11) were present in all four habitats.

Species richness values can be greatly affected by the different survey criteria or survey techniques used. The subplots in this study were widely distributed within the different habitats, whereas sample plots in most other studies are contiguously arranged. This distribution pattern of sample units may have increased the chances of sampling a larger number of species, in view of the fact that most tropical species are known to demonstrate spatial aggregation (Hubbell, 1979; Poulsen, 1996 for herbaceous species; Hubbel et al., 1999).

In spite of the problems related to the use of different methodologies and classification systems, the species richness encountered in this study is quite notable. The 1288 individuals identified belong to 291 species, a value that must be considered very high. Additionally, the species/area ratio is also very high, with the 291 species occurring in only 144 m^2.

The number of individuals identified only to genus was high because of the inherent difficulties of identifying sterile and young plants. Otherwise, the number of species is highly reliable, if not underestimated, as a function of using conservative criteria to differentiate the species and excluding the plants not positively identified from the analysis.

Within each of the four habitats surveyed, from 103 to 138 species were identified in 36 subplots of 1-m^2 spread out over 3 ha. This number is quite high when compared, for example, to the results of Gentry & Dodson (1987), who found 153, 163, and 339 species (excluding trees with more than a 10 cm diameter) in three areas of 1000 m^2 in Ecuador. Our values are also high when compared to the results of Duivenvoorden (1994), who sampled 10 areas of 1000 m^2 and found from 40 to 313 species in each. Moreover, 40% of the areas surveyed yielded less than 138 species (the highest value in the present study). Likewise, Galeano et al. (1998) working in Colombia surveyed three areas of 1000 m^2 and found 191, 240, and 403 species (excluding all plants with a diameter greater than 10 cm).

Considering that in the works cited above the survey areas were approximately 7 times greater than the area of the present study (144 m^2), and approximately 28 times greater than the area surveyed in each of the four habitats (36 m^2), the values observed indicate an extremely high species richness in the general study area. These results, as well as other studies of the arboreal vegetation of the region (Veloso, 1946a; Thomas et al., Chap. 3), are in agreement with Gentry & Dodson (1987), who postulated that the high indexes of arboreal species richness in tropical forests is accompanied by equally high indexes of species richness of other life forms.

The 291 species, 165 genera, and 69 families identified in the present survey correspond approximately to 29%, 35%, and 54%, respectively, of the totals for these taxa on the checklist of the flora of the Una Biological Reserve (Amorim et al., Chap. 4). There certainly must be a large number of uncataloged species in this Reserve, although the number of families not yet listed may be small. Moreover, differences probably exist in terms of the proportions of species representing the different growth habits. Nonetheless, these results are quite expressive in light of the fact that the present survey sampled fully half the families and almost one third of the species already cataloged, even though the research was concentrated in only one part of the Reserve and covered less than 0.5% of its total area.

Although studies concerning all of the different growth habits have been undertaken in undisturbed tropical forest habitats, studies of a similar nature have been rare in areas disturbed by anthropic factors such as fire or by the natural formation of treefall gaps. An immense volume of published literature concerning natural disturbances has concentrated on the effects of treefall gaps on arboreal species. Few studies have examined the effects of natural disturbances specifically on shrub species (Denslow et al., 1990; Ellison et al., 1993); lianas (Putz, 1984; Schnitzer et al., 2000); or herbs (Dirzo et al., 1992). Brokaw (1986) cited a number of examples of studies analyzing one or a few nontree species that exhibited increased growth and/or reproductive rates in treefall gaps, although studies concerning whole communities of nontree species were not mentioned.

Communities of herbaceous species have been more intensively studied, permitting comparisons between different areas of tropical forests, in spite of the different definitions used for this group. Poulsen (1996) encountered 73 strictly terrestrial herbaceous species in a 1 ha area in Borneo. Poulsen & Balslev (1991) listed 96 terrestrial herbaceous species in a 1 ha area in Ecuador, with an average of 14 species in the 100 m^2 subplots. Duivenvoorden (1994) listed seven to nine herbaceous species in 10 1000 m^2 plots. In the present study, 28 strictly terrestrial herbaceous species were sampled in 144 1-m^2 subplots. This appears to be a very high index of herbaceous species richness when compared to studies that sampled significantly larger areas.

Dirzo et al. (1992) studied herbaceous plants in treefall gaps in Mexico. They found 52 species in 124 1-m^2 plots, although they included hemiepiphytes and nonwoody vines in the herbaceous growth habit category. Considering only the 36 1-m^2 subplots analyzed in the present study, 33 species were identified in these same three categories. If all four habitats are considered, 69 species were surveyed in 144 1-m^2 subplots, a result quite similar to that seen at the Mexican site.

The low abundance and richness of epiphytes registered in this survey are possibly related to the sampling method employed, which eliminated trees taller than 5 m or more than 8 cm in diameter, thus excluding the major habitats of these plants. Migenis and Ackerman (1993) encountered the majority of epiphytic orchids in their survey fixed to trees with diameters greater than 16 cm. Fontoura (2001) observed that both individuals and species of epiphytes were most frequently encountered on trees with diameters between 10 and 20 cm. Other studies (Gentry & Dodson, 1987; Galeano et al., 1998) observed a great richness of epiphytes, probably because they included large trees in their samples. Nevertheless, this growth habit seems to have little representation in the lower stratum.

In evaluating the data on density, richness, and the distribution of plant growth habits among the different habitats, we observed that the burned area could be distinguished from all the others by the presence of a high proportion of exclusive species, as well as by the fact that the most abundant species were exclusive.

Some of these most abundant exclusive species (*Scleria secans*, *Pteridium aquilinum*, and *Becquerelia cymosa*) are residents in the lower stratum, remaining there during their entire life cycle. Nonetheless, as the transient species (trees such as *Miconia mirabilis*, *Eschweilera alvimii*, and *Cecropia pachystachya*, for example) establish themselves, the light environment will change. According to Gilliam et al. (1995), as light energy becomes more limited, conditions begin to favor the growth of seedlings and the resprouting of woody species.

In spite of the strong dominance of a few species, the overall species richness in the burned area was relatively high. This observation is in agreement with the prediction of Connell (1978) that species richness can be high at the beginning of the successional process, even though the species composition is quite different than that seen before the disturbance.

Of the species sampled in the burned area (considering all growth habits), 29% were also sampled in the understory, which suggests that the species from the forest interior are reestablishing themselves in this area. This is probably due to the occurrence of only one fire event in the area, with no previous history of cutting or serious disturbances, which allowed the forest to recuperate more rapidly (Woods, 1989; Uhl & Kauffman, 1990; Finegan, 1996). Additionally, the fact that the burned area lies within a landscape matrix that includes a number of fairly well-conserved, adjacent, forest fragments probably facilitates the recuperation of this habitat.

Although a reasonable number of understory species were able to establish in the burned area, the number of arboreal species there was significantly lower, possibly due to some environmental constraint to establishment. Additionally, there was also a low number of arboreal species in the forest understory near the burned area (UB). These facts suggest that there may be some shared constraints to the dispersion of certain species to these areas, because they are close to one another but distant from the other study areas (G and UG) and from the largest forest block in the region. The fact that the other three growth habits are underrepresented in the burned area and in the adjacent forest understory may reinforce this hypothesis. Studies to evaluate the characteristics of the species not sampled in these areas and the possible factors limiting dispersion and establishment of these species would advance our knowledge of the structure of these communities.

The burned area appears quite different from the other habitats in terms of the distribution of the different growth habits, partially confirming the hypothesis that the presence of trellises will benefit growth habits dependent on supporting structures. The proportions of lianas and scandent plants in this habitat increased, although hemiepiphytes were essentially absent. That absence is possibly due to the fact that these plants were not able to establish themselves in such a hostile habitat. Most species of Araceae, the predominant family among the hemiepiphytes, prefer a more humid habitat as noted by Ribeiro et al. (1999) in Amazonas and confirmed by our results showing a larger quantity of hemiepiphytes in the forest understory.

The treefall gaps, being well-illuminated environments, also show a high abundance of hemiepiphytes, although this may be related to their presence preceding the formation of the gap. These plants seem to be resistant to small disturbances, but may not be able to establish themselves in highly disturbed habitats. The reduced presence of lianas in these treefall gaps would seem to disagree with the works of Putz (1984), Brokaw (1986), and Schnitzer et al. (2000), who suggested a preference of this growth form for these habitats due to the increase in light and the availability of support. Overall, the canopy openings associated with treefall gaps did not seem to specifically benefit any growth habit, because no significant differences were found between the treefall gaps and the adjacent understory.

Gentry (1986 apud Galeano et al., 1998) suggested that in the Chocó region of the Pacific coast of Colombia where the richness of lianas is very low, these vines are functionally replaced by species of hemiepiphytes. In contrast to the results obtained by Galeano et al. (1998), the low abundance and richness of lianas and the high abundance of hemiepiphytes found in the understory and treefall gaps in this work (as well as the inversion observed in the burned areas, with a high abundance of lianas and a low abundance of hemiepiphytes) seem to agree with Gentry's suggestion.

A majority of the works that have compared the species composition of treefall gaps with that of the understory have evaluated only the arboreal species (e.g., Barton, 1984; Brokaw, 1985; Uhl et al., 1988; Brokaw & Scheiner, 1989; Tabarelli & Mantovani, 2000), sampling essentially only young individuals over 1 m tall. The numbers of individuals and species ignored in this methodology are enormous. In the present study, for example, for each arboreal individual surveyed, another 2.7 individuals of other growth habits are present in the same area. These numbers significantly alter all previously discussed considerations of competition in treefall gaps and seem to agree with the statement by Schnitzer & Carson (2000) that it would be extremely premature to make any definitive conclusions concerning the importance of treefall gaps in the maintenance of species diversity in tropical forests.

Because the objective of a majority of the studies concerning treefall gaps is to understand which arboreal species will occupy that newly liberated space, it is important to consider that the various species of the different life-forms present in the lower stratum of the forest, be they resident or transient species, have an important role in the processes of competition between the potential colonizers (Gilliam et al., 1995).

Long-term studies accompanying the initial processes of establishment, whether in natural treefall gaps or following other disturbances, must include all the life-forms present to be able to produce results capable of clarifying the dynamics of tropical forests.

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Appendix 5-1

Species and number of individuals found in the four habitats in Una Biological Reserve, Bahia, Brazil. Habitats: G = treefall gaps, UG = understory near gaps, B = burned area, UB = understory near burned area. Gowth Habits: TR = trees, TL = treelets, SH = shrubs, SS = subshrubs, HE = herbs, WV = woody vines, VI = vines, HP = hemiepiphytes, SC = scandent plants, EP = epiphytes, X = unknown. ("Incertae sedis" = plants that could not be classified in any taxa because they were in poor condition; "ni" = plants for which was a preliminary identification at family or genus level was possible but could be either a new species or a species already described, but in another growth stage. These two categories of plants were not used in data analysis).

FAMILY	SPECIES	GROWTH HABIT	G	UG	B	UB	TOTAL
ACANTHACEAE	*Justicia* sp.	HE		3		3	6
	Justicia symphyantha Lindau	HE	2				2
	Ruellia affinis (Nees) Lindau	SC	1	2			3
ANACARDIACEAE	*Thyrsodium spruceanum* Benth.	TL		1			1
ANNONACEAE	*Guatteria oligocarpa* Mart.	TL		1		2	3
	Guatteria sp.	TR	1	1	1		3
	Xylopia sp.	TR		3			3
	ANNONACEAE sp.1	X				1	1
	ANNONACEAE sp.2	X				1	1
APOCYNACEAE	*Blepharodon nitidum* (Vell.) J. F. Macbr.	VI			2	1	3
	Condylocarpum cf. *intermedium* Müll. Arg.	VI		3			3
	Gonioanthela riedelii (E. Fourn.) Malme	VI			1		1
	Himatanthus phagedaenicus (Mart.) Woodson	TR			1	1	2

	Lacmellea aculeata (Ducke) Monach.	SC		2			2
	Tabernaemontana salzmannii A. DC.	TL	1				1
	APOCYNACEAE sp. 3	X	1				1
	APOCYNACEAE sp. 4	X			1		1
ARACEAE	*Anthurium pentaphyllum* (Aubl.) G. Don	HP				1	1
	Anthurium sp.	HE			1		1
	Heteropsis oblongifolia Kunth	HP	1	3		2	6
	Philodendron fragantissimum (Hook.) Kunth	HP	9	7		1	17
	Philodendron insigne Schott	HE		1			1
	Philodendron rudgeanum Schott	HP	2				2
	Philodendron surinamense (Miq.) Engl.	HP	6	20		14	40
	Rhodospatha latifolia Poepp.	HP	11	19	1		31
	ARACEAE ni	X		1		1	2
ARALIACEAE	*Schefflera morototoni* (Aubl.) Maguire, Steyerm. & Frodin	TL			1		1
ARECACEAE	*Bactris* cf. *ferruginea* Burret.	TR	1	2	3		6
	Bactris hirta Mart.	SS	3	1		1	5
	Euterpe edulis Mart.	TR	16	11	3	12	42
	Geonoma elegans Mart.	SS	1	3		2	6
	Geonoma pauciflora Mart.	SS		6	1	12	19
	Geonoma ni	HE				2	2
ASTERACEAE	*Baccharis calvescens* DC.	SS			2		2
	Conocliniopsis prasiifolia (DC.) R. M. King & H. Rob.	HE			1		1

(continued)

Appendix 5-1 *(continued)*

FAMILY	SPECIES	GROWTH HABIT	G	UG	B	UB	TOTAL
	Cyrtocimura scorpioides (Lam.) H. Rob.	SS			4		4
	Mikania argyreiae DC.	VI			3		3
	Mikania cf. *nigricans* Gardner	VI		1	2		3
	Mikania sp. 1	VI			4		4
	Mikania sp. 2	VI		1			1
	Mikania sp. 3	VI			1		1
	Piptocarpha aff. *pyrifolia* Baker	VI			1		1
	Piptocarpha sp.	SC			1		1
BIGNONIACEAE	*Adenocalymma* cf. *coriaceum* DC.	WV			4	2	6
	Adenocalymma sp. 1	VI	1				1
	Adenocalymma sp. 2	VI			1		1
	Memora sp.	VI			1		1
	Tabebuia stenocalyx Sprague & Stapf	TR	2				2
	BIGNONIACEAE sp. 3	X		1			1
BOMBACACEAE	*Eriotheca macrophylla* (K. Schum.) A. Robyns	TR		1		5	6
BORAGINACEAE	*Cordia* cf. *magnoliaefolia* Cham.	TR	1			1	2
	Cordia polycephala (Lam.) Johnst.	SH			2		2
	Cordia sp. 1	SH	1	1			2
	Cordia sp. 2	TR			1		1
	Cordia trachyphylla Mart.	SH			1		1
	Tournefortia sp.	SC			1		1

BROMELIACEAE	*Aechmea* cf. *lingulata* (L.) Baker	HE				1	1
	Aechmea mollis L. B. Sm.	HE	1	3			4
	Aechmea sp. 1	EP		1			1
	Cryptanthus pseudopetiolatus Philcox	HE	3				3
	Lymania smithii Read	EP				1	1
	Ronnbergia brasiliensis E. Pereira & I. A. Penna	EP	1	1			2
	Streptocalyx curranii L. B. Sm.	EP		1		1	2
	Vriesea cf. *platynema* Gaudich.	EP			1		1
	Vriesea sp.	EP				1	1
BURSERACEAE	*Protium* aff. *heptaphyllum* (Aubl.) Marchand	TR	1	1			2
	Protium aracouchini (Aubl.) Marchand	TR	2	9		2	13
	Protium heptaphyllum (Aubl.) Marchand	TR	3				3
CECROPIACEAE	*Cecropia* cf. *pachystachya* Trécul	TL			6		6
	Pourouma mollis Trécul	TR	6				6
	Pourouma velutina Mart. ex Miq.	TR	1	1		1	3
CHRYSOBALANACEAE	*Couepia belemii* Prance	TR	2	5		1	8
	Hirtella sp.	TR	1				1
	Licania belemii Prance	TR	1	1			2
	Licania cf. *hoehnei* Pilg.	TR			1		1
	Licania hoehnei Pilg.	TR		1	2	3	6
	Licania hypoleuca Benth.	TR	1				1
	Licania lamentanda Prance	TR	1				1

(continued)

Appendix 5-1 *(continued)*

FAMILY	SPECIES	GROWTH HABIT	G	UG	B	UB	TOTAL
	Licania littoralis Warm.	TR	4	2		1	7
	CHRYSOBALANACEAE ni	X	1				1
CLUSIACEAE	*Rheedia* sp.	TR			1		1
	Tovomita bahiensis Engl.	TL		1	1	1	3
	Tovomita longifolia (Rich.) Hochr.	TL	2		1	1	4
	Vismia guanensis (Aubl.) Choisy	SH			4		4
	Vismia macrophylla Kunth	TR			1		1
COMMELINACEAE	*Dichorisandra thyrsiflora* J. C. Mikan	SS	2	2		1	5
CONNARACEAE	*Connarus blanchetii* Planch.	SC		1		1	2
	Rourea discolor Baker	WV			1		1
CYATHEACEAE	*Cyathea* sp.	TL	1	1			2
CYCLANTHACEAE	*Evodianthus funifer* (Poit.) Lindman	HP	35	15		7	57
CYPERACEAE	*Becquerelia* cf. *cymosa* Brongn.	HE	2	1	2		5
	Becquerelia clarkei T. Koyama	HE			9	4	13
	Becquerelia cymosa Brongn.	HE	2	6	10	6	24
	Scleria acanthocarpa Boeck.	HE	2	1			3
	Scleria secans (L.) Urban	SC			46		46
	Scleria sp.	HE			1		1
DENNSTAEDTIACEAE	*Pteridium aquilinum* (L.) Kuhn	SS			15		15
DILLENIACEAE	*Davilla lacunosa* Mart.	VI	1		2		3
	Davilla macrocarpa Eichler	VI	1	3	4	1	9

	Davilla sp.	VI	1			3	4
	DILLENIACEAE sp. 1	VI	2	1			3
DIOSCOREACEAE	*Dioscorea* sp. 1	VI			1	1	2
	Dioscorea sp. 2	VI			1		1
DRYOPTERIDACEAE	*Cyclodium meniscioides* (Willd.) Presl.	HE	3			2	5
	Stigmatopteris guianensis (Kl.) C. Chr.	HP	2	7			9
ERYTHROXYLACEAE	*Erythroxylum martii* Peyr.	SH	1				1
	Erythroxylum sp.	SH	1				1
EUPHORBIACEAE	*Croton macrobotrys* Baill.	TR	1				1
	Dalechampia ilheotica Wawra	VI			4		4
	Drypetes cf. *sessiliflora* Allemão	TR	1			2	3
	Mabea piriri Aubl.	TR	2				2
	Mabea sp.	TR		1			1
	Pera glabrata (Schott) Baill.	TR			1		1
	Pera heteranthera (Schrank.) I. M. Johnst.	TR	1				1
	Sebastiania multiramea (Klotzch) Müll. Arg.	SH		1	1		2
	Senefeldera multiflora Müll. Arg.	SH	1		1	1	3
FLACOURTIACEAE	*Banara kuhlmannii* (Sleumer) Sleumer	TR	3				3
	Banara sp.	TR		1			1
	Carpotroche brasiliensis (Raddi) A. Gray	TR	1	1	1		3
	Casearia commersoniana Cambess.	TL		1	1		2
	Casearia decandra Jacq.	TL		1			1
	Casearia sp. 1	TL		1			1

(continued)

Appendix 5-1 *(continued)*

FAMILY	SPECIES	GROWTH HABIT	G	UG	B	UB	TOTAL
HIPPOCRATEACEAE	*Cheiloclinium cognatum* (Miers) A. C. Sm.	WV	4			2	6
	Cheiloclinium sp.	WV		3		5	8
	Peritassa aff. *laevigata* (Hoffmanns.) A. C. Sm.	WV	2	1		1	4
ICACINACEAE	*Discophora guianensis* Miers	TL		3			3
LACISTEMACEAE	*Lacistema pubescens* Mart.	TR			1	1	2
	Lacistema robustum Schnizl.	TL		3			3
	Lacistema sp.	TR	1				1
LAURACEAE	*Licaria bahiana* Kurz.	TR	2	4			6
	Ocotea aff. *divaricata* (Poiret) Mez	TR	1	1			2
	Ocotea cf. *pretiosa* (Nees & Mart. ex Nees) Benth. & Hook.f.	TR				2	2
	Ocotea pretiosa (Nees & Mart. ex Nees) Benth. & Hook.f.	TR	1	1	1	1	4
	Ocotea sp. 1	TR	2				2
	LAURACEAE sp.2	TR		2		2	4
LECYTHIDACEAE	*Eschweilera alvimii* S. A. Mori	TR				7	7
	Eschweilera ovata (Cambess.) Miers	TR	2	2			4
	Lecythis pisonis Cambess.	TR		2			2
	LECYTHIDACEAE ni	TR		1			1
	LECYTHIDACEAE sp. 1	TR				1	1
LEGUMINOSAE	*Andira* sp.	TR	1				1

	Arapatiella psilophylla (Harms) R. S. Cowan	TR	9				9
	Bauhinia angulosa Vogel	WV	2			2	4
	Bauhinia sp.	X				1	1
	Copaifera langsdorffii Desf.	TR	1				1
	Dalbergia frutescens (Vell.) Britton	SC		2			2
	Inga sp. 1	TR	1	1		1	3
	Inga sp. 4	TR	1				1
	Inga vera Willd.	TR		1	2		3
	Machaerium lanceolatum (Vell.) Macbr.	SC	2	2	1		5
	Moldenhawera sp.	TR				1	1
	Peltogyne angustiflora Ducke	TR		1			1
	LEG. MIMOS. ni	X			1		1
	LEG. PAPIL. ni	X	1				1
	LEG. PAPIL. sp. 1	X	1				1
	LEG. PAPIL. sp. 2	X		1			1
	LEG. ni	X	1			1	2
LOGANIACEAE	*Spigelia kleinii* L. B. Sm.	HE	2		1		3
	Strychnos aff. *bahiensis* Krukoff & Barneby	SC	1				1
LOMARIOPSIDACEAE	*Lomagramma guianensis* (Aubl.) Ching	HP	1	7		6	14
	Lomariopsis marginata (Mart.) J. Sm.	HP	4	4			8
MALPIGHIACEAE	*Banisteriopsis* sp.	VI		1			1
	Heteropterys coleoptera A. Juss.	SC		1			1
	Heteropterys sp.	VI		1	3		4

(continued)

Appendix 5-1 *(continued)*

FAMILY	SPECIES	GROWTH HABIT	G	UG	B	UB	TOTAL
	Stigmaphyllon aff. *blanchetii* C. E. Anderson	VI		1			1
	MALPIGHIACEAE sp. 1	X				1	1
MALVACEAE	*Pavonia morii* Krapov.	SH	1				1
MARANTACEAE	*Calathea sciurioides* Peters.	HE	3	10		7	20
	Calathea sp. 1	HE		2	12	10	24
	Calathea sp. 3	HE		1			1
	Monotagma grallatum Hagberg	HE	3	2	1	5	11
MELASTOMATACEAE	*Clidemia hirta* (L.) D. Don	SS			1		1
	Henriettea succosa (Aubl.) DC.	TR			3		3
	Leandra rhamnifolia (Naudin) Cogn.	HE	2				2
	Leandra rufescens (DC.) Cogn.	SS			1		1
	Miconia amoena Triana	TR	4		1	1	6
	Miconia cf. *rimalis* Naudin	TR			2		2
	Miconia hypoleuca (Benth.) Triana	TR			1		1
	Miconia lurida Cogn.	TR			1		1
	Miconia mirabilis (Aubl.) L. O. Williams	TR			16		16
	Miconia octopetala Cogn.	TR				1	1
	Miconia ruficalyx Gleason	TR	3	1	1	1	6
	Miconia sp. 1	X			1		1
	Miconia sp. 2	X			5		5

MELIACEAE	*Guarea* sp. 1	TR		1			1
	Trichilia sp. 1	TR		1		1	2
	Trichilia sp. 2	X	1	2			3
	MELIACEAE sp. 1	X			1		1
MENDONCIACEAE	*Mendoncia blanchetiana* Profice	VI				1	1
MENISPERMACEAE	*Chondodendron microphyllum* (Eichler) Moldenke	VI	1		1	1	3
	Orthomene cf. *schomburgkii* (Miers) Barneby & Krukoff	SC		2			2
	Orthomene sp.	VI	1	1			2
MONIMIACEAE	*Siparuna cymosa* Tolm.	TR			2	3	5
MORACEAE	*Brosimum rubescens* Taub.	TR	1				1
	Brosimum sp.	X	1	1		1	3
	Dorstenia gracilis Carauta, M. Valente & D. S. Araújo	HE	2				2
	Helicostylis tomentosa (Poepp. & Endl.) Rusby	TR	2	5		2	9
	Sorocea hilarii Gaudich.	SH		1			1
	Sorocea sp.	X	1		1		2
MYRSINACEAE	*Myrsine* sp.	X	1			1	2
MYRTACEAE	*Calyptranthes* sp.	X		2		1	3
	Eugenia punicifolia (Kunth) DC.	TR	2				2
	Eugenia sp. 1	X	2	1	1	3	7
	Eugenia sp. 2	X				1	1
	Eugenia sp. 3	X		1			1

(continued)

Appendix 5-1 *(continued)*

FAMILY	SPECIES	GROWTH HABIT	G	UG	B	UB	TOTAL
	Eugenia sp. 4	X	1		1		2
	Gomidesia martiana O. Berg.	TR			1		1
	Gomidesia sp. 1	X		1			1
	Gomidesia sp. 2	X				1	1
	Marlierea cf. *racemosa* (Vell.) Kiaersk.	TR	2			1	3
	Marlierea obversa D. Legrand	TL		1		1	2
	Marlierea verticillaris O. Berg.	SC				1	1
	Marlierea sp.	SH		1		5	6
	Myrcia acuminatissima O. Berg.	TR	1	1	1		3
	Myrcia cf. *fallax* (Rich.) DC.	TL	1	2		3	6
	Myrcia gigantea (O. Berg.) Nied	TR	1				1
	Myrcia sp. 1	X	2				2
	Myrcia sp. 2	X		2		1	3
	Myrcia sp. 4	X				1	1
	Myrcia sp. 5	SH			1		1
	Myrcia sp. 6	X	1			1	2
	Plinia cf. *callosa* Sobral	TR		2		4	6
	Plinia sp. 1	X	1			6	7
	Plinia sp. 2	X		1			1
	MYRTACEAE sp. 3	X				1	1

	MYRTACEAE sp. 6	X	1				1
	MYRTACEAE sp. 9	X		1			1
	MYRTACEAE sp. 11	X	1				1
	MYRTACEAE sp. 12	X				1	1
	MYRTACEAE sp. 13	X			1		1
	MYRTACEAE sp. 14	X				1	1
NYCTAGINACEAE	*Guapira* cf. *obtusata* (Jacq.) Lundell	TL	1				1
	Guapira opposita (Vell.) Reitz	SH	4	5	1	1	11
	Guapira sp. 2	X	1				1
OLACACEAE	*Heisteria perianthomega* (Vell.) Sleumer	TR	2	1			3
	Heisteria sp.	TR				1	1
PASSIFLORACEAE	*Passiflora haematostigma* Mart. ex Mast.	VI			5		5
PIPERACEAE	*Peperomia* sp.	HE	1				1
	Piper arboreum Aubl.	SH	1				1
	Piper cf. *macrophyllum* H. B. K.	SH		2	1		3
	Piper sp. 1	SS	3				3
POACEAE	*Criciuma* aff. *asymetrica* Soderstr. & Londoño	SC				2	2
	Ichnanthus sp.	HE	5			1	6
	Lasiacis ligulata Hitchc. & Chase	SC	1		6		7
	Merostachys sp.	SC	17	2		23	42
	Olyra latifolia L.	HE	1			3	4
	Pariana cf. *lanceolata* Trin.	HE	1				1
	Paspalum corcovadense Raddi	HE			3		3

(continued)

Appendix 5-1 *(continued)*

FAMILY	SPECIES	GROWTH HABIT	G	UG	B	UB	TOTAL
	POACEAE ni	HE			1		1
POLYGALACEAE	*Securidaca* cf. *leiocarpa* S. F. Blake	SC	1		1		2
POLYGONACEAE	*Coccoloba declinata* (Vell.) Mart.	SC	2	3	1		6
RUBIACEAE	*Alibertia* sp.	SH	1				1
	Amaioua intermedia Mart.	TL		1		1	2
	Amaioua sp. 2	X				1	1
	Coccocypselum lanceolatum (Ruiz & Pav.) Pers.	HE			3		3
	Coussarea sp. 1	SH	2				2
	Coussarea sp. 2	SH	1	1			2
	Faramea cf. *martiana* Müll. Arg.	SH		1		1	2
	Faramea sp. 1	SS				1	1
	Faramea sp. 2	SS		1			1
	Ixora grandifolia Müll. Arg.	TR	1	2		1	4
	Malanea cf. *macrophylla* Bartl. ex Griseb.	SC		2			2
	Psychotria cf. *minutiflora* Müll. Arg.	SS	4	3	7	2	16
	Psychotria erecta (Aubl.) Standl. & Steyerm.	SH		1			1
	Psychotria jambosioides Schltdl.	SH	1	1	3		5
	Psychotria mapourioides DC.	TL	1		2		3
	Psychotria platypoda DC.	SS	2		2	4	8
	Psychotria purpurascens Müll. Arg.	SS	23	6	7	37	73

	Psychotria sp. 1	SS				2	2
	Randia armata (Sw.) DC.	TR		1			1
	Simira cf. *glaziovii* (K. Schum.) Steyerm.	SH	1	2		1	4
	Stachyarrhena harleyi J. H. Kirkbr.	TR		2		3	5
RUTACEAE	*Dictyoloma vandellianum* A. Juss.	TR	1				1
	RUTACEAE ni1	X				1	1
SAPINDACEAE	*Cupania rugosa* Radlk.	TL	2				2
	Paullinia trigonia Vell.	VI			1	1	2
	Paullinia sp.	VI				1	1
	Talisia sp. 1	X			1		1
	Talisia sp. 2	X				3	3
SAPOTACEAE	*Ecclinusa ramiflora* Mart.	TR	3	4	3	3	13
	Micropholis gardneriana (A. DC.) Pierre	TR				1	1
	Micropholis guyanensis (A. DC.) Pierre	TR	1	2			3
	Pouteria aff. *bangii* (Rusby) T. D. Penn.	TR	3	3			6
	Pouteria sp. 1	TR	1	4			5
	Pouteria sp. 2	TR		2			2
	Pouteria sp. 3	TR	5	1		5	11
	Pradosia lactescens (Vell.) Radlk.	TR				1	1
SIMAROUBACEAE	*Picramnia coccinea* W. W. Thomas	TL	1			1	2
	Simaba cedron Planch.	TL	1	1		3	5
	Simarouba amara Aubl.	TR		1	1		2

(*continued*)

Appendix 5-1 *(continued)*

FAMILY	SPECIES	GROWTH HABIT	G	UG	B	UB	TOTAL
SMILACACEAE	*Smilax* sp. 1	VI		1			1
	Smilax sp. 2	VI	1	1			2
SOLANACEAE	*Solanum polytrichum* Moric	SH	1				1
	Solanum rupincola Sendtn.	SC			1	1	2
	Solanum sp. 1	X			1		1
TECTARIACEAE	*Triplophyllum funestum* (Kunze) Holttum	HE	2	2			4
THELYPTERIDACEAE	*Thelypteris conspersa* (Schrad.) A. R. Smith	HE			1		1
THYMELAEACEAE	*Daphnopsis racemosa* Griseb.	SH				1	1
TRIGONIACEAE	*Trigonia nivea* Cambess.	SC			1		1
VERBENACEAE	*Lantana undulata* Schrank	SS			3		3
VIOLACEAE	*Paypayrola blanchetiana* Tul.	TL	9	11		3	23
	Rinorea guianensis Aublet	TR	2	3		1	6
VITACEAE	*Cissus paulliniifolia* Vell.	VI				2	2
VITTARIACEAE	*Antrophyum* sp.	EP	1				1
Incertae sedis	Incertae sedis	X	5	4		3	12
Total			361	336	295	320	1312