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NON-TIMBER FOREST PRODUCTS INTEGRATED WITH NATURAL FOREST MANAGEMENT, RIO SAN JUAN, NICARAGUA[1,2]

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Abstract. In the Atlantic lowland tropical rainforests of the Rio San Juan region, Nicaragua, we are conducting applied vegetation community analyses within an attempt to integrate non-timber forest products with natural forest management. Two long-term sampling plots were evaluated: one primary tropical rainforest plot before and 1 yr after selective logging, and another plot 9 yr after selective logging with and without Hutchinson Liberation Silviculture treatment (in which selected young trees are released from competition for light). The purpose of the study was to evaluate changes in community ecology variables with logging, damage, regeneration, and silviculture, both for useful plant species and for the plant community as a whole, and to evaluate the potential for incorporating non-timber forest product management with silvicultural management. One year after logging there was an increase in species (from 19 ± 5 to 33 ± 10 species/10 m^2) and density (from 42 ± 19 to 120 ± 60 plants/10 m^2) due to establishment or increase of secondary species (vines, grasses, balsa, cecropia) and to seedling regeneration after logging. The more severe the logging damage the more severe were the effects on some variables, particularly increased densities of vines and secondary species. Forest plots 9 yr post-harvest appeared to be returning to pre-harvest levels of species (28 ± 6 species/10 m^2) and density (76 ± 21 plants/10 m^2). Hutchinson Liberation Silviculture, while promoting growth of desired timber, did not significantly affect either non-timber forest products or the basic physiognomy of the forest. These results are contrasted with other silvicultural systems, particularly the Hartshorn Strip Clearcut, in which regeneration was dominated by resprouts and the proportion of vines was even higher. Hutchinson Liberation Silviculture provides the potential for simultaneous management of non-timber forest products, and moreover, non-timber forest product management holds the potential for significantly reinforcing silvicultural management.

Key words: Atlantic lowlands; logging damage; non-timber forest products; Rio San Juan, Nicaragua; silviculture; tropical biodiversity; tropical rainforest; tropical vegetation ecology.

INTRODUCTION

Non-timber forest products can be harvested as an alternative to tropical deforestation (Peters et al. 1989, Schwartzman 1989, Allegretti 1990, Anderson 1990, Plotkin and Famolare 1992). Harvest and management of non-timber forest products can be integrated with natural forest management for timber. Panayotou and Ashton (1993) review the value of non-timber forest products and make the case for multi-use forest management. Incorporating extraction of other products with timber (Repetto and Gillis 1988) to the support of natural forest management on extensive tropical forestry lands would provide a great tool for conservation: the integration of non-timber forest products with natural forest management may optimize the economically productive forest biomass. Historically, up until the middle of this century when timber gained predominance, the incorporation of non-timber forest products with timber extraction was the rule (Whitmore 1990). Nonetheless, data on the production and reproduction of non-timber forest products within timber management are rare or nonexistent (Panayotou and Ashton 1993). The primary goal of this study is to quantify the abundance, density, and diversity of non-timber forest products before and after logging. The severity of logging damage is of particular concern.

At a more regional level, we have a second goal: addressing the rapid deforestation of the Caribbean Atlantic lowland tropical rainforests (Sader and Joyce 1988). There are ≈ 5 × 10^5 ha of Atlantic lowland tropical rainforest within the International Peace Park (Si-a-Paz, Fig. 1) on the northern border of Costa Rica and the southern border of Nicaragua (Morales and

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[2] For reprints of this 54-page group of papers on integrated conservation and development, see footnote 1, p. 857.

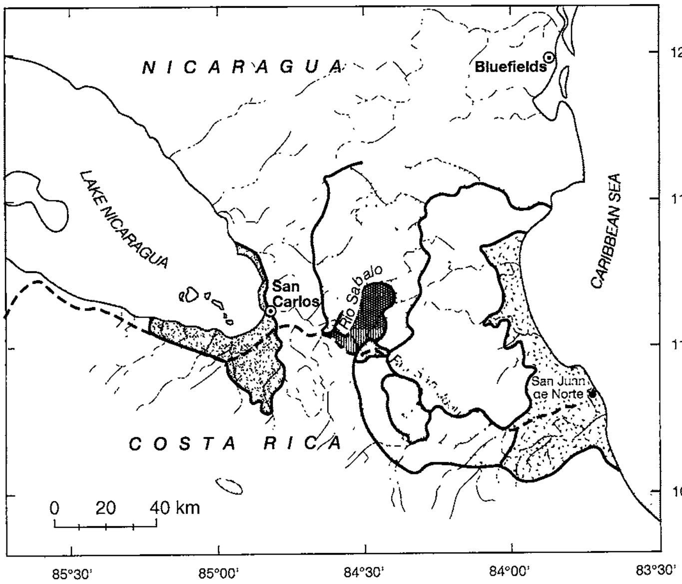

FIG. 1. Research site. Components of the International Peace Park (Si-a-Paz) within the countries of Nicaragua and Costa Rica, including the various preserves, monuments, and buffer zones, and the experimental areas. The present study is located within the darkest screened area including the Rio Sabalo, Nicaragua. Redrawn from official maps provided by IRENA (Instituto de Recursos Naturales), Managua, Nicaragua.

Cifuentes 1989). Within the Si-a-Paz buffer zone, we are working to find alternatives to the tropical deforestation (UCA/CATIE/SAREC 1991) prevalent in the Atlantic lowlands and increasing along the Rio San Juan due to the relocation of refugees in the region. Our concentration on the reincorporation of non-timber forest products with natural forest management is a practical recommendation for increasing the value of the tropical rainforest outside of the core preserve to compete with other land uses, which offer alluring short-term returns, but which further deforest the Caribbean lowlands. Thus, we are attempting to provide the direct link between conservation and alternative resource uses discussed by Alpert in the introduction, as well as the ecological data he finds lacking. The research provides both data on the impact of natural forest management and on tropical biodiversity and forest regeneration.

Concisely, the primary goals of this study are the integration of non-timber forest products with natural forest management, the investigation of an alternative to deforestation of the Atlantic tropical lowlands of Central America, and a community analysis of tropical biodiversity and regeneration. We approach these through ecological application of tropical vegetation analyses.

METHODS

The vegetation of a Central American, Atlantic lowland, tropical rainforest was sampled in southern Nicaragua near the border with Costa Rica (Fig. 1) along the rivers Rio San Juan, Rio Sabalos, and Rio Santa Cruz in the experimental area of the International Peace Park ("Si-a-Paz", Fig. 1). Two sampling sites were established. The sampling site called "Los Filos" (Fig. 2a) was a primary tropical rainforest site with long-term sampling plots established in 1991 (see Castillo 1993 and Salick 1992*a*), subsequently logged (in 1992), and resampled (in 1993). The sampling site called "La Lupe" (Fig. 2b) was originally a portion of the same primary tropical rainforest, but was logged in 1984 with long-term sampling plots established and measured in 1990 (Salick 1992*a*, Mejia 1993), Hutchinson Liberation Silviculture (UCA/CATIE/SAREC 1991) was applied in 1992, and plots were remeasured in 1993 (Mejia 1993 and this study). Thus, the two sites within the same forest taken together represent a relayed series from primary forest, to logged forests 1 and 9 yr post-harvest, with silvicultural treatments applied as a variable treatment at 8 yr after harvest.

Hutchinson Liberation Silviculture (UCA/CATIE/SAREC 1991, Hutchinson 1993) includes prescribed methodologies for selecting individual young trees deemed most promising for future timber harvest and methodologies for then releasing these individuals from competition for light by cutting or poison-girdling shading vegetation. All treatments are tailored for regenerating individuals and are very locally applied for minimal impact on the forest as a whole. The method was chosen for integration of non-timber forest product harvesting in anticipation of its low impact on these products, as well.

Long-term sampling plots were established to monitor timber stands and growth (UCA/CATIE/SAREC 1991, Salick 1992*a*, Castillo 1993, Mejia 1993). Regeneration was monitored within subplots; the location of the stratified-random 100-m^2 sample subplots within the 1-ha long-term plots is displayed in Fig. 2 for both Los Filos (Fig. 2a) and La Lupe (Fig. 2b). Within these subplots, complete vegetation sampling was carried out within random 10-m^2 subsubplots (5×2 m). All plants including seedlings and herbs were counted and measured except when carpeting an area; then the order of magnitude of the species population within the sub-

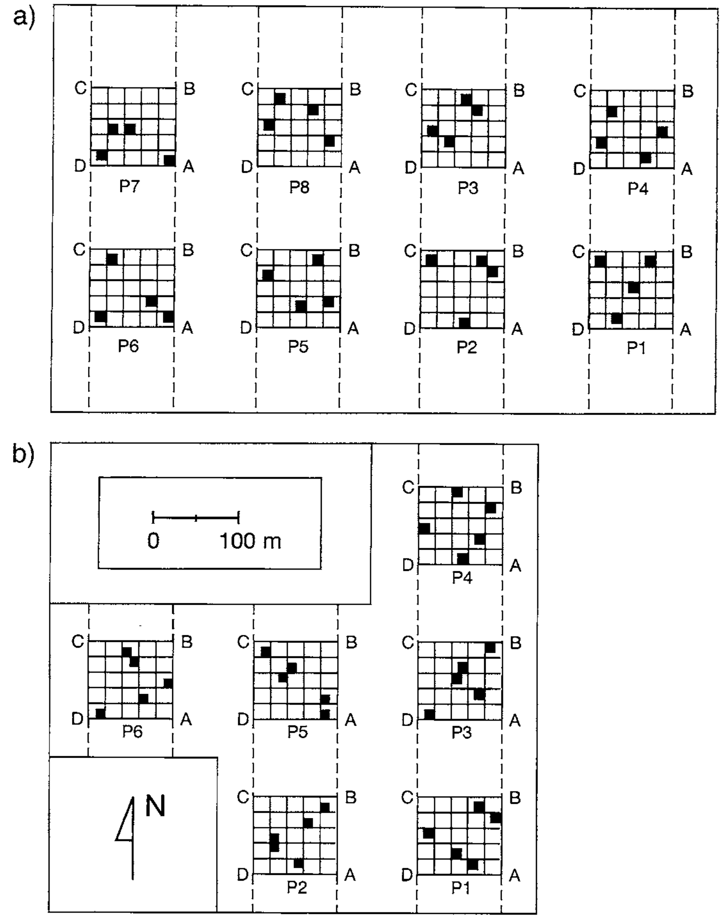

FIG. 2. Long-term sampling plots. (a) The sampling site called "Los Filos" was a primary tropical rainforest site with long-term sampling plots established in 1991, subsequently logged in 1992, and resampled 1993. (b) The sampling site called "La Lupe" was a primary tropical rainforest logged in 1984 with long-term sampling plots established and measured in 1990, with Hutchinson Liberation Silviculture applied in 1992 to three (plots P1, P3, and P6) of the six 1-ha experimental plots (plots P2, P4, and P5 remaining without silviculture as controls). The plots then were resampled in 1993. Thus, the two sites taken together represent a relayed series from primary forest (Los Filos 1991), to logged forests 1 yr (Los Filos 1993) and 9 yr post-harvest (La Lupe 1993) with untreated controls and silvicultural treatments applied at 8 yr after harvest. Permanent 100-m^2 subplots are indicated with darkened squares within which a 10-m^2 subsubplot is chosen randomly each sampling year.

subplot was estimated. Individual multistemmed or spreading plants were counted only once, offset by size and cover. Cryptogams, with problems of collection and identification, and epiphytes, for lack of aerial collection equipment, were underrepresented in the sampling. The plots and subplots are permanent (used by the foresters for measuring trees and regenerating saplings, respectively) whereas the subsubplots (one in each subplot, for sampling all vegetation in this study) are chosen randomly each sampling year. The subsubplots used in this study are moved to minimize local disturbance caused by sampling (i.e., walking and pawing through the seedling and herbaceous layer) while still providing representative samples within subplots.

The treatments sampled were (a) before (1991) and (b) 1 yr after (1993) logging at Los Filos, and at La Lupe 9 yr after logging (1993) (c) with and (d) without Hutchinson Liberation Silviculture (Mejia 1993). The sites and treatments are henceforth referred to as (a) primary forest (Los Filos before logging); (b) logged forest, year one (Los Filos after logging); (c) logged forest, year nine with silviculture (La Lupe treatments of Hutchinson Liberation Silviculture); and (d) logged forest, year nine control (no silvicultural treatment).

The variables compared include basic vegetation sampling parameters such as species–area curves (compiled by tallying additional species encountered in each successive 10-m^2 subsubplot and adding these to the running total), species richness (species/10 m^2), density (plants/10 m^2), species diversity (H'/10 m^2), plant height distributions, and growth form distributions. Major emphasis is placed on useful plant species including non-timber forest products, applying parameters such as variety of uses (use categories/10 m^2), intensity of use (density of uses/10 m^2), species–area curves for useful species only, and plant use categories [aesthetic (**A**); construction (**C**); edible (**E**); firewood (**F**); hunting (**H**: animal habitat); intoxicant (**I**); medicinal (**M**); oils (**O**); poison (**P**); resins, gums, and latex (**R**); shade, living fences (**S**); timber (**T**); utility (**U**: vines, wraps, string, processing); wood for other than timber (**W**); and other (**X**)]. Additionally, at Los Filos after logging the subplots were subjectively rated for severity of logging damage, and parameters are compared among severity-of-logging-damage categories, rated as severe (e.g., logging road or patio through plot or refuse piled in plot), moderate (e.g., skid trail, path, or tree felled in or through plot), or little (e.g., no damage, tree felled nearby, some fallen debris).

Statistical testing was done by analyses of variance with orthogonal contrasts where data were normal or where transformations (log) provided normal data. For categorical data (height, growth forms, and use), nonparametric Kruskal-Wallis analyses of variance or Mann-Whitney *U* statistics (two categories) were used.

Plants and their uses were identified in the field by "Don Cristobal", a local plant expert variously employed by logging companies and by scientific and development projects as the most reliable plant identifier in the region. As a boy, he was trained by his uncle as an herbalist, and as a young man he cruised timber constantly in the area, so that he knows the forests of the region well. A single "expert" informant was used, in spite of problematic individual bias, to keep data comparable among sites and treatments. Even then, data presented here are somewhat different than published in previous studies (Salick 1992*a*) due to our ever-increasing appreciation of plants and uses in this underexplored region.

Botanical voucher specimens, all too often sterile, were miraculously identified by Dr. Michael Grayum of the Missouri Botanical Garden and other experts. Vouchers were collected concurrently with sampling, immediately outside of the long-term plots to reduce disturbance in the plots while optimizing specimen identity. Vouchers are listed in the Appendix and deposited at the Missouri Botanical Garden (St. Louis, Missouri, USA), with regional duplicates placed at the Universidad Centroamericana (Managua, Nicaragua), Universidad Nacional Agraria (Managua), and INBIO (San Jose, Costa Rica).

Results

Species–area curves for all plant species (Fig. 3a) and for useful plant species (Fig. 3b) show similar trends. The logged forest (year one) has the most species, followed by the logged forest (year nine) either with silviculture or the control, with the fewest species in the primary forest. These trends are statistically borne out by analyses of variance for a basic set of vegetation sampling parameters and useful-plant statistics.

Species richness (Table 1a) significantly increased with logging, comparing the primary forest with the same forest 1 yr after logging, whereas there was no significant difference with silviculture. Useful-plant richness was also greatest 1 yr after logging (17 ± 4 species/10 m^2 before logging, 26 ± 8 species/10 m^2 1 yr after logging, and 23 ± 6 species/10 m^2 9 yr after logging [means ± 1 SD]). Similarly, plant density and diversity significantly increased following logging, comparing the primary forest with the same forest 1 yr after logging. Again, useful-plant density and diversity were greatest 1 yr after logging (before logging: 37 ± 13 useful plants/10 m^2 and $H' = 2.4 \pm 0.4$ for useful plants; 1 yr after logging: 85 ± 48 useful plants/10 m^2 and $H' = 2.7 \pm 0.4$ for useful plants; 9 yr after logging: 50 ± 10 useful plants/10 m^2 and $H' = 2.7 \pm 0.3$ for useful plants). There were no significant differences with silviculture for either total vegetation or for useful plants. Variety of plant uses was not significantly different among treatments, whereas intensity of use, which is very dependent on density, followed the density trends. With severe logging damage (Table 1b with orthogonal contrasts) there were significant increases in variety of useful plants and intensity of use.

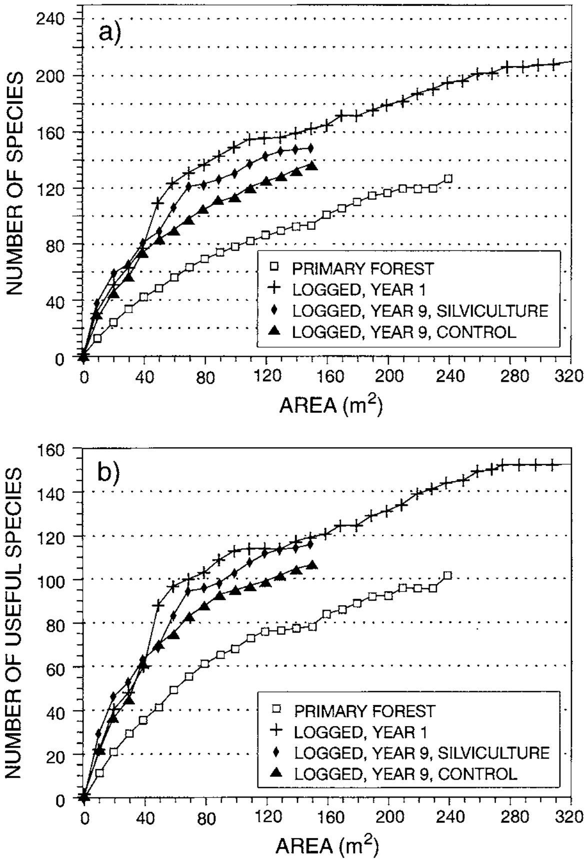

FIG. 3. Species–area curves show similar trends for (a) all plant species and for (b) useful plant species. The forest 1 yr after logging has the most species, followed by the forest 9 yr after logging either with or without silviculture (no significant difference with silvicultural treatment). The primary forest had the fewest species. Increase of species with disturbance appeared to be due to the greater numbers of smaller, regenerating plants and the influx of secondary species.

Refining the comparisons of useful plants to use category (Table 2) allowed us to identify a significant relative decrease in edible species from 22% before logging to 15% 1 yr after logging (potentially swamped by the influx of secondary species) and a significant increase in the utility category, to which vines contributed heavily, from 17% before logging to 23% 1 yr after logging (Table 2a). Non-timber wood products including balsa and cecropia increased with severity of damage from 1% to 11% (Table 2b). Silviculture did not diminish any category of useful plants (Table 2a).

TABLE 1. Effect of logging, recovery period, and employment of Hutchinson Liberation Silviculture (in which selected young trees are released from competition for light), on some vegetation measures in an Atlantic lowland forest in Nicaragua. Data are means ± 1 SD.

a) Comparison of primary and logged forest

Vegetation and useful-plant statistics*	Primary forest	Logged, year 1	P	Logged, year 9: Silvicul.	Logged, year 9: Control	P
Species richness (spp./10 m²)	19 ± 5	33 ± 10	0.000	28 ± 8	28 ± 6	0.789
Density (plants/10 m²)	42 ± 19	120 ± 60	0.000	75 ± 28	76 ± 21	0.924
Shannon Wiener diversity (H′/10 m²)	2.47 ± 0.45	2.82 ± 0.40	0.004	2.73 ± 0.37	2.72 ± 0.33	0.889
Variety of uses (uses/10 m²)	9 ± 1	10 ± 1	0.640	9 ± 1	9 ± 1	0.271
Intensity of use (no. uses/10 m²)	66 ± 20	148 ± 82	0.000	36 ± 12	36 ± 17	0.916

b) Comparison of damage categories 1 yr after logging

Vegetation and useful-plant statistics*	Damage categories: Little	Moderate	Severe†	P	Orthogonal contrasts
Species richness (spp./10 m²)	31 ± 10	34 ± 12	35 ± 9	0.657	
Density (plants/10 m²)	110 ± 58	104 ± 46	166 ± 74	0.137	
Shannon Wiener diversity (H′/10 m²)	2.75 ± 0.43	2.89 ± 0.40	2.82 ± 0.39	0.662	
Variety of uses (uses/10 m²)	9 ± 1	10 ± 1	11 ± 1	0.014	1 = 2 (0.081) 1 < 3 (0.004) 2 = 3 (0.136)
Intensity of use (no. uses/10 m²)	117 ± 56	135 ± 64	228 ± 110	0.031	1 = 2 (0.436) 1 < 3 (0.009) 2 < 3 (0.047)

* Species richness was significantly lower in the primary forest than in the same forest 1 yr after logging, whereas there was no significant difference with silviculture. Similarly, plant density and diversity were significantly less in the primary forest than in the same forest 1 yr after logging, whereas there was no significant difference with silviculture. Variety of plant uses was not significantly different among treatments, whereas intensity of use, which is very dependent on density, follows the density trends.

† With severe logging damage there were significant increases in variety of useful plants and intensity of use.

Densities of selected important non-timber forest products (Table 3) can be compared among La Lupe (1990 and 1993), Los Filos (1991 and 1993), and a local farmer's forest (see Salick 1992*a*) to elaborate species distributions. The most obvious trend is the patchiness of species distributions that is well known for many tropical rainforest species. Nonetheless, individual species indicated particular patterns. Anona (*Rollinia* spp., Annonaceae) and Maquengue (*Socratea* spp., Palmae) were planted by the farmer and thus appeared more densely in the farmer's forest. Raicilla (*Psychotria ipecacuanha,* Rubiaceae) was also planted by the farmer, but in addition had been extracted to disappearance in the non-tenured forests of La Lupe

TABLE 2. Distributions of plant use categories relative to forest management history. Use categories of useful plant species: aesthetic (**A**); construction (**C**); edible (**E**); firewood (**F**); hunting (**H**: animal habitat); intoxicant (**I**); medicinal (**M**); oils

a) Plant use distributions among forest histories*

Treatment	A	C	E	F	H	I	M
	Use categories (% plants/10 m²)						
Primary forest	3.7 ± 3.6	30.0 ± 11.8	21.6 ± 10.8	16.1 ± 12.8	36.4 ± 14.2	0	24.1 ± 21.4
Logged, year 1	3.9 ± 7.0	25.1 ± 9.3	15.1 ± 7.6	16.7 ± 9.2	34.4 ± 12.6	0.1 ± 0.5	25.8 ± 13.5
P	0.358	0.110	0.017	0.403	0.673	0.386	0.147
Logged, year 9, silviculture	2.9 ± 2.9	21.5 ± 9.3	14.9 ± 6.3	20.3 ± 15.2	28.3 ± 6.0	0.4 ± 0.9	18.9 ± 9.9
Logged, year 9, control	2.6 ± 2.7	26.6 ± 11.7	11.5 ± 7.5	17.0 ± 8.3	27.4 ± 9.0	0.8 ± 1.7	22.1 ± 10.4
P	0.883	0.152	0.171	0.917	0.419	0.654	0.300

b) Plant use distribution among damage categories in forest 1 yr after logging†

Damage categories	A	C	E	F	H	I	M
	Use categories (% plants/10 m²)						
Little	4.8 ± 9.2	23.2 ± 8.0	16.6 ± 7.5	15.7 ± 6.5	36.2 ± 13.4	0	30.0 ± 10.6
Moderate	2.8 ± 5.0	28.4 ± 10.5	14.4 ± 6.9	17.9 ± 10.2	29.3 ± 8.8	0	24.0 ± 16.2
Severe	4.1 ± 6.1	23.1 ± 9.1	13.3 ± 9.6	16.5 ± 12.7	39.6 ± 15.2	0.4 ± 1.1	21.2 ± 13.1
P	0.609	0.297	0.599	0.758	0.298	0.168	0.311

* With logging there was a relative decrease in edible species (potentially swamped by the influx of secondary species) and an increase in the utility category (to which vines contribute heavily). Silviculture did not diminish useful plants.

† With severity of damage, non-timber wood products increased, including balsa and cecropia.

and Los Filos. Mimbre (*Heteropsis* sp., Araceae) had also been extracted to disappearance in all forests. Secondary species like balsa (*Ochroma lagopus*, Bombacaceae) and guarumo (*Cecropia* spp., Cecropiaceae) were dense only after logging (Los Filos 1993) and then in patches of severely disturbed forest. The low densities of individual species, potentially extracted, are of concern if sustainable harvesting is to be attempted (e.g., hule, kamibar, maquenque, pita, sarsaparilla, etc.). Low densities of valuable wild germplasm like cacao (*Theobroma* spp., Sterculiaceae) may complicate conservation.

Plant height distributions (Fig. 4, Table 4) allowed us to identify the basis for the increases in species, density, and diversity with logging. Seedlings and small plants were significantly more numerous in the logged forest after 1 yr (98 plants/10 m^2) than in the primary forest (21 plants/10 m^2). The only significant difference with silviculture was a very slight decrease in the number of pole-sized trees (5–10 m). Small pole-sized trees (1–5 m) significantly increased with severity of logging damage (from 5 to 14 trees/10 m^2), easily identified in the field as even aged stands of secondary species like balsa and cecropia. An additional statistic registered was regeneration by resprouting (asexual reproduction), which was low (3.1% of all plants 1 yr after logging).

Plant growth form distributions (Table 5a) underwent great changes before vs. after logging, but evidenced no significant differences with silvicultural treatment. Notable with logging were the significant increases in vines (from 1 to 11 vines/10 m^2), trees (predominantly tree seedlings, from 15 to 53 individuals/10 m^2), herbs (from 7 to 34 plants/10 m^2, and grasses (from 0.3 to 6.4 plants/10 m^2). Vines further increased with severity of logging damage (Table 5b; reinterpreted in percentages, vines represented 5.4% of the overall flora with little damage, 9.5% with moderate damage, and 12.6% with severe damage).

Discussion

In the Atlantic lowland tropical rainforest of the Rio San Juan region, Nicaragua, 1 yr after logging, an increase in plant species and density was measured due to secondary species (vines, grasses, balsa, cecropia) and seedling regeneration following harvest. The more severe the logging damage the more severe the effects on some variables, particularly increases of vines and secondary species. Nine years after logging, as species richness and densities were falling to intermediate levels, Hutchinson Liberation Silviculture had not significantly affected either non-timber forest products or the basic physiognomy of the forest. This minimal thinning treatment, applied to increase growth and regeneration of preferred timber species, had few side effects.

There are many comparisons and some contrasts that we can make with other silvicultural techniques, in particular with the previous work of Salick (1992*b*) on Hartshorn's (1989) Strip Clearcuts in Peru. In both these studies increased number of species, density, and diversity after logging were found; the explanations are in the small size of regenerating plants allowing for greater density and the mix of secondary and primary forest species generating greater richness and diversity.

With both selective logging (Nicaragua) and strip clearcut (Peru), vines increased after logging and with increased disturbance. Vines were less dominant (8.9% of individuals) in Nicaragua 1 yr after selective logging, as compared to clear-cut strips in Peru (22% of individuals, Salick 1992*b*). Presumably this can be explained by the severity of disturbance caused by clearcutting. This supposition is supported by the data with-

(**O**); poison (**P**); resins, gums, and latex (**R**); shade, living fences (**S**); timber (**T**); utility (**U**: vines, wraps, string, processing); wood for other than timber (**W**); and other (**X**). Data are means ±1 SD.

Use categories (% plants/10 m^2)							
O	**P**	**R**	**S**	**T**	**U**	**W**	**X**
0.2 ± 0.8	0	0.2 ± 1.0	2.2 ± 9.6	24.1 ± 15.4	17.2 ± 16.7	3.1 ± 3.5	1.4 ± 2.6
2.3 ± 5.5	0.1 ± 0.6	0.4 ± 1.3	3.4 ± 9.1	20.3 ± 12.4	22.8 ± 11.4	4.7 ± 7.0	0.6 ± 1.4
0.063	0.386	0.299	0.017	0.524	0.017	0.912	0.148
0.9 ± 1.5	0.2 ± 0.5	0	0.7 ± 1.5	26.8 ± 12.1	21.7 ± 9.9	2.0 ± 2.7	0.9 ± 1.7
1.9 ± 3.6	0.2 ± 0.8	0.7 ± 1.7	2.0 ± 4.3	24.6 ± 10.9	20.8 ± 10.9	2.5 ± 3.3	1.7 ± 2.7
0.683	0.962	0.073	0.557	0.548	0.917	0.912	0.335

Use categories (% plants/10 m^2)							
O	**P**	**R**	**S**	**T**	**U**	**W**	**X**
0	0	0.1 ± 0.4	4.6 ± 13.7	14.8 ± 9.2	22.0 ± 10.0	0.9 ± 1.8	0.8 ± 1.7
2.5 ± 6.5	0	0.3 ± 0.7	1.3 ± 2.0	22.6 ± 13.1	25.6 ± 13.4	5.1 ± 5.4	0.5 ± 0.9
6.3 ± 7.2	0.4 ± 1.2	1.0 ± 2.7	4.7 ± 5.0	26.8 ± 13.7	19.5 ± 10.5	10.9 ± 10.9	0.5 ± 1.4
0.011	0.168	0.743	0.077	0.059	0.603	0.005	0.440

TABLE 3. Densities of plants producing selected important non-timber forest products are compared among La Lupe (1990 and 1993), Los Filos (1991 and 1993), and a local farmer's forest (see Salick 1992*a*) to elaborate species distributions.

Non-timber forest products	Scientific name	Plant densities (no./ha) Los Filos 1991	Los Filos 1993	La Lupe 1990	La Lupe 1993	Farmer forest 1991	Use
Anona	*Rollinia pitieri*	0	6	3	0	13	Fruit
Alcanfor	*Protium* sp.	25	16	20	3	38	Anesthetic, insect repellent
Alcotan	*Piper* cf. *dariense*	229	284	0	53	147	Anesthetic
Balsa	*Ochroma lagopus*	0	116	0	0	0	Toys, carving, stuffing
Bijagua	*Calathea* spp. *Pleiostachya* sp.	17	9	63	110	20	Food wraps
Cacao	*Theobroma* spp. *Herrania purpurea*	8	0	3	0	0	Fruit and seeds
Cebo	*Virola koshnuii*	42	25	53	27	0	Timber, medicinal salve
Chichicaste	*Myriocarpa longipes*	8	0	0	0	7	Medicinal tea from roots
Chicle	*Sorocea pubivena* *Lacmellea panamense*	8	106	20	120	0	Gum latex
Chilamate	*Ficus tonduzii*	4	3	3	3	0	Fruit, fabric from bark
Copalchil	*Croton schiedeanus*	12	72	46	40	0	Bark treats fever/malaria
Escalera de mico	*Bauhinia quianensis*	12	12	0	0	0	Medicinal tea from vine
Guarumo	*Cecropia* spp.	25	384	33	27	0	Medicinal tea from leaves
Hombre grande	*Quassia amara*	12	3	33	80	27	Bark used against fever
Hule	*Castilla elastica*	4	6	0	13	13	Rubber, water proofing
Kamibar	*Copaifera aromatica*	0	3	7	7	7	Antibacterial sap
Majagua	*Heliocarpus appendiculatus*	0	9	0	3	7	Rope from bark
Maquengue	Various palms	4	3	0	0	40	Palm hearts
Mimbre	*Heteropsis* sp.	0	0	3	0	0	Wicker
Ojoche	*Brosimum* sp.	58	144	30	193	40	Edible seeds
Pita	*Bromelia* sp.	4	0	47	7	0	Fruit, string
Quina	*Ocotea* sp.	50	22	7	3	0	Against fever and malaria
Raicilla	*Psychotria ipecacuanha*	0	0	0	0	47	Medicinal root
Sarsaparilla	*Smilax* sp.	0	16	10	17	0	Roots strengthen blood

in the selective logging system in Nicaragua demonstrating that vines increased with severity of logging damage (5.4% with little damage, 9.5% with moderate damage, and 12.6% with severe damage—still well below 22% with clear-cutting).

With both logging systems, grasses appeared and secondary species increased, particularly cecropia and balsa. There is a socioeconomic difference between Nicaragua and Peru, however, in that along the Rio San Juan balsa is particularly important since it is sold to the island of Solentiname for their famous bird carvings, which provide jobs and money to the local economy.

Unlike the strip clearcut, regeneration by resprouting was relatively unimportant under selective logging while seedlings were dominant. Moreover, palms remained unaffected by selective cutting, whereas their density and species were reduced significantly with

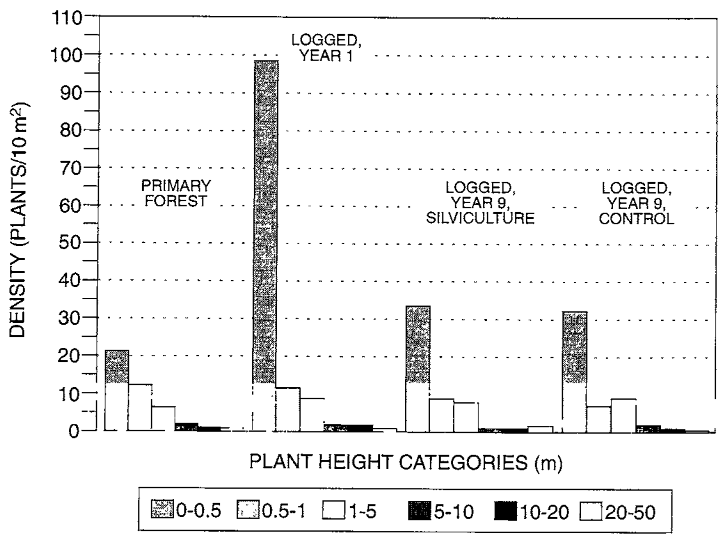

FIG. 4. Plant height distribution. Seedlings and small plants are significantly more numerous in the forest 1 yr after than in the primary forest, advancing an explanation of the increase in species diversity after logging.

TABLE 4. Plant height distributions relative to forest management history in Nicaraguan Atlantic lowlands. Data are means ±1 SD.

a) Plant height distributions among stand histories*

	Height categories (m)					
	0.1–0.5	0.6–1.0	1.1–5.0	5.1–10.0	10.1–20.0	20.1–50.0
Treatment	Plants/10 m²					
Primary forest	21.1 ± 20.2	12.3 ± 9.8	6.3 ± 4.3	1.5 ± 2.0	0.5 ± 1.0	0.3 ± 0.6
Logged, year one	97.6 ± 59.2	11.3 ± 10.8	8.3 ± 7.5	1.1 ± 1.3	1.1 ± 1.7	0.3 ± 0.7
P	0.000	0.311	0.425	0.875	0.104	0.654
Logged, year nine, silviculture	55.5 ± 28.4	8.9 ± 4.6	8.6 ± 5.8	0.7 ± 1.0	0.7 ± 1.0	0.9 ± 1.2
Logged, year nine, control	55.7 ± 19.3	6.8 ± 4.3	10.9 ± 4.3	1.7 ± 1.5	0.7 ± 1.2	0.4 ± 1.1
P	0.694	0.307	0.095	0.030	0.809	0.066

b) Plant height distribution among damage categories†

	Height categories (m)					
	0.1–0.5	0.6–1.0	1.1–5.0	5.1–10.0	10.1–20.0	20.1–50.0
Damage categories	Plants/10 m²					
Little	93.9 ± 58.5	8.4 ± 6.3	4.7 ± 4.0	1.5 ± 1.5	0.8 ± 1.1	0.4 ± 0.6
Moderate	79.8 ± 43.9	12.1 ± 13.5	8.9 ± 6.2	1.2 ± 1.2	1.2 ± 1.9	0.4 ± 1.0
Severe	134.7 ± 74.3	15.3 ± 12.4	14.1 ± 10.8	0.4 ± 0.8	1.1 ± 2.2	0.1 ± 0.4
P	0.229	0.535	0.019	0.192	0.932	0.681

* Seedlings and small plants were significantly more numerous in the logged forest after 1 yr than in the primary forest. The only significant difference with silviculture was a very slight decrease in the number of pole-sized trees (5–10 m).

† Small pole-sized trees (1–5 m) significantly increased with severity of logging damage, easily identified as even-aged stands of secondary species like balsa and cecropia.

clear-cutting. Palms are particularly important non-timber forest products in both regions (and worldwide), so their accommodation within selective logging is important to optimize the diversity of products in natural forest management. As in Peru, mimbre (*Heteropsis* sp., Araceae) is on the verge of disappearing because of overharvesting. This is possibly the single most important non-timber forest product exploited for innumerable uses including tying, weaving, and wicker.

Hutchinson Liberation Silviculture is most notable

TABLE 5. Growth form of plants in Nicaraguan Atlantic lowland forest stands of various land use histories. Data are means ±1 SD.

a) Plant growth-form distributions among stand histories*

	Growth-form categories (plants/10 m²)								
Treatment	Climb.	Epiph.	Fern	Grass	Herb	Palm	Shrub	Tree	Vine
Primary forest	0.4 ± 0.9	0.8 ± 1.1	0.4 ± 1.2	0.3 ± 0.9	7.1 ± 9.7	6.7 ± 4.9	8.2 ± 10.4	15.0 ± 6.4	1.2 ± 1.4
Logged, year one	1.6 ± 2.1	0.6 ± 1.5	4.3 ± 7.4	6.4 ± 19.3	33.7 ± 32.8	6.4 ± 4.0	3.0 ± 5.7	53.1 ± 30.6	10.6 ± 12.6
P	0.001	0.212	0.001	0.024	0.000	0.797	0.000	0.000	0.000
Logged, year nine, silviculture	0.7 ± 1.1	0.4 ± 0.7	2.1 ± 3.4	0.1 ± 0.3	25.5 ± 22.4	5.2 ± 5.9	10.8 ± 7.0	26.5 ± 9.9	3.8 ± 2.8
Logged, year nine, control	0.3 ± 0.5	0.1 ± 0.5	1.9 ± 2.4	0.1 ± 0.5	28.1 ± 19.0	5.5 ± 3.6	9.9 ± 7.0	26.9 ± 10.5	3.1 ± 2.0
P	0.341	0.169	0.895	0.962	0.589	0.296	0.618	0.934	0.734

b) Plant growth-form distribution among damage categories in logged forest† 1 yr after logging

	Growth-form categories (plants/10 m²)								
Damage categories	Climb.	Epiph.	Fern	Grass	Herb	Palm	Shrub	Tree	Vine
Little	1.8 ± 2.4	0.3 ± 0.6	6.6 ± 9.2	5.3 ± 13.6	38.0 ± 40.6	7.2 ± 4.4	3.4 ± 6.4	41.1 ± 18.6	5.9 ± 5.3
Moderate	1.6 ± 2.2	0.6 ± 0.7	2.1 ± 2.3	1.2 ± 2.0	28.6 ± 27.8	6.9 ± 3.0	1.9 ± 5.5	51.0 ± 27.0	9.7 ± 10.6
Severe	1.1 ± 1.3	1.1 ± 3.0	4.0 ± 9.2	17.6 ± 36.7	34.3 ± 27.8	3.9 ± 3.9	4.0 ± 5.6	78.9 ± 41.3	20.9 ± 19.8
P	0.823	0.316	0.393	0.343	0.746	0.230	0.055	0.200	0.026

* Plant growth-form distributions underwent great changes before vs. after logging, but evidenced no significant differences with silvicultural treatment. Notable with logging were the significant increases in vines, trees (predominantly tree seedlings), herbs, and grasses.

† Vines further increased with severity of logging damage.

for minimally affecting the forest, as measured here by both the vegetation and useful-plant statistics. If this treatment does in fact aid regeneration of desirable timber species (Mejia 1993), it may prove the ideal silvicultural system with which to incorporate management of non-timber forest species. However, one of the primary motivations for this study is the reciprocal consideration: How can non-timber forest product management strengthen natural forest management?

Hutchinson Liberation Silviculture provides the potential for simultaneous management of non-timber forest products, and moreover, non-timber forest product management holds the potential for significantly reinforcing the silviculture. Once the compatibility of the products is demonstrated, as in this study, there is the possibility of using non-timber forest product extraction to reduce the costs of silviculture. One of the major drawbacks to silviculture is that it needs to be applied 20–30 yr before any further profits will be realized. Any expense, however minimal, discounted over such a long period will significantly reduce the economic feasibility of a system. If the cost of silvicultural treatments can be offset by the collection of non-timber forest products, then the economics might again stabilize. Such was historically the case; in 1938 timber represented 55% of forest extraction and "minor" products 45%, whereas today timber is 95% of forest extraction with minor forest products having been largely forgotten (Whitmore 1990).

A plan might be to send out a team of local collectors (see Alpert's introduction and support of local participation) to harvest non-timber forest products 8–10 yr after logging. In exchange for the permit to collect and the profits earned, these collectors would perform a low-intensity, low-skill silvicultural treatment to improve regeneration of desired timber species at no cost to the forestry sector. A low-intensity treatment like Hutchinson Liberation Silviculture could be adapted to the skills and work routine of forest collectors. The major cost of silviculture is often getting a team in the field for the needed time; simultaneous collecting would discharge this cost. It should be clearly noted that this is not a wholesale approbation for logging tropical forests, but support for natural forest management of both timber and non-timber forest products coordinated with preservation (where genetic stock and seed sources of primary species are maintained). This is the case in the International Peace Park, where natural forest management is meant to be used as a buffer to the central preservation area of Atlantic tropical lowland rainforest.

Lest we be overoptimistic about management of non-timber forest products, an all-too-frequent problem in the field (Plotkin and Famolare 1992), let us recognize problems (Browder 1992, Clemente 1993). Tenure and markets remain major issues for non-timber forest product management (Salick and Offen 1992). Restricting extraction to silvicultural teams when forestry control is negligible would pose another uncertainty. Densities of particular products may be low (Table 3). Valuation of non-timber forest products remains preliminary (Peters et al. 1989). There is ample evidence for mismanagement of non-timber forest products, which may be difficult to overcome (Offen 1993); in the Rio San Juan, we see a lack of raicilla and mimbre in the untenured forest plots (Table 3). Management of diverse non-timber forest products in congruence with silvicultural and campesino cycles is planned, but our optimism must remain guarded.

Yet, the reincorporation of non-timber forest products with natural forest management seems the most pragmatic recommendation for increasing the value of the tropical rainforest outside of reserves and preserves to compete with other land uses, which offer alluring short-term returns through deforestation. Not only do these products add value in their own right, but they can help defray the costs of silviculture and reduce discounting over long silvicultural cycles. We are convinced of the theoretical compatibility of the management and must get on with the practical details of the ecological and socioeconomic applications.

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APPENDIX

Useful plant species included in this study and previous studies (see Salick 1992) with families, scientific names, common names, sites at which collected, use categories, abbreviated uses from primary sources only, and Salick collection numbers. Collection sites: C = El Castillo, F = Los Filos, L = La Lupe, M = Marcelo. Plant use categories: aesthetic (**A**); construction (**C**); edible (**E**); firewood (**F**); hunting (**H**: animal habitat); intoxicant (**I**); medicinal (**M**); oils (**O**); poison (**P**); resins, gums, and latex (**R**); shade, living fences (**S**); timber (**T**); utility (**U**: vines, wraps, string, processing); wood for other than timber (**W**); and other (**X**).

Family	Scientific name	Common name	Site of collection	Use category	Use	Collection number
Adiantaceae	*Adiantum tetraphyllum*	Palma oro, Raiz oro	L,F	**M**	Roots and stems used for kidneys	8160
Agavaceae	*Cordyline fruticosa*	Cana agria	F,L	**M**	Medicine for kidneys	7869
Anacardiaceae	*Mosquitoxylum jamaicense*	Carolillo	L,M	**T**	Timber	
Anacardiaceae	*Spondias mombin*	Jobo	F,L,M	**H**	Animals eat fruit	8072
Anacardiaceae	*Tapirira myriantha*	Caobillo	F,L	**T**	Timber	8139
Annonaceae	*Rollinia pitieri*	Anona	F,L,M	**E,H,F**	People/animals eat fruit, firewood	7894
Annonaceae	*Rollinia*?	Anona montera	F	**F**	Firewood	
Annonaceae	*Rollinia*?	Anona negra	C	**E,F,W**	People/animals eat fruit, instruments	
Annonaceae	*Xylopia bocatorena*	Palanco	F,L,M	**C,H**	Poles for house, animals eat fruit	8046, 8142
Annonaceae	*Xylopia* sp.	Manga larga fina	C	**T**	Timber	
Apocynaceae	*Lacmellea panamensis*	Leche de vaca	F,L	**E**	Drink sap (milk)	7856
Apocynaceae	*Tabernaemontana crysocarpa*	Cachito	F,L,M	**F,U**	Firewood, charcoal, shoe heels	
Araceae	*Anthurium clavigerum*	Manuelon	C	**A**	Ornamental	7842
Araceae	*Anthurium consobrinum*	Hoja de Piedra	C,F,M	**M,R**	Glue, pain medicine	7827, 8067
Araceae	*Anthurium consobrinum*	Mata piedra	F	**U,H**	Wrap, birds eat seeds	8009
Araceae	*Dieffenbachia oerstedii*	Coyanchigua	C,F,L	**P**	Stem used as rat poison	7811, 8153
Araceae	*Heteropsis oblongifolia*	Bejuco del homre	C	**U**	Bind houses, baskets	7845
Araceae	*Heteropsis* sp.	Bejuco mujer	L	**U**	Tie things and weaving	
Araceae	*Monstera* cf. *tenuis*	Hoja de la tamagaz	F,L	**M**	Against snake (tamagaz) bite	8113
Araceae	*Rhodospatha wendlandii*	Ventanilla	C,F,L	**A**	Ornamental	7844
Araceae	*Spathiphyllum friedrichsthalii*	Ribarbol	C	**M**	Boil stem against hepatitis	7831
Araliaceae	*Dendropanax* sp.	Pan blanco	C,F,L,M	**X,F**	Soft wood for carving, firewood	7821, 7870
Aspleniaceae	*Dictyoxiphium panamense*	Lengua de vaca	M	**A**	Ornamental	8057
Aspleniaceae	*Dictyoxiphium panamense*	Lengua del cierbo	C,F,L,M	**M**	Tea for fever, for kidneys	7808, 7855
Aspleniaceae	*Tectaria rivalis*	Palmilla	C	**A**	Ornamental	7848
Bignoniaceae	*Anemopaegma orbiculatum*?	Bejuco blanco	F	**U**	Tie house and fences	8116
Bignoniaceae	*Tabebula guayacan*	Cortez	F,L	**T**	Timber	
Bignoniaceae	*Xylophragma seemannianum*	Bejuco blanco	F,L	**U**	Tie roofs	7899, 8011
Bombacaceae	*Ceiba pentandra*	Ceiba	C,F,L,M	**T,M**	Timber, latex for skin	7878
Bombacaceae	*Ochroma lagopus*	Balsa	F	**W,U,C**	Housing, toys, bed slats, cotton for pillows	
Boraginaceae	*Cordia* aff. *panamensis*	Muneco	F,M	**T**	Wood for houses	8096
Boraginaceae	*Cordia bicolor*	Muneco	L	**T**	Wood for houses	7877
Boraginaceae	*Cordia* sp.	Laurel pataste	F	**T**	Timber	
Bromeliaceae	*Bromelia* sp.	Pita	C,F,L	**E,H,U**	People/animals eat fruit, string	7809, 7867
Burseraceae	*Protium* sp.	Alcanfor	C,F,L,M	**F,M**	Firewood, dressing wounds	7873, 7818, 8017, 8097
Burseraceae	*Protium* sp.	Fosforo	F,L	**F**	Firewood	7868

APPENDIX. Continued.

Family	Scientific name	Common name	Site of collection	Use category	Use	Collection number
Burseraceae	*Protium* or *Tetragastris panamensis*	Kerosin	F,L	**F,T**	Firewood, wood for houses	7882, 8012
Cecropiaceae	*Cecropia* sp.	Guarumo blanco	F	**W,H,C**	Bed slats, aminals eat seeds, housing	8128
Cecropiaceae	*Cecropia* sp.	Guarumo colorado	F	**W,H,C**	Bed slats, animals eat seeds, housing	8138
Cecropiaceae	*Cecropia peltata*	Guarumo	F,L	**W,H,C**	Bed slats, animals eat seeds, housing	
Cecropiaceae	*Pourouma bicolor* ssp. *Scobina*	Pasica	C,F,L	**U,H**	Leaves for sand paper, bird seed	7835, 8109
Clusiaceae	*Vismia macrophylla*	Ronchil	L	**M**	Sap from leaves for insect bites	7890
Combretaceae	*Aegiphila elata*?	Papa miel	F,L	**E,H**	People and animals eat fruit	8154
Combretaceae	*Terminalia amazonia*	Guayabo negro	C	**C,F,U**	Floors, firewood, sugar processing	
Combretaceae	*Terminalia bucidoides*	Guayabo de charco	F,L	**T**	Timber	
Combretaceae	*Terminalia oblonga*	Guayabon	L	**T**	Timber	
Combretaceae	*Terminalia* sp.	Guayabo	L	**T**	Timber	
Compositae	*Mikania*? sp.	Bejuco reina	F,L	**M**	Leaves for hives	8120
Cyclanthaceae	*Carludovica* sp.	Escobar	F,L	**X**	Brooms	7897, 8007
Dilleniaceae	*Tetracera portabellensis*	Bejuco de hojachigua	F,L	**C,U,E**	Wash clothes, gives water, bind houses	8035, 8115
Elaeocarpaceae	*Sloanea medusula*/ *Cespedezia macrophylla*	Tabacon	C,L,M	**F**	Firewood	7843
Elaeocarpaceae	*Sloanea* sp.	Naranjo	F,L	**U,C**	Sturdy for stakes, poles	
Euphorbiaceae	*Acalypha diversifolia*	Varia negra	C,F,L,M	**M,H,S**	Animals eat leaves, for hemorrhaging	7854, 8016, 7812
Euphorbiaceae	*Acidoton nicaraguensis*	San antonio	F,L,M	**F**	Firewood	7875, 8054
Euphorbiaceae	*Adelia triloba*	Cuentita	M	**H**	Animals eat fruit	8088 (mixed sample)
Euphorbiaceae	*Alchornea latifolia*	Coje del agua	M	**M**	Gum used as tonic, good for baldness	8073
Euphorbiaceae	*Croton schiedeanus*	Copalchil	C,F,L	**F,T,C**	Firewood, wood for house, poles	7853, 7872
Euphorbiaceae	*Croton smithianus*	Algodon	F,L,M	**F**	Firewood	7862, 8090
Euphorbiaceae	*Hyeronima alchorneoides*	Nanciton	F,L	**T**	Timber	
Euphorbiaceae	*Omphalea diandra*	Papa caribe	F,L	**E,H**	People and animals eat fruit	8144
Euphorbiaceae	*Pausandra trianae*	Sapotillo	M	**C,H,F**	House pillars, firewood, fruit for monkeys	8059
Flacourtiaceae	*Lunania parviflora* or *mexicana*	Plumillo	F,L	**C**	Poles	8146
Flacourtiaceae	*Casearia corymbosa*	Cuentita	M	**H**	Animals eat fruit	8088 (mixed sample)
Flacourtiaceae	*Laetia*? sp.	Areno negro	C	**T**	Rustic wood for house	
Flacourtiaceae	*Lunania mexicana*	Manga larga	L,M	**U,F,T**	Firewood, fishing poles, timber	8063, 7826
Flacourtiaceae	*Zuelania guidonia*	Cerito	C	**T**	Timber	
Flacourtiaceae	*Zuelania guidonia*	Palo de plomo	F,L	**U**	Wrap food	7925
Gesneriaceae	*Episcia lilacina*	Tercio pelo	C,L,M	**M**	Put in alcohol for snake bite	7806
Gramineae	*Panicum pilosum*	Grama montera	L	**H**	Animal feed	7910
Gramineae	*Paspalum conjugatum*	Grama amarga	F	**H**	Eaten by horses	8136
Guttiferae	*Garcinia (rheedia) infermedia*?	Azufre	F,L	**E,H**	People and animals eat fruit	8158
Heliconiaceae	*Heliconia* cf. *mathiosiae*	Plantanillo	C,F,L	**U**	Wrap tamales	8104
Heliconiaceae	*Heliconia* sp.	Chahuiton	F,L	**C**	Roofing	7902

APPENDIX. Continued.

Family	Scientific name	Common name	Site of collection	Use category	Use	Collection number
Humiriaceae	*Sacoglottis trichogyna*	Guaviluna	F,L,M	**F,H**	Firewood, animals eat seeds	
Humiriaceae	*Sacoglottis trichogyna*	Rosa	C,M	**F,T**	Firewood, timber	
Hydrangeaceae	*Hydrangea* sect. *cornidia*	Bejuco garobo	F,L	**U**	Tie things	8111
Lauraceae	*Licana*? sp.	Canela	C	**E,F**	Cook bark, firewood	7838
Lauraceae	*Licana*? sp.	Canela silvestre	C	**E,F**	Cook bark, firewood	
Lauraceae	*Ocotea* cf. *paulii*	Aguacate del monte	L,F,M	**H,F,T**	Fruit for animals, firewood, timber	7941, 8013
Lauraceae	*Ocotea*? sp.	Quina	F,L	**M,C**	Medicine, poles	8105
Leguminosae	*Copaifera aromatica*	Kamibar	C,F,L,M	**M,T**	Sap is antibacterial, timber	7837
Leguminosae	*Dialium guianensis* or *pterocarpus*	Tamarindo	C,F,L,M	**E,T,H**	Timber, people/animals eat fruit	7939, 8010
Leguminosae	*Dipteryx panamensis*	Almendro	C,F,L,M	**W,H**	Posts, animals eat fruit	
Leguminosae	*Inga sapindoides*	Guabo	C,F,L,M	**F,C,E,H**	Firewood, poles, people/animals eat fruit	8132
Leguminosae	*Inga* sp.	Guavilla	C,F,M	**F,E,H**	Firewood, animals/people eat fruit	8005, 8071
Leguminosae	*Inga thibaudiana*	Guavilla	L	**F,E,H**	Firewood, animals/people eat fruit	7891, 7881
Leguminosae	*Lonchocarpus* sp.	Chaperna	M	**F,C**	Firewood, posts	8095
Leguminosae	*Lonchocarpus* sp.	Zopilote	F,L	**T,F**	Rustic wood for house, firewood	7938
Leguminosae	*Ormosia schippi*	Coralillo	M	**T**	Timber	
Leguminosae	*Pentaclethra macroloba*	Gavilan	F,L	**T**	Wood for houses	
Leguminosae	*Petrocarpus hayessi*	Sangregrado	C,L	**M,F,T,E**	Timber, firewood, brush teeth, sugary bark	7850
Leguminosae	*Swartzia cubensis*	Costilla de danto	L	**H,F**	Animals eat seeds, firewood	7935
Leguminosae	*Tachigali* sp.	Pavon	F,L	**T,F**	Wood for houses, firewood	8047
Loganiaceae	*Strychnos* sp.	Bejuco curarina	F,L	**H**	Animals eat fruit	8149
Loganiaceae	*Strychnos brachistantha*	Curarina	L	**M**	Roots used for snakebite	7919
Malpighiaceae	*Byrsonima crispa*?	Nancite	F	**E,H**	People and animals eat fruit	8117
Malpighiaceae	*Heteropteris macrostachya*	Hojancha	F,L	**M**	Used for fevers	7928
Malvaceae	*Malvaviscus arboreus*	Bejuco mapola	F,L	**M,U**	Tie nacatamales, flower induces vomiting	8133
Marantaceae	*Calathea* sp.	Bijaua negra	F,L	**U**	Food wrap	
Marantaceae	*Calathea* sp.	Bijaua lucia	M	**U**	Food wrap	8058
Marantaceae	*Calathea* sp.	Bijauilla	L	**M**	Sap of leaves used for insect bites	7906
Marantaceae	*Calathea lutea*	Bijaua blanca	L	**U**	Food wrap	7898
Marantaceae	*Hylaeanthe hoffmannisi*	Huisirana	F,L	**E,H**	Animals and people eat fruit	8162
Marantaceae	*Pleiostachya* sp.	Pata paloma	F,L	**U**	Wrap tamales	7900
Marantaceae	*Pleiostachya* sp.	Bijaua	C,L	**U**	Food wrap	7866
Marantaceae	*Pleiostachya* sp.	Palomilla	M	**U**	Food wrap	8051
Marantaceae	*Spethiphyllum laeve*	Bijauilla	F	**M**	Sap of leaves used for insect bites	8121
Marattiaceae	*Danaea nodosa*	Camotillo	L	**P**	Poison	7918
Melastomataceae		Capirote montanero	F,L	**H,F**	Firewood, birds eat seeds	
Melastomataceae	*Leandra dichotoma*	Capirote	C,F,L	**F,H**	Firewood, birds eat seeds	7864, 7833, 8123
Melastomataceae	*Miconia paleacea*	Dorado	M	**C**	Roofing	8080
Melastomataceae	*Mouriri myrtilloides*	Gasparillo, chumultacu	C,L,M	**C,E,F**	Poles, spice, building, firewood	7852, 8064
Meliaceae	*Carapa nicaraguensis*	Cedro macho	C,F,L	**T**	Timber	

APPENDIX. Continued.

Family	Scientific name	Common name	Site of collection	Use category	Use	Collection number
Meliaceae	*Cedrela mexicana*	Cedro real	M	**T**	Timber	
Meliaceae	*Guarea*	Pavon	F,L	**T,F**	Wood for houses, firewood	8127
Meliaceae	*Guarea grandifolia*	Pronto alivio, palo indio	F,L	**T,M**	Wood for house, bark for rheumatism	8003
Meliaceae	*Guarea guidonia*	Cerillo	M	**F,W,E,H**	Firewood, poles, animals/people eat fruit	8060
Meliaceae	*Guarea pterorhachis*	Lengua de mujer	F	**C**	Hard poles	7859
Meliaceae	*Guarea pterorhachis*	Palo de rosa	C,F,L	**F**	Firewood	8152
Meliaceae	*Swietenia macrophylla*	Caoba	M	**T,C**	Timber, roofing	
Meliaceae	*Trichilia montana*	Cacoahuillo	L	**H,C**	Animals eat seeds, housing, poles	7880
Meliaceae	*Trichilia pallida*	Cacoahuillo	F	**H,C**	Animals eat seeds, housing, poles	8048
Meliaceae	*Trichilia septentrio5nalis*	Culebro	C,F,L	**T,F**	Wood for house, firewood	
Monimiaceae	*Siparuna* sp.	Palo de manzana	F,M	**H,F**	Birds eat fruit, firewood	8148
Moraceae	*Brosimum lactescens*	Ojoche	F,L	**E,H,T**	House wood, people/animals eat fruit	8024
Moraceae	*Brosimum lactescens*	Ojoche blanco	M	**E,H,T**	House wood, people/animals eat fruit	8084
Moraceae	*Brosimum* sp.	Ojoche colorado	C,F,L	**F,T,E,H**	Firewood, timber, people/animals eat fruit	
Moraceae	*Brosimum* sp.	Ojoche hembra	F,L	**E,H**	People and animals eat fruit	
Moraceae	*Brosimum* sp.	Ojoche macho	L	**E,H**	People and animals eat fruit	7886
Moraceae	*Castilla elastica*	Hule	C,F,L,M	**R**	Water proofing, rubber	8086
Moraceae	*Ficus* sp.	Higo	L	**H**	Fruit for animals	
Moraceae	*Ficus insipida*	Chilamente	F	**T**	Timber	8014
Moraceae	*Ficus tonduzii*	Chilamate	F,L	**T,H**	Timber, animals eat fruit	7934
Moraceae	*Perebea angustifolia*	Ojoche negro	F,L,M	**F**	Firewood	8078
Moraceae	*Pseudolmedia oxyphyllaria*	Ojoche macho	F	**E,H**	People and animals eat fruit	8036
Moraceae	*Sorocea affinis*	Sardinillo	F,L	**C**	Building, poles	7933
Moraceae	*Sorocea pubivena*	Ojoche	C,M	**E,H,T**	House wood, people/animals eat fruit	7817
Myristicaceae	*Virola sebifora*	Fruta dorada	C,M	**M,T,H**	Latex against cancer, timber, animals eat fruit	7824
Myristicaceae	*Virola koschnyii* or *sebifera*	Conchillo	F,L	**T**	Timber	7932
Myristicaceae	*Virola koschynii* or *sebifera*	Cebo	C,F,L	**M,T**	Timber, latex for dermatitis	7815
Myrsinaceae	*Ardisia* sp.	Uva	F,L	**E,I,H**	Animals/ people eat fruit	7860, 7893
Myrtaceae	*Calyptranthes pallens*	Arayan	F,L	**H**	Animals eat fruit	8151
Ochnaceae	*Ouratea*	Olivar	F,L	**C**	Sticks	7926
Olacaceae	*Minquartia guianensis*	Manu	C,L,M	**T,C,W,H**	Timber, fences, poles, animals eat fruit	
Palmae	*Asterogyne martiana*	Suhita	C,F,L,M	**C,E,H**	Palm roof, people/animals eat fruit	7803, 7909, 8075, 8106
Palmae	*Bactris hondurensis*	Huiscoyol	C,F,L,M	**W,C**	Wood for house, fence	7813, 8077
Palmae	*Calyptrogyne ghiesObreghteana*	Cola de gallo	F,L,M	**C,E,H**	Roof, stems for house, animals/people eat fruit	8082, 8107
Palmae	*Carludovica palmata*	Palma de sombrero	C	**X**	Used for hats	7826
Palmae	*Chamaedorea pinnatifrons*	Makengue	M	**C**	Roof supports	8055
Palmae	*Cryosophila warscewiczii*	Escobar	M	**X**	Brooms	8053

APPENDIX. Continued.

Family	Scientific name	Common name	Site of collection	Use category	Use	Collection number
Palmae	*Elaeis oleifera*	Makengue	C	**C**	Roof supports	7846
Palmae	*Geonoma* sp.	Surtua	C	**C**	Thatch roofs	7810
Palmae	*Geonoma congesta*	Cana de danto	F,L	**C,H**	Roofing, animals eat seeds	7908, 8102
Palmae	*Geonoma cuneata*	Cola de gallo	C	**C,E,H**	Roof, stems for house, animals/people eat fruit	7801
Palmae	*Geonoma deversa*	Cana de danto	M	**C,H**	Roofing, animals eat seeds	8052
Palmae	*Geonoma* sp.	Cana de danto sin espinas	L	**C,H**	Roofing, animals eat seeds	
Palmae	*Geonoma* sp.	Palmilera	F,L	**C,M**	Roofing, induce vomiting	7871
Palmae	*Prestoea decurrens*	Sursula	F,L	**C**	Roofing, building	7921, 8101
Palmae	*Reinhardtia simplex*	Makengue amarga	C,M	**U**	Used in processing lard	8069
Palmae	*Socratea exorihiza*	Makengue	F	**C**	Roof supports	8126
Palmae	*Welfia georgii*	Palmilera	C,M	**C,M**	Roofing, induce vomiting	8079
Palmae	*Welfia georgii*	Palmera	F,L	**E,H,C**	Thatch, people and animals eat seeds	7904
Passifloraceae	*Passiflora ambigua*	Granadilla	F	**E,H**	People and animals eat fruit	8103
Passifloraceae	*Passiflora quadrangularis*	Granadilla blanca	F	**E,H**	People and animals eat fruit	8159
Passifloraceae	*Passiflora* sp.	Granadilla montera	F	**E,H**	People and animals eat fruit	
Passifloraceae	*Passiflora vitifolia*	Guillito (Granadilla)	F	**E,H**	Animals and people eat fruit	8135
Piperaceae	*Piper* cf. *dariense*	Alcotan	C,F,L	**M**	Anesthetic for stitches, toothache	7802, 8030
Piperaceae	*Piper nudifolium*	Cordoncillo	C(F,L)	**U,A**	Perfume, tomato stakes	7804
Piperaceae	*Piper phytolaccaefolium*	Quina	F,L	**M,C**	Medicine, poles	8030
Piperaceae	*Piper sancti-felicis*	Cordoncillo	M(F,L)	**U,A**	Perfume, tomato stakes	8091
Piperaceae	*Piper* sp.	Cordoncillo blanco	F,L	**U,F**	Stakes, firewood	
Piperaceae	*Piper* sp.	Cordoncillo negro	F,L	**U**	Stakes	8122
Rhamnaceae	*Colubrina spinosa*	Pichipan	C,F,L,M	**F**	Firewood	7911
Rhamnaceae	*Gouania lupuloides*	Bejuco miona blanca	F,L,M	**E,M**	Drinking water, good for kidneys	8157
Rubiaceae	*Chimarrhis* cf. *Parviflora*	Platano	F,L	**T,W**	Timber, posts	8137
Rubiaceae	*Chomelia recordii*	Crucita blanca	M	**F**	Firewood	8065
Rubiaceae	*Faramea stenura*	Trompillo	L	**C,H**	Poles, fruit for animals	7930
Rubiaceae	*Genipa americana*	Iguatil	F,L	**E,H**	Animals and people eat seeds	8002
Rubiaceae	*Genipa* sp.	Iguatil blanco	C	**I**	Wine	
Rubiaceae	*Guettarda turrialbana*	Palo de azucar	F,L	**T**	Timber	8145
Rubiaceae	*Hamelia axillaris*	Pata de venado	F,L,M	**T,F,M**	Timber, firewood, sap for insect bites	8001, 8140
Rubiaceae	*Morinda panamensis*	Tirisia	F,L	**C,X**	Poles for house, wood for carving	7903
Rubiaceae	*Posoqueria latifolia*	Jasmin	F,L	**A,H**	Flower, perfume, monkeys eat fruit	7863, 8021
Rubiaceae	*Posoqueria latifolia*	Lirio	L	**H**	Fruit for monkeys	8150
Rubiaceae	*Psychotria ipecauanha*	Raicilla	C,L,M	**M**	Medicinal roots	7807, 7914, 8085
Rubiaceae	*Psychotria racemosa*	Frutillo	C	**F,H**	Firewood, birds eat seeds	7820
Rubiaceae	*Psychotria racemosa*	Serita	M	**H**	Birds eat fruit	8066
Rubiaceae	*Psychotria suerrensis*	Atostado	M	**F**	Firewood	8062
Rubiaceae	*Psychotria suerrensis*	Pimienta	F,L	**H,U**	Bird food, whips	7942, 8100
Rubiaceae	*Randia* cf. *pittieri*	Crucifijo	F,L	**H**	Monkeys eat fruit	8143

APPENDIX. Continued.

Family	Scientific name	Common name	Site of collection	Use category	Use	Collection number
Rubiaceae	*Simira maxonii*	Iguatil rojo	L,M	**E,H**	Animals and people eat seeds	8098
Rutaceae	*Toxosiphon lindenii*	Naranjillo	M	**C**	Poles	8087
Rutaceae	*Zanthoxylum* sp.	Lagarto blanco	F	**T**	Wood for houses	8129
Rutaceae	*Zanthoxylum* sp.	Lagarto negro	F	**T**	Wood for houses	8156
Rutaceae	*Zanthoxylum belizense*	Lagarto	F,L,M	**T**	Wood for houses	
Sapindaceae	cf. *Cupania*	Cola de pava	F,L,M	**F,H,T,C**	Firewood, timber, animals eat fruit, beehives	
Sapindaceae	*Paullinia* sp.	Alcanjura	C	**P,U,H**	Fish poison, bind houses, animals eat fruit	7814
Sapindaceae	*Paullinia* sp.	Conjura	C	**P,E**	Arrow and fish poison, seeds for drink	
Sapindaceae	*Paullinia sessiliflora*	Palo bejuco	L,M	**F**	Firewood	8074
Sapindaceae	*Paullinia tenuifolia*	Bejuco coralero	F	**U**	Tie	8118
Sapindaceae	*Serjania paucidentata*	Bejuco coralero	F,L	**U**	Tie	8015
Sapindaceae	*Talisia nervosa*	Lengua de mujer	F	**C**	Hard poles	8004
Sapindaceae	*Talisia nervosa*	Mamon	C,F,L	**T,H,E**	Timber, animals/people eat fruit	7836, 7923
Sapotaceae	*Chrysophyllum* or *Vitex* sp.	Bimbayan	L	**T**	Timber	7937
Sapotaceae	*Manilkara zapota*	Nispero	L	**T**	Timber	
Sapotaceae	*Manilkara zapota*	Nispero macho	F,L	**T,H**	Timber, animals eat seeds	
Sapotaceae	*Mastichodendron capiri*	Tempisque	C	**T**	Timber	
Sapotaceae	*Pouteria*	Sapotillo	C,F,L	**T,H,F**	Timber, firewood, fruit for monkeys	7822, 7931
Simaroubaceae	*Quassia amara*	Hombre grande	C,F,L,M	**M**	Bitter bark for malaria, fever, snakebites	7832, 7845
Simaroubaceae	*Simaruba amara*	Aceituno	C,F,L,M	**T,M**	Timber, root for amoeba	8044
Smilacaceae	*Smilax*	Sarsaparilla	C,F,L	**M**	Roots used as medicine	7830, 7915
Smilacaceae	*Smilax*	Sarson	C	**M**	Roots used as medicine	7840
Solanaceae	*Solanum hayesiae*	Lava plato	F,L	**M**	Roots cooked in water for snakebite	8131
Solanaceae	*Solanum lancifolium*	Tomatillo	F,L	**H**	Birds eat fruit	8130
Staphyleaceae	*Turpinia occidentalis*	Chilillo	F,L	**W,C**	Poles, fencing	7892, 8155
Sterculiaceae	*Guazuma invira*	Capulin blanco	F,L	**T**	Timber	7896
Sterculiaceae	*Herrania purpurea*	Cacao de ardilla	C	**E,H**	Animals and people eat fruit	7829
Sterculiaceae	*Herrania purpurea*	Cacao de mico	F,L	**E,H,W**	Animals/people eat fruit, poles	7912, 8042
Sterculiaceae	*Sterculia recordiana*	Panama	F,L	**T**	Wood for houses	8045
Sterculiaceae	*Theobroma simiarum*	Cacao	C	**E,H**	Animals and people eat fruit	
Sterculiaceae	*Theobroma* sp.	Cacao de madera	C	**T**	Timber	
Sterculiaceae	*Theobroma* sp.	Cacao silvestre	C	**T**	Timber	
Tectariaceae	*Pleuroderris michleriana*	Crespillo	M	**A**	Ornamental	8083
Tilaceae	*Apeiba membranaceae*	Peine de mico or tapa botija	F,L	**O,T**	Timber, fruit has oil for hair	7889, 8023
Tiliaceae	*Heliocarpus appendiculatus*	Majagua real	M	**U**	Pulp wood	8093
Tiliaceae	*Heliocarpus appendiculatus*	Majagua blanca	F,L	**U**	Ties from bark	8114
Tiliaceae	*Luehea seemannii*	Guacimo	L	**F,T**	Firewood, timber	
Tiliaceae	*Luehea seemannii*	Guacimo colorado	F	**F**	Firewood	
Tiliaceae	*Trichospermum mexicanum*	Capulin	F,L,M	**F**	Firewood	
Ulmaceae	*Ampelocera macrocarpa*	Yaillo	C,F,L	**F,T,C**	Wood for house, firewood, poles	7823, 7884, 8019
Ulmaceae	*Celtis schippii*	Huesillo	F,L	**C,F**	Building, firewood	7865

APPENDIX. Continued.

Family	Scientific name	Common name	Site of collection	Use category	Use	Collection number
Urticaceae	*Myriocarpa longipes*	Chichicaste	C,F,M	**F,C**	Firewood, poles	7805
Violaceae	*Rinorea* sp.	Siete nudo	C,F,L	**C,U**	Roof supports, poles	7816, 7857, 8141
Vitaceae	*Vitis tiliifolia*	Bejuco miona negra	F	**E,M**	Drinking water, good for kidneys	8134
Vochysiaceae	*Vochysia guatemalensis*	Palo de agua, barba	F	**T**	Timber	8108
Zingiberaceae	*Costus* sp.	Cana agria	M	**M**	Medicine for kidneys	8049
Zingiberaceae	*Renealmia pluriplicata*	Gingiblon	C	**E,X**	Repels snakes, wild ginger	7828
Zingiberaceae	*Renaealmia brevis-capa?*	Gingiblon	F,L	**X**	Bathe in infusion to repel snakes	8124
Zingiberaceae	*Renealmia cernua*	Gingiblon	F,L	**X**	Bathe in infusion to repel snakes	8125
Unidentified specimens		Anisillo	M	**A**	Perfume	
		Bejuco cagalero	F,L	**M**	Tea stops women's hemorrhaging	
		Bejuco china cameco	F	**U**	Tie	
		Bejuco cola de leon	F,L	**M**	Medicine from roots	
		Bejuco hojancha	L	**M**	Used for fevers	
		Bejuco seda	F	**U**	Tie	
		Cafecillo	F,L	**A**	Flower, perfume	
		Caimito	F,L	**E,H**	Animals/people eat fruit	
		Capaillo	C	**E,H**	Eaten by aminals and people	
		Casado	L	**C**	Housing	
		Casca	F,L	**C,H**	Roofing, animals eat seeds	
		Cereso	F	**C**	Poles	
		Clavel	F	**A**	Flowers	
		Cocomico	L	**M**	Stem used for fever	
		Cola de leon	M	**A**	Ornamental	
		Cola de pavon	F	**T**	Timber	
		Coludo	F,L	**A**	Decorative gardens	
		Come negro	L	**T**	Timber	
		Coralero	C	**I**	Intoxicant in alcohol	
		Corona cristo	F,L	**M**	Roots used for hemorrhaging	
		Coroso	M	**C**	Roofing	
		Corre sapo	L	**T**	Timber	
		Crucita	M	**F**	Firewood	
		Disipela	F,L	**M**	Medicine for "Disipela"	
		Escalera de mico	F	**M**	Used with sarsaparilla to strengthen blood	
		Gallito	M	**A**	Ornamental	
		Guabo campano	F	**H**	Animals eat fruit	
		Guabo restrajero	L	**E,H**	People and animals eat fruit	
		Guarito	L	**F**	Firewood	
		Guatucu	L	P	Seeds are rat and people poison	
		Guayabillo	F	**T**	Timber	
		Gutire	F	**E,C**	Animals eat fruit, poles	
		Hoja de la bala	F	**M**	Eat leaves against ant bite	
		Hoja tiesa	M	**A**	Ornamental	
		Huevo de cangrejo	F	**C**	Poles	
		Huevo de gato	F	**E,H**	Animals and people eat fruit	
		Jicarillo	F,L,M	**H**	Monkeys eat fruit	
		Jicarillo blanco	L	**H**	Monkeys eat fruit	
		Jiliotropa	M	**A**	Ornamental	
		Laurel	F	**T**	Timber	

APPENDIX. Continued.

Family	Scientific name	Common name	Site of collection	Use category	Use	Collection number
Unidentified specimens		Lava plato lucio	F	**M**	Against faintness from snakebites	
		Leche amarillo	F	**T**	Timber	
		Licopodium	L	**A**	Ornamental	
		Manu macho	F	**T**	Timber	
		Maria	M	**M**	Bark cooked for diarrhea	
		Marillon	F	**T**	Timber	
		Melon	M	**T**	Timber	
		Meneito	F,L	**E,H**	People and animals eat fruit	
		Pacaya	F,L	**E,H**	Edible fruit	
		Palete de macho	F	W	Bed slats	
		Palmareal	C	**X,C,M**	Hats, roof, induce vomiting	
		Palmera de carisco	M	**C**	Thatch	
		Palmito	M	**E**	Eat new growth	
		Palmito dulce	M	**E**	Eat new growth	
		Palo de flus	F,L	**M**	Leaf base cooked for hemorrhages	
		Palo de manchon	F	**F**	Firewood	
		Palo de tigre	F,L	**U**	Stems for planters	
		Pan seguro	L	**H**	Pasture grass	
		Parra	F	**H**	Birds eat seeds	
		Pimienta blanca	M	**F**	Firewood	
		Pimienta negra	P	**C**	Wood for house	
		Pinta machete	L	**M**	Chew and put on wound to stop bleeding	
		Piojo	C	**C**	Wood for construction	7851
		Quiquisquio or tequisquillo	F,L	**H**	Animals eat roots	
		Rapiro	C	**U**	Wood glue	
		Rayoro	L	**M**	For kidneys	
		Retaner	F	**H**	Eaten by animals	
		Ronron	F,L	**F**	Firewood	
		Sonsaple	F	**M**	Seeds for diarrhea	
		Talcacao	L	**T**	Timber	
		Til blanco or jagua	C	**I**	Wine	
		Tololo	C	**T,F,H**	Timber, firewood, bird seed	
		Totolquelite	F	**H**	Animals eat leaves	
		Uva macho	F,L	**H**	Animals eat fruit	
		Varia blanca	M	**C**	Posts for house	