A Stem-based Ethnobotanical Quantification of Potential Rain Forest Use by Mirañas in NW Amazonia

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Abstract

Potential plant uses in Colombian Amazonia were analyzed in relation to landscape, stem diameter, habit, and family taxonomy, on the basis of one experienced informant and applying a 2.5 cm diameter cut-off. In 30 0.1 - ha plots, 13,934 plant stems were recorded, 90% of which had some kind of usefulness. The proportion of useful stems was lowest in floodplain and highest in swamp and white sand plots. Between 0 and 11% of the useful stems in the plots were from lianas. Fuel uses were important. Thicker stems were more useful for Food and Animal Food than slender stems. In logistic regression, family taxonomy had a stronger effect on the probability of stem usefulness than DBH, habit (liana or not) or landscape. Individual plants from one family (or genus or species) often show little variation in usefulness, hampering the binary analysis by means of logistic regression of use against plant taxonomy.

Introduction

Quantitative ethnobotany provides a numerical framework for the exploitation of vegetation resources by local people (Alexiades 1996, Martin 1995, Prance *et al*. 1987). Analysis of the potential use of plants and vegetation in forest plots is a widely used approach to describe the significance of neotropical forests for forest-dwelling communities (e.g. Anderson & Posey 1985, Balée 1986, 1987, Boom 1987, Carneiro 1978, Toledo *et al*. 1995). The importance of plants for local communities is often described by means of use values. A simple but straightforward way to calculate use-values is to count the various uses attributed to each species (Boom 1987, 1990; Paz y Miño *et al*. 1991). Prance *et al*. (1987) attempted to combine information from indigenous informants and the ethnobotanical researchers and applied use values of 1 (major use), 0.5 (minor use) or 0 (no use) per category of use. Phillips & Gentry (1993a), on the basis of earlier advances by Adu-Tutu *et al*. (1979), proposed a way of valuing the utility of plant taxa (so-called informant-consensus or informant-indexed valuation method), which allowed the researcher to incorporate information from multiple informants in an ethnobotanical survey. Kvist *et al*. (1995) combined the approaches of Prance *et al*. (1987) and Phillips & Gentry (1993a), and defined use-values by allowing the informants (instead of the researcher) to assess the importance of the species for a particular kind of use.

The methods mentioned above share two properties. They tally the different uses or use categories per species (botanical or folk species), and species that have multiple uses or uses in more than one use category score highest (Anderson & Posey 1985, Balée 1986, 1987, Boom 1987, Carneiro 1978, Kvist *et al*. 1995, Phillips & Gentry 1993a, Prance *et al*. 1987, Toledo *et al*. 1995). A species-based use valuation, however, neglects the fact that local people assign uses to plant individuals instead of species. The species classification can be seen as merely a property of a plant that determines its potential usefulness, just as its phenological condition, development, and production may do so (Phillips 1993, Phillips & Gentry 1993b,

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Sánchez *et al*. 2001). This aspect becomes very important when the survey includes slender treelets as well as big trees of the same species. Rewarding multiple-purpose use in valuation procedures is based on the assumption that plants are more appreciated by people when the likelihood of their use becomes larger. This assumption may not be correct in species-rich rain forests that offer a great variety of uses by plants from many different species.

In the present study the potential usefulness was recorded of each plant individual encountered in a series of small plots in various landscapes in the middle Caquetá area. By applying a diameter cut-off of 2.5 cm, the survey incorporated more information from the forest understory than most other quantitative ethnobotanical studies in the region (which mostly applied a 10 cm cut-off). Binary use information of stems (i.e., a stem was useful or not for a particular kind of use or use category) was analyzed by means of logistic regression as a function of landscape, stem diameter, habit, and family taxonomy. The main research question was to find out to what extent these factors contributed to explaining the patterns in potential usefulness, as derived from information from an experienced member of the Miraña community.

Study area

Location and site description

The study area is located in the river basin of the Caquetá River, between 71°50’ W and 0°55’ S, in Colombian Amazonia. The area is still largely covered by so-called virgin forests that lack signs of recent human intervention. The main landscape units in this area (Duivenvoorden & Lips 1993, Lips & Duivenvoorden 2001) comprise well drained floodplains, swampy areas (including permanently inundated backswamps and basins in floodplains or fluvial terraces), areas covered with white-sand soils (found on high terraces of the Caquetá River and in less dissected parts of the Tertiary sedimentary plain), and well drained uplands (which are never flooded by river water). The latter unit can be subdivided into less dissected areas (low fluvial terraces of the Caquetá River), and dissected areas (high fluvial terraces of the Caquetá River and a Tertiary sedimentary plain). Soils and landscape units are called well drained when soil drainage (according to FAO 1977) is imperfectly to well drained (FAO drainage class ≥ 2), and poorly drained when soils are poorly to very poorly drained (FAO drainage class < 2). The area receives a mean annual precipitation of about 3060 mm (1979-1990), and monthly rainfall is above 100 mm (Duivenvoorden & Lips 1993). Mean annual temperature is 25.7°C (1980-1989) (Duivenvoorden & Lips 1993). The region is classified as humid tropical forest (bh-T) according to Holdridge *et al*. (1971), and Afi (tropical, humid, without dry season), following the system of Köppen (1936).

The Miraña community

The Miraña indians belong to the Bora linguistic family (Patiño 1985). They originally lived in the middle and upper catchment areas of the Cahuinarí River (a main tributary of the Caquetá River), but were expelled from these areas when the first non-indigenous tradesmen and settlers arrived. In the seventeenth century the Miraña population experienced a severe reduction in size. Many Mirañas were transported to Brazil by Portuguese slave raiders in order to work on the extraction of cacao (*Theobroma cacao* L.), **zarzaparilla** (*Smilax officinalis* H.B.K., and *S. syphylitica* Mart.) and cotton (*Gossypium herbaceum* L.), or the cultivation of sugar cane along the Caribbean coast. In the 19th century and the early part of the 20th century the Miraña community became involved in the extraction of rubber and animal skins. From this time up until the present, they have been active in fishery of catfish (e.g. *Brachyplatystoma filamentosum* Lichtenstein, *B. flavicans* Castelnau, *Pseudoplatystoma tigrinum* Valenciennes, and *P. fasciatum* L., Rodríguez 1991).

At the present time about 700 Miraña indians (Chaparro 1996) live in houses along the Caquetá River, each house inhabited by a single family (Gullot 1979). In the middle and lower Caquetá area, between 120 and 200 km east of Araracuara, four Miraña settlements are found: San Francisco, Caño Solarte, Puerto Remanso del Tigre, and Mariamanteca. The territory claimed by the Miraña community as a whole includes substantial parts of two indigenous reserves in Colombian Amazonia (Predio Putumayo and Mirití-Parana).

Traditionally, the Mirañas practice slash-and-burn agriculture (with *Manihot esculenta* Crantz as a main crop), hunting, fishing, and extraction of forest products. The women concentrate on nursing children, preparation of food, and cultivation of herbs and crops in home-gardens and **chagras** (small fields). Daily activities of the men comprise hunting, fishing, cultivation of coca (*Erythroxylum coca* Lam.) and tobacco (*Nicotiana tabacum* L.), as well as extraction of medicinal plants from the surrounding forests (Rojas 1996). The Miraña community, as well as the other indigenous communities in the Middle Caquetá area (Andoke, Huitoto, Muinane, Yukuna, Matapí), have collaborated with a variety of ethnobotanical studies in the recent past (Garzón & Macuritofe 1990, La Rotta 1982, La Rotta *et al*. 1989, Sánchez 1997, Sánchez & Miraña 1991, Sánchez & Rodríguez 1990, Sánchez *et al*. 1991, Sánchez *et al*. 2001, Van der Hammen 1992).

Methods

Field sampling

A total of 30 plots were located in the above-mentioned landscape units (Figure 1). In order to establish the plots,

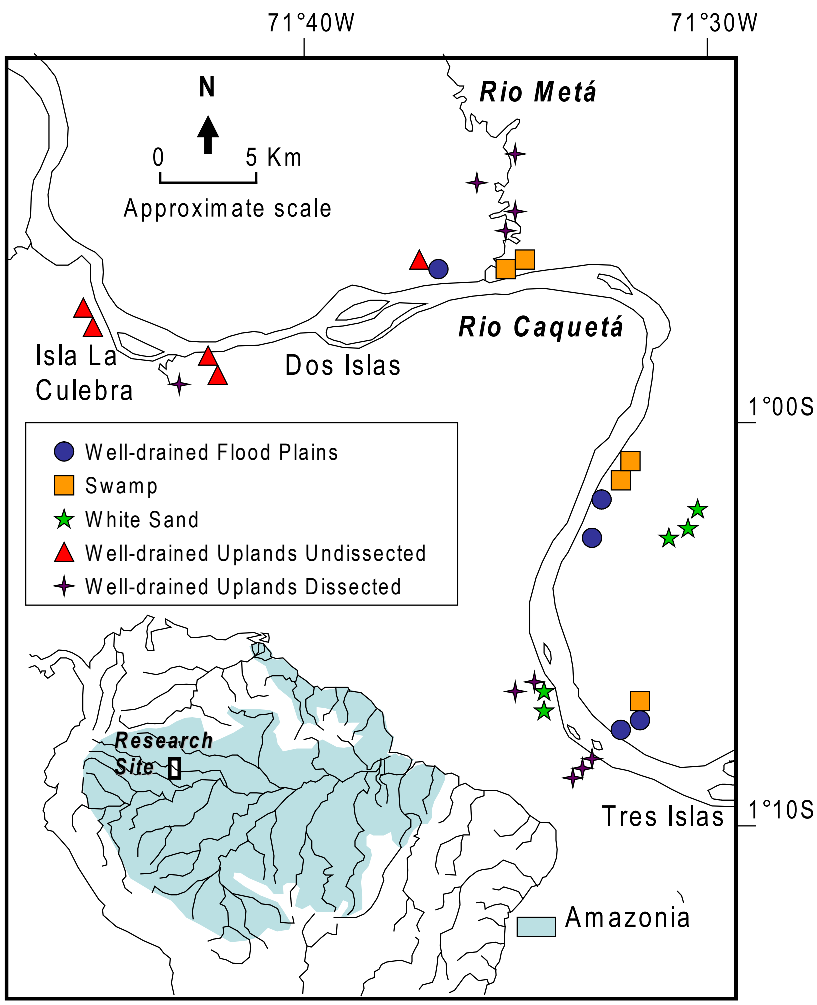

Figure 1. Location of 0.1-ha sample plots in the Metá area (Colombian Amazonia).

starting locations along the Caquetá River and the direction of the tracks along which the forests were entered, were planned on the basis of interpretation of aerial photographs (Duivenvoorden 2001). During the walk through the forests, soils and terrain forms were rapidly described, and the forest was visually examined. In this way sites with homogeneous soils and physiognomically homogeneous forest stands were identified. In these stands, rectangular plots were delimited by compass, tape, and stakes, working from a random starting point, with the restriction that the long side of the plot was parallel to the contour line. All plots were established in mature forests that did not show signs of recent human intervention, with a minimum distance of 500 m between plots (Figure 1). Plots were mapped with GPS. Plot size was 0.1 ha and most plots had a rectangular shape (20 x 50 m). Plots were subdivided into subplots of 10 x 10 m, in which all vascular plant individuals with DBH ≥ 2.5 cm were numbered. The DBH of all individuals was recorded with a tape-measure. Fieldwork took place in 1997 and 1998.

Botanical data collection

Botanical collections (vouchers MS2900-7049 and AD3900-4092) were made of all species found in each plot. Identification took place at the Herbario Amazónico (COAH), and the herbarium of the Missouri Botanical Garden (MO). The nomenclature of families and genera follows Mabberley (1989), with the exception of Caesalpiniaceae, Fabaceae, and Mimosaceae, which were treated as separate families. Within families or groups of closely allied families, specimens that could not be identified to species because of a lack of sufficient diagnostic characteristics, were clustered into morpho-species on the basis of simultaneous morphological comparisons with all other specimens. Details on floristic composition of the studied plots, including complete species lists are given by Duque *et al*. (2001, 2002).

Use information and informant selection

For all plots, and for all individual plants with DBH ≥2.5 cm in each of the plots, an old and experienced community member from the Miraña group of San Francisco (Petei Miraña) provided use information. A daily wage was paid to the informant, in a similar way to the field assistants from the same community who helped in collecting the plants. In most cases, the use information was given in the form of an answer to simple questions, for example: for what purpose is this plant used? how is it used? which parts are used? what is the name of this plant in Miraña? is there a translation of this name in Spanish? These questions were asked in Spanish during informal conversations while viewing the plants in the plots. Afterwards, while pressing and drying the botanical collections, the conversation about the uses of plants continued on frequent occasions. These latter activities usually took place in the afternoon and the evening of the same day of plant collection. The informant had knowledge of the Spanish language. He had collaborated in ethnobotanical and ecological field surveys (particularly in close relationship with the first author) during several occasions since 1988.

Use categorization

During previous intensive contacts with the Miraña community and Petei Miraña in particular (Sánchez & Miraña 1991), use categories were created that allow the best description of forest use by the Mirañas. In this categorization process, all uses of trees (DBH≥10 cm) found in 18 plots of 0.1 ha in various landscapes were listed and classified according to their principal association with the environment (round-house, house, cultivated field, shelter, forest, river) and the basic need they covered (food for men or animals, medicines, dance, clothing, and the preparation of coca and an extract of *Nicotiana tabacum* called **ambíl**). In this way, uses could be arranged in the following ten categories (in brackets, the association with the environment or basic need):

- Food (substances that people eat) including plants that produce fruits or other edible products, either direct or after certain preparation. Plants that have an indirect role in the production of consumable insects, for instance palms that act as substrate for consumable insect larvae (*Rhyncophorus palmarum* L. and other species from Coleoptera) are also included.

- Animal foods, substances that wild terrestrial animals and birds eat (**pepiadero**), and bait eaten by fish (**carnada**), including plants that attract game (e.g. many palms that produce fruits highly appreciated by peccaries (*Tayassu* sp.).

- Wood and fibers as materials for construction, including plants used for building temporal shelter places, huts, houses, and roundhouses, as well as lianas and fibers derived from inner barks as binding materials.

- Tools for hunting or fishing, including plants that are used to construct blowpipe, darts, arrows, fishing rods, bows, traps, as well as plants used to make curare (to hunt game) and fish poison (**barbasco**).

- Domestic utensils and tools (used in and around the house, and in the **chagra**), including spiny palm roots used as material for grater of **yuca** (*Manihot esculenta*), fibers of palm leaves for hammocks, burnt and macerated bark as an additive to clay in order to make ceramics, exudates of barks and fruits to produce dyes, and palm leaves and bark fibers for baskets.

- Medicinals (to treat people), including plants that help treat (physical) illness, injuries, as well as snake bites or insect stings, and which may control symptoms such as diarrhoea, pain, fever, and inflammations.

- Cultural plants, including those used in ceremonial dances (perfumes, pipes, masks, body paintings), to communicate with the Gods (**dueños**, see Van der Hammen 1992), or during nightly conversations, councils or learning sessions, while preparing and using concentrates of coca and tobacco (**ambíl**), or species used as salt in the **ambíl**. This category also included plants that help to cure psychosis or to frighten off evil spirits.

- Fuel plants, including trees from which the wood, resins or extracted oils can be burned for heating, cooking (**leña**) or illumination (**popai**). This also includes trees from which the bark when burned produces sufficient heat to prepare ceramics.

- Other uses (used by non-indigenous settlers or mestizos). This category refers to applications, which are, in a broad sense, related to the presence of non-indigenous settlers in the area. Uses are related to construction and caulking of boats and canoes, axe-handles and tools in agriculture, the manufacture of handicrafts, and rubber extraction.

- No use (simply not used).

Analysis

Uses were defined for each plant individual (stem), and may refer to entire plants, or parts of plants (e.g. leaves, fruits, seeds, bark, stems, wood, etc.). Uses were not hierarchically ordered. Thus, uses in each category and multiple uses (uses in more than one category) were treated as equally important. Usefulness was analyzed in separate use categories and use categories combined on the basis of proportions of useful stems per plot, and the entire amount of stems from all plots. In these analyses, nominal factors were landscape (applying five terms: floodplain, swamp, white sand, undissected well drained upland; dissected well drained upland), habit (lianas including hemi-epiphytes versus trees) and family taxonomy, while DBH (diameter at 130 cm above ground-level) was entered as a quantitative factor. Prior to analysis, DBH values were transformed by means of the Box-Cox normalization in R-package (Casgrain *et al*. 2002). Kruskal-wallis analyses in JMP 3 (1994) were used to examine between-landscape differences of the proportion of useful stems in plots.

For all stems, simple logistic regressions were done of usefulness against normalized DBH. In these analyses the usefulness response was yes or no. Gaussian logit curves were tested instead of sigmoid curves when the so-called Lack of Fit test for the regression model was significant ($p<0.05$).

Multiple logistic regressions were done for usefulness of all stems against landscape, habit, and normalized DBH.

Table 1. Plot density of stems and useful stems with DBH≥2.5 cm in different landscapes in the Metá area, Colombian Amazonia (n=number of 0.1-ha plots; sd=standard deviation).

Landscape	n	All stems		Liana stems		All useful stems		Useful liana stems	
		mean±sd	total	mean±sd	total	mean±sd	total	mean±sd	total
Floodplain	5	296±52.7	1478	45±21.9	223	221±34.7	1107	10±7.3	48
Swamp	5		3334	23±12.6	113		3112	7±6.1	37
White sand	5		2592	1±1.0	5		2568	0±0.4	1
Upland not dissected	5	363±50.3	1817	44±18.1	219	312±41.3	1559	17±8.6	87
Upland dissected	10	471±43.3	4713	28±11.8	275	421±49.3	4211	7±5.0	69
ALL	**30**		**13934**	**28±19.9**	**835**		**12557**	**8±7.6**	**242**

However, in these analyses the regression coefficients for several families were frequently reported as unstable by JMP 3 (1994). In logistic regression, this may be a consequence of responses being perfectly predicted by the supplied factors or if there are more parameters in the model than can be estimated by the data. In order to avoid unstable regression coefficients for any family, the data set was reduced in size by including only those stems that belonged to families that were recorded with more than 250 stems in the study area. Even with this limited data set, the regression models of most use categories continued to produce unstable regression coefficients for several families. Only the outcomes of the models of All uses minus Fuel, Food, and Fuel were fully stable, and were further considered.

Results

Forest structure and composition

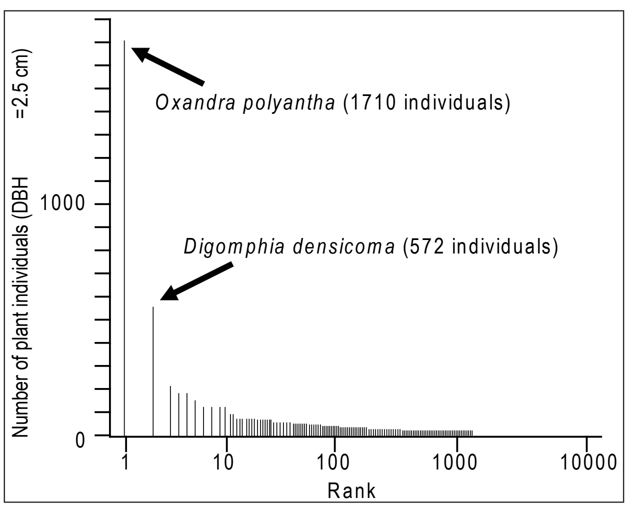

Figure 2. Rank-abundance plot of vascular plant species (DBH≥2.5 cm) in 30 0.1-ha sample plots in the study area.

In the 30 plots of 0.1 ha each, a total number of 13,934 stems (DBH≥2.5 cm) were recorded (Table 1), 13099 from trees and 835 from lianas. Floodplain plots showed the lowest stem density while swamp plots and white sand plots were richest in stems (on average 1.1 to 1.8 times more stems than the well drained upland plots (Table 1). Two tree species (*Oxandra polyantha* R. E. Fr. and *Digomphia densicoma* (Mart. ex DC.) Pilger) showed excessive stem numbers (Figure 2). *Oxandra polyantha* occurred with 1710 stems in swamps, while *D. densicoma* was recorded with 572 stems in white sand plots. Lianas contributed from 0 to 21% of the stems in the plots. They were rare in white sand plots (Table 1).

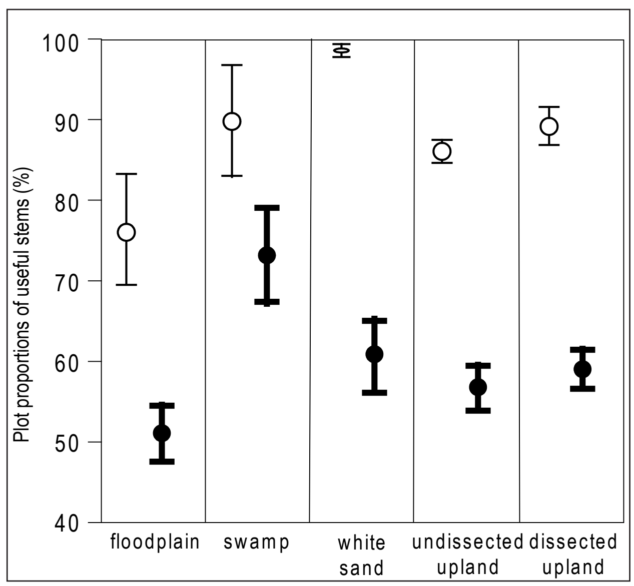

Figure 3. Mean (dots) and standard error (bars) of the proportion of useful stems (DBH≥2.5 cm) in plots in various landscape units in the study area. Thin lines: overall usefulness; thick lines: overall usefulness with Fuel use ignored. Differences between landscapes were significant (Kruskal-Wallis Chi-Square=16.8, p<0.005 with Fuel use included, and Kruskal-Wallis Chi-Square=9.5, p<0.05 without Fuel). See Table 1 for number of plots.

Most stems were found in small diameter classes (25% were with 2.5≤DBH<3.4 cm, 75% with 2.5≤DBh<8.8 cm, and only 0.5% with DBH≥50 cm). On the whole, lianas (DBH average 4.4 cm median 3.7 cm, 90% quantile 6.8 cm) were thinner than tree stems (DBH average 7.7 cm, median 5.2 cm, 90% quantile 15.0 cm). Lumping data from all plots, the DBH averages ranged from 7.2 cm (Upland not dissected) to 8.0 cm (Floodplain), while the DBH medians varied between 4.5 cm (Upland dissected) and 5.6 cm (White sand), and the 90% quantiles between 13.5 (White sand) and 16.6 cm (Floodplain).

Overall usefulness

A total of 12,557 stems (90% of all stems) had some kind of usefulness (Table 1). The proportion of useful stems was lowest in floodplain plots and highest in swamp and white sand plots (Figure 3). When the dominant Fuel uses were ignored, differences between swamps and the other landscapes became more pronounced, while usefulness of white sand plots decreased (Figure 3). Between 0 to 11% of the useful stems in the plots were from lianas. Tables 2-4 list the taxa with the highest number of useful stems found in the survey. Duivenvoorden *et al*. (2001) provide a complete listing of taxa including vernacular names in Miraña idiom.

Usefulness by use category

Fuel uses were by far the most important in this study, especially in white sand forests (Figure 4). On average, about 50% to 85% of the stems in the plots showed this kind of usefulness. Apart from Fuel, white sand forests were mostly characterized by a high proportion of stems useful for Hunting-fishing purposes. Swamp forests, in addition, contained many stems useful for Animal food and Construction purposes. Many of the useful stems in these three use categories in Swamps and White sand landscapes belonged to *Digomphia densicoma* and *Oxandra polyantha*. The other three landscapes scored relatively high proportions of stems useful for Food, Domestic and Medicinal uses (apart from Fuel uses).

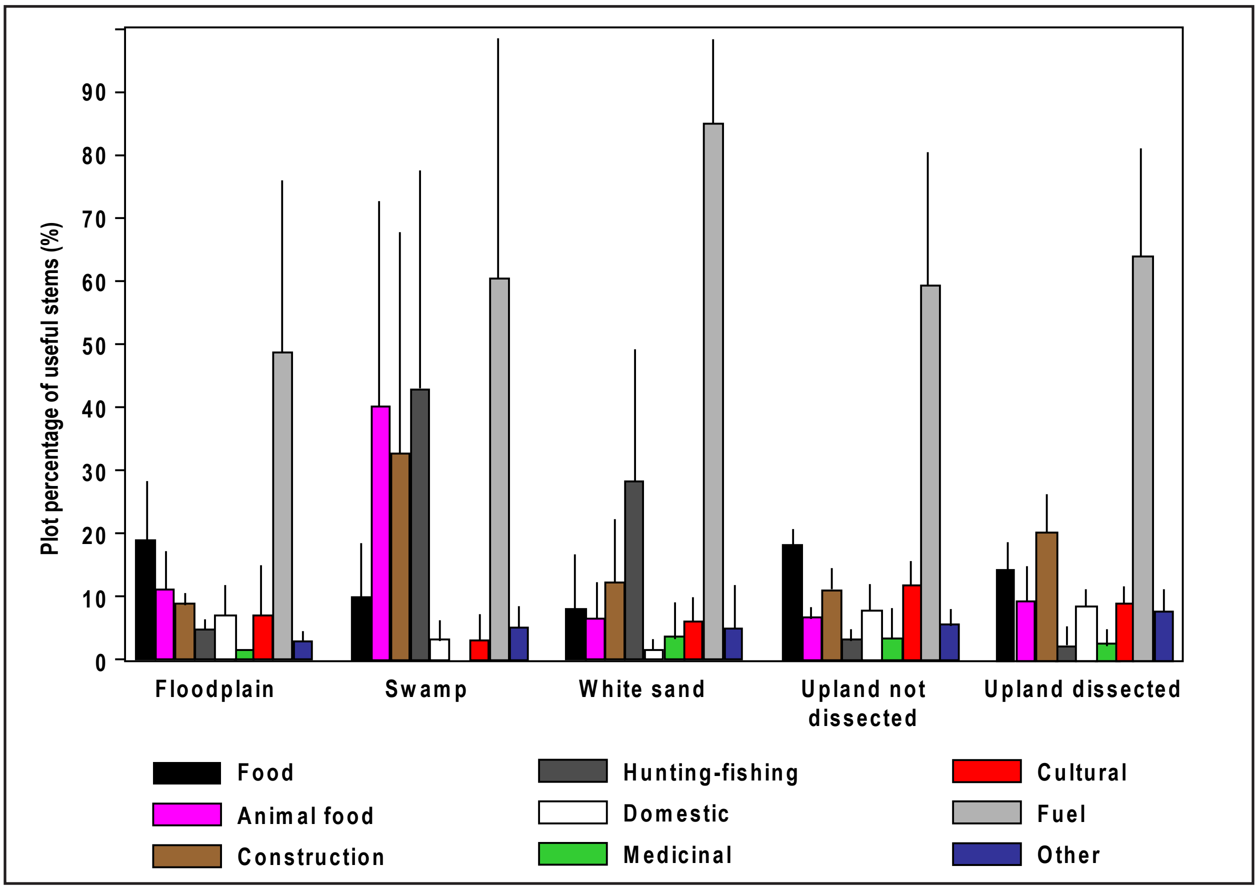

Figure 4. Percentage of useful stems (DBH≥2.5 cm) in 0.1-ha plots in various landscape units, arranged according to use category. The columns depict plot averages and the vertical lines one standard deviation. The thick lines in the columns for Animal food, Construction, Hunting/fishing, and Fuel uses indicate the average contribution of the two most dominant species in the survey (*Oxandra polyantha* and *Digomphia densicoma*). See Table 1 for number of plots.

Table 2. Families with highest amount of useful stems (DBH≥2.5 cm) in 30 0.1-ha plots in the Metá area, Colombian Amazonia.

Family	Stems	
Annonaceae	2419	19%
Bignoniaceae	808	6%
Fabaceae	568	5%
Myristicaceae	637	5%
Euphorbiaceae	581	5%
Clusiaceae	577	5%
Caesalpiniaceae	542	4%
Lecythidaceae	556	4%
Lauraceae	511	4%
Sapotaceae	444	4%
Rubiaceae	401	3%
Mimosaceae	320	3%
Chrysobalanaceae	400	3%
Burseraceae	397	3%
Arecaceae	343	3%
Moraceae	292	2%
Bombacaceae	265	2%
Myrtaceae	236	2%
Araliaceae	229	2%
Apocynaceae	187	1%
Other families	1844	15%
All useful stems	12557	100%

Table 3. Genera with highest amount of useful stems (DBH≥2.5 cm) in 30 0.1-ha plots in the Metá area, Colombian Amazonia.

Genus	Stems	
Oxandra	1874	15%
Digomphia	572	5%
Eschweilera	487	4%
Virola	344	3%
Ocotea	314	3%
Protium	293	2%
Macrolobium	283	2%
Licania	278	2%
Clusia	269	2%
Iryanthera	269	2%
Dendropanax	227	2%
Pouteria	227	2%
Swartzia	209	2%
Clathrotropis	199	2%
Tabebuia	178	1%
Tovomita	159	1%
Guatteria	142	1%
Inga	140	1%
Micropholis	127	1%
Tachigali	116	1%
Other genera	5850	47%
All useful stems	12557	100%

Table 4. Species with highest amount of useful stems (DBH≥2.5 cm) in 30 0.1-ha plots in the Metá area, Colombian Amazonia.

Species	Stems	
Oxandra polyantha R.E. Fries	1710	14%
Digomphia densicoma (Mart. ex DC) Pilger	572	5%
Dendropanax palustris (Ducke) Harms	225	2%
Clusia magnifolia Cuatrecasas	179	1%
Clathrotropis macrocarpa Ducke	177	1%
Eschweilera coriaceae (A.DC.) S.A. Mori	128	1%
Virola elongata (Bentham) Warburg	124	1%
Iryanthera polyneura Ducke	113	1%
Scleronema micranthum (Ducke) Ducke	103	1%
Macrolobium discolor Bentham	101	1%
Sandwithia heterocalyx Secco	97	1%
Pachira brevipes (A. Robyns) W.S. Alvers.	96	1%

Species	Stems	
Tabebuia ochracea (Chamisso) Standley	92	1%
Oxandra leucodermis (Spr. ex Benth.) Warm.	91	1%
Hevea pauciflora (Spr. ex Benth.) Muell.Arg.	85	1%
Tabebuia insignis (Miq.) Sandw. var. monophylla Sandw.	84	1%
Calycophyllum obovatum (Ducke) Ducke	83	1%
Virola surinamensis (Rol. ex Rottb.) Warb.	78	1%
Mauritia flexuosa L.f.	72	1%
Euterpe precatoria Martius	70	1%
Other species	8277	66%
All useful stems	12557	100%

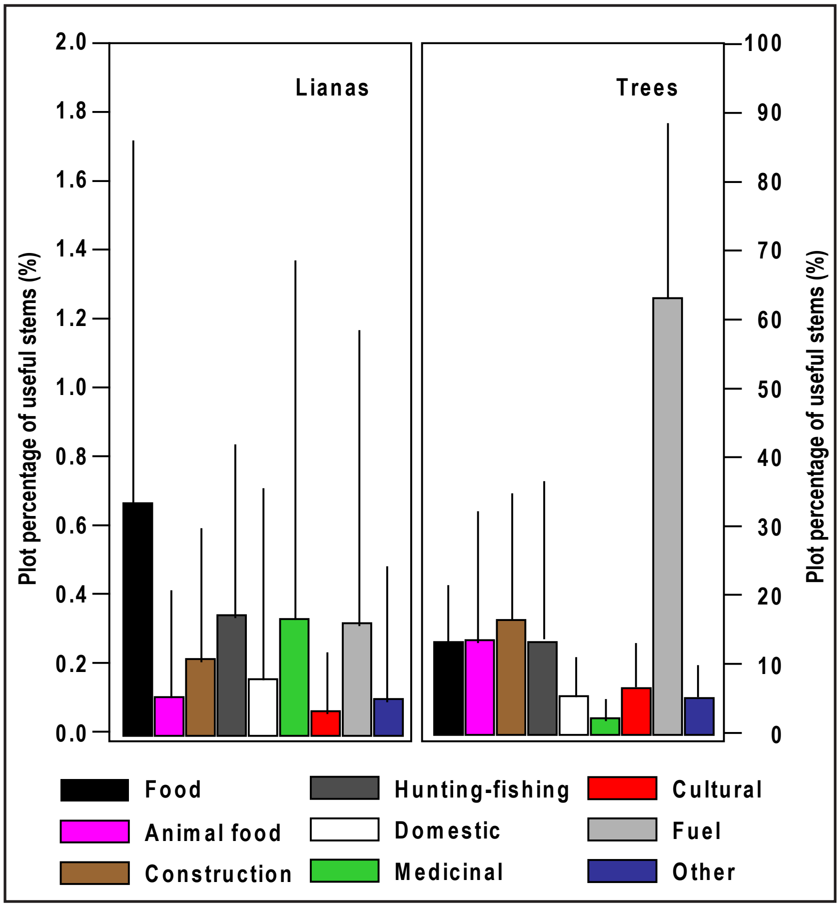

Figure 5. Percentage of useful lianas and trees (DBH≥2.5 cm) in 0.1-ha plots in various landscape units, arranged according to use category. The columns depict plot averages and the vertical lines one standard deviation.

Fuel use was far less dominant among lianas than among trees (Figure 5). On average, for most of the use categories, less than 1% of the useful stems in plots were from lianas. Only for medicinal uses were lianas almost just as useful as trees: on average, 2% of the stems with Medicinal usefulness in the plots were trees and 0.4% lianas (lumping all plot data, 2% of the stems with Medicinal usefulness were trees, while 5% were lianas).

Thicker stems were reported as more useful for Food and Animal Food than slender stems (Figure 6). Examples of species used for specific applications per use category are given in Appendix 1.

Usefulness against landscape, habit, and DBH

The coefficients of the multiple logistic regression model indicated how the log odds (ratio of the probability of usefulness to the probability of non-usefulness) change for a factor while controlling for the other factors. Positive coefficients for a particular factor imply that stems are more likely to become useful when this factor increases. Likewise, negative coefficients indicate a reduced probability of usefulness. The regression coefficients (Table 5) show that the probability of overall usefulness (without Fuel uses), and Fuel usefulness decreases when stems were lianas. However, being a liana had a slight favorable effect on usefulness in the Food category. The effects of DBH and landscapes on usefulness are comparatively small compared to those of certain families. Palms (Arecaceae) and Bombacaceae were especially useless for Fuel applications. Ignoring Fuel uses, the overall usefulness of these two families increased substantially. In an opposite way, several families (Lecythidaceae, Caesalpinaceae, Chrysobalanaceae, Clusiaceae, Fabaceae, Mimosaceae and Sapotaceae) were well appreciated for Fuel, but became less important when Fuel was ignored. Together with Moraceae, Myristicaceae, Burseraceae, palms and Bombaceae were valued for Food uses. On the other hand, if stems were from Bignoniaceae, Lauraceae, Lecythidaceae, and to a lesser extent Rubiaceae, the chances of the plant's usefulness as a Food resource decreased.

Discussion

Stem-based versus species-based approach

The stem-based approach applied in the current study allows a wide range of statistical analyses, which permit us to test falsifiable hypotheses (Phillips & Gentry 1993a). The method is explicit and results are potentially reproducible, generating objective information (apart from the subjective decision procedure in defining use categories; Kvist *et al*. 1995), that is, in principle, independent of the researcher. Negative data are also, by definition, included in the use information and not wasted, which enhances the potential statistical power of the analysis. Properties of plant individuals (e.g. production, phenology, time component of usefulness, taxonomic classification) can be easily included for explanation of potential usefulness.

The stem-based approach differs fundamentally from other studies where potential use patterns were analyzed on the basis of use information gathered from species (re-

Table 5. Results of logistic regression of usefulness of 10,696 stems (DBH≥2.5 cm) against family, landscape, habit, and DBH (normalised), for families that occurred with more than 250 stems in the area. Probability of coefficients (p) is below 0.0001, unless indicated otherwise: ns (non-significant) = p>0.05; *0.05<=p<0.001, ** = 0.0001<=p<0.001.

Terms		All minus Fuel	Food	Fuel
Intercept		-1.4	-3.6	-1.6
Habit (if liana)		-0.8	0.5**	-2.0
DBH		1.4	1.3	0.2ns
Landscape, if				
	Flood plain	-0.7	0.3*	-0.5
	Swamp	0.2**	-0.4	-0.2*
	White sand	0.3	-0.5	1.1
	Undissected well drained uplands	0.0ns	0.4	-0.1ns
	Dissected well drained uplands	0.2	0.3	-0.3
Family, if				
	Annonaceae	2.5	-0.7	0.7
	Arecaceae	2.3	3.0	-5.4
	Bignoniaceae	0.8	-3.9	0.2ns
	Bombacaceae	1.7	2.6	-2.0
	Burseraceae	0.2ns	1.5	0.4**
	Caesalpiniaceae	-1.3	-0.9*	0.9
	Chrysobalanaceae	-0.4	-0.8*	0.5
	Clusiaceae	-2.1	-0.4ns	0.6
	Euphorbiaceae	-0.2ns	1.0	0.2ns
	Fabaceae	-0.7	-0.5*	0.6
	Lauraceae	0.6	-3.0	0.1ns
	Lecythidaceae	-0.4	-2.8	1.6
	Mimosaceae	-2.7	0.6*	0.6
	Moraceae	0.5	2.3	-0.6
	Myristicaceae	0.5	1.9	1.2
	Rubiaceae	-0.4	-1.4*	0.1ns
	Sapotaceae	-0.7	1.4	0.4
R Square (U) whole model		0.27	0.29	0.18
Chi Square		3620	2193	2297
Probability whole model		<0.0001	<0.0001	<0.0001

views in Kvist *et al*. 1995, Phillips & Gentry 1993a;). Using stems, there is no need for any *a priori* taxonomic identification to analyze the use patterns. This approach might facilitate comparison of quantitative ethnobotanical studies in tropical forest plots. Species-based quantitative plot studies in tropical forests rely heavily on identifications of sterile specimens, which are often codified into morphotypes. Reference collections of plot studies from diverse neotropical forests easily contain thousands of specimens, which are often distributed over various herbaria or research institutes. Unless morphotypes are compared by one and the same researcher, inter-regional comparisons are confined to fully identified species, thus neglecting a substantial proportion of the species diversity in the analysis.

Per-stem aggregations of usefulness, however, may seriously inflate the perceived usefulness of forests by local communities when in practice many plants will be redundant and only a few might satisfy the occasional demand. A further drawback in the logistic per-stem analysis of usefulness against family taxonomy is the frequent re-

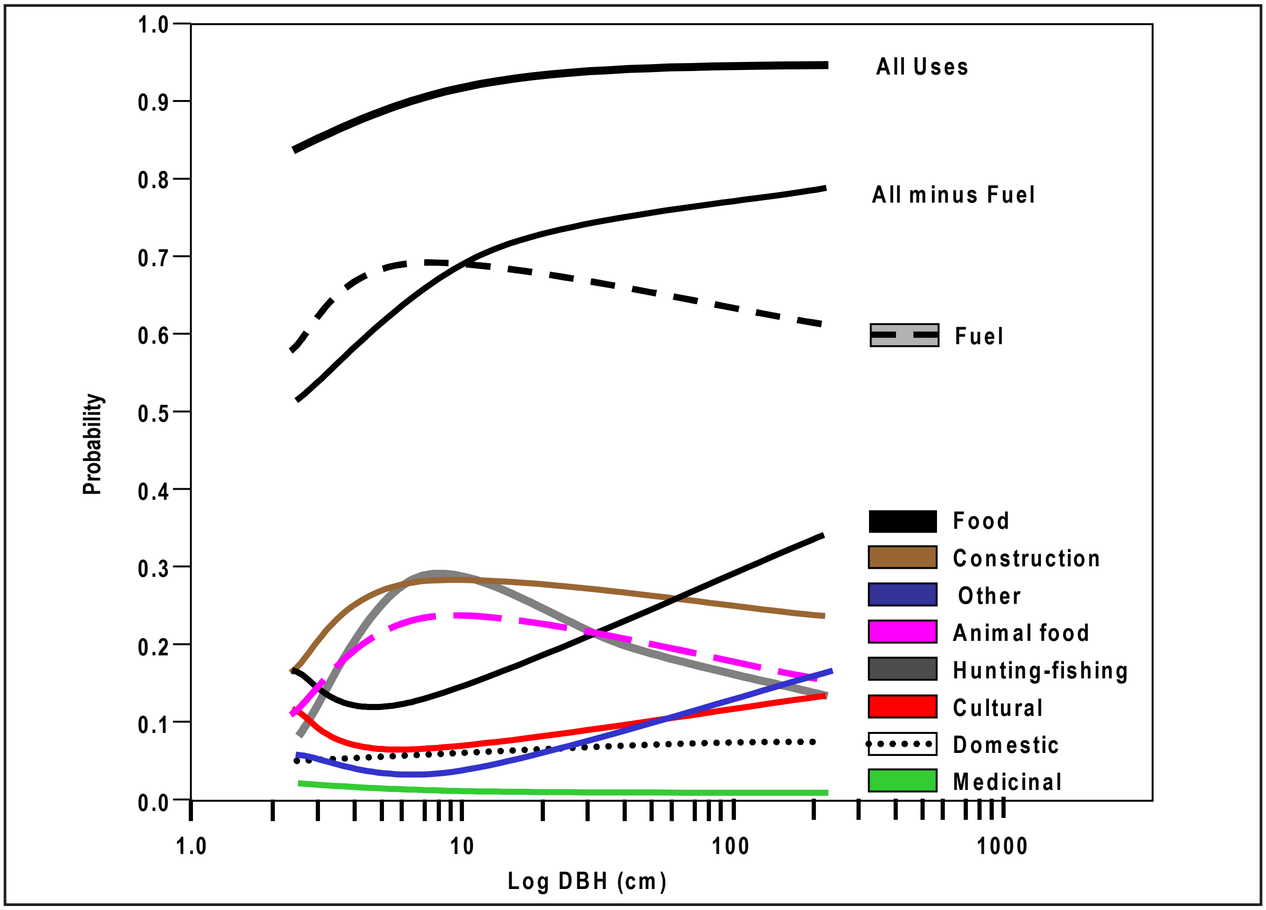

Figure 6. Logistic regression of stem usefulness (DBH≥2.5 cm) as function of DBH in forests of the Metá area (Colombian Amazonia). All models were significant with $p<0.0001$, except for the Domestic ($p=0.004$) and Medicinal use category ($p=0.045$).

porting of unstable regression coefficients. Plant individuals that belong to small classes of nominal variables (for example rare plant families, genera or species) often lack any variation in usefulness. The prediction of usefulness for such plants is (almost) certain, in which case the parametric model of logistic regression breaks down. In practice this might hamper the wide application of parametric logistic analysis to quantify the role of the taxonomic position of plants in defining the usefulness of tropical forests where rare species, genera or families are so numerous.

Binary versus multi-purpose usefulness

There are several arguments against using multiple uses in defining additive degrees of potential usefulness (Phillips & Gentry 1993a, Phillips *et al*. 1994, Prance *et al*. 1987). Due to the rare occurrences of most rain forest species, rare plants with just one particular use might be searched for more by local people than multi-purpose plants that have many but less specific applications. When plants are actually used, a single application is likely, especially when entire plant individuals are harvested. In species-rich tropical forests, many different species, each with specific potential applications, are widely available, which reduces the need for (and value of) multi-purpose species. One single use may be more important than a range of other uses, leading to arbitrariness in defining use-values on the basis of the number of uses or use categories. The comparison of potential usefulness of the different landscapes further illustrates the difficulty in interpreting potential usefulness. Phillips *et al*. (1994) argued that floodplain forests were more useful to mestizo communities in Amazonian Peru, essentially because these forests contained more species which showed multiple uses than other forests. However, on the basis of criteria of numbers of useful stems or useful species, differences between forests were small. These same patterns predominate in the current study. Landscapes contribute little to explaining binary categorized usefulness, simply because most stems are potentially useful, one way or the other.

However, the binary analysis of stem usefulness showed weaknesses as well. The Fuel use category dominated the overall usefulness record to such an extent where the binary analysis almost became trivial. A solution to ignore such dominant use categories leads inevitably to arbitrariness in the selection of use categories to be considered for analysis. Furthermore, experienced informants will know so many uses that virtually all plants will have an overall potential usage. All this hampers the binary analysis of usefulness whenever uses are combined into use categories, or separate use categories into one category of overall usefulness.

Finally, it is important to realize that the choice for a single-use or multi-purpose valuation procedure is based on assumptions on how people perceive the usefulness of plants. Testing of these assumptions is needed, and might be successful when realized uses are included in the survey, as a basis for predictions and extrapolations of the usefulness of plants, species, and forests (Kvist *et al*. 1995). In this, multidisciplinary views on the concept of usefulness of all parties involved might be considered (Berlin *et al*. 1973, Hunn 1982, Lee 1979, Stoffle *et al*. 1990, Turner 1988).

Informant-based patterns in potential rain forest use

The informant in the present study was extremely knowledgeable. His insights presumably reflected well the value that the Mirañas place on their forests. However, on the basis of one informant alone it is hazardous to draw conclusions on forest use by the whole of the Miraña community. For specific uses in the Hunting-fishing category, small diameters appeared somewhat advantageous, probably because slender trees are easily transformed into tools like blowpipes, arrows, fishing rods, and bows. Thicker stems were more useful for Food uses, which is likely due to increased fruit production in more mature trees. Very thin stems (with DBH<8 cm approximately, Figure 6) were less useful for Construction and Fuel uses because these require substantial amount of wood. More than habit, diameter, or landscape (where the plant occurs), family taxonomy (traits shared between genera and species from the same family) determined according to Petei Miraña whether or not a plant individual was useful. These results correspond to those obtained in mestizo communities in nearby Peruvian Amazonia (Phillips & Gentry 1993b). Although considered quite useless for Fuel uses by our informant, palms were among the most appreciated plant families, just as in studies where use values are based on multiple-uses of species (Kvist *et al*. 1995, Johnston 1998, Phillips & Gentry 1993b, Prance *et al*. 1987, Toledo *et al*. 1995).

On the basis of the information provided by Petei Miraña, it is evident that knowledge of how to make use of the great majority of plants and plant species in their territory is still present in Miraña community. A similar level of use knowledge has been found among other indigenous communities in Amazonia (e.g. Balée 1987, Boom 1989, Prance *et al*. 1987). Much of this information is probably only available in the minds of a few older members of the Miraña community, and it is likely to disappear when they die. This warrants strong efforts to systematically record ethnobotanical information in indigenous communities where oral ways of communication still prevail, for example according to the way the Matapí community in Colombian Amazonia documented its own history (Matapí & Matapí 2001).

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Appendix 1. Most commonly found specific uses per category.

Use category	Specific uses	Species examples
Food	fruit pulp	*Couma catingae* Ducke, *Mauritia flexuosa* L.f., *Pourouma mollis* Trec., *Pouteria caimito* Radlk.
	palm heart	*Euterpe precatoria* Mart.
	seed, almond	*Eschweilera chartaceifolia* Mori, *Cariniana micrantha* Ducke, *Compsoneura capitellata* (A. DC.) Warb., *Caryocar glabrum* (Aubl.) Pers.
	wood as substrate for insect larvae	*Astrocaryum aculeatum* G. Meyer, *Oenocarpus bataua* Mart., *Scleronema micranthum* (Ducke) Ducke
	leaves as substrate for insect larvae	*Apeiba aspera* Aubl., *Hebepetalum humiriifolium* (Planch.) Benth., *Diplotropis martiusii* Benth.
Animal food	bird food	*Trichilia maynasiana* C. DC., *Brosimum lactescens* (Moore) Berg, *Eugenia coffeifolia* DC.
	mammal food	*Parkia panurensis* Benth. ex Hopkins, *Eschweilera andina* (Rusby) Macbride
	fish bait	*Trichilia micrantha* Benth., *Iryanthera elliptica* Ducke, *Paullinia capreolata* (Aubl.) Radlk.
Construction	rope	*Psammisia roseiflora* Sleum., *Satyria panurensis* Benth. & Hook.f.
	pole, beam, rafter	*Oxandra polyantha* R. E. Fr., *Mouriri huberi* Cogn., *Minquartia guianensis* Aubl., *Licaria cannella* (Meissn.) Kosterm. , *Mezilaurus itauba* (Meissn.) Taub. ex Mez
	roof	**Lepidocaryum tenue** Mart., *Oenocarpus bataua* Mart.
	floor, wall	*Iriartea deltoidea* R. & P., *Socratea exorrhiza* (Mart.) Wendl., *Euterpe precatoria* Mart.
	fence	*Iryanthera juruensis* Warb., *I. tricornis* Ducke
Hunting-fishing	blowpipe	*Iryanthera juruensis* Warb., *Duguetia macrophylla* R. E. Fr.
	dart	*Pachira brevipes* (Rob.) Alv., *Oenocarpus bataua* Mart.
	fishing rod	*Oxandra polyantha* R. E. Fr.
	bow	*Ephedranthus amazonicus* R. E. Fr.
	arrow	*Astrocaryum aculeatum* G. Meyer
	harpoon	*Digomphia densicoma* (Mart. ex DC.) Pilger
	bird trap	*Lacmellea arborescens* (Muell. Arg.) Markg., *L. foxii* (Stapf) Markg., *Tabernaemontana disticha* A. DC.
	mammal trap	*Anaxagorea angustifolia* Timm.
	fish trap	*Iriartella setigera* (Mart.) Wendl.
	poison for hunting mammals	*Caryocar glabrum* Pers., *C. nuciferum* L.
	poison for fishing	*Strychnos amazonica* Kruk., *S. peckii* Robins.
Domestic	grater	*Socratea exorrhiza* (Mart.) Wendl.
	hammock	*Astrocaryum aculeatum* G. Meyer
	sieve (riddle)	*Souroubea guianensis* Aubl.
	jar, bowl (clay additive)	*Couepia canomensis* (Mart.) Benth. ex Hook.f., *Licania apetala* (Meyer) Fritsch
	dye	*Eschweilera alata* Smith, **Genipa americana** L.
	basket	*Oenocarpus bataua* Mart., *Eschweilera coriacea* (A. DC.) Mori, *Guatteria decurrens* R. E. Fr.

Use category	Specific uses	Species examples
Medicinal	gastritis	*Eschweilera alata* Smith, *E. albiflora* (A. DC.) Miers
	rheumatism	*Sloanea durissima* Spr. ex Benth., *Duguetia latifolia* R. E. Fr.
	bronchitis	*Protium altsonii* Sandw., *P. crassipetalum* Cuatrec.
	conjunctivitis	*Ampelozizyphus amazonicos* Ducke
	mycosis	*Marila tomentosa* Poepp., *Picramnia latifolia* Tul.
	diarrhoea, stomach pain	*Bauhinia guianensis* Aubl., *Machaerium macrophyllum* Benth., *Coussapoa orthoneura* Standl.
	cough	*Uncaria guianensis* (Aubl.) J.F. Gmel.
	toothache	*Osteophleum platyspermum* (Spruce ex A. DC.) Warb., *Piper hispidum* Sw.
	snake bite	*Carpotroche amazonica* Mart.
	healing	*Eschweilera punctata* Mori, *Iryanthera ulei* Warb., *Calycophyllum obovatum* (Ducke) Ducke
	skin parasites	*Piper laevigatum* Kunth, *Duguetia flagellaris* Huber
Cultural	perfume	*Guatteriella tomentosa* R. E. Fr., *Dipteryx odorata* (Aubl.) Willd., *Aniba vaupesiana* Kub.
	necklace	*Guarea grandifolia* DC., *Trichilia maynasiana* C. DC.
	flute	*Clathrotropis macrocarpa* Ducke, *Heterostemon mimosoides* Desf.
	masks	*Brosimum utile* (Kunth) Pittier, *B. parinarioides* Ducke
	body painting	*Goupia glabra* Aubl., *Alibertia hispida* Ducke, *Chimarrhis gentryana* Delprete, *Genipa americana* L.
	mortar, pestle	*Brosimum rubescens* Taub.
	salt for tobacco concentrate	*Siparuna decipiens* (Tul.) A. DC., *Gustavia poeppigiana* Berg, *Astrocaryum gynacanthum* Mart., *Matisia lasiocalyx* Schum.
	frighten off evil spirits	*Duquetia macrophylla* R.E. Fries, *D. ulei* (Diels) R.E. Fries
Fuel	wood for cooking	*Roucheria calophylla* Planch., *Miconia biglandulosa* Gleason, *Protium paniculatum* Engl.
	wood for lighting	*Couepia chrysocalyx* (Poepp.) Benth. ex Hook.f., *Sacoglottis amazonica* Mart.
	resins and oils for lighting	*Dacryodes chimantensis* Steyerm. & Mag., *Protium aracouchini* (Aubl.) March., *Copaifera reticulata* Ducke
	bark to prepare ceramics	Licania apetala (Meyer) Fritsch, Picramnia latifolia Tul.
Other uses	boat, canoe	*Anaueria brasiliensis* Kosterm., *Mezilaurus sprucei* (Meissn.) Taub. ex Mez, *Carapa guianensis* Aubl.
	axe-handle, tools agriculture	*Aspidosperma excelsum* Benth., *Iryanthera tricornis* Ducke, *I. polyneura* Ducke
	resins for caulking	*Odontadenia funigera* Woodson, *Moronobea coccinea* Aubl., *Symphonia globulifera* L.f.
	fibers for caulking	*Eschweilera punctata* Mori
	handicrafts for trade	*Brosimum rubescens* Taub.
	rubber	*Hevea pauciflora* (Spruce ex Benth.) Muell. Arg., *H. guianensis* Aubl.