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Estimating use-values and relative importance of Amazonian flood plain trees and forests to local inhabitants

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SUMMARY

Use-values have been advocated as a tool to compare the value of not just individual species, but also of plant families and forest types to local people, in order, for example, to identify species or habitats in need of special management or conservation. We estimated use-values in three forest types (upper restinga, lower restinga, tahuampa) on the Amazon flood plain south of Iquitos (Peru), compared two methodologies, identified the most valuable species and contrasted these valuations with the actual use of forest resources in local villages. A new method for estimating use-values was contrasted with the method of Phillips and Gentry (1993a). Despite philosophical and procedural differences, estimates were highly correlated (R^2=0.86). We discuss limitations of both methods and suggest some possible enhancements. The need to discriminate between past, present and potential uses is emphasised.

Keywords: Peru, varzea, quantitative ethnobotany, non-timber forest products, use-values.

INTRODUCTION

Sustainable forestry embraces the ecological, economic and social viability of timber and non-timber forest products. Some of these aspects are comparatively well understood and provide a factual basis for analysis, whereas other aspects (e.g. socio-economics of non-timber forest products) remain contentious and difficult to quantify. The present study examines four questions in the context of Amazon flood plain forests:

- Which tree and liana species are the most important to the local people?
- What are the most important forest types?
- Are theoretical valuations consistent with actual use by local communities?
- Are existing methods for valuing products and forests adequate?

This paper reports preliminary findings of a study of both timber and non-timber production from flood plain forests in the western Amazon. Our study, which began in 1993, examines flood plain forests along the lower Ucayali river, approx. 200 km south of Iquitos, Peru (4.5°S 73.5°W). The study is based on nine permanent plots; three in each of the three forest types inundated by 'white' (sediment-rich) water from the Ucayali river. These forest types have been defined as varzea (Prance 1979), riverine (Parodi and Freitas 1990), or restinga and tahuampa forests (Encarnacion 1993). Each plot is one hectare in area (100 × 100 m, except plot 4 which is 80 × 125 m), and is divided into 25 subplots (24 for plot 4) in which each tree and liana over 8.5 cm DBH, (diameter at breast height, 1.3 m above ground or ±20 cm above buttressing) is mapped, tagged and identified (about 4000 voucher specimens were taken). The plot-based studies are supplemented by a household and an ethnomedicinal study. The household study entails fortnightly surveys of 12 families in the villages of Yanallpa and Casa Grande to record the harvest and use of subsistence and commercial products from forests and waters throughout the year (Table 1). The ethnomedicinal study draws on 13 informants in seven communities to document identities and uses (1164 to date) of medicinal plants.

PHYSICAL SETTING

Our research is conducted from CIJH (Centro de Investigacion de Jenaro Herrera), a regional research station of IIAP (Instituto de Investigaciones de la Amazonia Peruana), about 160 km upstream from Iquitos, on the lower

Ucayali river some 70 km above its confluence with the Marinon where the Amazon proper begins. The area is still heavily forested and includes extensive flood plain forests along the Ucayali river (Parodi and Freitas 1990, Puhakka and Kalliola 1993), where active river dynamics maintain a mosaic of relatively young habitats in different successional stages (Foster 1990a,b, Puhakka *et al.* 1992, Salo and Kalliola 1991, Salo and Rasanen 1989). Although Jenaro Herrera is over 3000 km from the Atlantic ocean, it is only 125 m above sea level, a factor contributing to the pronounced seasonal inundation in these forests.

The people of this area *(ribereños)* tend to be Spanish speakers of mixed origin and derive their income mainly from the relatively fertile flood plains. They tend to be descendants of Amazonian natives rather than immigrants, and maintain an intimate knowledge of the local environment (Hiraoka 1992, Padoch 1988). In our project area, some residents descend from the original Cocama Amerindians. Others are recent immigrants from within the Peruvian Amazon, and very few originate from further afield (e.g. from the highland and coastal areas of Peru). Preliminary data suggest that the harvest from forests, rivers and lakes provides an important supplement to cultivated crops, and constitutes about half of village income (Table I). The value of these subsistence products is approximately equal to the value of the marketed products from these habitats. Thus the development of an efficient methodology to quantify the production and use of non-timber forest products from the flood plains is central to understanding the local economy and land use pattern.

TABLE 1. *Relative values of products harvested from forests, rivers and lakes during the six month period from September 1994 to February 1995 (preliminary results of a year-long survey).*

Activity		Yanallpa (%)	Casa Grande (%)
Fishing		32	60
Fruit collection:	aguaje‡	27	0
	other fruits	2	2
Construction materials		21	12
Aquarium fish		9	18
Hunting		4	2
Medicine		3	3
Handicraft		2	3

† Subsistence (53%) and commercial (47%) uses collectively represent approx. US$90/family/month. Sale of cultivated crops contributed a further $50/month to family income.

‡ Yanallpa has access to a large area of the palm *Mauritia flexuosa* ('aguaje'), an important source of income not available to Casa Grande.

Three forest types are recognized in the Peruvian Amazon flood-plains: upper restinga, lower restinga and tahuampa (Encarnacion 1993). Restingas are natural levees which may flood more (lower restinga, typically more than one month a year) or less frequently (upper restinga). Tahuampa forests may be flooded for at least three and often up to six months a year and are characterized by the presence of Lecythidaceae and Chrysobalanaceae, families indicative of infertile soils (Foster 1990a). Sapotaceae may also be present in considerable numbers. Forests on upper restingas are characterized by the Arecaceae, Moraceae (both indicative of fertile soils, Foster 1990a, Phillips 1993) and Meliaceae (mainly *Guarea macrophylla),* while lower restinga forest is characterized by the families Cecropiacaea and Rubiaceae, especially by *Calycophyllum spruceanum,* which is common as a large tree in the lower restinga, but absent from the upper restinga and the tahuampa.

Method

The terms *quantitative ethnobotany* and *use-value* are used to describe the study of and importance of trees to local people and compare the local importance of different species, families and forest types (e.g. Prance *et al.* 1987). Prance *et al.* (1987) calculated relative use-values, estimated by assigning scores for each recognised use for each species. These scores *(researcher-scores* in our terminology) could take the value zero (no use), half (used but judged of little importance by researchers) or one (important uses) within each of six categories based on researcher's own field experience and were summed to give a maximum use-value of six (Table 2). An advantage of using categories in this way is that multiple uses within a single category do not inflate the estimates. Other studies (e.g. Boom 1987, 1990, Paz y Mino *et al.* 1991) have simply counted the total number of identified uses for each species considered *(researcher-tally).*

TABLE 2. *Alternative procedures for estimating use-values.*

	Researcher- score † (Prance *et al. 1987)*	Informant-tally† (Phillips & Gentry *1993a)*	Informant-score (present work)
Categories	1. food ‡ 2. construction 3. technical‡ 4. medicinal 5. commerce 6. others	Irrelevant since multiple uses in category count equally and independently.	1. food 2. construction 3. technical 4. medicinal 5. commerce
Units	*0,* 0.5 or *1.0* in each category, judged by researchers, not by informants.	Nominally 1.0for each use identified, but averaged across informants so that consensus gives higher weights; no limit of number of uses in a category.	*0, 0.5, 1.0* or in each category, judged by informants; averaged across informants.
Taxa	botanical species	folk taxa	botanical species
Use-value	Score 0-6, sum of categories	Open ended (no maximum), average across repeated events and thereupon across informants.	Score *0-7.5,* sum of categories, average across repeated events and thereupon across informants.

† Our use of the term *tally* refers to a count of all recognised uses, where as *score* indicates the use of a pre-determined number of categories.

‡ The food category includes baits used to attract fish, and the technical category includes materials for the construction of canoes, axe-handles, etc.

Phillips and Gentry (1993a) used a nominal weight of 1.0 for each use identified in each *event* (defined as the interview of one person concerning the use of one species on one day), and averaged these first across repeated events with the single informants and thereupon across the informants, so that higher weights were obtained if more informants identified the same uses. This *informant-tally* offers some advantages for statistical analysis and hypothesis testing (Philips and Gentry 1993a,b, Phillips *et al.* 1994), but results in an open-ended tally with no maximum use-value. With this approach, the recognition of the individual uses directly influences the magnitude of the use-value (e.g., does roundwood used both for posts and beams of houses count as one or two different uses?).

In our study, we have attempted to combine the best elements of both the researcher-score (Prance *et al.* 1987) and informant-tally (Phillips and Gentry 1993a) methods, in a new *informant-score* for each species based on the following procedure:

- sample trees (and lianas) of each species are selected, marked and collected for herbarium identification,
- informants assess importance of species as a half (usable but suboptimal), one (suitable) or 1.5 (near-optimal) in each of five categories (Table 2),
- sum these to get a score in the range 0-7.5, for each event,
- calculate the average score of repeated events,
- calculate the average use-value across all informants.

The values 0.5, 1.0 and 1.5 (rather than 1, 2 and 3, or other alternatives) were used only to provide use-values comparable with those of Prance *et al.* (1987), Pinedo-Vasquez *et al.* (1990), Phillips and Gentry (1993a) and Phillips *et al.* (1994).

We questioned local inhabitants about their use of trees and lianas occurring in our plots, using structured interviews and a standard proforma previously tested (in September 1993). These preliminary interviews, and the plot establishment work during 1993, provided vernacular names of most trees and thus laid the foundation for the present work. However, the results presented here are based exclusively on interviews conducted during September-October 1994. One questionnaire was completed for each event. The questionnaire was designed to allow estimation of both informant-tallies and informant-scores.

Before the interviews, we marked 332 trees and lianas in our permanent plots, choosing well-developed representative individuals for ease of recognition (e.g. clear view of the crown). We planned to use one individual from each taxon, except for a few important species where we deliberately marked trees both in the restinga and tahuampa plots. However, our sample trees (and lianas; we refer to 'trees' for brevity) were selected before herbarium identifications were completed, and it later became evident that some species were included two, three or four times, while some other species were missed. Thus the 332 specimens represent 261 species in 50 families, while another 69 species (representing only 4% of stems) found in the plots were overlooked. Our ‘one specimen per species’ policy precluded the ability to examine several important issues relating to repeatability and reliability, but seemed desirable to minimise informant fatigue.

Our informants were recommended to us as being knowledgeable about forest plants and products. They were all men aged 43-63, experienced in fishing, hunting and collecting. We made no attempt to take a representative cross section of the population, since our goal was to estimate the potential utility of the forest and compare the potential and actual usage, rather than to analyze distribution of knowledge across the population (e.g. see Phillips 1993b). However, we are unable to test for gender bias in our data, and it is not clear how a female perspective might influence valuations. Ten informants participated; two visited all nine plots, four visited the three tahuampa plots only, and another four visited the restinga plots only, so that each plot (and each of the 332 marked trees) was visited by six informants, giving a total of about 2000 events.

Logistics (a boat with an outboard motor is required) prevented the informal ‘walk-in-the-woods’ advocated by Phillips (1993a), so informants accompanied us throughout the three days (usually) needed to visit and discuss the 332 marked trees and lianas. Informants received the same daily wage as that paid to our other field workers. Before the interviews, informants were instructed carefully and encouraged to admit if they did not know tree species or uses. Each event followed a standard procedure: the informant first had time to look at the tree and cut, smell or taste parts to assist recognition. After this, the interview began with the following questions:

- What is this tree called?
- What is it used for?
- Does it bear fruit?
- Is it used for construction?
- Is it sawn into boards?
- Does it have medicinal uses?

Informants were prompted to ensure that uses were not overlooked. Thus, for instance, if an informant failed to mention commercial applications of a specimen, we asked if they sold any plant parts, but recorded a commercial use only if the informant himself extracted the product for sale.

Generally, taxa that informants failed to recognise and name were not assigned any values. However, in a few instances, we provided the vernacular name to informants who failed to recognize a specimen, and if they then claimed to recognize the taxon, we recorded the uses stated. Other exceptions concerned uses for which identification was unnecessary, e.g. wood for construction, since it is possible to use wood of an unidentified taxon. Only one of the 332 marked trees remained unrecognised by all informants, but some of the apparent recognitions may not have been genuine in all cases.

Relative importance was assessed by negotiation. The basic assumption was that a useful product would score one, and this was adjusted up or down a half point only on firm information indicating inferior or superior properties. The lower rating (0.5) was assigned if the informant said the taxon was of low quality, little value, or did not find it worth taking home (e.g. fruits eaten only occasionally in the forest, and construction materials used only for temporary huts in hunting camps or in fields away from the village). The higher rating (1.5) was assigned when the informant explicitly indicated it was preferred (among the best) for a particular purpose, or if it served two or more distinct uses within a category (e.g. wood used for both canoes and axe handles). In the commerce category the higher rating was given for items that were consistently collected and sold, or if more than one product was sold. All medicinal and social applications were regarded equally (i.e. 1.0), since they were difficult for informants to quantify (e.g. "Is tree A better than tree B for witch-craft?").

Analysis

Two items in our questionnaire were excluded from the use-value calculations: firewood, because virtually all wood can be used in this way; and charcoal, since it is of very minor importance in the study area (elsewhere in the region, charcoal is produced for the Iquitos market, but transport costs from Jenaro Herrera are too high). The remaining items were combined into five categories: food, construction, technical, medical and commerce (Table 2).

Plant identifications by informants were checked by referring to botanical records, e.g. by ensuring that trees apparently with edible fruits do in fact bear fleshy fruits rather than woody capsules. Vernacular names given by informants suggested a significant incidence of such misidentification (i.e. there was not a one-to-one correspondence between vernacular names and herbarium determinations), but few could be detected in this way, and most of the information was recorded as given. However, this need not detract from our study, because for many uses correct identification may not be critical. For instance, medicinal remedies prepared from the ‘wrong’ tree will still be used. In contrast, fleshy fruits will not be found on a tree which bears woody capsules.

Family use-values were calculated as the average use-value of all species investigated for the specified family. Forest use-values represent the weighted average use-value per stem for that forest type, calculated by multiplying the use-values of individual species by the number of stems of that species, summing across species, and dividing by the total number of stems per plot. Determination of forest usevalues required use-values for each species, including species overlooked in this study. They were assigned the average use-value for the genus, or failing that, of the family. If no other members of the family had been investigated they were assigned a zero value (4 specimens only, viz. three small trees in the Quinaceae and Proteaceae and one liana in the Phylaccaceae).

Phillips *et al.* (1994a) amalgamated 496 taxonomic species into 272 'folk-species' and calculated use-values for the latter, thus increasing the number of events contributing to each use-value. We calculate use-values only for taxonomic species, since it is not feasible to combine our botanical taxa into a reasonable number of well-defined folk-species. This reflects, in part, the different vernacular names used by informants for the same taxon, the different comprehension of folk-species (i.e. broader or narrower groups), and misidentification by informants. We also question whether 'folk-species' always represent a group of botanical species (cf. genera) or whether they may reflect other attributes of plants (e.g. size, vigour, form). This question was not addressed in the present study, so our data may underestimate the 'true' use-value of a species (viz. we may record uses only for the mature phase represented by our sample tree or liana).

RESULTS

TABLE 3. *The highest-ranking species recorded in permanent plots, ranked according to informant-scores.*

Rank (Score)	Family	Species	Informant Score	Informant Tally	Rank (Tally)
1	Arecaceae	*Euterpe precatoria*	*5.08*	*7.00*	*1*
2	Meliaceae	*Cedrela odorata*	*4.83*	*4.17*	*5*
3	Arecaceae	*Socratea exorrhiza*	*4.00*	*4.00*	*6*
4	Arecaceae	*Scheelea cephalotis*	*3.83*	*4.83*	*2*
5	Moraceae	*Maquira coriacea*	*3.42*	*3.67*	*8*
6	Apacynaceae	*Aspidosperma rigidum*	*3.42*	*3.67*	*9*
7	Olacaceae	*Minquartia guianensis*	*3.33*	*4.17*	*4*
8	Rubiaceae	*Genipa americana*	*3.33*	*3.77*	*7*
9	Arecaceae	*Astrocaryum murimuri*	*3.33*	*3.33*	*15*
10	Myrtaceae	*Myrciaria floribunda*	*3.25*	*2.83*	*25*
11	Bombacaceae	*Ceiba pentandra*	*3.25*	*2.33*	*61*
12	Euphorbiaceae	*Hura crepitans*	*3.08*	*3.33*	*14*
13	Rubiaceae	*Calycophyllum spruceanum*	*3.08*	*1.83*	*105*
14	Mimosaceae	*Ormosia sp. l*	*3.00*	*2.83*	*27*
15	Sapotaceae	*Sarcaulis brasiliensis*	*2.92*	*4.17*	*3*
16	Lauraceae	*Aniba sp.2*	*2.92*	*3.50*	*10*
17	Sapotaceae	*Pouteria sp.3*	*2.92*	*3.33*	*13*
18	Anacardiaceae	*Spondias mombin*	*2.83*	*2.83*	*29*
19	Meliaceae	*Guarea macrophylla*	*2.63*	*3.15*	*17*
20	Fabaceae	*Lecointea amazonica*	*2.58*	*3.50*	*11*

Table 3 shows the highest-ranking species based on use-values calculated as informant-scores and contrasts these with the similar, but higher use-values obtained with the informant-tally method. A good correlation exists between estimates prepared by the two methods (Tally = 0.20 + 1.06 × Score, R^2=0.86, n=261), but this may be a special case since the different estimates derive from the same event (viz. the same informant, researcher, specimen and time). *Euterpe precatoria* is the most important species in both cases, and was rated second in a similar study by Phillips *et al.* (1994, surpassed only by an upland forest palm not found in our plots). However, some species are ranked very differently, *e.g. Ceiba pentandra* (rank 11 vs 61) and *Calycophyllum spruceanum* (13 vs 105). The four highest-scoring species include three palms and the commercial species *Cedrela odorata.* However, there is no binary distinction of useful or useless, and some use is found for all species, resulting in a broad range of use values with a near-normal distribution (μ =1.42, 6 =0.63, truncated at zero).

The informant-score method assigns high use-values to species that are favoured for some particular purpose, but have few other uses (e.g., *Calycophyllum spruceanum, Ceiba pentandra* and *Cedrela odorata* for marketable fuelwood, plywood and sawnwood respectively). In contrast, the tally method assigns higher values to general purpose species such as *Sarcaulis brasiliensis* (rank 15 vs 3; Table 3). In general, our informant-score method inflates the use-value of species that are prized for specific purposes, because the scoring rewards excellence and the maximum is limited by the number of categories. One problem with both methods is that scores may be inflated by past and potential uses not currently realized. This explains some apparent anomalies observed in the ranking of species, and the contradiction of local opinion which seems to regard tahuampa forest as less important than restinga forest, e.g. because palms are absent (except for some *Bactris spp.).* It seems that the restinga provides more plant products, while the main use of tahuampa is for fishing during the flood season. Notwithstanding this, we obtained similar mean-stem values for restinga and tahuampa (Table 4), in part because of the abundance of high-scoring Sapotaceae ('quinilla', Table 5) in the tahuampa. On average, trees in the upper restinga get a higher use-value with both methodologies (by about 14%, F_{17}=20.14, P<0.01 for the informant-scores), but since the stocking (number of trees/ha) varies, the per-hectare estimates for the three forest types are similar (P>0.1, Table 4). It is, however, difficult to gain a true insight into forest value in this way because estimates depend upon how individual use-values are weighted for tree size and vigour.

TABLE 4. *Use-values by forest type.*

Forest type		Mean use-value per tree	Stem number >10 cm DBH	Per ha use-value
Upper restinga	Mean	1.86	456	846
	Range	0.15	23	100
Lower restinga	Mean	1.58	566	893
	Range	0.18	75	103
Tahuampa	Mean	1.61	520	837
	Range	0.15	25	119

TABLE 5. *Families with high use-values estimated by informant-score and informant-tally methods.*

Rank	Family	Informant score	Informant tally
1	Arecaceae	3.77	4.53
2	Caryocaraceae	2.42	2.67
3	Sapotaceae	2.35	2.89
4	Meliaceae	2.05	2.17
5	Clusiaceae	1.97	2.39
6	Olacaceae	1.89	2.44

Similar apparent anomalies were also found at the family level, e.g. with the Annonaceae and Sapotaceae. The informant-score for the Annonaceae, close to the overall average of 1.42, is determined largely by its use for construction, while the Sapotaceae, one of the more highly-valued families (Table 5), has a variety of uses in all five categories (Table 6). However, in practice, Annonaceae are widely used for everyday applications, while the Sapotaceae are rarely used. Almost every traditional house in the region is constructed predominantly from Annonaceae poles (65% of poles in Yanallpa and Casa Grande; but *Minquartia guianensis is* favoured for beams). Sapotaceae are apparently not used as roundwood or sawnwood, locally or commercially, but are considered useful for fence construction; however since flood plain communities have few domestic animals, they construct few fences. Most Sapotaceae have edible fruits (Table 6), but household surveys suggest that they are rarely used or marketed (Table 1), even though they are occasionally eaten in the forest. It seems likely that Sapotaceae are not cut because the marginal benefit of using the timber (in preference to another taxon) is less than the value of fruit and other production that would be lost; the opportunity cost of using its timber is too high. Thus the high use-value relative to observed use of Sapotaceae may simply mean that people are keeping their options open: more than half of the total use-value can be realised by cutting Annonaceae (i.e. the construction category reflects 58% of the total use-value), but over 60% of the total use-value of Sapotaceae can be preserved by keeping the trees (Table 6).

TABLE 6. *Components of the use-values for Sapotaceae and Annonaceae*

Family	Sapotaceae	Annonaceae
Construction	**0.75**	0.84
Technical	0.27	0.05
Medicinal	0.13	0.08
Food	0.56	0.24
Commerce	0.44	0.23
Total	2.15	1.44

The medicinal component of the use-value warrants special attention because of the current debate surrounding 'biodiversity prospecting' and its ability to finance conservation (e.g. Mendelsohn and Balick 1995, Simpson *et al.* 1995). Medical remedies most frequently mentioned by informants in our study included treatments for diarrhoea, rheumatism, fever, pain, wounds, abdominal injuries and aching joints, all treated with between 5 and 8% of the species examined in both the plot and village-based studies. Some 60% of the species in plots were considered by at least one informant to have medicinal properties (173 species with 556 remedies recorded in 1994 events, Table 7). A similar number (750 events with 1164 remedies) were identified as medicinal by informants in the village studies, but few of these species(about 30) were among those recorded in the plots. Evidently the local people currently use only a few of the plot-species reported to have medicinal qualities on a regular basis. The fact that most plot-species were regarded as medicinal by only one or two informants (despite the use of 60% overall) suggests either a rather imprecise selection of medicinal species, or that medicinal plants are neither well known nor highly valued. This observation arises from the use of preselected specimens in our plots, and may not have been evident with informant-selected plants. Notwithstanding this, some families are more likely to be used for medicinal applications than others (e.g. Moraceae, Table 7). Nearly all the medicinal information about the Annonaceae concerned the locally renowned *Unonopsis floribunda* ('Icoja'). In contrast, the medicinal information concerning the Sapotaceae referred to many taxa and was given mainly by a single informant. Medicinal extracts from forest trees (e.g. preparations for 'frio' or colds) frequently use the bark in an alcoholic infusion containing material from several taxa, and nearly always include *Unonopsis floribunda,* but rarely involve any Sapotaceae, which are apparently used only because they look similar to other more desirable species (e.g. having latex similar to that in well-known medicinal species in the Apocynaceae and Moraceae).

TABLE 7. *Medicinal use of species within selected plant families with >50 events (usually 9 or more taxa each reported by 6 informants).*

Family	Total no. of taxa	No. of taxa with medicinal uses reported by at least		Events	
		1/6 informants	5/6 informants	Total (no.)	Medicinal (%)
Moraceae	14	14	12	90	63
Meliaceae	7	6	3	54	37
Fabaceae	15	14	5	102	31
Euphorbiaceae	16	12	5	114	28
Rubiaceae	13	7	2	84	20
Mimosaceae	18	12	1	134	16
Sapotaceae	11	5	1	84	11
Chrysobalanaceae	10	5	0	78	10
Annonaceae	17	5	1	138	9
Lecythidaceae	5	1	0	54	2
Lauraceae	18	1	0	138	1
Subtotal (11 families)	144	82	30	1070	20

Most data based on 6 informants, but all families listed included at least one taxon represented by more than one specimen, and so may in part, draw on 12, 18 or 24 events involving up to 10 informants. All data have been standardized to a 6-event basis. A high incidence of medicinal uses was also reported for some other families with fewer events (e.g. Celestraceae with 100% of 6 events indicating medicinal uses of *Maytenus macrocarpa).*

DISCUSSION

Several researchers have used the percentage of forest species recognised as useful as a measure of the ethnobotanical knowledge of the population (e.g. Boom 1987, 1990, Paz y Mino *et al.* 1991, Prance *et al.* 1987). We found that virtually every stem was considered useful in some way, and uses for all our 261 species have been reported. However, one should not infer that a use for every species implies an intimate knowledge of the forest. It may be that a more specialised use of fewer species (and no uses for some species) indicates a more specific knowledge allowing some species to be avoided, while the former (every species is used) reflects the reporting of trivial and casual uses. This does not imply that we doubt the knowledge of our informants, or consider them less well informed than those in other recent investigations (it is difficult to compare because methodologies of most workers are not clearly documented), but simply that we advocate cautious interpretation of such data.

Our interviews were based on specimens that we selected in advance. We suspect that earlier researchers have allowed informants to choose specimens they found interesting. This has important implications, since use-values may be inflated if informants select only specimens they recognize as usable (e.g., ignoring mis-information, a specimen known by only two of six informants will get a use-value three times higher with informant-selection). However, the use of preselected trees may result in more incorrect and ambiguous information, especially if informants recognise few of the trees. To minimize this risk, selected sample trees should be mature and typical of the species, since informants may not recognize juvenile specimens readily. The interview technique is also critical, as supplementary questions may prompt informants to state additional related uses, inflating the tally.

The informant-tally methodology is reputed to be objective (Phillips 1993a), but the classification of uses is unavoidably subjective, as uses can be defined more or less widely, so increasing or decreasing the resulting use-values (e.g.wood can be used for many different purposes within general categories such as handicraft and construction, while medicinal remedies may be even more prolific). This lack of repeatability is a serious limitation of both use-value methodologies, and they may benefit by employing elements of consensus-methodologies (see, for example, Friedman *et al.* 1986, Johns *et al.* 1990, Trotter and Logan 1986) which assign more weight when there is greater consensus among informants. However, this solution is not a panacea, since it confounds unit-value, demand and data quality.

Plants used medicinally are something of a special case, and pose some fundamental questions, especially with the tally-methods. A taxon may have a single highly specific application (e.g. *Maclura tinctoria* latex used to relieve toothache), while another may be used in a mixture containing several other plants to treat a variety of ailments (e.g., colds, rheumatism, pains, headache), or simply as a general tonic. The former, scoring a single unit, may be of specific pharmacological interest, while the latter, which may score several points (unless the various uses are interpreted as different symptoms of the same condition) may at best reveal just one of several potential candidates with possible pharmacological properties (assuming for simplicity, a specific active substance, and overlooking the possibility that it may be the mixture that contributes the medicinal qualities). This valuation may very well reflect the 'true' relative value perceived by users, if indeed there is a uniform and unchanging perception of value, but may not reflect the 'value' to a medicinal prospector. This situation has no simple solution, and it is necessary to consider the possible implications carefully when defining what constitutes a use and a use-category (cf. Table 2).

Our study has a number of limitations. While use-values offer some insight into the relative value of species, they take no account of demand, supply or substitutes, and do not even approximate the shadow prices that many researchers seek. By coupling studies of use-values and household economy, we have detected several species with potential uses not currently realised, but make no attempt to gauge why these are not utilised (e.g. inferior, tradition, transport, technological limitations), or if and under what circumstances such species might be utilized. We have assumed that indigenous uses relate consistently to botanical taxonomy (viz. family, genus, species) rather than being dependent on factors such as tree size and vigour, but we have made no attempt to test this assumption. Our results are also dependent on our classification of uses into five categories (Table 1), and a different classification might have yielded different results.

CONCLUSION

Returning to the four questions posed in the introduction, we conclude that:

1. While the palms have the highest use-values, there is no binary distinction of useful or useless, and some use is found for all species.
2. Although the mean per-stem value is higher in the upper restinga forest (because of species composition), the per-hectare value of the three forest types is about the same (because stem numbers differ).
3. Use-values for some species appear inconsistent with current use patterns, possibly reflecting past and potential uses not currently realised. Local people seem conscious of the opportunity costs of destructive use, and may use an apparently sub-optimal species (e.g. for construction) if this preserves future options.
4. Existing methods for estimating use-values provide a reasonable indication of the relative value of a resource to the local community, but fall well short of the shadow prices desired by many researchers, and suffer several limitations discussed below.

A major weakness of the use-value approach is that it may embrace potential but unrealised uses and so may inflate estimates. One way to separate present and potential applications is to couple the estimation of use-values with village-based research to record products that are actually used for subsistence and commerce. We have attempted to do this in the present study, but found that it substantially increased survey costs. Thus efficient estimation of usevalues for management and conservation planning may depend on new methods which discriminate explicitly between past, present and potential applications.

One possibility may be to assign larger weights for current uses, e.g., by asking informants if they currently use a resource, and if so, how often and in what amounts. Such information may help discriminate present and potential use-values, but this idea requires further field testing and elaboration. The sensitivity of use-values to number and definition of categories also warrants further research, as does the incorporation of elements from consensus methods which reward consistency among informants. This study poses more questions than answers, but hopefully will further the debate and add impetus to research in this area.

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