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Local values for harvested forest plants in Madre de Dios, Peru: towards a more contextualised interpretation of quantitative ethnobotanical data

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Abstract. This study builds on earlier quantitative ethnobotanical studies to develop an approach which represents local values for useful forest species, in order to explore factors affecting those values. The method, based on respondents' ranking of taxa, compares favourably with more time-consuming quantitative ethnobotanical techniques, and allows results to be differentiated according to social factors (gender and ethnic origin), and ecological and socio-economic context. We worked with 126 respondents in five indigenous and five immigrant communities within a forest-dominated landscape in the Peruvian Amazonia. There was wide variability among responses, indicating a complex of factors affecting value. The most valued family is Arecaceae, followed by Fabaceae and Moraceae. Overall, fruit and non-commercialised construction materials predominate but women tend to value fruit and other non-timber species more highly than timber, while the converse is shown by men. Indigenous respondents tend to value more the species used for fruit, domestic construction and other NTFPs, while immigrants tend to favour commercialised timber species. Across all communities, values are influenced by both markets and the availability of the taxa; as the favourite species become scarce, others replace them in perceived importance. As markets become more accessible, over-exploitation of the most valuable species and livelihood diversification contribute to a decrease in perceived value of the forest.

Abbreviations: INRENA – Instituto Nacional de Recursos Naturales (National Institute of Natural Resources); NTFP – non-timber forest product.

Introduction

Great hopes have been placed on the potential for forests rich in non-timber forest products (NTFPs) to support rural livelihoods in a way which makes development and conservation compatible (Peters et al. 1989; Johnston 1998; Wollenberg and Ingles 1998). Promoting and supporting sustainable forest product extraction has become integral to much development and conservation planning in the humid tropics. However, significant questions remain about the potential of NTFPs to support rural livelihoods, in part because we still only poorly understand the factors which influence the extent to which rural people depend on forests. For researchers therefore, a key challenge is to develop ways to effectively understand the value of plants to people, and particularly to reveal the contextual socio-economic and ecological factors that may influence these values.

During the last decade, ethnobotanists have increasingly focused on finding ways to express the commercial and non-commercial value of forests to rural people. Early quantitative methods were developed in an attempt to move beyond the simple listing of local plant names and uses to derive information which tells us more about the relative values of different plants. Prance et al. (1987) proposed separating 'major' and 'minor' uses but others have attempted to express values in terms that explicitly reflect the significance of plants as perceived by local participants (Phillips et al. 1994), or as recorded by direct observation of activities (e.g., Zent 1996). This work has largely focussed on developing quantitative ways to express use values (reviewed by Phillips 1996) although recent work has attempted to explore other less tangible values (e.g., Lawrence et al. 2000). Rural communities with access to forest resources have been consistently reported to use most of the species available to them (e.g., Boom 1987; Prance et al. 1987; Phillips et al. 1994). However, wherever relative values of species to each other have been investigated, comparatively few forest taxa account for most of the use-value attributed to the forest (Phillips and Gentry 1993a, b; Gilmore et al. 2002). Quantifying values should therefore help focus future research and development action on the most significant species.

Quantification can also help elucidate basic questions about which attributes of plants make them useful to people. For example, it has been shown (e.g., Moerman 1991; Phillips and Gentry 1993a; Galeano 2000) that some phylogenetically defined plant groups have properties that lend themselves to particular human uses. However, relative values attributed to species by people may also be related to their 'apparency' (Phillips and Gentry 1993b), in other words, how obvious or visible they are irrespective of any intrinsic 'usefulness' of the plant. This has been shown for trees with *mestizo* immigrants in the Peruvian Amazon (Phillips and Gentry 1993b), for lianas with Siona-Secoya people in Ecuadorian Amazon (Paz y Miño et al. 1995) and for trees with Afro-Americans in the Colombian Chocó (Galeano 2000). However, the abundance of a species is only a crude reflection of its overall apparency, and measures of ecological dominance (such as basal area) might better indicate the impacts of plant apparency on human values. Other traits that can draw human attention may only be expressed for a fraction of the plant's life-cycle and may be mostly irrelevant for a ground-based human operating in the forest interior. For example, flower traits – such as colour, size, scent, shape – may be largely immaterial for most people, since the probability of an Amazonian tree being fertile at any one point in time is less than 4% (Phillips et al. 2003a).

Most ethnobotanical work involves indigenous people, on the assumption that "their knowledge about the environment acquired through generations, can play an important role in . . . conservation" (Hanazaki et al. 2000). More recent immigrants to forest areas have been largely ignored, on the assumption that their knowledge is either less interesting or less forest related than that of indigenous people. Yet we are not aware of any direct comparison of indigenous and non-indigenous people's knowledge of plants and preferred modes of use in a given region. Here we explore the different values held by different forest users, both indigenous and non-indigenous, in the context of the extremely biodiverse Peruvian Amazonian forest. We describe and assess the application of a new methodology to quantify, in a relatively rapid but socially sensitive way, the values held by many different actors, and then explore the relationship between social group and values held for useful forest plants in different use categories. Finally, we explore the influence of a range of contextual factors on these values, including ecology, apparency, markets, access and resource quality, with the objective of enhancing understanding of priorities for research and policy in forest management. While we also recognise the significance of non-use values to forest conservation, the research reported here is part of a wider project relating values to utilisation practices, and we therefore focus on harvested taxa.

Biodiversity in the research area

The research was conducted in south-eastern Madre de Dios department, situated in lowland Amazonian Peru. The climate is typically Amazonian, with a mean annual rainfall of ca. 2300 mm, an average of 3–4 months a year receiving less than 100 mm, and a mean annual temperature of ca. 25 °C (Malhi et al. 2002). The natural vegetation of the region is humid lowland tropical forest, characterised by substantial edaphic and floristic compositional variation (e.g., Gentry 1988). Intensive biological research at a few sites within Madre de Dios has revealed very high levels of biological diversity, with individual sites having world records for numbers of species of birds (over 600) and various insect groups (e.g., at least 1250 butterflies, 150 dragonflies) (Pearson 1984; Lamas 1994; Parker et al. 1994). The flora is almost as exceptional as the faunal diversity, with more than 1000 tree species recorded in our study area (Phillips et al. 2003b). To a large extent the species diversity is thought to be driven by habitat diversity, with substantial species turnover between tightly packed adjacent habitats (Erwin 1984; Tuomisto et al. 1995), although some dominant tree species are ubiquitous throughout the landscape (Pitman et al. 1999). Ninety percent of the region remains covered by primary vegetation, so the human inhabitants of the area potentially have access to a great diversity of biological resources.

People and livelihoods

The subsistence livelihoods of both indigenous and immigrant forest communities are highly dependent on natural products extracted from the forest. For example, more than 20 species are used in house building (Phillips et al. 1994), particularly several trees in the palm family (Arecaceae), for example, *Iriartea deltoidea* – known in Amazonian Peru as *pona*, and *Euterpe precatoria* – known as *huasaí*, *Minquartia guianensis* (*huacapú*, Olacaceae), and several species of Annonaceae (collectively known as *espintana*). The cultural and livelihood significance of two species in particular – *castaña* (Brazil nut, *Bertholettia excelsa*) and *cedro* (Spanish cedar, *Cedrela odorata*) is indicated by the fact that they feature in myths of the Ese eja indigenous groups.

Immigrants from the Andes, who have settled in the zone, came initially to trade in skins, wild rubber, castaña extraction, and in the late 1970s, timber. By the mid-1980s most indigenous and immigrant communities had little or no standing stock remaining of the most expensive timbers, *caoba* (mahogany, *Swietenia macrophylla*) and *cedro*. Markets have been opening over the last 15 years for other species, especially *tornillo* (*Cedrelinga cateniiformis*, Fabaceae), *itauba* (*Mezilaurus* spp., Lauraceae), and *ishpingo* (*Amburana cearensis*, Fabaceae). These timber species, together with *castaña*, represent the main sources of income in most of the communities, both indigenous and Andean settler.

However, it is the unusual wealth of non-timber forest products (NTFPs) which is of particular interest to the debate on conservation and sustainable use. Of note are the Brazil nut tree, *castaña*, whose seeds are collected from the wild for local, national and international markets, and the palm species *Oenocarpus bataua* (*ungurahui*) and *Mauritia flexuosa* (*aguaje*) which produce oil-rich fruits sold locally, in addition to a wide range of fruits eaten at home. Other commercial products include fibre from *tamshi* (*Heteropsis* spp., Araceae), used to weave baskets and hats, and roofing materials particularly from the understorey palm *Geonoma deversa* (*palmiche*). Charcoal from *shihuahuaco* (*Dipteryx odorata*, Fabaceae) is occasionally commercialised.

Political factors

Political and institutional factors are also important to the context in which values are formed. In recent years both the Forestry Law and the Agrarian Reform have been revised, and although it is too early to assess impact on values, respondents' perceptions give us an indication of the effectiveness of these changes. The Forestry Law of 2000 requires forest users to obtain permission to extract *any* product, whether for subsistence or sale. This law is largely ignored by forest-dependent communities. More positively, in 1998 the government began to address problems of overlapping tenure. The Agrarian Reform of 1974 in principle allows farmers the rights to claim ownership, but high charges discouraged them from doing so; these have been waived since 1998 and more settler families are taking the opportunity to formalise their claims.

Methods

In this study data on plant use were collected primarily by reference to their regional vernacular name (e.g., *cedro*, *caoba*), and we present data using vernacular names (in italics) because these data do not always match individual botanical species one-to-one (in some cases a folk-taxon is used as the gloss for a whole botanical family, e.g., *moena* (Lauraceae, a family with >100 species in Madre de Dios)). The match between botanical and folk taxonomies in the region has been described in more detail elsewhere (Phillips and Gentry 1993a; Phillips et al. 1994), and in this paper we provide botanical synonymies both where taxa are first referred to in the text, and in Appendix 2.

The study combines quantitative and qualitative approaches to explore differences in values between men and women, and between indigenous and immigrant communities (which can be tested statistically), and the effect of geographical and economic context (which must be inferred from more qualitative data, and quantitative comparisons). This forms part of a larger research project involving sociologists, ethnobotanists, foresters, and botanists, with two purposes: (1) to gain a regional level understanding of plant uses, and (2) to assess the impacts of extractivists on harvested species and wider biodiversity.

Sampling

Because of the regional context of the project, our ethnobotanical strategy involved sampling as widely as possible. The study area, defined as a circle with radius of 50 km centred on the regional capital of Puerto Maldonado, contains 14 rural communities. By visual interpretation of a Landsat TM image (path 002 row 069) and local expert knowledge of the area (A. José Farfan) we included only the 11 legally recognised rural communities that have substantial access to primary forest (i.e., covering >50% of their territory). A further community was excluded on the basis that it is difficult to assign it as being either indigenous or non-indigenous. The 10 remaining communities therefore effectively represent a census, rather than a sample, of the region. Of these, five consist largely of immigrant families, and five mainly of people indigenous to the area (see Figure 1 and Table 1). Communities have access to mature forest on the two geomorphological formations in the region (Phillips et al. 2003) which correspond to the two higher-level vernacular categories of forest-type – '*altura*' forest, on the well-drained landscape on Pleistocene alluvium of the interfluvial plateaux and low hills, and '*bajio*' forest covering the poorly to well-drained landscape on alluvial deposits within the Holocene floodplain of the main rivers. A third major forest-type, '*aguajales*', swamps dominated by the palm *Mauritia flexuosa* (*aguaje*) occupies permanently waterlogged patches in both the Pleistocene and Holocene formations.

In each community, up to 14 people were asked to participate as unpaid volunteers. We limited the sample to adults who regularly extract materials from the forest. Several communities have multiple nuclei and/or consist of households stretched sparsely along many kilometres of river bank; we deliberately sought to include the full geographic range of the community. The respondents consisted of up to 10 men and four women in each community (Table 1). In total we worked with 126 respondents.

Data collection

The research team spent 15–20 days in each community, exploring the context and documenting background information on farming systems, migration patterns and

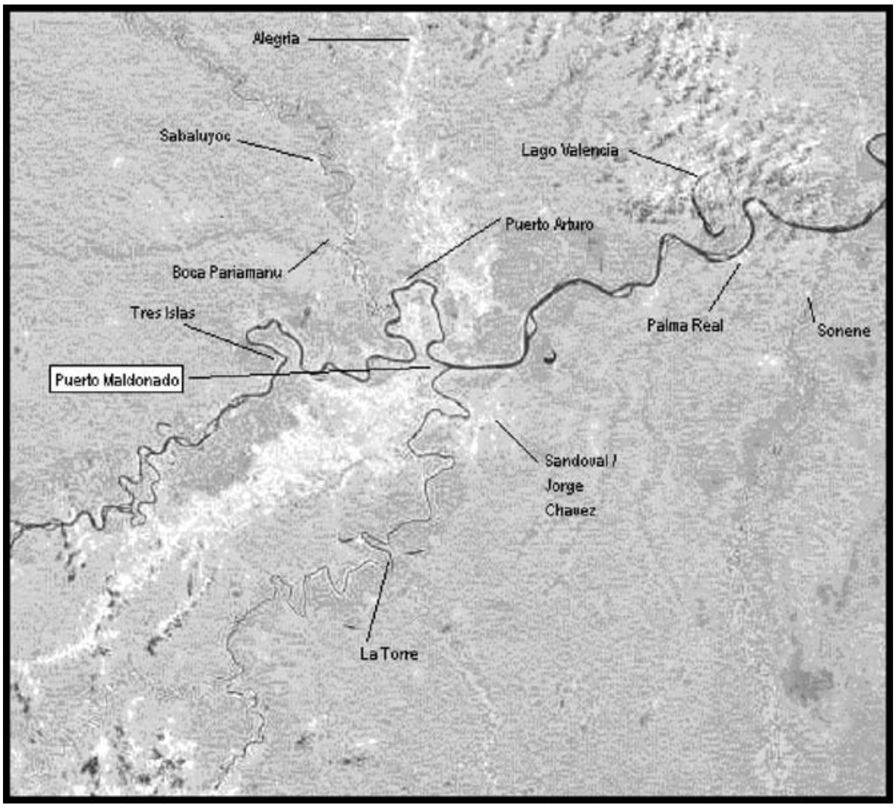

Figure 1. Map of case study locations.

use of forest products, as well as conducting detailed interviews with the sample of specialist forest users. Each respondent was asked to list in order of importance, the 10 most important taxa which s/he had harvested from the forest over the last 10 years. Responses were qualified with information about why they had selected those taxa. In addition, focused interviews were conducted with a small purposive sample of respondents to explore the effect of perceived legal and institutional changes.

Calculation of values for each taxon

Analysis focused on calculating quantitative indices which were then interpreted using the qualitative information. For each folk-taxon, an average value was derived as follows:

1. The rank was converted into a score; that is, a rank of 1 became a score of 10, a rank of 2 became a score of 9, etc. Respondents understood the concept of ranks more easily than that of scores, but most statistical analysis relies on scores (Maxwell and Bart 1995). Taxa that were not mentioned scored zero.

Table 1. Characteristics of the communities studied.

	La Torre	Sonene	Lago Valencia	Sabaluyoc	Boca Pariamanu
No. of inhabitants		~80	~240	~70	~84
Respondents interviewed	8 male 0 female	10 male 4 female	10 male 4 female	10 male 4 female	10 male 4 female
Ethnicity	Settlers	Indigenous (Ese eja)	Settlers	Settlers	Indigenous (predominantly Amahuaca)
Size and tenure	No fixed boundary although new de-gazetting process	Approx. 40 km^2	No fixed boundary	No fixed boundary	Approx. 40 km^2
Distance to market	6 h motorised canoe ('*peque peque*') or 3.5 h speedboat (55HP); very remote	7 h motorised canoe; very remote	6 h motorised canoe; very remote	4 h motorised canoe or 2 h road + boat; remote	2–3 h motorised canoe; moderately good access
Principal resources[1]	*Bajio*, *altura*, limited *aguajal*	Narrow *bajio* floodplain. Traditionally this community has also had access to *castañales* and hunting grounds well to the south	Predominantly *bajio* floodplain – with extensive altura further away	Narrow *bajio* floodplain. Community has also had access to the *castañales* (altura) to the west	Narrow *bajio* floodplain. *Castañal altura* overlaps with Sabaluyoc area
Other factors	Within boundary of Zona Reservada Tambopata-Candamo since 1990, and since September 2000 appears to lie within buffer zone of Parque Nacional Bahuaja Sonene: no commercial timber extraction has been permitted for several years	On left bank of river only – right bank is Bolivia		Very spread out community	

Table 1. (continued).

	Tres Islas	Palma Real	Puerto Arturo	Alegria	Sandoval / Jorge Chavez/ Loero
No. of inhabitants	~240	~224	~175	~225 in the central zone; 600 overall of whom 70% are permanent	?
Respondents interviewed	7 male 4 female	8 male 4 female	10 male 4 female	9 male 4 female	8 male 4 female
Ethnicity	Indigenous (Shipibos and Ese ejas)	Indigenous (Ese eja)	Indigenous and settlers (Quichua Runa, mestizo migrants and other indigenous groups). Complicated ethnic history	Settlers: 60% come from the high Andes	Settlers
Size and tenure	Approx. 325 km^2	Approx. 87 km^2	Approx. 37 km^2	No fixed boundary	No fixed boundary – study area includes three small nuclei of population
Distance to market	2.5 h motorised canoe or 1 h road	4.5 h motorised canoe; remote	30 min motorised canoe or 15 min road	1.5 h road; very easy access 'intense commercial activity with Bolivia'	1 h motorised canoe $+\frac{1}{2}$ to 1 h walking, that is, close but walking is laborious
Principal resources	*Altura*, *bajio*, several large *aguajales*	*Altura* and *aguajales*; little *bajio* floodplain	Predominantly *altura*, some *bajio*, very little *aguajal*	Almost purely *altura* – with limited *aguajales* and narrow river valleys with some *bajio* characteristics.	Mostly *altura* and some *aguajales*; almost no *bajio*

Table 1. (continued).

	Tres Islas	Palma Real	Puerto Arturo	Alegria	Sandoval / Jorge Chavez/ Loero
Other factors	Complicated ethnic history, and complicated boundary		Very close to Puerto Maldonado, hence higher levels of disturbed forest including tractor – extraction of timber by commercial companies	School and services have wide catchment. The only community with electricity. The only community with principal road access	Spread out community – Sandoval not really community. Close to market

[1]Principal resources. Main vegetation types accessible to people are described. *Bajio* = current and former Holocene floodplain areas, typically with relatively nutrient-rich but sometimes poorly drained soils, with *huacapú*, *espintana*, *pona*, and *huasai* used for house construction, *shihuahuaco*, and (originally) *caoba* and *cedro*. *Altura* = older, Pleistocene terraces on nutrient-poor but well-drained soils, with *castaña*, *palmiche*, and some *ungurahui*; where *castaña* is exploited and relatively frequent at ca. 1 adult tree ha^{-1} this forest is known locally as *castañal*. *Aguajales* = permanently water-logged swamps, dominated by the *aguaje* palm.

2. For each folk-taxon, scores were averaged for each sex in each community.

Thus, for a given taxon (*T*), we define its value attributed by the women (*f*) of a given community (*c*) as:

$$V_{Tfc} = \sum \frac{T_f}{n_f}.$$

We define its value attributed by the men (*m*) of a given community (*c*) as

$$V_{Tmc} = \sum \frac{T_m}{n_m}.$$

We define the value attributed by the whole sample in the community as

$$V_{Tc} = \frac{1}{2}\left(\sum \frac{T_m}{n_m} + \sum \frac{T_f}{n_f}\right).$$

And we define the regional value of each folk-taxon across all communities as:

$$V_{Tr} = \sum_{c=1}^{c=10} \frac{V_{Tc}}{10}.$$

In Appendix 1 we give a worked example of how each of these values are calculated. Other average values were calculated in a similar way, in each case taking account of different sample sizes in each community. Thus, for example, to compare values attributed to a given taxon (*T*) by the two broad ethnic groups (indigenous, immigrant), we compare the average of that taxon's value attributed by each of the five communities inhabited by that ethnic group (*E*):

$$V_{TE} = \sum_{c=1}^{c=5} \frac{T_{ce}}{5}.$$

We used these values in three kinds of analyses. Firstly, we generated summary statistics to indicate the basic characteristics of plant use in the region. Secondly, we used the taxon values to test hypotheses concerning the relationship between biological properties and values ascribed to plants. And thirdly, we used quantitative and qualitative approaches to investigate social aspects of plant value and use in the region.

Analysis of biological characteristics

To explore the impact of ecological apparency on plant values, we used the basal area (the cross-sectional area of trees at 1.3 m height or above buttresses) of all the botanical species corresponding to each folk-taxon as a proxy for biomass. In parallel studies (Baker et al. 2004) we have established a number of permanent tree plots within the study area, in both *bajio* (floodplain) and *altura* (well-drained) forest protected since

Table 2. Principal categories of plant uses, with examples and explanatory comments.

Category	Examples	Definition and comments
Timber	*caoba*, *cedro*, *tornillo*	Wooden products for construction. Generally sawn (thus requiring investment in tools such as chain saws), targeted for regional markets; destructively harvested; some impact on forest structure as these are large trees.
Roofing	Palms and grasses, such as *palmiche* and *caña caña*	Non-timber products (mostly leaves) for roofing houses. Generally no destructive harvesting. Low impact on forest structure, harvesting for community use, and small regional markets for *palmiche*.
Other construction	Roundwoods, such as *espintana*; and split palm stems used for walls, such as *huasai*	All other construction materials, mostly for housing. Local markets may exist, but little investment in tools or transport to urban markets is required. Generally destructively harvested, but with low impact on forest structure.
Fruit and other food	Commercial fruits such as *aguaje*, and fruits for home consumption, such as *pijuayo*	Non-timber food products. None require destructive harvesting, but some nevertheless are felled especially if collected for commercial markets.
Medicinal	Home remedies as well as more widely used taxa such as *uña de gato*, a well-known anti-inflammatory	Remedies for treating physical and psycho-spiritual conditions. Generally non-destructively harvested, generally not commercialised. Placed in a separate category to explore gender and ethnic differences.
Other non-timber forest products	Handicraft materials such as *tamshi*	All other non-timber forest products. Considered separately from food and medicinal plants because of their different gender and market relations.

1977. Using these plots, we estimated the basal area per hectare of each taxon that is used by respondents. Basal area scores were scaled up by correcting for the relative area of *altura* (57.0%) and *bajio* (19.7%) across the region, to generate an estimate of the mean basal area per hectare per species in the region.

Analysis of uses

To analyse the uses and values for different kinds of plants, it is necessary to group uses into broad categories. Such categories were largely suggested by the repeated use of descriptive words in interviews, such as ‘construction’, ‘food’, ‘medicine’. However, in some cases more detailed uses were described. Because the objective was to analyse impact of use, and relate this to contextual factors, markets and sustainability of use, we adopted categories based on ease of inference from the responses, and implications for impact of changing markets, population and land-use. These are shown in Table 2. In Appendix 2 we list taxa together with their key ecological and ethnobotanical attributes. However, for those plants with medicinal applications we follow recent convention in omitting their scientific names (cf. Laird 2002), recognising the sensitivities surrounding release of information on traditional uses of potentially commercial plants. One taxon, *uña de gato*, is so well known, however, that we mention this as an example (Table 2).

Results

While the sample includes equal numbers of indigenous and immigrant communities, and allows comparison of both ethnic groups and gender, it is clear from Table 1 that the communities also represent a complex range of ecological and economic factors which cut across the simple social comparisons. To understand the results, therefore, we need to apply both quantitative and qualitative analysis, exploring and validating apparent differences in value through the detailed interviews held with respondents.

Basic properties of the value results

(A) Numbers of taxa and range of values

The total number of harvested folk-taxa named in the respondents’ top 10 is 82, the majority of which were mentioned in three or fewer communities (Figure 2). This differentiation may be partly driven by spatial variations in ecology (Pitman et al. 1999), but results defy a simple environmental deterministic interpretation since most communities have access to the majority of species in our study (because they encompass all the main habitat types). There are also wide differences among individuals within the same community, and over half the species were nominated by 4% or less of the respondents. By exploring values, and the differences of values among respondents, we aim to identify some of the factors underlying this variation.

(B) Average taxon values

The average values calculated over the whole sample, and weighted to allow for different sample sizes among men and women, and in different communities (i.e., V_{Tr} as described in the Methods section above), are shown in Appendix 2. Because these values are averaged over the entire sample (not simply over the population who nominated that taxon) they are influenced by frequency of nomination since each non-nomination contributes a score of zero towards the overall average value.

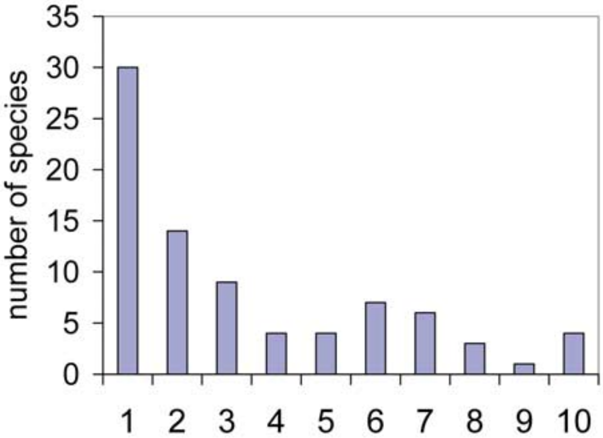

Figure 2. Number of taxa nominated as a function of the frequency of communities nominating them.

Potential biological controls on the values of species

(A) Are values related to the family-level affiliations of species?

The 82 nominated folk-taxa are in 35 families, only 12 of which are represented by more than one taxon (Table 3). The most valued family in terms of folk-taxa scores (V_{Tr}) is Arecaceae (palms). Fabaceae and Moraceae also score highly, suggesting that shared characters acquired deep in the evolutionary history of plants have predisposed them to being particularly useful (or not) for humans. The value of palms is underscored by the fact that 7 of the 15 most highly valued taxa are palms (Figure 3). Elsewhere in the Neotropics the Arecaceae have also been found to be the most or one of the most useful families (e.g., Prance et al. 1987; Piñedo-Vasquez et al. 1990; Galeano 2000). In the study region, features such as large, fibrous leaves (thatching), long-fibred durable stems (floors, walls, roofs), and oily fruits (eating, cooking) help make them exceptionally valuable to people.

(B) Are values related to apparency?

Values correlate with the regional basal area of taxa, but only weakly (Figure 4). Thus, the correlation between $\ln(V_{Tr})$ and ln(regional basal area apparency) is 0.267 (Pearson's correlation co-efficient, d.f. = 56, $P < 0.05$). Timber species tend to have relatively high value in relation to their apparency, and when *caoba* and *cedro* are removed, the correlation improves to $r = 0.368$ (d.f. = 54, $P < 0.01$).

Social perspectives on the nature of plant values in the region

(A) How do different uses contribute to people's values?

At the regional level, summarising across communities and sexes, fruit and construction (timber and other materials) account for the greatest number of taxa

Table 3. The most popular families in terms of total values and the number of taxa nominated.

Family	Total of species values (V_{Tr})	Number of taxa nominated
Arecaceae	182.9	12
Fabaceae (s.l.)*	41.4	11
Moraceae	25.5	7
Meliaceae	30.6	3
Sapotaceae	9.2	3
Lecythidaceae	67.3	2
Annonaceae	27.9	2
Lauraceae	12.7	2
Rubiaceae	6.1	2
Sterculiaceae	3.5	2
Clusiaceae	3.0	2
Euphorbiaceae	2.5	2

*Including Mimosoideae and Caesalpinoideae.

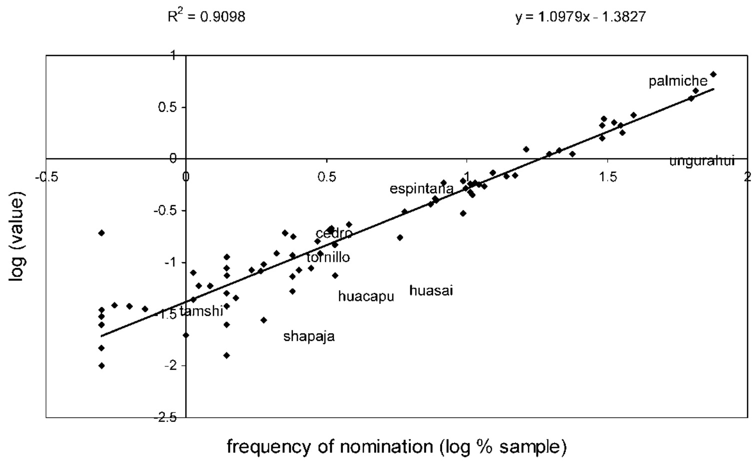

Figure 3. Relationship between frequency and score for each folk-taxon.

nominated, while a large range of harvested medicinal plants also feature in people's top 10 (Table 4). Two other features are notable: the high value placed on fruit species, even after the effect of *castaña* is excluded, and the extraordinary range of non-commercialised construction materials.

(B) How do men and women value taxa?

Table 5 shows the relative values attributed to folk-taxa by men and women (showing all taxa which received a value of 0.5 or more from either men or women). The principal timber trees (*cedro*, *tornillo*, *caoba*, *moena*, *quinilla*

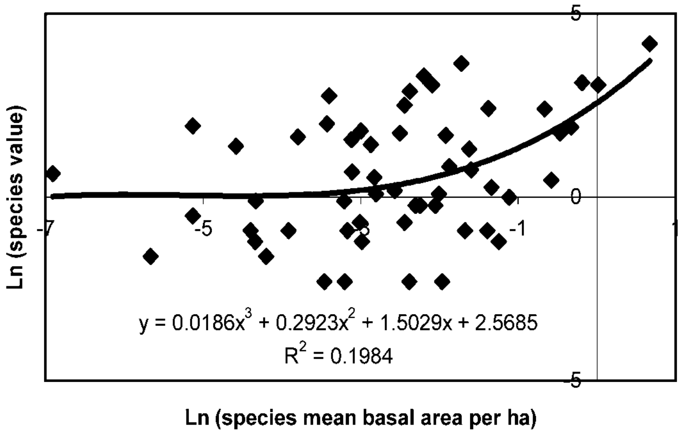

Figure 4. Relation between taxa values and the ecological 'apparency' of the resource. Apparency is expressed in terms of the mean relative biomass of the species in permanent plots located within the study region (see text for details of methods). The figure shows the relationship after excluding *caoba* and *cedro*; a third-order polynomial provides the solution which maximises *F*-value.

Table 4. The total value, number of taxa, and number of commercial taxa mentioned, separated according to principal use category.

Principal use (categories are not mutually exclusive)	Total values of all folk taxa $\sum V_{Tr}$*	Number of folk taxa	Number of commercial folk taxa (mentioned by >1 respondent)
Construction	3139	17	0
Fruit	8794	26	5
castaña	4928		
other	3866		
Medicine	21	11	0
NTFPs	266	7	2
Roofing	3395	7	1
Timber	1749	12	7

*Based on average regional values as explained in the Methods section.

(*Manilkara surinamensis*)) have significantly higher values for the men (Mann–Whitney *U*-test) while fruits and other NTFPs are more important for the women, some of them having significantly higher values: *ungurahui*, *pama* (*Pseudolmedia macrophylla*), and *charichuelo* (*Garcinia* spp.). This preference for particular uses is confirmed by an analysis of the frequency of different uses mentioned by men and women (Figure 5).

(C) How do indigenous and immigrant communities value forest plants?

Table 6 shows the relative value attributed to folk-taxa by indigenous and immigrant respondents (showing all taxa which received a value of 0.5 or more from

Table 5. The relative values attributed to taxa by women and men.

Folk taxon	Women's values, V_{Tf}	Men's values, V_{Tm}
Castaña	5.6	7.1
*Ungurahui**	3.9	3.2
Palmiche	3.3	5.1
Aguaje	2.1	1.9
Tamshi	1.8	0.7
Pona	1.6	2.3
Espintana	1.6	3.1
*Pama**	1.6	0.8
Chimicua	1.4	0.7
*Cedro**	1.4	3.4
Huacapú	1.3	1.8
Huasai	1.2	2.2
*Tornillo***	1.1	2.7
Sinami	1.0	0.5
Shapaja	1.0	1.2
Huicungo	0.9	0.2
Pijuayo	0.8	0.4
Coloradillo	0.8	0.3
Capirona	0.6	0.4
Ishpingo	0.6	0.5
Yarina	0.6	0.3
Cashapona	0.5	0.3
Palo Santo	0.5	0.9
Itauba	0.4	1.0
Caimito	0.3	0.5
*Caoba***	0.2	1.0
*Quinilla***	0.1	0.9
*Moena***	0.1	0.9

Significance level of difference between men and women, based on Mann–Whitney *U*-tests comparing female mean scores across the communities (i.e., V_{Tfc} = v.s. V_{Tmc}): *$p < 0.1$; **$p < 0.05$.

either ethnic group). Although there are only two statistically significant differences between values attributed by each ethnic group to a given taxon, there is a clear tendency for indigenous respondents to value plants used for fruit, NTFPs and domestic construction relatively highly compared with timber trees. Immigrants value timber taxa more highly than indigenous people, in every case except that of *moena*. This preference for particular uses is confirmed by an analysis of the frequency of different uses mentioned by indigenous and Andean settlers (Figure 6).

(D) To what extent is value influenced by markets?

The fact that the taxa which are most commercialised have positive deviations from the regression of local value on the frequency of nomination (Figure 3) suggests that markets may influence respondents' values. To explore this further, we compare average scores with marketability, as measured by the frequency with which respondents mentioned 'sale' as a 'use'. The results are shown in Figure 7,

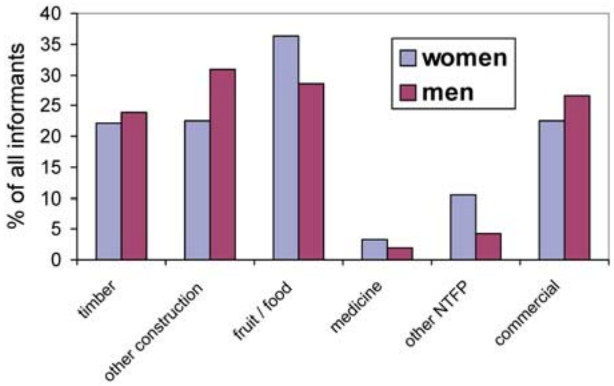

Figure 5. Distribution of uses mentioned by women and men, by major use-class.

Table 6. Relative value attributed to taxa by respondents from major ethnic division (indigenous and immigrant).

Folk taxon	Mean value for indigenous respondents, $V_{T\ ind}$	Mean value for immigrant respondents, $V_{T\ imm}$
Castaña	7.6	6.2
Palmiche	4.9	4.1
Ungurahui	3.7	4.1
Espintana	2.3	2.7
Tamshi	2.3	0.2
Cedro	2.1	2.9
Aguaje	2.1	2.5
Chimicua	1.9	0.5
*Shapaja**	1.8	0.6
*Tornillo**	1.8	2.4
Pama	1.8	0.9
Huacapú	1.6	1.9
Pona	1.5	2.5
Huasai	1.2	2.2
Huicungo	1.1	0.1
Pijuayo	1.0	0.3
Moena	0.9	0.4
Sinami	0.8	1.0
Capirona	0.6	0.5
Itauba	0.5	1.1
Palo Santo	0.5	1.0
Quinilla	0.4	0.5
Ishpingo	0.4	0.9
Yarina	0.4	0.6
Caoba	0.3	0.9
Coloradillo	0.3	1.0
Cashapona	0.2	0.7
Quillabordon	0.2	0.7
Sano Sano	0.0	0.6

Significance level of difference between men and women: *$p < 0.1$; **$p < 0.05$.

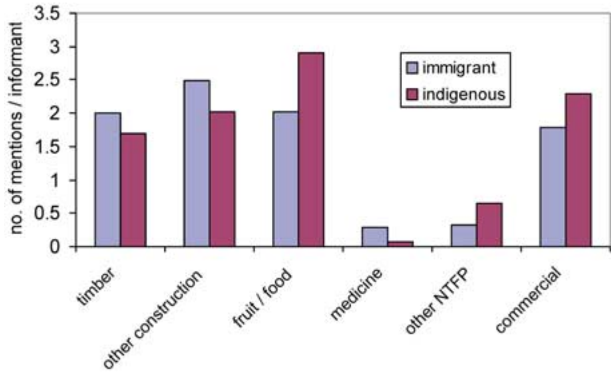

Figure 6. Distribution of uses mentioned by indigenous people and immigrants, by major use-class.

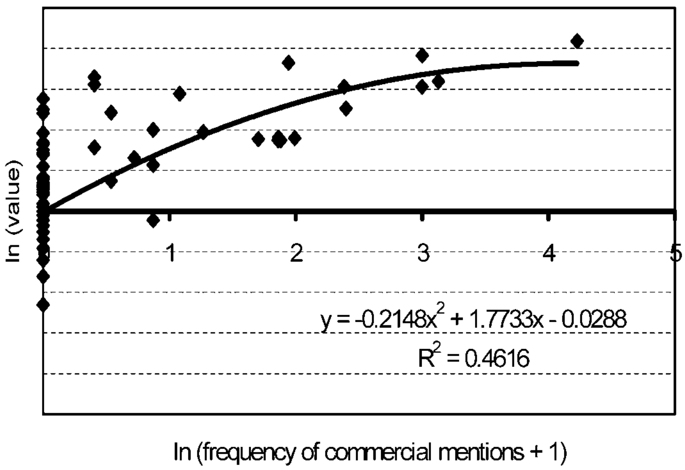

Figure 7. Relation between the value and the frequency with which respondents mentioned marketability for each taxon. The graph shows a second-order polynomial which provides the solution which maximises *F*-value.

and indicate that while markets may account for the high value of a few commercial taxa (especially *castaña*), other factors are operating too. For example, taxa with particularly high values in relation to the frequency of sale mentions include *pona*, *huasai*, *espintana*, all of which are very important in home construction.

We found no significant differences between ethnic groups or between sexes, in the importance of commercialisation of forest plants (Table 7), although immigrant women mentioned sale less frequently than other groups. Unexpectedly, commercialisation is mentioned just as frequently by indigenous men as by settler men, although the former benefit less from timber sales. Table 8 suggests an explanation for this, showing that immigrants (who are more connected with markets) focus on

Table 7. Frequency with which 'sale' of a folk taxon's product was mentioned, by each sex in each ethnic group.

	Women	Men
Immigrant	0.18	0.27
Indigenous	0.27	0.27

Units are the average number of mentions per taxon per respondent. No significant differences.

Table 8. The percentage of respondents nominating a taxon who also mentioned 'sale' as a use of that taxon, analysed by ethnic group.

Folk taxon	Immigrant	Indigenous
Caoba	100	25
Castaña	91	88
Ishpingo	88	0
Cedro	80	74
Tornillo	68	63
Tamshi	50	62
Moena	44	57
Pijuayo	25	50
Itauba	25	13
Palmiche	20	33
Aguaje	15	59
Quillabordon	14	33
Ungurahui	5	17
Huasai	3	6
Lagarto	0	100
Huicungo	0	57
Shihuahuaco	0	50
Pashaco	0	33
Sinami	0	20
Quinilla	0	11
Pona	0	6
Shapaja	0	4
Espintana	0	4

a few quality timber trees, while indigenous people sell a much wider range of plants, often in local markets for domestic use.

To test the possibility that local values are more strongly determined by commercialisation when communities are closer to markets we compared folk-taxa values in two remote communities – one indigenous (Sonene) and one immigrant (Lago Valencia), with two communities which have relatively easy access to markets – one indigenous (Boca Pariamanu) and one immigrant (Alegria). The top 15 taxa in each community are shown in Table 9. These results appear to be counter-intuitive – the community which mentions the largest number of commercialised forest plants in its top ranked taxa (Sonene) is indigenous and located further from markets than any other.

Table 9. Comparison of the top 15 taxa across four communities.

Sonene (indigenous, remote)	*V*	Lago Valencia (immigrant, remote)	*V*	Boca Pariamanu (indigenous, close to market)	*V*	Alegria (immigrant, close to market)	*V*
Castana	**6.9**	**Castana**	**8.9**	**Castana**	**7.2**	**Castana**	**7.1**
Palmiche	**6.3**	**Cedro**	**5.6**	**Palmiche**	**5.6**	*Ungurahui*	*5.8*
Tamshi	**4.7**	*Huacapu*	*3.8*	*Ungurahui*	*4.5*	*Aguaje*	*4.4*
Chimicua	*3.4*	*Espintana*	*3.5*	**Espintana**	**3.6**	**Cedro**	**3.3**
Huicungo	**3.4**	*Palo Santo*	*3.1*	*Pona*	*3.4*	**Palmiche**	**3.3**
Cedro	**3.3**	*Ungurahui*	*3.0*	*Capirona*	*2.9*	*Pona*	*2.6*
Pama	*3.2*	**Tornillo**	**2.8**	*Chimicua*	*2.9*	**Tornillo**	**2.2**
Ungurahui	**3.1**	*Yarina*	*2.3*	*Pama*	*2.4*	*Huasai*	*1.9*
Aguaje	**2.6**	**Palmiche**	**2.1**	**Quinilla**	**2.2**	**Caoba**	**1.8**
Pijuayo	**2.3**	*Huasai*	*1.8*	*Sinami*	*2.0*	**Charica Mono**	**1.8**
Huacapu	*2.2*	**Itauba**	**1.7**	*Huacapu*	*2.0*	*Caimito*	*1.7*
Huasai	**1.9**	*Aguaje*	*1.4*	**Cacao de monte**	**1.8**	*Pama*	*1.2*
Palo Santo	*1.7*	*Quinilla*	*1.2*	**Tornillo**	**1.3**	**Ishpingo**	**1.1**
Caimito	*1.6*	*Caoba*	*1.2*	**Itauba**	**1.3**	*Chimicua*	*1.0*
Sinami	**1.2**	**Ishpingo**	**1.1**	*Huasai*	*1.2*	*Isigo*	*0.8*
Total commercial	10		6		6		6

Folk-taxa which were stated by respondents in that community to have a commercial application, are printed in bold.

(F) To what extent do forest policy and regulations affect values?
Community members lack legal information, and have inaccurate perceptions of the law and forest regulations. This was particularly the case in the indigenous communities, which tend to be more remote and have less contact with officials. Many of the immigrant settlers have houses in the town, and are more familiar with official practice. Nevertheless, many respondents were acutely aware of broad recent changes, with control of forest extraction passing from the Ministry of Agriculture to the National Institute of Natural Resources (INRENA). They complained that the law had changed to prevent (in theory) *any* extraction of any product whether for home use or sale, whether sustainably or destructively harvested, without permission. People saw the law as yet another obstacle to be overcome in conducting their normal livelihoods.

Discussion

Within a region of the Amazon basin where high biodiversity, relatively high forest cover and increasing market influence affect the livelihoods of all forest communities, it is perhaps unsurprising that plants which provide cash, nutrition and construction materials should feature so overwhelmingly amongst those prioritised by respondents, and that at the same time there is great diversity in the range of taxa valued. Nevertheless, there are clear patterns of values related to variables, both intrinsic (social group) and contextual (ecology, markets, institutions). In this section we reflect on reasons for these patterns, seeking to:

1. Distinguish influences which are inherent cultural and livelihood attributes from those resulting from political, economic and institutional processes and hence conceivably subject to change;
2. Examine explanations based on resource use history and economic change;
3. Critically assess the methodology, discuss its usefulness and efficiency, and compare the results to those obtained by other authors using other methods.

Social group and plant values

The clearest patterns lie in the relationships between social group and taxon values. Even though there are few statistically significant differences (because of the small sample size in each community) the differences are consistent, which gives us confidence in our interpretation.

First, there are clear differences between plants considered important by men and by women. Women in every community valued fruit taxa more highly than men did, and usually also valued other NTFPs more. Both men and women are equally concerned with commercialisation of harvested plants, but their interest relates to timber in the case of men, and fruit/NTFPs in the case of women. This is consistent with reports from other researchers who find that women play a major role in the harvest and sale of NTFPs in Cameroon (Ndoye et al. 1998; Brown and Lapuyade 1999), the Philippines (Lawrence 1999), India (Misra and Dash 2000; Mohit and Baghel 2000) and across a wide range of countries (van Rijsoort 2000). Women consistently ranked fruit trees highly, while only those who specialise in handicrafts ranked other NTFPs highly, reminding us of the diversity of household livelihood strategies. Nevertheless, the consistent patterns have implications for the involvement of women in forest management decisions, where sustainable exploitation may depend on a focus on NTFPs; and conversely, for policy to focus on developing stable markets for NTFPs (Piñedo-Vasquez et al. 1990) in order to support women's economic development.

Comparisons between the two broad ethnic groups are more complex. Immigrants nominated a total of 68 folk-taxa, while indigenous respondents nominated 58, showing that immigrant preferences are no less varied than indigenous. In both cases, livelihood diversity within the community (cf. Coomes and Burt 2001) generates substantial variation in the kinds of species perceived as being significant, and may be more important than inter-ethnic variation. Researchers and development programmes need to pay close attention to this variation, and avoid simple 'ethnic determinism', that is, the assumption that belonging to a particular ethnic group or community may be the main factor defining a person's livelihood, or values.

There are, however, patterns of difference in taxa prioritised by the two ethnic groups. There is a stronger preference for NTFPs, fruit and construction materials among indigenous communities; the principal timber trees are less valued, but a wider range of taxa are considered saleable. The tendency for indigenous people to value fruit and NTFPs more highly than do immigrant people, can be partly explained by the fact that many indigenous people do not benefit directly from the timber trade but instead are employed as day labourers by immigrants who thereby derive a higher proportion of the profits for themselves. The wider *range* of traded species in indigenous communities may be attributable to intra-community trading, possibly as a result of stronger community-level interactions in the more spatially nucleated communities.

So, the ways in which people use and value the forest resources are strongly linked to social group, in turn linked to livelihoods through their settlement patterns, social relations and access to markets and capital. Some of these factors cut across social groups and in turn are affected by the ecological and political context. These aspects are discussed in the following sections.

Ecology and apparency

Overall, the communities are rather similar in terms of access to forest types, but mature *bajio* (floodplain) forest is scarce or almost absent from a few communities. Our analysis of the effects of ecological apparency on value related the overall regional biomass of each tree taxon with its value, so inter-community environmental differences were not taken into account. In spite of this, the correlation between plant values and ecological apparency was at least comparable to that reported in previous studies (Phillips and Gentry 1993b; Galeano 2000).

Higher correlation values were achieved once the two timber species with the longest harvesting history were removed from the sample. This may be because our plots underestimate the historical apparency of these species to people within living memory, as the reserved zones in which we have permanent plots were effectively cleared of *caoba* and *cedro* in the 1960s. This suggests the potential for negative feedback, whereby the apparency of a resource increases its value, but in turn that increased value may have a negative effect on its abundance. The potentially complicated interactions between resource abundance and value are discussed in the next two sections.

Markets, access and resource quality

It is widely assumed that sustainable development linked to forest conservation depends on the existence of markets, particularly for NTFPs (Piñedo-Vasquez et al. 1990; Mahapatra and Mitchell 1997; Gould et al. 1998; Perez and Byron 1999; Lawrence 2003) although this is controversial (Richards 1993). The logic is that markets increase locally perceived values, and hence harvesters' motivation to manage sustainably.

This study contributes evidence on the link between markets and values. On the one hand, as expected, markets affect the values of both NTFPs and timber, those which are most commercialised being ranked highly in all communities. All use categories (except medicine) included plants that were also perceived as commercially important, in particular timber (in terms of taxon numbers, and frequency of mention) and fruit (overwhelmingly influenced by *castaña*).

On the other hand, it is significant that correlations between frequency of marketability and value are not strong, even for immigrant males who might be reasonably expected to have the most commercially orientated perspective. In many cases fruit and construction materials used at home are near the top of respondents' lists. Furthermore, 15 medicinal taxa, none of them traded, were included in people's top 10. This finding contrasts with that of Piñedo-Vasquez et al. (1990) from northern Amazonian Peru, who found that ''the presence or absence of markets for specific forest products was found to be a major determinant of that species' overall use-value to *ribereño* [mestizo] populations''. Their method involved a complete inventory of the forest, with values assigned by researchers according to the number of uses mentioned (following Prance et al. 1987).

This difference is significant in two senses. First, methodologically, it illustrates the importance of seeking to elucidate value from the perspective of the people being 'studied', rather than those doing the studying, and thus relates to the long-standing 'emic'/'etic' debate in linguistics, sociology and cultural anthropology (cf. Harris 1964; Pike 1967 et seq.). A purely econometric approach would also overlook much of the value of harvested plants. Second, in a very specific sense it suggests that when values are attributed by local users, *even when those values are restricted only to the utilitarian values of harvested species*, subsistence emerges as having a significant effect on those values.

Furthermore, interpretation of the above results provides evidence that as communities 'develop', fewer forest products are relied on for trade. Communities closer to roads and populated by immigrants focus on fewer, more valuable plants. There are two interacting causes: degradation of the forest resource, and increasing alternative livelihood options, which are often considered more attractive and profitable. For example, in Alegría, which has the best communication, infrastructure and market access, many inhabitants are involved in shop-keeping, or perennial crop production. Conversely, the most remote community, Sonene, has the largest number of traded forest plants in its top 15, and is situated in some of the least exploited forest in terms of populations of economic species (Phillips et al., unpublished data).

Proximity to market may affect some products more than others. A comparison of the position of fruit taxa in remote and accessible communities suggests that fruit becomes more appreciated in communities closer to markets (partly because transport affects quality, and partly because communities close to markets have lost their timber resources). Hence, access, resource quality, and resource sustainability through harvesting method are all inter-related. We suggest that easy access to regional markets may narrow the range of species that are commercialised, as well as increasing the pressure on those that are traded.

All these factors confound analysis of the effect of resource tenure and access rights, an aspect which is of considerable interest but which would require a more specialised study. There is great confusion and overlap of rights to timber, NTFPs and land, further complicated by the recent (widely ignored) ban on any forest product extraction. However, individual responses in our study show that forest products are important not only to those who own them, but also for those who process them. *Castaña*, for example, was ranked as highly by landless respondents who base their livelihoods on shelling and processing the nuts, as by those who harvested them.

Running even more counter to prevailing economic expectations is the finding that price and perceived value have different relationships with scarcity. This is particularly evident with *caoba*, the highest-quality timber species in the area, now nearly extinct locally. Despite being the highest priced timber, *caoba* ranks lower than several other timber trees in terms of local perceived value. It has become so scarce, that while high prices make it attractive, it is unlikely to affect the finances of many households. Other ways in which scarcity may not be reflected in increased value are shown by taxa which appear to be being replaced in some communities. For example, various Annonaceae (collectively *espintana*), despite being the preferred roundwood species for house construction, are reported by respondents in Puerto Arturo, Sonene and Tres Islas to be disappearing, leading to higher values attributed to alternative roundwoods such as *bolaina* (*Guazuma crinata*, *G. crenatifolia*) and *palo santo* (Tachigali spp.). Other factors may also be at play – for example, respondents in Sabaluyo noted that there is a social preference to build with sawnwood so that as economic circumstances improve people shift their preferences to larger timber taxa such as *tornillo*.

Changing values

The previous section highlights several ways in which values may change, through the effect of ecological and human context on forest-based livelihoods. Timber prices change from year to year, as new species enter the market (Camara Nacional Forestal 2002); markets for NTFPs fluctuate even more unpredictably, as do annual harvests, and values change according to the role that such products play in diversified livelihood strategies. Furthermore, resources become less accessible (the most valuable timber species are now distant from most of the communities included here) and alternative income-making opportunities present themselves as infrastructure is improved.

Outside intervention can also change perceptions and values. For example, in Tres Islas (as in many of the communities) efforts are being made by teachers and extension workers to encourage women's groups to produce handicrafts, for which there is a market in Puerto Maldonado. Anecdotally, our discussions with respondents indicated that such handicrafts use local plants which the women had formerly considered rather unimportant, and cause them to reflect that it might be worth protecting a range of species, not knowing which will be valuable in the future. Wider attempts at intervention are less successful however, as shown by people's lack of awareness of, or resistance to, policy changes which seek to restrict extraction in the interests of conservation. With all this emphasis on values being influenced by context, and the certainty that context will change, policy makers need to understand the ways in which such values change. Therefore there is now an urgent need to develop time-series studies which explore how values respond to these changing contexts.

Assessment of the methodology

The methodology was designed to provide a relatively quick but sophisticated way of differentiating values based on local perceptions. The ranking process has several advantages for ethnobotanists:

- it is relatively rapid, so that a regional perspective can be developed based on many respondents and communities contributing to the study;
- it allows all taxa to be compared by respondents themselves, hence avoiding the issue of researchers weighting responses or categories of taxa;
- it permits comparison of the values of different social groups;
- it is much less time-consuming than the full inventories used in some quantitative ethnobotanical studies.

Respondents were limited to ranking 10 taxa each, and yet there was sufficient diversity of responses to provide information on the value and uses of 82 folk-taxa. This limit to responses, however, means that the results are not directly comparable to other ethnobotanical studies which have sought to document species' uses exhaustively. We suggest that information on 'total number of taxa used' has little management value in itself, while our technique permits greater insight into how and why species are valued, and therefore how robust these values are in the face of changes in the human and physical environment.

There are statistical advantages in selecting methods based on respondents' scores, rather than ranks (Maxwell and Bart 1995). In this case, ranking was appropriate because of the need to generate a region-wide picture within a project time-scale and because the concept of ranking is easier for respondents to understand. The method also integrates both commercial and non-commercial use-values, as respondents considered both economic value and daily use value in scoring taxa. This gives us a quicker and arguably improved alternative to standard economic analysis.

Our experience suggests that values are not absolute, and that it is not always easy for respondents to answer the question 'how important is this plant to you?'. Values vary from year to year, and are strongly influenced by recent circumstances. For example, five communities were visited in a year with exceptionally low *castaña* harvest (1998), which may have led respondents to undervalue this species. Furthermore, illegal activities inevitably undermine people's willingness to draw attention to important timber species, and we believe that they may be undervalued in our results here.

Finally, those who volunteered to make up the sample are those most familiar with the forest. The results do not represent *all* forest dwellers, but show patterns of difference between forest *users* of different communities. A more complex study looking at prospects for participation in forest management would have to explore the values of these additional stakeholders.

Conclusions

The paper set out to explore how forest dwellers' values vary across a range of plant species extracted from the forest, and possible reasons for such variation, with the objective of enhancing understanding of priorities for research and policy in forest management.

The findings support gender and (for the first time) ethnic differences in values, which can be explained in terms of livelihoods and access to forest, capital and markets. Using a quantitative method which permits detailed differentiation among local values we find that a few taxa have the highest values, namely those for which there are international markets. However, the wide range of species included in people's top 10 reflects livelihood diversity, and supports the argument that the sum total of community knowledge is much wider than simply an 'average'.

Importantly, however, we find that value co-varies with abundance, and that as one taxon becomes scarce its popularity may decline, to be replaced by others, this has important implications for forest management as it indicates a certain flexibility, not to say fatalism, in adapting to availability, such that explicit efforts to protect and manage for sustainable production of favoured species (whether commercial or not) are unlikely. We venture this conclusion with two caveats: this fatalistic adaptability takes place in an unfavourable policy and institutional context which provides no incentive or support for local management of the forest; and there are likely to be some species that are simply *not* substitutable, at least for indigenous populations, because of their cultural significance (as found in Indonesia (Sheil et al. 2002), and Cameroon (Wong et al. 2002)).

More promising is the finding that a wide range of taxa are valued (despite limiting respondents to nominating only 10 each), indicating the close links between livelihoods and the forest, and diversity of use both among and within communities. Immigrant communities demonstrate at least as much diversity of knowledge as indigenous ones, and show that they are also promising partners in forest management – if given supportive policy, and forest to manage. This last point is significant. The communities in this study represent a wide range of circumstances, with respect to forest quality and market access. Those within easy range of the city either diversify out of forest dependence (and therefore value it less) or concentrate on a few species worth transporting, leading to their decline (and consequently less valuable forest).

The Peruvian Amazon is known for its high concentration of commercial (and other) NTFPs, and these species featured strongly in responses – 10 of the top 15 taxa are NTFPs. Such plants are particularly valued by indigenous people and by women immigrants, highlighting the importance of their involvement in forest management research and decisions. Moreover, while there is great interest in combining forest development activities with forest conservation, intrinsic within this is the danger that researchers, development practitioners and policy-makers focus exclusively on the more marketable species. This does not always match with the priorities and livelihood activities of the forest communities. Research that is capable of determining relative species values needs to be prioritised and integrated with development programmes.

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Appendix 1

Example calculations showing how taxon values were computed for (1.1) the women in each community, (1.2) the men in each community, (1.3) the whole sample in the community, and (1.4) the regional value of each taxon across all communities. Example used = '*Castaña*' (=*Bertholettia excelsa*, the 'Brazil nut')

1.1. For a given taxon (t), its value attributed by the women (f) of a given community (c) is

$$V_{Tfc} = \sum \frac{T_f}{n_f}$$

Castaña, using Tres Islas example, female respondents only

Female respondent	Ranked *castaña*	Therefore, *castaña* score (T_f)
A	7	3
B	7	3
C	3	7
D	Did not mention	0
Totals: 4		13

Castaña, all communities together, female respondents only

Community	$\sum T_f$	n_f	V_{Tfc}
Alegría	27	4	6.75
Boca Pariamanu	35	4	8.75
La Torre	0	0	
Lago Valencia	40	4	10.00
Palma Real	17	4	4.25
Puerto Arturo	40	4	10.00
Sabaluyoc	19	4	4.75
Sandoval/Jorge Chavez/Loero	20	4	5.00
Sonene	19	4	4.75
Tres Islas	13	4	3.25
Totals: 9	230	36	57.5

Therefore

$$V_{Tfc} = \sum \frac{T_f}{n_f}$$
$$= 230/36$$
$$= 6.39.$$

1.2. For a given taxon (t), its value attributed by the men (m) of a given community (c) is:

$$V_{Tmc} = \sum \frac{T_m}{n_m}$$

Castaña, Tres Islas example, male respondents only

Male respondent	Ranked *castaña*	Therefore, *castaña* score
A	1	10
B	1	10
C	1	10
D	1	10
E	2	9
F	Did not mention	0
G	Did not mention	0
Totals: 7		49

Castaña, all communities together, male respondents only

Community	$\sum T_m$	N_m	V_{Tmc}
Alegría	68	9	7.56
Boca Pariamanu	57	10	5.70
La Torre	26	8	3.25
Lago Valencia	78	10	7.80
Palma Real	79	8	9.86
Puerto Arturo	84	10	8.40
Sabaluyoc	70	10	7.00
Sandoval/Jorge Chavez/Loero	41	8	5.11
Sonene	90	10	9.00
Tres Islas	49	7	7.00
Totals: 10	642	90	70.68

Therefore

$$V_{Tmc} = \sum \frac{T_m}{n_m}$$
$$= 642/90$$
$$= 7.13.$$

1.3. *Castaña* value attributed by the whole sample in Tres Islas is:

$$\begin{aligned} V_{Tc} &= \frac{1}{2}\left(\sum \frac{T_m}{n_m} + \sum \frac{T_f}{n_f}\right) \\ &= (49/7 + 13/4)/2 \\ &= (7.00 + 3.25)/2 \\ &= 10.25/2 \\ &= 5.125. \end{aligned}$$

1.4. The regional value of *castaña* across all communities is:

$$V_{Tr} = \sum_{c=1}^{c=10} \frac{V_{Tc}}{10}$$

Community	V_{Tc}
Alegría	7.15
Boca Pariamanu	7.23
La Torre	3.25
Lago Valencia	8.90
Palma Real	7.06
Puerto Arturo	9.20
Sabaluyoc	5.88
Sandoval / Jorge Chavez/ Loero	5.06
Sonene	6.88
Tres Islas	5.13
Totals: 10	65.73

Therefore

$$\begin{aligned} V_{Tr} &= \sum_{c=1}^{c=10} \frac{V_{Tc}}{10} \\ &= 65.73. \end{aligned}$$

Appendix 2

Useful forest taxa of south-eastern Madre de Dios, showing vernacular (folk) and botanical taxon name(s), principal use category, forest type in which it is encountered most frequently, its mean regional score, and the frequency of nomination expressed as the percentage of respondents who nominated each taxon weighted to correct for differences in the sample size for each sex in each community.

Vernacular species (= folk taxon)	Scientific name	Family	Principal use[1]	Forest type[2]	Regional value, V_{tr}	Number of male respondents nominating taxon	Number of female respondents nominating taxon	Weighted percentage of respondents nominating taxon[3]
Castaña	*Bertholettia excelsa*	Lecythidaceae	f	A	65.7	71	26	75
Palmiche	*Geonoma deversa*	Arecaceae	r	A	46.0	65	22	66
Ungurahui	*Oenocarpus bataua*	Arecaceae	f	A	38.4	51	25	63
Espintana	*Several genera*, especially *Oxandra*, *Xylopia*, *Malmea*	Annonaceae	c	A, B	26.9	45	11	39
Cedro	*Cedrela odorata*	Meliaceae	t	A, B	24.3	37	7	31
Pona	*Iriartea deltoidea*	Arecaceae	c	B	22.5	36	10	33
Aguaje	*Mauritia flexuosa*	Arecaceae	f	S	21.3	28	14	35
Tornillo	*Cedrelinga cateniiformis*	Fabaceae	t	A	21.3	32	9	30
Huasai	*Euterpe precatoria*	Arecaceae	c (f)	B	17.9	37	12	36
Huacapu	*Minquartia guianensis*	Olacaceae	c	B	15.8	30	11	30
Tamshi	*Heteropsis spp.*	Araceae	n	A	12.5	10	8	16
Pama	*Pseudolmedia macrophylla*	Moraceae	f	A, B	12.2	14	10	21
Shapaja	*Attalea phalerata*	Arecaceae	r (f)	B	11.3	24	8	24
Chimicua	*Pseudolmedia laevis*	Moraceae	f	A, B	11.1	13	9	20
Sinami	*Oenocarpus mapora*	Arecaceae	f	A, B	7.4	9	6	12
Itauba	*Mezilaurus* spp. (*M. itauba* (Meissn.) Taub. ex Mez, *M. lindaviana* Schw. & Mez.)	Lauraceae	t	A	7.0	21	3	15
Palo Santo	*Tachigali* spp.	Fab: Caesalpinoid	c	A	6.8	16	4	14
Ishpingo	*Amburana cearensis*	Fabaceae	t	A, B	6.1	7	4	10

Caoba	*Swietenia macrophylla*	Meliaceae	t	B	6.0	12	1	8
Platanillo	*Heliconia* spp.	Musaceae	r	B	5.9	1	0	1
Huicungo	*Astrocaryum murumuru*	Arecaceae	n	B	5.7	3	6	10
Moena	Several genera	Lauraceae spp.	t	A, B	5.7	15	2	11
Coloradillo	*Ouratea* sp.	Ochnaceae	t	A	5.4	8	5	12
Capirona	*Calycophyllum acreanum*, *C. spruceanum*, *Capirona decorticans*	Rubiaceae	c	B	5.2	6	5	10
Quinilla	*Manilkara surinamensis*	Sapotaceae	f	B	4.8	17	1	10
Yarina	*Phytelephas macrocarpa*	Arecaceae	r	B	4.5	7	5	10
Cashapona	*Socratea exorrhiza*	Arecaceae	c	B	4.2	5	4	8
Caimito	*Pouteria* spp. (especially *P. caimito*)	Sapotaceae	f	A, B	4.0	9	2	8
Quillabordon	*Aspidosperma* spp.	Apocynaceae	c	A, B	3.7	7	3	7
Pijuayo	*Bactris gasipaes* (cultivated), *B. dahlgreniana* (wild)	Arecaceae	f	B	3.1	7	5	11
Caña Brava	*Gynerium sagitatum*	Poaceae	r	River edge	3.0	9	4	10
Medicinal Plant 1			m	A, B	2.3	5	1	4
Medicinal Plant 2			m	B	2.2	1	2	3
Lagarto	*Calophyllum* sp.	Clusiaceae	t	A	2.1	3	1	3
Cacao de monte	*Theobroma speciosum*	Sterculiaceae	f	A, B	2.0	1	2	3
Catahua	*Hura crepitans*	Euphorbiaceae	t	B, S	1.9	4	0	2
Shica Shica	?	?Arecaceae	f		1.9	1	0	1
Chanca Mono	?		n		1.8	1	1	2
Estoraque	*Myroxylon balsamum*	Leg. Pap.	c	B	1.7	6	2	6
Misa	*Eschweilera* spp., *Couratari guianensis*	Lecythidaceae	r	A, B	1.6	3	1	3
Bolaina	*Guazuma crinata*, *G. crenatifolia*	Sterculiaceae	c	B, secondary	1.5	4	1	3
Lupuna	*Ceiba pentandra*	Bombacaceae	t	B	1.2	1	1	2
Negrillo	?		c	B, S	1.2	1	2	3
Yutubanco	*Ampelocera* spp./*Drypetes*	Ulmaceae/Euphorbiaceae	c	B	1.2	2	1	2
Tahuari	*Tabebuia serratifolia*, *T. incana*	Bignoniaceae	c	A	1.1	0	1	1

Appendix 2. (continued)

Vernacular species (= folk taxon)	Scientific name	Family	Principal use[1]	Forest type[2]	Regional value, V_{tr}	Number of male respondents nominating taxon	Number of female respondents nominating taxon	Weighted percentage of respondents nominating taxon[3]
Yanchoma	*Poulsenia armata*	Moraceae	n	B	1.1	0	1	1
Carahuasca	*Guatteria* spp.	Annonaceae	r	A, B	1.0	1	1	2
Charichuelo	*Garcinia* spp.	Clusiaceae	f	B	0.9	3	0	2
Limoncillo	?		t		0.9	0	2	3
Palo Llave	*Euceraea nitida*, *Laetia procera*, *L. suaveolens*	Flacourtiaceae	c	A	0.9	0	1	1
Medicinal Plant 3			m	Secondary	0.9	2	1	3
Guabas	*Inga* spp.	Fab: Mimosoid	f	B	0.8	0	1	1
Isigo	?	Burseraceae	f		0.8	0	1	2
Oreja de burro	?		c		0.8	2	0	1
Shihuahuaco	*Dipteryx odorata*	Fabaceae	f	B	0.8	1	2	3
Coquino	?		f		0.7	2	1	2
Medicinal Plant 4			m	B, secondary	0.6	0	1	1
Shebón	*Attalea butyracea*	Arecaceae	f	B	0.6	2	0	1
Pashaco	Several Fabaceae genera	Fabaceae	n	B	0.5	3	3	6
Shimbillo	*Inga* spp.	Fab: Mimosoid	f	B	0.5	2	1	2
Tamamuri	*Brosimum lactescens*	Moraceae	f	B	0.5	3	0	2
Almendrillo	*Caryocar* spp.	Caryocaraceae	t	A	0.4	1	0	1
Azucar	*Hymenaea courabil*, *H. parvifolia*, *H. oblongifolia*	Fab: Caesalpinoid	f	A, B	0.4	0	1	1
Huayo								
Lúcuma	*Pouteria tarapotensis*, *P. macrophylla*	Sapotaceae	f	A, B	0.4	2	0	1
Malata	?		f		0.4	1	0	1

Mashonaste	*Clarisia biflora*, *C. racemosa*, *Batocarpus costaricensis*	Moraceae	c	A, B	0.4	0	1	1
Medicinal Plant 5			m	B, secondary	0.4	1	0	1
Puño de Tigre	?		f		0.4	0	1	1
Medicinal Plant 6			m	B	0.4	0	1	1
Achipa	???		c		0.3	1	0	1
Medicinal Plant 7			m	A, B	0.3	0	1	1
Medicinal Plant 8					0.3	1	0	1
Nejilla	*Bactris* spp.		f	B, S	0.3	1	0	1
Medicinal Plant 9			m	A	0.3	1	0	1
Uchumuyaco	*Trichilia poeppigii*	Meliaceae	n	B	0.3	1	1	2
Atadijo	*Trema micrantha*	Ulmaceae	n	B, secondary	0.2	2	0	1
Huayruru	*Ormosia* spp.	Fab: Papilionoid	c	A, B	0.2	0	1	1
Anonilla	*Annona ambotay*, *Rollinia* aff. *microcarpa*, *Rollinia pittieri*	Annonaceae	f	A, B	0.1	0	1	1
Medicinal Plant 10			m	B	0.1			1
Medicinal Plant 11			m	B	0.1	1	0	1
Ubos	*Spondias mombin*, *S. venosa*	Anacardiaceae	f	B	0.1	1	0	1
Uvilla	*Pourouma* spp.	Moraceae	f	A, B	0.1	1	0	1

[1]Categories follow Table 2: timber (t); roofing (r); other construction (c); fruit and other food (f); medicinal (m); other non-timber forest products (n).
[2]A = Altura (well-drained forest on Pleistocene sediments); B = Bajio (well-drained forest on Pleistocene sediments). See Phillips et al. (2003) for detailed habitat descriptions.
[3]Percentage of all respondents who mentioned the species, weighted to correct for differences in the sample size for each sex in each community.
[4]Medicinal plants are not named, as some are not yet used commercially and we do not have permission from the respondents to disseminate this knowledge. Whilst some medicinal species are well known, for consistency we treat all in the same way.

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