CULTURAL, PRACTICAL, AND ECONOMIC VALUE OF WILD PLANTS: A QUANTITATIVE STUDY IN THE BOLIVIAN AMAZON[1]

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Reyes-Garcia, Victoria *(House 601;/#17, ICRISAT, Patancheru 502 324, Andhra Prades, India; Tel: +91 (40) 30 71 3682; Fax: +91 (40) 30 71 3074/3075; e-mail:* vreyes@brandeis.edu), **Tomás Huanca, Vincent Vadez** *(Sustainable International Development Program, Heller School for Social Policy and Management, Brandeis University, Waltham, MA 02454-9110),* **William Leonard** *(Department of Anthropology, Northwestern University, Evanston, IL 60208),* **and David Wilkie** *(Wildlife Conservation Society, 18 Clark Lane, Waltham, MA 02451-1823).* CULTURAL, PRACTICAL, AND ECONOMIC VALUE OF WILD PLANTS: A QUANTITATIVE STUDY IN THE BOLIVIAN AMAZON. *Economic Botany xx:xx. 2005.* *Researchers have developed several indices to estimate the significance of plant species for humans. We build on previous methods in ethnobotany and anthropology to develop a new way to value plant species along three dimensions: cultural, practical, and economic. We used interview and observational data on the use of wild plants by the Tsimane', a foraging-horticultural society in the Bolivian Amazon. We calculated the cultural, practical, economic, and total values of 114 plant species from 46 families. We found a low correlation between the practical and the cultural values of species: some species rarely used were frequently mentioned in interviews, whereas some species frequently used were rarely mentioned in interviews. Indices of cultural, practical, and economic value measure different dimensions of the importance of plant species to society. The combination of the three indices offers a more comprehensive valuation of the significance of plants for humans than the use of only one index.*

Key Words: Ethnobotanical knowledge, uses of plant, Tsimane' indigenous peoples, Bolivia, indices of cultural significance.

The interest in quantitative ethnobotany has grown steadily in the last two decades. Researchers have developed and applied quantitative methods to ethnobotanical data to test different hypotheses about the relation between plant species and humans. Some authors have developed indices of cultural significance that capture the importance of plants; these indices take into account cultural aspects, such as types of uses (Turner 1988) or taste of edible plants (Pieroni 2001). Other authors have proposed the use of indices that derive in part from ecological theory; they use the indices to determine the relative importance of different species or plant families to society (Begossi 1996; Benz et al. 2000; Phillips 1996). A third group of authors has estimated the economic value of forest goods for different ethnic groups (Godoy et al. 2002; Hecht, Anderson, and May 1988). What is lacking are studies that merge the different approaches to allow for a more comprehensive valuation of the importance of plants species for human societies. Our goal in this article is to take a first step in that direction.

Anthropologists and ethnobotanists have proposed several indices to estimate the cultural significance of plant species for humans. For example, Turner (1988) proposed an index of cultural significance that drew on the quality, intensity, and exclusivity of plant uses. Stoffle et al. (1990) modified the index proposed by Turner, adding a variable to measure the present use of the plant species. Recently, Pieroni (2001) proposed the inclusion of cultural variables, such as taste, to evaluate the importance of edible plants in a culture.

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Ethnobotanists have constructed indices to measure the use value of plant species. For example, Phillips and Gentry (1993) defined the total use value of a species as a relation between the number of uses mentioned in interviews and the number of interviews conducted. Plants mentioned with more frequency were assigned more use value than plants mentioned with less frequency. Similarly, Begossi (1996) proposed the application of indices of ecological diversity to ethnobotanical data collected through survey questions. Building on this method, researchers have calculated diversity indices using data on the number of participants who mentioned a plant species during interviews (Figueiredo, Leitao-Filho, and Begossi 1997; Rossato, Leitao-Filho, and Begossi 1999).

Still other authors have estimated the economic value of forest goods for different human societies. Some authors have studied the value of specific plant resources. For example, Hecht and her colleagues describe the importance of the babassu palm among landless farmers in the Brazilian state of Maranhao (Hecht, Anderson, and May 1988). Other authors have calculated the financial benefits of tropical rain forests for local users and for the humanity (Godoy et al. 2002; Pimentel et al. 1997; Peters, Gentry, and Mendelsohn 1989).

Previous researchers have constructed indices to measure the value of plant species combining cultural and practical dimensions, but the elaboration of those indices presents two problems. First, researchers have mainly relied in data from surveys and interviews. For example, Turner (1988) included questions about frequency of use to capture the relative importance of different plant species in daily life. But responses to interview questions do not necessarily bear a strong relation to daily uses of plants (Begossi, Hanazaki, and Tamashiro 2002; Byg and Balslev 2001; Ladio and Lozada 2004; Reyes-García et al. 2005). The elaboration of a comprehensive index would be more accurate if it combined observational data with interview data. Second, although researchers have combined cultural and practical dimensions of plant uses, we still lack an index that also includes the economic value of plants.

In this article we build on previous methods in quantitative ethnobotany and economic anthropology to develop a new way to value different plant species for a cultural group. We overcome some of the problems faced by previous research by using both observations and interview data. Our index takes into account three dimensions: the cultural significance, the practical daily value, and the economic value of plant species. We estimate the cultural value of a plant species as a function of its potential uses and the number of participants reporting the plant. We estimate the practical value of a plant species as a function of the number of uses observed, the number of times the species was used, and the potential lifetime of the good made from the plant. Last, we estimate the economic value of a plant species as a function of the number of times the plant was used and the estimated price of the plant species.

Since the practical and economic values of a plant species are calculated from the same data, we expect a high correspondence between these two indices. We expect that the practical and the cultural values of a plant species would not bear a strong association with each other. For example, it is possible that a plant scores high in cultural value, as might happen if most people in a culture can name the plant, but low in practical value, as might happen if people rarely use the plant, and even then only for paltry ends. For the study we rely on information on the use and value of wild and semicultivated plants by Tsimane' indigenous peoples, a foraging and farming society in the Bolivian Amazon.

METHODS

Two anthropologists, two biologists, and one agronomist conducted fieldwork during 18 months (May 1999–November 2000). The study forms part of a long-term research project in progress to measure the effect of markets on the quality of life of indigenous peoples.

THE PEOPLE

The Tsimane' are a foraging and farming society in the department of Beni in the Bolivian Amazon. The Tsimane' territory spreads from the foothills of the Andes to the northeast, reaching the edges of the Moxos savanna (14°35' S-15°30' S; 66°23' W-67°10' W). Habitats in the Tsimane' territory range from wet to moist subtropical and gallery forests, some of which abut savannas (Killeen, García, and Beck 1993). Recent dissertations (Byron 2003) and publications (Vadez et al. 2004) provide de-

tailed ethnographic information on the Tsimane', including description of traditional plant knowledge (Huanca 1999; Reyes-García 2001).

The Tsimane' economy centers on forest goods and subsistence agriculture (Godoy et al. 2002; Reyes-García 2001). Consumption of forest goods represents an average of U.S. $842/household/year, or 45 % of total Tsimane' household income. Tsimane' obtain game, fish, and wild and semicultivated plants from the forest all year. Tsimane' gather plants mostly near recently abandoned plots and during trips to the forest, and they use wild plants for food, firewood, medicines, house building, canoes, and crafts. The annual value of plants that Tsimane' gather (U.S.$268/household) represents around 17% of the total income of a household (Reyes-García 2001).

Tsimane' share knowledge on uses of plant species (Reyes-García et al. 2003), but because they have different access to plant substitutes, their daily dependence on plants varies. We conducted the research in two villages at different distances from the local market town of San Borja (population about 19,000). The first village, Yaranda (15°16.369' S, 66°50.838' W), lies about 50 kilometers in a straight line from the local town of San Borja, or three days canoeing upriver. The second study site, San Antonio (14°48.698' S, 66°39.761' W), is 10 kilometers away from the town of San Borja, or about three hours walking at a normal pace.

Sampling

We used two different sampling strategies to collect information during interview and direct observations. For interview data, we selected a stratified sample of 24 participants in each village for a total of 48 interviews. We selected participants so they would include adult men and women of all ages. For observational data, we interviewed all people over 15 years of age in the two villages. We chose this as the cut-off age because most acquisition of ethnobotanical knowledge occurs before the age of about 15 (Hunn 2002; Ohmagari and Berkes 1997; Ruddle and Chesterfield 1977; Zarger 2002) and because at this age Tsimane' adolescents start forming their own households. The total sample for the study included 174 adults, of whom 80 (46%) lived in the remote village of Yaranda and 94 (54%) lived in the accessible village of San Antonio. The sample was almost evenly split between women (48%) and men (52%). The average age of subjects was 32.3 years (sd=15.67). Only two households in the remote village (n=22) and three households in the accessible village (n=27) refused to participate in the study. The total sample of adults grew by three people because outsiders married into the villages while the study took place.

Free Listing

Free listing involved asking participants to spontaneously list the name of all the useful plants they knew and all the uses of each plant in their list. We asked each informant, "Can you tell me the names of all the useful wild plants you know?" and "What do you use them for?" Once informants stopped naming plants, we tried to prompt them to list more plants by asking, "Do you know any other wild plant that can be used as firewood?" Once they said they did not know any more plants that could be used for firewood, we asked the same question for medicine, dye, construction, canoe building, tools, or other uses.

Scan Observations

To capture uses of plants, we conducted weekly interviews from November 1999 until October 2000. Every week, at the end of a day chosen at random, we visited each household and asked each adult present in the household to report the name of all the plants s/he had brought to the household during the previous 24 hours. We conducted a total of 66 scan observations, 34 in the village of San Antonio and 32 in the village of Yaranda. Information included interviews with 174 adults with an average of 9.06 interviews/adult (sd=7.36; min=1; max=32). During scan observations we recorded the following: (a) the Tsimane' name of the plant species brought in by each adult, and (b) the intended use of the plant species. Data collected with this method might be biased because the method does not capture plant species consumed outside the household, such as fruits or nuts that can be consumed in the forest.

Specimen Identification

We collected voucher specimens for all plants reported as useful. We deposited voucher specimens at the Herbario Nacional de Bolivia, Universidad Mayor de San Andrés, La Paz. A key informant identified plant specimens in the

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local vernacular, and taxonomists from the herbarium provided the scientific nomenclature. We have described much of the Tsimane' ethnobotanical knowledge in a bilingual book in Tsimane' and Spanish (Nate, Ista, and Reyes-García 2000) and in two dissertations (Huanca 1999; Reyes-García 2001).

When conducting free listing and scan observations, we did not ask informants to identify voucher specimens corresponding to the plants named or brought to the household. Rather, we recorded the folk name of the species provided by the individual. Since we do not have individual-level correspondences between the folk names provided in free listing and scan observations and the scientific names, we refer to our data as ethnospecies (species based on folk name) rather than to plant species.

Data Analysis

We identified six categories of use: medicine, firewood, construction, tools, food, and other. Under the category "tools" we include mortars and grinding boards, food containers, mats, bags to store food, storage boxes, brooms, fabrics, bows, arrows, and weaving material. Under the category "other" we included uses that usually take place out of the household (e.g., canoe building) because those uses are not properly captured by scan observations. We also included uses reported with less frequency (e.g., dyes). Different uses of the same ethnospecies within the same category were counted as one, regardless of the number of uses within that given category. For example, a medicinal plant used for two different ailments was counted as one. For data from scans, we counted each ethnospecies brought by each adult as one, without taking into account the amount brought. When two different adults in the same household during the same day reported the same ethnospecies, we recorded them as two observations. Because local names of plants can change from one village to another, and because we do not have individual-level correspondence between the folk names provided in free listing and scan observations and the scientific names, we excluded from the analysis ethnospecies mentioned in only one village.

We calculated the cultural value of an ethnospecies using information from free listing, and we calculated the practical and economic values using observational information from scans. To calculate the cultural value of an ethnospecies, we used this formula:

$$CV_e = Uc_e * Ic_e * \Sigma IUc_e \quad (1)$$

where CV_e is the cultural value of ethnospecies *e*. Uc_e is the total number of uses reported for ethnospecies *e* divided by the six potential uses of an ethnospecies considered in the study (i.e., medicine, firewood, construction, tools, food, and other). Ic_e expresses the number of participants who listed the ethnospecies *e* as useful divided by the total number of people participating in free listing. IUc_e expresses the number of participants who mentioned each use of the ethnospecies *e* divided by the total number of participants. For example, if 15 participants listed ethnospecies X as medicinal, and 10 of them also listed it as edible, IU_e =(15+10)/48. We follow Turner (1988), Stoffle et al. (1990), and Pieroni (2001) in multiplying the components of the index to amplify variations.

To calculate the practical value of an ethnospecies, we used a similar formula:

$$PV_e = Up_e * Ip_e * DUp_e \quad (2)$$

where PV_e is the practical value of ethnospecies *e*. Up_e is the number of different uses observed for ethnospecies *e* during scan observations divided by the six potential uses of an ethnospecies considered in the study. Ip_e expresses the number of times ethnospecies *e* was brought to a household divided by the total number of informants participating in scan observations. The variable captures the share of participants who use the ethnospecies. DUp_e captures the duration of each use.

The calculation of the practical value is biased because some uses are more frequent than others. For example, people bring firewood to their households several times a week, but they might bring plants to craft tools only occasionally, as tools have a longer useful lifetime than firewood. Thus, in calculating the practical value of plants, ethnospecies used as firewood would appear more frequently because they have a shorter lifetime than plants to craft tools. The term DUp_e should help redress the bias. Based on ethnographic fieldwork, we assigned a duration of one day to ethnospecies brought for food and firewood, seven days to ethnospecies brought for medicines, 30 days to ethnospecies brought to make tools or for other uses, and 90 days to ethnospecies brought for

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house construction. For example, if an ethnospecies was brought on three occasions as medicine (3*7 days) and on two more occasions as an input to craft tools (2*30 days), the ethnospecies would have a duration of 1.23 = (21+60)/66 days, where 66 is the total number of scan observations.

To calculate the economic value of an ethnospecies we used the village price of the ethnospecies. For ethnospecies without a price, we used estimations from a previous study (Godoy et al. 2002), in which we asked villagers how much time it took them to find the good, multiplied the amount of time by the prevailing daily wage in the village, and assigned the resulting value to the ethnospecies. We used this formula:

$$EV_e = Oe_e * Pe_e \quad (3)$$

where EV_e is the economic value of ethnospecies *e*. Oe_e is the number of observations for ethnospecies *e*, i.e., the total number of times the ethnospecies was brought to any household in the sample, and Pe_e is the price of the ethnospecies.

We then calculate the total value of an ethnospecies (V_e), as the sum of its cultural, practical, and economic values:

$$V_e = CV_e + PV_e + EV_e \quad (4)$$

To calculate the total value, we assigned a practical and economic value of "0" to ethnospecies that people mentioned in free listing but did not bring into their households during scan observations. Similarly, we assigned a cultural value of "0" to ethnospecies that Tsimane' brought to their households during scan observations but did not mention during free listing. Last, before adding data on cultural, practical, and economic values, we normalized the three indices. For example, to normalize the practical value, we divided the practical value of a given ethnospecies by the mean practical value of all ethnospecies.

Since some of our calculations rely on assumptions based on fieldwork, we re-estimated our indices under different scenarios and assumptions. First, we computed the various indices with data for each of the two villages of the study. Second, we recalculated the practical value by assigning a different duration to species with different uses: we assigned a duration of one day to ethnospecies brought for food and medicine, two days to ethnospecies brought for firewood, 30 days to ethnospecies brought for other uses, 90 days to ethnospecies brought for crafting tools, and 365 to ethnospecies brought for house building. Last, we included a new interaction term in equation [3] to capture the relative importance of each use. We assigned low values to uses that could be easily substituted by another ethnospecies with the same use. For example, we assigned a value of one to ethnospecies used for firewood because one wood species used for firewood can be easily substituted by another. We assigned an importance of two to construction and other uses, three to food, four to ethnospecies used to craft tools, and five to medicines.

RESULTS

DESCRIPTION OF DATA

Participants in free listing mentioned a total of 89 ethnospecies, which had a total of 221 different uses. During a year of scan observations, participants brought 100 ethnospecies to their households; the ethnospecies had a total of 178 different uses. The final sample of ethnospecies reported (i.e., either cited or observed more than two times) was 114, from which only 61 were both cited and observed. The 114 plant species belonged to 46 different families. The most commonly represented families included Moracea (n=11) and Palmae (n=10). Twenty-six ethnospecies were cited during free listing as having only one use, 22 as having two uses, 19 as having three uses, and 22 as having more than three uses. During scan observations, Tsimane' brought 45 ethnospecies with only one use, 38 with two uses, 12 with three different uses, and only five with more than three uses.

Figure 1 represents the distribution of uses cited and observed for the six categories of use.

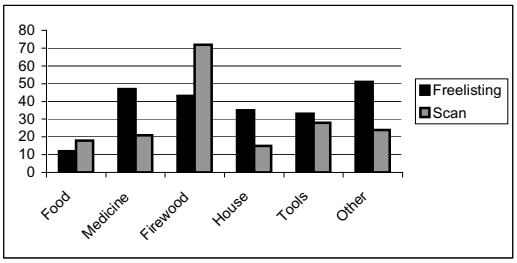

Fig. 1. Total number of uses cited (free listing) and observed (scan) for the different categories of use.

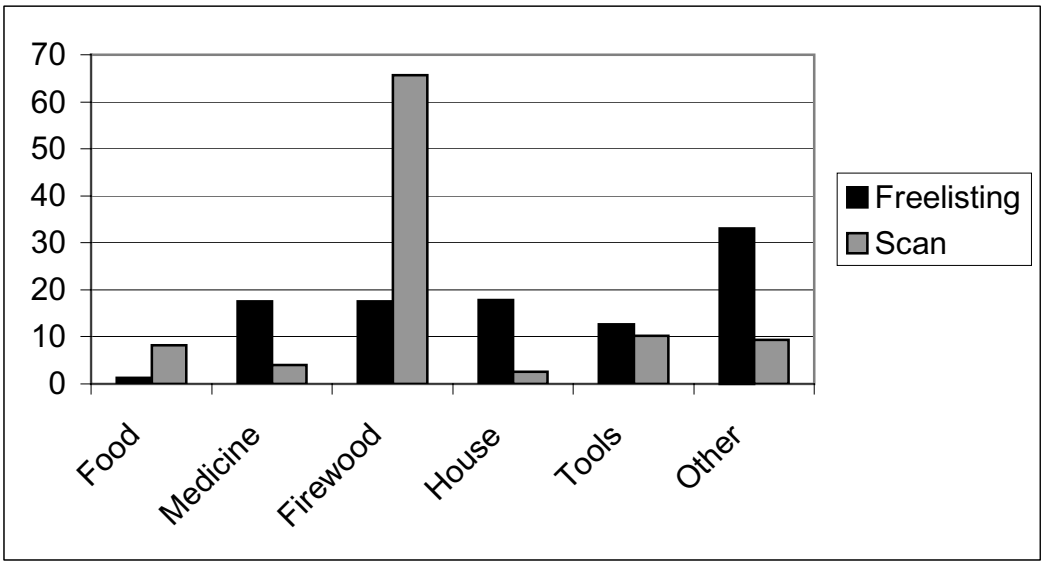

Fig. 2. Percentage distribution of uses of plants in free listing (n=1,471) and scan observation (n=1,550).

For most categories the number of uses reported was higher than the number of uses observed. For example, informants cited 47 different ethnospecies for medicine, but we only observed 21 ethnospecies being used as medicine. The two exceptions are ethnospecies in the categories of firewood and food. Tsimane' listed 43 ethnospecies as useful for firewood, but we observed the use of 72. Similarly, Tsimane' only listed the use of 12 ethnospecies as useful for food, but we observed the use of 18.

We follow Phillips and Gentry (1993), Begossi (1996), and Pieroni (2001) and take into account in our calculations not only the number of uses of an ethnospecies, but also the number of people who reported using the ethnospecies. Figure 2 shows the percentage distribution of all the uses recorded in free listing (n=1,471) and scan observations (n=1,550). Data from free listing is more homogeneously distributed across the six categories of uses. For example, ethnospecies used for medicines, firewood, and house construction each represent about 18% of the total number of ethnospecies cited in free listing. In contrast, 66% of all the ethnospecies brought to Tsimane' households during scans were for firewood.

Table 1 shows the annual economic value of ethnospecies in each category of use. The ethnospecies used as firewood were the most valuable, whereas the category of lowest economic value was medicine (Table 1).

TABLE 1. TOTAL ANNUAL ECONOMIC VALUE OF ETHNOSPECIES IN SIX CATEGORIES OF USE (IN BOLIVIANOS).

Category	Bolivianos*
Food	4,268
Medicine	611
Firewood	8,413
House	2,694
Tools	3,976
Other	2,772

*1 U.S.$=6 bolivianos, year 2000

CULTURAL, PRACTICAL, AND ECONOMIC VALUES

The cultural value of the 114 ethnospecies in our sample ranged from 0 to 20.3, the practical value ranged from 0 to 25.2, and the economic value ranged from 0 to 11.64. Thirty-one ethnospecies (or 27% of the total) had a cultural value of 0, meaning that they were observed during scans but were not reported during free listings. Twenty-two ethnospecies (or 19%) had a practical and economic value of 0. The total value of ethnospecies varied between 0.004 and 42.1. We classified ethnospecies into four groups (Table 2). About 19% of the ethno-

TABLE 2. FREQUENCY AND PERCENTAGE DISTRIBUTION OF THE CULTURAL, PRACTICAL, AND ECONOMIC VALUES OF 114 ETHNOSPECIES AMONG TSIMANE' AMERINDIANS, BOLIVIA, 1999–2000.

	Cultural Value		Practical Value		Economic Value		Total Value	
Mean	1		1		1		3	
SD	2.6		3.8		2.0		6.8	
Min.	0		0		0		.004	
Max.	20.3		25.2		11.6		42.1	
Range	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
No value (=0)	31	27.19	22	19.30	22	19.30	0	0.00
Very low(<0.1)	23	20.18	57	50.00	15	13.16	19	16.67
Low (<1)	38	33.33	23	20.18	53	46.49	45	39.47
High (<10)	20	17.54	9	7.89	23	20.18	42	36.84
Very high (>10)	2	1.75	3	2.63	1	0.88	8	7.02

species recorded fall in the category of very low total value (from 0 to 0.1), 39% had a low value (from 0.1 to 1), 37% had a high value (from 1 to 10), and 7% had a very high value (higher than 10).

We found a positive association between the three values. We regressed the cultural value against the practical value using robust standard errors to correct for heteroskedastic error terms and found a correlation coefficient of 0.217 between the two values (p=0.004). In a regression of the cultural value against the economic value of ethnospecies we obtained similar results (coefficient=0.333; p=0.029). In a third regression, we found that the association between the practical and economic value of ethnospecies was stronger than in the two previous regressions (coefficient =1.398; p<0.001).

Table 3 contains information on the cultural, practical, economic, and total values of each ethnospecies recorded. Ethnospecies are listed from higher to lower total value. Most ethnospecies with "very low total value" (V_e<0.1) were either cited or observed on few occasions, but were not captured by both methods used. Only two of the ethnospecies in this group were both cited and observed. Most of the ethnospecies reported as medicinal fall in the group of ethnospecies with "low total value" (1>V_e>0.1). Most ethnospecies with "high total value" (10>V_e>1) were listed and observed as having at least two but also three or more different uses. Ethnospecies in this group were cited as having mainly one use, either firewood, house building, or other, but most practical value of ethnospecies in this group is given by use as firewood. Four of the ten ethnospecies recorded in the Palmae family and four of the ten in the Moraceae family fall in this group. Ethnospecies with "very high total value" (V_e>10) were widely cited and observed as having many different uses. For example, *Attalea phalerata*, the species with a highest total value, was recorded with all the uses except food. Other species in this group include *Gynerium sagittatum* and *Geonoma deversa*, the preferred material for roofing, which is also an important commodity in the area. *Swietenia macrophylla* falls into this group and is one of the most commonly cited plants, but we did not observe any use of the plant during our research. Other ethnospecies in the group are *Hura crepitans*, *Bactris gassipae*, and *Cecropia concolor* Willd. Three of the ethnospecies in this group belong to the Palmae family.

To test how sensitive our results are to the assumptions made for the computation of values, we regressed the values reported in Table 3 against values found under four different assumptions. We found that the coefficients were high, positive, and statistically significant (Table 4), so we conclude that the model is robust to data collected in both communities and to different definitions of practical value.

DISCUSSION AND CONCLUSIONS

Ethnobotanical quantitative indices have been developed because qualitative ethnobotanical data (i.e., lists of plants and their uses) do not allow one to identify the special cultural or economic role of a plant species to society. In this article, we have taken a first step in developing a new way to assess the value of different

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TABLE 3. CULTURAL, PRACTICAL, ECONOMIC, AND TOTAL VALUES OF 114 PLANT SPECIES AMONG TSIMANE' AMERINDIANS, BOLIVIA, 1999–2000.

Scientific Name	Family	Tsimane' Name	Voucher	V_e	CV_e	PV_e	EV_e
Very high total value (V_e>10)							
Attalea phalerata C. Martius ex Sprengel	Palmae	Mana'i	TH277	42.11	7.85	22.61	11.64
Gynerium sagittatum (Aublet) P. Beauv	Poaceae	*Shuru'*	EP050	41.64	8.29	25.17	8.18
Geonoma deversa (Poiteau) Kunth	Palmae	*Cajtafa'*	TH191	28.39	0.54	20.90	6.96
Swietenia macrophylla (King)	Meliaceae	*Chura'*	Gullison, 1994	20.27	20.27	0.00	0.00
Bactris gassipae	Palmae	*Va'ij*	TH526	16.65	11.89	0.87	3.89
Hura crepitans L.	Euphorbiaceae	*Conojfoto'*	TH098	15.57	8.63	4.99	1.95
Indetemined	Flacourtiaceae	*Ava Ava*	TH099	15.03	0.77	6.18	8.08
Cecropia concolor Willd.	Moraceae	*Tyiruru'*	TH330	13.30	0.78	4.16	8.35
High total value (10>V_e>1)							
Rheedia cf. brasiliensis (Mart) Planch & Triana	Guttiferae	*Tsocoi*	TH130	9.49	0.94	0.10	8.45
Heliocarpus americanus L.	Tiliaceae	*Mü*	TH078	8.79	0.37	2.11	6.32
Ochroma pyramidale (Cav. ex Lam) Urban	Bombacaceae	*Cajñere'*	TH189	7.89	1.31	4.23	2.36
Scheleea sp.	Palmae	*Bitere*	TH447	7.82	0.00	5.56	2.26
Cedrela odorata	Meliaceae	*Siyamo'*	TH070	7.03	7.03	0.00	0.00
Thoracocapus bissectus (Vell.) Harling	Cyclanthaceae	*Tapi*	TH039	6.72	0.02	4.22	2.48
Iriartea deltoidea	Palmae	*Ojdo*	TH301	5.75	1.95	3.08	0.72
Callophyllum sf. Longiphyllum Willd.	Guttiferae	*Yäjdye'dye*	TH472	4.70	4.70	0.00	0.00
Cecropia sp.	Moraceae	*Tsanaj*	TH410	3.98	0.00	0.81	3.17
Inga punctata Willd.	Leguminosae-Mim	*Vishi'ri*	AN019	3.90	0.00	0.54	3.36
Inga cerstediana Benth. ex Seeman	Leguminosae-Mim	*Cu'na*	TH227	3.61	2.48	0.21	0.92
Astrocaryum murumuru C. Martius	Palmae	*Shibo'*	TH360	3.60	1.31	0.15	2.14
Guarea aff. guidonia (L.) Sleumer	Meliaceae	*Vapi*	TH441	3.51	2.96	0.06	0.50
Virola sp.	Myristicaceae	*Cam*	TH068	3.32	3.04	0.06	0.22
Caesaria sylvestris Sw	Flacourtiaceae	*Tavo'tavo'*	TH396	3.26	1.90	0.22	1.13
Xylopia aff. ochrantha Mart	Annonaceae	*Tutyi'*	TH425	3.02	2.40	0.15	0.47
Terminalia oblonga (Ruiz & Pavon) Steudel	Combretaceae	*Cotison*	TH008	2.38	1.43	0.10	0.85
Picramnia sellowii Planch	Simaroubaceae	*Itsi*	TH013	2.37	1.66	0.06	0.65
Clarisia racemosa	Moraceae	*Vavai*	TH090	2.37	2.33	0.00	0.03
Ficus sp.	Moraceae	*Muj pe*	TH018	2.32	1.10	0.20	1.02
Acacia loretensis	Leguminosae-Mim	*Shara'*	TH350	2.12	0.80	0.34	0.98
Vernonia patens BHK	Compositae	*O'ojvi*	AN001	2.12	0.05	1.35	0.72
Sida rhombifolia L.	Malvaceae	*Chip*	AN006	1.89	0.15	0.63	1.11
Triplaris americana L.	Polygonaceae	*Chij*	TH083	1.88	0.88	0.10	0.90
Serjania tenuifolia Radlk	Sapindaceae	*Vashi*	TH089	1.75	0.00	0.56	1.19
Leonia racemosa C. Martius	Violaceae	*RojRo'*	TH081	1.75	0.00	0.84	0.91

TABLE 3. CONTINUED.

Scientific Name	Family	Tsimane' Name	Voucher	V_e	CV_e	PV_e	EV_e
Tetragastris altissima (Aublet) Swart	Burseraceae	*Na'fa*	TH125	1.73	1.73	0.00	0.00
Sloanea obtusifolia	Elaeocarpaceae	*Shejsherena*	TH354	1.61	1.47	0.00	0.14
Inga sp.	Leguminosae-Mim	*Virui*	TH088	1.61	0.00	0.21	1.39
Cecropia membranacea Trécul	Moraceae	*Tyej*	TH426	1.54	0.00	0.01	1.53
Pouteria torta (Mart.) Radlk.	Sapotaceae	*Cojma*	EP026	1.53	0.91	0.18	0.43
Inga sp.	Leguminosae-Mim	*Shabut*	TH030	1.50	0.00	0.17	1.33
Tremma integerrima (Beurl) Standley	Ulmaceae	*Dyotoj*	TH011	1.45	0.10	0.50	0.86
Tephrosia vogelii J.D.	Leguminosae-Pap	*Chito'*	TH371	1.45	0.02	0.52	0.92
Uncaria guianensis (Aubl.) Gremlin	Rubiaceae	*Oveto'*	TH044	1.40	1.11	0.02	0.27
Ruizodendron ovale (Ruiz & Pavon) R.E. Fries	Annonaceae	*Ñej Ñej*	TH093	1.28	0.00	0.16	1.12
Maclura tinctorea	Moraceae	*Cotyij' Cotyij'*	TH224	1.22	0.80	0.01	0.41
Socratea exorrhiza	Palmae	*Vijri*	TH452	1.17	0.37	0.23	0.57
Indetermined	Flacourtiaceae	*Vajbason*	TH153	1.11	0.73	0.05	0.33
Ficus killipii	Moraceae	*Simaj*	TH037	1.09	0.80	0.01	0.27
Erythrina sp.	Leguminosae-Pap	*Cajpa'*	TH190	1.04	0.00	0.01	1.04
Lunania parviflora Spruce ex Benth	Flacourtiaceae	*Cajnason*	AN013	1.01	0.22	0.04	0.75
Low total value ($1>V_e>0.1$)							
Indetermined	Moraceae	*Bucuj*	TH182	0.88	0.48	0.01	0.40
Celtis schippii Standley	Ulmaceae	*Ñove'*	EP011	0.87	0.00	0.08	0.79
Ampelocera sp.	Ulmaceae	*Shepi'*	TH355	0.78	0.27	0.07	0.44
Iryanthera juruensis Warb.	Myristicaceae	*Po'cocos*	AN014	0.76	0.17	0.04	0.54
Cordia cf. tetrandra Aublet	Boraginaceae	*Juparety casmo*	EP055	0.73	0.00	0.16	0.57
Inga sp.	Leguminosae-Mim	*Cojno'no*	TH007	0.73	0.00	0.04	0.69
Hymenaea courbaril L.	Leguminosae-Pap	*Bejqui*	TH072	0.69	0.47	0.00	0.21
Ficus cf. insipida Willd.	Moraceae	*Titij*	TH123	0.68	0.45	0.00	0.23
Petiveria alliacea L.	Phytolaccaceae	*Eré*	EP064	0.67	0.12	0.05	0.50
Tessaria integrifolia R & P	Compositae	*Sijta*	TH383	0.64	0.56	0.00	0.00
Pilocarpus sp.	Rutaceae	*Tam'tac*	TH398	0.63	0.49	0.01	0.14
Schizolobium sp.	Leguminosae-Cae	*Co'shi'*	TH211	0.61	0.61	0.00	0.00
Passiflora sp.	Passifloraceae	*Shiveni*	EP012	0.59	0.59	0.00	0.00
Jessenia bataua	Palmae	*Jajru'*	TH265	0.54	0.37	0.03	0.14
Sapindus saponaria L.	Sapindaceae	*Shevijriqui*	TH107	0.52	0.52	0.00	0.00
Neea af. spruceana Heirmel	Nyc	*Vishi Vishi*	TH458	0.49	0.41	0.00	0.09
Indetermined		*Javujna*	EP016	0.48	0.17	0.01	0.30
Annona reticulata L.	Annonaceae	*Pise'rej*	TH118	0.47	0.00	0.01	0.46
Acalypha sp.	Euphorbiaceae	*Cabij'*	TH186	0.47	0.00	0.09	0.38

TABLE 3. CONTINUED.

Scientific Name	Family	Tsimane' Name	Voucher	V_e	CV_e	PV_e	EV_e
Carludovica palmata	Cyclanthaceae	*Tso'vety*	TH417	0.47	0.09	0.04	0.34
Pera benensis (Rusby)	Euphorbiaceae	*Apaijniquij*	TH161	0.46	0.23	0.00	0.23
Piper glabratum Kunth	Piperaceae	*Upuyu'*	TH046	0.43	0.00	0.16	0.27
Ceiba sp.	Bombacaceae	*Fuj fuj*	TH254	0.41	0.00	0.02	0.40
Acalypha benensis Britton	Euphorbiaceae	*Shoijno*	AN004	0.38	0.00	0.06	0.32
Pseudolmedia laevis (Ruiz & Pavon) J.F. Macbr.	Moraceae	*Ijsi'ta*	EP023	0.37	0.00	0.00	0.37
Pterocarpus sp.	Leguminosae-Pap	*Naba'ba*	EP021	0.37	0.00	0.09	0.28
Canna bangii Krauz	Cannabaceae	*Bu'bui*	EP049	0.37	0.37	0.00	0.00
Monotogma cf. laxun (P & E) K Schum	Marantaceae	*Su'rij*	TH387	0.37	0.00	0.10	0.27
Trichilia rubra CDC	Meliaceae	*Dyabaj-dyabaj*	TH243	0.34	0.18	0.01	0.15
Abarema sp.	Leguminosae-Mim	*Cujtyuju*	EP015	0.30	0.00	0.01	0.30
Capsicum frutescens L.	Solanaceae	*Shishi*	AN005	0.29	0.15	0.01	0.13
Bactris major Jacq. Martius	Palmae	*Cocojpe'*	TH216	0.26	0.00	0.05	0.22
Duguetia spixiana Mart	Annonaceae	*Veya*	TH448	0.25	0.11	0.00	0.14
Aniba canelilla (H.B.K.) Mez	Lauraceae	*Chorecho'*	TH206	0.24	0.15	0.01	0.09
Sloanea guianensis (Aublet) Bentham	Elaeocarpaceae	*Faj Faj*	TH499	0.22	0.13	0.00	0.09
Clarisa cf. biflora Ruiz & Pavon	Moraceae	*Mu'suruj*	TH020	0.20	0.11	0.00	0.09
Syagrus sancona Karsten	Palmae	*Batin*	TH170	0.17	0.17	0.00	0.00
Heliconea	Musaceae	*Paya*	TH313	0.17	0.00	0.12	0.04
Indetermined	Rubiaceae	*Mito*	TH279	0.15	0.02	0.00	0.12
Bixa orellana L.	Bixaceae	*Faj*	TH251	0.15	0.04	0.01	0.10
Guadua spp.	Gramineae	*Ton'*	TH503	0.13	0.13	0.00	0.00
Matayba sp.	Sapindaceae	*Vepi*	EP040	0.13	0.00	0.00	0.12
Zanthoxylum sp.	Rutaceae	*Vayuna*	TH053	0.11	0.00	0.01	0.11
Bixa urucurana Willdenow	Bixaceae	*I'fo'*	TH258	0.11	0.02	0.02	0.07
Tapirira guianensis Aublet	Anacardiaceae	*Shonoj*	TH069	0.10	0.00	0.00	0.10
Very low total value (V_e<0.1)							
Casearia	Flacourtiaceae	*Birina*	TH109	0.09	0.00	0.00	0.09
Pouteria cf. torta (Mart) Radlk	Sapotaceae	*So'rocaj*	TH038	0.08	0.01	0.00	0.07
Sparattanthelium burchellii Rusby	Hennandaceae	*Vayori*	AN023	0.07	0.00	0.00	0.07
Spondias mombin L.	Anacardiaceae	*Moco'*	TH122	0.07	0.01	0.00	0.06
Pouteria reticulata (Engler) Eyma	Sapotaceae	*Ujfare*	TH001	0.07	0.07	0.00	0.00
Salix humboldtiana Willd.	Salicaceae	*Sivin*	TH389	0.06	0.06	0.00	0.00
Fevillea sp.	Cuc	*Dyincava'*	TH076	0.06	0.06	0.00	0.00

TABLE 3. CONTINUED.

Scientific Name	Family	Tsimane' Name	Voucher	V_e	CV_e	PV_e	EV_e
Salacia sp.	Hippocr	*Tiribuj*	TH040	0.06	0.00	0.00	0.06
Erythrina sp.	Leguminosae-Pap	*Shaj*	TH345	0.06	0.00	0.00	0.06
Triplaris poeppigiana Wedd	Polygonaceae	*Jichi*	TH015	0.06	0.00	0.00	0.06
Ormosia nobilis	Leguminosae-Pap	*Queru Queru*	TH062	0.04	0.04	0.00	0.00
Virola sebifera Aublet	Myristicaeae	*Chafiij*	TH127	0.03	0.03	0.00	0.00
Indetermined		*Viroj Viroj*	EP031	0.03	0.03	0.00	0.00
Mimosa sp.	Leguminosae-Mim	*Cucush*	TH479	0.02	0.02	0.00	0.00
Palicourea crocea (Sw.)	Rubiaceae	*Quirisi*	TH484	0.01	0.01	0.00	0.00
Campelia zanonia (L.) HBK	Commelinaceae	*Ivinu*	EP019	0.01	0.01	0.00	0.00
Indigofera suffruticosa Mill	Leguminosae-Pap	*Shitiri*	TH365	0.01	0.01	0.00	0.00
Indetermined	Annonaceae	*Shayacas*	TH082	0.004	0.004	0.00	0.00
Indetermined	Leguminosae	*I'seji'*	TH256	0.004	0.004	0.00	0.00

plant species taking into account the cultural, practical, and economic values of plant species to people of one culture.

The cultural value of a plant species does not necessarily correspond with its practical or economic values. Some species, such as *Swietenia macrophylla*, are rarely used but frequently mentioned in interviews, whereas other species, such as *Guazuma ulmifolia*, are frequently used but rarely mentioned during interviews. Therefore, indices measuring the cultural and practical values capture different aspects of the importance of a plant species for humans. The index of cultural value captures the theoretical importance of a plant for a given culture, whereas the index of practical value reflects the relative intensity of use of a plant in daily life. Furthermore, the score of a plant in one index might change independently from the score of the plant in the other index. For example, differences between cultural and practical indices might reflect changes in the availability of species. *Swietenia macrophylla* and *Cedrela odorata* are two precious woods in the area with many previous uses among the Tsimane'. The diversity of uses of those species made them culturally significant, but the two species have been logged almost to extinction (Gullison 1995, 1996), which explains their low practical value at present.

We found a high correspondence between the practical and economic values of ethnospecies, which might be partially explained because we calculated those values using the same data from scan observations. Scan observations reflect the importance of plants for household consumption but are not a reliable method to estimate cash income from forest products, because many of the forest products that have a commercial value never enter the household, and therefore are not captured by scans. For example, our data might underestimate the importance of *Geonoma deversa* in the Tsimane' economy. Leaves from that palm are used to build roofing mats, yet an important part of the extraction and processing does not occur in the household but rather in camps near the area where the palm grows. Our data biases the economic importance of plants toward their consumption value and underestimates their value as a source of monetary income.

In sum, the various indices presented here measure different aspects of the importance of

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TABLE 4. SENSITIVITY ANALYSIS: REGRESSIONS OF THE VALUES REPORTED IN TABLE 3, AGAINST RECOMPUTED INDICES FOR DIFFERENT ASSUMPTIONS.

	San Antonio[a] N=81		Yaranda[b] N=109		Duration[c] N=114		Intensity[d] N=114	
Type of Value	Coeff	p	Coeff	p	Coeff	p	Coeff	p
Cultural	1.11	<0.000	0.99	<0.000	^		^	
Practical	0.52	<0.000	0.54	<0.000	0.91	<0.000	0.88	<0.000
Economic	0.69	<0.000	0.64	<0.000	^		^	
Total Value	0.69	<0.000	0.66	<0.000	0.96	<0.000	0.94	<0.000

^ Indicates that the values were identical to the values in Table 3.
[a] Data from San Antonio only.
[b] Data from Yaranda only.
[c] New assumptions for the parameter DUp_e in expression [2].
[d] New parameter in expression [2] capturing whether a use is easily substituted or not.

plants for people. Previous indices that rely exclusively on information from interviews fail to pick up the practical value and the economic importance of plant species. Similarly, observational data fails to capture plant species without much cultural value, but with frequent use in daily life. Information depending on only one of the three indices biases our understanding of the importance of plant species for people. The combination of the three indices offers a more comprehensive valuation of the significance of plants for humans than one might obtain from using only one index.

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