

Economic development and traditional knowledge: a deadlock?

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**Data from an Amerindian society**

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### **Data from an Amerindian society**

#### **Abstract**

Traditional knowledge accumulated over generations to help people protect their health and manage their habitats. If traditional knowledge vanishes with economic development, then economic development comes at the cost of losing humanity's heritage and diversity. We test the assumption by measuring ethnobotanical knowledge and skills among 476 Bolivian Amerindian adults. Independent of the proxy used, only the share of earnings from wage labor in personal income correlates with less ethnobotanical knowledge. We conclude that since not all forms of economic development erode traditional knowledge, the challenge lies in finding and promoting forms of development that do not undermine traditional knowledge.

**Keywords:** Traditional ecological knowledge, ethnobotany, economic development, indigenous peoples, Bolivia, Latin America

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#### **Introduction**

Traditional knowledge accumulated over generations to help peoples protect their nutrition (Jackson 1996; Johns 1996) and health (Etkin 2000; WHO 1993) and manage their habitats (Olsson, Folke, and Berkes 2004; Laird 2002; Redford and Padoch 1992). The possibility that traditional knowledge may be rapidly and widely lost in response to globalization has become a major concern of scholars and policy-makers (Agrawal 2002; Maffi 2001; Sillitoe 1998). This concern emerges from the presumed link between traditional knowledge and conservation and development (Orlove and Brush 1996; Warren, Slikkerveer, and Brokensha 1995; Chambers, Pacey, and Thrupp 1989). For example, researchers have said that traditional knowledge related to the habitat –or traditional ecological knowledge- contributes to ecological adaptation and might help design policies for conservation (Berkes, Colding, and Folke 2000; Posey 1997; Colchester 1994). The loss of traditional ecological knowledge concerns policy-makers because it represents the irreversible loss of information about different ways to manage natural resources.

Traditional ecological knowledge has attracted researcher's interest since the beginning of the nineteenth century. The initial interest focused in documenting how native peoples classified their environment (Berlin, Breedlove, and Raven 1966; Conklin 1954). By the mid-1980s, the international recognition of the potential value of traditional ecological knowledge generated increasing interest in the topic (WCED 1987).

At that point researchers shifted their interest from documenting how people classified their environment to studying how traditional ecological knowledge contributed to human adaptation. Researchers have found that traditional ecological knowledge resembles scientific knowledge developed through inductive methods (Miller et al. 2004) and that it can contribute to the conservation of biological diversity (Olsson, Folke, and Berkes 2004; Berkes 1999; Atran and Medin 1997), agriculture (Brush 2000; Brookfield and Padoch 1994; Warren, Slikkerveer, and Titlola 1989) health (Etkin 2000), nutrition (Jackson 1996; Johns 1996), and the management of natural resources (Bergmann et al. 2004; Davis et al. 2004; Price and Rulifson 2004; Gunnell and Krishnamurthy 2003; Mackinson 2001; Pandey 2001; Critchley, Reij, and Willcocks 1994).

Despite the growing interest in the topic, there has been little and fragmented quantitative research about the causes and rate of loss of traditional ecological knowledge. Although some researchers have linked the loss of traditional ecological knowledge to the expansion of the market economy (Godoy et al. 1998; Ross 2002; Reyes-García et al. 2005a), others have found persistence in traditional ecological knowledge despite large socio-economic changes (Zarger and Stepp 2004). The debate matters for policy because proving that integration to the market erodes traditional knowledge would hamper the possibility of simultaneously achieving conservation of traditional knowledge and economic development. The finding would mean that economic development comes at the cost of losing humanity's heritage and diversity. In contrast, if integration to the market economy does not affect or does not *always* affect the loss of traditional knowledge, then some forms of market incorporation could develop

without eroding traditional knowledge. The finding would help operationalize forms of development based in local capabilities (McSweeney 2004).

In this article we test how various forms of integration to the market economy affect traditional ecological knowledge. We use a new way of measuring ethnobotanical knowledge that stresses skills that draw on ethnobotanical knowledge, and compare results with standard measures of ethnobotanical knowledge that stress passive knowledge. We hypothesize that only some forms of integration to the market economy, namely activities that take individuals out of their culture and environment, correlate with the loss of traditional ecological knowledge. To explore the topic, we draw on information from 476 Tsimane' Amerindian— a foraging-horticultural society in the Bolivian Amazon.

### **The loss of traditional knowledge: previous findings from quantitative research**

Quantitative research on the loss of traditional ecological knowledge has focused on how knowledge varies by demographic, social, and economic characteristics of subjects. The research has produced both consistent and conflicting results. Researchers have consistently found that knowledge of natural resources depends on demographic characteristics of informants, such as age, sex, kinship relations, ethnicity, and position in a social network (Atran et al. 2002; Ross 2002; Caniago and Siebert 1998; Boster 1986), and on distance from cities or natural resources (Reyes-García et al. 2005a; Begossi 1996). Other researchers have studied the impact of acculturation on traditional ecological knowledge and have found a consistent negative correlation between traditional ecological knowledge and modern skills associated with acculturation, such as

schooling, academic skills, and fluency in the national language (Sternberg et al. 2001; Zent 2001; Benz et al. 2000).

Researchers have also studied the effects of integration to the market on traditional ecological knowledge. Orthodox thinking in anthropology and in economics predicts that traditional ecological knowledge will vanish as economic development unfolds (Schultz 1975), but recent empirical research suggests that traditional ecological knowledge need not always wane with modernization. In fact, the empirical literature on the effects of integration to the market on traditional ecological knowledge has produced conflicting and weak results. Some researchers find that integration into the market through the sale of crops and wage labor correlates with less knowledge of wildlife, but integration into the market through the sale of forest goods correlates with more knowledge of wildlife (Godoy et al. 1998). Other researchers find weak effects of individual market participation on traditional ecological knowledge. For example, Reyes-García and her colleagues (2005a) found that, although there is a link between traditional ecological knowledge and proximity to towns, canonical indicators of market economies (e.g. cash) bore no significant correlation with traditional ecological knowledge. Others find no erosion of traditional ecological knowledge. For example, on a comparative study over 30 years, Zarger and Stepp (2004) found no change in ethnobotanical knowledge among Maya children in Chiapas despite significant socioeconomic changes in the region. Last, some researchers find that local knowledge of the environment can increase with new economic activities based on the environment. In a study in a shrimp community in coastal Ecuador, Guest (2002) found that, controlling for time of residence in the region, villagers working in the shrimp industry

had significantly higher knowledge of shrimp ecology than villagers working in other activities.

In sum, previous empirical studies on the link between integration to the market economy and erosion of traditional ecological knowledge have produced conflicting and weak results. Later we argue that part of the answer to the puzzle may lie in the way researchers have defined and measured traditional ecological knowledge.

### **Hypothesis, definitions, and estimation strategy**

Building on previous findings, we hypothesize that only certain market activities will correlate with the loss of traditional ecological knowledge. Market activities that take people out of their culture and that reduce their interaction with the environment (such as non-farm wage labor outside a person's village) will cause a loss in the stock of traditional ecological knowledge of the person. Market activities that do not take people out of their culture and that do not reduce their interaction with the environment (such as sale of forest or crop products) will not reduce a person's traditional ecological knowledge.

To measure the economic importance of different economic activities in a subject's total income, we estimated the share in total personal income of different economic activities. Total personal income includes wage earnings, sale of goods, the value of goods obtained in barter, and the value of farm and forest goods consumed in the household. We focus on the share of each economic activity in total income, rather than on total income because it allows us to compare the relative importance of each economic activity in a person's total income.

We proxy individual traditional ecological knowledge with two variables: theoretical ethnobotanical *knowledge* and self-reported ethnobotanical *skills*. We used the cultural consensus model to measure individual theoretical ethnobotanical knowledge (Reyes-García et al. 2005a; D'Andrade 1995; Romney, Weller, and Batchelder 1986). The cultural consensus model is based on the assumption that there is a culturally correct answer for every question. Whatever the cultural reality, it is the same for all informants and is defined as the answer given by most people (Romney and Weller 1984). Therefore, culturally correct knowledge consists of agreement between informants. Individual knowledge is measured as the proportion of questions that each person answered in a correct way, where correct refers to the most frequent response. The use of cultural consensus to analyze data on traditional ecological knowledge has been used by several authors and is becoming a recognized method to measure variation in individual's traditional ecological knowledge (Rocha 2005; Miller et al. 2004; Guest 2002).

We also used another measure of traditional ecological knowledge that focuses on empirical, rather than on theoretical knowledge: self-reported ethnobotanical skills. We use this new variable because skills capture the practical dimension of ethnobotanical knowledge. The loss of traditional ecological knowledge might affect ethnobotanical skills before affecting theoretical ethnobotanical knowledge. Integration to the market economy is recent in many traditional societies. If economic development erodes ethnobotanical knowledge by enabling people to gain access to substitutes for plant products (Locay 1989), then we would expect to see economic development producing an effect on the skills to manufacture products from plants before producing an effect on theoretical knowledge. This is akin to recognizing a word but being unable to use it;

people most likely lose the ability to use words before they lose the ability to recognize them.

For the empirical estimation, we use the following linear approximation:

$$[1]. E_{ijvt} = \alpha + \beta K_{ijvt} + \gamma S_{ijvt} + \theta D_{ijvt} + \varepsilon_{ijvt}$$

where  $E_{ijvt}$  is the share of earnings from an economic activity in the total income of subject  $i$  of household  $j$  in village  $v$  at time  $t$ .  $K_{ijvt}$  captures an individual's theoretical ethnobotanical knowledge.  $S_{ijvt}$  captures a person's self-reported ethnobotanical skills.  $D_{ijvt}$  is a vector of variables that captures demographic attributes of the subject, and  $Z_{vt}$  are attributes of village  $v$  at time  $t$  that proxy for integration into the market (e.g., distance to market town).  $\varepsilon_{ijvt}$  is a random error term with standard properties. To estimate parameters we use ordinary least square regressions with robust standard errors. We run the regressions with a full set of village dummies ( $n=13-1=12$ ) and clustering by village.

The data collected does not allow us to identify the causality of the relation between individual's economic activities and traditional knowledge. For instance, people who work for wages outside their villages could lose traditional ecological knowledge, but the reverse could also happen; people who lack traditional ecological knowledge might side to wage labor outside their village.

## Methods

Research took place between May 2002 and November 2003 among Tsimane', a foraging and farming society of ~8,000 people in ~100 villages in the Bolivian Amazon.

The people: Byron (2003), Huanca (1999), Reyes-García (2001), Vadez and colleagues (2004), and Godoy and colleagues (2002) describe the Tsimane' economy and

the relative importance of income and consumption in household economy in detail, so here we only summarize key aspects of the Tsimane' economy relevant to our argument.

Tsimane' have been in contact with outsiders since the 17<sup>th</sup> century (Daillant 2003). They reached the middle of the 20<sup>th</sup> century in relative isolation, but are now in the early stages of continuous transition to a market economy (Godoy 2001). Tsimane' subsistence centers on hunting, fishing, and horticulture (Vadez et al. 2004; Godoy et al. 2002). Tsimane' take part in the market economy in two ways. Some earn cash by selling forest and agricultural goods – activities that take them to the forest and keep them in their culture– but others earn cash by working as unskilled wage laborers for farmers and ranchers – activities that take them away from the forest and their culture.

Tsimane' display a large ethnobotanical knowledge, comparable to the knowledge reported for other groups in the region (DeWalt et al. 1999; Boom 1987). Tsimane' reportedly know 414 different species of wild plants, of which only 46 plants (11 %) had no recorded use. The remaining 368 plants had a total of 571 different uses; some plants had more than three different, independent uses (Reyes-García et al. 2005b). However, Tsimane' employ only about half of the uses of plants they know with important differences between settings. People living far from market towns employ many plants with many purposes (e.g., firewood, medicine, tools), whereas people living closer to the market town use less plants and mainly for firewood because many plant products have been displaced by commercial substitutes (Reyes-García et al. 2005b). Differences in market participation and ethnobotanical knowledge allow us to estimate the relation between both variables.

The sample: To obtain a sample of villages with variance in the exposure to the market economy, we used distance from the village to the closest market town (mean=28.3 kms; sd=15.9). We interviewed all adults in 13 villages Tsimane' along the Maniqui river, for a total of 229 men and 247 women. The mean age of informants was of 34.4 years (sd=15.02). Informants had an average of 1.9 years of schooling (sd=2.27). Twenty nine per cent of the sample reported speaking the national language, Spanish.

Dependent variables: We used two dependent variables: personal income from wage labor and personal income from sale of goods (Table 1). Both are expressed as a share of total personal income. Total personal income includes cash earned through wage labor and the sale of goods, the value of goods obtained in barter, and the value of farm and forest goods consumed in the household. We measured wage earnings, sale of goods, and the value of goods obtained in barter by asking participants about their earnings from those activities during the two weeks before the day of the interview. We measured the value of farm consumption by asking about the amount of farm crops consumed by the entire household the week before the day of the interview and then calculating adult equivalents (Byron 2003). We measured the value of forest consumption by conducting weekly interviews on the amount and value of forest goods consumed. The total value of individual income was obtained by adding the different sources of income (labor, sale, and barter) and consumption (farm and forest) over the five quarters of the research. The average subject earned a total of 125 bolivianos in a two-week period, 80 bolivianos from cash earnings and 45 bolivianos from the imputed value of farm and forest goods consumed (7.1 bolivianos=US \$ 1). Most cash earnings came from sale of goods (35 bolivianos) and wage labor (34 bolivianos). Informants

received only the value of about 11 bolivianos from bartering goods. Last, we calculated the share of each economic activity in the total personal income of the person. The average share of earnings from wage labor in total yearly personal income reached 16% (sd=27). The average share of earnings from the sale of goods in total yearly personal income was slightly higher, 22% (sd=23).

INSERT TABLE 1 ABOUT HERE

Explanatory variables: To calculate theoretical ethnobotanical knowledge we collected similarity judgments across participants using a multiple-choice test of 21 randomly-selected plants. For the tests we asked participants whether they could use the plants for construction, firewood, food, medicine, or for other uses. For each plant, participants could choose none, one, or more potential uses. We use cultural consensus analysis (Reyes-García 2003; Romney, Weller, and Batchelder 1986) to calculate individual scores and found that the average score of theoretical ethnobotanical knowledge (range between 0 and 1) was 0.56 (sd=0.20, min=0.05, max=0.94). The coefficient of variation of theoretical ethnobotanical knowledge was 0.36.

Second, we asked participants to report their ability to use wild plants. We used information from free-listing (n=50) to construct a list of items crafted from plants. To select items from the list, we asked three key informants to identify items commonly crafted by men and items commonly crafted by women and to classify the items by their difficulty to make them. From the category of items, we randomly selected 18 objects from 15 different plant species (Table 2). We selected nine objects among the ones that key informants said were more commonly made by men and nine among the ones that were said to be more commonly made by women. Within each group of nine objects, we

selected three items that key informants considered easy to make, three that they considered of medium difficulty, and three that they considered hard to make. We asked participants whether they had ever made on their own the items from the list. We weighted scores to reflect that only some people reported knowing how to make difficult objects: the score for an object was inversely proportional to the number of participants reporting knowing how to make the object. Weighted scores of ethnobotanical skills ranged from 0 to 10.1, with a mean score of 4.1 (sd=1.82). We found higher variance in ethnobotanical skills (coefficient of variation=0.44) than in theoretical ethnobotanical knowledge (coefficient of variation=0.36). The share of participants able to make each object varied by the object, and ranged from 15% to 74% of the sample. Only two objects were so hard to make that fewer than 25% of participants reported knowing how to make them.

We explore the relation between the two variables used to measure ethnobotanical knowledge. We found a positive and statistically significant correlation between theoretical ethnobotanical knowledge and ethnobotanical skills. The regression of theoretical ethnobotanical knowledge against ethnobotanical skills (while controlling for village-to-town distance) produced a coefficient of 0.13 ( $p=0.002$ ;  $n=416$ ).

INSERT TABLE 2 ABOUT HERE

## **Results**

Table 3 shows the regression results using wage earnings as a share of total personal income as a dependent variable. We find that an increase of one percent in the score of ethnobotanical skills correlates with a ~0.06% lower share of wage earnings in

total personal income ( $p < 0.001$ ) (column [1]). Theoretical ethnobotanical knowledge did not correlate significantly with the share of wage earnings in total personal income (column [2]). In column [3] we include both theoretical ethnobotanical knowledge and ethnobotanical skills and find that a one-percent increase in skills correlates with a  $\sim 0.07\%$  decrease in the share of wage earnings in total personal income ( $p = 0.004$ ). In column [3] we find that a one-percent increase in theoretical ethnobotanical knowledge did not correlate with the share of wage earnings in total personal income.

Table 4 shows the same regression model but using the sale of farm and forest products as a share of total personal income as a dependent variable. We find that an increase of one percent in the score of ethnobotanical skills correlates with a  $\sim 0.06\%$  higher share of sales in total personal income ( $p < 0.001$ ) (column [1]). An increase of one percent in the score of theoretical ethnobotanical knowledge also correlates with a  $\sim 0.06\%$  higher share of sales in total personal income ( $p < 0.1$ ), but only when using the variable theoretical ethnobotanical knowledge alone (column [2]). When we include both theoretical ethnobotanical knowledge and ethnobotanical skills in the model (column [3]) only ethnobotanical skills correlates significantly with the share of sales earnings in total personal income. An increase of one percent in the score of ethnobotanical skills correlates with a  $\sim 0.06\%$  higher share of earnings from the sale of goods in total personal income ( $p < 0.001$ ) (column [3]).

We tested the robustness of the results in two different ways (not shown). First, we took the logarithm of monetary income from wage labor and the sale of goods instead of the share of these variables in an individual's total income. The results held up. As in Table 3, we find that an increase of one percent in the score of ethnobotanical skills

correlates with lower income from wage labor. Doubling an individual's ethnobotanical skills correlated with a decrease of ~250% in the level of wage earnings ( $p < 0.01$ ).

Theoretical ethnobotanical knowledge did not correlate with wage earnings. We find that an increase of one percent in the score of ethnobotanical skills correlates with ~1.4% higher income from the sale of goods ( $p = 0.006$ ), and a one percent increase in the score of theoretical ethnobotanical knowledge correlates with ~2.4% higher income from the sale of goods ( $p = 0.04$ ).

Second, we ran a similar regression model but inverting dependent and explanatory variables. Recall we did not have instrumental variables to control for the endogeneity of ethnobotanical knowledge or ethnobotanical skills, so the test would allow us to know whether the magnitude of the effect from ethnobotanical knowledge to income or from income to ethnobotanical knowledge is roughly the same. We found essentially the same results. The theoretical ethnobotanical knowledge of an individual is not related in a statistically significant way to the share of income from wage labor or to the share of income from sales. We ran another regression using ethnobotanical skills as a dependent variable. We found that higher ethnobotanical skills correlated with a lower share of personal income from wage labor ( $p = 0.01$ ) but it did not correlate with the share of income from the sale of products. We therefore conclude that although we cannot identify causality, the magnitude of the effect from either knowledge to income or from income to knowledge is similar.

## **Discussion and conclusions**

Results of this paper advance our understanding of traditional ecological knowledge at several levels.

At the methodological level, we find that how one defines and measures ethnobotanical knowledge matters. We measured theoretical ethnobotanical knowledge and ethnobotanical skills and found that the two variables correlated weakly. We also found more variation in ethnobotanical skills than in theoretical ethnobotanical knowledge. Lower variation in theoretical ethnobotanical knowledge than in ethnobotanical skills might explain the weak results of previous research that have drawn on theoretical ethnobotanical knowledge to explain intra-cultural variation of knowledge. The regressions produced stronger results for ethnobotanical skills than for theoretical ethnobotanical knowledge in part because skills contained more variation.

At the theoretical level, the results presented here advance our understanding of the relation between economic development and individual retention of ethnobotanical knowledge. First, we found that participation in wage labor correlates with less ethnobotanical skills, but not with less theoretical ethnobotanical knowledge. Second, we found that the sale of forest or farm products correlates with more ethnobotanical skills and with more theoretical ethnobotanical knowledge. The findings help up after various tests of robustness. The findings indicate that some forms of economic development can take place without eroding traditional ecological knowledge. Due to the weakness of results in previous research, the identification of the specific economic activities that correlate negatively with ethnobotanical knowledge is an important step in our understanding of the relation between economic development and individual retention of

ethnobotanical knowledge. However, this study does not allow to infer causality. Future studies should advance our understanding of how this relation operates by providing a convincing identification strategy.

One could argue that the findings might indicate that some forms of economic development erode traditional ecological knowledge at a faster rate than others. This would be true if we had found that some economic activities were completely unrelated with ethnobotanical knowledge. But we found that activities that take Tsimane' to the forest and that keep them in their culture correlate in a positive way with the theoretical knowledge and the ethnobotanical skills of the subject. The finding suggests that this economic activity does not erode ethnobotanical knowledge.

Another important finding is the high traditional knowledge elasticity of income ( $\% \Delta Y / 1\% \Delta X$ ). For example, when we regressed the logarithm of income from wage labor (dependent variable) against the logarithm of ethnobotanical skills, we found a negative elasticity of 2.50; when we regressed the logarithm of income from sale of products against the logarithm of ethnobotanical skills, we found a positive elasticity of 1.44. The results suggest that changes in ethnobotanical skills produce important short-run changes in the types and levels of earnings.

In sum we find that only some economic activities erode traditional ecological knowledge. The finding has an important policy implication: economic development and preservation of traditional ecological knowledge might be simultaneously achieved *only if* economic development takes place through activities that keep people in their habitat and their culture. The challenge lies now in finding and promoting local forms of development that do not undermine traditional knowledge.

### **Acknowledgement**

Research was funded by the National Science Foundation (grants BCS-0134225 and BCS-0322380) and the Wenner-Gren Foundation for Anthropological Research (Gr-7250). We thank H.R. Bernard, R. Godoy, and F. Putz for commenting on earlier drafts. We also thank L. Apaza, E. Conde, J. Dávila, H. Rivas, Y. Lobo, P. Pache, E. Tayo, S. Cari, J. Cari, M. Roca, D. Pache, J. Pache, and V. Cuata for help collecting the information and for logistical support.

**Table 1:** Descriptive statistics (n=476)

Variable	Definition	Mean	Std. Dev.	Min	Max
<b>Dependent</b>					
Share of wage	Share of wage earnings in total yearly personal income	16	25	0	96
Share of sale	Share of earnings from sale of goods in total yearly personal income	22	23	0	92
<b>Explanatory</b>					
Knowledge	Agreement with the sample on uses of 21 randomly-selected plants	0.56	0.20	0.05	0.95
Skills	Score in a test of ability to make 18 objects from plants	4.1	1.82	0	10.1
<b>Control</b>					
Age	Age of participant, in years	34.4	15.02	15.0	90.3
Male <sup>a</sup>	Sex of the participant	0.5	0.50	0	1
School grade	Maximum school grade attained	1.9	2.27	0	13
Writing	Ability to write his/her name	0.7	0.88	0	2
Spanish <sup>a</sup>	Fluency in spoken Spanish	0.3	0.46	0	1
Village-to-town distance	Kilometers from village to closest town	28.3	15.95	6	48

<sup>a</sup> Binary variable. Name of variable = 1; excluded category=0.

**Table 2:** Percent of male (n=229) and female (n=247) Tsimane' participants reporting having manufactured items from plants

Item	% male	% female	% total
<b>Items commonly crafted by men</b>			
Bow from the stem of <i>Bactris gasipaes</i>	86.5	2.0	42.7
Cooking spoon from the wood of <i>Aspidosperma rigidum</i>	86.9	31.6	58.2
Axe handle from wood of <i>Casearia sylvestris</i>	86.5	6.5	45.0
Glue from the latex of <i>Brosimum utile</i>	82.1	8.1	43.7
Wooden mortar from the wood of <i>Pouteria torta</i>	76.4	9.7	41.1
Food container from the leaf sheath of <i>Iriarteia deltoidea</i>	55.0	17.8	35.7
Canoe from the wood of <i>Hura crepitans</i>	50.2	2.0	25.2
Spinning support from the wood of <i>Clarisia racemosa</i>	48.9	12.6	30.0
<b>Items commonly crafted by women</b>			
Sleeping mat from the leaves of <i>Gynerium sagittatum</i>	47.6	98.0	73.7
Carrying bag from the fibers of <i>Gossypium sp.</i>	1.3	96.8	50.1
Floor mat from the leaf of <i>Scheelea sp.</i>	18.3	95.1	58.2
Storage bag from the leaf of <i>Scheelea sp.</i>	18.3	91.1	56.1
Necklace from the seeds of <i>Ormosia nobilis</i>	26.2	86.2	57.4
Spinning fiber from the seeds of <i>Gossypium sp.</i>	12.2	81.8	48.3
Dye with the heart wood of <i>Maclura tinctoria</i>	13.5	73.3	44.5
Mat from the leaves of <i>Gynerium sagittatum</i>	17.5	67.6	43.5
<b>Items crafted by men and women</b>			
Fabrics from the bark of <i>Poulsenia armata</i>	21.8	26.3	24.2
Strainer from the stem of <i>Ischnosiphon cf. puberulus</i>	16.2	13.7	14.9

**Table 3:** Multivariate OLS regressions of the share of wage labor in total yearly personal income against ethnobotanical knowledge and skills (n=416)

Explanatory variables:	Share of wage earnings in total personal income		
	[1]	[2]	[3]
Knowledge (log)		.02	.03
Skills (log)	-.06**		-.07**
Age	.001	-.001	.0003
Male	.19**	.18**	.18**
School grade	.03**	.03**	.03**
Writing	.01	.01	0.01
Spanish	.09**	.09**	.10**
Village-to-town distance	-.004	-.002**	-.001

Note: Regressions contain a constant and a set of binary variables for village of residency (not shown) and clustering by village.

[1] does not include the variable knowledge. [2] does not includes the variable skills

\*  $p \leq 0.10$ ; \*\*  $p < 0.01$

**Table 4:** Multivariate OLS regressions of the share of sales in total yearly personal income against ethnobotanical knowledge and skills (n=416)

Explanatory variables:	Share of earnings from sale of goods in total personal income		
	[1]	[2]	[3]
Knowledge (log)		.06*	.05
Skills (log)	.06**		.06**
Age	.001	.001	.001
Male	.04	.04	.03
School grade	-.01*	-.003***	-.01*
Writing	.005	-.01*	.002
Spanish	-.008	-.001	.002
Village-to-town distance	-.006**	.001	-.007**

Note: Regressions contain a constant and a set of binary variables for village of residency (not shown) and clustering by village.

[1] does not include the variable knowledge. [2] does not includes the variable skills

\*  $p \leq 0.10$ ; \*\*  $p < 0.01$

**References Cited**

- Agrawal, A., Indigenous knowledge and the politics of classification. International Social Science Journal 54, 2002, 287-97 pp.
- Atran, S., D. Medin, Knowledge and action: Cultural models of nature and resource management in Mesoamerica. In: M. Bazerman, D. Messick, A. Tinbrunsel, K. Wayde-Benzoni (Editors), Environment, Ethics, and Behavior. San Francisco: New Lexington Press, 1997, pp. 171-208.
- Atran, S., D. Medin, N. Ross, E. Lynch, V. Vapnarsky, E. Ucan Ek', J. Coley, C. Timura, M. Baran, Folkeology, Cultural epidemiology, and the Spirit of the Commons. A Garden Experiment in the Maya Lowlands, 1991-2001. Current. Anthropology 43(3), 2002, 421-51 pp.
- Begossi, A., Use of ecological methods in ethnobotany: Diversity indices. Economic Botany 50(3), 1996, 280-89 pp.
- Benz, B.F., J. Cevallos, F. Santana, J. Rosales, S. Graf, Losing knowledge about plant use in the sierra de Manantlan Biosphere Reserve, Mexico. Economic Botany 54(2), 2000, 183-91 pp.
- Bergmann, A., H. Hinz, R. Blyth, M. Kaiser, S. Rogers, M. Armstrong, Using knowledge from fishers and fisheries scientists to identify possible groundfish 'Essential Fish Habitats'. Fisheries Research 66(2-3), 2004, 373-79 pp.
- Berkes, F., Sacred Ecology: Traditional Ecological Knowledge and Resource Management. Philadelphia: Taylor & Francis, 1999.
- Berkes, F., J. Colding, C. Folke, Rediscovery of traditional ecological knowledge as adaptive management. Ecological Applications 10(5), 2000, 1251-62 pp.

Berlin, B., D.E. Breedlove, P.H. Raven, Folk taxonomies and biological classification.

Science 154, 1966, 273-75 pp.

Boom, B., Ethnobotany of the Chacobo indians, Beni, Bolivia. Advances in Economic

Botany 4, 1987, 1-68 pp.

Boster, J.S., Exchange of varieties and information between Aguaruna manioc

cultivators. American Anthropologist 88, 1986, 429-36 pp.

Brookfield, H., C. Padoch, Appreciating agrodiversity: A look at the dynamism and

diversity of indigenous farming practices. Environment 36 (5), 1994, 6-43 pp.

Brush, S.B., Ethnoecology, biodiversity and modernization in Andean potato agriculture.

In: P. Minnis (Editor), Ethnobotany. Norman: University Oklahoma Press. 2000.

Byron, E., Market Integration and Health: The Impact of Markets on the Nutritional

Status, Morbidity, and Diet of the Tsimane' Amerindians of Lowland Bolivia.

PhD. Dissertation. Gainesville: University of Florida, 2003.

Caniago, I., S.F. Siebert, Medicinal plant economy, knowledge and conservation in

Kalimantan, Indonesia. Economic Botany 52(3), 1998, 229-50 pp.

Chambers, R., A. Pacey, L.A. Thrupp, Farmer First: Farmer Innovation and Agricultural

Research. London: Intermediate Technology Publications. 1989.

Colchester, M., Salvaging nature: Indigenous peoples, protected areas and biodiversity

conservation. Geneva: United Nations Research for Social Development. 1994.

Conklin, H.C., An ethnoecological approach to shifting agriculture. Transactions of the

New York Academy of Sciences 17(2), 1954, 133-42 pp.

- Critchley, W., C. Reij, T. Willcocks, Indigenous soil and water conservation. A review of the state of knowledge and prospects for building on traditions. Land Degradation and Rehabilitation 5(4), 1994, 293-314 pp.
- D'Andrade, R.G., The Development of Cognitive Anthropology. Cambridge: Cambridge University Press. 1995.
- Daillant, I., Sens Dessus Dessous. Organization sociale et spatiale des Chimane d'Amazonie boliviane. Nanterre: Societe d'ethnologie. 2003.
- Davis, A., J. Hanson, H. Watts, H. MacPherson, Local ecological knowledge and marine fisheries research: the case of white hake (*Urophycis tenuis*) predation on juvenile American lobster (*Homarus americanus*). Canadian Journal of Fisheries and Aquatic Sciences 61(7), 2004, 1191-201 pp.
- DeWalt, S., G. Bourdy, L. Chavez de Michel, C. Quenevo, Ethnobotany of the Tacana: Quantitative inventories of two permanent plots of Northwestern Bolivia. Economic Botany 53(3), 1999, 237-60 pp.
- Etkin, N.L., Eating on the Wild Side: The Pharmacologic, Ecologic, and Social Implications of Using Noncultigens. Tucson: University of Arizona Press. 2000.
- Godoy, R., Indians, Markets, and Rainforest. Theory, Methods, Analysis. New York: Columbia University Press. 2001.
- Godoy, R., N. Brokaw, D. Wilkie, D Colón, A. Palermo, S. Lye, S. Wei. Of trade and cognition: Markets and the loss of folk knowledge among the Tawahka indians of the Honduran Rain Forest. Journal of Anthropological Research 54, 1998, 219-33 pp.

- Godoy, R., H. Overman, J. Demmer, L. Apaza, E. Byron, T. Huanca, W. Leonard, E. Pérez, V. Reyes-García, V. Vadez, D. Wilkie, A. Cubas, K. McSweeney, N. Brokaw. Local financial benefits of rain forests: Comparative evidence from Amerindian societies in Bolivia and Honduras. Ecological Economics 40, 2002, 397-409 pp.
- Guest, G. Market integration and the distribution of ecological knowledge within an ecuadorian fishing community. Journal of Ecological Anthropology 6, 2002, 38-49 pp.
- Gunnell, Y., A. Krishnamurthy. Past and Present Status of Runoff Harvesting Systems in Dryland Peninsular India: A Critical Review. Ambio 32(4), 2003, 320-24 pp.
- Huanca, T., Tsimane' Indigenous Knowledge. Swidden Fallow Management and Conservation. Ph.D. dissertation. Gainesville: University of Florida. 1999.
- Jackson, F., The coevolutionary relationship of humans and domesticated plants. Yearbook Physical Anthropology 39, 1996, 161-76 pp.
- Johns, T., The Origins of Human Diet and Medicine: Chemical Ecology. Tucson: University of Arizona Press. 1996.
- Laird, S. Biodiversity and Traditional Knowledge: Equitable Partnerships in Practice. London: Earthscan. 2002.
- Locay, L. From hunting and gathering to agriculture. Economic Development and Cultural Change 37, 1989, 737-56 pp.
- Mackinson, S. Integrating local and scientific knowledge: An example in fisheries science. Environmental Management 27(4), 2001, 533-45 pp.

- Maffi, L. On Biocultural Diversity. Linking Language, Knowledge, and the Environment. Washington, D.C: Smithsonian Institution Press. 2001.
- McSweeney, K. The Dugout Canoe Trade in Central America's Mosquitia: Approaching Rural Livelihoods Through Systems of Exchange. Annals of the Association of American Geographers 94(3), 2004, 638-61 pp.
- Miller, M.L., J. Kaneko, P. Bartram, J. Marks, D. Brewer. Cultural consensus analysis and environmental anthropology: Yellowfin tuna fishery management in Hawaii. Cross-Cultural Research 38(3), 2004, 289-314 pp.
- Olsson, P., C. Folke, F. Berkes. Adaptive co-management for building resilience in social-ecological systems. Environmental Management 34(1), 2004, 75-90 pp.
- Orlove, B., S.B. Brush. Anthropology and the conservation of biodiversity. Annual Review of Anthropology 25, 1996, 329-352 pp.
- Pandey, D.N. A bountiful harvest of rainwater. Science 293, 2001, 1763 pp.
- Posey, D. Indigenous People and Sustainability: Cases and Actions. Gland, Switzerland: UICN. 1997.
- Price, A., R. Rulifson. Use of traditional ecological knowledge to reduce striped bass bycatch in the Currituck Sound white perch gill-net fishery. North American Journal of Fisheries Management 24(3), 2004, 785-92 pp.
- Redford, K., C. Padoch. Conservation of Neotropical Forests. Working from Traditional Resource Use. New York: Columbia University Press. 1992.
- Reyes-García, V., Indigenous People, Ethnobotanical Knowledge, and Market Economy. A Case Study of the Tsimane' Amerindians, Bolivia. Ph.D. dissertation. Gainesville: University of Florida. 2001.

Reyes-García, V., R. Godoy, V. Vadez, L. Apaza, E. Byron, E. Pérez, W. Leonard, D.

Wilkie. Is ethnobotanical knowledge held communally? Evidence from Bolivian Amerindians. Science 299, 2003, 1707 pp.

Reyes-García, V., V. Vadez, E. Byron, L. Apaza, W. Leonard, E. Pérez, D. Wilkie.

Market economy and the loss of ethnobotanical knowledge: Estimates from Tsimane' Amerindians, Bolivia. Current Anthropology Forthcoming, 2005a.

Reyes-García, V., V. Vadez, R. Godoy, T. Huanca, W. Leonard. Knowledge and uses of

wild plants: A comparative study in two Tsimane' villages in the Bolivian lowlands. Economic Botany Under review, 2005b.

Rocha, J. Measuring Traditional Agro-Ecological Knowledge: An example from peasants

in the Peruvian Andes. Field Methods Forthcoming, 2005.

Romney, A.K., S. Weller. Predicting informant accuracy from patterns of recall among

informants. Social Networks 6(1), 1984, 59-77 pp.

Romney, A.K., S. Weller, W. Batchelder. 1986. Culture as consensus: A theory of culture

and informant accuracy. American Anthropologist 88(2), 1986, 313-38 pp.

Ross, N. Lacandon Maya Intergenerational Change and the Erosion of Folk Biological

Knowledge. In: J. Stepp, F. Wyndham, R. Zarger (Editors), Ethnobiology and

Biocultural Diversity. Athens, GA: International Society of Ethnobiology. 2002.

Pp. 585-92.

Schultz, T.W. The value of the ability to deal with disequilibria. Journal of Economic

Literature 1975.

Sillitoe, P. The development of indigenous knowledge. Current Anthropology 39, 1998,

223-52 pp.

- Sternberg, R., C. Nokes, P. Geissler, R. Prince, F. Okatcha, D. Bundy, E. Grigorenko, The relationship between academic and practical intelligence: a case study in Kenya. Intelligence 29, 2001, 401-18 pp.
- Vadez, V., V. Reyes-García, L. Apaza, E. Byron, T. Huanca, W. Leonard, E. Pérez, D. Wilkie. Does integration to the market threaten agricultural diversity? Panel and cross-sectional evidence from a horticultural-foraging society in the Bolivian Amazon. Human Ecology 32(5), 2004, 635-46 pp.
- Warren, DM., LJ. Slikkerveer, D. Brokensha. The Cultural Dimension of Development: Indigenous Knowledge System. London: Intermediate Technology Publications. 1995.
- Warren, DM., LJ. Slikkerveer, S. Titlola. Indigenous Knowledge Systems: Implications for Agriculture and Industrial Development. Ames: Iowa State University. 1989.
- WCED, Our common future. Oxford: Oxford University Press. 1987.
- WHO, IUCN, WWF, Guidelines on the Conservation of Medicinal Plants. Gland, Switzerland: IUCN. 1993.
- Zarger, R., J.R. Stepp. Persistence of botanical knowledge among Tzeltal Maya Children. Current Anthropology 45, 2004, 413-18 pp.
- Zent, S. Acculturation and Ethnobotanical Knowledge Loss among the Piara of Venezuela: Demonstration of a Quantitative Method for the Empirical Study of Traditional Ecological Knowledge Change. In: L.Maffi (Editor), On Biocultural Diversity: Linking Language, Knowledge, and the Environment. Washington D.C.: Smithsonian Institution Press. 2001. Pp. 190-211.