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ANALYSIS

Local financial benefits of rain forests: comparative evidence from Amerindian societies in Bolivia and Honduras☆

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Abstract

Researchers generally express the local value of tropical rain forests in dollars/ha/year. The approach is problematic because it produces low values to local users, underestimating the importance of the forest expressed as a share of household consumption or earnings. Here we contribute to valuation studies of rain forests by estimating the financial importance of the forest measured in three ways: (1) the contribution of forests to annual household consumption and (2) earnings; and (3) the value of a hectare of rain forest to villagers measured through the biological goods consumed and sold. We collected panel data on consumption and earnings from 81 households in four villages of two Amerindian societies in two nations (Tsimane', Bolivia; Tawahka, Honduras). Analyses suggest: (1) forests account for a large share of household consumption (median ~38.5%; range 14.65–53.11%); (2) forests contribute more to household consumption than to household earnings (median ~22.69%; range 16.56–44.81%); (3) the relative

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contribution of forests to household consumption and earnings falls among villages closer to towns; and (4) the range of values/year of rain forest/ha is US$7.10–9.70 using 1999 dollars or US$18.46–46.56 using purchasing power parity indexes, below previous estimates. Results show much variation in forest values; valuation methods and stakeholder perspectives affect the variation. Given the variation, a useful strategy to promote forest conservation would transfer income to villagers to compensate them for non-local forest values.

Keywords: Valuation; Rain forest; Consumption; Earnings; Amerindians; Tsimane'; Tawahka; Bolivia; Honduras; Environmental compensation payments

1. Introduction

The conservation of tropical rain forests reflects a delicate and complex trade off between the net benefits that rural people or local users receive from clearing the forest for other uses (e.g. farmlands, pasturelands), the net benefits that rural people or local users receive from using the forest without clearing it, and the net benefits that the rest of the world receives from a standing forest in such things as carbon sequestration, biological diversity, and hydrological services. Conservation requires that the net financial benefits that rural people or local users receive from a standing forest exceed the net financial benefits that they might receive from clearing the forest for other uses. The continuous loss of tropical rain forests, more marked and more readily visible in some regions of the world than in others (Matthews, 2001; Victor and Ausubel, 2000; Angelsen, 2001), suggests that in much of the developing world rural people and local users receive more benefits from clearing tropical rain forests than from conserving them. To reduce incentives to clear rain forests one could transfer part of the global benefits produced by the forests to rural communities or to other local users (Dixon and Pagiola, 2000). If villagers and other local actors enjoy secure property rights over the rain forest, the transfer would raise the local benefits of conservation relative to the local benefits of conversion, lowering the motivation of villagers and other local actors to deforest.

Although we know much about the private financial benefits and costs of clearing rain forest for other uses (Repetto and Gillis, 1988) and about the determinants of deforestation (Angelsen and Kaimowitz, 1999), we know much less about the financial value of standing rain forests to local users, or about the total global economic benefits that standing rain forests produce for the rest of the world (Chomitz and Kumari, 1998; Daily, 1997; Godoy et al., 2000; Lampietti and Dixon, 1995; Panayotou and Ashton, 1992). And we know even less about the relative contribution of the rain forest to household consumption and to household income as rural economies modernize (Cavendish, 2000).

Local users might prefer the direct, short-term benefits of the forest in consumption or sale, but other stakeholders might prefer the long-term, indirect benefits of the forest in environmental services. Differences in emphasis might reflect differences in rates of private time preference and tenure security. Rates of private time preference, also known as private discount rates, vary among people within a community, and the same may be true across different stakeholders (Godoy and Jacobson, 1999). Differences in the short and in the long-term benefits assigned to the forest might also reflect differences in tenure security over the forest (Godoy et al., 2001). In much of the developing world, rural communities in the rain forest do not enjoy secure rights of property to the forest. Lack of clarity over tenure rights will induce people to obtain the short-term, direct benefits of the rain forest.

So far researchers have generally expressed the local value of tropical rain forests by the annual dollar value produced by a hectare of rain forest in physical goods for consumption and for sale. Though important as a first step in the empirical analysis of forest valuation, the method of valuing forests per unit of land sidesteps the economic contribution of the forest to local users. The forest might have a low value to local users when expressed in dollars per hectare, but it might have a high value when expressed as a share of household consumption or earnings.

Here we contribute to valuation studies of tropical rain forests by presenting empirical estimates of the financial importance of the forest to local, rural users measured in three ways: (a) the contribution of forests to annual household consumption, (b) the contribution of the forest to annual household earnings, and (c) the value of a hectare of rain forest to villagers measured through the biological goods households remove from the rain forest for consumption and for sale.

2. General approach

We use comparative and quantitative methods from human ecology and from natural resource economics to estimate the value of goods removed from the forest. We did research among the Tsimane' Amerindians of the department of Beni in the Bolivian lowlands and among the Tawahka Amerindians in the Mosquitia of eastern Honduras. Although the territories of both ethnic groups face encroachment from loggers, ranchers, and small farmers, the villages selected for the study did not face direct threats from encroachers. We collected information during eight consecutive quarters in Honduras (1995–1996) and during five consecutive quarters in Bolivia (1999–2000). We monitored the flow of all biological goods from the forest, whether plants or animals, whether timber or non-timber, into the household to get a comprehensive estimate of the total value of forest goods to villagers measured by all the goods they extracted from the forest. We equate consumption with all the forest goods entering the household irrespective of whether people later ate, wore, stored, or sold the goods or put them to other uses.

To facilitate comparison and generalizations we took the following steps: (a) we tried to use similar methods to collect information in different villages and nations; (b) we quantified the amount and value of all goods entering households, (c) we compared results between villages, nations, and years, and (d) we express values in inflation-adjusted 1999 dollars and in purchasing power parity terms. Purchasing power parity refers to the amount of foreign currency needed to buy a standard basket of goods in a foreign nation that in the United States would cost a fixed number of dollars (e.g. 1 dollar). The measure allows one to control for differences in the costs of living across countries that are not captured by market exchange rates.

3. Selection of villages and households

In each nation we compared the extraction and the sale of forest goods in two villages: one close

Table 1
Demographic and economic characteristics of Tawahka (Honduras) and Tsimane' (Bolivia) Amerindian villages and households

	Village proximity to nearest market town					
Village proximity to nearest market town	Far			Close		
Country	Bolivia	Honduras		Bolivia	Honduras	
Village name	Yaranda	Yapuwás		S. Antonio	Krausirpe	
Distance to nearest market town (km)	47	47		10	30	
Sample of households in study	22	16		27	16	
Average household size	5.77	6.21		5.80	8.11	
Average age of household head	38.58	36.8		35.29	39.10	
Average maximum education of household head	1.91	1.84		1.14	2.78	
Years of study	1999/2000	1995	1996	1999/2000	1995	1996
Mean annual value of household consumption in current US dollars	1259	961	1269	1925	2664	2426
Mean annual value of household earnings in current US dollars	286	265	199	385	2571	2685
Mean annual value of consumption + earnings per person in US dollars	267	197	236	398	645	630

to the market (10–30 km) and one farther away from the market (47 km) (Table 1). We collected information from villages differing in their proximity to a major market town because distance proxies for integration to the market, which, in turn, affects how people use forests (Demmer and Overman, 2001; Godoy, 2001). Villages far from major market centers tend to use forests chiefly for their own consumption, whereas communities closer to major market towns tend to extract and sell selected forest goods in demand by outsiders. In selecting two communities at different distances from major market towns we obtained variance on an important determinant of forest use. The village-to-market distance that we measured glosses over the distance from the village to the nearest road or the distance from the village to a minor market center, both of which might also have an independent effect on how people use the forest.

We used several criteria to select villages. Villages had to be safe for researchers. They had to share a similar ecology; in Honduras and in Bolivia the two villages lay along the same river basin. Pilot surveys suggested that the villages were representative of the ethnic groups. The two villages had to be at different distances from a major market town to capture different degrees of integration to the market. We limited the study to only two villages in each nation to obtain panel information or detailed, repeated longitudinal observations from the same people and households over time. By interviewing the same people over time, we enhanced rapport and the quality of the information collected relative to the information we might have collected from doing a single but larger cross-sectional study. Financial, logistical and personnel constraints made it impossible to study more than two villages in either nation.

In three of the four villages we collected information on all (or most) of the households and people. In Bolivia, we collected information from 22 households in the remote village (two households refused to take part in the study) and from 27 households in the more accessible village (three households did not want to participate). In Honduras we collected information on all 16 households in the remote village, but we drew a sample of 16 households in the more accessible village because we could not study the entire population of that village ($n = 53$ households). The 16 households we selected in the more accessible village of Honduras consisted of 11 of the more affluent households and five of the poorest households. We focused on the more affluent households in the more accessible village to obtain variance in income and wealth; the poorer village already captured the lower end of the distribution of income and wealth, so we made sure that the sample from the more accessible village covered the top end of the income distribution.

The information in Table 1 suggests that households in Honduras were larger, ranging from 6.21 people in Yapuwás to 8.11 people in Krausirpe. Households in Bolivia contained fewer people (5.77–5.80). The average age of household heads was roughly similar in the four sites (35.29–38.58 years in Bolivia; 36.8–39.10 years in Honduras) as was their maximum educational attainment (1.14–1.91 in Bolivia; 1.84–2.78 in Honduras). The mean annual value of personal earnings and consumption was about two to three times higher in the villages close to the market (US$630–645 in Honduras; US$398 in Bolivia) than in the villages far from the market (US$197–236 in Honduras; $267 in Bolivia).

4. Methods to collect information

Five researchers did fieldwork in Honduras from June 1994, until December 1996. Five researchers did field work in Bolivia from May 1999, until November 2000. During days chosen at random each month (in Honduras) or each quarter (Bolivia), researchers identified, measured, weighed, and valued all goods entering households from 6 am (Honduras) or 7 am (Bolivia) until 6 pm and noted the place of origin and mode of procurement of the goods.

Of the 140 days in which we measured household consumption in Honduras, 71 took place in the more remote village of Yapuwás (47 km from nearest town) and 69 took place in the more accessible village of Krausirpe (30 km from nearest town), 54 in 1995 and 86 in 1996. In

Bolivia, we measured household consumption one day each quarter during five consecutive quarters in each of the two villages: Yaranda (47 km from nearest town) and San Antonio (10 km from nearest town).

We could not measure consumption frequently in the same households in Bolivia because the houses in the village extended over a large area and, in the village of San Antonio, over the two sides of the river. Consequently, in Bolivia researchers had to spend an entire day measuring the consumption of each household. Households in the villages of Honduras were closer together, so two researchers in 1 day could monitor all the goods brought into all the households in the sample of a village. In one day in Bolivia, one to two researchers could, at most, only monitor the consumption of two to three households.

Since we chose at random the day to measure consumption within each quarter and covered five quarters, and since we sampled 49 of the 53 households in the two villages of Bolivia or 92.45% of the entire population of the two villages, the method for valuing consumption in Bolivia should yield an unbiased estimate of the mean value of consumption for a household during any 1 day of the year for each of the two villages. When multiplied by the number of days in the year, the mean daily value of consumption from 5 days spread out throughout the year should produce a reasonable, unbiased estimate of the mean value of consumption per year for the household, subject to caveats discussed later.

We valued goods in the state of processing the goods were in when they entered the household. We used the buying price paid by the household to value the good. For goods without a price in Honduras, we asked a group of Tawahka once a month to reach consensus on how much of a good with a known price (e.g. sugar) they would exchange in the village for the forest good without a price. For goods without a price in Bolivia, we asked villagers the 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 good. To determine the source and the level of cash earnings during the 30 days before the interview we interviewed all adults, or people over the age of 16. During 1995 and 1996 we did 9 and 11 surveys of earnings in Honduras. In Bolivia we did five surveys of earnings, one during each quarter; in Bolivia, as in Honduras, we asked people to recall the level and the sources of their cash earnings during the 30 days before the interview. We converted domestic values to international values by using the yearly (Honduras) or the local quarterly (Bolivia) exchange rate and by using the purchasing power parity index. The latest purchasing power parity indexes we found were for 1998: 2.6 for Bolivia and 4.8 for Honduras (World Bank, 2001).

In the estimations we include fish, game, wild plants, persistent crops in second-growth forest, firewood, and timber brought to the household or sold, but exclude domesticated animals, minerals, water, industrial goods, and cultivated crops.

Since people sold forest goods to outsiders and (in Honduras) to each other, we also estimate and report the gross annual value of the forest/hectare from the sale of forest goods. We estimate separate values of the forest from the consumption and from the sale of forest goods because we could not link a good brought from the forest now with the later sale of the same good and thus avoid double counting.

Omitting sales of forest goods from the survey of cash earnings (assuming these must have first entered the household and thus have been counted as consumption) was not an option for two reasons. First, people sometimes sold forest goods (e.g. timber) to traders at the point of extraction; those goods never entered the village. Second, the processing of raw materials of forest goods increases the value of the goods at the time of sale. Instead, we add the values of consumption to the value of sales to estimate a potential upper range and ensure robustness in empirical results.

We use a foraging radius of 3 km from the village based on all-day focal follow of foragers, but subtracted 2.4 hectares of farmlands for each household in Honduras and 1.5–3.0 hectares of farmlands for each household in Bolivia to adjust for lands under active cultivation. A focal follow is a method of collecting behavioral information that consists of shadowing a person—in this case a person who goes to the forest to farm, forage,

or do other activities. A radius of 3 km captures well the maximum distance traveled by an ordinary Amerindian in our sample in an ordinary day, though Amerindians are known for traveling far in search of fish, game, or timber (Godoy et al., 1993; McSweeney, 1999). For example, the Tawahka from the more accessible village of Krausirpe often took trips lasting several days to make dugout canoes, which they later sold to outsiders. We subtracted a total of 5 hectares for Yapuwás and 19 hectares for Krausirpe in Honduras and 15 hectares for San Antonio and 6 hectares for Yaranda in Bolivia to adjust for the area of the nucleated settlement. We expanded consumption values by $365/x$ and earnings by $12/y$, where x and y are the number of days or months in a year in which we measured consumption or earnings. We report gross values of forest per hectare because we did not collect information on foraging or manufacturing costs.

5. Measurement errors, biases and caveats

The methods used to collect information create measurement errors, which produce positive and negative biases that pull estimations in opposite directions. We do not know the net effect or the magnitude of the biases, but discuss them briefly before discussing the empirical results.

5.1. Positive biases

Since we assumed a foraging radius of only 3 km from the village, and since we double counted the value of some goods when they entered the household and when they left the household later for sale, the estimates are biased upward. For example, the Tawahka from the richer village of Krausirpe extracted valuable logs several days away from their village to make dugout canoes; the value of those canoes were imputed to a foraging area with a radius of only 3 km from the village. The omission of extraction or manufacturing costs also produces an upward bias. The omission of extraction costs weakens the comparison between the villages because in Bolivia we used time invested in foraging to value many goods; higher values in the villages closer to the market might reflect higher wages.

Last, the estimates of forest value we present are averages for an entire village and, since we had a small sample of households, outliers will influence estimated mean values. The more accessible village in Honduras, Krausirpe, provides an apt example of what we mean. As we shall see below, the annual sales value/hectare in the more accessible village in Honduras (US$4.14–4.39/ha/year) was much higher than the annual sales value/hectare in the more remote village (US$0.13–0.26/ha/year) in part because a few households in the more accessible village had the physical capital to extract valuable timber several days away from the village for canoes and for sawn wood. If one excluded the outliers, the value of the forest/hectare from the sale of forest goods would be lower. We focus on mean rather than on median values to facilitate comparisons with previous studies (e.g. Costanza et al., 1997).

5.2. Negative biases

The omission of water and ecological services valued by villagers, and the omission of the insurance and the cultural value of the forest reduce the estimated value of the forest. The valuation of forest goods at the moment people brought them into the household excludes the value of forest goods people might have consumed while in the forest. Further, an overvalued foreign exchange rate in Bolivia from the drug trade and from the export of gas and hard minerals lowers the price of tradable goods. The use of purchasing power parity indexes corrects, in part, for the bias from a potentially overvalued exchange rate. We did not collect prices in cities so we cannot tell whether village prices mirror urban prices. Since village prices are often lower than city prices and since exchange rates and purchasing power parity indexes are based on urban prices, the estimates we present may still be lower than they should be despite the use of the purchasing power parity index. Last, the low frequency of observations for household consumption in Bolivia will bias the estimate of consumption down if the annual extraction of some crops and animals was confined

to short periods of time lasting only a few days or weeks; quarterly measures of consumption will not capture with accuracy forest goods with a brief seasonal appearance.

5.3. Caveats

Although we tried to use the same methods to collect information in the two nations, this was not always so. For example, we used a different method in Bolivia and Honduras to value forest goods without a market price. In Bolivia we valued forest goods without a price by imputing a wage on the search cost of finding and transporting the good to the village, but in Honduras we elicited direct information about people's willingness to pay for those goods. The non-random selection of households could also introduce biases. If wealthier households were more likely to trade, then some of the differences discussed later between richer and poorer villages might reflect the non-random selection of households.

6. The economic importance of the forest in household consumption and earnings

Elsewhere we provide a complete list of all the plants and animals obtained from the forests of the four villages (Apaza, 2001; Demmer et al., 2001; Demmer and Overman, 2001; Pérez, 2001; Reyes-García, 2001). In this section we summarize some of the more important forest goods extracted. We then compare the use of forest goods using broad categories, such as plants, game, and fish, between the two nations and villages and discuss the relative importance of the forest in total household consumption and earnings. In Section 7, we turn to a discussion of the value of the forest per hectare.

6.1. Forest goods used

6.1.1. Bolivia

In the more remote village in Bolivia, Yaranda, game was an important source of animal protein. Common animals hunted in Yaranda included the white-tailed deer (*Odocoileus virginianus*), paca (*Agouti paca*), brown agouti (*Dasyprocta variegata*), collared peccary (*Tayassu tajacu*), brown capuchin monkey (*Cebus apella*), and tejon (*nasua nasua*). The most important fishes were sábalo (*Prochiludus nigricans*), pacusillo (*Schizodon fasiatum*), surubí (*Pseudoplatysome fascia*), and paleta (*Surubim lima*). In the more accessible village of Bolivia, San Antonio, people relied on smaller animals for much of their animal proteins. Common animals hunted in San Antonio included jochi colorado (*Nasua nasua*), capivara (*Hydrochaeris hydrochae*), chichilo (*Saimiri boliviensis*), and tatú (*Dasypus septemcintus*). The most important fishes were small sardines and benton (*Hoplias melabaricus*), found in ponds.

Forest products were important in both communities, although in Yaranda people reported using a higher number and diversity of plant species. The most important category was firewood. Gathering of edible plants was important between October and December when most tree species were fruiting. Tsimane' appreciate the fruits of the palms *Attalea phalerata* and *Bactris gasipaes*. They also consume other fruits, such as *Rheedia acuminata* and *Inga* sp. In the more remote community of Yaranda people bartered roofing mats made from jatata (*Geonoma deversa*) in exchange for commercial products, such as sugar and alcohol.

6.1.2. Honduras

Common useful plant species found in the old-growth forest of the Tawahka included mahogany (*Swietenia macrophylla*, fam. Meliaceae), various types of cedars (*Cedrela* spp., Meliaceae), cortes (*Tabebuia* sp., Bignoniaceae), laurel (*Cordia alliodora*, Boraginaceae), manga larga (*Vochysia ferruginea*, Vochysiaceae), paleto (*Dialium guianense*, Fabaceae), San Juan (*Vochysia hondurensis*, Vochysiaceae), and Santa Maria (*Calophyllum brasiliense*, Clusiaceae).

The most common animals seen during transect walks in the two villages included collared and white-lipped peccary (*Tayassu tajacu* and *T. pecari*), agouti (*Dasyprocta punctata)*, Central American spider monkeys (*Ateles geoffroyi*), yellow-crowned parrots (*Amazona ochrocephala*), scarlet and great green macaw (*Ara macao* and

Table 2
Composition of mean annual value of household consumption among Tawahka (Honduras) and Tsimane' (Bolivia) Amerindians (%)

	Village proximity to nearest market town					
Village proximity to nearest market town	Far			Close		
Country	Bolivia	Honduras		Bolivia	Honduras	
Name of village	Yaranda	Yapuwás		S. Antonio	Krausirpe	
Years of study	1999/2000	1995	1996	1999/2000	1995	1996
Items						
Crops	42.27	34.97	44.99	34.06	45.42	62.04
Animals and animal products	1.25	5.22	5.31	1.64	2.89	8.26
Total farm	43.52	40.19	50.30	35.70	48.31	70.30
Forest						
Plants	15.78	21.88	25.20	17.51	19.46	10.26
Game	19.50	8.46	7.24	12.46	5.56	3.73
Fish	17.21	6.91	7.87	23.14	0.85	0.66
Total forest	52.49	37.25	40.31	53.11	25.87	14.65
Purchases	4.00	22.56	9.39	11.18	25.82	15.05
Total	100.00	100.00	100.00	100.00	100.00	100.00

Table 1 contains sample size and dollar value of household consumption from which we estimated the shares shown in Table 2.

Ara ambigua), and the great tinamou (*Tinamus major castanaeiceps*).

6.2. Household consumption

In Table 2 we present estimates of the composition of mean annual household consumption, broken down by farm goods (crops and domesticated animals) and forest goods (plants, game, and fish) extracted by the household, and by goods bought by the household.

The information in Table 2 suggests that forest goods accounted for about half (52.49–53.11%) of the total value of household consumption in the two villages of Bolivia, but in Honduras the shares declined from 37.25–40.31% in the more remote village to 14.65–25.87% in the more accessible village. In Honduras, the relative contribution of the forest to household consumption declined in the more accessible village because it was overshadowed by the growing importance of cultivated crops (e.g. rice, cacao, beans). In the more remote village of Honduras, cultivated crops accounted for 34.97–44.99% of household consumption, but in the more accessible village cultivated crops accounted for 45.42–62.04% of household consumption.

Among forest goods, wildlife was more important than plants in Bolivia and plants were more important than wildlife in Honduras. By wildlife we mean fish and game, but not plants. In Bolivia, the relative contribution of wildlife to consumption was twice as high as the relative contribution of plants and plant products. In the remote and accessible villages of Bolivia, wildlife accounted for 36.71% (remote) and for 35.60% (accessible) of household consumption, whereas plants accounted for 15.78% (remote) and for 17.51% (accessible) of household consumption. In the remote and accessible villages of Honduras, wildlife accounted for 15.11–15.37% (remote) and for 4.39–6.41% (accessible) of household consumption, whereas plants accounted for 21.88–25.20% (remote) and for 10.26–19.46% (accessible) of household consumption.

6.3. Household earnings

In Table 3 we present estimates of the composition of mean annual household earnings. Earnings refers to cash earned from wage labor and from selling goods. In Honduras the value of earnings excludes pawned items, rent, remittances, gifts, or

loans repaid, but includes the gross earnings from retail shops owned and operated by the household. In Bolivia, earnings also includes the value of goods received in barter. In Honduras, the most important source of earnings from the forest was the sale of dugout canoes and sawn wood. As mentioned, people in the more accessible village had access to motorboats and found it easier to travel far to obtain logs. In Bolivia, the most important source of earnings was thatch palm, more abundant near the remote village. Traders came to the remote village to buy or barter for thatch palm.

The information in Table 3 suggests that the importance of the forest in household earnings declined among villages closest to the market. If we add the earnings from sale of forest products to the wages earned in jobs related to forest activities, we find that in Bolivia the share of earnings from the sale of forest goods declined from 44.81% to 21.03% between the more remote and the more accessible village. In Honduras, the forest accounted for 24.36–32.85% of household earnings in the remote village; in the more accessible village, the forest accounted for only 16.56–17.48% of household earnings.

In sum, we draw the following tentative conclusions about the relative contribution of the forest to household consumption and earnings. First, the forest accounts for a large share of household consumption (median $\sim$38.5%; range 14.65–53.11%). The shares ranged from a low of 14.65% in the more accessible village of Honduras during 1996 to 52.49–53.11% in both villages of Bolivia. Second, the sale of forest goods and the wages from forest-based activities contribute more to household consumption than to household earnings (median $\sim$22.69%; range 16.56–44.81%).

Table 3
Composition of mean annual household earnings among Tawahka (Honduras) and Tsimane' (Bolivia) Amerindians (%)

	Village proximity to nearest market town					
Village proximity to nearest market town	Far			Close		
Country	Bolivia	Honduras		Bolivia	Honduras	
Village name	Yaranda	Yapuwás		S. Antonio	Krausirpe	
Years of study	1999/2000	1995	1996	1999/2000	1995	1996
Items						
Sale of farm products						
Crops	2.33	3.93	6.34	42.24	7.97	12.93
Animals and animal products	2.81	17.51	13.88	4.00	1.76	1.16
Total farm	5.14	21.44	20.22	46.24	9.73	14.09
Sale of forest products						
Plants	37.8	9.74	9.90	7.43	14.56	14.96
Game	0.32	0.14	1.06	10.04	0.38	0.22
Fish	0.00	2.11	1.99	1.39	0.13	0.06
Total forest	38.13	11.99	12.95	18.86	15.07	15.24
Sale of other goods	0.26	5.56	5.50	2.41	64.30	63.28
Wage labor in						
Forest activities	6.68	12.37	19.90	2.16	2.41	1.32
Agriculture	1.23	15.21	28.75	12.80	0.64	0.18
Other	48.56	33.43	12.68	17.52	7.85	5.89
Total wage labor	56.47	61.01	61.33	32.48	10.90	7.39
Total	100.00	100.00	100.00	100	100.00	100.00
Total forest: sale of forest goods + wage labor in forest activities	44.81	24.36	32.85	21.03	17.48	16.56

Table 1 contains sample size and dollar value of household earnings from which we estimated the shares shown in Table 3.

Table 4
Average annual value of consumption and sale of goods from a hectare of tropical rain forest among Tawahka (Honduras) and Tsimane' (Bolivia) Amerindians (US$/ha/year)

	In 1999 dollars			Purchasing power parity (1998)		
	Consumption	Sale	Both	Consumption	Sale	Both
Honduras						
1995						
Far	3.23	0.26	3.49	15.52	1.24	16.76
Close	11.64	4.14	15.78	55.87	19.86	75.73
Average	7.37	2.20	9.70	35.38	10.55	46.56
1996						
Far	3.23	0.13	3.36	15.49	0.62	16.11
Close	7.75	4.39	12.14	37.18	21.07	58.25
Average	5.42	2.19	7.75	26.03	10.53	37.18
Bolivia						
1999/00						
Far	3.90	1.05	4.98	10.14	2.73	12.95
Close	8.10	1.10	9.40	21.06	2.86	24.44
Average	6.00	1.08	7.10	15.60	2.81	18.46

Consumption = value for consumption. Sale = value from sales. Both = value of consumption and sale added. Purchasing power parity index for 1998 from World Bank (2001) (Table 5.6): 2.6 for Bolivia and 4.8 for Honduras. Honduras: consumer price index of the Banco Central de Honduras (1999 = 100) used to convert 1995 and 1996 prices to 1999 prices. IMF average yearly exchange rate used to convert lempiras to US dollars (1995, 9.47 lempiras = 1 US$; 1996, 11.705 lempiras = 1 US$). Sample includes 16 households in each village. Bolivia: local quarterly exchange rate used to convert bolivianos to US dollars. Sample includes 27 households in village closer to market (San Antonio) and 22 households in village far from market (Yaranda).

This is true for both countries and for all villages except for the more accessible village in Honduras in 1996. In that year in the village of Krausirpe, Honduras, the forest accounted for 16.56% of household earnings (15.24% from the sale of forest goods and 1.32% from wage labor in forest-related activities), but it accounted for only 14.65% of household consumption. Last, the relative contribution of the forest to household consumption and to household earnings generally declines among villages closer to the market. The only exception is the consumption of forest goods in Bolivia, which remained unchanged at about 52–53% in the remote and in the accessible village.

7. The economic importance of the forest as a land cover

Table 4 contains the results of the estimations of forest values per hectare expressed in 1999 dollars and in purchasing power parity terms. Several findings merit discussion.

First, the annual value of consumption and, to a lesser degree, the annual value of sale of forest goods falls within the same range in Honduras and in Bolivia. For example, the average annual value of consumption ranged between US$3.23 and US$11.64/hectare/year in Honduras and between US$3.90 and US$8.10/hectare/year in Bolivia. The annual value of sale of forest goods ranged from a low of US$0.13/hectare/year in Honduras to a high of US$4.39/hectare/year in Honduras. The total annual value of forest goods consumed and sold was US$3.36–15.78/hectare/year in Honduras and US$4.98–9.40/hectare/year in Bolivia.

Second, the villages closer to the market extracted two to four times more total value from the forest than the villages farther from the market. For example, the more accessible village of San Antonio in Bolivia obtained US$8.10/hectare/year from the consumption of forest goods, but

the village of Yaranda, farther away, obtained only US$3.90/hectare/year. In Bolivia the difference in the annual value from the sale of forest goods between the accessible and the remote village was small (US$1.05/hectare/year in the remote village versus US$1.10/hectare/year in the more accessible village), but in Honduras the difference was large. In Honduras, the more accessible village sold US$4.39–4.14/hectare/year in forest goods, compared with the more remote village, which sold only US$0.13–0.26/hectare/year.

At least two reasons might explain why villages closer to market towns extract much higher financial value from a hectare of rain forest than villages farther away. First, villagers closer to the market town (in Honduras) had access to capital equipment that allowed them to expand their foraging radius and extract and sell forest goods of higher value, such as logs to make canoes. Second, our method of valuing non-priced goods in Bolivia might have biased the estimate in favor of the village closer to market town. In Bolivia we valued goods by the opportunity cost of labor in finding and in extracting goods in the forest; to the extent that the opportunity cost of labor is higher in villages closer to towns because of greater employment opportunities, the method would result in higher values for goods in more accessible villages.

Third, the forest is worth 2.4–5.5 times more to local populations as a purveyor of goods for consumption than as a purveyor of goods for sale. For instance, in Bolivia the annual value per hectare of the forest measured by the goods sold reached US$1.08/hectare/year, but the annual value of the forest measured by the goods consumed reached US$6.00/hectare/year. In Honduras, villagers in 1995 and 1996 obtained US$7.37 and US$5.42/hectare/year in benefits from the forest from the consumption of forest goods; during those two years they only received US$2.20/hectare/year in benefits from the sale of forest goods.

Fourth, the annual value of a hectare of tropical rain forest measured by all the goods villagers consumed or sold from the rain forest lies below the lower end of previous estimates. Costanza and his associates reviewed studies that valued raw materials and food from the rain forest and found that average worldwide annual values (converted to 1994 dollars with an additional correction for purchasing power) for food production and for raw materials were US$32 (food) and US$315 (raw materials) per hectare (Costanza et al., 1997). Their ranges were US$6–75/hectare/year for food and US$43–1014/hectare/year for raw materials or US$49–1089/hectare/year for both types of goods combined (mean US$347/hectare/year). A review of about two-dozen studies of the value of non-timber forest goods suggests that the median annual value was about US$50/hectare/year (Godoy et al., 1993). Our range of annual estimates for the four sites lies between US$7.10 and US$9.70/hectare/year using 1999 dollars or US$18.46–46.56/hectare/year using purchasing power parity indexes, considerably lower than previous estimates.

8. Conclusions and implications

At least two implications — one for policymakers and one for researchers — flow from the study.

First, since we do not have information on the net financial benefits of conversion in the four villages, we cannot say whether the low annual values/hectare for local benefits we found might act as an impetus to clear forest. The low financial value of tropical rain forest might explain why some people clear forests for cattle ranching or for cultivation of commercial crops even when they have secure rights of property to rain forests. Outsiders moving into the tropical rain forests of Latin America probably obtain even lower values from the rain forest than the values just presented, since, as newcomers to the forest, they lack the knowledge of how to use forest resources. Policy researchers need to take the next step and compare the value of the forest to rural people and to local users from the consumption and from sale of forest goods against what rural people and local users could get from clearing the forest to plant crops or raise animals.

We realize that the decision to clear forest reflects many forces besides the annual value/hectare of the forest as a purveyor of goods for sale and for consumption (Godoy and Contreras, 2001; Godoy et al., 1997) and that one must compare the local benefits people obtain from a standing forest with the local benefits they obtain from conversion, if we are to understand the private motivations to clear forest. Indeed, we have shown that the forest yields substantial benefits to the household economy. As the information in Table 2 suggests, the median value of forest goods in household consumption ranged between 37.25 and 40.31%. Even though the forest has a low absolute value when expressed in annual dollars/hectare, it is still important for its contribution to the household economy.

Second, researchers need to estimate the local, national, and the global benefits of the forest to decide on the amount of the income transfer that the rest of the world needs to make to developing nations to compensate rural people and other local users for the global and for the national benefits provided by their forests and, in so doing, increase the financial incentives of rural people and other local users to conserve forests. So far researchers have taken a narrow view of forest valuation. Researchers have spent much effort estimating the value/hectare of rain forests to villagers, while ignoring the value/hectare of the rain forest to outsiders, or they have estimated the global and the national benefits of a hectare of rain forest without taking into account the value/hectare of the rain forest to villagers. As far as we know, researchers who take a global, national, or local perspective have yet to meet to collect primary information on the value of a particular rain forest at one place and time and weave together their different methods and findings to arrive at a total valuation of a rain forest from multiple viewpoints. Valuable though such case studies might be, they need to be replicated with the same methods among many sites to allow for generalizations. Even in this study, a sample of only four villages in only two nations does not allow one to draw strong generalizations about the value of the rain forest/hectare or about the contribution of the rain forest to the household economy as economic development unfolds.

The value of the forest in carbon sequestration, in storing biological diversity, and in providing ecological services may be larger than the value of the forest as a purveyor of biological goods to villagers. Costanza and his associates suggest that the total annual value of a tropical rain forest (excluding food and raw materials) to the world may reach US$1660/ha (Costanza et al., 1997). The value of the forest to the rest of the nation will vary by the number of people affected by the use of the forest upstream. The value of the forest to the rest of the world will depend on the biological richness of the forest and on the amount of carbon sequestered by the forest. Recent evidence suggests that the value of biological diversity may be lower than previously assumed and that the value of carbon sequestration may vary widely from place to place (Costanza et al., 1997; Dixon and Pagiola, 2000; Toman, 1998).

If future empirical research shows that a tropical rain forest produces very different values to local, national, and global stakeholders, one may conclude that the rest of the nation and the world ought to develop mechanisms for transferring income to villagers to compensate them for the non-local values supplied by their forests. The World Bank is developing systems to give land users an additional payment when they adopt land use practices that generate benefits to the rest of the world (Dixon and Pagiola, 2000; Pagiola, 2001; Pagiola and Platais, 2001). Transfers could take other forms, such as a subsidy to improve the training of teachers or village leaders, or a direct payment to parents to send their children to school; it could also come as a payment without restrictions to protect the forest (Ferraro, 2001; Godoy et al., 2000; Godoy et al., 2001; Godoy and Contreras, 2001). When coupled with effective mechanisms of monitoring and compliance, such transfers could help finance improvements in the quality of life of local people without destroying the forest. The transfers could produce a win–win situation for local people, plants, animals, scientists and for the rest of the world.

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