Changes in Forest Use Value through Ecological Succession and Their Implications for Land Management in the Peruvian Amazon

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Abstract: *Research on local use values of forests across an ecological succession informs land-use decisions and conservation planning. I evaluated use values of three age classes of secondary forest: fallow fields (<5 years old, $8.20/ha/year), young secondary forest (5–20 years old, $20.60/ha/year), and old secondary forest (>20 years old, $6.80/ha/year). I quantified daily forest product use and calculated use values in dollars per hectare per year for three communities in the northern Peruvian Amazon. I made three comparisons between forest types: number of useful species, value based on different use categories, and overall use values. Old secondary forest had the greatest number of total species present and species collected. Wood, food, and medicine were the three most valuable use categories. The value different families extracted from local forests varied enormously, but median forest values were lower for all forest types than potential gains from agricultural land use (e.g., coffee $167/ha/year). Values of different-aged stands on privately owned lands in two communities did not differ significantly, whereas in the third community, young secondary forest had a significantly greater value than other forest types. Old secondary forests were the most valuable source of wood products, and wood was the only use category in which there was any difference in the value of products extracted from different-aged forest stands. The value of all three forest types on open-access (nonprivate) lands was minimal (mean in each forest type, $0/ha/year). Local people can utilize the valuation results to develop land-use strategies that balance forest product use, agricultural productivity, and biodiversity conservation.*

Key Words: Amazon, Cordillera Azul, ethnobiology, forest products, forest valuation, land management, secondary forests, use value

Cambios en el Valor de Uso del Bosque por medio de la Sucesión Ecológica y Sus Implicaciones para la Gestión de Tierras en la Amazonía Peruana

Resumen: *La investigación sobre valores de uso de los bosques en una sucesión ecológica proporciona información para la toma de decisiones sobre uso de terreno y para planear la conservación. Evalué valores de uso de tres clases de edad de bosque secundario: campos de barbecho (<5 años de edad, $8.20/ha/año), bosque secundario joven (5-20 años de edad, $20.60/ha/año) y bosque secundario maduro (>20 años de edad, $6.80/ha/año). Cuantifiqué el uso diario de la producción forestal y calculé los valores de uso en dólares por hectárea por año para tres comunidades en el norte de la Amazonía Peruana. Hice tres comparaciones entre los tipos de bosque, el número de especies útiles, el valor basado en diferentes categorías de uso y los valores de uso totales. El bosque secundario maduro tuvo el mayor número total de especies y especies colectadas. Las tres categorías de uso más valiosas fueron madera, alimento y medicina. El valor que diferentes familias extraen de los bosques varió enormemente, pero los valores forestales medianos fueron menores en todos los tipos de bosque que las potenciales ganancias del uso de suelo para agricultura (e. g. café $167/ha/año). Los valores de fragmentos de diferentes edades en terrenos privados en dos comunidades no variaron significativamente, mientras que en la tercer comunidad, el bosque secundario joven tuvo un valor significativamente mayor*

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que los otros tipos de bosque. Los bosques secundarios maduros fueron la fuente más valiosa de productos de madera, y la madera fue la única categoría de uso en la que hubo diferencia en el valor de los productos extraídos de fragmentos de bosque de diferentes edades. El valor de estos tres tipos de bosque en terrenos de acceso abierto (no privados) fue mínimo (media en cada tipo de bosque, $0/ha/año). Los habitantes locales pueden utilizar los resultados de valuación para desarrollar estrategias de uso de terreno que balanceen el uso de productos forestales, la productividad agrícola y la conservación de biodiversidad.

Palabras Clave: Amazonía, bosques secundarios, Cordillera Azul, etnobiología, gestión de tierras, productos forestales, valor de uso, valuación de bosque

Introduction

Tropical secondary forests are some of the fastest-expanding ecosystems on the planet. In 1990 the Food and Agricultural Organization of the United Nations (FAO) estimated that secondary forests covered 165 million ha in Latin America alone (FAO 1996). This figure has undoubtedly grown since the FAO study and will continue to do so as populations increase, more land is cleared for agriculture and pasture, and more rural people relocate to urban areas and abandon old fields (Thomlinson et al. 1996; Smith et al. 1997; Smith et al. 1999). Although the expansion of areas covered in secondary forests reflects the continued loss of mature forest stands in the tropics, it does not imply "total forest loss" (de Jong et al. 2001). In many instances, land is simply being converted from one forest type to another. Cost-benefit analyses of this conversion are needed from different stakeholder perspectives to assess the impacts on biodiversity, ecosystem function, and local livelihoods.

In rural communities throughout the tropics, people must balance the need to transform forests into cropland against the goods and services that intact forests provide. A farmer managing a swidden-fallow cycle must weigh the costs and benefits of various ecological and economic factors. During initial community and farm establishment on the forest frontier, all clearing for fields typically occurs in old-growth forests. As time progresses and more fields are left to fallow, farmers must balance the benefits of soil recuperation, the costs of clearing, and the opportunity costs of continuing to farm on old fields. In many cases, once enough secondary forest is available to have a sufficient fallow cycle, cutting of old-growth stands is no longer favored because the larger trees in these forests require far more work to fell and offer only moderately better soil fertility beneath them (Smith et al. 1997). In the Peruvian Amazon, once the full fallow phase of agricultural development has been reached, 60–80% of abandoned fields are recultivated following a fallow period (Smith et al. 1997). In contrast, only 13% of abandoned fields are conserved for the intended purpose of forest product extraction.

Studies on the long-term dynamics of swidden-fallow systems in the Peruvian Amazon show that farmers have a "limited knowledge of the economic potential of secondary forests" (Smith et al. 1997; de Jong et al. 2001). As forest frontiers develop, greater market access often leads to shorter fallow periods, with farmers seeking to increase crop production for sale. Both Smith et al. (1997) and de Jong et al. (2001) conclude that unless local farmers see increased benefits from older secondary forests during the later stages of agricultural development, fallow cycles will continue to shorten. Added benefits could come from the management of economically valuable species in forest fallows or via incentive programs such as carbon-offset credits (Godoy et al. 2000). However, various ethnic groups in different regions of the Amazon already use improved fallow management to add value to secondary forest plots (Dubois 1990), and many groups harvest more products from secondary forest than old-growth stands (Grenand 1992; Kohn 1992; Chazdon & Coe 1999). Before broad conclusions can be drawn about the usefulness of secondary forests and the subsequent implications of their value for agricultural land management, more detailed data should be collected. The value of secondary forests in different age classes has not been analyzed, and although the average per-hectare value of all secondary forests may be low, how this value is distributed among secondary forests of different ages may become key to planning optimal clearing regimens. I sought to help fill this gap through the study of secondary forest use and management.

Methods

Site Location

I focused my work in the three communities closest to the northwestern boundary of the Cordillera Azul National Park in northeastern Peru (6°15′–9°00′S and 75°20′–76°40′W) at an elevation of between 200 and 500 m in tropical moist forest. These communities represent the mixed ethnic heritage of the region: Santa Rosa de Chipaota is a Quechua Lamista indigenous community with a population of 522, and Vista Alegre and Nuevo Loreto (populations of 340 and 400, respectively) are populated by both Quechuas and people of mixed indigenous and Spanish descent.

Sample Selection

Because I could not study the entire population of all three communities (Nuevo Loreto has 80 households, Santa Rosa 88, and Vista Alegre 49), I sampled a subset of households. I sampled households that were within a 2-hour walk of the community center, that were permanent residents of the community, and that had agreed to participate in the study (3 households in Nuevo Loreto, 5 in Santa Rosa, and 2 in Vista Alegre refused to take part). In total, approximately one-third of all households (25 in Nuevo Loreto, 24 in Santa Rosa, and 18 in Vista Alegre) were sampled within each community. A Peruvian university student resided in each community from November 2001 through April 2002 to collect data on the use of forest products on a daily basis from participating families.

Data Collection

Age is an appropriate means of defining forest successional stages in the Cordillera Azul because of the relatively consistent land-use histories in the region. Large-scale pasture establishment has not occurred, and land-use has been dominated by subsistence-level agriculture. I relied on informants' memory of forest stand ages to classify land into fallow fields (1–5 years old), young secondary forest (5–20 years old), and old secondary forests (>20 years old). Because of the lack of more detailed information on land-use history and the limits of locally recognized forest classifications, I designated all forests over 20 years as old secondary. In the communities studied, farmers undertake limited management of fallow lands with occasional trips to collect fruits from some previously planted crops and infrequent weeding to encourage the growth of some planted species.

To define categories of forest product use, informants produced lists of these categories, such as medicine and food. To reduce the total number of use categories, informants sorted the preliminary lists of categories into a smaller subset (Roos 1998; Bernard 2002). The groups of products thus recognized were associated further via hierarchical clustering with Anthropac (Borgatti 1996) to produce six to eight final-use categories. These were food, medicine and poisons, wood (commercial and domestic wood products, including firewood), weavings (e.g., baskets, mats, roofing), adornments (e.g., leather, jewelry, musical instruments), and other. I chose this method instead of a priori designation of categories (Prance et al. 1987; Phillips & Gentry 1993) because it is based on in situ culturally sensitive perceptions of forest use and avoids strong researcher bias.

I quantified forest product use (flora and fauna) in 67 households over a 6-month period spanning both wet and dry seasons to control for seasonal variations in forest product availability. To reduce informant fatigue and encourage long-term involvement, I developed a participatory ethnobiological methodology based on the work of Leesberg and Chavez (1994). Each day, informants recorded the name of the species collected and the quantity (in locally relevant units; e.g., sacks of palm fruit), forest type where the product was collected, whether a special trip was made to collect the forest product or whether it was encountered while on another errand, time spent gathering the product, and whether the good was sold (and its price) or used in the household. In all but one of the households sampled at least one person was literate and able to record the necessary information. In the one illiterate household a neighbor assisted in recording forest product use on a daily basis.

On a weekly basis I used semistructured interviews to review the information recorded by each household to allow for any corrections or clarifications of the size and quantity of goods collected during that week. In these interviews the heads of household identified where they collected each forest product: on their land, on a neighbor's parcel, or on open-access land. Each family typically holds title or usufruct rights over a parcel of land including fields, fallows, and older forest. Open-access lands are not privately owned and include government-controlled lands (such as the national park) and communal land. If a household collected no forest products I recorded a zero, regardless of whether or not the family was present in the community during the week in question. I estimated average weights for each species from interviews or from sample weighings at the end of the study.

I determined the value of goods with one of three prices: community price, forest gate price, or estimated trade value. The community price is the amount of currency paid to purchase a set quantity of a good within the community. Forest gate price is the amount paid by traders who purchase goods in the community to sell in regional markets, or the regional market price minus the costs incurred by a community member traveling to sell forest products. Finally, for those goods not normally bought or sold (e.g., medicinal plants), I modified a method from Godoy et al. (2000). A group of community leaders provided a list of 10 items purchased by community members (e.g., bread, matches, salt) with incrementally increasing prices. I then surveyed community leaders individually to ascertain where on the list of goods with known value the forest product with no known price would fall. I averaged results to produce a final price approximation. I converted prices to U.S. dollars based on the May 2002 exchange rate.

Forest products sold to the market carried only the forest gate price, whereas those consumed in the household I valued using either the village price or the estimated trade value. I subtracted the costs of obtaining the product from the final value (Godoy et al. 1993; Melynk &

Bell 1996). Extraction costs were estimated from a combination of the data on time allocation and the average daily sums paid for wage labor in the communities. I subtracted extraction costs from final values only if a trip was made especially to collect the forest product in question. Costs of extraction also included shotgun shells for hunting trips. I did not subtract the supply costs of machetes, fish nets, and chainsaws from the final forest value because of their long-term use (Melynk & Bell 1996).

To determine a final value in the form of dollars per hectare per year, I divided the final value of the forest product (after cost) by the collection area. I determined collection areas separately by forest type for those products collected on the informant's own parcel, those from a neighbor's land, and those from open-access territory. I estimated each participant's land holdings in semistructured interviews, where heads of households were asked to list all forest holdings with accompanying ages. I checked forest ages against major events in the lives of the family (e.g., childbirths, deaths, major illnesses). When informants indicated that a forest product was collected from a neighbor's parcel, I used the average size of a land holding for the forest type in the community.

I defined open-access lands as those areas not claimed by any family in the participating community or adjoining communities. In the community of Vista Alegre, open-access lands all fell outside the area of influence of local landholders, whereas in Nuevo Loreto and Santa Rosa, open-access lands were within the village boundaries interspersed with private lands and beyond village lands. In Vista Alegre I shadowed key informants on their trips to collect forest products. I considered the average distance informants traveled during collection trips to be the radius of a circular collection area (Godoy et al. 2000). For Nuevo Loreto and Santa Rosa, I further divided the open-access collection area into two zones. Zone 1 covered open-access lands within the community's boundaries. I calculated the total area of zones 1 and 2 using the average distance traveled on collection trips. I calculated the percentages of each forest type in the land holdings of the average participating household and multiplied these percentages by the total area to determine the composition of zone 1. Zone 2 was outside the area of agricultural influence and was composed entirely of old secondary forest. I calculated use values separately for open-access land and private land. I multiplied the dollars-per-hectare values calculated in the 6-month participatory study by (365/[no. of days of data collection]) to determine final use values in dollars per hectare per year.

Analysis

I made three comparisons between forest types: the number of useful species, the value of different use categories, and the overall use values. I analyzed useful species and use categories separately to account for potential difference in species presence between forest types and, in turn, the difference in forest product availability. Forest product availability and a forest's overall use value should influence local forest management decisions. I analyzed the value of use categories within forest types and the overall forest use values with Friedman tests followed by post hoc Nemenyi pairwise comparisons. I also compared the use values of the three forest types after controlling for community, use category, and both community and use category.

Table 1. Number of species extracted from different forest types in three communities in the northern Peruvian Amazon.

	Animals		*Plants*	
Forest type	*total species*	*unique* species*	*total species*	*unique* species*
Fallow fields	45	4 (2)	138	44 (21)
Young secondary	49	3 (0)	109	17 (2)
Old secondary	81	26 (15)	143	46 (27)
All forest types	91		233	

**Unique species are those collected only in that forest type. Numbers in parentheses refer to species unique to that forest type and represented by more than one collection event (nonsingletons).*

Results

Species Harvested

The old secondary forest had the greatest number of species and the highest number of species unique to that particular forest type for both animals and plants (Table 1). Young secondary forest had the smallest number of unique species. Of the 21 plant species unique to fallow fields and used by families more than once, 14 were herbaceous, whereas none of the species collected multiple times in the other forest types—29 in total—were herbaceous. The animal species unique to fallow fields or young secondary forest were all small-bodied birds, rodents, and fishes, whereas many of the animals found only in old secondary forest were large-bodied mammals, such as tapirs (*Tapirus terrestris*), pumas (*Puma concolor*), large primates, and giant armadillos (*Priodontes maximus*). Although the majority of species were found in multiple forest types, this does not indicate that they contributed equally to the overall value of each forest type. For example, participating families recorded use of *Swietenia macrophylla* (for wood) 76 times. Seventy-one of these collection events occurred in old secondary forest, whereas four were in young secondary forest and only one was in fallow fields.

Use-Category Values

Wood, food, and medicine were the three most valuable categories in each of the three forest types on private lands

Table 2. Results of Friedman test comparing values of categories of forest product use in three forest types in the Cordillera Azul, northern Peruvian Amazon.[a]

	All communities		Within communities	
Forest type	p	*post hoc comparisons[b]*	p[c]	*post hoc comparisons[b]*
Fallow fields	<0.001	f > m, v, a, o; w > a	NL 0.157	v > a, o
			SR <0.001	f > m, v > a, o; w > a, o
			VA <0.001	f > w, o > m, v, a
Young secondary	<0.001	w > m, v, a, o; f > v, a, o; m > a, o	NL 0.001	f, m, w > a, o
			SR <0.001	f, w > m, v > a, o
			VA <0.001	w > f, m, v, a, o; f > v, a, o
Old secondary	<0.001	f, w > m > v, a, o	NL <0.001	f, w > m, a, o; v > a, o
			SR <0.001	f, w > m, v > a, o
			VA <0.001	w > f, m, v, a, o; f > v, a, o

[a]n = 67 *families.*
[b]*Abbreviations: f, food; m, medicine and poisons; w, wood; v, weavings; a, adornments; o, other.*
[c]*Abbreviations: NL, Nuevo Loreto; SR, Santa Rosa; VA, Vista Alegre*

(Tables 2 & 3). Due to the very low use values of open-access lands (medians in all forest types of $0/ha/year), I did not compare the value of different use categories in open-access forest types. Food and wood were the only use categories with median values above $0.20/ha/year in each of the forest types (Table 3). In fallow fields, food was significantly more valuable than four of the five other use categories (Table 2). When I combined data from all informants (Table 4), wood had an overall value nearly three times that of the second most valuable category, food. However, analyzing data separately by informant ($n = 67$; Table 2) showed wood to be significantly

Table 3. Values of use categories in different forest types for 67 households from three communities in the Cordillera Azul, Peruvian Amazon.

			Range ($/ha/year)	
Forest type	*Use category*	*Median value ($/ha/year)*	*minimum*	*maximum*
Fallow fields (private lands)	all	8.20	−5.60	305.70
	food	1.19	−1.90	66.78
	wood	0.00	−4.27	281.63
	medicine	0.10	−4.70	41.90
	weavings	0.00	−0.20	21.50
	adornments	0.00	−1.98	7.66
	other	0.00	0.00	24.60
Fallow fields (open-access lands)	all	0.00	0.00	4.00
Young secondary (private lands)	all	28.60	−3.85	1034.80
	food	2.40	−1.99	121.06
	wood	3.30	−7.50	1000.90
	medicine	0.00	−10.80	88.50
	weavings	0.00	−9.65	110.82
	adornments	0.00	−0.49	5.12
	other	0.00	−0.05	20.99
Young secondary (open-access lands)	all	0.00	−0.20	458.60
Old secondary (private lands)	all	6.80	0.00	1183.00
	food	1.02	−0.25	301.84
	wood	3.50	0.00	1167.20
	medicine	0.10	0.10	48.20
	weavings	0.20	−3.70	15.50
	adornments	0.00	−12.99	2.79
	other	0.00	−1.99	8.73
Old secondary (open-access lands)	all	0.00	0.00	2.30

Table 4. Total value of forest products and number of species used from different forest types in the Cordillera Azul, Peruvian Amazon.*

Use category	*Forest type*	*Value in private lands ($/ha/year)*	*Value in open-access lands ($/ha/year)*	*Number of species*
Food	fallow	5.21	0.76	79
	young secondary	2.24	0.82	78
	old secondary	2.18	0.61	115
Medicine	fallow	3.48	0.05	67
	young secondary	8.48	0.29	40
	old secondary	1.30	0.03	48
Wood	fallow	14.24	1.17	28
	young secondary	30.09	5.22	34
	old secondary	9.84	2.43	63
Weavings	fallow	3.13	0.01	10
	young secondary	4.31	0.05	12
	old secondary	0.84	0.05	21
Adornments	fallow	0.27	0.02	23
	young secondary	0.40	−0.52	14
	old secondary	0.34	0.02	47
Other	fallow	4.72	0.17	10
	young secondary	4.12	−0.16	8
	old secondary	0.25	0.00	17

**Data represent composite values for all 67 families participating in the study.*

larger in value than only adornments. This reflects the highly skewed distribution of wood values from fallow fields. Although 57 families had fallow-field food values above zero, only 19 had positive wood values. Of the 19 positive values for wood, 10 were above $10/ha/year and 2 were above $200/ha/year. Of the 57 families with food values above zero, only 10 had values above $10/ha/year, and none were over $70/ha/year.

In both young and old secondary forests, wood (median values of $3.30/ha/year and $3.50/ha/year, respectively) had a greater value than medicine, weavings, adornments, and other uses but was not significantly different from food (median values of $2.40/ha/year and $1.02/ha/year) (Table 2). In both of the older forest types, food appeared to be the second most valuable category, with more worth than three (young secondary) or four (old secondary) of the five other use categories. Medicine was the third most valuable use category in young and old secondary forests. Medicine always maintained a higher value than both adornments and other uses in both of these forest types, whereas in young secondary forests the value of medicine was also statistically greater than weavings and could not be differentiated from food. The median value of medicine in each use category, however, was never above $0.10/ha/year.

Of the 3672 forest product collection events recorded, local families used items for home consumption in 3301 (90%) of the cases and sold the products in only 371 (10%) of the events.

Forest-Type Values

Friedman test results pointed to significant differences in the values of the three forest types on private lands, with post hoc comparisons showing young secondary forests to be of significantly greater value than old secondary forests ($p = 0.012$; Table 5). This pattern was also evident in the median values for each of the three forest types: fallow fields at $8.20/ha/year, young secondary forest at $20.60/ha/year, and old secondary forest at $6.80/ha/year (Table 3). The range of values for each forest type was large, however, and the distributions were far from normal. Just over half the families (35 of 67) extracted a greater value of forest products from young secondary forests than from either of the two other forest types.

When I analyzed forest use values separately by community and/or use category, results varied. When I examined communities separately, only Nuevo Loreto showed any significant difference in the use value of the three forest types ($p = 0.001$; Table 5). In Nuevo Loreto, young secondary forest was of greater value than either fallow fields or old secondary forest.

The only use category that demonstrated a difference in forest values was wood ($p = 0.015$; Table 5), in which old secondary forests were of the most value (median value of $3.50/ha/year) and significantly more valuable than fallow fields (median value of $0.00/ha/year) (Tables 3 & 5). Forest types differed in value as sources of wood products in Nuevo Loreto ($p = 0.015$; Table 5) and Santa Rosa ($p = 0.093$; Table 5). In both of these communities, wood products from old secondary forests were worth more than those from fallow fields, whereas the results for wood from young secondary forests varied. The relative values of forests as food sources also varied within some communities. In both Santa Rosa ($p = 0.073$; Table 5) and Vista Alegre ($p = 0.023$; Table 5), secondary forests (both young and old) were worth more than fallow fields, but in Nuevo Loreto forest values for food products did not

Table 5. Results of Friedman test comparing forest-use values ($/ha/year) for different forest types in 6-month study in the Cordillera Azul, northern Peruvian Amazon.

Data included			
community[a]	*use category*	p *value*[b]	*post hoc comparison*[c]
All (private)	all	0.012**	b > c
All (open-access)	all	0.009**[d]	
Community differences (private land)			
NL	all	0.001**	b > a, c
VA	all	0.329	
SR	all	0.503	
Use category differences (private land)			
all	food	0.532	
all	medicine	0.724	
all	wood	0.015**	c > a
all	weavings	0.427	
all	adornments	0.439	
all	other	0.152	
Significant categories within communities (private land)			
NL	wood	0.015**	b, c > a
SR	wood	0.093*	c > a, b
SR	food	0.073*	b, c > a
VA	food	0.023**	b > c > a
VA	other	0.090*	a > b, c

[a]*Abbreviations: NL, Nuevo Loreto; SR, Santa Rosa; VA, Vista Alegre. Private lands consist of parcels owned by participating families or neighbors' parcels that participating families use for forest extraction. Open-access lands are not owned by any community member.*
[b]*Significance level:* ***$p < 0.001$; **$p < 0.05$; *$p < 0.1$.
[c]*Abbreviations: a, fallow fields; b, young secondary; c, old secondary.*
[d]*Nemenyi's post hoc pairwise comparisons indicate no significant difference between any forest-type pairing. Post hoc sign tests point to significant differences with b, c > a.*

differ. In the other four use categories (medicine, weavings, adornments, and other) I found no difference between the values of the three forest types in any of the three communities.

The young secondary forest of the community of Nuevo Loreto was the only forest type in any of the three communities that had a value significantly higher than that of the other two forests, and wood was the only category with differences in forest values in this community. Of the 27 families from Nuevo Loreto that participated in the study, 12 extracted a greater value of wood products per hectare from young secondary forests than any other forest type. In the 12 families, 11 species provided most of the wood-based value of young secondary forest, but only four species, *Guazuma crinita*, *Alseis* spp., *Ochroma pyramidale*, and *Gynerium sagittatum* were used by more than three families. These 12 families used all but two of the actual trees they cut down for house construction. Half of these 12 families had arrived in the community within the last year, and the materials were being collected for first-time house construction, whereas the others were extracting wood for routine house maintenance. None of the families sampled in the other two communities had arrived within the last year.

The overall per-hectare value of open-access lands was minimal (Tables 3 & 5). The collection zones on open-access lands (>5000 ha/community) covered much larger areas than on private holdings. Although the total value of forest products after cost on these lands was very high, $25,979, or 52% of the total value of all extracted products ($50,192), the median per-hectare values of open-access lands in each forest type were all $0.00/ha/year. As was the case with all forest values presented here, there was notable variation among the families harvesting products. In fallow fields on open-access lands, only seven families had forest use values over $0.00/ha/year, and only one family extracted more than $1.00/ha/year from open-access fallows. In young secondary forests, 11 families extracted more than $1.00/ha/year worth of goods from open-access young secondary plots, and only one collected more than $100.00/ha/year. In old secondary forests, only two families extracted more than $1.00/ha/year.

Discussion

The value of goods that different families extract from forests of different age classes varied enormously. Although such variation in results among the different participating families does not lend itself to broad generalization about land use, some patterns do emerge.

The median values of secondary forests in the Cordillera Azul were low (between $6.80/ha/year and $28.60/ha/year). The values of these forests on a per-hectare basis were lower than most previous estimates of values for forest product use. Costanza et al. (1994) reviewed studies worldwide on the extraction of food and raw materials from rainforests and found values between $49.00/ha/year and $1089.00/ha/year. In addition, Godoy et al. (1993) analyzed results from 24 different studies of nontimber forest products in the tropics and found a median value of $50.00/ha/year. More recently, long-term studies of forest use in Honduras and Bolivia used more rigorous methodologies and produced much lower local use values for tropical rainforest stands, $7.10–9.70/ha/year (Godoy et al. 2002). None of these previous studies, however, examined how forest value changes over ecological succession.

Forest stands in the tropics, regardless of age, appear to be less valuable than alternative land uses that follow forest conversion. Pinedo-Vasquez et al. (1992) reached a similar conclusion in comparing extraction of nontimber forest products with agriculture- and pasture-based incomes in Peru. Swidden agricultural plots were worth an average of $137.00/ha/year over a typical 7-year rotation. The collection of fruits and latexes from the forests yielded only $43.00/ha over a 2-year period. Similarly, in the Cordillera Azul, the per-hectare value of at least two major agricultural products, coffee ($167.00/ha/year) and coca ($197.00/ha/year), greatly outweighed the annual net gain from forest product collection (Gavin 2002). This leads to the conclusion that local people can be expected to continue to clear forests of any age for agriculture unless they are given incentives to conserve forest. Godoy et al. (2000) suggest that conservation cannot depend on local forest use value and that local people need to be compensated (e.g., with carbon sequestration credits) for the regional and global ecological services provided by the land they own and manage. Costanza et al. (1994) estimate the value of the ecological services provided by tropical forests at over $2000/ha/year.

When analyzing the conservation implications of low forest use values, researchers must also recognize the limits of current methods of valuing forest. The high percentage of forest products used for home consumption (90%) in the Cordillera Azul highlights the need for forest-valuation techniques that accurately quantify this local use. Several recent studies point out the challenges in studying home consumption of forest goods and call for the use of direct-observation methods similar to those employed in this study (e.g., Gram 2001; Gavin 2002; Godoy et al. 2002). In addition, in focusing only on the market value of forest food products, forest-valuation studies have not included the externality represented by the nutritional value of local forest-based foods.

Forest conservation can also ensure access to medicinal plants, which often serve as the principal health-care option for both local rural people and regional urban residents (Shanley & Luz 2003). Forest-valuation methods often exclude the health-care value of forests for nonlocal residents.

Current valuation methods also do not quantify the importance of forests as “natural insurance” or “safety nets” to local people. The collection of forest goods may serve as an alternative income or subsistence product source in case of agricultural failure, and it can help provide emergency cash flow (Pattanayak & Sills 2001; Wunder 2001).

Although per-hectare values of forests across all age classes may be relatively low, the overall contribution of forests to local economies through increased earnings and home consumption rates may be significant (Godoy et al. 2002). Despite the fact that forest conservation may be crucial for sustaining local communities, poor market access and low densities of commercial species in many tropical areas may limit the role forests can play in poverty alleviation (Wunder 2001). Although many valuation studies show consistently low forest use values, forest conservation can still be considered vital to the survival of rural communities because of the important functions that forests fulfill for local nutrition, alternative health care, and food and economic security.

A comparison of per-hectare use values among different-aged forests yields important information for the local management of swidden-fallow agricultural systems. For example, in two of the communities surveyed, Santa Rosa and Vista Alegre, I observed no change in forest value as a result of ecological succession. What did change, however, was the importance of the different use categories. Fallow fields produced a higher value of forest products extracted for food. As forests age, wood becomes increasingly important. In forests over 20 years old, wood provided the greatest value per hectare of any forest good.

If farmers in these two communities wish to maximize land value while ensuring access to all necessary forest products, they should manage swidden-fallow cycles to encourage the greatest range of forest ages possible. The ideal management regime would involve a diversity of fallow periods, with clearing alternating between different-aged forests. Because all forest types on private land in these communities are not significantly different in value, this land-use scenario would not affect the overall value of a farmer’s parcel. It would, however, guarantee access to an array of different species and tree sizes.

The impacts of a diversity of fallow periods on crop production and biological diversity would be more variable. The older the forest before it is cleared, the better the soil fertility and the better the crop yield but the more difficult the task of clearing. A system that varies the age of forest stands to be cleared may also allow farmers to hedge their bets between higher initial clearing costs and higher potential crop production versus lower clearing costs with lower possible benefits. In terms of biodiversity, the greatest richness is undoubtedly in the older forest stands. Any swidden-fallow system that can minimize the cutting of older forest stands will maximize the conservation of biological diversity. However, in developing management plans for buffer zones around national parks based on an integrated conservation and development approach, such as those in communities surrounding the Cordillera Azul, a proper balance must be struck between biodiversity conservation and maximum possible land-use values for local people. If private land parcels can be managed to maximize benefit, then less pressure may be placed on the resources in open-access lands, including within the park.

The value and management of open-access lands is distinct from those of the private holdings. Open-access lands were worth the most in terms of total value, but the large area they covered means that per-hectare values were negligible relative to those of private lands. The need for continued access to the resources provided by open-access areas is clear based on their overall worth, but few incentives exist for individual community members to properly manage this land. Although the use values of private holdings established by this study provide the impetus for particular land-use decisions, the data from open-access areas only provide additional evidence of the “tragedy of the commons.”

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