Valuation of an Amazonian rainforest

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Exploitation of non-wood resources would provide profits while conserving Amazon forests. Yet little is done to promote their development.

TROPICAL forest resources have traditionally been divided into two main groups: timber resources, which include sawlogs and pulpwood; and non-wood or 'minor' forest products, which include edible fruits, oils, latex, fibre and medicines. Most financial appraisals of tropical forests have focused exclusively on timber resources and have ignored the market benefits of non-wood products. The results from these appraisals have usually demonstrated that the net revenue obtainable from a particular tract of forest is relatively small, and that alternative uses of the land are more desirable from a purely financial standpoint. Thus there has been a strong market incentive for destructive logging and widespread forest clearing.

We contend that a detailed accounting of non-wood resources is required before concluding *a priori* that tropical deforestation makes financial sense. To illustrate our point, we present data concerning inventory, production and current market value for all the commercial tree species occurring in one hectare of species-rich Amazonian forest. These data indicate that tropical forests are worth considerably more than has been previously assumed, and that the actual market benefits of timber are very small relative to those of non-wood resources. Moreover, the total net revenues generated by the sustainable exploitation of 'minor' forest products are two to three times higher than those resulting from forest conversion.

Our findings are based on an appraisal of an area along the Rio Nanay near to the small village of Mishana (3°47'S, 73°30'W), 30 km south-west of the city of Iquitos, Peru. Annual precipitation in the region averages 3,700 mm; soils are predominantly infertile white sands. The inhabitants of Mishana are detribalized indigenous people called *ribereños* who make their living practising shifting cultivation, fishing and collecting a wide variety of forest products to sell in the Iquitos market.

A systematic botanical inventory of 1.0 ha of forest at Mishana showed 50 families, 275 species and 842 trees ≥ 10.0 cm in diameter[1]. Of the total number of trees on the site, 72 species (26.2%) and 350 individuals (41.6%) yield products with an actual market value in Iquitos. Edible fruits are produced by seven dicotyledonous and four palm species, sixty species produce commercial timber and one species, *Hevea guianensis* Aubl., produces rubber. The forest also contains medicinal plants, lianas and several understorey palms of commercial importance in the region, yet these species were too small to be included in our sample.

Annual production rates for all the fruit trees and palms in our sample area were either measured by counting and weighing all the fruits produced by a sub-sample of adult trees (4 species), or estimated from interviews with local collectors (7 species). Latex yields for wild *Hevea* trees were taken from the literature[2]. The merchantable volume of each timber tree was calculated using published regression equations relating diameter at breast height (137 cm) to commercial height[3].

TABLE 1 Annual yield and market value of fruit and latex produced in one hectare of forest at Mishana, Rio Nanay, Peru

Common name	Species	No. trees	Annual production per tree	Unit price (US$)	Total value (US$)
Aguaje	*Mauritia flexuosa* L.	8	88.8 kg	10.00/40 kg	177.60
Aguajillo	*Mauritiella peruviana* (Becc.) Burrett	25	30.0 kg	4.00/40 kg	75.00
Charichuelo	*Rheedia* spp.	2	100 fruits	0.15/20 fruits	1.50
Leche huayo	*Couma macrocarpa* Barb. Rodr.	2	1,060 fruits	0.10/3 fruits	70.67
Masaranduba	*Manilkara quianensis* Aubl.	1	500 fruits	0.15/20 fruits	3.75
Naranjo podrido	*Parahancornia peruviana* Monach.	3	150 fruits	0.25/fruit	112.50
Sacha cacao	*Theobroma subincanum* Mart.	3	50 fruits	0.15/fruit	22.50
Shimbillo	*Inga* spp.	9	200 fruits	1.50/100 fruits	27.00
Shiringa	*Hevea quianensis* Aubl.	24	2.0 kg	1.20/kg	57.60
Sinamillo	*Oenocarpus mapora* Karst.	1	3,000 fruits	0.15/20 fruits	22.50
Tamamuri	*Brosimum rubescens* Taub.	3	500 fruits	0.15/20 fruits	11.25
Ungurahui	*Jessenia bataua* (Mart.) Burret	36	36.8 kg	3.50/40 kg	115.92
Totals		117			697.79

Fruit yields measured for *M. flexuosa*, *J. bataua*, *P. peruviana* and *C. macrocarpa*; estimated yields for other fruit trees based on interviews with local collectors.

We collected average retail prices for different forest fruits in 1987 by making monthly surveys of the Iquitos produce market. We obtained rubber prices, which are officially controlled by the Peruvian government, from the agrarian bank office. Four independent sawmill operators in Iquitos were interviewed to determine the mill price of each timber species. All market data were converted from Peruvian intis to 1987 US dollars using an exchange rate of 20 intis to the dollar.

The labour investment associated with fruit collection and latex tapping was estimated in man days per year based on interviews and direct observation of local collecting techniques. We then calculated cumulative harvest costs using a wage rate of US$2.50 per man day, the minimum wage in Peru during 1987. Based on previous studies conducted in Mishana[4], we assumed that transport costs for fruit and latex are 30% of the total market value of these products. Studies by the Food and Agriculture Organization[5] suggest that logging and transport costs in the Peruvian lowlands equal 30–50% of the total value of the timber harvested; we used a 40% extraction expense in our study.

Based on our estimates of the density, productivity and market price of each fruit tree and palm, one hectare of forest at Mishana produces fruit worth almost $650 each year (Table 1). Annual rubber yields amount to about $50. After deducting the costs associated with collecting and transporting this material to market, net annual revenues from fruit and latex are $400 and $22, respectively.

Given that both fruit and latex can be collected every year, the total financial value of these resources is considerably greater than the current market value of only one year's harvest. Clearly, the net revenue generated by all future harvests must also be estimated and included in the analysis. We used a simple discounting model to calculate the net present value (NPV) as V/r, where V is the net revenue produced each year and r is a 5% inflation-free discount rate, of these annuities. Assuming that 25% of the fruit crop is left in the forest for regeneration, the NPV of sustainable fruit and latex harvests is estimated at $6,330 per hectare.

The Mishana forest also contains 93.8 $m^3 ha^{-1}$ of merchantable timber (Table 2). If liquidated in one felling, this sawtimber would generate a net revenue of $1,000 on delivery to the sawmill. A logging operation of this intensity, however, would damage much of the residual stand and greatly reduce, if not eliminate, future revenues from fruit and latex trees. The net financial gains from timber extraction would be reduced to zero if as few as 18 fruit trees were damaged by logging.

Periodic selective cutting presumably would be more compatible with annual fruit and latex collection. Yield functions derived for the 60 commercial timber species at Mishana using stand-table projection and a mean diameter increment of 0.3 cm yr^{-1} indicate a maximum sustainable harvest of about 30 $m^3 ha^{-1}$ every 20 years. Multiplying this volume by a weighted average market price of \$17.21 m^{-3} and deducting harvest and transport costs gives a net revenue of about \$310 at each cutting cycle. Discounting a perpetual series of these periodic revenues back to the present yields a net present value (NPV = $V/(1-e^{-rt})$, where t is the number of years between harvests), of \$490 for timber.

Based on the assumption of sustainable timber harvests and annual fruit and latex collection for perpetuity, we estimate that the tree resources growing in one hectare of forest at Mishana possess a combined financial worth of \$6,820. Fruits and latex represent more than 90% of the total market value of the forest, and the relative importance of non-wood products would increase even further if it were possible to include the revenues generated by the sale of medicinal plants, lianas and small palms. In view of the disproportionately low NPV of wood resources and the impact of logging on fruit and latex trees, timber management is a marginal financial option in this forest.

We acknowledge that these projections are subject to temporal changes in market prices, production levels and harvest intensities that could either increase or decrease the actual market benefits obtainable from the forest. Moreover, we realize that not every hectare of tropical forest will have the same market value as our plot in Mishana. Further studies are needed to determine how floristic composition, productivity and distance to markets influence the financial worth of a forest. Yet we believe that the NPVs calculated in this study provide a useful economic benchmark for comparing alternative land-use practices and management options for Amazonian forests.

Our results indicate that the financial benefits generated by sustainable forest use tend to exceed those that result from forest conversion. Using identical investment criteria, that is discounting a perpetual series of net revenues at a 5% interest rate, the NPV of the timber and pulpwood obtained from a 1.0-ha plantation of *Gmelina arborea* in Brazilian Amazonia is estimated at \$3,184 (ref. 6), or less than half that of the forest. Similarly, gross revenues from fully-stocked cattle pastures in Brazil are reported[7] to be \$148 $ha^{-1} yr^{-1}$. The present value of a perpetual series of such pastures discounted back to the present is only \$2,960, and deducting the costs of weeding, fencing and animal care would lower this figure significantly. Both these estimates are based on the optimistic assumption that plantation forestry and grazing lands are sustainable land-use practices in the tropics.

TABLE 2 Merchantable volume and stumpage value of the commercial timber tree in one hectare of forest at Mishana, Rio Nanay, Peru

Commercial name	Genera included	No. trees	Wood volume (m^3)	Mill price (per m^3) (US\$)	Stumpage value (US\$)
Aguano masha	*Trichilia*	4	0.55	14.80	4.88
Almendro	*Caryocar*	1	0.08	14.80	0.71
Azucar huayo	*Hymenaea*	1	0.10	14.80	0.89
Cumala	*Iryanthera, Virola*	83	19.77	19.00	225.38
Espintana	*Guatteria, Xylopia*	7	1.47	21.00	18.52
Favorito	*Osteophloeum*	2	3.90	14.80	34.63
Ishpingo	*Endlicheria*	4	0.82	14.80	7.28
Itauba	*Mezilaurus*	3	0.29	14.80	2.57
Lagarto caspi	*Calophyllum*	2	0.25	40.30	6.04
Loro micuna	*Macoubea*	1	1.37	14.80	12.17
Machimango	*Eschweilera*	5	0.76	20.15	9.19
Machinga	*Brosimum*	10	24.61	14.80	218.53
Moena	*Aniba, Ocotea*	6	0.75	42.00	18.90
Palisangre	*Dialium*	1	0.27	14.80	2.39
Papelillo	*Cariniana*	1	1.19	14.80	10.57
Pashaco	*Parkia*	19	4.19	14.80	37.21
Pumaquiro	*Aspidosperma*	12	10.22	14.80	90.75
Quinilla	*Chrysophyllum, Pouteria, Manilkara*	34	9.18	31.80	175.15
Remo caspi	*Swartzia, Aspidosperma*	28	11.65	14.80	103.45
Requia	*Guarea*	4	1.06	14.80	9.41
Tortuga caspi	*Duquetia*	1	0.13	14.80	1.15
Yacushapana	*Terminalia*	2	0.71	14.80	6.31
Yutubanco	*Heisteria*	2	0.53	14.80	4.70
Totals		233	93.85		1,000.78

Twenty-three commercial names represent 28 genera and 60 tree species.

The results from our study clearly demonstrate the importance of non-wood forest products. These resources not only yield higher net revenues per hectare than timber, but they can also be harvested with considerably less damage to the forest. Without question, the sustainable exploitation of non-wood forest resources represents the most immediate and profitable method for integrating the use and conservation of Amazonian forests. Why has so little been done to promote the marketing, processing and development of these valuable resources?

We believe that the problem lies not in the actual value of these resources, but in the failure of public policy to recognize it. Tropical timber is sold in international markets and generates substantial amounts of foreign exchange; it is a highly visible export commodity controlled by the government and supported by large federal expenditures. Non-wood resources, on the other hand, are collected and sold in local markets by an incalculable number of subsistence farmers, forest collectors, middlemen and shop-owners. These decentralized trade networks are extremely hard to monitor and easy to ignore in national accounting schemes.

The non-market benefits of tropical forests have been discussed recently[8,9]. Tropical forests perform vital ecological services, they are the repository for an incredible diversity of germplasm, and their scientific value is immeasurable. The results from this study indicate that tropical forests can also generate substantial market benefits if the appropriate resources are exploited and properly managed. We suggest that comparative economics may provide the most convincing justification for conservation and use of these important ecosystems. □

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