ELSEVIER

Ecological Economics 36 (2001) 109–117

ECOLOGICAL ECONOMICS

www.elsevier.com/locate/ecolecon

ANALYSIS

Economic valuation of special forest products: an assessment of methodological shortcomings

Søren Gram *

Centre for Development Research, The Danish Board of Technology, Antonigade 4, DK-1106 Copenhagen K, Denmark

Received 15 July 1998; received in revised form 6 June 2000; accepted 16 June 2000

Abstract

The study analyses strengths and weaknesses of different methods for calculating the economic importance of forest products extracted by rural populations. The results show that methods frequently used by scholars are subject to serious uncertainty. The study is based on a 1-year survey in two flood plain villages in the Peruvian Amazon. Different methods were studied in relation to local extraction of timber and non-timber products, including plants, fish and animals. Both products for the market and for subsistence use have been included. A combination of interview methods, observations and notes taken daily by the households was applied.

Keywords: Peru; Amazon; Rainforest; Timber; Non-timber; Indigenous peoples; Extraction

1. Introduction

The Earth Summit in 1992 led to increasing political attention to environmental problems resulting from global deforestation (UN, 1992). Yet, there is no indication that the deforestation rate of natural tropical forests has decreased. Destructive mining operations, plantations, non-sustainable logging and conversion of forest land to large-scale agriculture are still economically favourable options compared to such activities as sustainable extraction of non-timber forest products that could preserve the natural forest.

Two main causes of this fact can be identified. First, several services provided by the forest, such as CO_2 storage, conservation of biodiversity and maintenance of regional climate, represent externalities for companies investing in large-scale economic operations in the forests.

Second, a wide range of products from natural forests, rivers and lakes is extracted by local forest dwellers. However, these products are mainly used for subsistence purposes or exchanged at local markets; therefore, they are less attractive for commercial investments and non-local decision makers.

* Fax: +45-33910509.
E-mail address: sg@tekno.dk (S. Gram).

0921-8009/01/$ - see front matter
PII: S0921-8009(00)00213-5

For example, while extraction of non-timber products has been carried out by local dwellers, timber companies have completely dominated the commercial market outside the forest. This has led to a situation where timber management has excluded and often destroyed non-timber products.

The purpose of this paper is to assess different methods for valuating local extraction activities and improving studies of local use-values in order to give weight to such local forest products in land-use planning.

In this study, forest products are defined as products found and used by local dwellers in forest areas. These include wood products as well as non-timber products such as fish, animals, fruits, medicinal plants and other plant products.

In recent years, scholars have tried to valuate the economic importance and sustainability of local extraction activities in order to adjust the market failures and search for ways to include the local economy of forest products in land-use planning (Broekhoven, 1996; Hedge et al., 1996; Melnyk and Bell, 1996; Olsen, 1997).

These studies have contributed to the understanding of subsistence economy. However, the figures presented so far regarding local extraction of forest products span from a yearly per hectare value of less than one US$ to several hundred US$ (Godoy et al., 1993). In some cases it is concluded that non-timber forest products could bring significant benefits to poorer sections of rural communities (Myers, 1988; Balick and Mendelsohn, 1992; Adger et al., 1995). In other cases the scholars are more sceptical (Browder, 1992; Pérez, 1995). Further, the results are rather difficult to compare because of biological and socioeconomic differences between the study areas.

Even studies carried out in the same areas have produced different results regarding the economic importance of the same products (Padoch and de Jong, 1989; Peters et al., 1989). Thus, a closer look at different valuation methods is needed.

Some methods are based on inventories, for example, counting the amount of medicinal plants or fruit produced in one hectare of forest and multiplying this by the market price (Peters et al., 1989). This method has been criticised for leading to maximum harvesting assessments and unrealistic expectations regarding the economic potential of forest product extraction because issues related to limited markets, sustainability, durability, collection and transport to markets have not been taken sufficiently into account. (Bodmer, 1990; Pinedo-Vasquez et al., 1990).

In such calculations of potential per-hectare values, sociocultural factors among the forest dwellers are often left out. Economic analyses are needed that integrate the context of the choices faced by rural populations. These should include local factors that will influence land-use priorities, such as lack of secure land tenure, low level of price stability for forest products, non-economic preferences, and traditions and taboos regarding extraction of certain products.

Some scholars have tried to cope with these problems by refining the inventory method and using local collectors in ethnobotanical surveys (Grimes et al., 1994). This method creates valuable supplementary knowledge, but is still subject to some uncertainty, however, (as pointed out by the authors themselves), because the local collectors have no experience harvesting sustained maximum levels for market sale.

As an alternative, studies based on interviews with forest dwellers regarding their actual harvest have been used (Padoch, 1988; Hedge et al., 1996). In some cases, the interview method can be used with advantage, but in other cases, as discussed in this paper, the method can be subject to serious uncertainty. People may find it difficult to remember details and researchers and local dwellers often have different understandings of what can be regarded as extraction activities.

Some studies simply ignore the extraction of timber products (Grimes et al., 1994) in spite of the fact that they are frequently used for a range of different purposes such as local construction of houses and canoes.

Other problems arise if the studies of forest products do not cover a whole-year cycle or do not include both market and subsistence products (Padoch, 1988). Some studies include only terrestrial animals (Paucar and Gardner, 1981), some only fish (Beyley and Petrere, 1989) and others only flora (Schwartzman, 1989).

2. Case study

2.1. Area and population

The case study area is situated in the Peruvian Amazon ~170 km south of the main town, Iquitos, which is connected to the area via the Ucayali River. The forest inundates annually, particularly from March to May, leaving only the highest areas dry. The flooding has prevented forest conversion into plantations or cattle ranging, so there are still huge areas of natural forest. Kvist et al. (1995) describe the project area in more detail.

The occupation of the flood plain people in the area is mainly based on a combination of farming, fishing, hunting and extraction of forest products. Some flood plain people are immigrants from other forest areas, and some are descendants of the Cocama Indians who traditionally inhabit the area.

2.2. Methods applied

As an alternative to inventories that count the amount of different products located in the forest, we have studied the actual local extraction and use of forest products. Such valuation considers local preferences and current market conditions for both timber and non-timber products. The method gives a picture of forest value under actual sociocultural conditions.

Selection of the village households to participate in the study took place as follows: (i) interviews in ten flood plain neighbouring villages with similar occupation and access to market; (ii) selection of two typical villages, one village primarily inhabited by Cocama Indians (Casa Grande, 34 households) and a larger village dominated by non-Cocamas (Yanallpa, 82 households); (iii) interviews with all households in these two villages, and (iv) selection of six households in each of the two villages for close collaboration during 1 year from September 1994 to September 1995.

The selected households represent various levels of extraction activities in relation to different forest products. They correspond to the levels of activities found during the interviews among the households in the two villages. Subsequently, weekly field-work in the villages confirmed that the 12 selected households represent the general level of activities in an adequate way.

Data were collected among the 12 households regarding:

- which products the local dwellers actually extract from forest, rivers and lakes,
- quantity of products extracted,
- where they are collected,
- preparation and end use of products,
- value of products,
- farming activities (yield and economic value),
- other income,
- time used for the different activities.

Different methodological approaches were applied:

i. The 12 households wrote down their activities daily in a notebook (which products, where collected, how much, etc).
ii. People from each household were interviewed every 14th day regarding their activities during the previous 14 days.
iii. People were regularly asked about yesterday's meal.
iv. Every month people were asked about their general main activities that month.
v. Every week throughout the year, 3 days (and 2 nights) were spent at the 12 households in turn, in order to observe daily activities.

In addition, market prices were collected every month at the local market and at the main market in Iquitos.

A comparison of the collected data shows that the different methods applied led to widely different results. Therefore, it became necessary to make an appraisal to determine the limits of each method in relation to the different topics.

3. Discussion of methods

3.1. Calculating value of forest products

To determine the quantity of products collected, their location, preparation, end use and value, the different methods applied (i–v) were used in combination. The 14th-day interviews (method ii) were based on a questionnaire, but

people were asked supplementary questions according to results obtained from the other methods.

The households' notebooks (method i) were often used in the 14th-day interviews (method ii). We could ask specific questions based on the activities recorded in the book. For example, if it were said that no game was caught during the previous 14 days, while the notebook recorded that the male spouse had been on a hunting trip, more details could be requested. A possible motive for any discrepancy could be that people are cautious not to mention catching of protected animals.

Observations made during the weekly stays at the different households (method v) were much used at the 14th-day interviews (method ii)to ask for specific information which people did not recall themselves or record in their notebooks. A few examples illustrate this:

- When people are in the forest, e.g. to hunt or fish, they often collect a variety of fruits and the like to eat during the stay. People did not regard this as an activity in itself and did not record it.
- Repairing the canoe for 1.5 h before a fishing trip was typically seen as a 'delay' rather than an activity and was not recorded.
- Bringing back resins from a fishing trip (e.g. to repair the canoe) was not registered separately. It was regarded as part of the fishing activity and not as a gathering activity for construction. Thus, the value of the resin was not recognized.

Fishing is a main activity in which most household members participate. While the male spouse is away on a longer fishing trip with net or spear, some children may go to the river with a hook and catch their meal. In this way, fish come to the hut daily from here and there, making it difficult for people to recall the exact amount or number of the different species consumed. But when the fish are sold, this takes place at one time in large quantities to passing buyers. This makes the amount sold much easier for people to remember than the amount consumed.

During observations (method v), we collected important information about the diversity of fishing activities. However, method (iii), asking about yesterday's meal, proved to be an effective short-cut to contribute realistic results regarding the quantity of fish consumed.

Based on the quantity of collected products, the economic value was calculated (Table 1). Costs related to obtaining or processing the products were deducted, for example, cost of cartridges, fishing equipment and salt for food preservation.

The value of the products is equal to the forest gate price, meaning the price paid by a local or passing buyer for the collected or processed product. If the collector himself brings the product to market to get a better price, costs related to transportation are deducted.

The value of products used for domestic consumption or local exchange are analogously calculated as the forest gate price, corresponding to the price that the local dweller would pay if he were to buy the product. Values of products never sold were estimated on the basis of observations of local exchange with other products. The value in Peruvian Soles was converted into the USD equivalent according to the current exchange rate.

Fish constitute a basic source of local consumption and represent a substantial value for the local dwellers. Because of the yearly flooding, fish enter the forest in the rainy season and feed, for example, on fruit from trees. Thus, fish are an important natural forest product.

The quantity of natural forest products used locally for subsistence forms a more important part in the local economy in the two villages than the quantity taken to market. The extracted forest

Table 1
Average value per household of natural forest products extracted by the 12 households in 1 year[a]

Type of product	Consumption and local exchange	Sold	Total
Fish	678	222	900
Game	70	20	90
Gathering[b]	371	297	668
Total	1119	539	1658

[a] By type of products (US$).
[b] Fruit, timber, leaves, fibre, herbs, palm heart, honey, firewood, aquarium fish, eggs, resin, etc.

products were found to make up 57% of the local economic value compared to products from fields (including fallow and domestic animals) which make up 41%, and other income (mainly wages) making up 2%.

The household income[1] in the non-Cocama village, Yanallpa, was 28% larger than in the Cocama village, Casa Grande. The difference is mainly due to more active farming among the non-Cocama residents, while the Cocamas had a more relaxed attitude.

Scholars often deduct the cost of labour from the net-income (Peters et al., 1989; Houghton and Mendelsohn, 1996). This is somehow misleading if the purpose is to compare the income from forest activities with other income-generating activities, such as wage labour. Furthermore, in this area the socioeconomic reality is that, except for a few 'patrons', it is not a realistic option for the local people to hire someone else to extract forest products.

If long-term land-use planning is to be implemented, a discount rate should be applied allowing a comparison of the future economic potentials in alternative options.

The point-of-view in this paper is the actual extraction of forest products based on a day-to-day decision made by the local forest dwellers. The different alternatives consist of extraction, slash-and-burn farming, and labour work. Most occupation is based on a combination of those without a long-term perspective justifying discounting.

3.2. The unsuitability of Western classification systems

Indian subsistence activities in rain forest areas normally refer partly to farming activities (domesticated resources) and partly to hunting, fishing, and collection of a wide range of products (non-domesticated resources). As the occupation of rain forest Indians is usually a combination of these activities, it is not possible to simply classify them as, for example, farmers or fishermen. The occupation is too complex to be classified according to Western classification systems (Lundberg, 1995). It fluctuates and can be adjusted to current conditions according to such factors as changes in the game population.

In the flood plains, the occupation of the forest dwellers is well adapted to the yearly flooding of the forests. Crops are sown when the water withdraws from the forest, and the yields are harvested before the water returns. The terrestrial animals are mainly hunted in the wet season when the forest is accessible by canoe and the animals gather at the dry spots. Fish are caught when the water has receded to the small lakes.

To study the seasonal variations in the occupation of the forest dwellers, we calculated the monthly value of different categories such as 'fish', 'fruit', 'crop' and 'game'. Such categories proved to lose their meaning in the local context. They produced a meaningless picture in which the categories showed no conspicuous peak seasons for income generation.

This proved to be due to a considerable diversity in local use of forest products and occupation. For example, special fish species are caught outside the general fishing season when they have valuable roe. Special species of bananas can survive the floods and are used in the wet season when other (and more popular) crops cannot grow. Some species of wild fruits ripen outside the general season. And in the dry period outside the hunting season, some animals come close to the villages to feed on the crops and are therefore hunted then.

The conclusion is that individual species of fruits, fish, animals and crops have their specific seasons. However, our general categories of fish or fruit, etc. did not reflect these differences nor did they reflect the broad spectrum of extraction activities carried out by the local dwellers.

3.3. Calculating daily net-income

In accordance with other studies (Hedge et al., 1996), we found a slightly higher daily net-income for extraction activities than for farming activities. Calculation of daily net-income of the extraction activities is used for a more detailed discussion of

[1] Including subsistence products.

Table 2
Average time per household used during 1 year for extraction activities for the 12 households calculated in three different ways (in person-days)

Activities	Notebook and 14-day interviews (methods i and ii)	Monthly general interviews (method iv)	Observation (method v)
Fishery	172	108	193
Hunting	6	16	0
Gathering	69	18	191

strengths and weaknesses of the different methods applied.

The daily net-income of working with the different activities is calculated as the ratio of value of product to time used to collect or produce the product. The calculation of value has been discussed above; the focus here is on the determination of time used to carry out the activities, exemplified by fishing, hunting and gathering (Table 2). Activities of less than 1/2 h have not been recorded. Transportation time is included and is divided according to the time used for the different activities carried out during the trip.

To determine the time, the notebook was used as a basis at the 14th-day interviews. Thus, methods (i) and (ii) were applied together (Table 2). Method (iii) (yesterday's meal) is not relevant in relation to time.

The 14th-day interviews combined with the daily notes taken by the local people themselves proved to catch much information when dealing with a main activity like fishing (Table 2). As discussed above, some loose fishing activities are missing compared to the observed time. When asking in general terms for the fishing activities during the month in question (method iv), some more information is lost because people have to recall over a longer period of time (Table 2).

As seen in Table 2, hunting is a more special case. A completely opposite picture emerges since we did not get all the information, either by observation or in the thorough 14th-day interviews. Noisy white observers on a hunting trip are not an advantage for the bag (method v) (Table 2). And as mentioned above, people are rather cautious when it comes to telling about episodes of illegal catch (methods i and ii), while talking about hunting in general terms (method iv) is not so dangerous.

Gathering is an important case illustrating the limitations of interview methods. Neither the general questions regarding monthly activities nor the more thorough 14th-day interviews catch information of importance compared to observations (Table 2). This is due to the fact that people do not consider gathering as an activity as such. Such activities as collecting honey, eggs and resins are often integrated into other activities, for example, hunting or fishing. When by chance some useful products are found, they are consumed at the spot or brought back home. Only in specific cases do people go into the forest with the declared purpose of collecting, for example, fruit and medicinal plants.

Even firewood is often brought home from a fishing trip and is not called to mind in an interview situation. Here, the observation method shows its advantage, especially to determine the time used in different extraction activities. However, observers should be aware that their presence might change the attitude of the people studied. Furthermore, observation is a rather time-consuming activity and should be used as a supplement to help adjust other and less time consuming methods.

3.4. Calculating per-hectare values

When scholars compare figures of different land-use alternatives, such as forestry and extraction of non-timber products, they often indicate the economic value that one hectare of forest can generate. One should then be aware that if the amount of extracted products change substan-

tially from year to year, nothing can be said about the sustainability of the activities, and the per-hectare values may not reflect what the forest can generate on a long-term basis.

During the interviews all households in the two villages were asked about long-term changes in extraction activities. Except for some changes regarding hunting for specific species, the extraction was regarded as reasonably constant by the villagers. This indicates that the actual per-hectare values reflect what the forest delivers over time. However, this indication is based on interviews only. Repeating the study of local extraction activities after 5 and 10 years would strengthen knowledge of stability regarding per-hectare values.

If the forest, with a minimum of extra effort from the local dwellers, could generate more welfare, people would probably already have made use of this possibility. It is worth considering, however, that our figures reflect the actual use of products and that development of new market links and new extraction and processing methods probably could increase the local income from extraction activities (Shankar et al., 1996).

Another issue important to consider is that forest areas lying fallow can inaccurately be regarded as natural forest, even though it is extensively managed (Gómez-Pompa and Burley, 1991; Colchester and Lohmann, 1993). The forest area in question has not been cultivated in recent times, as the yearly flooding prevents such farming activities. But in other, and more dry areas, the forest can be subject to periodically recurring slash-and-burn farming, changing the forest composition away from that of natural forest.

In some places the forest has a concentration of, for example, commercially valuable fruit palms; some places are well known turtle breeding areas; and some lakes are especially good fishing areas. The fact that forest products are not distributed equally throughout the forest constitutes a fundamental problem choosing an area to investigate when methods based on forest inventories are used.

Also when methods based on the actual local extraction of forest products are used, the greatest difficulty regarding calculation of per-hectare values is the determination of the forest area in question. Even when the site of the extraction of every single forest product is recorded, as is the case in this study, the delimitation of the exact extraction area will be subject to some uncertainty.

When mapping the forest area used by villagers for extraction activities, an area is defined within a borderline with the village in the centre. This area is referred to as the maximum area (Table 3). The maximum area includes some forest areas that are seldom or never used for extraction. By deducting these localities, a minimum area is defined for extraction. The minimum area is within the same borderline, but includes only localities frequently used by villagers for extraction of forest products. Using the maximum and minimum areas in each of the two villages gives differences in per-hectare values of 10 and 17%, respectively.

Sometimes people go hunting for days in enormous, distant forest areas that are subject to visits from people from many different localities in the surrounding forests. It is practically impossible to make an exact determination of the size of the area used or the amount of goods extracted. In our calculation of per hectare-value, we have ignored products originating from such distant areas.

The use of forest resources is not always separated according to rights of use among different villages, and there is some overlap. Also people from towns sometimes visit the area to extract forest products. This makes the indicated figures for per-hectare values minimum figures, since more products are extracted from the area by people coming from outside.

Table 3
Use-value per hectare per year of non-managed natural forest[a] (US$)

Locality	Minimum area	Maximum area
Casa Grande	US$10.5	US$9.0
Yanallpa	US$16.8	US$15.3

[a] The figures are based on all households' extraction in the two villages and have been calibrated according to the different levels of activity among the households.

Last, it is worth emphasizing that the results represent data collection for 1 year in 1994–1995. Both market prices and quantity of yield from forest and farm land can vary from year to year because of climatic differences in the flood plain forests.

4. Conclusion

Present-day knowledge about the economic importance of local extraction of forest products seems to be based on a doubtful foundation because the different methods used by scholars have led to different results.

It is found that application of different methods results in widely different conclusions regarding the actual use-values of local fishery, hunting and gathering activities. Thus, conclusions regarding the importance of such extraction activities compared to farming and other occupations seem to depend on the selected method. In particular, it is found that interview methods are connected with substantial shortcomings, especially in regard to gathering activities.

In the study areas, it is found that the yearly per-hectare values of extracted products from natural forest represent between US$ 9 and 17. As some products extracted by townspeople are not recorded, the real per-hectare values are probably slightly higher. Per-hectare values depend very much on the locality, making generalizations difficult. It should also be noted that cultural values and forest services like CO_2 storage are not included in the valuation.

The study suggests that local extraction, including gathering, fishing and hunting, is the most important economic activity in the area studied. The value of extracted products exceeds farming and wage earnings. The results also suggest that the local use of forest products exceeds the quantity going to the market.

If access to forest products were to become limited, for example, in connection with forest conversion or establishment of reserves, the prices of forest products would increase radically. If this were to happen, current prices of forest products would become insufficient as a basis for calculating the income people would need to buy the products they formerly extracted themselves.

If a development initiative would result in limiting local access to forest resources, consequences in regard to extraction activities should be thoroughly studied in advance.

Acknowledgements

The author expresses his thanks to Danish colleagues from the Centre for Development Research and the Royal Veterinary and Agricultural University. Thanks are also due to Peruvian colleagues from Instituto de Investigaciones de la Amazonia Peruana (IIAP) and to the people of Casa Grande and Yanallpa.

References

Adger, W.N., Brown, K., Cervigni, R., Moran, D., 1995. The economic value of forest in Mexico. Ambio 24, 286–296.

Balick, M.J., Mendelsohn, R., 1992. Assessing the economic value of traditional medicines from tropical rain forests. Conservation Biol. 6, 128–130.

Beyley, P.B., Petrere, M., 1989. Amazon fisheries: assessment methods, current status and management options. In: Dodge, D.P. (Ed.), Proceedings of the International Large River Symposium, Can. Spec. Publ. Aquat. Sci, pp. 385–397.

Bodmer, R.E., 1990. Fruits of the forest. Nature 343, 109.

Broekhoven, G., 1996. Non-timber forest products. IUCN Forest Conservation Programme, Gland.

Browder, J.O., 1992. The limits of extractivism. BioScience 42, 174–182.

Colchester, M., Lohmann, L., 1993. The struggle for land. World Rainforest Movement, Malaysia.

Godoy, R., Lubowski, R., Markandya, A., 1993. A method for the economic valuation of non-timber tropical forest products. Econ. Botany 47, 220–233.

Gómez-Pompa, A., Burley, F.W., 1991. The management of natural tropical forests. In: Gómez-Pompa, A., Whitmore, T.C., Hadley, M. (Eds.), Rain Forest Regeneration and Management. UNESCO, France, pp. 3–18.

Grimes, A., Loomis, S., Jahnige, P., Burnham, M., Onthank, K., Alarcón, R., Cuenca, W.P., Martinez, C.C., Neill, D., Balick, M., Bennett, B., Mendelsohn, R., 1994. Valuing the rain forest. The economic value of nontimber forest products in Ecuador. Ambio 23, 405–410.

Hedge, R., Suryaprakash, S., Achoth, L., Bawa, K., 1996. Extraction of non-timber forest products in the forest of Biligiri Rangan Hills, India. 1: Contribution to rural income. Econ. Botany 50, 243–251.

Houghton, T., Mendelsohn, R., 1996. An economic analysis of multiple-use forestry in Nepal. Ambio 25, 156–159.

Kvist, L.P., Andersen, M.K., Hesselsøe, M., Vanclay, J.K., 1995. Estimating use-values and relative importance of Amazonian flood plain trees and forests to local inhabitants. Commonwealth Forestry Rev. 74, 293–300.

Lundberg, M., 1995. Flexibilitet och anpassning inom ett försörningssystem i Amazonas: Amueshas i Peru. University of Uppsala, Sweden.

Melnyk, M., Bell, N., 1996. The direct-use values of tropical moist forest foods: the Huottuja Amerindians of Venezuela. Ambio 25, 468–472.

Myers, N., 1988. Tropical forest: much more than stocks of wood. J. Trop. Ecol. 4, 209–221.

Olsen, C., 1997. A qualitative assessment of the sustainability of commercial non-timber forest product collection in Nepal. Forestry Discussion Paper 12, Royal Veterinary and Agricultural University, Copenhagen, 30 pp.

Padoch, C., 1988. The economic importance of marketing of forest and fallow products in the Iquitos region. Adv. Econ. Botany 5, 74–89.

Padoch, C., de Jong, W., 1989. Production and profit in agroforestry. In: Browder, J.G. (Ed.), Fragile Lands of Latin America. Westview Press, London, pp. 102–113.

Paucar, A., Gardner, A., 1981. Establishment of a scientific research station in the Yasuni national park of the republic of Ecuador. National Zoo, Washington, DC.

Pérez, M.R., 1995. A conceptual framework for CIFOR's research on non-wood forest products. CIFOR, Indonesia, Working Paper, no. 6, p. 17.

Peters, C.M., Gentry, A.H., Mendelsohn, R.O., 1989. Valuation of an Amazonian rain forest. Nature 339, 655–656.

Pinedo-Vasquez, M., Zarin, D., Jipp, P., 1990. Land use in the Amazon. Nature 348, 397.

Schwartzman, S., 1989. Extractive reserves in the Amazon. In: Browder, J.O. (Ed.), Fragile Lands of Latin America. Westview Press, London, pp. 150–163.

Shankar, U., Murali, K.S., Shaanker, R.U., Ganeshaiah, K.N., Bawa, K.S., 1996. Extraction of non-timber forest products in the forest of Biligiri Rangan Hills, India. 3: Productivity, extraction and prospects of sustaninable harvest of Amla Phyllanthus Emblica. Econ. Botany 50, 270–279.

UN, 1992. A non-legally binding authoritative statement of principles for a global consensus on the management, conservation and sustainable development of all types of forests, New York.