



ELSEVIER

Ecological Economics 39 (2001) 437–447

**ECOLOGICAL
ECONOMICS**

www.elsevier.com/locate/ecolecon

ANALYSIS

Can non-timber forest products match tropical forest conservation and development objectives?

J.E. Michael Arnold ^a, M. Ruiz Pérez ^{b,*}

^a *CIFOR Research Associate, Madrid, Spain*

^b *Department Ecology, Facultad de Ciencias-Edificio Biológicas, Universidad Autónoma de Madrid and CIFOR Research Associate, 28049 Madrid, Spain*

Received 26 March 2001; received in revised form 6 August 2001; accepted 6 August 2001

Abstract

The contributions that non-timber forest products (NTFPs) can make to rural livelihoods, and the fact that their use is less ecologically destructive than timber harvesting, have encouraged the belief that more intensive management of forests for such products could contribute to both development and conservation objectives, and have led to initiatives to expand commercial use of NTFPs. This paper reviews evidence that indicates that this ‘conservation through commercialisation’ thesis needs to be revised. In practice, the selective nature of market demand, and the uneven distribution of resources of use value within forests, mean that with NTFP harvesting the resource can become altered and degraded. The pressures that market forces can place on local control mechanisms, and the conflicting interests of those using forest resources for subsistence and income generation, can also result in poorer users becoming disadvantaged as NTFP commercialisation is intensified. An approach that recognises such areas of conflict, and attempts to arrive at a realistic balance between development and conservation, is proposed. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Tropical deforestation; Non-timber forest products; Forest conservation; Rural development

* Corresponding author. Tel.: +34-91-397-8000; fax: +34-91-397-8001.

E-mail address: manuel.ruiz@uam.es (M.R. Pérez).

1. Introduction

Historically, non-timber forest products¹ (NTFPs) were usually considered to be of little importance, a status reflected in their designation as ‘minor’ forest products. Much of their use was seen as being primarily of only local interest, and such commercial exploitation as took place was characterised as associated with lack of capital and technology, and often with exploitative use of labour (Homma, 1992). However, during the last 10–20 years there has emerged growing interest in attributes of NTFPs that appeared to be relevant to the growing focus on rural development and conservation of natural resources. This was articulated in three main propositions. One was that NTFPs contribute in important ways to the livelihoods and welfare of populations living in and adjacent to forests. Another was that exploitation of NTFPs is less ecologically destructive than timber harvesting and other forest uses, and could therefore provide a sounder base for sustainable forest management. The third was that increased commercial harvest of NTFPs should add to the perceived value of the tropical forest, thereby increasing the incentives to retain the forest resource.

Numerous authors stressed the apparent coincidence of conservation and development objectives that NTFPs appear to contribute to in these ways (see, for example, Myers, 1988; Nepstad and Schwartzman, 1992; Panayotou and Ashton, 1992; Plotkin and Famolare, 1992). Some valuation exercises suggested that the potential income from sustainable harvesting of NTFPs could be considerably higher than timber income, or income from agricultural or plantation uses of the forest sites (e.g. Peters et al., 1989; Balick and Mendelsohn, 1992). This resulted in the ‘conservation by com-

mercialisation’ hypothesis (see Evans, 1993) that has led to initiatives to expand and provide markets for NTFPs in order to tap an increasing share of this apparent store of sustainably harvestable wealth in tropical forests. It has also been argued that this potential could be considerably enhanced by drawing on indigenous knowledge and building on the sustainable systems of use that local people often seemed to have created (Posey, 1982; Prance, 1990; Stiles, 1994; Redford and Mansour, 1996). As a consequence, the heightened interest in NTFPs has been linked to the issue of empowering local people, and recognising and legally securing their rights to manage their forest resources (see, for example, Dove, 1993).

In this paper we review the evolution of the debate about these propositions and the lessons that appear to be emerging in practice, suggesting ways in which the original propositions might need to be revised.

2. Conservation

2.1. *The ecological perspective*

The maintenance of a forest-like structure associated with NTFPs production is generally acknowledged as being positive, contributing to some of the classical forest environmental functions like carbon storage, nutrient cycling, erosion control and hydrological regulation (Myers, 1988; Gillis, 1992). Moreover, forests and home gardens managed for NTFP production can retain large amounts of plant and animal biodiversity (Michon and de Foresta, 1997), particularly when compared with alternative land uses (Boot, 1997), while providing an important source of income.

However, the propositions outlined above, and their interpretation, have raised concern that arguments about the relatively benign impact of harvesting for NTFPs have been over-stated or misunderstood. Thus, the exploitation of forest resources has a differentiated effect, depending on the type of species and the parts being harvested. The extraction of bark can lead to the death of the individual, while the harvesting of fruits and flowers may have negative results in the whole popula-

¹ The expressions non-timber forest products, non-wood forest products, and minor forest products, are frequently used interchangeably. The term non-timber forest products is used in this paper to denote any product other than timber dependent on a forest environment. It is restricted to tradable material products, and their processed derivatives, and does not include services derived from the forest such as carbon sequestration, nutrient cycling or amelioration of water flows.

tion (Peters, 1994; Witkowski and Lamont, 1994). Some species are better able to sustain continuous offtake than others. In the case of plants, those exhibiting abundant and frequent regeneration and rapid growth will prevail (Cunningham and Mbenkum, 1993; Peters, 1994). Likewise, rodents, ungulates and other animals that have broad niches and rather prolific reproductive strategies are more able to stand heavy hunting (Bodmer et al., 1988; Fa et al., 1995).

There is a clear reduction in the composition and abundance of primary forest species and those of a more restricted habitat (Thiollay, 1996; García-Fernández et al., 2000). NTFP harvesting results in direct and indirect pressures on the forest, due to competition between humans and animals for some forest foods (Boot and Gullison, 1995). Though animals show different abilities to withstand pressure according to taxonomic groups, those that tend to be most heavily affected by hunting and other human activities include the most important predators and seed dispersers. Their depletion or removal can rapidly influence such forest characteristics as composition and structure of vegetation (Bodmer et al., 1988; Redford, 1992; Fitzgibbon et al., 1995). Finally, NTFP gathering also affects the genetic diversity of the population being exploited, especially when harvesting flowers or fruits that show differential traits resulting in different degrees of pressure (like larger fruits) (Peters, 1994).

Unless harvesting is controlled, some species will therefore become genetically impoverished or depleted much more rapidly than others. Over long periods of time, tropical forests can and do recover from even heavy use if allowed the time to do so without further disturbance. But this does not happen if there is repeated harvesting at short intervals relative to the forest's regeneration cycle (Poore et al., 1989), unless there is a monitoring and control system that provides a constant flow of information about the ecological response of species to varying degrees of exploitation (Peters, 1994). However, as was pointed out in the discussion about forest-derived agroforest systems, forests can be managed in ways that minimise the ecological impact of harvesting.

2.2. *The impact of market forces*

A number of researchers have been developing and testing models and hypotheses to assist in predicting how market forces are likely to have an influence on forest structure and use. Thus, Wilkie and Godoy (1996) argue that, with increased exposure to trade and markets, per capita incomes rise, imported goods are substituted for some NTFPs and others are exploited primarily for sale. As alternative uses of labour become more attractive, use of the forest is increasingly concentrated on higher-value NTFPs. Thus, unless their use is controlled, or the species concerned are domesticated or replenished, their presence in the resource could diminish. In another influential model, based on Brazilian experience, Homma (1992) postulates that as commercial demand for a forest product emerges, output first expands then, as quantities and quality from wild sources decline, prices will rise. Inelasticities of the supply of naturally occurring products then lead to development of domesticated sources and synthetic alternatives that replace the natural source.

Both of these models point to selective harvesting of those species that are more valued by the market place, and a consequent change in the composition of the remaining forest stock. In practice, these uni-directional evolutionary paths are not inevitable. Shifts in demand for forest products, for example, could reduce pressure on the resource or transfer it to another resource. Institutional measures to control the way in which the forest is used would also modify the impact of harvesting. For instance, forest management interventions, by increasing the productivity of the NTFP species, could prove to be an alternative to domestication, or could delay or modify the progression towards domestication. As Balée (1989) and Dufour (1990) have argued, the boundaries between wild and domesticated are not clear cut, giving ample room for a large variety of systems with good conservation potential. Some authors have proposed that we should think in terms of forest domestication rather than species domestication (Boot, 1997; Michon and de Foresta, 1997). Prance (1990) also argues that well-planned domestication integrated with extractive activities

might help to curb the classical boom-and-bust cycles of extractive economies, contributing to their long-term maintenance. All these designs would allow retaining a good tree cover.

Nevertheless, it is clear that market demand is selective, and therefore works against the ecological objective of conserving the profile of biological diversity present in the untouched forest. Exposure to market pressures and opportunities is inescapably changing many subsistence-based use systems to market-oriented production systems, with clear losses of biodiversity (Rico-Gray et al., 1990; Lawrence, 1996; Bennett and Robinson, 2000). Moreover, as market prices seldom reflect the values of environmental and other 'external' costs and benefits, market demand may lead to short-term over-exploitation and even to local extinction of some plants and animals that provide highly desired products (Vasquez and Gentry, 1989; Witkowski and Lamont, 1994; Fa et al., 1995; Hansis, 1998). This divergence between market and real economic and societal values casts doubt on the argument that the increased values attributable to tropical forests as a result of higher commercial demand for NTFPs necessarily encourage conservation of the resource.

2.3. Impacts of local uses

Some authors (González, 1992; Grenand and Grenand, 1996) point out that, though forest dwellers often appear to have evolved patterns of use that enable them to live in equilibrium with the forest, this does not mean that they are acting to protect nature in the sense understood today. Rather, it is because their system has a strong subsistence component, is based on the abundance and diversity of the resource and its ability to renew itself, and the human population density is relatively low.

Much harvesting of NTFPs is in forest systems that have in the past already been disturbed by human use to a greater or lesser degree. Most collecting and harvesting of NTFPs is by populations who combine this with some form of agriculture. It is therefore taking place not in pristine forest, but largely in secondary forests, bush fallow, farm bush or agroforest. This is partly explained by

the proximity of these areas to the user communities and households, but also reflects the fact that in a number of respects such formations are more productive sources of desired species and products, and are more easily managed in a cycle of alternating cultivation and fallow (Posey, 1982; Davies and Richards, 1991).

In many situations, fallow land, farm bush and even the forest itself have in fact been found to be actively managed by local users to conserve or encourage particular species of value. The babaçu palm (*Orbygnia phalerata*) in north-east Brazil has long been integrated into local farmers' shifting cultivation systems (May et al., 1985), and farmers in the flood-plain forests of the Amazon area manage them to favour the economically more valuable species they contain (Anderson and Ioris, 1992). Damar, rattan and fruit gardens are examples of enriched forest management systems in Indonesia (Michon and de Foresta, 1997; Peluso and Padoch, 1996).

As the nature, rationale and consequences of managed local use have become better understood, it has been pointed out that much of what might be considered by ecologists and foresters to be degradation or depletion of a forest resource, can be considered to be transformation and even improvement of the resource by those depending on it for inputs into their livelihood systems (Leach and Mearns, 1996). This has been accompanied by growing appreciation that associating conservation exclusively with such global values as biodiversity conservation has contributed to too narrow an assumption about linkages between human activity and forest change (Forsyth et al., 1998).

3. Development

3.1. NTFPs and rural household livelihoods

NTFPs are generally most extensively used to supplement diets and household income, notably during particular seasons in the year, and to help meet medicinal needs. NTFPs are also widely important as a subsistence and economic buffer in hard times. As is shown in Table 1, the importance of forest foods and incomes thus often lies more in

Table 1
Forest outputs and rural livelihoods

Livelihood inputs	Characteristics	Impacts of change
Subsistence goods	Supplement or complement inputs of fuel, food, medicinal plant products, etc. from the farm system; often important in filling seasonal and other food gaps, particularly in hard times; forest foods enhance palatability of staple diets, and provide vitamins and proteins	Can become more important where farm output and/or non-farm income declines Likely to decline in importance as incomes rise and supplies come increasingly from purchased inputs, or as increasing labour shortages/costs militate against gathering activities, or market demand diverts subsistence supplies to income generating outlets
Farm inputs	Forests provide starting point for rotational agriculture; on-farm trees provide shade, windbreaks and contour vegetation; trees/forests also provide low cost soil nutrient recycling and mulch. Other inputs include arboreal fodder and forage, fibre baskets for storing agricultural products, wooden ploughs and other farm implements, etc.	Trees can become increasingly important as a low capital means of combating declining site productivity, and a low labour means of keeping land in productive use (e.g. home gardens) Increased capital availability, and access to purchased products, likely to lead to substitution by other materials (e.g. by pasture crops, fertiliser and plastic packaging)
Income	Many products characterised by easy access to the resource, and low capital and skill entry thresholds; mainly low return activities, producing for local markets, engaged in part-time by rural households, often to fill particular income gaps or needs; overwhelmingly very small, usually household-based enterprises (with heavy involvement of women, as entrepreneurs as well as employees); Some forest products provide the basis for more full-time and higher return activities; usually associated with higher skill and capital entry thresholds, and urban as well as rural markets	With increasing commercialisation of rural use patterns some low-input low-return activities can grow; however, some produce 'inferior goods' and decline, others are displaced by factory made alternatives, and others become unprofitable and are abandoned as labour costs rise Higher return activities serving growing demand are more likely to prosper, particularly those serving urban as well as rural markets; as this happens an increasing proportion of the processing and trading activity is likely to become centred in small rural centres and urban locations
Reduced vulnerability	Some low input gathering activities involve raw materials for industrial processes and external markets Can be important in diversifying the farm household economy—e.g. providing counter-seasonal sources of food, fodder and income Also important in providing a reserve that can be used for subsistence and income generation in times of hardship (crop failure, drought, shortage of wage employment, etc), or to meet special needs (school fees, weddings, etc.)	Gathered industrial raw materials tend to be displaced by domesticated supplies or synthetic substitutes The 'buffer' role of forests and trees can continue to be important well into the growth process Likely to decline in importance as government relief programmes become more effective, or new agricultural crops, or access to remittance incomes, make it less necessary to fall back on forest resources in times of need

Source: Based on Arnold (1998).

its timing than in its magnitude as a share of total household inputs (Chambers and Leach, 1987; de Beer and McDermott, 1989; Falconer and Arnold, 1989; Scoones et al., 1992; FAO, 1995; Townson, 1995).

Use of some NTFPs is dwindling as people gain more access to purchased goods, as improved supplies of food crops have diminished the need to depend on forest foods, or as the opportunity cost of gathering foods, fuelwood, etc. rather than purchasing them, becomes higher. Supplies available for subsistence use can also fall as shortages emerge, and when their need for income forces the poor to sell products they would have otherwise used themselves (Falconer and Arnold, 1989; Ogle, 1996). Nevertheless subsistence use of NTFPs generally remains large and very important, as does their buffer role.

The role of income from forest products in household livelihood systems also changes, often rapidly, with changes in the demand for these products. Some forest products are goods that fall out of consumption patterns as incomes rise, e.g., those forest foods displaced by more convenient purchased foods. Others, such as mats, are vulnerable to competition from factory-made alternatives as improved transport infrastructure opens up rural areas to outside supplies (FAO, 1987). But demand for others, such as wooden furniture, rises with prosperity. Some products have large, diversified and stable markets; others face highly volatile markets, or demand that is seasonal and subject to sharp price fluctuations. While some products thus can provide a strong basis for livelihood systems, a number provide at best short-term opportunities, or generate only marginal returns to those engaged in their harvest and preparation.

Patterns of use differ among groups or households, and within households by gender and age. Forest foods and forest products income can be particularly important for poorer groups within the community (Siebert and Belsky, 1985; Fernandes and Menon, 1987; May et al., 1985; Jodha, 1990; Gunatilake et al., 1993; Cavendish, 2000). But the poor may not have access to the skills, technology or capital necessary to be able to benefit from the opportunities presented by growing markets for NTFPs. As a consequence, control over these

opportunities, and over the resource, are often progressively captured by the wealthier and more powerful, and the households with the most labour, at the expense of the poorer within the community. Market forces can in this way create pressures on local collective systems of control over forest resources used as common property that can contribute to their breakdown, leading to uncontrolled and often destructive use of the resource (McElwee, 1994).

There is therefore a danger that poorly focused initiatives to increase commercialisation of NTFPs could both disadvantage the very poor among local users, and encourage over use of the forest resource. A great deal of the attention that has been given to NTFPs at the interface between conservation and development has been on ways of making trade in products for markets in developed countries more remunerative and stable to producers. However, these are trade flows that are very susceptible to changes in market requirements, to domination by intermediaries, and to shifts to domesticated or synthetic sources of supply. Although the typical boom-and-bust sequence of responses to such short-term market opportunities may provide significant employment and income initially, in the longer term it can be very disruptive for rural economies, particularly where the trade has encouraged people to move away from more diversified and less risky agriculture-based livelihoods (Browder, 1992; Homma, 1992).

Some of those commenting on cases where the adverse impacts of NTFP trades have been very pronounced, have even argued that efforts to support development by promoting NTFP markets without securing the appropriate conditions (notably tenure and political rights) can be counter-productive (see, for example, Gray, 1990; Dove, 1993). As was noted above, trading NTFPs is likely to be appropriate for only those able to do so profitably. The existence in many poor and economically stagnant forest situations of huge numbers of people still engaged in low-return NTFP activities which have little prospect of other than short-term existence presents particular issues. Encouraging people to commit themselves to low-return commercial NTFP activities once higher-return or less arduous alternatives emerge could impede the

emergence of better livelihood systems. It may be more fruitful to help people move into other more rewarding fields of endeavour rather than seeking to raise their productivity in their current line of work (Arnold et al., 1994).

3.2. Impacts of forest and environmental policies

Government policies often assert state control over the forest resource, or over-ride local rights, thereby further undermining the authority and effectiveness of community level institutions to control and manage forest use. Government policies can also constrain local efforts to realise more of the potential that NTFPs can contribute to household livelihoods. Because they give high priority to conservation objectives, many governments have set in place forest and environmental policies and regulations designed to limit rather than encourage production and sale of NTFPs (Deweese and Scherr, 1995). Restrictions placed on forest use in order to protect forests brought into community forestry schemes, and put them under sustainable forest management, can impose costs on local people which reduce their incentive to become involved. Allowable harvests may be reduced, and the structure of benefits changed as the composition of the forest changes under management. It is in fact difficult to find programmes that have not had at least a transitional adverse impact on those who have had to cut back or give up earlier gathering or grazing activities.

One widespread result of such changes in the policy and institutional situation has been ineffective local control of NTFP resources, and an environment in which household decision making and market forces fail to generate sustainable use of local forest resources. Moreover, it is often unclear which institutional models might be appropriate at present in situations marked by increasing conflict and lower commonality of purpose, and increasingly ineffective conflict resolution mechanisms that such policies and practices engender (Neumann, 1996). This obviously raises questions about the argument that increased local harvesting and trade of NTFPs necessarily increases effective commitment to conservation and sustainable management and use of natural resources (Jodha, 1990;

Davis and Wali, 1993; Lynch and Talbott, 1995).

In short, as information about the role of NTFPs in rural development has accumulated, it has become apparent that some forest products have economic characteristics that make them attractive to rural households—ease of access to the resource, low capital and skill thresholds to harvesting and processing, and outputs that help reduce households' exposure to risk. For those trapped in poverty NTFP activities can comprise an important part of their coping strategies. However, the high transactions costs associated with meeting market demand for many NTFPs mean that they are much less likely to be an attractive option for those emerging from poverty, and with alternative wealth generating options available. Commercialisation therefore does not necessarily provide opportunities for development for many of the rural poor in or adjacent to forested areas. Equally, commercialisation of NTFPs could exacerbate rather than reduce the pressures that cause over use of forest resources (Cavendish, 2000; Byron and Arnold, 1999).

4. Discussion

The discussion above suggests that the proposition that increased use of NTFPs is congruent with forest conservation needs to be qualified and elaborated. In practice, the different stakeholders with an interest in a forest and the NTFPs it can yield are unlikely to seek the same balance between developmental and conservation objectives. For instance, it is unlikely that the economic goals of local users will yield the same outcomes as the conservation goals of those concerned with preserving biodiversity (Wells et al., 1992).

It is important to recognise that divergence of interests between development and conservation does not necessarily mean that the different balances between the two that result are less or more 'sustainable' than the other. Rather it is the recognition that sustainability has a number of different dimensions. The objective of ecological sustainability is usually expressed in terms of maintaining forest cover and biodiversity. The goal of sustainable forest management has usually focused on

maintaining a continuous flow of stated outputs, while retaining the productive capacity of the forest intact. Economists, on the other hand, tend to focus on the sustainability of economic benefits. As the benefits people seek to obtain from the forests change over time, pursuit of this objective is likely to entail changes to the resource base. Essentially, local management systems that alter the structure of the forest resource in favour of particular outputs can be seen to be giving priority to this economic objective.

Some have argued that a belief that there is a commonality of interest among different categories of users can arise from misunderstandings by local and environmental interest groups about each other. For instance, conservation NGOs failing to recognise that local communities give priority to tenurial and livelihood issues, and local communities mistakenly believing that conservation NGOs will provide assistance in meeting such needs (Stocks, 1996). It has also been suggested that conservation groups have on occasion sought to ally themselves with local development goals that are at variance with their interests as a way of 'buying time' until a better way is found of achieving conservation aims (Redford and Stearman, 1993). Similarly, forest dwellers may seek a common cause with conservationists where this can help them secure land titles and other guarantees (Mendes, 1992).

Another factor in shaping the initial proposition, and in explaining the strength of the support it received, can now be seen to be a measure of misunderstanding or misinterpretation of some of the data on which they were based. NTFP harvesting may frequently be less damaging than alternative land uses like cattle ranching or intensive logging, but it is not without impact. While it can help to preserve a tree cover that resembles a forest-like structure and performs several of its environmental functions, it does not maintain the same level of biodiversity and quality of species of a primary forest.

Likewise, in extrapolating from studies that arrived at high estimates of the potential value of offtake from particular forest situations, and arriving at conclusions about commercial revenues that might be generated, some of the features character-

ising the situations to which the original point estimates referred have been overlooked or lost sight of (Simpson et al., 1996). The result has sometimes been to raise expectations beyond what can realistically be achieved. A recent study of experience with initiatives to encourage conservation-compatible types of forest production in Latin America concluded that, in practice, these provide only limited scope for enhancement of the incomes of those engaged in them, and so can have the effect of discouraging sustainable forest management. Thus, with the exception of some situations well endowed with commercially exploitable products, and well placed with respect to access to markets, harvesting and sale of NTFPs was found not to be financially rewarding (Southgate, 1998; Phillips, 1993).

In brief, it is now clear that strategies based on the assumption that developmental and conservation interests in NTFPs coincide can be unrealistic. It could be more effective to focus on understanding the areas in which they do coincide, and those in which they are in conflict, and in determining what balance between development and conservation is desirable and achievable. Different situations have different potentials, and limitations, that call for different possible responses (Ruiz Pérez and Byron, 1999). NTFP gathering can contribute as a component of a wider conservation strategy that would encompass a spectrum from intensively transformed to little disturbed forests seeking for diversity both at species, ecosystem and landscape levels.

In doing so, it will be necessary to take account of the arguments that the pursuit of conservation has been too much driven by northern concepts and donor preoccupations, at the expense of those who depend on forests locally. Also, arguments that the conventional approach to the issue of the balance between conservation and development at this level has been based on flawed assumptions about how rural people and the 'environment' interrelate. It is argued that there is need for greater appreciation that the poor may experience their own environmental problems, which need to be addressed separately from environmental policies seeking to satisfy concerns about global values. To address these local concerns there is a need to move away

from macro-scale approaches and policies, to a more situation-specific focus, reflecting the protective mechanisms that local users themselves adopt, and the attributes of a resource that they value and seek to conserve (Forsyth et al., 1998). This could favour a shift from a predominantly protective orientation in forest management towards encouraging sustainable systems for production of livelihood benefits in as 'environmentally friendly' a way as possible (Freese, 1997).

At the same time, we need to recognise the implications of the widely different roles that NTFPs play in the livelihoods of different categories of the poor who draw on forests. It may be necessary to plan separately for those among the very poor and disadvantaged who continue to rely on such NTFPs for survival, and for those engaged in NTFP activities that form part of the process of growth and development. In other words, it may often be necessary in designing and implementing policy and other institutional interventions to distinguish between those who can improve their livelihoods through NTFP activities, and those who have no other option but to continue to gather NTFPs in order to survive.

Acknowledgements

The paper builds on work on non-timber forest products carried out at the Center for International Forestry Research (CIFOR) over a number of years. The authors wish to express their appreciation to those of their colleagues, and other collaborators, who contributed to the development of the ideas expressed in this paper over that period. In particular, they wish to thank Lini Wollenberg, Neil Byron and Jenne de Beer for comments on an earlier draft paper on this topic.

References

- Anderson, A.B., Ioris, E.M., 1992. The logic of extraction: resource management and income generation by extractive producers in the Amazon. In: Redford, K.H., Padoch, C. (Eds.), *Conservation of Neotropical Forests: Working from Traditional Resource Use*. Columbia University Press, New York, pp. 179–199.
- Arnold, J.E.M., 1998. Forestry and sustainable livelihoods. In: Carney, D. (Ed.), *Sustainable Rural Livelihoods: What Contributions Can We Make?* Department for International Development, London, pp. 155–166.
- Arnold, J.E.M., Liedholm, C., Mead, D., Townson, I.M., 1994. Structure and growth of small enterprises using forest products in Southern and Eastern Africa. OFI Occasional Papers No 47, Oxford Forestry Institute, Oxford.
- Balick, M.J., Mendelsohn, R., 1992. Assessing the economic value of traditional medicines from tropical rain forests. *Conservation Biology* 6, 128–130.
- Balée, W., 1989. The culture of Amazonian forests. In: Balee, W., Posey, A. (Eds.), *Resource management in Amazonia: indigenous and folk strategies*. *Advances in Economic Botany* 7, 1–21.
- Bennett, E.L., Robinson, J.G., 2000. Hunting of wildlife in tropical forests. Implications for biodiversity and forest peoples. *World Bank Biodiversity Series No. 76*. World Bank, Washington DC.
- Bodmer, R.E., Fang, T.G., Moya, I.L., 1988. Primates and ungulates: a comparison in susceptibility to hunting. *Primate Conservation* 2, 79–83.
- Boot, R.G.A., 1997. Extraction of non-timber forest products from tropical rain forests. Does diversity come at a price? *Netherlands Journal of Agricultural Science* 45, 439–450.
- Boot, R.G.A., Gullison, R.E., 1995. Approaches to developing sustainable extraction systems for tropical forest products. *Ecological Applications* 5 (4), 896–903.
- Browder, J.O., 1992. The limits of extractivism: tropical forest strategies beyond extractive reserves. *BioScience* 42, 174–182.
- Byron, N., Arnold, J.E.M., 1999. What futures for the people of the tropical forests? *World Development* 27 (5), 789–805.
- Cavendish, W., 2000. *Rural Livelihoods and Non-Timber Forest Products*. University of Oxford and Imperial College (unpubl.).
- Chambers, R., Leach, M., 1987. *Trees to meet contingencies: savings and security for the rural poor*. Discussion Paper 228, Institute of Development Studies, University of Sussex, Brighton, UK.
- Cunningham, A.B., Mbenkum, F.T., 1993. Sustainability of harvesting *Prunus africana* bark in Cameroon. *People and Plants Working Paper No. 2*, May 1993. UNESCO, Paris, France.
- Davies, A.G., Richards, P., 1991. *Rain forest in Mende life: resources and subsistence strategies in rural communities around the Gola North Forest Reserve (Sierra Leone)*. A report to ESCOR, UK Overseas Development Administration, London, UK.
- Davis, S.H., Wali, A., 1993. *Indigenous territories and tropical forest management in Latin America*. Policy Research Working Paper Series No. 1100, World Bank, Washington, DC.

- de Beer, J.H., McDermott, M.J., 1989. The Economic Value of Non-Timber Forest Products in Southeast Asia. Netherlands Committee for IUCN, Amsterdam, The Netherlands.
- Deweese, P.A., Scherr, S.J., 1995. Policies and markets for non-timber tree products. Draft Working Paper, International Food Policy Research Institute, Washington, DC.
- Dove, M.R., 1993. A revisionist view of tropical deforestation and development. *Environmental Conservation* 20, 17–24, 56.
- Dufour, D.L., 1990. Use of tropical rainforest by native Amazonians. *BioScience* 40, 652–659.
- Evans, M.I., 1993. Conservation by commercialization. In: Hladik, C.M., Hladik, A., Linares, O.F., Pagezy, H., Semple, A., Hadley, M. (Eds.), *Tropical Forests, People and Food: Biocultural Interactions and Applications to Development*. MAB Series, vol. 13'. UNESCO, Paris and Parthenon Publishing Group, Carnforth, UK, pp. 815–822.
- Fa, J.E., Juste, J., Pérez del Val, J., Castroviejo, J., 1995. Impact of market hunting on mammal species in Equatorial Guinea. *Conservation Biology* 9, 1107–1115.
- Falconer, J., Arnold, J.E.M., 1989. Household food security and forestry: an analysis of socioeconomic issues. *Community Forestry Note 1*, FAO, Rome, Italy.
- FAO (Food and Agriculture Organization), 1987. Small-scale forest based processing enterprises. *Forestry Paper 79*, FAO, Rome, Italy.
- FAO (Food and Agriculture Organization), 1995. Report of the International Expert Consultation on Non-Wood Forest Products. *Non-Wood Forest Products*, 3, FAO, Rome, Italy.
- Fernandes, W., Menon, G., 1987. Tribal Women and Forest Economy. Indian Social Institute, New Delhi, India.
- Fitzgibbon, C.D., Mogaka, H., Fanshawe, J.H., 1995. Subsistence hunting in Arabulo-Sokeke Forest, Kenya, and its effect on mammal population. *Conservation Biology* 9, 1116–1126.
- Forsyth, T., Leach, M., Scoones, I., 1998. Poverty and environment: priorities for research and policy, an overview study. Prepared for the UNDP and European Commission, Institute of Development Studies, Brighton (unpubl.).
- Freese, C. (Ed.), 1997. *Harvesting Wild Species: Implications for Biodiversity Conservation*. John Hopkins University Press, Baltimore, MD.
- García-Fernández, C., Casado, M.A., Ruíz Pérez, M., 2000. Benzoin gardens and diversity in North Sumatra, Indonesia.
- Gillis, M., 1992. Economic policies and tropical deforestation. In: Nepstad, D.C., Schwartzman, S. (Eds.), *Non-timber products from tropical forests: evaluation of a conservation and development strategy*. *Advances in Economic Botany* 9, 129–142.
- González, N., 1992. We are not conservationists. *Cultural Survival Quarterly* 16 (3), 43–45.
- Gray, A., 1990. Indigenous people and the marketing of the rainforest. *The Ecologist* 20, 223–227.
- Grenand, P., Grenand, F., 1996. Living in abundance. The forest of the Wayampi (Amerindians from French Guiana). In: Ruíz Pérez, M., Arnold, J.E.M. (Eds.), *Current Issues in Non-Timber Forest Products Research*. CIFOR-ODA, Bogor, Indonesia, pp. 177–196.
- Gunatilake, H.M., Senaratne, A.H., Abeygunawardena, P., 1993. Role of non-timber forest products in the economy of peripheral communities of Knuckles National Wilderness area in Sri Lanka: a farming system approach. *Economic Botany* 47, 275–281.
- Hansis, R., 1998. A political ecology of picking: non-timber forest products in the Pacific Northwest. *Human Ecology* 26 (1), 67–86.
- Homma, A.K.O., 1992. The dynamics of extraction in Amazonia: a historical perspective. In: Nepstad, D.C., Schwartzman, S. (Eds.), *Non-timber products from tropical forests: evaluation of a conservation and development strategy*. *Advances in Economic Botany* 9, 23–32.
- Jodha, N.S., 1990. Rural common property resources: contributions and crisis. *Economic and Political Weekly Quarterly Review of Agriculture* 25 (26), 65.
- Lawrence, D.C., 1996. Trade-offs between rubber production and maintenance of diversity: the structure of rubber gardens in West Kalimantan, Indonesia. *Agroforestry Systems* 34, 83–100.
- Leach, M., Mearns, R., 1996. Environmental change and policy: challenging received wisdom in Africa. In: Leach, M., Mearns, R. (Eds.), *The Lie of the Land: Challenging Received Wisdom on the African Environment*. James Currey, Oxford, for The International African Institute, London, UK, pp. 1–33.
- Lynch, O.J., Talbott, K., 1995. *Balancing Acts: Community-Based Forest Management and Forest Law in Asia and the Pacific*. World Resources Institute, Washington.
- May, P.H., Anderson, A.B., Balick, M.J., Unruh, J., 1985. Babaçu palm in the agroforestry systems in Brazil's mid-north region. *Agroforestry Systems* 3, 275–295.
- McElwee, P., 1994. *Common property and commercialisation: developing appropriate tools for analysis*. MSc Dissertation, Oxford Forestry Institute, University of Oxford, UK (unpubl.).
- Mendes, F., 1992. Peasants speak: Chico Mendes—the defence of life. *The Journal of Peasant Studies* 20 (1), 160–176.
- Michon, G., de Foresta, H., 1997. Agroforests: pre-domestication of forest trees or true domestication of forest ecosystems? *Netherlands Journal of Agricultural Science* 45, 451–462.
- Myers, N., 1988. Tropical forests: much more than stocks of wood. *Journal of Tropical Ecology* 4, 209–221.
- Nepstad, D.C., Schwartzman, S., 1992. Introduction: non-timber products from tropical forests: evaluation of a conservation and development strategy. In: Nepstad, D.C., Schwartzman, S. (Eds.), *Non-Timber Products from Tropical Forests: Evaluation of a Conservation and Development Strategy*. *Advances in Economic Botany* 9, vii–xii.
- Neumann, R.P., 1996. Forest products research in relation to conservation policies in Africa. In: Ruíz Pérez, M., Arnold, J.E.M. (Eds.), *Current Issues in Non-Timber Forest Products Research*. CIFOR-ODA, Bogor, Indonesia, pp. 161–176.

- Ogle, B.A., 1996. People's dependency on forests for food security. Some lessons learnt from a programme of case studies. In: Ruiz Pérez, M., Arnold, J.E.M. (Eds.), *Current Issues in Non-Timber Forest Products Research*. CIFOR-ODA, Bogor, Indonesia, pp. 219–241.
- Panayotou, T., Ashton, P., 1992. *Not by Timber Alone. Economics and Ecology for Sustaining Tropical Forests*. Island Press, Washington, DC.
- Peluso, N.L., Padoch, C., 1996. Changing resource rights in managed forests of West Kalimantan. In: Peluso, N.L., Padoch, C. (Eds.), *Borneo in Transition: People, Forests, Conservation, and Development*. Oxford University Press, Kuala Lumpur, Malaysia, pp. 121–136.
- Peters, C.M., 1994. *Sustainable Harvest of Non-Timber Plant Resources in Tropical Moist Forest: An Ecological Primer*. Biodiversity Support Program, Washington, DC.
- Peters, C.M., Gentry, A.H., Mendelsohn, R.O., 1989. Valuation of an Amazonian rainforest. *Nature* 339, 655–656.
- Phillips, O., 1993. The potential for harvesting fruits in tropical rainforests: new data from Amazonian Peru. *Biodiversity and Conservation* 2, 18–38.
- Plotkin, M., Famolare, L., 1992. Preface. In: Plotkin, M., Famolare, L. (Eds.), *Sustainable Harvest and Marketing of Rain Forest Products*. Conservation International-Island Press, Washington, DC, pp. xiii–xv.
- Poore, D., Burgess, P., Palmer, J., Rietbergen, S., Synnott, T., 1989. *No Timber without Trees: Sustainability in the Tropical Forest*. Earthscan, London, UK.
- Posey, D.A., 1982. The keepers of the forest. *Garden* 6, 18–24.
- Prance, G.T., 1990. Fruits of the rainforest. *New Scientist* 13 January, 42–45.
- Redford, K.H., 1992. The empty forest. *BioScience* 42, 412–422.
- Redford, K.H., Stearman, A.M., 1993. Forest-dwelling native Amazonians and the conservation of biodiversity: interests in common or in collision? *Conservation Biology* 7, 248–255.
- Redford, K.H., Mansour, J.A. (Eds.), 1996. *Traditional People and Biodiversity Conservation in Large Tropical Landscapes*. America Verde Publications for The Nature Conservancy, Arlington, Virginia.
- Rico-Gray, V., García-Franco, J.G., Chemas, A., Puch, A., Sima, P., 1990. Species composition, similarity and structure of Mayan homegardens in Tixpeual and Tixcacaltuyub, Yucatán, México. *Economic Botany* 44, 470–487.
- Ruiz Pérez, M., Byron, N., 1999. A methodology to analyze divergent case studies of non-timber forest products and their development potential. *Forest Science* 45 (1), 1–14.
- Scoones, I., Melnyk, M., Pretty, J., 1992. *The hidden harvest: wild foods and agricultural systems: a literature review and annotated bibliography*. IIED, SIDA and WWF, London, UK and Gland, Switzerland.
- Siebert, S., Belsky, J.M., 1985. Forest product trade in a lowland Filipino village. *Economic Botany* 39, 522–533.
- Simpson, R.D., Sedjo, R.A., Reid, J.W., 1996. Valuing biodiversity for use in pharmaceutical research. *Journal of Political Economy* 104, 163–185.
- Southgate, D., 1998. *Tropical Forest Conservation: An Economic Assessment of the Alternatives in Latin America*. Oxford University Press, New York.
- Stiles, D., 1994. Tribals and trade: a strategy for cultural and ecological survival. *Ambio* 23, 106–111.
- Stocks, A., 1996. The Bosawas natural reserve and the Mayangna of Nicaragua. In: Redford, K.H., Mansour, J.A. (Eds.), *Traditional People and Biodiversity Conservation in Large Tropical Landscapes*. America Verde Publications for The Nature Conservancy, Arlington, Virginia, pp. 1–31.
- Thiollay, J.M., 1996. Rain forest raptor communities in Sumatra: the conservation value of traditional agroforests. In: *Raptors in Human Landscapes*. Academic Press Ltd, New York, pp. 245–262.
- Townson, I.M., 1995. *Forest products and household incomes: a review and annotated bibliography*. Tropical Forestry Papers 31. CIFOR and OFI, Oxford, UK.
- Vasquez, R., Gentry, A., 1989. Use and misuse of forest harvested fruits in Iquitos area. *Conservation Biology* 3, 350–361.
- Wells, M., Brandon, K., Hannah, L., 1992. *People and Parks: Linking Protected Area Management with Local Communities*. World Bank/WWF/USAID, World Bank, Washington.
- Wilkie, D.S., Godoy, R.A., 1996. Trade, indigenous rain forest economies and biological diversity. Model predictions and directions for research. In: Ruiz Pérez, M., Arnold, J.E.M. (Eds.), *Current Issues in Non-Timber Forest Products Research*. CIFOR-ODA, Bogor, Indonesia, pp. 19–39.
- Witkowski, E.T.F., Lamont, B., 1994. Commercial picking of *Banksia hookeriana* in the wild reduces subsequent shoot, flower and seed production. *Journal of Applied Ecology* 31, 508–520.