CAN NON-MARKET VALUES SAVE THE WORLD'S FORESTS ?[1]

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Introduction: the Forest Crisis

It seems fair to say that, from a world standpoint, forestry is in crisis. While it would be foolish to be complacent - the historical evidence of social collapse due to deforestation is all too stark (Perlin, 1989) - there is little evidence that the current supply of timber is scarce, and little evidence that it will become scarce in the near-term (Sedjo and Lyons, 1990; Hyde *et al*, 1991). But there is a concern that the non-timber functions of forests are becoming increasingly scarce (Krutilla, 1967; Panayotou and Ashton, 1992). Those non-timber functions include the maintenance of biological diversity, carbon sequestration, local non-timber products, environmental protection, broader life support functions, recreational use, and 'passive value' - the value of forests independent of any use now or in the foreseeable future. The clue to the simultaneous presence of non-timber scarcity and, if not timber abundance then timber adequacy, lies in the fact that non-timber functions of forests are as much a product of the *type* of forest as they are of the geographical extent of forests. Biodiversity, for example, would appear to be a function of heterogenous forests rather than uniform ones, although that is not a hard and fast rule. The forest crisis is then a crisis of non-timber function loss, and it is easy to see that such a crisis could emerge almost unnoticed in a world where, until recently, forest policy was determined by commercial timber interests alone.

If non-timber values (NTVs) are disappearing, why would we not expect the same economic feedback forces to apply to them as to timber ? In other words, non timber scarcity should raise the price of non-timber functions, encouraging new supply. That is does not happen this way arises from two fundamental features of the forest context.

The first is that, in the developing world, some non-timber functions have prices but that the relevant markets are often the domain of the poor, the vulnerable and the powerless. Whether it is wildmeat, nuts, honey or fuelwood, the market agents involved in these products cannot compete with the superior power of the forest concessionaires - governments and the multinationals. Even if market prices for non-timber products yield higher per hectare revenues than timber - a debateable issue in itself, as we shall see - insecurity of property rights make for uneven competition.

The second feature of the forest context is common to the developed and developing world and emphasises the title of this symposium: many functions have no market. If markets are missing, then the implicit ruling price is zero. Non-market functions count for nothing. It is hardly surprising then

1 This paper was presented at the International Symposium on the Non-market Benefits of Forestry organised by the Forestry Commission in Edinburgh in June 1996.

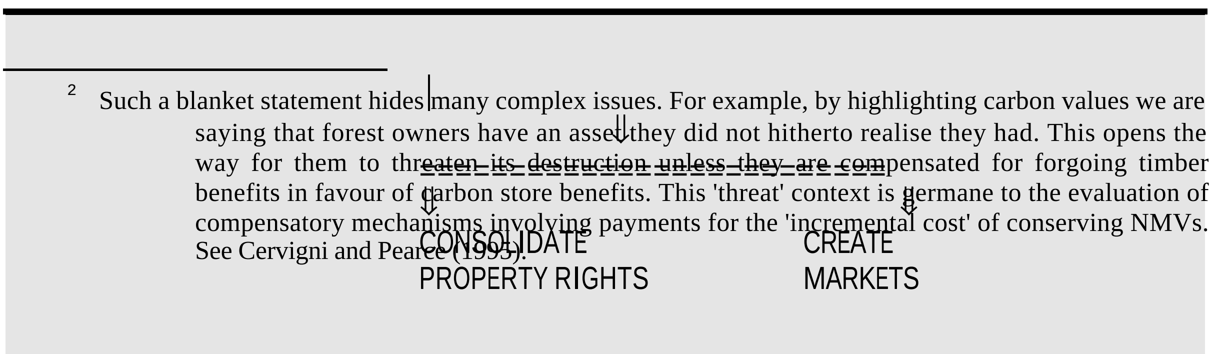
that in a competition between land uses, and it is this competition that defines the problem for the forest sector just as it does for land-based biological resources generally (Swanson, 1991; Brown *et al*, 1993), forests with high non-market value will lose out.

The recipe for reversing this situation or, more realistically, for slowing it down, therefore appears obvious. It consists of the two stages of policy advice that any practising environmental economist would give: *demonstrate and capture.*

Demonstration means demonstrating the underlying economic value of non-timber values. In the case of marketed NTVs, the issue is more one of bringing to the attention of policy makers and opinion makers the ways in which forests serve local communities who already market and utilise forest functions. In the case of non-market values the issue is more complex since it is necessary first to impute the economic values. The extent to which these non-market valuation exercises have been successful is of course open to debate, but even in the course of a decade economic research has made major inroads into this problem of demonstrating value. The questions that arise then are (a) how far are these estimated non-market values representative of the broad spectrum of forest values ? and (b) do the economic value estimates we already have justify the avoidance of deforestation and/or afforestation ? Demonstrating value requires the full panoply of valuation techniques and these are discussed at length in various papers in this Symposium.

The issue of value capture is the second stage of the exercise. There is little point in demonstrating non-market value if those values cannot be converted into flows of real resources. Otherwise they are just 'paper money', entries in an albeit interesting balance sheet, but of no practical significance. The essential reason for this is that the battle over land use is a battle of real economic values. It is about who makes most profit from the different ways in which land might be used. As much as we might like the battleground to be different one, for example an issue of morality, of ethical norms, it is the conflict of economic values that defines the real world and, given world population growth and a finite supply of land, it is a conflict that will remain for a very long time. Thus non-market value must be captured, appropriated. Not only must there be a conversion to real resource flows, but at least part of that flow must accrue to those who surrender a preferred land use for the sake of NMVs. If, for example, the world wants forests as carbon stores, the world must pay those capable of providing that function but who currently receive no income from conserving carbon store functions[2]. Capture mechanisms vary widely but they certainly involve definition and enforcement of property rights where their absence or insecurity makes it impossible for landowners or users to capture NMV. Beyond that, markets need to be created through, for example, forest tourism, optimised entry charges, debt-for-nature swaps, transferable development rights, and even global benefits markets through eg the Global Environment Facility and joint implementation for carbon reduction.

We can summarise the model of economic valuation in terms of a flow diagram - see Figure 1.



[2] Such a blanket statement hides many complex issues. For example, by highlighting carbon values we are saying that forest owners have an asset they did not hitherto realise they had. This opens the way for them to threaten its destruction unless they are compensated for forgoing timber benefits in favour of carbon store benefits. This 'threat' context is germane to the evaluation of compensatory mechanisms involving payments for the 'incremental cost' of conserving NMVs. See Cervigni and Pearce (1995).

1 Figure 1: Demonstration and Capture

⇓

YES NO

⇓

CAPTURE ECONOMIC VALUE

DEMONSTRATE VALUE
OF NON-TIMBER FUNCTIONS

⇓

COMPARE TO ALTERNATIVE
LAND USE VALUE

⇓

BIGGER ?

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⇓

What Do We Know About Non-Market Values ?

Tropical Forests

The task of summarising the state of the art in estimating non-timber values in the tropical forest context has been made comparatively easy by a number of recent surveys: Godoy *et al*. (1993), Pearce and Moran (1994), Southgate (1996) and Lampietti and Dixon (1995). There are of course substantial difficulties in reaching general conclusions, primarily because appropriate guidelines for carrying out such studies, such as those set out in Godoy *et al*. (1993) and Godoy and Lubowski (1992) have not been followed. The result has been a mixture of legitimate and illegitimate valuation procedures. The types of mistake made have included generalisation from studies of a small area of forest to wider areas, with little regard for (a) the fact that the area in question will not be typical of the whole forest area simply because of variations in distance to market, and (b) ignoring the fact that, in a hypothetical world where the whole forest was exploited for non-timber products, the prices, and hence the profitability, of non-timber production would fall[3]. Another methodological issue is the extent to which values are based on maximum sustainable yield or on actual harvests, which are often very much less, ie the values that emerge are sensitive to what is assumed about the management regime in place. Godoy *et al*. (1993) also point out that some studies value the stock and some the flow, the former being an interesting measure for wealth accounting but of little value when comparing competing land use values. Studies also vary as to whether they report revenues or revenues net of labour and other costs. Finally, little account has been taken in many of the studies of the extent to which the relevant non-timber activity is itself sustainable, so that what is being compared may well be two non-sustainable land use options.

Lampietti and Dixon (1995) divide non-timber values into extractive, non-extractive and preservation values. Extractive values involve an actual harvest, eg of nuts or rattan. Non-extractive values should be more correctly titled non-extractive use values since they involve use but not harvest of the forest. They include recreation and tourism, but also the indirect ecological functions of forests such as watershed protection and carbon storage. Preservation values are what most now call non-use or passive use values.

Tropical Forests: Extractive Values

Taking extractive values first, Lampietti and Dixon note that most of the studies relate to Central and South America (14 studies out of 20 analysed). Average per hectare values come to $86-101 for Central and South America and $60-65 for Asian countries. The Central and South American results are exaggerated by the Peters *et al* (1989) study which has been severely criticised (Godoy *et al*, 1993; Southgate, 1996). Godoy *et al*. (1993) report 23 different estimates from studies which only partially overlap with those reported in Lampietti and Dixon (1995). The authors resist the temptation to average the results since they are more concerned to identify differences in methodology and errors as factors accounting for the variation in values. Ignoring the caveats, an average of $50 per hectare per year is obtained (Pearce and Moran, 1994). Some more recent studies suggest higher extractive values. Thus, Adger *et al*. (1995) report values from just 2 US

3 A rare attempt to secure spatially varied valuations using GIS systems for Rio Bravo in Belize is Eade (1995).

cents per hectare up to $1537 for te'lom grove (groves in rainforests) management and coffee growing, and around $6 ha for pharmaceuticals in Mexico. Boj_ (1993) reports extractive values in private woodlands in Zimbabwe of US$39 per hectare. An extensive study by Kramer *et al* (1995) of the Mantadia National Park in Madagascar found that villagers would lose around $91 per household per year from forgone forest products (rice, fuelwood, crayfish, crab, tenreck and frogs). This converts to just $3.2 per hectare[4]. In contrast, Houghton and Mendelsohn (1996) find present values of fodder, fuelwood and timber (mainly the first two) of $2200-3600 per hectare for the Nepalese Middle Hills, or around $176 - 288 per hectare in annuity form (at a 5% discount rate).

With regard to pharmaceutical products, the subject of extensive debate, Pearce and Puroshothaman (1995) suggest values of $0.01 to $21 ha per year, based on established probabilities of finding a successful drug from plant species currently at risk. This assumes a tropical forest area of 1 billion hectares. Ruitenbeek (1989) has rough estimates of medicinal plant value in the Korup forest, Cameroun, which translate to around $0.2 to $0.7 per hectare. Using a very different approach, Simpson *et al* (1994) suggest that, taking an optimistic point of view, a pharmaceutical company's willingness to pay would be a maximum of $20 per hectare in Western Ecuador and very much less, perhaps $1 per hectare, elsewhere. Thus, adopting different approaches, these studies produce very low values for pharmaceutical values. Mendelsohn and Balick (1995) suggest a value of undiscovered tropical forest drugs to the pharmaceutical companies of $2.8-4.1 billion. They divide this by 3.1 billion hectares of tropical forest to obtain average values of $0.9 to $1.3 per hectare. The 3.1 billion hectares figures appears to be an exaggeration, whereas the Pearce-Puroshothaman (1995) estimate appears too low. Using a figure of 1.7 billion hectares of total tropical forest, the Pearce-Puroshothaman figures would reduce further to a range of nearly zero to $12.3 per hectare, and the Mendelsohn-Balick figures would rise to $1.6 to $2.4 per hectare[5]. The high values of Pearce-Puroshothaman reflect values to society rather than values to drug companies, ie values based on lives saved and the value of a statistical life. The comparable Mendelsohn Balick figure for social values would be around 50 times the private willingness to pay figure. It seems clear that pharmaceutical values will not 'save' tropical forests unless the social value of genetic material is translated into private willingness to pay.

Overall, the conclusions on extractivism appear to be that, in some circumstances, there are high values to be obtained and these may help the case for conservation[6]. Average values have little general meaning but, such as they are, the estimates suggest that $50 per hectare may be a very rough rule of thumb, but there are clearly situations in which higher values can be achieved and others where $50 will seriously exaggerate the net revenues. As a general rule, however, limited faith can be put in non-timber extractive values to save tropical forests. This contrasts with some of the grander claims made in the past (Myers, 1984; Peters *et al*, 1989). Southgate (1996) warns against the exaggerated view that South American extractivists can live by non-timber products alone - they will invariably deforest as well - and against the assumption that extractivism is inevitably sustainable. Extractivists tend to be poor. Net returns to vegetable ivory collection in Ecuador and rubber

[4] $91 x 351 households = $31,941 across an area of 9,875 hectares = $3.2 per hectare.

[5] In contrast, Balick and Mendelsohn (1992) suggest annual net revenues of $19-61 per hectare for Belize.

[6] We abstract from an alternative argument which would express NTVs as a percentage of household income. Kant *et al* (1996) show that household incomes in West Bengal are increased by 20-30% because of income from non-timber products, and that the effect is biggest for the poorest households.

tapping in the Amazon basin, for example, tend to be only just above the opportunity cost of labour. Southgate concludes:

> '..although it might provide limited amounts of supplementary income for forest dwelling populations, commercial non-timber extraction comprises a very shaky foundation for an integrated strategy of habitat conservation and local economic development' (Southgate, 1996, p.45).

Tropical Forests: Non-Extractive Values

Non-extractive values tend to comprise recreation and indirect ecological functions such as watershed protection and carbon storage. Of these, recreation and carbon storage have attracted the most study.

Recreation

Adger *et al*. (1995) suggest ecotourism values for Mexican forests of some \$8 ha pa, whilst Tobias and Mendelsohn (1991) use the travel cost method to obtain values of \$52 per hectare for Monteverde in Costa Rica. One would expect high values for rare ecosystems such as Monteverde. Kumari (1995) estimated a potential recreational value of M\$57 ha for her study site in Malaysia, but in present value terms and at 8% discount rate. The cash flows suggest an annual income of about \$5 per hectare. For 'conventional' tropical forest, then, values of \$5-10 ha might seem appropriate.

Ecological Functions

Lampietti and Dixon (1995) find a limited number of studies dealing with erosion prevention and which are capable of estimation of benefits on a per hectare basis. Magrath and Arens' (1989) study of soil erosion in Java suggests minimum estimates of damage of \$2-7 per hectare. Cruz *et al*'s (1988) study of Philippines suggests \$17-28 ha; Ruitenbeek's (1992) Korup study implies \$14 ha for fisheries protection and \$2 ha for flood control. To these estimates we can add Kumari's (1995) detailed analysis for Malaysia. This suggests hydrological benefits in terms of conserved agricultural output equal to \$25 ha pa. Domestic water benefits and fisheries protection would add a further \$2-3 in each case. Overall, then, watershed protection functions do seem to have values which cluster around \$30 ha pa once a reasonably wide range of functions is considered[7].

Carbon Storage

Unquestionably the largest value dominating the use values of tropical forests is that relating to carbon sequestration. Lampietti and Dixon's values for this function are too low due to the adoption of somewhat outdated estimates of the marginal damage from carbon dioxide releases. All forests store carbon so that, if cleared for agriculture there will be a release of carbon dioxide which will contribute to the accelerated greenhouse effect and hence global warming. In order to derive a value for the 'carbon credit' that should be ascribed to a tropical forest, we need to know (a) the net

[7] In contrast, however, Adger *et al*'s study for Mexico suggests just 4 cents per hectare for watershed protection.

carbon released when forests are converted to other uses, and (b) the economic value of one tonne of carbon released to the atmosphere.

Carbon will be released at different rates according to the method of clearance and subsequent land use. With burning there will be an immediate release of CO_2 into the atmosphere, and some of the remaining carbon will be locked in ash and charcoal which is resistant to decay. The slash not converted by fire into CO_2 or charcoal and ash decays over time, releasing most of its carbon to the atmosphere within 10-20 years. Studies of tropical forests indicate that significant amounts of cleared vegetation become lumber, slash, charcoal and ash; the proportion differs for closed and open forests; the smaller stature and drier climate of open forests result in the combustion of higher proportion of the vegetation.

If tropical forested land is converted to pasture or permanent agriculture, then the amount of carbon stored in secondary vegetation is equivalent to the carbon content of the biomass of crops planted, or the grass grown on the pasture. If a secondary forest is allowed to grow, then carbon will accumulate, and maximum biomass density is attained after a relatively short time.

Table 1 illustrates the net carbon storage effects of land use conversion from tropical forests; closed primary, closed secondary, or open forests; to shifting cultivation, permanent agriculture, or pasture. The negative figures represent emissions of carbon; for example, conversion from closed primary forest to shifting agriculture results in a net loss of 194 tC/ha. The greatest loss of carbon involves change of land use from primary closed forest to permanent agriculture. These figures represent the once and for all change that will occur in carbon storage as a result of the various land use conversions.

The data suggest that, allowing for the carbon fixed by subsequent land uses, carbon released from deforestation of secondary and primary tropical forest is of the order of 100-200 tonnes of carbon per hectare.

The carbon released from burning tropical forests contributes to global warming, and we now have several estimates of the minimum economic damage done by global warming, leaving aside catastrophic events. Recent work suggests a 'central' value of $20 of damage for every tonne of carbon released (Fankhauser and Pearce, 1994). Applying this figure to the data in Table 1, we can conclude that converting an open forest to agriculture or pasture would result in global warming damage of, say, $600-1000 per hectare; conversion of closed secondary forest would cause damage of $2000-3000 per hectare; and conversion of primary forest to agriculture would give rise to damage of about $4000 - 4400 per hectare. Note that these estimates allow for carbon fixation in the subsequent land use.

[INSERT TABLE 1 HERE]

There are problems with these values of the indirect carbon storage functions of tropical forests. First, the science of global warming is uncertain and this suggests that the values need to be multiplied by some unspecified probability that the effects are certain. The Intergovernmental Panel on Climate Change's Second Assessment Report (IPCC, 1996) now suggests that 'the balance of evidence suggests that there is now a discernible human influence on climate' but its quantification is still limited. Put another way, the context is pure uncertainty rather than risk. Second, the $20 per tonne carbon value is itself uncertain. It is the product of a Monte Carlo simulation so that it encompasses a good deal of the uncertainty about impacts and values, but it does not deal with the potential for surprises or extreme events (Fankhauser, 1995). Third, even if the values are broadly correct and global warming is a 'real' phenomenon, the avoidance of deforestation or investment in afforestation may not be cheapest ways of reducing carbon emissions. The opportunity cost of conservation is clearly the 'development' benefit forgone, ie the returns to forest clearance for agriculture, timber or livestock. It seems very likely that these forgone values are indeed very low in many cases. For example, Schneider (1992) reports upper bound values of $300 per hectare for land in Rondonia, Brazil. The figures suggest carbon credit values 2-15 times the price of land in Rondonia. These 'carbon credits' also compare favourably with the value of forest land for timber in, say Indonesia, where estimates are of the order of $1000-2000. If land is worth $300 per hectare in a development use, then the cost of conservation on global warming grounds becomes, say, $3 per tonne carbon ($300 divided by 100 t/ha, say). If the land is worth $2000, then carbon conservation costs $20 per tC. The latter cost is certainly not the cheapest way of conserving carbon, and, if some commentators, including the IPCC, are correct, even $3 per tonne could be quite expensive[8]. Compared to investments undertaken by the Global Environment Facility in its Pilot Phase, however, carbon reduction at $3 tC might be relatively cheap.

Tropical Forests: Preservation Values

The final category of value in the Lampietti-Dixon survey is preservation value, by which is meant passive or non-use value. The only estimate of such value for tropical forests is that of Kramer *et al*. (1994). This reports average WTP of US citizens for protection of an additional 5% of the world's tropical forests. *One time* payments amounted to $29-51 per US household, or $2.6-4.6 billion. If this WTP was extended to all OECD households, and ignoring income differences, a broad order of magnitude would be a one-off payment of $11 - 23 billion. Annuitised, this would be, say, $1.1 to 2.3 billion p.a. Taking 1.7 billion hectares as the area for total tropical forest, 5% of it would come to 85 million hectares, so that annual willingness to pay would be $13 to $27 ha. Obviously, the assumptions being made here are fairly heroic, but they bear comparison with some of the use values identified above, and also pale into insignificance when compared to the carbon storage values.

Pearce (1996) looks at other potential estimates of global value. One approach is to see what the values for 'similar assets' would imply. Willingness to pay studies for the conservation of biological resources suggest average payments of perhaps $10 p.a. per person. This would produce a fund of $4 billion p.a. when applied to OECD households. This would translate to around $2.3 per hectare if applied to all tropical forest. An alternative is to look at *implicit* prices in debt-for-nature swaps. How far the procedure of estimating implicit prices of this kind is open to doubt, although it has been used by some writers - see Ruitenbeek (1992) and Pearce and Moran (1994). The range of implicit values is from around 1 cent/ha to just over 4 dollars/ha (Pearce, 1996).

The estimates of non-use value are clearly very speculative and it is not even clear that the methodologies in question are eliciting non-use rather than some mixture of use and non-use values. As we have seen, the only direct approach based on contingent valuation suggests fairly significant values of $13-27 ha for a small part of the total forest stock. The more indirect approaches suggest

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8 Although it is not exactly clear what IPCC believes with respect to low cost, zero cost and even negative cost options for reducing emissions since the statements are not very clear. They appear to suggest, however, that 10-30% gains in energy efficiency over and above existing or near-term projected levels are feasible.

very much lower values of perhaps one tenth of the direct values.

Conclusions on Tropical Forest Values

Extracting some kind of consensus from the above estimates is clearly hazardous. More as a guide for future research than anything else we can speculate on the following annual values:

Extractive Values:	$ 50 ha
Non-extractive:	
recreation	$ 5-10 ha
ecological	$ 30 ha
carbon	$ 600-4400 ha
Non-Use	$ 2-27 ha

Whichever way the analysis is done, the major role of carbon values is revealed. Should, for some reason, global warming not remain a serious issue of concern, then tropical forests might be found to have measured environmental value of around $100 per hectare, far from enough to justify conservation on economic grounds.

Temperate Forests

Much the same analysis can be carried out for temperate forests. Rather than repeat the procedure in detail this section highlights some findings of recent research. Pearce (1994) reviews UK forestry from a cost-benefit standpoint. Accounting for timber, recreation and carbon values, and using the 'official' discount rate of 6% he finds that afforestation is not justified save for uplands spruce plantations. Otherwise net present values are negative. Some modifications are required to this analysis. Thus the carbon values used were $12 per tonne of carbon and we have seen that $20 is closer to a minimum estimate. Table 2 repeats the Pearce (1994) analysis with modified carbon values. The effect remains similar: only one of the forest types is socially profitable.

[INSERT TABLE 2 HERE]

Put another way round, particular combinations of circumstances are required to justify afforestation. Pearce (1996) identifies these as (a) community forests where there are high recreational values, (b) spruce in uplands, (c) fir, spruce, broadleaves in lowlands with high recreational values and a 20% discount off market values for land to reflect shadow prices, and (d) pine in lowlands where there are at least moderate recreational values and where the shadow price of land might be at a 50% discount.

Since the picture is not a very optimistic one for advocates of temperate forestry it is worthwhile seeing what other factors might change the outcome of this analysis. The obvious one is non-use values. Bateman *et al* (1994) suggest a convenient classification of willingness to pay outcomes for good with varying characteristics. They suggest that, where an asset has many substitutes, willingness to pay is likely to be in the range UK£2-5 per household per annum. As the availability of substitutes falls, mean WTP rises to £10-19 per annum. Finally, where there are no effective substitutes and the asset in question is threatened in a significant way, values may range from £27-35 per annum. Most temperate forests would fall into the category of substitutable assets, and the non-use component of

WTP could be expected to be very small, even insignificant. If this is correct, adding non-use values to the picture portrayed in Table 2 is unlikely to make any real difference. The other 'missing' value in the analysis of Pearce (1994) is use values for biodiversity. Here we might expect some positive values but their size is indeterminate until more research is forthcoming.

Will Non-Timber Values Save the Forests ?

If the future of the world's forests rested solely on the demonstration and capture of non-timber value, we might expect some forests to be saved and many to disappear. Despite early claims that non-timber values will prove to be highly significant, and often in excess of the alternative land-clearance values, non-timber values may well be insufficient to justify the prevention of deforestation and the planting of new forests. The most favourable circumstances appear to be where recreational values are high and where they are consistent with some degree of continued extractivism, and, above, where carbon storage values can be appropriated. Pearce (1996) details the kinds of emerging markets for carbon sequestration and, provided the scientists do not change their minds about the threat of global warming, one can expect 'trades' in carbon to grow. Perversely, if the major environmental threat of global warming is removed, the fate of the forests would appear to be compromised. But this need not be a matter for despondency. What it tells us is that the economic arguments based on valuation are perhaps less powerful than we originally thought. But, even if we discount the moral arguments for forest conservation, and they appear not to have prevented an accelerating trend in deforestation, it remains the case that a substantial amount of deforestation arises from perverse incentives such a subsidies to land clearance, and from insecure or barely defined property rights. Pressures on state revenues may ultimately see the former decline, whilst the need to protect land against a rapidly rising population should force the pace on conferment of property rights. If so, the future of the forests is reasonably secure. Let us hope so.

Table 1 Changes in Carbon with Land Use Conversion

(tC/ha)

	Original C	Shifting Agriculture	Permanent Agriculture	Pasture
Original C		79	63	63
Closed primary	283	-204	-220	-220
Closed secondary	194	-106	-152	-122
Open forest	115	-36	-52	-52

Shifting agriculture represents carbon in biomass and soils in second year of shifting cultivation cycle.

Source: Brown and Pearce (1994)

Table 2 Cost Benefit Appraisal of UK Forestry

Forest type	1	2	3	4	5	6	7	8
Timber	-975	-3839	-1276	-458	-3173	-4283	-2605	-1653
Recreation	314	547	261	268	2091	547	412	412
Carbon	237	312	334	351	356	411	279	424
NPV	-424	-2980	- 681	+161	- 726	-3325	-1914	-817

Forest types

1 semi natural pinewoods, uplands
2 semi natural broadleaves, lowlands
3 semi natural broadleaves, uplands
4 spruce, uplands
5 community forests
6 native broadleaves, lowlands
7 pines, lowlands
8 fir, spruce, broadleaves, lowlands

Source: adapted from Pearce (1994)

References

N.Adger, K.Brown, R.Cervigni and D.Moran, 1995. Total Economic Value of Forests in Mexico, *Ambio*, 24(5), 286-296.

M.Balick and R.Mendelsohn, 1992. The Economic Value of Traditional Medicine from Tropical Rain Forests, *Conservation Biology*, 6, 128-139.

J.Boj_, 1993. Economic Valuation of Indigenous Woodlands, in P.Bradley and K.McNamara (eds), *Living With Trees: Policies for Forest Management in Zimbabwe,* Technical Paper 210, World Bank, Washington DC.

K.Brown, D.W.Pearce, C.Perrings and T.Swanson, 1993. *Economics and the Conservation of Global Biological Diversity*, Working Paper No.2, Global Environment Facility, Washington DC.

K.Brown and D.W.Pearce, 1994. The Economic Value of Non-Market Benefits of Tropical Forests: Carbon Storage. In, J.Weiss (ed), *The Economics of Project Appraisal and the Environment*, Edward Elgar, London, 102-123.

R.Cervigni and D.W.Pearce, 1995. North South Resource Transfers, Incremental Cost and the Rio Environment Conventions, Centre for Social and Economic Research on the Global Environment, University College London and University of East Anglia, *mimeo*.

W.Cruz, H.Francisco and Z.Conway, 1988. The On-site and Downstream Costs of Soil Erosion in the Magat and Pantabangan Watersheds, *Journal of Phillipine Development*, Vol.XV, No.1, 85-112.

J.Eade, 1995. *Spatial Economic Valuation: Benefits Transfer Using Geographical Information Systems*, World Conservation Monitoring Centre, Cambridge, *mimeo*.

S.Fankhauser and D.W.Pearce, 1994. The Social Costs of Greenhouse Gas Emissions. In OECD, *The Economics of Climate Change*, OECD, Paris, 71-86.

S.Fankhauser, 1995. *Valuing Climate Change*, Earthscan, London.

R.Godoy and R.Lubowski, 1992. Guidelines for the Economic Valuation of Nontimber Tropical-Forest Products, *Current Anthropology*, 33(4), August-October, 423-433.

R.Godoy, R.Lubowski and A.Markandya, 1993. A Method for the Economic Valuation of Non-timber Tropical Forest Products, *Economic Botany*, 47(3), 220-233.

K.Houghton and R.Mendelsohn, 1996. An Economic Analysis of Multiple Use Forestry in Nepal. *Ambio*, Vol.25, No.3, May, 156-159.

W.Hyde, D.Newman and R.Sedjo, 1991. *Forest Economics and Policy Analysis*, World Bank Discussion Papers 134, World Bank, Washington DC.

IPCC (Intergovernmental Panel on Climate Change), 1996. *Second Assessment Report, Volume I*, Cambridge University Press, Cambridge.

S.Kant, J.Nautiyal and R.Berry, 1996. Forests and Economic Welfare. *Journal of Economic Studies*, 23(2), 31-43.

R.Kramer, N.Sharma and M.Munasinghe, 1995. *Valuing Tropical Forests: Methodology and Case Study of Madagascar*, Environment Paper No.13, World Bank, Washington DC.

R.Kramer, E.Mercer and N.Sharma. 1994. *Valuing Tropical Rain Forest Protection Using the Contingent Valuation Method*, School of the Environment, Duke University, Durham, NC. *mimeo*

J.Krutilla, 1967. Conservation Reconsidered. *American Economic Review*, 57, 777-786.

J.Lampietti and J.Dixon, 1995. *To See the Forest for the Trees: a Guide to Non-timber Forest Benefits*, Environment Department, World Bank, *mimeo*.

W.Magrath and P.Arens, 1989. *The Costs of Soil Erosion on Java: a Natural Resource Accounting Approach*, Working Paper No.18, Environment Department, World Bank, Washington DC.

R.Mendelsohn and M.Balick, 1995. The Value of Undiscovered Pharmaceuticals in Tropical Forests. *Economic Botany*, 49(2), 223-228.

N.Myers, 1984. *The Primary Source: Tropical Forests and Our Future*, Norton, New York.

T.Panayotou and P.Ashton, *Not by Timber Alone: Economics and Ecology for Sustaining Tropical Forests*, Island Press, Washington DC.

D.W.Pearce, 1994. Assessing the Social Rate of Return from Investment in Temperate Zone Forestry, in R.Layard and S.Glaister (eds), *Cost-Benefit Analysis,* 2nd edition, Cambridge University Press, Cambridge, 464-490.

D.W.Pearce, 1996. Global Environmental Value and the Tropical Forests: Demonstration and Capture, in W.Adamowicz, P.Boxall, M.Luckett, W.Phillips and W.White (eds), *Forestry, Economics and the Environment*, CAB International, Reading, 11-48.

D.W.Pearce and D.Moran, 1994. *The Economic Value of Biodiversity*. Earthscan, London.

D.W.Pearce and S.Puroshothaman, 1995. The Economic Value of Plant-based Pharmaceuticals, in T.Swanson (ed), *Intellectual Property Rights and Biodiversity Conservation*, Cambridge University Press, Cambridge, 127-138.

J.Perlin, 1989. *A Forest Journey: The Role of Wood in the Development of Civilization*, W.W.Norton, New York.

C.Peters. A.Gentry and R.Mendelsohn, 1989. Valuation of an Amazon Rainforest. *Nature*, 339, 655-656.

J.Ruitenbeek, 1992. The Rainforest Supply Price, *Ecological Economics*,1(6), 57-78.

R.Sedjo and K.Lyon, 1990. *The Long Term Adequacy of World Timber Supply*, Resources for the Future, Washington DC.

R.Simpson, R.Sedjo and J.Reid, 1994. *Valuing Biodiversity: an Application to Genetic Prospecting*, Discussion Paper 94-20, Resources for the Future, Washington DC.

D.Southgate, 1996. *What Roles Can Ecotourism, Non-timber Extraction, Genetic Prospecting, and Sustainable Timber Play in an Integrated Strategy for Habitat Conservation and Local Development ?* Department of Agricultural Economics, Ohio State University, Report to Inter-American Development Bank, *mimeo*.

T.Swanson, 1994. *The International Regulation of Extinction*, Macmillan, London.

D.Tobias and R.Mendelsohn, 1991. Valuing Ecotourism in a Tropical Rain-Forest Reserve, *Ambio*, 20(2), April, 91-2.