



institut du développement durable et des relations internationales – 6, rue du Général Clergerie – 75116 Paris – France – Tél. : 01 53 70 22 35 – iddri@iddri.org – www.iddri.org

idées
POUR LE DÉBAT

N° 03/2002 | RESSOURCES NATURELLES

(ex-Les séminaires de l'Iddri n° 4)

How valuable are the tropical forests?

Demonstrating and capturing economic value as a means of addressing the causes of deforestation

David W. Pearce (University College London, UK)

David W. Pearce a présenté
cette communication lors de la
conférence qu'il a donnée, le

5 décembre 2001 à Paris, dans
le cadre du séminaire
Economie de l'environnement
Tous droits réservés

et développement durable, co-
organisé par l'Iddri et le
MEDD.

Les séminaires de l'Iddri, n° 4

How valuable are the tropical forests?

Demonstrating and capturing economic
value as a means of addressing
the causes of deforestation

David W. Pearce
University College London,
United Kingdom

*Conférence donnée dans le cadre du séminaire
Economie de l'environnement et du développement durable,
coorganisé par l'Iddri et le Medd. Paris, 5 décembre 2001.*

© Iddri, 2002.

Diffusion : 6, rue du Général Clergerie – 75116 Paris – France
Téléphone : 01 53 70 22 35 – iddri@iddri.org – www.iddri.org

Mise en pages : Ulys communication. Montpellier.

Contents

Avant-propos	5
The issue	7
Proximate and fundamental causes of deforestation	8
Non-market values	11
The empirical evidence on non-market values	12
Costs and benefits of forest conversion	14
Tropical forest conservation policy	16
Market creation	17
References	21
Notes	23

Avant-propos

Des écologistes comme Norman Myers ont depuis longtemps alerté les gouvernements et l'opinion publique sur les taux alarmants de déforestation des forêts tropicales qui sont considérées comme un des écosystèmes parmi les plus riches de la planète. Les écologistes pour leur part estiment souvent que les forêts tropicales ont une valeur intrinsèque, c'est-à-dire une valeur en soi, indépendante de toute évaluation humaine, et qu'elles échappent à toute évaluation économique.

La contribution de David W. Pearce se situe à l'opposé : en tant qu'économiste, il pense que toutes les décisions concernant la préservation et l'utilisation durable des forêts tropicales impliquent des coûts et qu'il convient de rapprocher ces coûts des avantages procurés par l'arrêt ou le ralentissement de la déforestation des forêts tropicales.

Il s'interroge d'abord sur les raisons qui poussent agriculteurs et coupeurs de bois à adopter des pratiques non durables afin de comprendre ces échecs du marché. En ce qui concerne l'abattage du bois, des perspectives de profit plus élevé à court terme en l'absence de toute incitation à replanter après une rotation et l'abattage clandestin favorisent le recours à des pratiques non durables. Du côté des

agriculteurs, c'est, dans l'ensemble, leur préférence pour des taux d'escompte annuels très élevés qui les incite à préférer les techniques du brûlis plutôt que l'adoption de pratiques plus favorables à l'environnement comme l'agroforestrie.

Si les observations recueillies montrent que ce sont généralement les pratiques non durables qui sont les plus profitables en serait-il de même si des valeurs non prises en compte actuellement par le marché étaient réintégrées dans le calcul économique ?

David W. Pearce propose une taxinomie des valeurs qui sont associées aux écosystèmes forestiers. Celles-ci vont des valeurs d'usage direct qui sont liées aux prix du marché, aux préférences qui ne sont pas révélées par le marché en passant par les valeurs de non-usage qui requièrent des méthodes d'investigation plus élaborées. Les données empiriques rassemblées en suivant cette approche montrent que les valeurs hors-marché dans l'ensemble peuvent être considérables.

Dès lors, plutôt que de continuer à fonder les politiques de conservation des forêts tropicales sur la base de zones protégées, politiques qui se sont avérées largement inefficaces, ne vaudrait-il pas mieux les élaborer sur des mécanismes propres à capturer ces valeurs hors-marché ? David W. Pearce se lance dans un vibrant plaidoyer en faveur de la création de marchés comme une (il ne dit pas « la ») solution à la déforestation. A l'appui de sa thèse, il cite des exemples récents de création de marchés dans le domaine de la fixation du carbone par les forêts ou du rôle des forêts dans la protection des bassins versants. Toutefois, ces marchés ne surgissent pas spontanément : ils doivent être organisés et nécessitent l'intervention d'un intermédiaire qui peut, le cas échéant, être un gouvernement.

Par sa contribution David W. Pearce apporte une piste de réflexion intéressante que l'Iddri pourrait approfondir dans ses travaux sur la biodiversité en analysant, sur la base des expériences en cours, les potentialités et les limites de la création de tels marchés.

Michel Potier

How valuable are the tropical forests?

The issue

FAO's Forest Resources Assessment 2000 (FAO, 2001) suggests that, globally, the rate of deforestation for all forests is some 9 million hectares per annum, or about 0.2% per annum. Rates of loss appear to be insignificant in Asia, Oceania, and even North and Central America. Europe shows a net gain. The largest losses are in tropical areas in Africa and South America. For these two regions alone, the average annual loss is 0.56% per annum. But the aggregated data also conceal further losses in tropical areas. The overall loss rate for Asia, for example, is surprisingly small, but it conceals annual loss rates of 1.9% in Yemen, 1.8% in Nepal, 1.6% in Sri Lanka, 1.5% in Pakistan, 1.4% in Philippines and Myanmar, and 1.2% in Indonesia. The North and Central America figures conceal startling annual loss rates of 5.7% for Haiti, 4.6% for El Salvador and 2.3% for Belize, while two of the Caribbean Islands have loss rates of 4.9% (St Lucia) and 3.0% (Netherlands Antilles). FAO's assessment appears to imply some slowing down in global rates of loss, and in rates of loss in tropical areas generally. The interpretation of FAO data is dis-

puted. For example, FAO counts new plantations as offsetting losses in natural forest. Since plantations lack the biological diversity features of tropical forests, the aggregation procedure is misleading if biodiversity is the issue of concern. Excluding plantations, forest loss might be 16 million hectares per annum and tropical forest loss may actually have increased in the 1990s compared to the 1980s (WRI, 2001). Whatever the correct interpretation, it is clear that tropical forest loss remains a matter of grave concern.

Table 1. FAO data on rates of forest loss

Region	1990 forest area 1000 ha	2000 forest area 1000 ha	Absolute annual change 1000 ha	% annual change
Africa	702,503	649,866	- 5,264	- 0.78
Asia	545,827	542,116	- 371	- 0.07
Oceania	201,992	201,163	- 83	- 0.04
Europe	1,030,804	1,039,513	+ 871	+ 0.08
North and C. America	555,003	549,306	- 570	- 0.10
S. America	910,478	874,194	- 3,628	- 0.41
WORLD	3,946,608	3,856,159	- 9,045	- 0.23

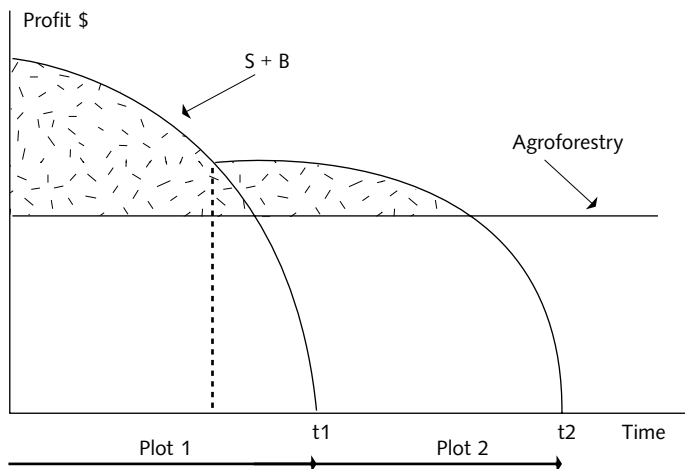
Proximate and fundamental causes of deforestation

Given this concern, the issue arises as to the best way to conserve what remains or, at least, to slow down the rate of forest loss. While other factors are at work, the two major, and interrelated, proximate causes of forest loss are logging –legal and illegal– and conversion to agriculture –crops and pasture. Hence, any policy to address deforestation has to understand the motivations behind these activities. In each case we need to ask why loggers and farmers opt for essentially non-sustainable practices. There are sustainable alternatives such as sustainable forestry and forms of sustainable agriculture such as agroforestry. Again, many factors are at work but we select one dominant one. From the standpoint of the agent converting the

forest, it is more profitable to adopt unsustainable practices than sustainable practices. In the case of logging, this is fairly clearly shown in the available, though limited, data on rates of return to alternative forestry regimes (Pearce *et al.*, 2002). This finding holds independently of any subsidies that may be given to logging practices. Moreover, there are considerable profit incentives for illegal forestry since illegal practices are cheaper than regulated forestry which may limit the timber that may be taken or limit the technologies used to extract timber. Since economic rents in timber extraction can be very high, there is extensive pressure to log illegally and to share some of the rent with corrupt officials and politicians who can either reduce the potential enforcement of forest regulations or ensure that concessions are granted (Contreras-Hermosilla, 2001). Finally, high discount rates in logging practice mean that there is little or no incentive to replant after one rotation, especially as there remains a substantial 'frontier' of unlogged forest to which the logging company can move.

As far as agriculturists are concerned, the picture is similar. Figure 1 illustrates the sequence of slash and burn agriculture *versus* a sustainable alternative such as agroforestry.

Figure 1. A 'nutrient mining' model



The farmer starts on plot 1 by setting fire to the forest in the dry season. The resulting ash contains most of the nutrients of the forest since these are stored mainly in the biomass. Farming is worthwhile only in so far as these nutrients, which are now an exhaustible resource, contribute to soil fertility. As he depletes the nutrients so it is possible that profits decline in the manner shown. At some point, t_1 , the farmer judges that the plot is not worth exploiting further and he moves to plot 2. Plot 2 starts with lower profits since plot 2 is likely to be further from the market, but it is easy to imagine variations on this idea, e.g. if new logging roads open up new areas. The earlier the farmer vacates plot 1 the more chance there is that secondary forest will grow back and the site can be restored as forest land. In sustainable slash and burn systems –plot 1 would be left fallow for a number of years and would then be ‘revisited’ and cleared once more. In practice, as the number of farmers increases through population growth, out-migration from cities or even pure land speculation, so fallow periods are not observed and the sites become exhausted and are not usable for agriculture or as a forest. Also, if sites are held on to because of a shortage of frontier land (new sites) –i.e. the closer is t_1 to t_2 – the less likely it is that plot 1 will restore itself. The role of population pressure in reducing fallow periods, and hence causing ‘permanent’ deforestation, is thus evident. It is possible to imagine loss of fallow stimulating technological change, i.e. forms of intensive agriculture on plot 1 and there is indeed some evidence for this (Tiffen *et al.*, 1994; Schneider, 1995). Overall, however, the picture is one of financial incentives to deforest.

The alternative to slash and burn, agroforestry, is shown in Figure 1 as a stream of constant profits. Since this stream must eventually outweigh the short-run profit streams of slash and burn, it would seem that agroforestry is the more profitable land use. However, farmers’ discount rates tend to be very high (Schneider, 1995; Cuesta *et al.*, 1997; Poulos and Whittington, 1999). Accordingly, farmers pay little attention to distant returns. Indeed, at discount rates of 20-30% *per annum*, little attention will be paid to returns more than a few years ahead (although there is some contrary evidence, Godoy *et al.*, 2001). Overall, then, agroforestry’s sustainable

returns will, when discounted, compare unfavourably with slash and burn. This immediately suggests one policy option, namely efforts to reduce discounting through, for example, special credit provision to counteract the high lending rates in informal credit markets.

Non-market values

If unsustainable land uses are (generally) more profitable than sustainable forest land uses the focus of attention shifts to the non-market values of conserved or sustainable used forests. If the overall social rate of return to sustainable uses exceeds the overall social rate of return to unsustainable uses, then from a social standpoint, the sustainable use should be preferred. Figure 2 illustrates the basic model.

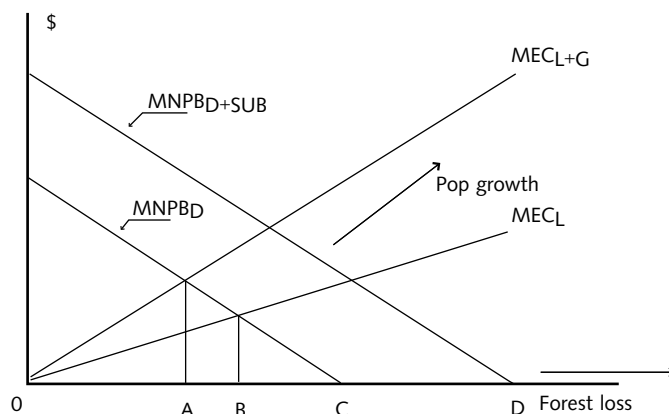
The curves are:

$MNPB_D$ = the marginal net development benefits from converting the forest to, say, agriculture

$MNPB_{D+SUB}$ = marginal net development benefits including subsidies to convert the land

MEC_L = marginal external costs borne locally from forest conversion

MEC_{L+G} = marginal external costs borne locally and by rest of world from forest conversion



There are 4 points of interest. C = the local private optimum, i.e. all externalities are disregarded and there are no subsidies. D = the local private optimum, i.e. all externalities are disregarded and forest conversion is subsidised. B = the local social optimum, i.e. local externalities are internalised but global externalities are ignored. A = the global social optimum, i.e. all externalities are internalised. Assuming a global view is taken, the desirable position is A.

We can measure government failure as distance CD –i.e. the amount of forest land that is lost due to government subsidies to conversion. Local market failure is measured by BC, and global market failure by AB. The entire distance A-D measures the amount of forest conversion that takes place inefficiently. Only amount OA is efficient conversion, i.e. the optimal externality. Population growth also increases rates of forest loss by increasing the demand for 'developmental' benefits, e.g. land for food.

This simple model suggests that at least some forest conversion could be avoided if the non-market values of forests could be integrated into land use decisions. The first step, then, is to establish what these non-market values are.

The empirical evidence on non-market values

There is now a voluminous literature on the non-market values of forests. It is conveniently surveyed in Pearce and Pearce (2001) and is summarised here.

Forests generate a substantial number of goods and services which benefit humankind. These values might be conveniently classified as:

- Direct use values: values arising from consumptive and non-consumptive uses of the forest, e.g. timber and fuel, extraction of genetic material, tourism.
- Indirect use values: values arising from various forest services such as protection of watersheds and the storage of carbon.
- Option values: values reflecting a willingness to pay to conserve the option of making use of the forest even though no current use is made of it.

- Non-use values (also known as existence or passive use values): these values reflect a willingness to pay for the forest in a conserved or sustainable use state, but the willingness to pay is unrelated to current or planned use of the forest.

Summed together these values constitute the total economic value of the forest ecosystem¹. Classified in this way, Table 2 summarises the economic values. It is important to understand the limitations of the summarised estimates. Values will vary by location so that summary values can do no more than act as approximate indicators of the kinds of values that could be relevant.

Table 2. Summary economic values

(\$ ha/pa unless otherwise stated)

Forest good or service	Value in tropical forests
Timber	
conventional logging	200-4400 (NPV) ¹
sustainable	300-2660 (NPV) ¹
conventional logging	20-440 ²
sustainable	30-266 ²
Fuelwood	40
NTFPs	0- 100
Genetic information	0-3000
Recreation	2-470 (general) 750 (forests near towns) 1000 (unique forests)
Watershed benefits	15-850
Climate benefits	360-2200 (GPV) ³
Biodiversity (other than genetics)	?
Amenity	-
Non-use values	
Option values	n.a.
Existence values	2-12 4400 (unique areas)

Notes:

1. Net present value.

2. Annuitised NPV at 10% for illustration.

3. Assumes compensation for carbon is a one off payment in the initial period and hence is treated as a present value. It is a gross value (gross present value) since no costs are deducted.

Source: Pearce and Pearce (2001).

Nonetheless, the table suggests that the dominant values are carbon storage and timber. Second, these values are not additive since carbon is lost through logging. Third, other values do not compete with carbon and timber unless the forests have some unique features or are subject to potentially heavy demand due to proximity to towns. Unique forests (either unique in themselves or as habitat for unique species) have high economic values, very much as one would expect. Near-town forests have high values because of the use of NTFPs and fuelwood. Uniqueness tends to be associated with high non-use value. Fourth, non-use values for 'general' forests are very modest.

Overall, then, non-market values can be considerable. But for much tropical forest, the values are low, contrary to the general popular view that the value of information in the forests is spectacularly high. The relevant framework is, of course, the value of marginal or discrete changes in forests. In areas where major change is under way, these values should be high, in accord with the economic view that the values rise as the remaining forest diminishes. There are also potential discontinuities in the damage functions, e.g. at some point removal of forest cover can result in substantial damage from landslides as has been witnessed in Thailand and St Lucia. Finally, some of the values are heavily disputed, as with the values of genetic material for pharmaceuticals (Pearce and Pearce, 2001; Simpson, 2002). This shows up in the ranges in Table 2.

Costs and benefits of forest conversion

Some attempt can be made to look at the likely costs and benefits of converting existing forests to alternative uses. Unfortunately, the data remain very limited, and there is the added problem that costs and benefits obviously vary by forest location. Table 3 brings the estimates together.

While Table 3 is illustrative only –cost-benefit outcomes will be very much dependent on the actual location of the forests– it does suggest several likely conclusions. First, converting primary forest to any use other than agro-

Table 3. Costs and benefits of changing forest land use

(\$/ha/pa) (- shows losses, + shows gains)

Original land use Alternative uses	Nutrient mining cycle: logs/crops/ ranching	Conventional logging	Agroforestry	Agribusiness
Primary forest	- 223 (to - 3630) ¹ +172 to 209 ²	-150 (to -3000) ⁵ + 20 to 440 ⁶	- 2 (to -470) ¹⁰ + 135 ⁹ to 317	n.a.
Secondary forest	- 121 (to -1050) ³ +172 to 209 ²	- 83 (to -600) + 10 to 220 ⁸	0 + 135 ⁹ to 317	n.a.
Open forest	- 50 ⁴	n.a.	No losses? + 135 ⁹ to 317	n.a.

Notes:

1. Assumes losses of carbon, all watershed effects, all NTFPs, all recreation, all genetic information, all non-use value. High losses relate only to scarce hotspots with high bio-prospecting value. No other account taken of biodiversity.
2. Based on Wunder (2000). Based on losses of carbon, NTFPs and watershed values only. High value reflects high watershed values.
3. Carbon losses plus national value for NTFPs.
4. Assumes half carbon loss and half watershed values lost. High value reflects high watershed and high genetic information values.
5. See Table 17.
6. Assumes half original carbon lost, all NTFPs lost and half watershed values are lost.
7. Assumes half timber values of primary forest.
8. Based on Cuesta *et al.* 1997 updated to 2000 values, but note this estimate is taken from a NPV at a 25% discount rate. Hence we have projected the value also at 10% in order to make it comparable to other values.
9. Assumes tourism values only lost. For the justification of keeping other forest values see Chomitz and Kumari (1996).

forestry or very high value timber extraction, is likely to fail a cost-benefit test. Second, the conversion of secondary forest to the 'cycle' of logging, crops and ranching could make *prima facie* economic sense. As with the primary forest conversion, however, it needs to be borne in mind that the 'sequence' of land uses does not always occur and many conversions to slash and burn agriculture would make no

economic sense. Third, the conversion of secondary forest and open forest to agroforestry appears to make economic sense, assuming that most of the forest's services (including biodiversity) are retained. Fourth, and worth repeating, the comparisons all assume that non-market values are actually captured through some market creation mechanism. Fifth, the non-market values almost certainly fail to capture the economic value of biodiversity which, apart from the value of genetic information, is omitted from the analysis. Sixth, carbon storage is of the utmost importance to the economic case for forest conservation.

Tropical forest conservation policy

Forest conservation policy to date has tended to opt for the gazetting of unused forest land as a protected area. Such policies will be effective only in so far as (a) there are adequate monitoring and enforcement measures if there are competing uses for the land, or (b) there are no competing uses. Since the context of policy concern is one of land that has competing uses, the former condition becomes critical. Much of the literature on environmental compliance relates to industrialised countries with strong institutions (Cohen, 1999) but there is a rapidly emerging literature on corruption and non-compliance in developing countries (Contreras-Hermosilla, 2001). The kinds of policies needed have to be very wide ranging and may often take the form of wholesale political reform. Measures that have been successful in reforming subsidy systems –a major generator of rents– and which have adverse environmental effects are reviewed in Pearce and Finck von Finckenstein (1999). More recently, Rice *et al.* (1997) have suggested that a policy of allowing first rotation logging followed by protection may be the best policy. Ultimately, however, policies that rely on designating areas as officially protected are risky because the policy can create a set of losers –those who can no longer access the forest for timber and other products. This problem remains regardless of who holds the property rights to the protected area, although the biggest problems arise when a government holds the rights

but fails to invest in enforcement mechanisms. Unless the losing group is compensated in some way, a considerable tension remains, placing the forest still at risk.

While enforceable protection remains a viable and desirable policy in some circumstances, the difficulties involved have prompted a reappraisal of conservation policies. Once the relevance of non-market values is understood, the obvious solution is to ensure that those values are turned into real resource flows. This is the process of 'capture' of non-market values. So long as the sum of net private conservation (or sustainable use) benefits and non-market benefits exceeds the net benefits from conversion, the workings of the market should encourage conservation and sustainable use. This process of 'market creation' has been proceeding apace in recent years.

Market creation

Even before the Convention on Climate Change and the Kyoto Protocol were negotiated, some private companies in the USA were paying for the growing of trees in poorer countries. As trees grow, so they 'fix' or 'sequester' carbon. Hence growing trees helps to reduce global warming, although a problem arises when they end their lives because the carbon is then released again. Why would a firm voluntarily want to fix carbon? The two main reasons originally were (a) to get good environmental publicity and (b) to learn about these 'carbon deals' in anticipation that they would be formalised by the climate agreements as a legitimate way of reducing CO₂. In the latter case the idea is that the firm paying for the tree growing would claim a paper 'credit' for the CO₂ it has reduced. If, one day, the firm is given a limit on its carbon emissions, it could claim the credit against that limit. Such deals are also known as joint implementation. Now that the details of the Kyoto Protocol (originally negotiated in 1997) have been established, these kinds of deals will be legitimate, i.e. emitters in rich countries will claim offsets or credits against their carbon emission targets based on what they have done in poor countries. The idea is that firms facing

emission targets in rich countries will find it cheaper to reduce carbon emissions in poor countries than in their own. So joint implementation promises to be more cost efficient than if the carbon reductions occur in the rich country only. It is one further step away to think about the use of the carbon credits secured by the firms that pay for the carbon reduction. If they can buy and sell emission credits then we have a tradable emissions credit system. As is well known, like environmental taxes, tradable permit systems have the virtue of minimising the compliance costs in any regulation.

There are now many hundreds of 'carbon deals' virtually all of which are not directly linked to the Kyoto Protocol, but some of which will seek retrospective credit under the Protocol's 'Clean Development Mechanism'. Deals that have been done and which relate mainly to environmental 'PR' are those between Peugeot and Brazil, and between Shell and Gabon. These were brokered by 'Pro-Natura', a company formally set up to negotiate such deals. The effect is to establish property rights in carbon dioxide emissions or, the same thing, in the receiving capacity of the global environment.

In the same way, deals are beginning to emerge that relate to the local externalities from forest conversion. In Colombia, downstream farmers have established contracts to pay upstream forest owners to conserve the forests that protect and regulate their water supplies. New York City has chosen to protect upstream catchments in the Croton and Catskills watersheds, rather than pay nearly \$5 billion for water treatments plants that it will need to deal with the projected pollution of water if the catchment is not protected. US experience is showing that for each dollar invested in catchment protection, several dollars can be saved in avoided treatment expenditure. Perrier helps surrounding farmers to reforest and protect filtration areas so that the quality of Perrier water is not affected adversely by farm runoff. In 1996, Costa Rica developed a new Forestry Law which recognised the role of forests in carbon fixation, watershed protection, biodiversity protection and scenic beauty. Funds raised by an energy tax are to be used to pay forest landholders who provide these environmental services. The government also brokers deals whereby carbon is

'sold' to international and domestic buyers, the funds again being used to pay forest landholders to conserve these functions. Prices are set for the compensation on a per hectare per time basis, but these may change over time.

There are many other such examples. What began as a set of 'textbook' solutions to the deforestation problem is quickly evolving into a whole new array of real world conservation policy instruments. Several questions arise. If conservation can be brought about by bilateral and multi-lateral bargains through the market place, why have such markets not emerged before?

In some cases the answer is that they have and that it is only now that information about them has emerged because of the new focus on market creation as a solution to deforestation.

In other cases, such as carbon deals, there was no incentive to create markets because the relevant constraint –some form of voluntary or mandatory carbon emission limit– was not in place. It is no accident that carbon deals date only from around 1989.

In the remaining cases, the relevant 'paradigm' shift has not been in place. Asking why market solutions have not occurred much before is akin to asking why governments world-wide have relied on traditional forms of environmental policy when solutions based on taxes and tradable permits systems have been known for decades. As long as these solutions remain in the academic arena and not in the policy arena, little will happen. To begin with, policy language has to change and that requires a cumulative process of communication, advocacy and experimentation. In this respect the role of those academics who do engage in the policy process and the role of some of the NGOs has been a crucial element in changing the focus of policy. National 'think tanks' and international bodies such as the OECD and the World Bank have also been vital: OECD, for example, has been a consistent advocate of market based environmental solutions since the inception of its Environment Directorate in 1971. In contrast, the World Bank was a late-comer to these approaches, perhaps because environmental economics was applied much later to developing country problems than to developed country problems.

Finally, while markets emerge 'naturally' in most respects there is a case for arguing that the kinds of bargains that characterise market creation require flows of information that do not necessarily emerge from markets. The links between forests and watershed protection may not be readily understood, as the various cases of catastrophic damage from deforestation show. Even where they may be understood, the context is often one of externality 'at a distance' so that the sufferer may be located a long way from the source of the externality. The scope for 'natural bargains' is then very limited. In all these cases there is a role for an intermediary or broker. Brokers have emerged fairly automatically in the carbon offset context. It is too early to say if a similar process will take place for other externalities. Governments may often have to 'nudge' the markets into being, but with the presumption being that governments themselves have no particular expertise in managing the resulting markets.

International efforts to find a global solution to deforestation through some Forest Convention have, to date, systematically failed. The process of valuation and capture through created markets is very much a 'bottom up' solution based on mutually beneficial trades. Moreover, they avoid the protected area syndrome: all parties gain from market creation, whereas at least one party loses with command and control style measures. The prospect exists that tropical deforestation can be slowed down by nothing more than the mutual self-interest of those who gain and those who lose from deforestation.

References

Chomitz, K. & K. Kumari. 1996. The domestic benefits of tropical forests: a critical review. Working paper 96-19. CSERGE, University of East Anglia and University College London.

Cohen, M. 1999. Monitoring and enforcement of environmental policy, *in* H. Folmer and T. Tietenberg (eds), *The International Yearbook of Environmental and Resource Economics 1999/2000*. Cheltenham: Edward Elgar, 44-106.

Contreras-Hermosilla, A. 2001. Law compliance in the forestry sector: an overview. Rome: FAO, mimeo.

Cuesta, M., G. Carlson & E. Lutz. 1997. An empirical assessment of farmers' discount rates in Costa Rica. Washington DC: World Bank.

Dixit, A & R. Pindyck. 1994. *Investment under uncertainty*. Princeton: Princeton University Press.

FAO (Food and Agriculture Organisation). 2001. *Forest resources assessment 2000*. Rome: FAO.

Godoy, R., K. Kirby & D. Wilkie. 2001. Tenure security, private time preferences and the use of natural resources among lowland Bolivian Amerindians. *Ecological Economics*, 38, 105-118.

Pearce, D.W., & C. Pearce. 2001. *The value of forest ecosystems: a report to the secretariat of the convention on biological diversity*. Montreal: CBD.

Pearce, D.W. & D. Finck von Finckenstein. 1999. Advancing subsidy reforms: towards a more viable policy package. New York: United Nations.

Pearce, D.W., J. Vanclay, & F. Putz. 2002. A sustainable forest future? *in* D.W. Pearce, C. Pearce & C. Palmer (eds), *Economic valuation in developing countries*. Cheltenham: Edward Elgar.

Poulos, C. & D. Whittington. 1999. Individuals' time preference for life-saving programs: results from six less developed countries, Department of Environmental Science and Engineering, University of North Carolina at Chapel Hill, mimeo.

Rice, R., R. Gullison & J. Reid. 1997. Can sustainable management save tropical forests? *Scientific American*, 276, 34-39.

Schneider, R. 1995. Government and the economy on the Amazon frontier. Environment paper No. 11. Washington DC: World Bank.

Simpson, D. 2002. Biodiversity. Washington DC: Resources for the Future.

Tiffen, M., M. Mortimore & F. Gichuki. 1994. More people, less erosion: environmental recovery in Kenya. Chichester: Wiley.

World Resources Institute. 2001. Understanding the FRA 2000. Washington DC: World Resources Institute.

Wunder, S. 2000. The economics of deforestation: the examples of Ecuador. London: Macmillan.

Note

1) Laos of relevance is quasi-option value which is the value of information secured by not committing to an irreversible decision. This notion of option value is familiar in financial economics –see Dixit and Pindyck (1994).

