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Sustainable Forestry in the Tropics: panacea or folly?

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Abstract

The profitability of uncontrolled logging can be a significant obstacle to sustainable forest management, especially in the tropics. Rice *et al*. (1997) have argued that not only does traditional selective logging provide higher returns but also incurs less damage to forests than sustainable forest management systems that involve harvesting of many species and the creation of large gaps in the forest canopy to foster regeneration of light-demanding species. They claimed that protected areas were the only viable way to conserve forest ecosystems and proposed that loggers be allowed to log forests selectively once, after which the forests should become parks. Here we respond to the challenge posed by Rice *et al*. by exhaustively reviewing the evidence regarding the viability and desirability of sustainable forest management in the

tropics. Following Rice *et al*., we use the term conventional timber harvesting to refer to existing practice, which typically pays little attention to maintaining long-term timber supply. Sustainable timber management implies taking steps to ensure forests continue to produce timber in the longer term, while maintaining the full complement of environmental services and non-timber products of the forest.

Empirical studies tend to confirm the conclusion of Rice *et al*. (1997) that although sustainable timber management sometimes provides reasonable rates of return, conventional timber harvesting is generally more profitable. This implies that without additional incentives, one cannot expect companies to adopt sustainable management. The shortsightedness of many loggers, the slow rise in international timber prices, political uncertainty, and tenure insecurity simply reinforce this tendency. However, we reject the claim that sustainable timber management generally damages forests more than conventional logging. Rice *et al*. base their conclusion largely on the particular case of mahogany extraction in Bolivia, and even there it may not hold. In many cases, sustainable timber management performs better in terms of carbon storage and biodiversity conservation than conventional logging approaches, as well as producing more timber. If new carbon markets emerge, sustainable forest management might compete effectively with conventional timber harvesting. Timber certification systems may also provide a sufficient incentive for sustainable forest management in certain circumstances.

Introduction

Concern about the depletion of the world's forests has led to many international calls for radical efforts to reduce deforestation, including the United Nations Intergovernmental Forum on Forests of the UN Commission on Sustainable Development (1999), and the World Commission on Forests and Sustainable Development (1999). This concern reflects an appreciation of the ecological and economic functions of forests: as providers of timber and many non-timber products, as the habitat for much of the world's biological diversity, and as regulators of local, regional and global environments. These functions are at risk. Most forest clearance is in tropical areas where there are great demands for agricultural land. In temperate and boreal areas the pressures from logging are more important. But in all areas, forestry itself has an important role to play both as a partial cause of deforestation, and, if practised wisely, as a potential source of salvation for at least some of the world's forests. In terms of its causal role, forestry tends to open up primary forest areas, enabling colonists to move in, using roads forged by the timber companies. In some parts of the world, forests are converted not to agriculture but to biomass plantations of fast growing trees or to other agro-industries based on tree-crop plantations such as palm oil and rubber. Here the primary agent is not the peasant, but the richer elements of local and international society.

How, then, can the world's forests be used more wisely? It is this complex question that we seek to answer in this paper. Some argue for outright protection, caricatured perhaps in the phrase 'fence and forget'. Others argue for 'sustainable forest management', and still others for systems of forest management that rely on acceptance of an initial period of exploitation of valuable species followed by outright protection. The issue, then, is the *optimal use of forested land*[1], which begs the question of what is meant by 'optimal'. This is addressed shortly.

Forested land may be retained as forest or it may be converted to non-forest uses such as agriculture, grazing, urban expansion, or industrial tree crops. The first question, then, is under what circumstances is it better to convert forest land to non-forest uses, and when not.

[1] We use the term forested land rather than forest land to make it clear that we are dealing with land that still has forest on it, rather than land which has a potential to be used for forest in one form or another.

If it can be shown that forest land is best retained as forest - where ‘best’ needs to defined - the further issue arises of *what kind of forestry* is to be preferred. Here the issue is clouded in terminological confusion because the words used in reference to forestry have come to mean different things to different people. But, in order to focus the debate we choose three archetypes familiar in the literature: *conventional logging* (CL), *sustainable timber management* (STM) and *sustainable forest management* (SFM). We adopt this terminology not because we think it is free from misinterpretation, but because the literature on the role of forestry in deforestation has adopted it, making it extremely difficult to elicit the lessons from that literature without using that language. We devote some time to explaining what we mean by the terms below and why, in an ideal world, we would prefer a different terminology. For the moment, we take CL to be more short-term in focus, less concerned with forest regeneration through management, and often lacking in government control. We take STM to be a forest management system that aims for sustained timber yields. We take SFM to be a system of forest management that aims for sustained yields of multiple products and services from the forest.

There have been recent challenges to the idea that conservation is best served through sustainable timber or forest management (Vincent, 1992; Kishor and Constantino, 1993; Howard *et al.,* 1996; Rice *et al.,* 1997; Bowles *et al.,* 1998). One argument is that conservation can only be served by outright protection (Bowles *et al.,* 1998), i.e., while SFM has the potential for protection, it is inferior to outright protection. Another view is that conservation might be better served by an initial period of well managed logging followed by protection (Rice *et al.,* 1998a; Rice *et al.,* 1998b; Cannon *et al.,* 1998). Against this, it is argued that outright protection has a limited chance of being successful in face of the high costs of protection, pressures to use forests for profit, and human population growth (but see Bruner *et al*., 2001; Vanclay 2001). It follows that in many places sustainable forest management offers the only chance of maintaining forests and biodiversity (Whitmore, 1999).

The Theme

In terms of the debate about the optimal use of forested lands, the existing literature tends to focus on the *financial* returns from STM, SFM and CL and on physical descriptions of the comparative *ecological impact profiles* of these forms of forest management. The focus on financial returns is justified insofar as actual forest use is determined by relative profits. The focus on ecological impact profiles is relevant for a full *economic* assessment.

An economic assessment makes several potentially major adjustments to a financial analysis: the existing financial costs and benefits are adjusted to 'shadow values' to reflect the true opportunity cost of the resources involved; and environmental and social costs and benefits ('externalities') at the national and global level are included.

(1) The first modification adjusts *financial* costs and benefits to reflect *shadow prices*. A shadow price, say the price of labour or the exchange rate, differs from a financial price in that it reflects the true *opportunity cost* of the resources in question. For example, the ruling wage rate would be used in a financial analysis, but if the labour employed would otherwise be unemployed, the shadow wage rate will tend to be closer to zero (since the wage in alternative employment is, effectively, zero). A shadow exchange rate is the rate that would prevail if trade were free and open, rather than, as is often the case, managed through trade quotas and tariffs. It is important to understand that this shift to shadow pricing alters the stakeholder perspective. Whereas financial costs and benefits are relevant to the logger or concessionaire, shadow priced costs and benefits are relevant from the standpoint of the forest owning nation.

(2) The second modification adds in all environmental and social consequences that affect the wellbeing of anyone within the *nation*. Thus, if indigenous peoples are adversely

affected by the forest development, their wellbeing must be counted in any economic study. Similarly, if logging contributes to soil erosion, flooding or loss of biodiversity, an economic analysis would attempt to take these into account. It is important to understand that ecological functions of forests have a parallel in economics – all ecological functions are economic functions.

(3) The third modification constitutes a *global* analysis and would additionally include the gains and losses of people outside the country in which the forest is located. Thus, if individuals in another country experience a loss of wellbeing from knowing that deforestation, perhaps indirectly caused through logging, is taking place, that loss of wellbeing has also to be accounted for. This loss of wellbeing is relevant regardless of whether it emanates from a loss of any *use value* (e.g., ecotourism or carbon storage) or any loss of *non-use value*, i.e. wellbeing unassociated with any direct use of the forest.

It is not always appreciated that economic analysis is potentially quite different to financial analysis. An economic analysis might, for example, sanction an activity that is wholly unprofitable from a financial standpoint.

In this paper we try to build up the overall picture, as best we can, by beginning with financial analysis and extending it to full global economic assessment. It is important to understand that a global economic assessment is useful only insofar as it *demonstrates* the superiority of one form of forest land use over another, i.e., it shows, in an accounting sense, which land use is 'best'. Unless there are corresponding cash flows that *capture* those values, the exercise remains interesting but unlikely to change the way forests are treated. For example, SFM may turn out to be financially inferior to CL, but this does not mean that SFM is to be dismissed. An economic analysis that includes all social and environmental externalities can guide us to the relevant conclusion. Now suppose the economic analysis demonstrates that SFM is superior to CL, regardless of the contrary finding for the financial analysis. Since the financial costs and benefits 'drive' the land use decision, SFM can only be introduced if forest land use is regulated in some way, or if forest land users are compensated for the difference between the profits under CL and the profits under SFM. In this paper we are concerned mainly with the demonstration phase. The broad issue of designing compensatory and 'capture' incentives is not addressed in detail here except indirectly by reference to the literature (e.g., Pearce, 1996). Capture mechanisms include carbon trading, watershed protection payments and forest certification.

The Terminology of Forest Management

As noted above, the terminology used in the debate over the appropriate use of forested land has become confusing. 'Logging' rightly refers to the process of harvesting timber from a forest, even though timber harvesting may appear more 'value-neutral'. Logging, however, can be a legitimate part of good or 'wise' forest management. In the same way, the literature now refers to 'conventional logging' as if it too characterises undesirable treatment of forest. To a forester, however, conventional logging might characterise standard forest management practice as opposed to unconventional means of timber extraction, e.g., the use of helicopters. But some conventional logging is not practised wisely, so that it becomes possible to contrast poor management practice with, say, reduced impact logging (RIL). To a forester, RIL would simply be a feature of any good management system. In what follows we maintain the more popular image of conventional logging as meaning use of the forest for short-term timber supplies, aimed solely at short-term profits and without significant government control. Management plans may or may not exist for this type of timber harvesting, and, while the potential is there for switching to a more long-term sustained timber yield, it is more likely that forest degradation, forest loss, and conversion to non-forest use will follow.

In terms of timber volumes, conventional timber harvesting may be sustainable or unsustainable. But the connotation of conventional logging is that it is often unsustainable, i.e., not focused on long-term timber supplies. Sustainable timber management (STM) therefore arises when a forest management plan is fully implemented for timber and focuses on long-term non-declining flows of timber.

Sustainable forest management embraces the view of the forest as yielding many different products and providing many different ecological services. Sustainable forest management will therefore produce an array of products and services that may or may not include timber. SFM therefore relates to the *multiple use* of the forest. To a forester, the term ‘management’ could relate to the management of resources, inventorying and yield calculation, and to silvicultural practice (e.g. climber cutting), so that, on some definitions, SFM is already embodied in good practice timber harvesting. Again, then, the terminology of SFM is not ideal but is retained here to convey the idea of multi-product uses and with a focus on the longer term.

‘Protection’ is also ambiguous. For ardent environmentalists it almost certainly means the maintenance of the structure and composition of the forest without change caused by human intervention. For others it risks being confused with ‘conservation’ which is the proper management of the forest for the sustained yield of some product(s), service(s), or some combination of products and services. Again, foresters would argue that they have always been in the business of conservation in this sense (as indicated by the traditional term of ‘Conservator’). ‘Protection’ also conjures up the image of leaving a forest totally alone when, in practice, some management of fire and invasive exotic species is still likely to be required to conserve structure and composition.

The Meaning of 'Optimal' Forest Land Use

What is 'optimal' depends on the viewpoint of the economic agent making the decision to convert forest land or to adopt a particular forestry regime. Hence we need to identify the *stakeholders*.

From the standpoint of most *logging companies* a forest exists to be logged. In principle, a forest will not be logged if it is unprofitable to do so, although it is perfectly feasible that loggers may log land at a loss if subsidies prevail. If logging is profitable, the regime used will generally be that which maximises profits, subject to any regulations on harvesting that may be in place. In addition to obligations under relevant legislation, logging companies may voluntarily attenuate maximum profits if they feel some obligation towards the environment. In some cases it would appear that the most profitable regime is not employed. RIL might, for example, lower costs but not be used, perhaps because of ignorance, fear that investments in training may not be recouped, or other reasons that remain unclear (Putz *et al*., 2000).

Forest owners include national and regional governments, local communities, indigenous groups, individuals and companies not engaged in logging. They may have several motives relating to the forest: as a supply of products including timber, as an environmental resource, as a stewardship objective, and so on.

From the standpoint of *forest dwellers* a forest exists to provide an array of ecological and economic functions ranging from timber, fuelwood and wildmeat, to protection against floods.

From the standpoint of *poor agricultural colonists,* forests exist for the land they provide for timber, crops and livestock, mainly the latter two. Such colonists may nonetheless have complex mixes of motives. For instance, Mourato (1999) showed that slash and burn cultivators in Peru exhibit a strong concern for the conservation values of their forests. Nor is the image of colonists being poor always correct: they may also be wealthy individuals or companies looking to exploit subsidies, to speculate on land values, or to anticipate conversion to lucrative plantations and agro-industries.

From the standpoint of the *conservationist* the forest exists to provide ecological functions, amenity and the provision of wellbeing to forest peoples. Motivations vary and may range from a desire to make direct use of the forest (e.g., ecotourism) to a concern for the intrinsic rights of biodiversity to exist.

From the standpoint of *national governments*, forests may serve any of the above functions depending on the extent to which governments have the wellbeing of particular stakeholders at heart. They may prefer:

- logging to preservation because it provides employment and tax income;
- conversion because it may yield higher returns than timber production;
- conversion and colonisation because of the need to 'establish' political frontiers and accommodate migrants;
- conservation because of a concern for vulnerable indigenous groups, because of the potential income from sustainable uses of the forest, because there are financial inducements to conserve, or because they have forest protection as a general social objective.

From the standpoint of the *world as a whole* there may be a preference to log forests for the valuable timber they contain, or to conserve forests for their local and global ecological functions. In the latter case, there may be a preference to conserve forests because of their role in providing biodiversity and in storing carbon that would otherwise be released to the atmosphere, contributing to global warming. The relevant agents reflecting 'world' interests include some activities by bilateral and multinational aid agencies, various UN organisations not directly involved with aid, the Global Environment Facility, and international NGOs.

The viewpoints of the stakeholders necessarily conflict; otherwise there would be no problem. Different uses of forested land are often incompatible. The only options for 'resolving' these conflicts of values are:

(1) to impose a given use on all stakeholders, regardless of the differences of viewpoint. This 'solution' is potentially unstable because one or more stakeholders will lose from the imposed land use. Hence they have a continuing incentive to break the agreement by securing its subsequent rejection, or by 'illegally' using the forest for their own purposes.

(2) to find an agreement which adopts a given use of the forest land and in which those who lose are compensated in some way for forgoing their use of the land. On this solution, all stakeholders are (ideally) better off with the agreed land use than they were without it.

The second solution suggests the meaning of 'optimal': it is a land use which is judged socially the most beneficial overall, but in which those who lose from the land use are compensated for their losses. This definition accords with elementary game theory (for a brief introduction see Perman *et al*., 1999).

In practice, actual compensation for losses is often not feasible. At the very least then, forest land should be allocated to those uses that maximise, as far as possible, the aggregate *social value of the forest land.* If gains and losses are measured in monetary terms, then this requirement is equivalent to a standard cost-benefit analysis approach and the compensation is potential rather than actual. Put another way, gainers have to be able to compensate losers and still have net gains to show (Pearce, 1986). In practice, while we may not be able to assign economic values to all functions, the cost-benefit approach is a reasonable way of organising the framework for analysis.

A convenient language to describe stakeholders' interests is that of 'private' and 'social' gains and losses. 'Private' refers to the private interests of the stakeholder, i.e., what benefits him or her. 'Social' takes the wider, social perspective and the jurisdiction may be local, national, regional or global. In theory, governments or global agencies should take the social standpoint, but it is well known that this is not always the case. Both perspectives are relevant to determining 'optimal' forest land use because adopting a social perspective without acknowledging that some stakeholders' private interests may be compromised will, as noted above, be potentially unstable.

The Meaning of Sustainable Forest Management

Optimal land use is not necessarily the same thing as sustainable land use (Toman and Ashton, 1994; Pearce, 1999). The current debate about forestry is partly about sustainability, i.e. about making use of forested land in a sustainable fashion. In large part, converting forest land to agriculture – in tropical regions – is not sustainable because soils may not have the capacity to sustain agricultural activity indefinitely, although the case for perennials is far stronger in this respect. There are, however, many cases in which tropical forests have been converted and successful agriculture follows (see e.g. Schneider, 1995). In other cases, provided suitable fallow periods prevail, forested land can be converted for short-term agricultural use and then be cleared again and reused after the fallow period. This 'cycle' of agriculture and forest regeneration is also potentially sustainable.

As noted above, the debate mixes two different aspects of sustainability:

(1) sustainable *timber* management (STM) in which the focus is on a sustained yield of timber over long time periods; and

(2) sustainable *forest* management (SFM) in which the focus is on the many products and services of the forest sustained over long periods of time.

While it is generally thought that STM is consistent with SFM, it is at least open to argument that STM may not maintain all the components of biodiversity, including ecosystem and landscape-level structures and processes Putz *et al*., 2000). Thus, it is important to distinguish STM from SFM. In sustainable timber management, timber is extracted with regard to a continuous future supply of wood through investment in regeneration. STM also tends to be associated with minimisation of damage to residual stands (see Vanclay, 1996a,b), possible investment in finding uses for currently non-merchantable species, and accelerated growth of merchantable species in managed stands.

Many writers have offered definitions of SFM (e.g., Dickinson *et al.,* 1996; Reid and Rice, 1997; IFF, 1999), but perhaps the most complete definition comes from Bruenig (1996): '… management should aim at forest structures which keep the rainforest ecosystems as robust, elastic, versatile, adaptable, resistant, resilient and tolerant as possible; canopy openings should be kept within the limits of natural gap formation; stand and soil damage must be minimised; felling cycles must be sufficiently long and tree marking so designed that a selection forestry canopy structure and a self regulating stand table are maintained without, or with very little, silvicultural manipulation; production of timber should aim for high quality and versatility … The basic principle is to mimic nature as closely as possible to make profitable use of the natural ecosystem dynamics and adaptability, and reduce costs and risks …'.

The Context for the Analysis

The context for this paper is one where the starting point is an existing forest. Thus, we do not discuss the optimal use of bare or degraded land. Additionally, although land uses that involve conversion of the forest are relevant to the analysis, they are incidental to the main focus which is on the appropriate form of forestry. It may or may not be the case that land conversion is socially or privately 'better' than a given forestry use. Finally, outright protection is also relevant to the analysis but is not the main focus. Like conversion, protection has to be part of the analysis because forest practices are capable of being a precursor to a protected area classification. Conventional logging, for example, is frequently a precursor to agricultural colonisation, and hence to land conversion. One current argument is that protection might follow on from an initial period of logging.

The Private Interests of the Logging Companies

The empirical evidence

From the logging firm's point of view, the use of the forest will be dictated by the option providing the largest private financial rate of return. Empirical evidence relating to these rates of return is limited (but see Pearce *et al*., 2000). A particular problem concerns the fact that STM and SFM systems have rarely been in place long enough for an accurate picture on financial returns to be obtained (Dickinson *et al.,* 1996). Furthermore, it is seldom to the logging firm's advantage to reveal the actual costs of logging operations. Double accounting is therefore commonplace when record books are accessible at all. Those few studies that compare STM/SFM and CL therefore tend to be based on financial model simulations. Additionally, where there is additional evidence on the rate of return to STM/SFM, authors often do not attempt a comparison with CL, contenting themselves with a demonstration that STM/SFM is profitable *per se*. A recent review of some 30 studies (Pearce *et al*., 2000) revealed that:

(1) STM is potentially profitable at 'reasonable' discount rates of 5–10% (in real terms), and

(2) STM is almost systematically less profitable than 'liquidation' forestry and other forms of conventional logging.

These conclusions echo those already reached by other commentators, e.g., Bach and Gram (1996). Nonetheless, while this inequality of profitability explains the widespread preference of loggers for CL, it does not justify it. The reason for this, as indicated previously, is that the financial cost benefit calculation of the logger is not the same as that for society generally and certainly not for the world as a whole.

Factors that could favour the financial profitability of STM

Advocates of STM have drawn attention to four main factors that might increase the financial return to STM relative to CL: discount rates, future price increases, incremental growth rates for timber volume, and property rights.

The discount rate

One 'price' of potential importance for the SFM versus CL debate is the discount rate. For the financial perspective the relevant discount rate is that of the logger or concessionaire. For the national perspective, the relevant rate is the social discount rate. The two rates can be expected to differ, with the social rate being below the private rate (Pearce, 1986). Surprisingly little is known about discount rates in developing countries, but they tend to be so high that it is difficult to justify even the most conventional of development projects (Pearce *et al*., 2000). In the context of forestry they are effectively fatal for any investment with a long-term focus.

While high personal discount rates appear to be the norm on the basis of the empirical evidence, it is important to stress that few studies exist that adopt rigorous methodologies for estimating those discount rates. Additionally, some poor communities do manage timber production on a non-exploitative basis, suggesting that communal discount rates may be markedly less than purely personal rates (see Pinedo-Vazquez and Rabelo, 1999).

Timber prices

If timber prices are expected to appreciate then there is some benefit to curtailing the harvest now in favour of the future (effectively, price increases can be thought of as a deduction from the discount rate). But future timber prices are unlikely to grow rapidly. Some of the high price increases simulated in the STM studies, e.g., Howard and Valerio (1996), are based on protected forest industries. World prices are a better guide. Moreover, world price ('border prices') would be the relevant magnitude in economic, as opposed to financial, studies. Rice *et al.* (1998) use 2% p.a. growth in real prices which may, however, be an exaggeration of future price increases. Work at Resources for the Future (Sohngen *et al.,* 1998) suggests baseline price growth rates well under 1% p.a. for the next 100 years. Even with a high demand scenario, price increases barely exceed 1% per annum over the next 60 years. These results are consistent with other estimates of long-term trends (e.g., see Brooks *et al.,* 1996). Overall, it seems unlikely that future price increases will confer significant advantages on STM relative to CL. More generally, as long as timber is 'abundant', stumpage prices will be low, making STM financially vulnerable (Southgate, 1998).

Timber volume growth rates

Timber volume growth rates have an effect similar to real relative price increases. If growth rates are faster under STM then the difference can be regarded as the equivalent of a reduction in the discount rate. Rice *et al.* (1998) suggest 2% p.a. as an average for growth relevant to STM, i.e., 2% per annum in volume of the stand. However, quotations of percentage growth rates are not very meaningful. First, growth depends on stand condition such that growth is an inverse 'U' shaped curve relative to stand condition (low at poor states and low again if there is high density and crowding, although the latter is rare in managed natural forests) – see Vanclay (1994a). Second, large trees may have small percentage growth rates but substantial incremental yields in terms of cubic metres of wood. Third, account has to be taken of damage in CL to residual trees (10-40 cm dbh) that will form the next crop in polycyclic management operations. Surviving damaged trees grow slowly and will not contribute to the next commercial crop due to stem defects. Most of the growth benefit from RIL and STM derives from higher stocking and fewer weed-dominated areas, such as vine blankets. Overall, STM could easily result in volume increments of commercial species that are 2-4 times higher than after CL.

Property rights

It is widely argued that insecure or short-term property rights encourage CL, so that longer-term rights would encourage a switch to SFM, or at least STM. Rice *et al*. (1998) accept the argument in principle but argue that longer-term concessions would not alter the underlying financial costs and benefits, favouring CL. But tenure might also encourage better environmental choices of equipment and the training of staff, or at least enable better choices to be made. Boscolo and Vincent (1998) simulate the effects of longer-term concessions on the timing of harvests in Malaysia and show that, in their model, it would make no difference. Generally, it does not pay to leave trees standing. Probably the best way to accommodate the concession length issue is to regard longer concessions as an *enabling* device for STM, which, without additional incentives such as performance bonds, will nonetheless be unlikely to lead to STM.

Efficiency and best practice

One remaining issue concerns the extent to which the STM systems reflect ‘best practice’. That is, what is being observed may not be the most efficient form of STM, making cost comparisons misleading. Various inefficiencies need to be addressed: (a) ratio of usable wood to cut wood; (b) ratio of cut wood to wood at the mill gate; and (c) ratio of mill output to mill input. Do (a) and (b) vary by type of management regime? How do loggers respond to efficiency improvements and why don’t they adopt them automatically? Part of the problem seems to be that critics are damning STM as it has been practised. Defenders of STM and SFM are saying that past systems were poorly implemented, e.g., by excessive canopy opening, inappropriate log transport, inappropriate machinery, lack of training and planning, etc. In other words, we need to know what would constitute an efficient system.

Efficient STM or SFM may be difficult to attain, since efficiency implies an agreed objective and the reality is that no such consensus exists. Objectives might, for example, embrace recreating the original stand, regenerating harvested species, conserving ‘habitat’ trees, minimising gaps, and so on. The reality seems to be that SFM is itself an ‘elastic’ concept, making the criticism that it has not been practised when it should have been, difficult to evaluate.

Valorising non-commercial timber species

It has been argued that ‘valorising’ non-commercial timber stock will provide less incentive to use regimes that damage residual stands (Buschbacher, 1990). Rice *et al.* (1998) argue, on the other hand, that expanding the commercial range of species simply results in all species being exploited. The reality is complex and depends on prices for such species, supervision, and what the management regime is trying to achieve. In Queensland, the valorisation of species took pressure off the best and most accessible areas, and good supervision of the operations meant that the additional species harvested did not result in degradation of the residual stand (Vanclay, 1996a,b). But it is hard to generalise on the valorisation issue.

Concessionaires and confidence

Sustainable forest practices require confidence in the long-term future. Many of the world's most valuable forests are in areas where there is a potential for rapid political change and the insecurity that it engenders. The effect of lack of security will be to reduce confidence in the future and hence to favour short-run exploitation. The effect is the same as that of a high discount rate.

The National Perspective

The national perspective on land use options differs from the financial analysis outlined above in several ways. First, logging may not be the 'best' use of the forest land, so that there may be broader options. Second, attention now has to be paid to the *sequencing* of land use. One possibility is that logging is followed be either protection or conversion (and to which we might add abandonment). Which one follows will determine the flow of costs and benefits to the nation. Third, financial gains and losses should no longer be as relevant as economic gains and losses, i.e. financial flows should be shadow priced. Fourth, all forest values other than timber values become relevant. Fifth, if global values exist and can be converted to resource flows of benefit to the nation, then they too become relevant. We address each modification in turn.

Widening the options to all forest land uses

In practice there will be combinations of uses that should also be considered, e.g. agroforestry, clearance for plantation forestry, oil palm, etc. But the principle is the same; whereas a private logger might reasonably consider only the financial costs and benefits of logging options, the nation state should consider all options and evaluate their economic values.

Sequencing of land use

Surprisingly little attention appears to be paid in the CL versus SFM debate to the sequencing issue. It is well known that logging opens up frontier land that may then be colonised by agriculturists. Sequencing may happen the other way round. The land may initially be cleared for agriculture and taking timber may be an ancillary operation aimed at helping recover the costs of conversion. Repetto (1990) is of the view that most deforestation arises from the initial action of logging which creates access to hitherto inaccessible forest land. In their review of econometric studies of deforestation Kaimowitz and Angelsen (1998) find that deforestation is higher when land is accessible, when timber and agricultural prices are high (encouraging logging and conversion), when rural wages are low, and when there are opportunities for long distance trade. Of these factors, several – accessibility, timber prices, and trade potential – all relate to logging. Southgate (1998) documents cases where most road construction in forested areas has come from loggers, encouraging conversion to cropland and pasture. Low stumpage prices might contribute to conversion because even the modest rates of return that might be expected from agriculture compare favourably to forestry at low stumpage prices.

This picture contrasts with the one suggested by some analysts who argue that CL *could* be followed by outright protection (Rice *et al.,* 1998a; Rice *et al.,* 1998b; Cannon *et al.,* 1998). Their argument is that loggers are unlikely to return to the same area after the initial logging phase because:

(a) they do not practice sustainable forestry, thus making future timber stands unlikely to be of commercial interest, and because

(b) they have high discount rates, also making future yields unattractive.

The land is therefore potentially available for protection without the further threat of logging. The argument has some force, but there are several problems.

First, the picture of loggers entering an area only once is often not accurate. Loggers often return 5-10 years after the first harvest to harvest trees that have become commercially valuable because of changes in transport infrastructure, in milling methods, and market potential. Re-entry loggers may also be different people to the first-time entrant: smaller operators with lower operating costs acting as agents for small mills working in formerly high-graded areas. The 'protect after logging' scenario thus has to relate to a context in which the threat of subsequent logging intervention remains.

Second, even if the threat of further logging is removed, the threat of colonisation for non-timber purposes is not removed and, indeed, is, *ex hypothesi*, more likely. Colonisation may be for subsistence agriculture but also for agro-industrial use such as oil palm. Additionally, the 'logging followed by protection' view is based on what could happen rather than on what actually has happened in the past. However, there is an argument that says protection is easier after CL because land prices fall once loggers withdraw. Land can then be bought cheaply for protection purposes.

Third, CL may degrade the forest to such an extent that what remains is not worth protecting. Substantial canopy opening increases susceptibility to fires and weed infestation. A spiral of degradation may become irreversible.

Conventional logging followed by protection has indeed occurred, for example in Queensland, in the Noel Kemp Mercado carbon offset project in Bolivia, and in parts of Africa. But how far these examples arise simply because there were funds available for subsequent protection and because there was low population pressure on available land is unclear. Indeed, it is hard to envisage many circumstances in which there will be limited pressures to convert the land. The choice is not between 'logging followed by protection' and SFM/STM, but between some form of continuous forestry and land conversion. The potential for logging to be followed by protection may therefore be smaller than some of the literature acknowledges, although Reid and Rice (1997) accept that STM will be best suited to areas where there are strong pressures to colonise the forest for conversion. And, of course, protection is costly and in no way avoids the need for continued management.

One other form of sequencing has strong arguments in its favour. Here the aim would be to meet timber demand from plantations, leaving natural forests to be managed mostly for non-timber purposes. The sequence is then to afforest rapidly to establish plantations on degraded lands, accepting some loss of natural forest in the interim, then protecting the remaining natural forest whilst meeting demand for timber from plantations. Hunter (1998) describes this situation for New Zealand. The appeal of such a policy in New Zealand, and in the USA where some environmental groups are calling for cessation of all logging on National Forests, carries the suggestion that this option may be best for countries with relatively high per capita incomes. A country like Malaysia, where there are already extensive lowland plantations, could adopt such a policy, but lower income countries are still likely to face formidable pressures for conversion of natural forest, so that finding profitable forest management systems is still important. The New Zealand and Malaysia examples raise the interesting issue of whether there might be an 'environmental Kuznets curve' (EKC) for forest protection. EKCs exist when growth in income per capita first results in environmental degradation and then, after some turning point, a reduction in degradation. Such curves have been found for air pollution. In the current case, the hypothesis would be that countries opt for more forest protection and more plantations as incomes pass a certain point.

Again, it needs to be recalled that protection is not costless. Not only are there continuing management costs, but there are capital costs of fencing and establishing management institutions. To these must be added the value of the protected land in uses forgone.

Shadow pricing private costs and benefits

The analyses of costs and benefits to loggers have typically all been in terms of financial rather than economic flows. Exceptions are the World Bank studies reported by Grut (1990).

Allowing for non-timber values

The recognition of non-timber values alters the focus of analysis from STM to SFM. In economic language, the relevant measure is now *total economic value* (TEV) from the different possible land uses. TEV comprises use and non-use values and both are capable of expression in monetary terms by estimating the relevant *willingness to pay* (WTP) for those functions (Pearce, 1993; 1996). The basic argument is that, even if STM is 'worse' than CL in financial terms, if the WTP for the incremental non-timber benefits of SFM exceeds the financial deficit, SFM will be preferred from a national perspective. More formally,

$$SFM > CL, \text{ if } WTP_{ntv} > \Pi_{cl} - \Pi_{stm} \qquad \text{....[1]}$$

Where 'ntv' is non-timber values and Π is profit.

Contrary to Bawa and Seidel's (1998) contention that there is no experience of timber regimes that integrate NTPs into the management system, Romero (1999) found that RIL had no effect on the available biomass of epiphytic bryophyes that are harvested and sold by local people in Costa Rica. Similarly, Salick (1995) found that non-timber forest products (NTFPs) and natural forest management for timber were compatible in Nicaragua. In small-scale natural forests, integration of NTFPs with timber is more the rule than the exception (see Pinedo-Vazquez and

Rabelo, 1999). However, Putz *et al.* (2001) note that management invariably involves favouring some wildlife species over others.

The evidence on environmental impacts of logging regimes

The presumption in inequality [1] above is that environmental benefits under STM/SFM exceed those under CL. This has been challenged by Rice *et al.* (1997; 1998a; 1998b). They argue that the physical effects of CL on the forest were relatively mild for the case they studied in lowland Bolivia. However, that case relates to extremely low intensity mahogany harvesting, and it would be hard to envisage that it would also hold for the much more intensive harvesting characteristic of the eastern Amazon, or the dipterocarp forest of southeast Asia. Rice *et al.* (1998) and Reid and Rice (1997) argue that STM/SFM can be just as destructive of the total forest as CL, a view supported by Bawa and Seidler (1998). Uncontrolled logging, it is argued, may be comparatively benign, especially on flat lands that are logged when soils are dry and where there is a low density of commercially exploitable species. However, under less favourable conditions, CL may be very destructive.

STM can also be destructive, especially in the short-term, if it involves major canopy clearance in an effort to encourage regeneration of light demanding species, but much depends here on the management system in place. The Malayan Uniform System (Manokaran, 1998; Ashton and Peters, 1999) removed most of the canopy, but successfully regenerated the basal area of primary forest. Manokaran (1998) described the effects of selective logging during the 1950s at Pasoh, Malaysia, and observed that by the mid 1990s the regenerated forest was well stocked with commercially valuable dipterocarp species, unlike the less successful selective management system practised in the hill dipterocarp forests. In contrast, the selective logging practised in Queensland caused relatively little disturbance and was successful in providing a viable harvest and maintaining the forest (Vanclay, 1994b; 1996b).

Biodiversity

Part of the problem with the discussion on environmental impacts concerns the characterisation of the environmental objectives of forest management. Whereas Rice *et al.* (1997) talk primarily in terms of the maintenance of biodiversity, others would argue that what matters is the maintenance of ecosystem functions and ecological processes. Some of the concern about avoiding management-induced changes in tropical forest composition is based on the concept of 'climax communities', and the idea that tropical forests are unchanging and lacking in resilience. Given the long history of substantial human impacts on tropical forests and the large areas of tropical forest currently under some sort of silvicultural management by people, the incompatibility of management for timber with biodiversity maintenance seems largely unfounded. For example, many researchers have reported that stands with mahogany almost certainly suffered severe natural disturbances in the past, or regenerated in agricultural clearings that were abandoned centuries ago (e.g., Lamb, 1966). Despite this evidence for ecological resilience, much more research is needed on how to mitigate the deleterious impacts of forest management operations. For example, how should untreated reserves be distributed within managed forests, and is it preferable, from a biodiversity maintenance perspective, to concentrate or disperse logging operations?

Unfortunately, the issue is far from clear cut, even at the level of biodiversity (Putz *et al*., 2001). First, all forest management is likely to reduce biodiversity relative to pre-intervention conditions, or at least to change species composition. The very term 'management' means that something is being done to the forest that would not have happened without intervention. Second, the issue then becomes one of comparing the biodiversity profile – i.e. the nature and extent of diversity – under the different management regimes, say SFM and CL. Thus, Rice *et al.* (1998b) make a biodiversity conservation argument in favour of introducing protection after logging has taken place. They suggest that even CL followed by protection is superior to STM/SFM because the former halts the process of forest domestication. But this is a double-edged argument, for CL could just as easily result in the loss of species dependent on large canopy openings. Certainly, CL stands are especially prone to weed infestations due to excessive damage and lack of pre- or post-logging treatments to discourage weeds and encourage potential crop trees. Even though it does not constitute STM or SFM, reduced impact logging (RIL) would be a substantial step in the right direction. Thus, pre-felling vine cutting can substantially reduce post-logging incidence of serious vine infestations, and also reduce logging damage where vines tie together tree crowns. RIL thus constitutes a major step forward.

Additionally, there has been a tendency to generalise from single localities and case studies. The work of Rice *et al.* relies heavily on observations in the dry forests of northern Bolivia where, if sustainable timber exploitation for the species currently harvested is to be practised, substantial canopy manipulation is required in order to provide the conditions for the regeneration of light-demanding species, especially *Swietenia macrophylla*. The structure and composition of the forest would thus have to change in a substantial way to avoid loss of the canopy species currently most valuable. Even for these forests, it is unclear that species loss due to management need be significant. These forests have survived major disturbances in the past, and proper zoning of the forest should ensure biodiversity is retained.

Not all commercially valuable timber tree species require substantial canopy disturbance for regeneration. In southeast Asian dipterocarp forests, for example, minimising damage to residual stands is important to protect the abundant advanced regeneration of commercial species present before harvesting and to reduce the likelihood of vine infestation once the canopy is opened. The valuable canopy dominants in the forests of much of the Guyana Shield area in northern South

America are also negatively affected by the substantial canopy openings required to regenerate mahogany in northern Bolivia.

Thus, it is not possible to say that STM systems necessarily result in less biodiversity than CL systems. Without careful management, they may do so. If one of the aims is to conserve biodiversity, then management systems should be capable of achieving that aim. In doing so, it may well be the case that the financial returns to STM fall since there will often be a trade-off between biodiversity objectives and maximum financial return. Given that biodiversity conservation figures prominently in Forest Stewardship Council certification, any price or marketing gains from certification will also reduce the profit differential between CL and SFM.

An interesting study by Stephens (1999) in South Australian *Eucalyptus regnans* forests shows that conservation strategies for Leadbeater's possum are best effected through forest reserves, with a close second-best approach being modified harvesting regimes. 'Best' and 'better' in this context are measured by the survival probability of Leadbeater's possum (the 'effectiveness' of the strategy) and the forgone timber values (the cost). The modified harvesting regimes involved the retention of small habitat patches within harvested areas, suggesting, again, that careful logging is consistent with biodiversity protection.

Carbon

Forest-based carbon sequestration, both by conserving carbon already stored in forests and by sequestering additional carbon by stimulating tree growth, has become an important focus for foresters because of the role that forest carbon release plays in accelerating global warming. This role was given official recognition in the 1997 Kyoto Protocol to the 1992 Framework Convention on Climate Change. Countries can benefit in terms of achieving their emission reduction targets by engaging in 'carbon trades' whereby they offset some of their own emission targets by reducing net emissions in another country. The issue here is how different management regimes affect carbon storage.

Silvicultural practices affect carbon balances. Thus, if vines are cut and left to decompose, carbon is released in the short-term from the decomposition process, but can be offset later by the faster growth of the trees freed of vines. SFM, practised properly, involves minimum site preparation and extended rotations, whereas clear-cutting results in loss of necromass and soil organic matter which may well not be offset by subsequent sequestration through faster tree growth. In general, then, silvicultural practice benefits the carbon balance. Exceptions might include savannah woodlands (e.g., the pine forests of Central America) that are invaded by shade tolerant and less fire resistant trees. Restoring the open stands will result in carbon releases that may not be compensated for by increasing sequestration in the remaining trees.

Dixon (1997) conducted a survey of experience with silvicultural practices in forty countries, showing carbon sequestration benefits ranging from 5 tC/ha/ann on average at high latitudes to 40 tC/ha/ann at low latitudes. If these practices were applied to the 600 million ha of land suitable for forest management in the nations surveyed, conservation of carbon would be of the order of 100-300 mtC/ann over a 50 year period. The economic efficiency of such measures is unlikely to compare favourably to the costs of reducing greenhouse gas emissions through energy-related schemes, or from plantations, but Dixon suggests that the practices in question could sequester carbon at some $13/tC, lower than the $20-30/tonne often quoted.

In comparative simulations of carbon sequestration in Malaysian forests logged by trained crews following RIL guidelines and with CNV methods, Pinard and Putz (1996; see also Boscolo and Vincent, 1998) showed that the use of RIL techniques conserved carbon in the harvested stands and resulted in substantially greater rates of post-harvesting sequestration due to higher stocking of potential crop trees and fewer problems with vines and other weeds.

If forests were managed according to their mixed timber and carbon value, as opposed to their timber value alone, significant changes would need to occur in management practices. Standing volumes and rotation ages would need to be increased, and there would need to be substantial increases in investment in silviculture. Leakage issues would loom large under such a scenario, given the large and growing international demand for paper and other wood fibre products. With long rotations, natural forest succession would occur which, in some cases, would reduce the attractiveness of forests for early successional species of plants and animals, as well as for recreation, so some of the 'carbon gains' would be offset by other factors. Despite these misgivings, the clear implication is that the attachment of economic values to carbon via trading and/or meeting domestic emission reduction targets could substantially favour better managed forests. However, a more sceptical view is offered by Smith *et al*. (1999b).

Numerous 'carbon offset' projects exist either in actual or simulated form. Details of the various deals and their costs per tonne of carbon reduced can be found in Pearce *et al.* (1998). Few of the deals relate to forest management. The offset projects can be analysed to elicit the average costs per tonne of carbon equivalent reduced. However, since the deals have not generally been developed on a cost efficient basis (selecting the cheapest options first) such an analysis is not particularly helpful. Estimates of the prices at which carbon will trade under the 'flexibility mechanisms' in the Kyoto Protocol do, however, suggest that around $10/tC is likely to be a mean price, provided substantial trading takes place and it is likely that carbon may trade at between $5 and $15/tC. The importance of these figures can readily be seen. For forest conservation as a whole, compared to conversion, forests may secure a carbon 'credit' of $750 to $2250/ha on this basis (Assuming 50tC to 150tC is emitted by conversion). For the comparison between SFM and CL, of course, the gains would be far more modest. If Dixon's (1997) figures are adopted, incremental gains over CL may range from 5-41tC, or $25 to $615/ha.

However, great care needs to be taken in multiplying carbon storage or sequestration estimates by unit money values for traded carbon. The procedure is correct if the price of traded carbon is an equilibrium price, i.e. one that equates supply and demand for traded carbon. That price will be sensitive to the number of deals done. If there are vast 'offers' of carbon from countries seeking to capitalise on the carbon value of sustainable forestry, it may have the effect of forcing the price of carbon down, thus reducing the economic returns from carbon conservation. These 'system wide' effects have been stressed in a number of studies, e.g. Sohngen *et al.* (1998).

Willingness to pay for certified timber

There are two approaches to securing an economic measure of the value of non-timber forest values. The first rests on what people are willing to pay for timber certified as coming from 'sustainable' forests, the idea being that 'sustainable' timber embodies all non-timber values in some premium over the world price for timber. The second attempts directly to estimate the economic value of the various forest functions independently.

If consumers of wood products are willing to pay a premium to guarantee that the forests supplying the products are sustainably managed, then that willingness to pay can be thought of as an approximation of the WTP in equation [1] above. Similarly, if forest companies are willing to adopt sustainable practices in order to secure some marketing gain from certification, then the costs of certification provide a lower bound of the additional value of certification.

Certification schemes exist to guarantee the sustainability of various forests, akin to 'eco-labelling' of various products. Certification costs are around \$0.2-1.7/ha for developing countries (Crossley and Points, 1998) and \$0.2-3/ha for assessment and \$0.02-0.07/ha per annum for licensing and auditing in the USA (Mater *et al.,* 1999). Accordingly, any WTP above this level of cost represents the 'net premium' for SFM. Evidence of WTP for certified timber by premium consumers is equivocal, and there is no clear evidence that consumers are WTP more (Barbier *et al.,* 1994; Forsyth *et al*., 1999).

Crossley and Points (1998) suggest that certified products are securing premia of 5-15% in some cases, but that the real benefits of certification for industry lie in securing greater market share and longer-term contracts. There is some evidence that companies gaining certification secure higher company value, i.e. the value of certification shows up in share prices on the stock exchanges.

If we take the range 5–15% as a likely measure of premium, the argument in Gullison (1995) and Rice *et al.* (1997) is that this is far from sufficient to compensate for the additional profitability of CL over SFM. But their argument is suspect, as a typical ratio of *financial profits* for CL relative to STM would be, say, 1.5. For STM to become competitive it is not necessary for *prices* to rise by 50%. A hypothetical numerical example shows that the price premium need only be a fraction of the difference in profits between CL and STM. If costs of CL are 75 and those for STM are 100, but both face the same market price of 150, then the ratio is 75/50 = 1.5. The net price premium that will make profits equal is given by

$$p^* = (C_{ST}-C_{CL})/P$$

where P is the common log price. In the numerical example, p* = 17% (25/150), which is considerably different to 50%. It is true that this premium is gross of certification costs, so that the true price premium required for parity between profits in the two regimes is higher than 17%.

Willingness to pay for non-timber products and services

A more direct approach is to seek the WTP that people express for the particular non-timber products and services from forests. We review what is known about these WTPs, but note that they need to be applied to the *differential flow* of environmental products and services from SFM as opposed to forests that are just logged. The total values would be relevant if all such services were lost, as they might be from forest conversion. The differential values are relevant for the CL/SFM comparison. The importance of this distinction is that we know a reasonable amount about the economic value of forest services, but, apparently, little about the differential flows of those services according to different forest management regimes.

Environmental economists have made great progress in eliciting economic values for forest products and services. Recent surveys include Godoy *et al.* (1993), Pearce and Moran (1994), Lampietti and Dixon (1995), Southgate (1996), Chomitz and Kumari (1996), Pearce (1998), and Pearce *et al.* (1999). There are of course substantial difficulties in reaching general conclusions from WTP studies, 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. 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, i.e., 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 gross 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.

It is clearly hazardous to try to find some kind of consensus from the estimates of Pearce *et al.* (2000). Table 1 reports indicative annual values, but care needs to be taken in generalising any of these numbers (Southgate *et al.,* 1996). 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/ha, far from enough to justify outright protection on economic grounds.

Table 1. Indicative values of forest land for non-timber uses..

Category of Use	US $ /ha/ann
Non-timber extractive values:	50
Non-extractive:	
recreation	5–10
ecological	30
carbon	600–4400
Non-Use:	2–27

One of the few studies that attempts to place an economic value on the differential flows of goods and services from CL and SFM is Kumari (1995; 1996) for the peat swamp forests of North Selangor in Malaysia. The analysis relates to the differential benefits of moving from an existing unsustainable timber management system, based on Malaysian Stateland forest practice, to sustained forest management. The sustainable systems are markedly better than the unsustainable system, showing a 13% improvement on CL. Although there is a decline in timber revenues, non-timber (mainly agro-hydrological and rattan) and global benefits (carbon and conservation of endangered species) increase more than enough to offset the losses. It is of course, open to question whether this analysis is typical for forests generally. Importantly, the global benefits will not accrue to forest owners or concessionaires without institutional change which compensates them for storing carbon in the biomass. Existing carbon trades, and those expected under the Kyoto Protocol, thus become extremely important. In essence, Kumari's analysis provides the 'demonstration' phase, but not the capture phase of the analysis, as she herself notes. Nonetheless, Kumari's approach, which is essentially traditional incremental cost-benefit analysis, is the correct one and is likely to be the only one that can capture all the relevant changes in the multiple outputs of different forest management regimes.

Smith *et al.* (1999a; see also Mourato, 1999) conducted a contingent valuation study of slash-and-burn farmers in the Ucayali region of the Peruvian Amazon. They sought the farmers' willingness to accept compensation simultaneously to conserve part of the forest outright and to switch to multistrata agroforestry for the rest of the forest. Farmers were first asked their willingness to accept (WTA) compensation (from electric utilities engaged in carbon offset projects) for the combined preservation/agroforestry package, and were then asked by how much they would discount the stated WTA to secure access to the environmental services of the conserved part of the land. The difference between the two WTA measures gives a willingness to pay measure (i.e., in terms of forgone compensation) for the environmental services. The results were, in average terms:

- $218 compensation required for forgoing one hectare of forest that would be converted to outright preservation;
- $138 compensation for forgoing one hectare of forest that would be converted to agroforestry;
- $67 willingness to pay for environmental services for forest preservation
- $41 willingness to pay for environmental services for agroforestry.

The difference between the two WTP estimates reveals that farmers are aware of the difference in the value of environmental services from agroforestry compared to preservation. The study is significant in that it elicits (a) the compensation farmers would need to fill the 'gap' between the returns to agroforestry and the returns to slash and burn agriculture, and (b) the willingness to pay of farmers for forest services of which they are well aware. The gap between agroforestry and slash-and-burn returns is a perceived one and is highly influenced by farmers' discount rates, i.e., returns are higher to agroforestry over a long period but lower if the time horizon is limited to a few years. Interestingly, the stated WTA to switch to agroforestry compared very well with the difference in the annual stream of returns when viewed from this short-term perspective, indicating that farmers were well aware of the returns from different systems.

The relevance of the study lies mainly in the information provided about farmers' perceptions about the forest, but in so far as agroforestry can be thought of as a form of SFM, it suggests that the social returns to SFM are higher than slash-and-burn provided the 'rest of the world' is willing to pay for carbon services from the forest.

An Economic Model of Sustainable Forestry

One way of encapsulating the previous discussion is to place it in the context of an economic model of forested land use. Sustainable forestry can only exist if returns to it exceed those of alternative uses of the land *and* exceed the costs of management, including the costs of preventing entry by colonists. Hyde (1999) suggested that these conditions will tend *not* to prevail in the earlier stages of development so that, generally, the poorer the nation the less likely it is for sustainable forestry to emerge as a viable land use option. But the analysis also suggests that if non-market values are high, there could be substantial returns from managing forests on a sustainable basis. The additional condition, of course, is that the returns must be capable of 'capture' by the forest owner, whether it is a private individual or the state.

Our analysis suggests that most non-market values will not be high enough to change the underlying and somewhat pessimistic conclusion of Hyde's approach, i.e., that sustainable forestry is potentially viable but risky in areas where development is still at the early stages. The fairly clear exception, however, is carbon, and the few case studies that are relevant seem to confirm that carbon values from carbon trading could produce the situation where a significant sustainable forest sector emerges based on non-market values. Additionally forest certification offers considerable promise, depending on the extent to which stated WTP is confirmed by actual WTP.

Conclusions

In this paper we have reviewed the available literature in an attempt to cast some light on the issue of the *type* of forest management regime that is best suited to the overall aim of slowing the rate of loss of the world's forests and biodiversity. The traditional argument that 'sustainable forestry' is the most preferred option has recently come under criticism from those who argue that it is neither profitable nor necessarily environmentally preferable to conventional logging.

Finding general conclusions is complex, not least because the terminology in the literature is confusing and often value-laden, even regarding 'logging' as an undesirable activity *per se*. While not entirely satisfactory, we adopt the language of 'conventional logging', 'sustainable timber management', 'sustainable forest management' and 'protection'. The essential differences are that sustainable systems pay more regard to longer term outcomes than do conventional systems, and that sustainable systems are likely to involve far more regulatory supervision than conventional systems.

The model adopted proceeds from a comparison of financial rates of return to differing forest management systems, through to economic rates of return, and from there to wider rate of return concepts that include non-market values, e.g. biodiversity conservation and carbon storage. There are then at least three stakeholder perspectives on these rates of return: those of the logger, those of the nation, and those of the world as a whole. In reality, there are many different divisions of interest, from those of illicit forest users, indigenous peoples, enforced migrants and so on. The rough benchmark is that forested land should be used for the highest *social* value use, i.e. the use that maximises the broad concept of rate of return indicated above. This notion requires that any values not embodied in the market place be 'captured' through various incentive mechanisms. Those mechanisms - such as debt-for-nature swaps, carbon offsets, green image investments etc., - are not discussed here. The idea of maximising a rate of return also does not embrace the crucially vital question of the *distribution* of gains and losses. While important, these concerns lie outside the scope of this paper.

A survey of financial rates of return reveals that sustainable systems appear capable of earning returns in excess of some 'modest' discount rate (5%, and in some cases 10%), but cannot compete financially with other systems. Given the nature of the management process for sustainability, this is not unexpected and conforms with the critics' view of sustainable management.

Are there any factors that mitigate this inequality? We looked at the various arguments that have arisen, from improving concessionaire property rights, to the future of timber prices, and the valorisation of non-commercial species. None appears to give sustainable timber management any financial edge over conventional systems. All have some role to play, but it is not significant. The evidence on discount rates tends to reinforce the critics' arguments. Recent studies suggest that discount rates in poor countries are very high, indeed, so high that few investments of any kind, let alone in forestry, would seem to be economically justified. But if the focus is on sustainable and unsustainable forest systems, then high discount rates simply reinforce the initial preference for conventional systems based on rapid liquidation of the timber and other resources without regard for future harvests or other impacts.

Some of the critics of SFM as a conservation strategy have argued that logging should be permitted so as to get an initial period of damage over and done with, leaving the way open for protection. The argument rests on the assumptions that future logging threats are minimised, and that land is cheaper once the loggers have gone. There are doubts about this argument: logging once may simply lead to subsequent visits from the same or other loggers; loggers open the way for colonists; and damage may be so extensive that protection ceases to have much of a conservation justification. Sustainable systems are also open to threat since they too open up forests to colonists. The extent to which they will avoid being converted by colonists rests heavily on their financial viability, which, as we have seen, may not be very strong.

The focus therefore shifts to non-market values. Are these higher under sustainable management than conventional logging? Our review suggests that they are. It is true that sustainable forestry loses some environmental benefits relative to the pre-intervention period. But there is no necessary link between sustainable forestry and environmental damage. Part of the problem arises from extrapolating from limited experience, e.g. with mahogany, to tropical forestry in general. This said, research on 'biodiversity impact profiles' is not strong enough yet to reach firm conclusions. For carbon storage, the picture seems fairly clearly in favour of sustainable systems.

The final stage of the analysis asks if these non-timber values are sufficiently important that they outweigh the financial deficit of sustainable forestry when compared to conventional logging. While there is only a limited number of studies to guide us in this respect, those that exist seem fairly uniform in finding that the non-market benefits of sustainable systems are significant. All tend to acknowledge that timber yields are less on a comparative basis but that non-timber values more than offset the relatively lower yield. The role of carbon is highlighted because a survey of non-market values suggests that carbon values dominate the non-market values overall, a conclusion echoed in the case studies reviewed here. Other indirect evidence is also marshalled, e.g., there appears to be a marked willingness to pay by consumers for natural regeneration of forests and for sustainable managed systems.

The prospects for sustainable forest management is low in the early stages of development, and increases as the values attached to the forest and its services rises over time. Extended to include carbon and biodiversity values, it is arguable that the potential for sustainable forestry is far greater, even in the early stages of development, than might be thought.

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