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NOTE

The views expressed in this paper are strictly those of the authors only.

TO THE READER

Over the past few decades, governments, environmentalists, and development agencies have engaged in a broad range of activities and spent hundreds of millions of dollars to support the sustainable management of tropical forests. Despite these efforts, at present, almost no logging of natural forests in the tropics can be considered sustainable. Most projects have failed or are never adopted because returns to investments in sustainable forest management (SFM) are usually lower than those earned from conventional logging or other land uses. Logging companies, therefore, are not likely to invest in SFM unless forced to do so by government.

Governments have attempted to make SFM a more viable option for land use through a variety of policies intended to increase its profitability. These efforts have done little to change investors' behavior, however, because most policies aimed at increasing the profitability of SFM (such as more secure land tenure) also increase the profitability of conventional logging and therefore fail to make SFM a *relatively* more attractive land use. Even if SFM were financially attractive, from a conservation perspective, limited circumstances exist that would warrant its implementation on conservation grounds; in some cases, in fact, SFM would result in more damage to the forest than would otherwise occur. Furthermore, even where SFM holds environmental advantages over other forestry systems, it is generally not the most cost-effective strategy for achieving conservation objectives. For example, outright forest protection following an initial round of selective logging may be both less costly to timber companies and better for conservation than SFM.

Given that SFM has not yet proven to be effective in conserving tropical forests, other approaches to reconciling conservation and development merit careful consideration. More empirical research is needed to determine the best combination of approaches. In the meantime, protected areas, which are perhaps the only tool that has succeeded in protecting large areas from deforestation (Bruner *et al.* 2001), should continue to be the cornerstone of conservation strategies.

TABLE OF CONTENTS

INTRODUCTION

Current patterns of tropical timber production pose a significant threat to the conservation of biological diversity. Johns (1997) estimates that nearly one third of remaining tropical forest is officially allocated to timber production. With increased foreign investment in forestry (Bowles *et al.* 1998b, Sugal & Mittermeier 1999) and expanding wood demand (FAO 1993, Uhl *et al.* 1997), the area of primary forest subject to logging is growing, particularly in the tropical Americas.

Within this context, recent efforts to promote conservation in tropical forests have focused on one of two approaches: outright protection of high priority areas and sustainable forest management. Although it is widely recognized that protection is the most desirable conservation strategy, protected areas currently comprise only eight percent of tropical forests (WWF/WCMC 1996). Expanding protected areas is often seen as too costly and politically unfeasible, particularly if the forest has economically attractive concentrations of commercial timber or valuable agricultural land. In these situations, the opportunity cost of conservation – the earnings that a landowner would need to forego in favor of forest protection – is considered too high for developing countries, where the majority of these forests lie.

Outside of protected areas, the standard approach to achieving biodiversity conservation in tropical forests is sustainable forest management (henceforth, SFM). SFM typically combines harvesting guidelines designed to increase the growth of marketable timber with efforts aimed at lowering the damage to commercial trees. Those favoring SFM argue that unless economically viable uses of tropical forests are found, most are doomed to agricultural conversion (Hartshorn 1998). Governments and development agencies have consequently devoted years of effort and hundreds of millions of dollars to promoting SFM.

Nevertheless, at present, almost no logging in the tropics (outside plantations) can be considered sustainable. This issue of *Advances in Applied Biodiversity Science* considers why sustainable forest management has met with such limited success, despite much effort over the past two decades. We begin with a brief overview of the scope and diversity of efforts to support SFM. Next, we consider one of the most important obstacles to the broader adoption of SFM – its lack of financial attractiveness – and examine how various policies intended to promote SFM have attempted to address this fundamental shortcoming. Finally, we consider the conditions under which SFM represents an appropriate conservation tool based on its environmental impacts, including a brief review of its cost effectiveness compared to other available options. We conclude that SFM has limited usefulness as a conservation strategy, and that before it is promoted in a given area, it should be carefully evaluated against other conservation and development options.

THE HISTORY OF SFM

Pristine Amazonian rain forest. Despite years of effort and public investment, very few tropical forests are managed sustainably.

During the past two decades, many hundreds of initiatives have been launched to define and promote sustainable forest management. These efforts have ranged from conferences and workshops to international trade agreements, to on-the-ground projects in dozens of countries around the world.

One of the first large efforts was the Tropical Forestry Action Plan (TFAP). Begun in 1985 by the World Bank, the FAO, and others, the goal of TFAP was to combat deforestation by implementing detailed action plans in individual tropical countries. Winterbottom (1990) estimates that roughly $28 million was spent in each of 11 TFAP countries surveyed and that overall spending in the forestry sector by donor countries and development institutions doubled to more than $1 billion during the 5-year period in which the TFAP was implemented. Despite this spending, the TFAP eventually came to be seen as a failure because it was not curbing deforestation; increasingly, the plan was viewed in many countries simply as a way of promoting more forest development (Winterbottom 1990).

Shortly thereafter, in 1990, the International Tropical Timber Organization (ITTO) was created to administer a trade agreement between the major producers and consumers of tropical timber. Early on, ITTO adopted an objective of bringing all tropical timber produced by member countries to sustainable levels by the year 2000. Even now, after the decade has drawn to a close, this target is far from being met.

Since 1992, dozens of countries have been engaged in efforts to develop so-called "criteria and indicators," or guidelines for evaluating progress in implementing programs for sustainable forest management. In the past five years, more than 100 countries have committed to one of the seven "processes" that have been developed for this purpose in different regions around the world (Wijewardana 1998). Other initiatives have aimed to promote SFM through market mechanisms such as "buyers groups" for sustainably harvested timber products, through legislative actions to mandate such purchases, and through various approaches to certify timber production as sustainable. For example, the Forest Stewardship Council (FSC), an organization founded by a coalition of foresters, timber companies, and environmental groups, has developed standards that have been widely used in certifying timber operations since 1993. Although certification has increased dramatically in recent years, with 1.1 million hectares of natural tropical forests certified to date (FSC 2000), these efforts have still barely scratched the surface of the 1.7 billion hectares of tropical forests remaining in the world (FAO 1997).

Individual countries have also provided an enormous amount of development assistance for SFM. European countries have perhaps the strongest tradition of assistance in tropical forestry, tracing back to the early colonial period. Today, approximately three-quarters of a billion dollars are spent annually on international forestry assistance in the tropics, roughly two-thirds of which comes from the European Community and its member countries (Shepherd *et al.* 1998). Germany, the European Commission, the Netherlands, the UK, France, and Sweden provide the lion's share of European investment (see Table 1). A large portion of the European Community's forestry assistance is spent explicitly on supporting SFM, including 15 and 34 percent of all funding from Germany and the UK, respectively (Shepherd *et al.* 1998). Other categories of expenditures, such as institutional development, rural development, and research, indirectly support SFM efforts.

TABLE 1: Overseas development assistance to forestry, 1995

	Forestry Budget (US $ Millions)
Germany	166.3
European Commission	86.0
Netherlands	79.7
UK	49.0
France	37.7
Sweden	35.8
Total (all European countries)	**500.0**

Source: Shepherd et al. 1998

The United States and Japan also have invested heavily in sustainable forest management. USAID, for example, has committed more than $250 million to efforts related to SFM since 1994 (Hester, pers. com. 1998).

Given the level of support and funding for SFM, there is a surprising diversity of opinion about how it is defined. Most definitions include ensuring a constant or increased flow of wood from a forest as a primary management objective. Many definitions, however, include a variety of other factors, such as protecting the rights of indigenous people and local communities, and maintaining biological diversity.

A recent study by the International Institute for Environment and Development (IIED 1996) examined the degree of consensus in the definition of SFM among 12 major international forestry initiatives. The authors found considerable disagreement even in terms of the general categories used in assessing sustainability, particularly with regard to issues related to biological diversity. Agreement on silvicultural guidelines was much more common (see Table 2).

At least in general terms, there is also much greater agreement about the central role of silviculture at the project level. Efforts intended to ensure a future supply of wood, in fact, are one of the main characteristics that distinguish SFM from traditional timber mining. A continuous wood supply is also central to providing timber producers with an economic incentive to protect the forest from agricultural conversion.

While, in theory, most silvicultural systems can ensure sustainable harvests (see boxed information on Silvicultural Systems Used in SFM, page 12), for a variety of reasons, they rarely have been put into practice. For example, the Malaysian Uniform System was abandoned because it could not compete financially with agricultural land uses, while the Tropical Shelterwood System, which required costly interventions to remove weeds and vines, could not compete with either agriculture or more conventional logging. The Celos system and the Strip-Clearcut System were basically experimental efforts and have yet to be proven in a commercial setting.

The lack of financial success of these silvicultural systems has been echoed time and again as efforts to promote SFM have proceeded, and has given rise to more recent attempts at low- or reduced-impact logging. Such efforts focus more on reducing the physical impact of logging than on providing a constant flow of timber. Reduced-impact logging may involve careful planning of skid trails to reduce distance traveled and to minimize loss of forest cover and soil erosion, and directional felling of harvested trees to minimize damage to the surrounding forest (Johns 1997). There is some evidence that such systems can increase the profitability of logging (Holmes *et al.* 2000). However, since reduced-impact logging does not generally involve the silvicultural investments needed to ensure a continued supply of wood, it is not likely to be sustainable over the long-run, and therefore is unlikely to differ from conventional logging in failing to provide economic incentives to keep the forest from being converted to other uses.

In contrast to SFM and reduced-impact logging, logging as it is actually practiced in the tropics often involves the swift cutting of a limited number of highly valued species with little attention given to the condition of the residual stand and no investment in regeneration. This kind of logging is commonly called unsustainable because another harvest of the target species may not be possible for a very long time, if ever (Gullison 1995).

TABLE 2: Scope and agreement among 12 recent initiatives to assess the sustainability of forest management

Issue Addressed	Agreement Among Initiatives
Sustained Yield of Forest Goods and Services	
Productive Functions of Forests (e.g., sustained timber yields)	70 %
Protective Functions of Forests (e.g., soil, watershed management)	90 %
Health and Vitality of Forests (e.g., control of insects and fire)	60 %
Management for Sustained Yields (e.g., written management plans)	60 %
Average	**70 %**
Socioeconomic Impacts	
Impact on Indigenous People (e.g., protection of traditional rights)	50 %
Impact on Local Communities (e.g., consultation and involvement)	60 %
Impact on Employees (e.g., adequate wages, safe working conditions)	48 %
Economic and Financial (e.g., reinvestment to forestry sector)	71 %
Average	**57 %**
Maintaining Biological Diversity	
Environmental Impact Assessment	42 %
Maintenance of Ecosystem Diversity (e.g., system of reserves)	88 %
Maintenance of Species Diversity (e.g., monitoring programs in place)	33 %
Maintenance of Genetic Diversity (e.g., seed banks of commercial species)	33 %
Average	**49 %**

Source: IIED 1996

Silvicultural Systems Used in SFM

Most SFM projects employ polycyclic felling systems, such as the Celos system developed in Suriname (Boxman *et al.* 1985). The term polycyclic refers to the fact that only larger trees are cut during the initial harvest so that smaller trees may provide another crop in 25-40 years. Regeneration is encouraged by some combination of careful logging and transport, cutting vines that connect treetops prior to harvest, leaving seed trees, enrichment planting, and removal or poisoning of non-commercial trees.

Other sustainable forestry systems include the Malaysian Uniform System (MUS), a monocyclic system in which all marketable trees are harvested in a single cut. Large, non-commercial stems are removed immediately following harvest and additional silvicultural treatments are repeated at regular intervals over the course of the 60-year or more cutting cycle.

The Tropical Shelterwood System (TSS), practiced in West Africa during the Second World War, called for opening the forest canopy several years prior to harvest to allow seeding and advance the regeneration of trees that would eventually be cut. This treatment was developed to respond to the fact that valuable species were sparsely distributed in the forest and dispersed their seeds at irregular intervals.

The Strip-Clearcut System, developed for a recent pilot project in Peru's Palcazú Valley, involved clearcutting a series of narrow strips from which as many species as possible would be marketed. The strips were meant to mimic natural disturbance in the area and were cut wide enough to allow sufficient light for seedlings, but narrow enough so that they could be fully seeded by adjacent standing trees (Hartshorn 1990).

For an overview of some of the predominant silvicultural systems used in tropical forests, see Buschbacher (1990).

THE ECONOMICS OF SFM

The initial harvest of timber yields the greatest financial return.

This section considers the economics of why loggers typically prefer conventional logging to SFM. We begin with an overview of the lack of financial incentives for sustainable management, and then review in more detail the factors that make SFM less profitable than conventional logging.

The lack of financial attractiveness has long been recognized as an important obstacle to broader adoption of SFM. A 1989 World Bank country study for the Philippines states that:

> …concessionaires have no interest in the second cut, and extract as much as possible on the first cut. This is mainly due to financial self-interest: the net value of the second cut, discounted to the present at interest rates reflecting the opportunity cost of capital in the Philippines, is trivial compared to the value of the initial harvest (World Bank 1989).

In other words, SFM is financially unattractive because the returns from investments in future timber production are commonly lower than those earned by rapidly harvesting marketable trees and investing the profits elsewhere (Kishor & Constantino 1993, Vincent 1995, Rice *et al*. 1997, Reid & Rice 1997, Pearce *et al.* 1999). The three main factors on which this outcome depends are the rate of change in timber prices, the growth rate of commercial tree species, and the discount rate. To illustrate why investments in SFM are generally judged inferior, each of these factors is considered in turn below.

Timber Prices

In the past four decades, tropical timber prices have grown only modestly. Varangis (1992) found that average annual price appreciation has been 1.2 percent per annum in real terms over the period 1950 to 1992. More recent data, presented in Table 3 below, paint a similar picture. From 1995 to 2000, real annual price growth was between 0.17 percent and 2.69 percent (also see Figure 1).

Kishor and Constantino (1993) note that even if future timber supplies from natural forests decline, substitution from other sources will likely dampen any long-term upward trend in prices. The authors state that "before real prices could increase [substantially] over a long period of time, demand would shift towards substitutes, namely temperate timber and plantation timber, and slow down the price appreciation" (Kishor & Constantino 1993).

Tree Growth Rates

The growth rate of commercial tree species in tropical forests also is relatively low. In an old-growth forest, net growth is zero by definition. Over time, unmanaged forests exist in a steady state in which the volume of new growth is equal to the volume lost through mortality.

In logged forest, in contrast, net tree growth should be positive. Jonkers (1987), for example, found growth rates ranging from 0.27 and 0.54 cubic meters per hectare per year in logged forest in Suriname. In another study in Suriname, De Graaf and Poels (1990) found that certain silvicultural treatments increased commercial tree growth during the first few years following harvest from 0.5 to 2 cubic meters per hectare per year. Reid and Rice (1997) report figures based on a literature review ranging from 0 to 4 cubic meters per hectare per year. Annual growth in most forests is clustered in the range of 0.5 to 2 cubic meters per hectare per year. The commercial growing stock in these forests ranges from approximately 50 to 100 cubic meters per hectare (Howard, pers. com. 1995), so percentage volume growth could potentially range from 0.5 percent per year in a slow-growing, well-stocked forest, to 4 percent per year in a fast-growing, poorly-stocked forest. Annual growth rates over an entire cutting cycle would likely be considerably lower, however, since the initial boost in growth from silvicultural treatments declines with time (Whitmore 1984, Silva *et al*. 1995).

Real Interest Rates

The final factor that affects returns to investment in SFM is real, or inflation adjusted, interest rates. Interest rates are commonly used to gauge the opportunity cost of capital. A more direct measure of opportunity cost in this context would be expected earnings in the forest sector. Interest rates (or more precisely long-term lending rates) are used instead, as information on interest rates is widely available. Interest rates are likely to be a conservative proxy for opportunity cost since any company using borrowed funds would need to realize a rate of return at least as great as the lending rate in order to repay the loan. The forest's growth in value must outstrip the value of alternative investments or

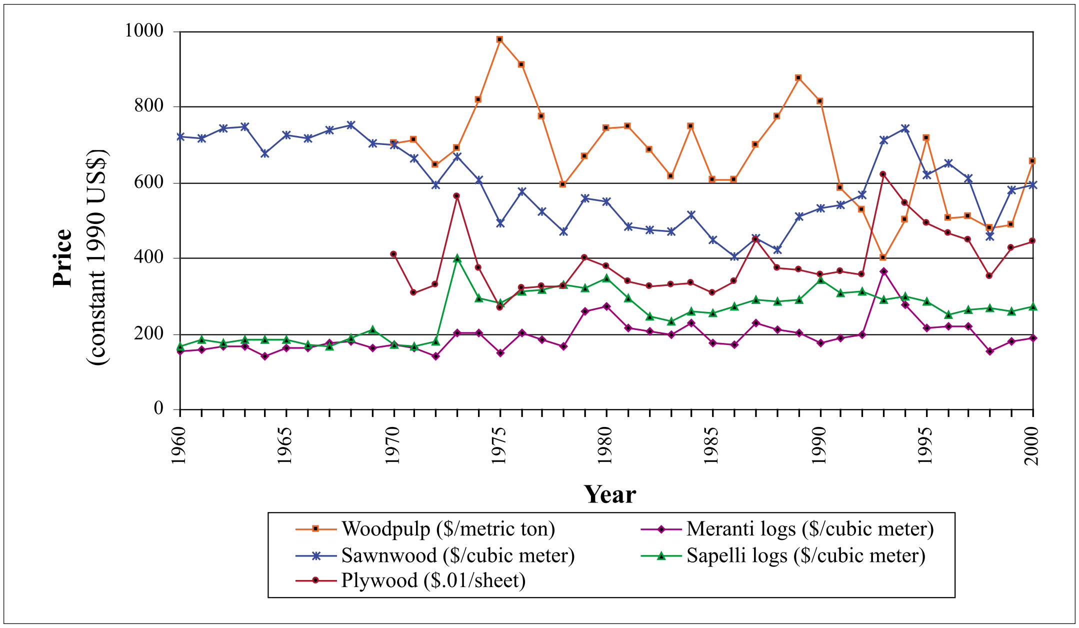
TABLE 3: Percentage annual real price growth for tropical timber, by product

Time Period	Sawnwood	Plywood	Pulpwood	Meranti logs*	Sapelli logs*
1961-1970	-0.20	-	-	1.41	0.65
1971-1980	-1.62	2.97	1.52	7.45	11.78
1981-1990	0.23	0.06	1.66	-3.00	0.41
1991-2000	2.27	4.77	0.83	4.49	-2.06
1961-2000	**0.17**	**2.60**	**1.34**	**2.59**	**2.69**

Source: World Bank 2001

* Meranti and Sapelli are hardwoods commonly traded in Asia and Africa, respectively.

FIGURE 1: Tropical timber price trends,1960 - present



Source: World Bank 2001

loggers will have an incentive to harvest trees immediately and invest the proceeds elsewhere.

High interest rates common in developing countries are a particularly difficult hurdle (see boxed information on Paragominas, Brazil, page 16). Whereas real interest rates rarely reach 10 percent per year in industrialized countries, they are often much higher in developing countries due to scarce capital and higher risk. Real interest rates in South America, for example, have averaged 10 to 20 percent or more in recent years, compared to 4 percent in the United States (Banco Central de Bolivia 1994, 1995; Banco Central de Ecuador 1995; IMF 1995; Muller, pers. com. 1995; Banco Central de Reserva del Peru 1996; CEA 1996; Editora BBT 1996; Rice *et al.* 1997).

These three factors taken together mean that deferring the harvest of marketable trees via SFM is unattractive because slow tree growth and modest price appreciation cannot keep pace with high interest rates in developing countries:

Where V = volume and P = price:

[illegible]

[illegible]

In other words, where tree growth and prices rise by 2 percent per year (a rough average of the range of figures noted above), the annual change in value is approximately 4 percent. This return is comparable to those from low risk investments such as money market accounts or long-term treasury securities in the United States. That producers would be reluctant to accept such low returns for a risky investment like long-term timber production should not be surprising. In fact, risk factors such as political instability, insecure tenure, and poor weather might well make producers unwilling to invest in SFM even if its expected returns were much more competitive.

Studies throughout the tropics confirm these findings. Kishor and Constantino (1993), for example, compared the relative profitability of four land use options in Costa Rica: cattle ranching, plantation forestry, natural forest management, and conventional profit-maximizing logging (*i.e.*, forest liquidation). The authors found that at discount rates ranging from 4 to 35 percent, liquidation was the most attractive option. At all discount rates, liquidation was roughly twice as profitable as natural forest management stemming from the fact that the bulk of returns from liquidation accrue in the initial two-three years. In Guatemala, Reid and Howard (1994) found that conventional logging was 21-55 percent more profitable than logging under two different "sustainable" options. And in Pará, Brazil, Hardner and Rice (1994) found that, at a conservative 10 percent interest rate, the opportunity cost of leaving marketable trees in one mixed-age stand was approximately US $2,885 per hectare.

The Illustrative Case of Paragominas

A combination of high interest rates, slow tree growth, and modest price appreciation have discouraged widespread adoption of SFM in the tropics. For a number of reasons, the hurdles to implementing SFM are particularly high in Brazil, as illustrated by that country's economic situation during the mid-1990s. As a result of the government's *Plano Real*, which relied on high interest rates to reduce inflation, short-term interest rates in Brazil soared to 50 percent or more (Banco Central do Brasil 1998). Throughout the early 1990s, interest rates in Brazil were much higher than those of other countries in Latin America, which typically averaged 10 to 20 percent per year (IMF 1997).

High interest rates increase the opportunity cost of reducing timber harvests to sustainable levels. In addition, in Brazil, the policy of high interest rates resulted in decreased investment in housing and construction, lowering domestic demand for wood and depressing local wood prices. Over the period 1990-1995, premium sawn wood prices dropped an average of 15 percent in real terms, from $336 to $291 per cubic meter, while medium-grade sawn wood prices declined by nearly 25 percent, from $216 to $174 per cubic meter (Stone 1996). This trend is particularly important to timber companies in Brazil, where nearly all timber production is sold at home (ITTO 1998).

For companies in the timber-producing center of Paragominas in southern Pará, these price declines coincided with rising costs caused by a growing local scarcity of wood. Over the past 20 years, the distance to accessible timber supplies has risen as the nearly 200 sawmills in Paragominas have exhausted an ever-widening circle of forest. Between 1990 and 1995 the average distance to obtain logs increased by 38 percent, a trend which has increased transport costs and allowed landowners to charge the mills substantially higher prices for timber (Stone 1996).

Because most of the wood produced in the Amazon is consumed in other areas of Brazil, where producers are not subject to high transport costs, timber companies in areas where timber is increasingly scarce have little ability to pass on rising costs in the form of higher prices to consumers. Instead, many of the larger mills in Paragominas have attempted to reduce costs by spreading their fixed costs over a larger quantity of production. This strategy has not, however, been sufficient to hold profits steady. Companies in Paragominas are therefore producing more and earning less. In recent years, average production has risen from 4,300 to 5,600 cubic meters per year, while profit margins have fallen from 15 percent per year to only 2 percent per year (Stone 1996). These poor financial results explain why there is little or no sign of forest management in Paragominas. Instead, high interest rates, rising production costs, and declining wood prices have created an almost irresistible incentive to liquidate the native forest.

Loggers transport timber to one of the 200 sawmills in Paragominas.

POLICIES INTENDED TO ENCOURAGE INVESTMENTS IN SFM

Sawmills process timber to comply with value-added requirements.

In light of SFM's lack of financial competitiveness, a variety of policies have been advanced to stimulate its broader adoption. Most policies have sought to achieve this goal by increasing the private financial returns from logging. Broader adoption of SFM has not been constrained, however, by the profitability of logging *per se*, but rather by the profitability of long-term management *relative* to conventional logging and other land uses. Unless loggers are forced to adopt SFM through strong government control, increasing the profitability of logging alone may in fact increase the pace and scale of conventional "unsustainable" logging. A review of the following policies indicates that few address the need to make future harvests more financially attractive than current harvests.

Larger Markets for Lesser-Known Species

Efforts to promote the sale of a larger number of lesser-known tree species provide a case in point. In most tropical forests only a small number of tree species have established commercial markets. This problem is compounded in remote and inaccessible forests, where transport costs are high, and in areas with limited domestic demand. Here, only one or two species may be able to "pay their way" out of the woods.

Some have argued that unless markets are created for a wider variety of species, producers will have little choice but to overexploit currently harvested species. Creating markets for a larger number of commercial species is intended to make long-term management more attractive (Toledo 1997) and to encourage greater care in logging since trees with little value are often damaged during harvests (Johnson & Cabarle 1993). Developing markets for more species is also intended to reduce the number of roads required since timber would be more concentrated and a smaller area of forest would be needed to supply a given sawmill (Buschbacher 1990).

Despite these intentions, there is nothing, such as faster growth rates or a brighter price outlook, to suggest that investments in managing new species will be any more attractive than investments in managing currently marketed species. By itself, creating markets for a larger number of species may simply lead to more species being overexploited. This can be seen in places such as Costa Rica where there are well-established markets for dozens of different tree species, yet almost no investment in SFM (Kishor & Constantino 1993, Howard & Valerio 1996). The same is true in southern Pará, Brazil where as many as 60 species are cut due to easy access and the large internal Brazilian market (Hardner & Rice 1994, Stone 1996, Gerwing *et al*. 1996, Barretto *et al*. 1998).

More Efficient Logging and Wood Processing

Policies to reduce the waste and inefficiency of logging and log processing in tropical forests have also been advanced as a means of promoting broader adoption of SFM. Current standards of efficiency in the tropics can be extremely low. Whereas a modern sawmill in the U.S. can convert 50 percent or more of a log into usable product, conversion efficiencies as low as 35 percent are common in the tropics (Gerwing *et al.* 1996, Karsenty 1998). The same pattern of inefficiency exists in logging, where half of the usable wood is often left in the forest (Stewart 1992, Gullison *et al.* 1997).

Greater logging and milling efficiency is seen as a way of increasing profits and thereby providing a greater incentive to manage for the long term while reducing the amount of damage done by logging (since less logging will be needed for a given amount of output) (Johnson & Cabarle 1993, Gerwing *et al.* 1996, Holmes *et al.* 2000). Increasing efficiency, however, does not necessarily result in higher profits. Investments leading to greater physical efficiency may either raise or lower profits depending on their relative costs and benefits. Moreover, even where such investments are cost effective vis-a-vis current harvests, they may do little to stimulate investments in future management. Conventional loggers, who are only interested in maximizing profits from the current stand, can be just as efficient as those practicing SFM.

Finally, there is no *a priori* reason to presume that if greater efficiency leads to higher profits, it will lead to less forest being logged. Economic theory suggests the contrary – that producers would respond to such efficiency gains by harvesting a greater amount of forest (Barr, Forthcoming). In fact, some of the largest, most highly capitalized loggers tend also to be the most efficient – suggesting that greater efficiency may, in some cases, be associated with more rather than less forest destruction.

Greater Tenure Security

Arguments favoring greater tenure security as a means of promoting more sustainable forest management rest on the premise that, without it, no producer will invest in future management (Buschbacher 1990, Paris & Ruzicka 1991, Johnson & Cabarle 1993). This observation has led many tropical countries to increase the length of their timber concessions. For example, over the past ten years, Bolivia has converted all of its annual cutting permits to 40-year renewable contracts (Pacheco 1998). Similarly, when Peru's constitution was rewritten in 1993, it included a proposal to privatize public forests in an effort to stimulate better forest management (Hardner & Rice 1998).

While secure tenure may be necessary to promote investments in long-term management, it is not likely to be sufficient in itself. If SFM is financially unattractive relative to conventional logging *irrespective* of tenure security, granting longer concession durations or private property rights is not going to stimulate its broader adoption. In Costa Rica, for example, Kishor and Constantino (1993) found that, despite a long tradition of stable property rights, conventional logging is financially preferable to SFM across a broad range of discount rates. Private property is also the norm for vast areas of forest in Brazil where there are virtually no examples of SFM. In these and other cases, the factors that discourage investments in SFM outweigh the added benefit of land security. In fact, in many cases, granting more secure tenure may simply lower the risk of making larger investments in conventional logging, thereby leading to swifter liquidation of the resource.

Log Export Bans and Value-Added Processing

Log export bans have been promoted as a way of advancing SFM by providing a strong incentive for domestic wood processing. According to this view, the larger investments that come with processing along with the harvest of a wider variety of species, more local employment, and higher profits, all help promote better forest management since people with a long-term investment in a resource are more likely to manage it properly (Bomsel *et al.* 1996).

With these objectives in mind, many tropical timber-producing countries have implemented bans or placed quotas or levies on log exports. In Africa, export bans have been implemented in Cameroon, the Ivory Coast, and Ghana (ITTO 1997). Indonesia replaced log export bans with levies in 1993, but their magnitude (US $500-$4,500/m^3) continues to ensure that few logs are exported legally (Johnson 1996).

Ironically, because of inefficient production, government tax revenues and industry profits would often be higher *without* local processing. Log export bans necessarily eliminate revenue from taxes on log exports. They also depress domestic log prices, thereby reducing profits from domestic sales. These foregone government revenues and industry profits effectively translate into subsidies for value-added producers, who often receive additional tax inducements such as subsidized credit for the purchase of capital equipment, no import duties, and tax holidays on production. For example, Barama, a Malaysian logging company with one of the largest timber concessions in Latin America, enjoys a 25-year tax holiday in Guyana. However, despite government assistance, value-added processing facilities often are only marginally profitable due to great inefficiencies. Thus, rather than creating value added, local processing in these cases effectively leads to a net *loss* in resource value (Repetto & Gillis 1988, Weins 1993, Karsenty 1998). In addition, since the employment and investment created by processing result in substantial political influence, particularly where the investments constitute a sizable portion of the local economy, reducing timber harvests to ensure sustainability can be extremely difficult. Investments in the plywood industry in Malaysia and Indonesia, for example, have led to excess processing capacity and strong political support for continued logging despite its impacts on the resource (Repetto 1988, Weins *et al.* 1992, Barber *et al.* 1994, Barbier *et al.* 1995, Karsenty 1998). The current installed capacity in these two countries is now far in excess of what their forests are able to supply (Karsenty 1998).

In the end, log export bans are unlikely to promote SFM as they do little to make it more profitable than conventional logging. By subsidizing domestic processors and creating contrary political incentives, export bans and other trade restrictions are more likely to exacerbate the problem of unsustainable resource use. As one observer has noted, experience shows that as value-added and local employment increase, the political will to hold harvests to sustainable levels declines (Karsenty 1998).

Timber Certification and Green Labeling

Unlike most policies intended to promote SFM, timber certification acknowledges the need to increase the profitability of *future* timber harvests by tying management changes to the prospect of a tangible economic reward. Timber certification benefits producers through higher prices, larger market share, or both. To date, there is little evidence that consumers are paying higher prices for certified products (Varangis *et al.* 1995, Webster & Proper de Callejon 1998), resulting in few incentives for a large number of producers to alter their management (Bowles *et al.* 1998a). Although the demand for certified products is increasing significantly, these kinds of products will likely continue to represent a minute portion of the total market. As such, the contribution that certification programs can make to forest conservation is constrained.

At present, only 24 percent of tropical timber production enters international trade (ITTO 1999), and the vast majority of tropical timber exports go to countries (e.g., Japan, China, Korea) where the demand for certified timber is currently weak. Most tropical timber is consumed in the country in which it is produced. Brazil, for example, which accounts for a large fraction of remaining tropical forests, consumes nearly all of its timber production at home (ITTO 1999).

By far the largest potential demand for certified timber is in Western Europe and to a lesser extent the United States. Together, however, these two countries account for less than seven percent of tropical timber demand (see Table 4). Only a small percentage of U.S. and European markets, moreover, are ever likely to be involved in certification. At present, certified production accounts for an estimated one to three percent of tropical timber imports in Europe (Webster & Proper de Callejon 1998). According to a study conducted by the World Bank, certified producers might eventually capture as much as 10 percent of the U.S. market and up to 20 percent of the European market (Varangis *et al.* 1995). Though far more than at present, these market shares would account for less than one percent of total tropical timber production based on the production and consumption levels presented in Table 4.

More or Less Rent Capture by the Government

Finally, different observers have argued that SFM can be promoted through both higher and lower government rent capture. Paris and Ruzicka (1991), for example, argue that governments should capture less economic rent so loggers will be better able to invest in management:

> Imposition of a forest charge levied on the volume of timber extracted will *not* solve the problem of forest depletion [*i.e.,* deforestation] and will more likely *aggravate* it. At worse, such a levy will undermine the ability of the sustainable operator to continue to invest in forest maintenance by diminishing the funds available for this purpose.

Most authors, however, have taken the opposite view (e.g., Repetto 1988, Gillis 1992, Johnson & Cabarle 1993). Karsenty (1998) notes that some researchers, such as Gillis (1992), view capturing more rent for the state as a way to limit the propensity of logging operators to act with a short-term, rent-seeking focus. Karsenty found this view echoed by Weins *et al.* (1992), noting that:

> If the goal of maximizing his profits over a long period is the operator's only guiding principle, then a reduction in short-term profitability should lead operators to conclude that it is in their interest "to invest in trees" and to select operating methods that will minimize waste and hold out the promise of a healthy second cut (Karsenty, p. 2).

The same argument was cited in a study dealing with deforestation in the Philippines which concluded that the "failure of the government to collect significant rent from [timber] licensees largely explains the rapid depletion of timber resources during the last two decades" (World Bank 1989).

The truth, however, is that government rent capture may have much more to do with the distribution of profits from logging than with providing an incentive for better or worse management. Certainly, as Paris and Ruzicka (1991) argue, where companies are inclined to manage sustainably, lowering their profits will leave them with fewer resources to do so and may force them to focus more on the short term. Not being taxed, though, is hardly likely to stimulate long-term management. Low tax collection has long been the norm for timber production in tropical countries and has not resulted in widespread management. Moreover, although lower taxes affect the profitability of both current and future harvests, their impact is disproportionately on the present, making current harvests more profitable. This is the *opposite* of what a policy measure would need to do to promote long-term over short-term management.

TABLE 4: U.S. and European imports of tropical timber, 1999

	Tropical Timber (Thousand m^3, RWE)
U.S. Imports	4,639
European Imports	10,231
Total Production	228,224

Source: ITTO 1999

Note: Roundwood equivalents (RWE) were calculated based on the following conversion rates: m^3 log/m^3 product for sawnwood (1.82); veneer (1.90); and plywood (2.30) (Johnson 1998).

THE CONSERVATION EFFECTIVENESS OF SFM

Roads facilitate logging in otherwise inaccessible forests.

Previous sections have illustrated that SFM usually is not financially attractive compared to conventional logging and that policies intended to encourage its broader adoption have been largely unsuccessful because they have failed to address this fundamental shortcoming. Given that governments must therefore commit resources to bring about a switch from other land uses to SFM, they should consider several issues in deciding whether these investments are sound. First they should determine whether SFM would cause more or less environmental damage than would likely occur in its absence. That SFM will always represent an environmental improvement should not be taken for granted. In situations in which SFM would be environmentally preferable, governments should additionally determine whether promoting SFM is the most effective use of scarce conservation dollars. To address these issues, we first discuss three possible scenarios that might occur in the absence of SFM and how their environmental impacts are likely to compare to those of SFM. The alternative outcomes include: no logging or other destructive development, conventional logging, and forest conversion for agriculture or other land use. We then examine the cost effectiveness of one possible alternative to SFM that has received surprisingly little attention as a means of achieving forest conservation, specifically protecting certain forests that have already been harvested through conventional logging.

In a first scenario, there is little or no immediate threat of logging or forest clearing for development. In these instances, SFM might be used to "secure" a forest against the threat of future conversion. It is questionable whether this would be a sensible approach, however, since sustainable logging itself may increase the threat of forest conversion by providing more road access. Moreover, even where it is done carefully, logging increases the intensity and frequency of fires (Holdsworth & Uhl 1997) and can have a variety of significant negative impacts on biodiversity (Frumhoff 1995, Bawa & Seidler 1998).

A second scenario is that the alternative to SFM is "uncontrolled" logging. SFM has been promoted in these instances to rationalize timber harvesting and reduce negative environmental impacts. However, SFM is not necessarily less destructive than conventional logging. The relative damage caused by conventional and sustainable logging will depend, in part, on the intensity of harvests, or the volume of wood removed per hectare. Harvest intensities under SFM are fairly uniform in different areas because the guidelines used to design sustainable silvicultural systems are quite consistent in this regard. Available timber volumes are typically assumed to average 1 cubic meter per hectare per year, and sustainable harvests usually range from 10 to 30 cubic meters per hectare on a 10- to 30-year rotation (Cannon *et al.* 1998b).

This range of harvest intensities is generally higher than that of conventional logging due to the harvest of a wider variety of commercial tree species and the need for post-harvest treatments to promote growth and regeneration in the residual stand (Howard *et al.* 1996, Rice *et al.* 1997). As indicated by Table 5, conventional logging is clearly more intensive than SFM in the remaining areas of dipterocarp forest in Southeast Asia. Elsewhere, conventional harvest intensities only appear to approach those of SFM in easily accessible forest close to centers of domestic timber demand in Brazil (see also boxed information on Paragominas on page 16).

Moreover, even where conventional logging is initially more intensive, it may still be preferable to SFM on an environmental basis if logging is halted and the forest is subsequently protected. With time, previously logged forest may be able to regain its former structural and compositional characteristics (Horne & Hickey 1991, Cannon *et al.* 1998a). In a commercial setting such as SFM, in contrast, these changes are essentially permanent since the interval between timber harvests is usually far less than the time required for primary forest characteristics to re-emerge (Horne & Hickey 1991).

In a third scenario, cases where the alternative land use involves forest conversion, SFM is clearly preferable on environmental grounds and should be promoted. Nonetheless, where the threat of forest conversion is overwhelming or where the value of land for agriculture is high, any attempts to impose SFM are likely to be expensive. If SFM prevents agricultural development in these areas, it will do so only because the government is able to force landowners to adopt it. This is an important issue because the government has a choice of whether to use SFM or some other means to achieve its conservation objectives. As we show below, evidence suggests that SFM may not be the most cost-effective conservation option available for achieving conservation goals.

One of the basic arguments in support of SFM as a conservation strategy is that, with loggers in the forest and employment benefits going to local populations, protection will be relatively inexpensive. Those making a living from the forest will have a financial incentive to protect it themselves. In contrast, alternative means of achieving conservation goals, such as including expanding protected areas, are seen as lacking this advantage and, therefore, as more costly and difficult to implement. However, there are a number of reasons why achieving conservation through SFM may in fact be the more difficult and costly approach. First, imposing SFM itself requires significant expenditures that parks do not require, including the costs of enforcing regulations to retain seed trees, to log less valuable trees, and to reduce logging damage. All of these costs are to ensure a continued supply of timber, and hence, to provide loggers with an incentive to protect the forest. Second, preventing illegal activities, such as hunting and agricultural clearing, becomes increasingly difficult with loggers already in the forest, and with increased road and transport access (Auzel & Wilkie 2000). Similarly, as noted earlier, controlling and preventing fires is also more difficult and costly in the context of logging (Holdsworth & Uhl 1997).

In light of SFM's limitations as an approach to conservation, alternative strategies warrant careful consideration. One approach that holds particular promise on both economic and environmental grounds is the protection of forest that has already been lightly logged. The opportunity cost of protecting forest from which the commercially valuable timber species have been removed can be substantially lower than for unlogged forest, making this strategy economically, therefore politically, attractive. From an ecological standpoint, this approach enables the process of forest recovery to occur in contrast to sustained logging, which continues to disrupt the forest's natural regenerative functions.

One case study explicitly considers the conservation benefits of this approach. Cannon and his colleagues (1998b) examined the cost effectiveness of protection of a forest following logging relative to various other land use options, including protection of unlogged forest, protection following conventional logging, conventional logging without protection, and SFM. A computer simulation for the Chimanes Forest in Bolivia was used to compare the economic and ecological impacts of each of these options. Profitability was used as a measure of economic performance, and structural and compositional changes (relative to unlogged forest) served as an indicator of conservation effectiveness.

The study found that protection following a brief period of logging caused less damage and was more profitable than SFM. In fact, protection following logging resulted in 95 percent of the structure of the unlogged forest being retained at a cost of only 9 percent of the maximum profits available from conventional logging. SFM maintained only a third of the structure of the unlogged forest, at a cost of nearly two-thirds of the profits available from conventional logging (Cannon *et al.* 1998b) (See Table 6, page 24). These figures suggest that, in some places, government revenue could go further toward achieving conservation goals by protecting logged forests than by pursuing SFM. In this particular study, protection following logging was more than twenty times as cost effective as SFM at achieving conservation objectives. In other words, for a given reduction in profit, forest protection following logging could be implemented on 20 times as much forest area as SFM.

As a conservation strategy, protection following logging could take one of several forms, depending on the circumstances. Clearly, unlogged forest would provide superior ecological benefits and should be favored as a target for protection

TABLE 5: Harvest intensity of conventional logging in selected regions

Source	Country	Comments: Forest Condition	Comments: Harvest Composition	Harvest Intensity (m^3/ha)
Barreto *et al.* (1998)	Brazil – Paragominas (far Northeast Pará)	Remnant pristine forest, flat terrain, easily accessible, supplies local lumber demand	3 to 8 trees/ha – large commercial trees > 45 cm dbh, up to 50 species	30
Uhl *et al.* (1991)	Brazil – Tailandia (Northeast Pará)	Lightly logged forest	10-15 species removed – small-scale operations	16
Veríssimo *et al.* (1995)	Brazil – (Central Pará)	Highly selective logging in inaccessible pristine forest	1 tree species harvested (mahogany)	5
Richards (1991)	Mexico (Southeast)	Area had been selectively logged years previously	Small-scale extraction of high value species	5
Mendoza & Ayemou (1992)	Cote d'Ivoire	Average of 6 companies – different forest conditions	10 commercial species harvested (2nd entry)	20 (range 3 - 27)
Ahmad (1996)	Indonesia – Irian Jaya	Pristine forest	Commercial species > 50 cm dbh	11
Ahmad (1996)	Indonesia – Kalimantan	Dipterocarp	Commercial species > 50 cm dbh	51
Kollert *et al.* (1995)	Malaysia – Deramakot, Sabah	Pristine lowland dipterocarp	Harvested between 1962 and 1968	110

Source: Cannon et al. 1998b
Note: "dbh" is "diameter at breast height"

wherever possible. However, in cases where forest has already been logged using conventional methods, governments and conservationists face a choice of protecting the residual forest or supporting efforts to implement sustainable logging in perpetuity. In this case protection will almost certainly be the better choice for conservation. Protection is also unlikely to be very expensive in terms of forgone logging benefits since conventional logging will have already removed the lion's share of the forest's current timber value.

Another option might involve conservationists approaching an existing logging operation with a timber concession on public lands and offering to retire all or a portion of the concession through an annual cash payment. The payment would cover any forgone profits for areas not yet harvested or, where loggers are charged an annual area tax, could actually lower the company's tax liability for lands that have already been cut and which therefore have little prospect of contributing to the company's future revenues. The amount of cut and uncut forest retired through this approach would be subject to an open negotiation between conservationists and the individual company.

Finally, conservationists could enter into a mutually beneficial agreement with loggers prior to the initiation of any logging activity in cases where outright protection is not an option. The agreement might, for example, involve a single, carefully controlled harvest in specified areas, a ban on all company-sponsored hunting within the concession, and a road system planned to minimize the risk of agricultural incursion. In exchange, conservationists could agree to continue government payments throughout the remainder of the concession term following an early exit by the logging company. In some cases this might even involve the *company* agreeing to fund subsequent protection since, with no logging planned after the initial harvest, there would be no reason to spread harvests evenly over an entire 20- to 30-year cutting cycle. Instead, sustainable logging levels could be applied to the entire concession over a much shorter time period. This would mean more revenue in the company's pockets earlier (and hence much higher profits overall) and a shortening of the time during which access is provided to the concession and the forest is subjected to the disturbance caused by logging.

One example of where this approach (protection following logging) has been implemented is in the southern Amazon Basin, where three electric utility companies in partnership with a U.S. conservation organization financed the expansion of Bolivia's Noel Kempff Mercado National Park. Funding for the project was arranged as a carbon offset, where the energy companies involved may eventually receive credit under the Framework Convention on Climate Change for the carbon that otherwise would have been lost through logging or land conversion. The area was considered a conservation priority because past logging had been highly selective so that the majority of the forest's biological value was maintained. Since most of the area's high value tree species had already been removed, the cost of acquiring the land was also extremely low — roughly US $2.50 per hectare (Petterson 1998).[6] Similarly, in 1999, Conservation International paid $2.22 per hectare for the logging rights to a 45,000-hectare concession that was later added to Bolivia's Madidi National Park.

TABLE 6: Ranking conservation and development options by selected criteria, Chimanes forest, Bolivia

	Relative to Unlogged Forest		Relative to Conventional Logging	
Option	**Structure Retained**	**Composition Retained**	**Profit**	**Opportunity Cost**
Protection of unlogged forest	100%	100%	0%	100%
5 years of conventional logging, then protection	95%	99%[1]	91%	9%
50 years of conventional logging, then no protection	62%[2]	98%[3]	100%	0%
50 years of conventional logging, then SFM	33%[2]	80%[3]	37%	63%

Source: Cannon et al. 1998b

Note: Profit and opportunity costs are calculated assuming a discount rate of 15 percent.

[1] In year 5 (average of years 1 to 10)
[2] Average of years 41 to 50
[3] In year 50

CONCLUSION

Today, almost no logging of natural forests in the tropics can be considered sustainable. Few companies have chosen SFM over conventional logging or other land uses because slow tree growth, modest price appreciation, and high interest rates combine to make SFM an unattractive land use. Efforts to make SFM more viable have tended to focus on increasing its profitability, but they have failed to make SFM a relatively more attractive option. Even if SFM were financially viable, it would rarely be justified on conservation grounds and, in fact, might result in more damage to forests than would otherwise occur. Furthermore, even where SFM is environmentally preferable, it is generally not the most cost-effective method for achieving conservation objectives. Because SFM has limited usefulness as a conservation tool, alternative approaches, such as protecting lightly logged forests, should be carefully considered. Meanwhile, protected areas should continue to be the cornerstone of any sensible conservation strategy.

ENDNOTES

1 Figures include all certified natural forests in tropical countries,including those in Brazil, Mexico, and Namibia, which are not entirely in the tropics.

2 The initiatives were: ITTO (three different sets of criteria), Montreal Process, Helsinki Process, Canadian Process, Forest Stewardship's Council Principles and Criteria, Soil Association: Responsible Forestry Programme, Rainforest Alliance: Smart Wood Certification Programme, SCS Forest Conservation Programme, Canadian Standards Association Sustainable Forestry Management System, and AF&PA Sustainable Forestry Principles and Implementation Guidelines.

3 Economic rent is defined here as the difference between the return derived from a factor of production and the remuneration needed to keep this factor in its same use.

4 Structural and compositional damages are used here as indirect measures of the conservation value of forests because they are known to correlate with the richness and diversity of various species groups (MacArthur *et al.* 1962, Karr & Roth 1991, Catling & Lefkovich 1989, Holloway *et al.* 1992, Gullison & Nissan 1998).

5 As shown in the table, the ratio of the forest structure retained to opportunity cost for SFM is 0.5 (*i.e.,* 0.33/ 0.63). In contrast, the ratio of the forest structure retained to opportunity cost for protection following conventional logging is 10 (*i.e.,* 0.95/0.09).

6 The overall cost of this project was $9.5 million (Petterson 1998). The $2.50 per ha quoted above is the amount paid to compensate timber concession holders for their lost future income.

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