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Jerome K. Vanclay

Saving the Tropical Forest: Needs and Prognosis

Many attempts to reverse deforestation in the tropics have failed because they addressed symptoms rather than causes. Many pressures come from outside the forest, so a multi-sectoral approach is needed. The real causes and some possible solutions are examined. Whilst there is scope for further research, many problems can be overcome through increased community participation, better communication, more effective management and the implementation of a few simple guidelines.

INTRODUCTION

Tropical forests have the interest of the public and the attention of the media, so that no week passes without some reference to tropical rainforests in the popular press. Unfortunately, it is often simplistic and ill-informed. Nonetheless, much support for these forests has been mobilized, and the controversy surrounding rainforests and "old-growth" forests has influenced elections and government policies in several countries. This paper reexamines some issues, attempts to clarify some areas of confusion, and examines the prognosis for the tropical forests.

SIGNIFICANCE OF THE RAINFOREST AND THE TIMBER TRADE

Any attempt to rectify the problems in the tropical forests must discriminate between symptoms, problems, and other issues. Too much effort has been misdirected because the real issues and problems were not identified.

The Wet and Dry Tropics

Not all tropical forests are rainforests. Much of the tropics is arid and only 40% is forested (Table 1). About half the tropical forest is rainforest; the remainder comprises seasonal forests, savannah woodland and other forms of open forest. "Tropical moist forest" is the collective term for rainforest, seasonal or monsoon forest, and mangroves¹.

Table 1. Forest Area relative to Land Area within the Tropics.

Forest Type	America	Africa	Asia	Overall
Total Forest	50%	30%	40%	40%
Moist Forest	40%	10%	30%	25%
Rain Forest	30%	5%	20%	20%

Whilst the tropical moist forest has the limelight, the tropical woodlands are also of great importance. It is these forests that may be under the greatest threat of

overuse through the gathering of fuelwood and fodder, from grazing, and from the resulting soil erosion. This is not just an ecological disaster, but a human tragedy. Many people suffer malnutrition not only because of food shortages, but also because



Figure 1. Consumption of tropical wood².

of a shortage of fuel with which to cook.

Fuelwood is a major forest product. Of the total tropical wood supply, 83% is consumed as fuelwood, 13% is consumed locally as timber, and only 4% is exported to enter the international timber trade² (Figure 1). Clearly, sustainable production of industrial timbers is only part of the solution; more efficient production and consumption of fuelwood is also essential. Sustainable production of all forest products will be difficult to attain. The international timber trade is a more tractable problem, as it is dominated by few players: 70% originates in Malaysia and Indonesia, and 80% is destined for Japan, the EC and the USA².

Carbon Dioxide and Climate Change

There is no doubt that the CO₂ levels in the atmosphere are higher than any time in the past 160,000 years, that they are still increasing at an alarming rate, and that this will have a significant impact on our climate³. We should not complacently expect a benevolent warming, bringing the Mediterranean to the Baltic; the implications are more serious than that⁴. Consider the slight warming of the Pacific that triggers the El Niño Southern Oscillation, and influences the weather not only in the Pacific, but from India to the Amazon, causing floods, droughts and other extremes⁵.

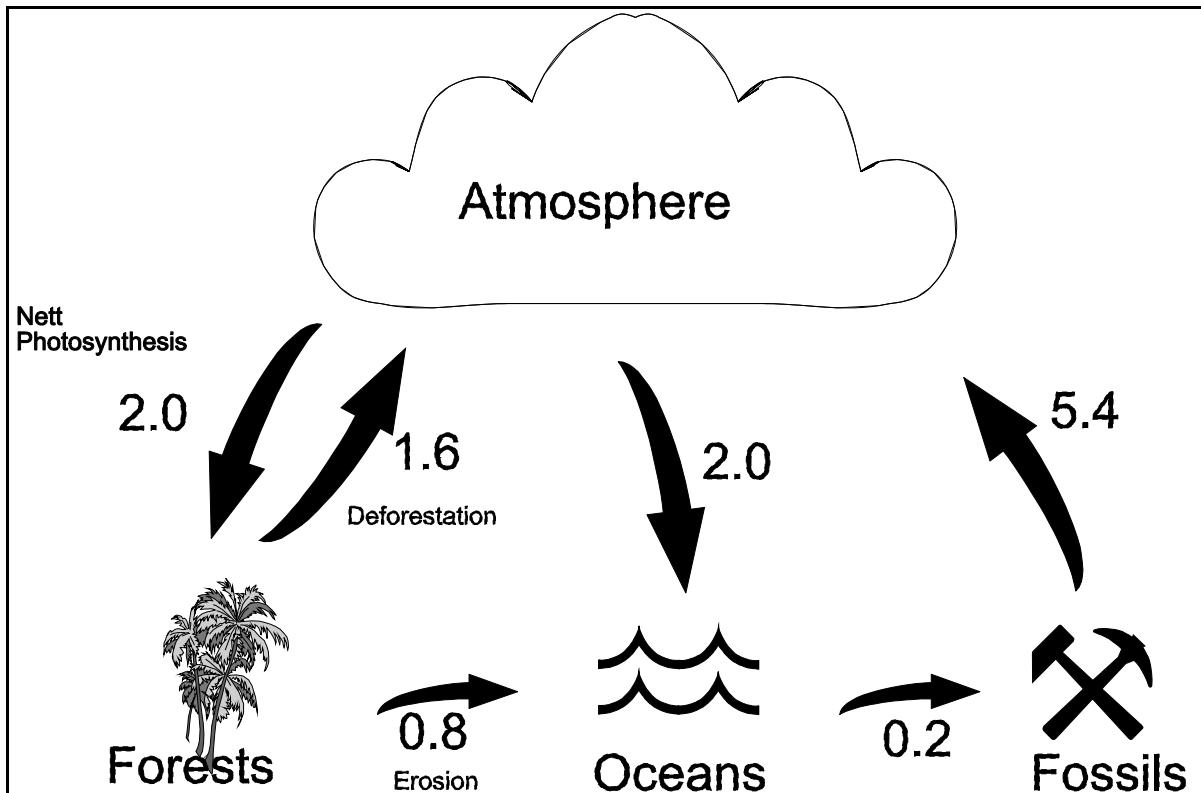


Figure 2. Carbon Dioxide Fluxes (in gigatons of carbon)³.

The tropical forest cannot compensate for our reckless consumption of fossil fuels (Figure 2). Estimates are plagued by unreliable data and many assumptions, but it seems that the destruction and burning of all the tropical moist forest would cause a comparatively small increase in atmospheric CO₂ levels^{3,6}; less than the contribution from fossil fuels this century. And sustainable timber production should be CO₂-neutral or beneficial, since durable products store carbon and vigorous regeneration has higher nett photosynthesis. Carbon dioxide is a problem for the industrialized nations and it is imperialistic to suggest otherwise. Nor will plantations solve our dilemma, as to offset current CO₂ output may require over a billion hectares of well managed plantations⁷, several times the existing worldwide plantation area⁸ and half as much as the remaining area of natural tropical forest worldwide! If trees were so efficient at fixing carbon, we would use wood instead of fossil fuels. To solve our CO₂ problem, the industrialized nations simply have to reduce emissions; we could begin by examining road and rail subsidies⁹. But there are other good reasons for saving the tropical forests.

Biodiversity

Tropical rainforests are rich in plant and animal species, and may have 50-90% of the world's species. But this has little relevance for the management of these and other forests. A balanced conservation strategy is necessary for all habitats, people still need to eat, and conservation schemes still need local support to succeed. Contrary to

popular belief, many rainforests are not so fragile. They have evolved with change, and their species richness provides some resilience. Well managed forests may retain most of the diversity of the primary forest, both in terms of numbers and diversity of species^{10,11,12}, and may support animals that cannot survive in small isolated primary forest reserves¹³.

Who are the real beneficiaries of biodiversity? Few species, often from secondary forest, satisfy most needs of local communities. Some species attract tourists, but diversity itself is rarely an attraction. Plant based pharmaceuticals from only 90 plants may account for 25% of prescription drugs and US\$40 billion in sales each year, but these statistics cannot indicate the potential value of the other 250,000 plant species. Biodiversity offers potential for enhancing the productivity of domestic plants and animals and for finding new pharmaceuticals, but who will benefit and when? And how great is the potential: pharmaceutical firms don't own much rainforest. The current custodians of the forest have more pressing problems than slim possibilities for curing cancer and AIDS, and history suggests that the industrialized nations will be the major beneficiaries. We need to find more equitable ways of sharing the costs and benefits of this unrealized potential¹⁴. Until we do, developing countries will have little incentive for conserving rainforests for their biodiversity.

LOSS OF THE TROPICAL MOIST FOREST

Rate of Deforestation

Some 17 million hectares of tropical forest are destroyed each year¹⁵. Africa has the highest rate of destruction (1.7%/year), but about the largest area deforested is in tropical America. About half the area deforested becomes shifting cultivation, whilst the remainder is converted to permanent agriculture, grazing, plantations and other uses. Although agriculture accounts for more than three quarters of all deforestation, commercial timber extraction is significant in some areas.

Table 2. Symptoms and Causes of Rainforest Destruction.

SYMPTOMS	CAUSES	SOLUTIONS
Erosion, flooding & landslides	Poverty & overpopulation	Education, training & information
Species extinctions	Corruption	Co-operation
Destructive logging	& greed	Social Security
Shifting cultivation	Imperialism	Land Tenure
Migrants & squatters	Bureaucracy	Boost agricultural
Industrial	Ignorance &	production
monocultures	carelessness	Rehabilitate land
	International	Economic Stability
	trade policy	Broad Outlook

Before the turn of the century, half the people in developing countries will have insufficient fuelwood, and only 10 out of the present 33 timber exporting nations will

remain timber exporters. Apart from the loss of invaluable resources, this will have a serious impact on the balance of trade of these nations. Deforestation is inevitable when profits are easily reaped and costs remain undefined; this is the tragedy of the commons¹⁶, and may only be moderated by community loyalty¹⁷. Estimates of the dollar value of rainforests and alternative land uses are convenient for politicians and other decision makers, but convincing valuations of intact forest and sustainable harvests are not yet available. Some attempts vary as much as 100-fold in their assessments of sustainable production of forest products^{18,19,20}.

Causes and Symptoms

It is not easy to discriminate between causes and symptoms of deforestation, or to identify the real causes. Too often, symptoms rather than causes are blamed and attempts at alleviating the problems are thus misdirected. The real problems are difficult ones, often originate outside the forest, and may be intractable; but hiding the symptoms does not cure the problem. Table 2 summarizes some symptoms and causes of rainforest destruction. Although discretely tabulated, they are all interrelated. It is important to recognize several items as symptoms rather than causes (e.g., shifting cultivation), to focus on the real causes. Many presumed causes of deforestation are, like unsustainable logging practices, merely symptoms of more serious and more difficult problems. To solve the deforestation crisis, we have to recognize and understand the real causes; only then will we find a solution.

Erosion, Flooding and Landslides

Erosion is one obvious outcome of unsustainable land use, and may be caused by forestry, agriculture and other land uses. Erosion may cause flooding and landslides, and may create problems far downstream²¹. However, good land husbandry can minimize erosion and reduce flooding and landslides. Logging and other forest operations need not have adverse hydrological effects²². Logging was blamed for, and banned following, disastrous floods in Thailand in 1988 (and elsewhere²³), but it was only one factor. The torrential rain also triggered landslides in natural forest, and clearing for rubber plantations and other crops also contributed^{24,25}.

Endangered Species

It is unfortunate but inevitable that many species will become extinct as a result of land use changes in the tropics. Even if all tropical forest destruction could be arrested immediately, fragmentation and invasion by exotic species already condemn many primary forest species with extinction²⁶. Although inevitable, the new equilibrium may be slow to appear. The tree Calvaria major is threatened because germination apparently depended upon the dodo²⁷, which was exterminated centuries ago. Some theories indicate the approximate number of species that may be lost, but we cannot identify them. The "rare and endangered" species may not be the most vulnerable; several species have fallen from abundance to extinction in a few years (e.g., carrier pigeon). However, species dependent upon large areas of forest, those that require undisturbed primary forest, and some epiphytes may be susceptible. This doesn't

mean preserving all the big tracts of remaining "primeval" forest. On the contrary, the protection, consolidation and rehabilitation of fragmented, degraded and secondary forest may be critical to the survival of some species. We need to reappraise the status of both existing reserves and of disturbed areas, before the latter are further degraded.

The best way to ensure the survival of plant and animal species is to reserve representative areas, protected from artificial disturbance, and buffered with managed forest. Within such a system and when confined to the buffer areas, timber harvesting may not threaten any species. A selection harvesting system is preferred within the buffer area to maintain a semi-natural habitat; plantations are no alternative²⁸. Sensitive management of buffer areas for timber and other forest products may be the best way to preserve the integrity of reserves and balance conflicting demands for production and preservation. Currently about 5% of the tropical forest is protected in national parks and other reserves. This is insufficient to ensure the survival of many species, even if further increases occur. It is the management of the land surrounding these protected areas that will determine the ultimate fate of many species.

Logging Practices

Is logging a cause or an artifact of deforestation? Why does timber harvesting often lead to degradation and deforestation? Sometimes the objective is to deforest the land, and logging is simply an accessory. Often lack of interest, investment, supervision and training collectively guarantee poor harvesting practices. Often the sociopolitical environment and the conditions of the concession promote a short-term outlook and hamper investment in better training, equipment and practices. If these real problems can be identified and overcome, then sustainable timber production can be achieved through a few simple guidelines^{29,30}.

Shifting Cultivators and Squatters

Timber harvesting and "landless poor" often work in concert to deforest. The loggers provide access roads and remove the big trees, while the poor destroy the remaining vegetation and begin subsistence cultivation. But is logging the cause? Without loggers and logging roads, people still need to eat, and would continue to occupy what they see as under-utilized land. If the loggers merely provide the path of least resistance, then stopping the timber harvest will neither cure the problem nor stop the deforestation.

The "landless poor" includes traditional forest dwellers and migrants. The forest dwellers may be shifting cultivators or hunter gatherers, whose territorial claims may or may not be recognized. The Penan conflict in Sarawak is largely an issue of land rights and community involvement, rather than opposition to timber harvesting per se, and harvesting of timber and other forest products could be compatible with their lifestyle and aspirations³¹. Shifting cultivation by traditional forest dwellers may be sustainable where it occurs at subsistence level, uses hand tools, involves limited cash cropping, and supports a stable population; under these circumstances it may not encroach on primary forest. Deforestation may occur when populations increase, cash cropping escalates, or when power tools are used for clearing and cultivating.

Traditional forest dwellers may want their forest to be logged, to simplify agricultural clearing, to bring a road to their village³², or to get some de facto title to the land. In all cases, harmonious timber harvesting requires participation by local communities in the planning, conduct and benefits of all operations.

Migrants may be transient or permanent, legal or illegal. Legal transients include the families of the forest workers, who may establish house and garden close to forest operations, especially if a forest sawmill is involved. The impact and duration of these subsistence gardens may be small, but they may convey the initial impression of a "stream of landless poor following logging roads into the depths of the jungle".

The permanence of illegal migrants or squatters may depend primarily on their detection and eviction by the authorities. Such migrants may be "landless poor" from nearby or from abroad, or they may be speculators, neither landless nor poor. Eviction of the true landless poor is counterproductive, as they will simply move to another under-utilized area of forest and start again, and the chance of detection may be small.

Eviction may exacerbate deforestation, but granting tenure invites a rush of speculators. If the flow of migrants cannot be stopped at its source, one solution may be to grant limited tenure subject to an agreed cultivation system (e.g., agroforestry or trees-with-crops). However, this approach relies on trust between both parties, and farmers may uproot trees, fearing that their land will be depossessed when the trees mature. Part of the problem lies in the perception that forests are under-utilized, and thus part of the solution is greater participation and better use of non-timber products. In short, to get the forest to serve more people in more generous ways.

Permanent legal migrants include the victims of transmigration schemes that move people from over-populated to under-populated regions, in an attempt to improve the economies of both regions. This may be futile, as it does not address the problems at the source, and creates additional problems at the destination. It may simply be colonialism, exporting the unwanted from their home territory to strengthen territorial claims over insecure colonies. It is unfortunate for the victims and the land alike; there are usually good reasons for under-populated lands, including diseases and limited land capabilities. Preventive medicine, soil amelioration through drainage and fertilizers, and new plant varieties may overcome some of these problems, but many remain. Foremost among the problems is the fact that many migrants are simply not equipped (experience, training or funds) for the new problems they face. Regrettably, many of these lands are doomed to be degraded and abandoned.

Industrial Agriculture

Agricultural cash crops at both the industrial and family scale have led to the destruction of vast areas of tropical forest. Sugar cane, coconut, rubber, oil palm, coffee, cocoa, tea, many spices and other crops are produced on land that once supported rainforest, and encroachment continues. These crops are eagerly sought by the same nations who would ban timber harvesting, and provide an important source of employment and income for nations and individuals. Substitutes or alternatives may be available, but may have other undesirable ecological consequences, and substitution by consumers may simply force a substitution by producers - and a switch to a crop with lower return may lead to increases in area cultivated.

REAL CAUSES OF DEFORESTATION

The most important issues for tropical forest management are often omitted from forestry textbooks and training courses. Temperate forestry in industrial nations is comparatively easy; most causes and effects are internal to the forest. In the tropics, the external forces are more important than silviculture, and have to be addressed.

Poverty and Over-Population

The cycle of poverty and population is probably the most pressing problem in world today³³. Poverty will remain until populations stabilize, and populations will grow until poverty is alleviated; condoms are not enough. The link between population and poverty is clear: In developed nations, most people want children for self-fulfilment or companionship; in developing countries they want children for support in their old age. The lucky few with social security, pension schemes and aged care, need not be afraid to grow old without a family. For most people, the only form of security and aged care is their children. Until we can change that, we won't solve the population problem. Nepal has one of the highest population growth rates, not despite, but because of its high infant mortality. Because child mortality is high, parents have many children so that some may be around when they get old. Infant mortality, emigration, and the lack of social security all contribute to high population growth, to deforestation, and to a shortage of resources.

The world's human population already consumes 40% of terrestrial primary productivity³⁴, and it may double within 40 years — for many of us, within our lifetime. We must choose between quantity and quality of life. Those with security have the choice - and children in the developed world consume ten times the resources of those in developing countries. Instead of big families, we must have extended families. We retain the right to have many children, but it is our responsibility (and capability) to limit our fecundity. To provide appropriate social security in the third world, we must stimulate social, political and economic development by forging social, political and economic links through trade and cultural exchanges.

Corruption and Greed

The wealthy landowners, the influential elite and the multinational corporations are also instrumental in shaping the future of the forest. Their influence is rarely visible, but occasionally the extent and nature of this influence become evident.

During the late 1980s, a political dispute in Papua New Guinea (PNG) led to a Commission of Inquiry with unprecedented powers (e.g., ability to seize documents and subpoena witnesses) to investigate the timber industry. The report by Justice Barnett (who was assaulted and almost paid with his life for his thoroughness) is lengthy and not readily available, but some summaries have been published^{35,36}. Many politicians, several community leaders and most logging companies were exposed as corrupt. One revelation was that companies were transferring profits to tax havens (e.g., Singapore) by falsely declaring amounts and values of log exports and equipment imports, thus depriving the PNG people of their share of the benefits. While not all countries or companies are corrupt, we may assume that the PNG Industry was

not unique, but is characteristic of many nations and operations in the tropics^{37,38}. Education and information may help people recognize the value of forest resources, learn how to participate in land use planning, and better understand democracy and the responsibilities it demands of both politicians and constituents.

Imperialism and Bureaucracy

Imperialism takes many forms, and whilst colonial empires are almost gone, imperialism remains as dual standards which permit destructive harvesting. It is the right and the responsibility of every nation to set the minimum standard, but this can and should be improved upon. If for example, Japan imposed the same stringent environmental requirements on Japanese operations in Malaysia as it does on operations in Japan, there would be little opposition to their role in Sarawak and elsewhere³⁹.

Inefficient, understaffed and ill-equipped forest services invite corruption. The PNG situation was exacerbated by the limited capability of the Provincial Forest Services, many having insufficient staff and resources. Staff rely on logging firms for transport, cannot arrive unannounced, and have limited opportunities to inspect operations⁴⁰. Low staff turnover and little peer review limits innovation and contributes to corruption. Throughout the tropics, forest services are sufficient to facilitate, but unable to control exploitation.

Ignorance and Carelessness

Sustainable timber harvesting relies heavily on the skill and the will of machine operators^{30,41}, but training and incentives for these operators are often neglected. This is inexcusable, as this responsibility lies wholly within the forestry sector, is cost effective, and may enable a major reduction in the environmental impact of operations.

For example, damage to remaining trees can be reduced if the chainsaw operators control the direction in which trees fall. Erosion, soil and nutrient losses can be minimized when the tractor driver is skilled and understands consequences. Training may increase profitability of logging operations, as fuel consumption decreases, breakage of timber and equipment is reduced, and productivity is enhanced. Careful harvesting may save contractors US\$8 per cubic metre harvested, and may increase the value of future harvests by 30%⁴². It also saves lives and reduces injuries; currently the fatality rate amongst loggers in Sarawak is 21 times higher than in Canada. However, social, political and economic stability are necessary before such investments become attractive for logging firms.

International Trade Policies

Trade and tax policies also have an impact on the rainforest. Efforts to influence domestic prices also influence prices and production worldwide, and so shape the destiny and behaviour of farmers in the tropics. Changes in policy may be worse than the status quo, as increased prices or demand may stimulate new clearing for industrial agriculture and cash cropping. Reduced prices and diminished markets may deprive many of their incomes and force them to cultivate a bigger area of a less productive

crop, or to abandon their farm to the loan-sharks and start subsistence cultivation in the forest.

Links between rainforests and agriculture policy may be far-reaching. The Netherlands imports fodder for livestock; tapioca from Thailand and soybeans from Brazil are cheaper than European alternatives. Almost 4 million tonnes of tapioca a year are imported, mostly from Thailand, from 700,000 ha of cultivation⁴³. Over 3 million tonnes of soybeans come mainly from Brazil, and correspond to almost 2 million ha of cultivated land. The total area of soybean production in Brazil is about 10 million hectares, much of which was once forested land. Would import restrictions help? Could the EC duties on tapioca, which amount to US\$40 million a year, be deployed to boost sustainable production? Could Thailand produce livestock and meat products to keep the nutrients (e.g., nitrogen pollution in Netherlands), employment and added value in Thailand?

POPULAR SOLUTIONS

Clearly, it will not be easy to solve the problems of deforestation and degradation in the tropical rainforest. Yet it can be done, and it must be done. Although there is scope for some technical research⁴⁴, much of the solution lies in the application of a few simple and well established principles. Whilst the principles are simple, their application may not be. Successful implementation of any solution will require patience, understanding, and the co-operation of many individuals and institutions.

Plantations

Critics of rainforest harvesting advocate that the world's timber should be drawn from "fast growing" plantations established on deforested land rather than from the natural forests. Unfortunately, there are several practical difficulties. Rarely is there sufficient land available in suitable tracts for efficient plantation management. Where land areas are sufficient, soil and rainfall may not promote fast growth. Fast growth usually means monocultures, fertilizers, pesticides and cultural practices that diminish other values. Plantations also incur considerable financial risks and environmental hazards. Whilst there is certainly a place for plantations, we should consolidate better management of existing plantations before we advocate increased plantation areas.

Technology and human needs change rapidly compared to tree growth, so flexibility is necessary. Future markets for plantation timber are uncertain, so plantations should first satisfy local needs such as fuelwood and construction materials. High value timbers may be a better prospect than "fast growing" species for fibre.

Portable Sawmills

The portable sawmill enables the conversion of logs in the forest, and may reduce soil disturbance and road construction costs, and increase benefits from local processing. Unfortunately, these benefits may not be realized. Like the chainsaw, the portable sawmill is just a tool, and can be used wisely or destructively. Many portable sawmill operations create too much soil disturbance, leave piles of sawdust and debris, and get a lower recovery than conventional sawmills. Perhaps the only certain benefit is the reduction in transport costs between the forest and the market.

Tropical Timber Bans

Boycotts on tropical timber have been promoted as one way to save the tropical rainforest, and have been effected by many authorities²⁵. Although no governments have yet implemented such bans, they are under consideration by several nations. Would they help to reduce the loss of rainforest? To answer this question, we need to examine three scenarios: a total ban, a ban effected by some consumers, and a ban effected on some producers.

Although unattainable, it is instructive to consider the effect of a total ban by all consumers on all producers of tropical timbers. Would it save the rainforest? If effected, it would stop the international trade in tropical timber in its present form (it might continue in a less recognizable form such as paper pulp), but domestic consumption would continue. Exporting nations would suffer a loss of foreign earnings, a trade imbalance and unemployment. The natural forest would become "worthless" and might be converted to "more productive" forms of land use. Detrimental side effects of such a ban probably would outweigh the benefits. However, the scenario is unlikely to arise.

It seems improbable that a simultaneous ban could be effected, and it is more likely that the EC would support a ban whilst Japan would not. The message to producers would be that future markets were doubtful and that they should "make hay while the sun shines". The remaining consumers, as astute entrepreneurs, would offer lower prices. The result would be an escalating harvest with diminished returns to the producer countries. In the rush to realize profits before the opportunity ceased, some countries would further neglect environmental guidelines and supervision. By itself, a ban will be counter-productive: we need both the carrot and the stick. While calls for bans remain, we must deliver a clear message that we will continue to purchase, and pay a premium for timber produced in a sustainable way. One difficulty is that few sustainable harvesting operations currently exist⁴⁵, and this may appear bluff. In the short term, we must grant some producers this recognition, even if they do not presently reach the ultimate standard. And we need to devise clear criteria for sustainability, to show all producers where they stand, and to help them reach the required standard.

The third scenario bans non-sustainable production whilst supporting sustainable production, to minimize negative implications of limited participation. The difficulty lies in assessing what constitutes sustainability and in defining the time frame necessary to achieve it. Criteria and procedures for assessing sustainability have recently been proposed^{46,47}, but no field operations have yet been assessed in this

way. Few existing operations will satisfy these provisions, so interim standards may be necessary. Excessive haste in demanding compliance, may trigger economic and social difficulties with detrimental effects on the forest (e.g., subsistence agriculture). This scenario offers the best solution, but care and understanding will be necessary for effective implementation.

Labelling

In theory, labelling of timber would enable consumers to exert their preference for sustainable products. Unfortunately, the validity of labels is hard to control. Regional labelling may enable species-level controls but may penalize a country for its neighbour's indiscretions. National (and concession-based) labelling pose considerable difficulties in tracing timber, and create opportunities for importing and reexporting through green-certified ports. The challenge is to provide reliable labelling at a modest cost. Whilst most tropical timbers could command higher prices, the extra revenue should accrue to the country of origin (and be invested in better forest management), rather than to a monitoring bureaucracy. Some illegitimate labels may be an acceptable price to pay for a realistic ceiling on monitoring costs. Accreditation schemes also must include plantations to minimize pressure for conversion of natural forests to plantations and other land uses.

Sustainable Timber Production

Is sustainable timber production from rainforests possible? What constitutes sustainable production? Is it relevant to the survival of the rainforests? After all, it is human nature to use available resources, irrespective of sustainability. We should strive for "wise use" of these resources, but strict sustainability may be hard to ascertain. However, as long as we achieve "wise use", does it matter if some external inputs are necessary to maintain the system? Why are we so insistent that rainforest management is sustainable, when little else in developing countries works well, and when our agricultural systems and energy consumption are clearly unsustainable?

These questions are relevant. Many agricultural projects on rainforest soils have failed, but similar examples exist for every ecosystem; here in Europe drifting sand can be found where once was productive agricultural land. Clearly, there is a limit for every ecosystem, but provided we stay within that limit, sustainable production should be possible. Although precise definition of the limit may be complex, effective operational guidelines are easy to define. Harvesting of timber and other products may be sustainable provided that few nutrients are lost (both directly by harvesting, and indirectly through erosion), that soil disturbance and erosion are minimized, and that natural habitats and processes are not disrupted³⁰. Sustainable management of tropical forests is feasible. The Queensland^{41,48,49,50} and CELOS^{51,52} systems are well documented examples of sustainable timber production systems, but other examples also exist^{53,54,55}.

ALTERNATIVE SOLUTIONS

These forest sector initiatives are only part of the solution. The population-poverty cycle remains a major obstacle needing major social, political and economic reform. It cannot be solved by the forestry sector alone, but requires a concerted and sustained multi-sectoral effort. To be effective, such reform efforts must be supported internally, but opportunities to initiate and influence reform are available. The developed nations can do much to create a favourable economic environment by fostering trade and tourism, and to stimulate new ideas through education and cultural exchanges.

Land Tenure

Land reform is a prerequisite for eliminating deforestation. Land and resources are rarely distributed equally, but in many developing countries the inequality is extreme; the poorest have nothing, and nothing to lose by destroying the forest. In Brazil for example, 4.5% of landowners have 81% of the farmland whilst 70% of rural families are landless⁵⁶. Unless these landless have satisfactory employment, they have little choice but to clear the forest.

Secure tenure may also limit deforestation. Some deforestation occurs because the harvesting agreement provides a de facto title deed. Elsewhere, traditional land owners may clear lands not immediately required for agriculture because they feel they have a more secure claim on cleared lands. Official recognition of ownership and efficient resolution of disputes over all lands regardless of land use, may prevent such deforestation.

Many timber harvesting concessions are short term agreements, and may not be renewed. Companies have no incentive to do a good job if their concessions may be lost to less conscientious competitors within a few years. Thus one necessary incentive for sustainable management is secure tenure for concessionaires, conditional upon good performance.

Agricultural Production

Much deforestation is triggered by hunger and other factors outside the forest. Improved production from existing agricultural lands and existing timber plantations through higher yields and less degradation will relieve the pressure on the remaining natural forests. Agroforestry offers the potential to provide fuelwood, fodder and other benefits from agricultural lands without reducing agricultural yields⁵⁷. It may be possible to modify agricultural systems to provide greater conservation values and less of a barrier to migration between remaining forested areas.

Information

Good policy and management rely on efficient provision of information to politicians and constituents, to policy makers and land managers, and to the public in both developed and developing countries. Policy makers are rarely given substantiated facts on the costs of deforestation and degradation. People must know the value of

forests, the rate of deforestation, and the economic and ecological consequences of their loss. And this information must be clearly and concisely communicated.

In many countries, women are the main users of the forest, and the main victims of deforestation. For example, fuelwood is usually collected by women, for whom deforestation means more work. Many obstacles restrict input by women during community consultation and planning, and one solution may be more women foresters.

Most forest services and training centres are male dominated, both in developed and developing countries, and incentives for the recruitment of women may be helpful. Many forestry schools are located in the forest, away from other centres of learning, and offer little opportunity for forestry trainees to broaden their communication skills across disciplines.

Stability and Outlook

Political and economic stability is a prerequisite for long term corporate investment in sustainable timber production. Stability in trade policies and commodity prices may avoid the destructive "boom and bust" that destroys much rainforest, for timber as well as for farmland. Progressive reform in the tropical timber trade, and in other areas, needs a broad outlook to see both sides of the issues, and to appreciate possible unintended consequences of our reforms, protectionism and policies.

Research

While there is considerable scope for forest research in the tropics, a lot can be done by implementing existing knowledge. Many forest services have much potentially useful information languishing as unpublished reports, and the collation and dissemination of this material could be cost-effective. Many trial plots and experiments could provide useful data for species selection and silviculture; documented failures provide as much information as successes. Consolidating such information may not have the appeal of a new experiment, but it eliminates the long wait for growth plots to reach a useful age.

Taxonomy is essential to support research in the tropical rainforest; it is a prerequisite for documenting and communicating results. Most forest services have species lists with undescribed taxa known only by a local name or specimen number. The silvicultural characteristics of many species remain unknown, little is known about nutrient cycling in most forests, few species have been screened for useful compounds, and efficient techniques for processing and utilizing the less common species are unknown. Some species may have a pivotal or "keystone" role^{58,59} in providing food during lean times and in acting as vectors for dispersal of seed. We need to know the identity of these species and more about their roles. Processing of forest products in the tropics is often primitive and dangerous; considerable scope exists to improve the safety and efficiency of the extraction and processing of timber and other forest products^{41,60}. Most forest services have insufficient or inadequate growth data from the natural forest, thus growth models and simulation studies cannot be made, and we can only guess the sustainable timber yield.

SHAPING THE FUTURE OF THE RAINFORESTS: WHAT CAN WE DO?

What can we — as individuals, organizations and nations — do to effect these solutions? There is much to be done with limited resources, so we should interact with, rather than duplicate existing initiatives such as the Tropical Forestry Action Plan of the United Nations Food and Agriculture Organization⁶¹, the ITTO action plan⁶², and the new Centre for International Forest Research (CIFOR) of the Coordinating Group for International Agricultural Research (CGIAR)⁶³.

Reform starts at home

Direct action may feel good, but do little to help the cause. Buy labour-intensive goods manufactured in developing countries to boost employment and wealth. Be selective and thrifty with timber, and ask your supplier how it was produced, about the royalties paid and where it was processed. Choose sustainable tropical timber first, as it needs support. Don't simply switch to temperate timbers or plastics, but apply the same criteria for sustainability to all the goods you consume.

Lobby for reform in trade policies, to stimulate trade with developing countries, in manufactured goods rather than primary products. Existing trade barriers cost developing countries over US\$100 billion a year in income foregone, a figure half as large again as total foreign aid, and more than enough to service the debt to outside creditors. Half the third world debt is owed by 27 countries with 97% of the tropical forest, countries with a nett deficit whose debt is increasing every year.

Training in communication and management

Foresters in many tropical countries are well trained in forestry and may hold higher degrees from prestigious universities in Europe and north America. Unfortunately, these achievements have not been translated into good forest management, perhaps because of overemphasis on technical training instead of management. Sustainable forestry is like a major civil engineering undertaking: it involves land use plans, community consultation, the timely involvement of many individuals from many different disciplines, quality control over all operations, and efficient accounting and revenue collection. But how much training is devoted to management, accounting, public relations and communication? Ph.D. students may choose to study in prestigious technical areas such as gene transfer, micropropagation and mycorrhiza, but return to management and administration positions. It may be better to provide on-the-job exchanges to give hands-on management experience in efficient organizations. The Barnett Report³⁶ suggests that emphasis on accounting is essential.

Provide information

Tropical forestry is hampered by both too much and too little information, much of which is unavailable to key players. Many forest services lack current information, and receive few foreign scientific journals. It is easy to support institutions with journal subscriptions, but few aid agencies want such small projects.

Much of the important information on tropical forestry does not appear in journals, but in the "grey literature" of various aid agencies. It doesn't appear in Current Contents, Forestry Abstracts or on-line databases, and isn't available to many potential readers. Whilst confidentiality between donors and recipients requires some restrictions, it is unfortunate that so much information has such a limited audience.

Many forest services lack good maps and reliable area estimates of their forest estates, and these deficiencies can be overcome using satellite technology. Satellite data have proven utility for forest management and mapping⁶⁴, and Global Positioning Systems offer the possibility of efficient forest surveying. Support, co-operation and training in these technologies may provide a cost effective way to improve information for forest management.

Foster social, political and economic stability

How can we stimulate reform? How do people develop higher expectations of their political and social systems? Many factors are involved, but experiences and expectations of individuals are key factors. Bans may hasten reform, but isolation may not be productive, and increased social and economic links may also stimulate reform. How much aid should be reward and how much should try to influence reform and development? What role can and should the timber trade play in influencing human rights? There are no easy answers, but more open discussion of these topics may lead to a more satisfactory conclusion for all parties.

SUMMING UP

We won't "save" the tropical forest overnight, but there is much we can do to improve the prognosis for these forests and the people dependent upon them. We should not get carried away with reactive and emotive "solutions", but should try to identify and alleviate the real causes — even though this is much more difficult. Much can be achieved locally, by exerting consumer preference, providing information, asking questions and lobbying politicians. The most important thing is to begin.

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Biography

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