# The Tropical Forests as a Global Resource: Impacts of Trade-Related Policy

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**Abstract**:

This paper analyses the impacts of trade and trade policy on tropical deforestation. Distinctions are made between the different costs and benefits pertaining to forest use, their distribution and natural vis-à-vis industrial forest features. It is emphasized that forest management is determined by the incentives that confront the relevant actors, and their interdependent behavior. International trade is not a major cause of deforestation, and barriers to log exports worsen the situation. While trade liberalization and consumer action are argued to have a potential for favorable impacts through pressure for institutional reform, a socially optimal management of the tropical forests requires that presently non-commercial values be taken into account. As producer countries face considerable difficulties in exploiting biological diversity, compensation for absorption of $CO_2$, e.g., in a market for tradable carbon rights, stands out as the best opportunity to narrow the gap between private and social benefits. While problems such as those associated with moral hazard would have to be overcome, such a scheme should seek to correct the present policy and market failures spurring deforestation and favoring industrial rather than natural forest features.

**Keywords**: Deforestation and trade policy; forest management and industrial vs. natural forest features; tropical timber trade; Economic benefits of biological diversity; $CO_2$-emission and absorption rights.
**JEL-classification:** F13; Q23; Q25; Q28.

## I. Introduction[1]

Much of the current degradation of tropical forests represents economic and ecological mismanagement which is costly for individual countries as well as for the world community. Although this partly applies to forests in temperate zones as well, the tropical forests are to a particularly high degree associated with benefits which neither markets nor policy makers have so far taken into account.[2] Their rich biological diversity possesses a potential for social gains, especially from the global perspective, which is much greater than the private benefits that can be captured. Similarly, in the face of mounting risks of global climate change, the dwindling absorption of $CO_2$ by these forests stands out as a significant external cost to the world as a whole. Even the potential commercial output from these forests, in the form of tropical timber and timber products, is far from optimized today.

The treatment of forests is crucially influenced by the benefits that those who manage them can hope to capture. Many studies have found that domestic institutions and policies in developing countries, including the lack of well-specified property rights, cause serious distortions in this respect (Binswanger, 1989; Mahar, 1989; Reis and Marguilis, 1991). The mainstream view is that international trade does not represent the major factor spurring degradation of tropical forests (cf. Barbier et al., 1994a). Nevertheless, there are several possible connections between mismanagement of tropical forests and international trade.

First, trade has been argued to be one of the factors which, especially in conjunction with other factors, drives the exploitation of tropical forests (Allen and Barnes, 1985). Second, impediments to trade, in the form of export bans in developing countries or import barriers in developed countries, may reduce the value of, and thereby the incentives for, sustainable forestry (Vincent, 1990; Braga, 1992). Third, trade based on intellectual property rights and/or other trade-related forms of international exchange may be a prerequisite for internalization of presently non-

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commercial values pertaining to tropical forests, but can also discriminate against poor countries in possession of these resources (Amelung, 1993; OECD, 1996a). Fourth, options for trade may exert an impact on institutional conditions, policies and management practices within forest-producing countries. Such impacts are in fact targeted by proposed schemes for, e.g., labeling products or certifying concessions or countries.

These apparently conflicting issues, and how trade-related policy can best contribute to sound management of forests, are considered in the present study. Main causes of deforestation and current trends are surveyed in Section II. The distribution of costs and benefits pertaining to forest use are discussed in section III, which adds to previous work by taking into account that impacts on the rate of deforestation are inter-related with those on the *natural* vis-à-vis *industrial* characteristics of forests. Commercial trade issues are addressed in Section IV, including: observed impacts of trade; impacts of barriers to exports in developing countries; liberalization of exports, and; consumer action. In Section V, presently non-commercial values in the areas of biological diversity and absorption of $CO_2$ are addressed. Attention is paid to the Biodiversity convention, the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), and to the option of marketable $CO_2$ emission and absorption rights. Section VI summarizes.

## II. Current trends

The annual rate of deforestation in the tropics has been estimated at about 0.9 percent for the 1980s (WRI, 1992).[3] The figure was the highest in Asia - 1.2 percent per year. Of individual countries, some with relatively small resources experienced the highest rates; Nigeria 5 percent and Costa Rica 4 percent. The greatest losses in absolute terms occurred in Brazil and Indonesia, where the annual deforestation rates were estimated at 1 percent or somewhat less.

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[2] Temperate forests are not addressed in the present paper.

[3] Estimates vary considerably, both for individual countries and for the aggregate deforestation rate. Some higher estimates draw on the extremely extensive deforestation which took place in the Amazon in 1987 when political turmoil triggered fires as a means to secure property right to forests.

Forests are not only depleted but also regenerated, which occurs either naturally through the establishment of secondary forest or through human intervention. Human involvement may aim at the restoration of previous forest, the artificial establishment of new forest on previously forested land or artificial establishment in previously unforested areas. The area planted each year in the tropics is estimated at some 15 percent of the area being deforested. As of 1990, less than 2 percent of the total tropical forest area constituted of plantations (FAO, 1992).

Clearing of land for agricultural purposes has generally been identified as the major cause of deforestation. Commercial forestry has shown up as the second most important factor, followed by cattle breeding and collection of firewood by smallholders (Johnson, 1991; Barbier et al., 1994a). The impacts of road construction have been found to be interlinked with population distributions (Pfaff, 1966), soil quality and tenure regulations (Chomitz and Gray, 1966). There are marked regional differences, however. In the Amazon region, lack of well-specified property rights for standing forest, subsidies and tax breaks for cattle ranching have been shown to play a major role (Binswanger, 1989; Mahar, 1989). The influences of population pressure and agricultural rents are also paramount (Schneider et al., 1990; Reis and Marguilis, 1991). Collection of firewood, due to poverty and rapid population growth, is the primary source of deforestation in large parts of Africa. Commercial forestry has so far been of the greatest importance in Asia and some individual African countries.

The role played by international trade in tropical deforestation is still unclear. Both production and trade in tropical timber products have expanded rapidly in recent decades. An overview of the developing countries with the largest forest land and/or exports, presented in Table 1, does suggest a linkage. Countries with large exports also experience rapid deforestation. Those with rapid deforestation similarly tend to have large exports. There is only one clear-cut case of a country with a relatively high deforestation rate without significant export revenues, i.e. Venezuela. Similarly, only Congo reports substantive exports without much deforestation.

**Table 1: Estimations of forest area, annual deforestation**

**rate and value of forest exports***

| Country | Forest area mill. ha 1990 | % of area deforested annually 1981-1990 | mill. USD of exports 1990 |
|---|---|---|---|
| Indonesia | 110 | 1.0 | 3 601 |
| India | 52 | 0.6 | 39 |
| Papua | 36 | 0.3 | 114 |
| Myamnar | 29 | 1.3 | 148 |
| Malaysia | 18 | 2.0 | 3 120 |
| | | | |
| Zaire | 113 | 0.6 | 24 |
| Congo | 20 | 0.2 | 62 |
| Gabon | 18 | 0.6 | 226 |
| Cameroon | 20 | 0.6 | 201 |
| Cote d'Ivoire | 11 | 1.0 | 278 |
| Ghana | 10 | 1.3 | 93 |
| | | | |
| Brazil | 561 | 0.6 | 1 472 |
| Peru | 68 | 0.4 | 4 |
| Bolivia | 49 | 1.2 | 30 |
| Mexico | 49 | 1.3 | 133 |
| Colombia | 54 | 0.7 | 17 |
| Venezuela | 46 | 1.2 | 0 |
| Guyana | 18 | 0.1 | 4 |
| Surinam | 15 | 0.1 | 1 |

* Developing countries with the largest forest area and/or largest exports of forest products

*SOURCE:* FAO (1993)

There may be considerable shifts in resource management over time. The developed countries which today possess extensive forests can be said to have passed a "break point" when deforestation was replaced by long-term management. The increased exploitation of forests for commercial use is generally viewed as a major factor having contributed to this change. Whether developing countries will follow a similar pattern, and what role trade plays and will play in that context, is a matter of debate. It should be made clear that most producer countries today already have adequate rules and regulations requiring sustainable forest management. A range of other policies, along with market failure, account for incentive structures which do not motivate compliance, however.

Higher prices for forest products, particularly stumpage prices, are necessary to reverse the present situation. In recent years, price increases have been observed for hardwood in Asia and Africa (ITTO, 1991a). Still, pressures for higher prices are likely to be counteracted by, e.g., greater supply of temperate forest products, technical progress and industrial conversion to other materials (Hyde et al., 1991). To this can be added continued access to forests protected by weak or no property rights, subsidies encouraging consumption and, as we will see, current trade policies. In addition, protecting tropical forests from competing land uses is likely to become increasingly difficult. Whereas the return on forest products is extremely long-term, tastes may be anticipated to change, political conditions or ownership rights may not be viewed as stable, and population increases account for rising need of land for other purposes. The establishment of monocultures increases vulnerability to, e.g., diseases and insects. Such factors add uncertainty regarding future returns and raise the desire to cash in immediately.

Before returning to the role played by trade and various trade-related policies, the following section surveys the costs and benefits which pertain to tropical forests and their relevance for the different actors which influence the management of forests.

## III. The distribution of costs and benefits

It is essential to distinguish between financial or private prices, which confront actors in the market place, and those which are relevant from the perspective of social welfare. Impacts which are neglected in the market are referred to as *externalities* (Pigou, 1932). Socially relevant prices can normally be derived from marginal utility expressed as, e.g., willingness to pay when individuals are confronted with appropriate alternative choices. [4] Divergence between market and social prices can arise for many reasons. In the area of ecological services, Perrings et al. (1992) emphasize three sources of divergence; the role of government, poverty, and market failures.

The applicability of this kind of conceptual framework is controversial. Current ecological economics tends to underline the need for conservation rather than preservation of biodiversity, which means focusing on the maintenance of sufficient biodiversity to ensure the resilience of ecosystems which deliver services fundamental to human activities and human life. Such values cannot be captured by willingness to pay, or any other measurement of consumer preferences alone. In the present context, however, it will be sufficient to consider costs and benefits irrespective of such concerns. The most obvious source of benefits from forest management is:

a) Returns from *industrial forestry,* emanating mainly from timber or timber processed products such as pulp & paper, furniture, rubber, nuts, fruits, etc.

Many other sources of gains can be distinguished (cf. Dixon and Sherman, 1990). Here, we make the following stylized characterization of benefits other than those cited above:

b) *Alternative commercial or non-commercial use of forest products*, such as that practiced in traditional harvesting of timber, herbs, food and medicines, or in the form of fuel for heating collected by villagers or new settlers.

c) The value of *alternative land use*, i.e. the gains following from

[4] The standard method of calculating social costs and benefits is “cost-benefit analysis”, through which effects typically are identified, quantified and valued in monetary terms. Cf. Little and Mirrlees (1974) and Helmers (1979).

conversion of land for the purpose of industrial or agricultural use. In poor countries with rapidly growing populations and compelling needs to mitigate poverty, there may be strongly competing socioeconomic needs for land.

d) Gains associated with *recreational values*, amenity, etc., which to some extent can be associated with eco-tourism. These may also show up as, e.g., higher values for property located in the vicinity of forests.

e) Gains in the form of *ecological services* associated with biodiversity. These may be partly commercially important due to options for new medicines, food, biotechnical products, etc., and partly genuinely non-commercial.

f) Currently *non-commercial values of standing forests as such*, e.g. in the form of absorbing and retaining $CO_2$, watershed and hydrological functions, stabilization of climate, etc.

These categories are neither exhaustive nor mutually exclusive.[5] For example, gains in terms of atmospheric stability or amenity are typically based on ecological services which, in the long run, sustain the adaptability and stamina of any forest. Throughout, a distinction should be made between net and gross gains, and also between expected and actual outcomes. Establishment of new forests requires investment in the form of plantation. From the revenue of timber products should be deducted the costs of harvesting and possibly the build-up of processing industries. Extraction of gains from genetic diversity may require research centres and biotechnical industry, and agreement on and reliability of intellectual property rights. Furthermore, a user may be confronted with the choice of reaping commercial gains with certainty by cutting the forest today, or hoping for uncertain future commercial or non-commercial gains if the forest is managed for the long

[5] As presently specified, the above points mainly reason in terms of user-values, i.e. gains that can be captured in connection to consumption. It is today widely accepted that forests and many other natural resources also possess non-user values, as in the form of “existence values” which people acknowledge without any intention of ever actually exploiting them. While such values are likely to be most significant in connection to e) and f) above, they are not here singled out.

term. The latter option may require investment under conditions plagued by severe shortage of resources and high discount rates.

Not only does the level of benefits matter, but also their expected distribution.[6] A broad distinction may be made between four categories of actors ranging from "local" to "global":

i) Forest owners, villagers and new settlers as well as authorities in the *local community*.

ii) Private actors, such as capital owners and firms engaged in timber production or processing, tourist industry, etc., in the wider *national economy*.

iii) The *national government* which, in principle, shapes national institutions and policy conditions.

iv) The *global community*, involving consumer and producer interests as well as governments worldwide.

The distribution of costs and benefits within and between these groups reflects incentive-structures which crucially influence management decisions. A systematic pattern, in space and time, is implied. Neighboring people and interests tend to be able to reap relatively large benefits from forest depletion and carry relatively little of the costs, while the benefits associated with conservation tend to be distributed relatively widely. For example, consumers worldwide benefit from climatic stability but carry little of the opportunity costs of not converting forest land for other purposes. The heaviest burden of conservation falls on poor countries, and particularly on people living in remote areas where there are few alternative sources of income (Wells, 1992).

Because the benefits of conservation are spread thin on many "consumers", some of whom are not even born today, coupled with ignorance and lack of information on

[6] The distribution has, more or less explicitly, been shown to influence forest management,

the long-term consequences of deforestation, it is relatively costly to organize political support in favor of it.[7] This situation is reflected in, e.g. granting of temporary concessions to forest land at too low prices, which is among the key factors countering appropriability of long term benefits and encouraging timber concessionaires to earn quick profits. In Congo, concessions for logging are set at 7 years, while Cote d'Ivoire uses 5 year renewable concessions (Grut et al., 1991). Administrative control with regular underpricing of stumpage prices, tax subsidies granted for logging and land acquisition laws which grant ownership in return for destroying forests are other examples of government intervention discriminating against standing forest (Repetto and Gillis, 1988; Repetto, 1990; Vincent and Binkley, 1991). The same forces are present in the formulation of trade policy.

The magnitude of costs and benefits, and their distribution, is consequently not exogenously determined or constant, but rather varies on the basis of policies, institutions, economic structures and conditions as well as the inherent interplay between the actors involved. Because the behavior of a certain agent must be anticipated to adjust in accordance with changing expectations of how others will act, costs and benefits accruing to different actors cannot be viewed in isolation. It is thus interesting to consider strategic interactions, as laid out in game theory. Where relevant, we will here apply the nowadays mainstream framework of subgame perfectedness, which extends beyond traditional non-cooperative games (Nash, 1951) by ruling out the usefulness of incredible threats.[8]

In addition to distinguishing between the interests which influence forest management, it is also important to take into account that the properties of the forest itself may vary and be influenced by human management. These properties may matter both for the scope of private and social values and for the risk of deforestation. Although the bulk of tropical forests still remains natural, industrial plantations are on the increase, both on land which was previously covered by forest

see for example Cardellichio et al. (1989).

7 As elaborated in public choice theory, public priorities are only partly guided by social considerations, while especially influential groups exert a disproportionately strong influence in the political process (Olson, 1982).

8 In a subgame perfect equilibrium, an agent cannot be induced by another player's deviation from equilibrium to deviate himself. The strategies planned after any conceivable subgame form a Nash equilibrium in themselves (Selten, 1975).

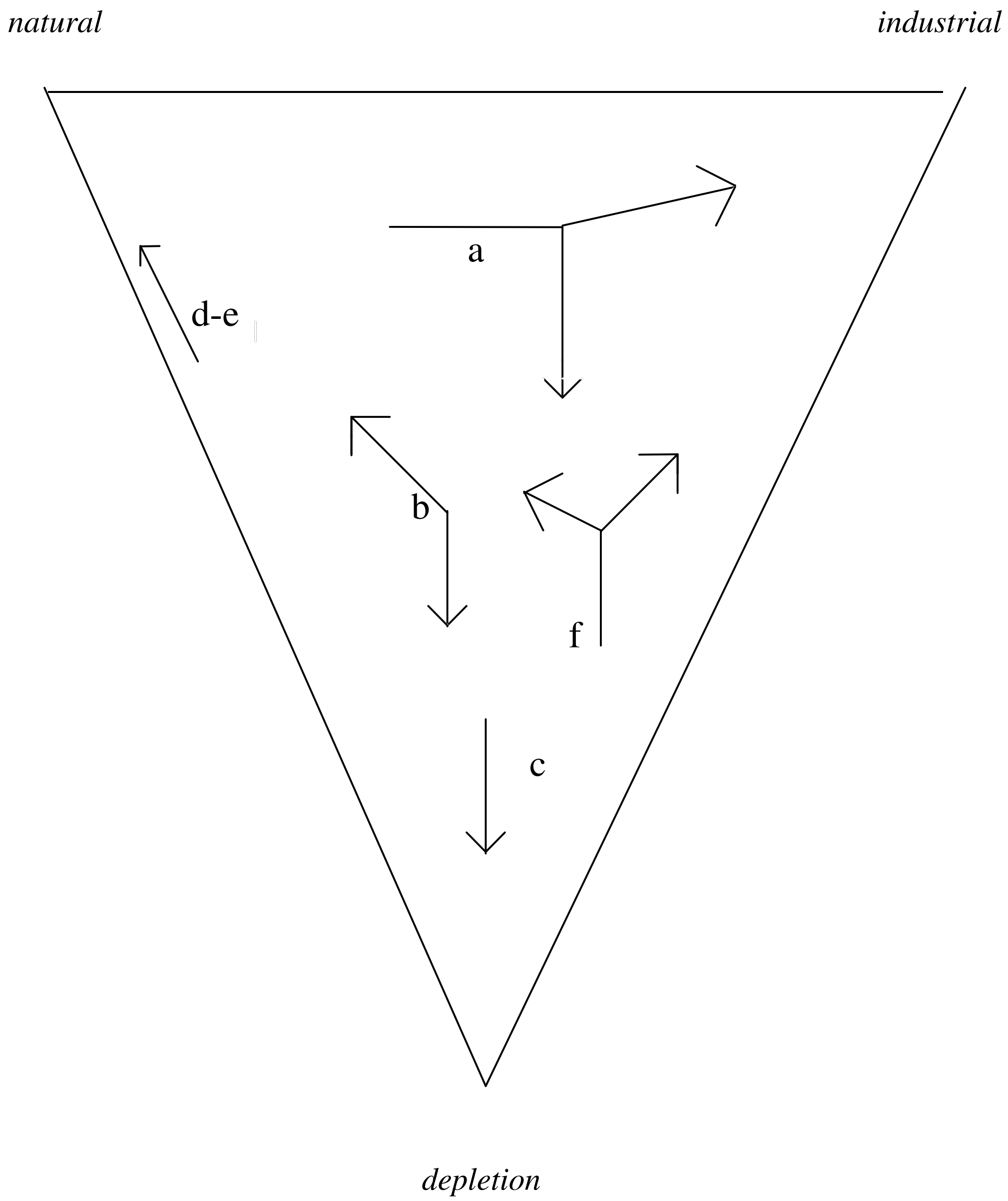
and elsewhere. To simplify, a distinction can be made between “natural” vis-à-vis “industrial” features of a forest. The former are pronounced in “preserved" forests, cherished by traditional forestry or by the creation of “protected” areas, and associated with a relatively high degree of genetic diversity. The latter follow from transformation by industrial use.[9]

It is far from evident how natural vis-à-vis industrial features of forests relate to each other, and to depletion. Does the establishment of industrial forests complement or substitute for natural forests? A relationship of substitution indicates that expansion of industrial forest, or proliferation of industrial forest features, occurs at the expense of natural forest. The link is likely to be complementary if plantations are established on previously non-forested land, which typically is not the case. However, conversion of some natural forest into industrial forest -- managed for long-term, sustainable use -- which takes the pressure off remaining natural ones, e.g., from intruders seeking accessible land or fuel, is also likely to account for a complementary relationship. The key issue in this context is what would happen in the absence of industrial expansion.

A proliferation of certain benefits, from the viewpoint of those who manage the forest, influences whether management will lean towards deforestation and/or will alter the characteristics of the forest. Distinguishing between impacts in this respect is helpful both for understanding the driving forces of deforestation and for a normative analysis, in order to ensure that policy measures are adequately tailored to their aims. Without any claims of mathematical precision or complete coverage of all possibilities, a broad categorization of likely impacts can be made using the categorization of benefits presented above. An illustration is provided in Figure 1,

[9] This represents a simplification, since some “natural” forests are characterized by little genetic richness while some “industrial” retain strong natural features. The distinction can only be argued to hold in a broad sense, and some alternative interpretations will be commented on below.

**Figure 1: Forces impacting on scope and characteristics of forest resources**




which maps impacts favoring natural features, industrial features and/or depletion in a triangular space. The points are as follows:

a) A pronunciation of the *gains from production of timber or timber products for commercial use* involves a push towards industrial forest features. While this typically counteracts natural characteristics, it cannot be said *a priori* whether it spurs or counteracts depletion.

b) More profitable *alternative use of forestry products* may push in different directions; i) Traditional use, e.g., practiced by indigenous tribes, tends to preserve natural forest and counters depletion; ii) New settlers or neighboring peoples demanding fuel, which can be reaped from the forest for free, spurs depletion.

c) A higher value of *alternative land use* for development, construction or agriculture, favors depletion.

d-e) Greater capturing of the presently non-commercial gains associated with *recreation* and *genetic diversity* typically supports natural forest features and counters depletion.

f) A proliferation of the presently *non-commercial values* associated with $CO_2$-absorption, stabilization of weather, hydrological functions, etc., counters depletion. Depending on the specific purpose, the impact may be towards industrial or natural features.

A certain pattern can be discerned. Depletion is typically driven by factors inherent to producer countries such as a higher opportunity cost for land, poverty, population pressure and failure to establish well-defined property rights. Industrial features are mainly spurred by higher commercial returns. Natural features are supported by traditional use or by internalization of presently non-commercial values. There are certain general lessons, neglected in public debate and also in academic studies, which can be drawn from this simple set-up. For example, measures supporting industrial forests should not be adopted to sustain natural forest features, unless there are complementarity between the two. Considering policy measures for countering depletion, it should be taken into account whether they reinforce natural or industrial features, since the two represent different values of the forest and relate to different stakeholders.

At the same time, a number of issues remain unresolved. Will the proliferation of commercial benefits spur depletion? Would compensation for $CO_2$-absorption favor industrial or natural features? Other questions are less explicit but equally important.

For example, does the notion that internalization of gains from biodiversity counters deforestation suggest that this is an effective means to achieve that goal? While such issues require further analysis, the following should be clear: An evaluation of how various forces and policies impact on forest management requires an understanding of how they influence the level and distribution of the costs and benefits confronting the actors who actually manage the forest.

## IV. Commercial trade issues

Depletion of tropical forests, similar to that of other natural resources, need not in itself be a problem from an economic point of view. Depletion *may* represent the socially optimal way of handling the resource over time (cf. Fisher, 1981). For example, exports of forest products may exert a positive overall impact on a country's economy even when the environment is harmed, due to the positive welfare contribution flowing from gains from trade. In principle, the higher the competitiveness of a country in timber exports and the smaller the divergence between the social and the private costs of production, the greater the potential for trade expansion to bring a net increase in world welfare despite negative environmental implications (Anderson, 1991).

A related argument is that the realization of higher incomes from trade may be anticipated to gradually raise demand for environmental values, leading to the establishment of appropriate institutions for forest management once society has reached an income level where this would represent an economically viable policy. In practice, however, this reasoning is of limited relevance. Poor people are not really different from rich people, but what differs is income and, hence, the ability to sacrifice material goods for a sound environment.[10] The poor are as unwilling as the wealthy to squander their resources. Moreover, mismanagement is commonly triggered by the breakdown of traditional institutional structures which in itself tends to widen income differences.[11]

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[10] It is generally reasonable to view tastes and preferences as similar irrespective of income (Stigler and Becker, 1977).

[11] Bengtsson (1995) shows that the problems following from the collapse of traditional collective property rights cannot simply be rectified through privatization.

In fact, we have already noted that current institutional conditions and policies cannot be presumed to reflect social values. Empirical observations and the above analysis provide ample evidence that the current degradation of tropical forests is associated with a systematic bias against long term social values, hence weakening an argument that current conditions make long term economic sense. Understanding the impacts of international trade or trade policies will to a large extent depend on how the institutional set-up, and thereby basic incentive structures, is affected (Andersson et al., 1995).

In the rest of this section, we will address four trade-related issues. The first two concern observed impacts: of the undertaking of commercial trade on forest degradation and; the corresponding impact of barriers to exports in producer countries. The third and fourth concern future-oriented policy options; would dismantling of barriers to log exports, as advocated by Vincent (1990), Braga (1992), and others, improve forest management? Second, would limitations to trade, or other consumer action in regard to commercial trade, be helpful?

### IV.A. Impacts of trade

The empirical literature has been somewhat divided on the impacts of commercial timber trade on tropical deforestation. Some have found an insignificant or relatively weak effect (Palo, Mery and Salmi, 1987). According to most recent studies, however, tropical wood exports do contribute to deforestation (Allen and Barnes, 1985; Schneider et al., 1990; Burgess 1993 and 1994). According to Barbier et al. (1994a), international trade has exerted a significant positive, although rather weak, impact on deforestation in the tropics as a whole. A 1 per cent increase in forest trade would be anticipated to increase the area cleared by 0.019 per cent.

Commercial logging has further been observed to disturb the balance of ecosystems. Although clear felling in moist forests is untypical, selective felling commonly has extensive direct as well as indirect impacts. These can be interpreted as an aspect of trade pushing industrial rather than natural features.

Regarding individual countries, a direct impact of massive log exports on deforestation has been documented in the Philippines, Nigeria and Cote d'Ivoire (Braga, 1992; Kumazaki, 1992). None of these countries have displayed high economic growth or social improvement over the observed periods, on the contrary they have all been viewed as conspicuous examples of political and economic mismanagement. In the case of Indonesia, Barbier et al. (1994a) did observe a positive relationship between international trade and deforestation, but it was unclear whether commercial production was the source of deforestation or rather the result of agricultural conversion.

On the whole, international trade does not stand out as one of the major forces causing deforestation. Still, certain substantive impacts are evident, including proliferation of industrial features as well as deforestation. The interlinkages between different forces are crucial. Logging operations have been observed to foster agricultural conversion and infrastructural investment indirectly by facilitating access to forest areas (Kummer and Turner, 1994, Barbier et al, 1994a). In the Philippines and Indonesia, the impact of trade cannot be disentangled from the short term concessions and frequent changes in domestic policy which have counteracted long term management. In the Amazon, logging industry has opened up previously inaccessible land to settlers pushed out of overpopulated regions and encouraged by land acquisition laws to clear the land of forest (Schneider et al, 1990). Relating back to Figure 1, it is clear that commercial trade can be interpreted as having pushed industrial features rather than natural ones, with a pronounced impact towards depletion when exacerbating the damage of domestic distortions.

IV.B. Barriers to exports

In many developing countries, trade in tropical timber products is circumscribed by highly interventionist policies, implemented in order to foster domestic processing industry. The major exporters of tropical timber products, Indonesia, Malaysia and Brazil, have banned log exports. By facilitating the establishment of local processing industry, these producer countries argue that export bans allow them to capture a greater share of the gains from forestry, and that incentives for long-term forestry are therefore strengthened. Other countries, such as Cote d'Ivoire, have implemented log export quotas, with the returns from the sales of these quotas being channeled into low interest loans to local processing industry (ITTO, 1990).

From a theoretical point of view, such interventionist trade policies are suboptimal for the producer country itself whether applied to support local processing industry or to address environmental externalities. A production subsidy would be a superior policy option in regard to the first objective (Braga, 1992). In regard to the second, a production tax, reducing output to the level where social cost equals marginal benefit, would be a better solution. In addition, because some of the environmental costs are borne by other countries, the optimal production tax is higher from the global perspective than from the national. By reducing domestic prices and raising production, the export restriction makes local producers more resistant to production taxes motivated by global considerations. In this way, export barriers can make it more difficult to address international environmental problems.

By discriminating in favor of local processing, export restrictions have also generated more intensive use of logs per unit of output, because of the relatively low efficiency of local processing industry. In Indonesia, this factor alone has been estimated to have resulted in an expansion of annual harvests by 10 percent (Hanna, 1991). Furthermore, while export restrictions have weakened the returns to forests by reducing stumpage values, the processing industry has done little to secure the long-term supply of raw material. The main reasons are artificially low royalties for gaining access to primary forest coupled with the establishment of a processing industry which is characterized by limited sunk costs and a high degree of conglomerate expansion. Industry has organized itself so that revenues from forestry can be extracted on a temporary basis and easily be transferred to other activities. In this case, local industry has thus reached a size and obtained an orientation which adds to the pressure on remaining forests. In fact, Table 1 indicates that the countries imposing export regulations consistently are among those which have displayed high exports along with a high rate of tropical deforestation.

Summing up, there is no evidence that export regulations would have impeded the degradation of forests. Nor have industrial plantations emerged as a viable alternative to the natural forest as a source of timber. Trade restrictions have thus spurred proliferation of industrial features as well as deforestation.

IV.C. Liberalization

Interventionist trade policies consequently do not constitute attractive means to establish local processing industry nor to address environmental problems. Does this imply that liberalizing exports can be anticipated to improve forest management?

The direct impact of trade liberalization increases the demand for forestry products. Given eroded traditional and presently weak property rights, temporary concessions, subsidies for clearing land of forest, etc., foreign demand adds to the excess demand of already established local industry without much hope of raising stumpage prices, resulting in a higher pace of forest degradation. Making log exports an option provides firms with an even stronger incentive to get hold of unprotected logs before they are reaped by others. For a favorable long-term boost to the supply of timber, liberalization would have to be accompanied by a removal of domestic institutional and policy conditions discriminating against sustainable forest management. In fact, trade liberalization strengthens the socio-economic rationale for improving the preconditions for sustainable forest management, since it increases the opportunities for social gains from such production. Liberalization also reduces the presence of rents for sheltered industries, thereby limiting the returns to well organized vested interests which may counter policy reform. Provided that comprehensive reform of this kind took place, liberalization could be expected to enhance sustainability in industrial forest use. However, whether the outcome would be less pressure towards deforestation cannot be said *a priori* , as noted in the opening remarks of this section. With respect to natural forest future, a weakening could thus be expected relative to industrial features, but it is unclear whether the impact would be towards an absolute worsening in the position of natural forest.

While liberalization should strengthen the political support for institutional reform, failure to deliver would certainly mean an escalation of the pressure for deforestation. Furthermore, it is conceivable that reform allowing any substantive boost to supply might occur only after some time. In the meantime, the impetus towards increased deforestation would particularly be associated with a deterioration in the support for natural forest features.

## IV.D. Consumer action

The second main policy issue concerns the impact of action by consumer countries to restrict tropical timber imports. Broadly speaking, one can divide consumer action into direct control or bans and consumer/trade boycotts. The former aim at reducing imports by consumer countries of timber products through quotas, tariffs or other official trade controls. So far there have been few government policy initiatives in this direction. The latter category, which aims at limiting trade generated by unsustainable production methods through "voluntary" action, is typically organized by consumers, trade organizations, regional authorities, etc. Informally this has already happened for several years, e.g., through industrial organizations denouncing imports and/or the use of tropical timber products.

Actions within either category which diminish the opportunities for exports in producer countries also weaken incentives for industrial forestry. The likely outcome is a short-term hampering of deforestation as demand for timber products declines, whereas the long-term consequences lean towards depletion since alternative use of land becomes relatively more profitable (Bourke, 1988).

To the extent that consumer action succeeds in altering the nature of forest management, on the other hand, there is a potential for reducing deforestation without limiting demand, i.e. while maintaining or even increasing the return to future supply of forestry products. This is, in effect, the aim of the suggested certification schemes, whether they target products, companies or countries. The potential impact is, however, connected to the expectation that failure to comply reduces access to markets. In contrast to an actual ban or quota, a *threat* on the part of consumer countries to implement trade barriers if sustainable forest management were *not* implemented, might spur a change in forest management, reducing deforestation and increasing future supply. Depending on the interpretation of industrial and natural features, the impact would be to strengthen the expected returns to sustainable industrial forests or to maintain natural forest features while allowing for commercial exploitation. Consumer action therefore has a potential to support industrial forestry in a way countering depletion and inducing greater complementarity between the two kinds of forest features. At the same time, a number of catches raise concerns about the usefulness of consumer action:

i) Harmonized standards as a basis for certification would be inefficient, because management practices would become less able to adapt to local conditions.

ii) It is difficult to verify and control whether forest management is implemented in a sustainable manner, which would still be the case in the presence of certification.

iii) If failure to comply with a standard means that the price of forest products will be reduced, the forests in question would become less able to compete with alternative land use, favoring deforestation.

iv) Working methods vary between producers depending on access to technology, openness of their operations, opportunity costs as well as attitudes. Certain producers are committed to sustainability today already while others are indiscriminate in their strive for short term gains. There is heterogeneity on the consumer side as well. Certain consumers shun goods produced in an unsustainable manner while others do not care, ruling out that any certification scheme could penetrate more than parts of the market.

v) For a threat of implementing trade barriers to exert an impact, it must be credible in the first place. This requires the presence of viable punitive measures, so that trade can be reduced if requirements are not complied with. Particularly in the case of threatened import bans, the requirement of subgame perfectedness raises question marks concerning credibility. From the view point of consumer countries collectively, it would not be desirable to have such a threat being carried out, since the result would be even weaker incentives for sustainable forest management in producer countries.

The first of these arguments should be of limited importance, since certification can be designed so as to allow for satisfactory flexibility in working methods. While the second, third and fourth counter-arguments may be more valid, they also have implications primarily for the way in which schemes are designed. The crucial role of certification is not to identify and punish those who fail to comply, but to create incentives for altering behavior, and to induce changes on the part of public authorities who formulate playing rules. For certification to be useful, it should thus target policy instruments as well as producers or products.

What about the fifth counter-argument? With consumer countries unwilling to lower the value of forest products, producers do not have to worry about the consequences of neglecting to comply with demands for sustainability. However, this is not equivalent to arguing that certification schemes or threats to impose trade measures would fail to exert an impact on management. This is because a situation in which threats are levied is costly in ways other than the mere risk of punitive action.

In this context, it is interesting to note that a certain shift has occurred in the attitudes of developing countries in regard to linking environment and trade in general, and to certification in particular. The former has shown up in the form of trade and environment becoming an accepted item on the agenda of the World Trade Organization (WTO). Regarding the latter, Malaysia - one of the most important trend-setters in the developing world when it comes to natural resource management - has moved from a completely defiant stance in the early 1990s to a cautiously favorable position. There are various possible interpretations of why this has occurred. One would be that certification has come to be viewed as an instrument to facilitate production, exports and price differentiation rather than as an impediment to trade. Another would be that certification schemes are expected to be less damaging for producer countries if they go along with them. This is because agreeing to certification may create goodwill without any real "cost", because it is difficult within a certification scheme to control and follow-up on failure to comply with stipulated standards. Defiance, on the other hand, could be interpreted as a signal of unsustainable policies and practices, and be used as a scapegoat by political interests in consumer countries acting to protect their own privileges.

Irrespective of which interpretation is most correct, the fact is that support for certification schemes is gaining ground. If such schemes are not to become meaningless, they must carry some credibility. With more and more countries and producers accepting, no matter how reluctantly, that consumers are entitled to information about products and processes, the message is radiated to the market place and to policy makers alike that conditions discriminating against sustainability are untenable. This being said, it should be made clear that issuing “threats” of various kinds is no solution: threats may be intimidating, counterproductive and give rise to retaliatory action. They are also likely to be abused by well-organized political interests (Hillman and Ursprung, 1992). The idea of linking environmental policy and the multilateral framework for international trade has gained wide support partly because of the realization that action in this area needs to be contained in an orderly structure (Andersson et al., 1995). In the present context, the key point is different -- the fear that unsustainable forest management will worsen the preconditions for trade may boost support within producer countries for rectifying the underlying distortions.

On balance, it appears that certification schemes and appropriate consumer “threats” do have a potential for narrowing the gap between social and private returns in forest management over the coming years. This should counteract degradation, and also support natural forest features to the extent that this is targeted. Given the practical difficulties, however, it is hardly realistic to anticipate that consumer action would bring about any substantial increase in forest prices or trigger any major overhaul of institutional conditions in producer countries. It is thus unlikely that policy options associated with international commercial trade alone represent the panacea to current deforestation problems. A search for a viable solution must include presently non-commercial values.

## V. Other trade-related issues

In the preceding section, we have mainly been concerned with impacts of international trade belonging to the a) category of costs and benefits presented in Section III. As already discussed at length, there are also other, presently non-commercial, values which tend not to be taken into account. Their presence makes it highly likely that the observed deforestation is socially undesirable.

Two categories of non-commercial values stand out as particularly important. First, the tropical forests possess a stock of genetic information which is "valuable" in a number of respects, e.g., because of the availability of options for the development of new products in the form of food or medicines.[12] Second, the reduced absorption or storage of $CO_2$ by the tropical forests coupled with increased emissions from developed and developing countries is increasingly predicted to bring global warming and a general destabilization of the climate.

In both these areas, countries hosting tropical forests have difficulties to capture the benefits which are perceived to pertain to them, while the costs of their degradation are borne by more or less all countries. Trade-related exchange is likely to be necessary for any possible alteration of this situation. In the following, we briefly examine implications for trade-related policy in these two areas.

### V.A. Biological diversity

The biological diversity of tropical forests is known to be greater than that of any other habitat on earth. Its properties have been refined through millions of years of evolution. Genetic diversity possesses an insurance function, due to the "portfolio effect" (Swanson, 1991). With returns subject to variance, risks diminish the greater the number of assets with uncorrelated returns which are part of the portfolio. A reduction of genetic diversity increases risks for, and the costs of, damage by insects, changes in climate, etc. However, it is clear that such depletion can be

[12] This is not to say that estimates of commercial output, or approximations of peoples' willingness to pay, represent an adequate measurement of such values. Shortcomings in regard to conservation have already been pointed out above. It may also be noted that the appreciation of ecological services is highly sensitive to what information is available. The evaluation of irreversible destruction of unique resources poses special problems, see Perrings et al. (1994).

driven by economic gains to specialization. The most dramatic reductions in genetic diversity have occurred in industrial agriculture. [13]

The value of genetic diversity is very much influenced by which technology and other resources are used to exploit it. Gains have been captured for a long time through traditional forestry, with entire cultures living with and by the forest in a sustainable manner. As these cultures disappear, the technologies used to extract those gains tend to be lost as well. At the same time, naturally available genetic information is known to represent large commercial values. To give one example, 4.5 per cent of the United States GDP has been estimated to belong in this category, with the returns to such medicines worth 40 billion dollars per year (UNEP, 1992).

Advances in biotechnology are widely anticipated to greatly enhance the potential commercial value of genetic diversity. Benefits of that kind cannot be taken for granted. It is conceivable that the marginal value to additional species may decrease, or that biotechnology may substitute for natural supply of genetic information. The advancement of combinatorial chemistry provides tools to generate and screen "synthetic" biodiversity, which has been observed to reduce industry's interest in natural product screening. Still, nature possesses a wealth of valuable and complex molecules which are unlikely ever to be discovered by synthesis at random. Natural isolates can commonly serve as a successful starting point for semi-synthetics. There thus seem to be demand for both natural screening and combinatorial synthetic approaches of exploring variations (Cantley, 1996). What combination of the two prevails will influence the commercial value of natural biodiversity. It is a peculiar and troublesome fact that the massive biological diversity of tropical forests is now being destroyed before any reasonable estimates of their potential commercial value can be made.

Realizing commercial gains requires access to technological and financial means. Notwithstanding the internationalization of financial markets, capital remains a critical restriction in especially the poorest developing countries. High indebtedness and the presence of sovereign risk on the part of a nation state raise real interest rates

[13] In the United States, for example, 95 percent of cabbage, 91 percent of field maize, 94 percent of pea, 86 percent of apple and 81 per cent of tomato varieties cultivated in the last century have today

and shorten time horizons. This discriminates against the long-term benefits that could potentially flow to the world community from biological diversity. Even more importantly, access to capital is impeded by the disadvantages suffered by developing countries relative to industrialized countries in their capacity to absorb and exploit technology needed for capturing commercial benefits.

Given the technological edge of industrialized countries, developing countries need to invest heavily if they are to catch up. In private firms, intangible investment must commonly rely on ”own” financing since creditors have difficulties appreciating their usefulness and the ability of the agents. A country may similarly have to rely extensively on public investment to reach the critical mass of resources and expertise which would make it possible to attract foreign technology and capital. Countries at the lower income levels are likely to find themselves in a vicious circle where forest depletion appears as one of the few means to obtain the resources without which commercial benefits cannot be captured from biological diversity. A development-path enabling exploitation of gains from biological diversity may simply not be attainable.

Under such circumstances, the preconditions for mutually beneficial cooperation or joint ventures between the supplier of genetic material and the supplier of the science and technology which can add value to it is crucial for the incentives of producing countries to maintain biological diversity.[14] This, in turn, is strongly influenced by the international playing rules which pertain to exploitation of genetic information (OECD, 1996b). This issue was addressed by the Convention on Biological Diversity, signed in Rio de Janeiro in June 5th 1992. The convention replaced the former principle of genetic resources as a freely accessible public good with the sovereign right of states over their natural heritage, including the authority to use national legislation to determine access to genetic information. A country providing genetic resources is thus, in principle, entitled to compensation for their commercial use. The sharing of benefits is to be based on mutually agreed terms.[15]

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been lost (FAO, 1996).

[14] Moves towards synthetic biodiversity can be observed in many fields, e.g. in pharmaceuticals.

[15] Articles 6 and 7 of the Treaty.

In April 1994, the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) was signed in Marrakesh.[16] The treaty stipulates the obligation of all members of the World Trade Organization to provide patents for both product and process innovations. Under Article 27 (3) (b), plants, animals, other micro-organisms and biological processes for the production of plants or animals can be excluded from patentability. Although genetic resources are not thereby automatically placed outside patentability, concerns have been raised that this articulation of the trade-related international regime of intellectual property protection deprives countries with limited financial means from access to technologies in this area.

Some developing countries have seen the prevailing situation as the result of developed countries' superior bargaining power. At the same time, it is clear that securing intellectual property to naturally available genetic resources would counteract the principle that what is public domain cannot be privatized (OECD, 1996a). It is interesting to note that more developed or scientifically advanced developing countries, such as Singapore and China, are currently hurrying to establish institutional structures which allow them to effectively trade with developed countries on the basis of the new regulatory frameworks for intellectual property rights. However, India and the Latin American countries in particular instead emphasize the Convention on Biological Diversity, claiming compensation for the availability of genetic resources irrespective of commercial trade.

While more advanced developing countries may have acceptable prospects in this respect, the fact remains that less developed countries have little hope of capturing any major commercial gains from maintaining biological diversity. For the latter, biological diversity provides little or no economic incentive to conserve tropical forests. At present, transfers of technology occur on a small scale and on an ad hoc basis through joint ventures, disclosure of selected R&D results, and concessionary technical cooperation or training programmes. There is thus a strong case for "consumer" countries to seek ways of expanding technology transfers and improving their quality, going beyond what occurs spontaneously in connection to

[16] The protection of intellectual property rights represents one of the three pillars of theWTO, with the others being trade in goods and the new agreement on trade in services.

commercial trade but in a way which is relevant for developing countries' ability to obtain greater commercial gains from biological diversity.

V.B. $CO_2$-absorption

Mounting scientific evidence suggests that emissions of greenhouse gases, particularly $CO_2$, coupled with reduced absorption due to deforestation, increase the risk for a rise in the earth's temperature and a general destabilization of weather conditions. Table 2 reports estimates of the human contributions, by countries/regions, in terms of major sources to the greenhouse effect calculated as "equivalent tons of $CO_2$". The dominating influence of carbon dioxide is underscored by the fact that fossil fuel emissions, as well as deforestation, are expected to continue to grow over coming decades. The single most important other source, CFCs, has been subject to reductions following the Montreal Protocol.[17] As can be further seen from the table, industrialized countries account for the bulk of emissions, although the relative importance of a country such as China has increased in the 1990s. The largest contributions of developing countries still emanate from deforestation. The total $CO_2$-contributions of land use have been estimated in the range between 30 and 40 percent of those from burning of fossil fuels, with Brazil accounting for some 40 percent of land use contributions.

The extent to which global temperatures will increase is still highly uncertain, as are the consequences for specific regions. The social costs inflicted on individual countries, or on humankind as a whole, are even more difficult to predict. Nordhaus (1992) estimated that the costs of anticipated temperature increases may amount to 1 per cent of world GDP, with an upper limit of 2 per cent. There still appears to be a risk of substantially higher figures, however, e.g., due to uncertainty regarding dynamic effects such as those related to climatic surprises or the resilience of ecosystems and the associated difficulties in accounting for risk aversion, question marks regarding how to apply discounting in the context of ecological conservation, and problems of extrapolating effects from industrialized to developing countries.

[17] For simplicity, the following discussion leaves out other contributions to global warming than $CO_2$.

**Table 2: Regional and National Contributions to Greenhouse Warming***

| Country | Emissions | | | Land | Total |
|---|---|---|---|---|---|
| | Fossil | Methane | CFC | | Use Fuel |
| Europe | 0.52 | 0.08 | 0.48 | - | 1.10 |
| US | 0.53 | 0.13 | 0.35 | 0.03 | 1.01 |
| USSR | 0.45 | 0.06 | 0.18 | - | 0.69 |
| Brazil | 0.02 | 0.03 | 0.02 | 0.54 | 0.61 |
| China | 0.26 | 0.09 | 0.03 | - | 0.38 |
| World | 2.50 | 0.80 | 1.40 | 1.20 | 5.90 |

* Each entry is reported as $CO_2$ equivalent from different sources

*SOURCE:* WRI (1990)

The consequences of a mere 2 degree rise in average temperatures on earth may involve entire countries being immersed in sea water, others being frequently hit by floods, increased storm damage, changes in precipitation causing major agricultural regions to become sterile, the overturning of prevailing patterns of vegetation, the destruction of existing ecosystems, etc. In the face of even greater increases in temperature, it may become necessary to adopt measures to reduce human contributions to global warming. Action forced through at a later stage is likely to be far more expensive than if precautionary steps had been taken earlier, because greater cuts will be needed more quickly, leaving less time for research into alternative solutions.

Most calls for action against rising levels of $CO_2$ in the atmosphere have focused on the need to reduce emissions from burning of fossil fuel through, e.g., carbon taxes. The social costs of modest taxes, in the range of 5 dollars per ton emitted, have been estimated to be low. However, stabilizing carbon consumption at 1988 levels in a country like the United States would require taxes of about 100 dollars per ton. The macroeconomic effects, exacerbated by sluggish adjustment of wages and prices, would probably inflict substantial costs on society (Poterba, 1991). These have been estimated at 1-3 percent of GDP, although the design and timing of measures will substantially influence the exact magnitude (Manne and Richards, 1990; Jorgenson and Wilcoxen, 1992). It is further clear that policies seeking to reduce emissions in individual countries on a unilateral basis are insufficient, and may even be counterproductive. Regulations or taxes unilaterally imposed will result in weakened competitiveness relative to other countries and, if sufficiently extensive, may lead to a relocation of industry and an increase in total emissions (Hoel, 1989).

In the face of mounting scientific evidence of severe risks from rising $CO_2$ levels it must be questioned for how long it is reasonable to postpone precautionary action. For measures to be effective, i.e., to lead to a first best optimal solution from the global perspective, marginal abatement costs must be equalized across countries (Bohm, 1993). Difficult political and ethical problems arise, however. For example, industrialized countries have been responsible for most of the rise in emissions which has taken place so far, and they also have a much greater ability to pay for reduced emissions than do developing countries. According to the OECD (1993), any realistic scheme to reduce $CO_2$-emissions requires that OECD countries move ahead first, e.g., by introducing emission taxes. At the same time, costs are higher and results in the form of reduced emissions increasingly meager, the fewer the number and the smaller the size of those economies which introduce taxes when others do not. So far, two countries -- Sweden and the Netherlands -- have introduced modest taxes unilaterally -- but no binding, international agreement to take collective, coordinated action is in sight.

One proposed way forward is to introduce a market for tradable carbon emission rights (or permits). This has been suggested particularly by the United States, while the European countries, e.g., at the Earth Summit in June 1997, have tended to favor other means to reduce emissions. Although the European countries now appear much more inclined than the United States to establish far-reaching and mandatory targets for reductions, their proposals are currently met with resistance. It remains crucial that $CO_2$ reductions be undertaken in an efficient way. A scheme for tradable carbon emission rights would favor equalization of marginal abatement costs across countries, hence supporting cost-efficiency. The number or scope of issued rights could be adjusted in line with changes in the perceived risk of costly climatic change, and allow for gradually increasing cuts in emissions, spurring technical progress and thus dampening private and social costs during the transition. Furthermore, the initial division of rights between countries could be arranged, or negotiated, in such a way as to address problems of equity and politics. Kverndokk (1991), among others, has calculated the consequences of various possible allocations of tradable permits between different kinds of countries.

A search for the most efficient way to address the global carbon balance should not neglect the removal of carbon from the atmosphere, however. Halting deforestation in the tropics, replanting or planting new forest, is known to represent by far the most cost-effective instrument to achieve that end. Available estimates indicate that the cost of removing a ton of carbon by saving tropical forest amounts to only about one-tenth of reducing emissions from burning of fossil fuel. Just as the marginal cost of pollution abatement should be equated across countries, efficiency in principle requires an equally large subsidy for removal of carbon from the atmosphere. Even a scheme only narrowing the gap in marginal abatement costs on the emission and absorption sides would have a potential for great efficiency gains compared to a scheme limited to only one of the two sides.

Progress in this respect could be achieved through a market for tradable carbon rights encompassing both payments for emissions and compensation for absorption of $CO_2$. This should ideally be arranged so that countries with tropical forests would both gain from maintaining them, pay for diminished absorption and obtain additional compensation for increased absorption. The scheme would be self-financed (with emissions financing increased absorption), the geographical, political and institutional distance between the main different contributors to global warming would be overcome, and there would be reduced costs for reaching any given abatement target in atmospheric $CO_2$.

At the same time, the implementation of such a scheme raises a number of questions. Some are of an equity/political nature while others are economic. Agreeing on the initial distribution of both entitlements to compensation for absorption and emission rights is likely to be more complicated compared to a scheme where only the latter is an issue. The greater the number of sources and sinks of $CO_2$ that are included in a market, the greater the potential efficiency gains but the greater the problems and costs of monitoring.[18] The rules governing the scheme may thus have to be considerably adjusted, which could have negative consequences for transaction costs (cf. Foster and Hahn, 1995). On the other hand, inclusion of the absorption side would account for more multiple and diverse participants, in principle making the market less susceptible to substantial market power by individual players (cf. Westskog, 1996).

A set of related questions, which are particularly relevant in the context of the present paper, is whether compensation for $CO_2$-absorption, e.g., through a market in tradable carbon rights, represents a viable strategy for narrowing the gap between social and private returns to forest management. In this respect, *moral hazard* represents a possible stumbling block. If governments/private actors view tropical forests as bargaining chips for obtaining monetary payments from industrialized countries -- financed within a market for trade in carbon, by taxes on $CO_2$-emissions or in other ways -- this might have unwanted effects. Given the difficulty to control forest management, it may be tempting for producer countries/actors to obtain funding for planting trees, and to then have them cut down while obtaining compensation for new ones.

Furthermore, we have seen that producer countries lack technological capabilities needed to exploit social gains accruing to biological diversity, biasing against natural forest features, while pursuing policies, in the areas of trade, taxation, property rights and others, which discriminate against sustainable forest management. Payments for $CO_2$-absorption would thus partially compensate for the reduction of stumpage values caused by trade barriers which serve to subsidize processing industry, in turn creating excess industrial demand for timber. Governments or individual forest owners considering whether to preserve genetic

[18] This may result in trade with $CO_2$-units without compensating reductions in emissions or absorption being made (UNCTAD, 1994). Under conditions of weak monitoring and enforcement, international inter-firm trading in emission-rights could even lead to increased emissions (OECD, 1992).

diversity rather than reshaping forests for industrial purposes would be biased in favor of the latter alternative.

On this basis, a possible scheme compensating producer countries for absorption of $CO_2$ should strive for the following:

i) *Verifiability;* Payments would have to be connected to an easily verifiable variable, such as the surface of land covered by forest as observed by satellite pictures.

ii) A manageable *scope*; This may require that payments and liabilities are eligible only above certain "floors" of emission/absorption. What must be secured is the ability of the scheme to punish and reward *changes* in emissions and absorption, not the transferring of resources per se.

iii) *Adequate timing, flexibility* and *predictability*; What matters is lasting rather than temporary reductions. Thus, a scheme should compensate for absorption at a sufficiently late point in time, making it easier for an outcome to be viewed as proven. This implies that it may be desirable to have the two sides of a carbon market function differently; emission rights may be issued/taxed continuously, while absorption would be compensated for in retrospect. Thus, in practice, it is probably unrealistic to strive for complete equalization of the marginal payment/compensation on the emission and absorption sides. Meanwhile, at both ends, an effective scheme must be able to balance between an element of *flexibility*, so that targets for reduction of atmospheric $CO_2$ can be adjusted when needed, and *stability* so that uncertainty can be minimized for participants. At least, it should be understood what is to determine the path of the scheme over time, so that well-founded expectations can be formed about the long-term payoff to alternative investments.

iv) *Institutional linkage*; An absorption scheme could help to correct, or diminish, distortions spurring deforestation, including those which are generated by specific institutional structures. Again, governments trigger deforestation through commercial trade policies, taxes, and land acquisition laws. Implementation of a scheme for compensation of absorption would in itself represent a bargaining chip that could be consciously used to catalyze change in such policies. In addition, the returns to forestry that would result from implementation itself would make the costs of such distortions more visible, thereby building up pressure on dismantling them. Finally, a scheme could be linked to improved mechanisms for transferring of technology and know-how in naturally friendly forestry and in management of natural parks, so as to reduce the present bias against natural forest features.

The prospects for adherence to these principles, and to the effective inclusion of the absorption side in a market for trade in $CO_2$, need careful consideration. Problems in design and implementation could hamper the functioning of the market to the extent that less favorable outcomes were obtained in regard to global warming. Adverse effects could be mitigated by less than equal compensation for absorption of a ton of $CO_2$ compared to the equivalent reduction in emissions, through separate trading arrangements for the two sides allowing for neutralization of the differences in conditions for monitoring and enforcement, or for a sequential strategy that introduced market mechanisms at slower pace on the absorption side. Again, while the problems in compensation for absorption must not be underestimated, a market for trade in carbon which is limited to the emission side is bound to be grossly inefficient. Nevertheless, a scheme incorporating compensation for absorption would have to be introduced in a way that, on balance, enabled a better outcome than if only the emission-side was included.

Beyond this, introducing a market which includes compensation for absorption of $CO_2$ on terms which stimulate desirable institutional change, is likely to be the most feasible and operational way to narrow the gap between social and private returns in the management of tropical forests. To the extent that global insurance payments in regard to global warming could trigger the correction of detrimental institutional conditions, this would in itself make the market more able to reward the long-term use of tropical forests. In case, down the road, global warming would turn out not to be a threat it would be possible to dismantle such a scheme and yet having invested the funds well in regard to the welfare of present and future generations.

## VI. Concluding remarks

This study has emphasized that forest management can only be understood in the light of the incentive structures confronting the relevant economic actors, the behavior of which is interdependent. International trade is not the main cause of tropical deforestation, whose prime sources must rather be sought in lack of adequate property rights, taxation and land acquisition laws in producer countries. While terms discriminating against the long-term values of forest management have been instituted less to foster social and economic development than to favor influential interest groups, policy decisions are also shaped by the economic options confronting countries, in turn closely related to international trade.

The study has distinguished between different values pertaining to forests and between the proliferation of alternative features of forests. Industrial features are spurred by commercial returns. Natural features are supported by traditional use or by the internalization of presently non-commercial values, such as those pertaining to biological diversity. In line with the mainstream literature, it has been concluded that international trade has contributed to tropical deforestation, directly as well as indirectly, but that interventionist trade policies, typically in the form of bans on exports of logs, have added to the problems by triggering excessive establishment of processing industry. Liberalizing exports under present conditions strengthens the incentives for institutional reform but favors industrial forest features, and will also lead to increased deforestation to the extent that such reform does not materialize. Foreign demand then adds to current excess demand while domestic distortions prevent increased supply. Consumer-related policy action, such as certification schemes, has a potential for inducing reform that favor complementarity between industrial and natural features, but also meets with practical difficulties.

A socially optimal management of tropical forests requires that values in presently non-commercial areas be taken into account. To what extent the potential gains from biological diversity can be exploited hinges on access to technology. The recent strengthening of intellectual property rights will allow only the most advanced producer countries to obtain any major share of the potential gains. Compensation for absorption of $CO_2$ thus stands out as the most operational way to narrow the gap between private and social gains, provided that the risks of global warming become viewed as sufficiently costly for countries to agree to the implementation of an international scheme. Equating the marginal costs of reduced emissions with the marginal costs of increased absorption, e.g., in a market for trade in emission and absorption of carbon, has major advantages in terms of efficiency. On the other hand, such a scheme would give rise to practical problems, including moral hazard. In addition, other policy and market failures would continue to provide a bias towards industrial rather than natural forest features. A scheme compensating for absorption of $CO_2$ would thus have to encompass verifiability, have a limited scope, appropriate timing of payments, and should be designed so as to impact on institutional structures. It could thus be used as an instrument to induce correction of prevailing policy failures, and market failures outside the area of $CO_2$-absorption, which currently trigger deforestation.

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