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INTERNATIONAL SUPPORT FOR BRAZILIAN FORESTS? An Evaluation of Project "Floram"

by

Thomas Andersson

Preliminary version. All comments are welcome.

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Postadress
Box 5501
114 85 Stockholm

Gatuadress
Industrihuset
Storgatan 19

Telefon
08-783 80 00
Telefax
08-661 79 69

Bankgiro
446-9995

Postgiro
19 15 92-5

11.89 10.000

International Support for Brazilian Forests?

An Evaluation of Project "Floram"

Thomas Andersson

The Industrial Institute for Economic and Social Research, Box 5501, 114 85 Stockholm, Sweden

Abstract

The emission of "greenhouse" gases and the deforestation of developing countries constitute inter-related international problems. Tentative calculations suggest that Floram, a currently planned program for extensive plantations in Brazil, has a potential for significant positive effects on the world as a whole. Plantations occur spontaneously today, but Floram does not pay for private firms, given policy distortions and the high rate of discount in Brazil. Ecologically and socially oriented investments which would account for long-term benefits, including most global benefits, do not pay fully from the socio-economic perspective of Brazil. Support from the international community is necessary to ensure that Floram is designed in a way which is sound from the global perspective, and could also help to trigger the policy corrections which are needed to curb the destruction of the Amazon.

International Support for Brazilian Forests?
An Evaluation of Project "Floram"[1]

1. Introduction

Human activities are exerting a major pressure on the global environment. The emission of "greenhouse" gases, mainly carbon dioxide (CO_2), methane and chlorofluorocarbons (CFCs), is one example. The effects are uncertain, but many scientists warn that global warming, a rising sea level and a general destabilization of climate are on the way (Bolin et al., 1986). Fossil fuels is the primary source of human emissions, but the burning of tropical forests may account for more than one fourth. Apart from their great importance to the global water cycles and climatic stability, the tropical forests are the earth's main genetic reservoir. The 'Brundtland Report' (WCED, 1987) states that " ...the mature tropical forests that still exist cover only 900 million hectares, out of the 1.5 - 1.6 billion that once stood."

Although forests represent great assets to the countries in which they are located, many of the benefits accrue to other countries. As pointed out by Ward and Dubos (1972) and Dasgupta (1976), the uncoordinated behaviour of individual nations with respect to common resources may result in global irrationality. A discrepancy arises between what is optimal from the viewpoint of each country and what is best collectively. Hoel (1989) shows that a country's unilateral reduction of globally harmful pollution may lead to higher total emissions, since other countries may find it desirable to pollute more as a direct consequence. In the same vein, reduced emissions of CO_2 should be synchronized between countries to dampen the administrative difficulties and distortional costs (Bohm, 1991; Poterba, 1991). Multilateral actions are discussed in, e.g., the Inter-governmental Panel on Climate Change, but the results are meager so far. Thus, an increasing number

1 The author is grateful to Jacques Marcovitch, director of Instituto De Estudos Avancados, Universidade de Sao Paulo, for kindly inviting me to study Floram. Thanks are also due to Mauro Victor, Instituto Florestal, Sao Paulo, for his insightful comments. Financial support from the Swedish Research Council for the Humanities and Social Sciences is gratefully acknowledged.

of countries are considering policies to reduce their carbon dioxide emissions unilaterally. Meanwhile, there is a growing pressure on the developing countries to halt their deforestation. Some developed countries have imposed restrictions on tropical timber imports. Soybeans and beef, whose production may involve deforestation, are beginning to be resisted.

In this situation, private and public interests in Brazil are considering a major plantation program for the purpose of combining economic development and environmental management. The project, labeled *Floram*, would put an additional 20 million hectares under forestry cover. If rightly managed, the result would be a considerable absorption of CO_2 from the atmosphere. It is also suggested that the program could help to check the deforestation of the Amazon, further dampening the emissions of CO_2 and preserving biological diversity. For these effects to emanate, the plantations must be coupled with extensive investments in research, education, social reforms, etc. As tax and property laws are major factors spurring deforestation, there must also be a substantial revision of present policies if deforestation is to be halted.

As Floram should benefit not only Brazil itself, we must consider under what circumstances the project is economically viable for Brazil, and/or for the world. This paper considers an evaluation of Floram, but it does not lay out a detailed social cost-benefit analysis. The focus is on contrasting the outcome of a social valuation on the national as compared to the international level. Thus, special attention is paid to the design of Floram under different circumstances, which will influence the distribution of costs and benefits. The purpose is to clarify the major consequences of support, or lack of support, by the international community.

Section II presents Floram. A tentative financial analysis of the project is discussed in Section III. Section IV considers the socio-economic consequences for Brazil as a country. This is in Section V expanded to a socio-economic analysis in global terms. Section VI concludes.

II. Project Floram

At the Conference on Climate and Development in Hamburg, Germany, in 1988, Professor Wilfried Bach from Munster University suggested that Brazil with its large territory and favourable conditions for forestry, should promote a major reforestation project. This could fix a great deal of carbon dioxide in phytomass, and thereby moderate

the greenhouse effect. Following the proposal, various private as well as public Brazilian institutions under the guidance of the Instituto De Estudos Avancados, Universidade de Sao Paulo, are now considering a program named *Floram*. The aim is to plant 20 million hectares of forest in 20 years. Three basic types of reforestation are envisaged:

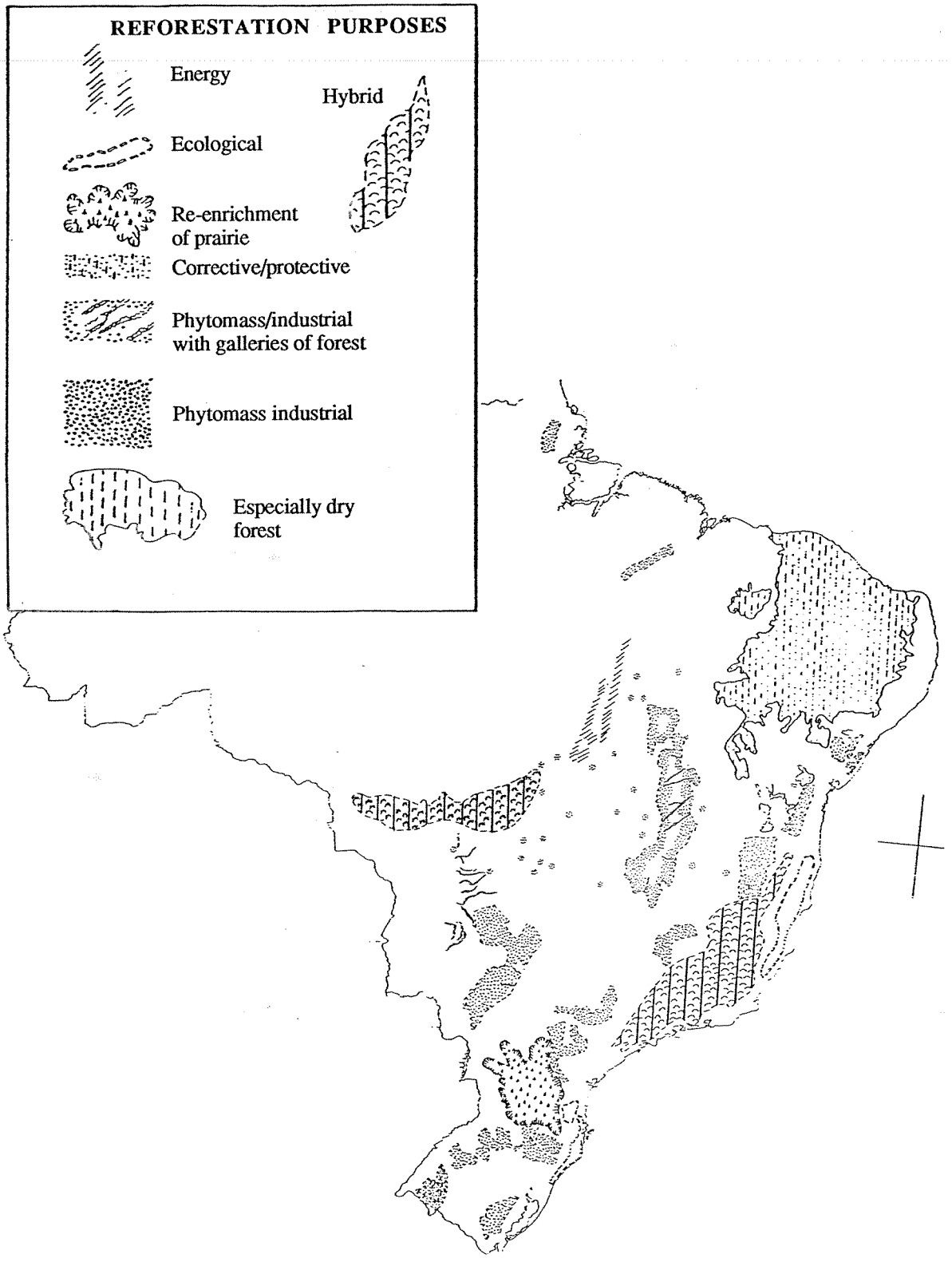
- ecological - for reconstruction of areas of ecological and landscape interest and for the protection of headwaters and springs (about 15 per cent),
- economic - for industrial exploration, but also addressing problems such as desertification and erosion (70 per cent), and
- hybrid - where both objectives are mixed (15 per cent).

Figure 1 shows what areas are planned for the project. The design will differ substantially between sites due to the geographical heterogeneity of the Brazilian landscape as well as of the economy. The project concerns the non-Amazonic regions, but the plan is to exert a favourable impact on the native forests of Brazil as well. Floram deals with areas with fairly undeveloped agricultural activities, where forestry is expected to improve the socio-economic conditions. Some of the land is presently owned by the government, and can readily be made available. Other areas are privately owned, which may cause problems. The goal is to engage private land owners and make them committed to the project. Still, purchasing of land will be necessary to some extent, which will take time and require a good deal of flexibility not to fuel local resistance.

Throughout, however, plantation is planned to go hand in hand with extensive involvement of the local population through general education, special training, free distribution of seeds, etc. Research programs are to develop techniques for sound forest management as well as integrated activities, such as agro-forestry. Furthermore, institutions are to be created which spread information and skills how to manage these techniques. In between industrial plantations and around water sites, ecological and hybrid forests are planned to protect the local environment. Ecological parks are to be created and existing ones to be expanded or restored. One example of the latter is the Central State Park in the neighborhood of Sao Paulo, which currently offers recreation to 1.5 million visitors each year as well as basic information about what is left of the Atlantic native forests.

Brazil has already lost most of its coastal rain forests, which originally covered some 20 million hectares. The Amazon, however, represents the largest rain forest in the

FIGURE 1: Areas planned for Floram



Source: Estudos Avacados (1990).

world. It constitutes 20 per cent of the world's tropical forests, and 80 per cent of the Brazilian forest. According to recent estimates, some 8.5 per cent of the Amazon region within Brazil has been deforested as of today (Reis, 1991). By planting in the non-Amazonic region, it is envisaged there will be a strategic protection of the Amazon itself. The plan is that there would be less demand for logging in the Amazon, the provision of new employment opportunities in other areas of the country would reduce the excess supply of labour, and the attitudes to forestry would be affected. I will return to these and other arguments below.

Over the years, about 6 million hectares of forest have been spontaneously planted in Brazil. This has largely been spurred by government tax subsidies which were established in 1966, but which have gradually been scaled down since then. As of today, Floram exists only on paper. Still, the plans for the project are already reported to have had some notable effects on forestry activities, resulting in new plantations which may not have come about otherwise.

In the following sections I discuss various evaluations of the project. It should be emphasized that the presentation builds on rough estimates. A comprehensive study of the economics of Floram will require further work. Still, the results presented here lend themselves to certain clear-cut conclusions which are unlikely to be reversed by more detailed studies.

III. Financial evaluation

The present study of Floram starts with the financial case, i.e. the costs and benefits which confront private actors in Brazil. Even from this perspective, there are many potential benefits pertaining to forests. Commonly, eucalyptus or pine is planted and harvested after about 6 years for industrial purposes. This has occurred since the late 1960s, when small landowners and large industries alike became eligible to reduce their income taxes through plantations. However, the plantations spurred by these incentives were not always well managed, and such subsidization is generally gone by now.

In the current situation, market prices render an approximate return from logging of 1800 USD (all values are given in 1991 prices) per hectare in Brazil. This figure stems from a forest growth of 50 square meters per hectare per year, and a price of 6 USD per square meter. The cost of plantation, maintenance and protection, on the other hand,

amounts to some 500 USD per hectare under favourable circumstances. While the benefits accrue after about 6 years, most of the cost is spent in the first year. Both the costs and benefits differ substantially between regions, and there are areas where the costs will be considerably higher. Depending on the soil and the climate, it may be optimal to cut the forest after 7 or 8 years. Figure 2 illustrates the costs and benefits of what is viewed as a rough average for the industrial forests.

After trees are planted, the second year requires special maintenance. What costs are required in this and the following years partly depend on the social pressure, i.e. how much protection is required to prevent people from moving in and burning or removing the forest. After harvesting in year 6, the land will be cleared for new forest. A new cycle, similar to the first one, is then started. Obviously, the rate of discount is crucial for the profitability of plantations. Like many developing countries, Brazil is heavily indebted and rationed in the international capital markets. As will be discussed, this accounts for a scarcity of capital and an upgraded discount rate. The capital markets of Brazil are fragmented, and rates of 30 per cent or more are applicable in many instances. Hardly any plantations are profitable in themselves under such circumstances. With a return of 1800 USD per hectare after six years and a discount rate of 20 per cent, a project would pay only if the costs discounted to the first year were below 470 USD. The project depicted in Figure 2 requires a discount rate below 15 per cent to be profitable.

This calculation is relevant only for current land owners, as others must also include the cost of purchasing land. Another even more important factor is the subsidization of agriculture in Brazil's income tax laws. Through various provisions, agriculture is virtually exempt from taxation.[2] For these reasons, and also because wood is priced at a low level compared to processed products, plantations pay only as integrated activities in Brazil. The major industrial benefits from replacing native forests with planted wood are associated with a more reliable supply of high-quality input.

Apart from industrial forests, Floram involves ecological and hybrid ones, as well as extensive investment in education, training and social involvement by the local population. Given all expenditures, the total cost has been estimated at 1000 USD per hectare. Although this is a rough figure I use this amount, discounted to the first year, as

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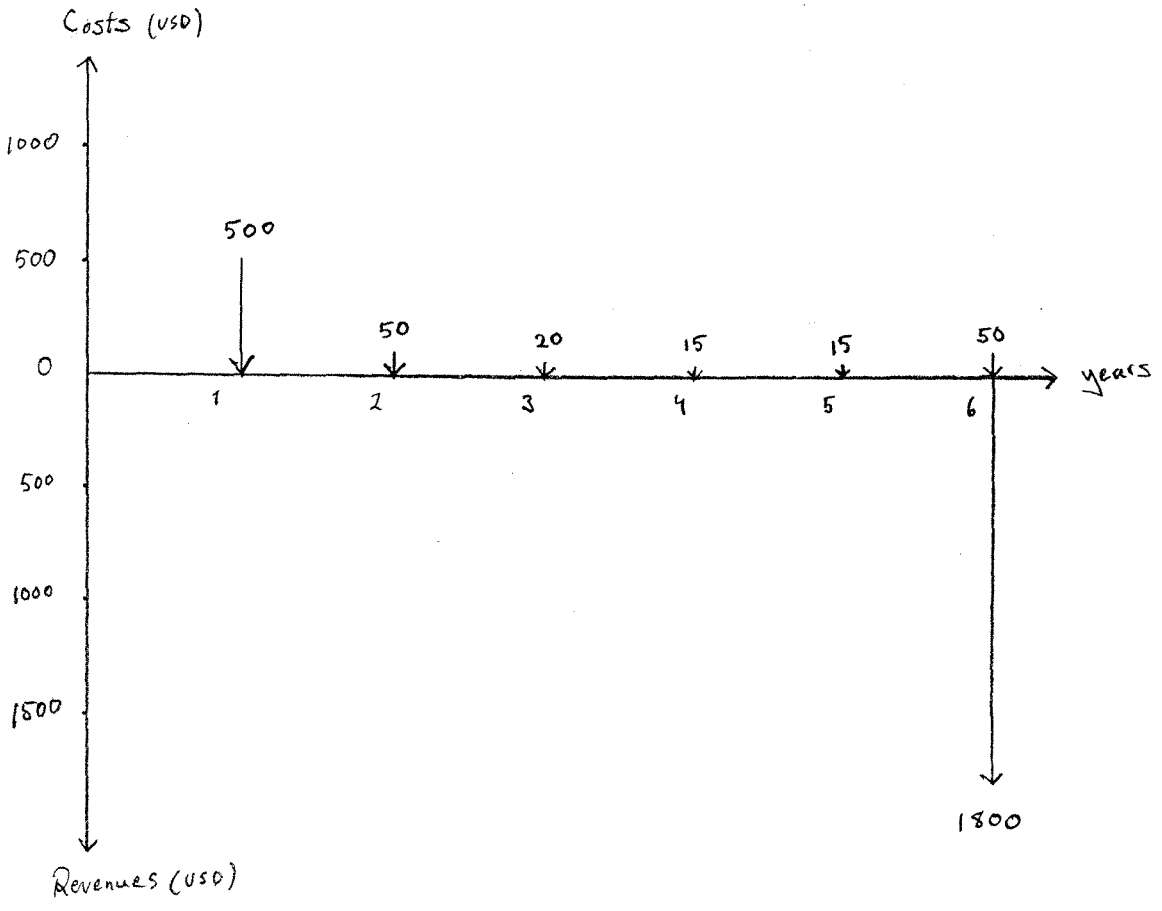
2 This creates a surge to crop land, counteracts forestry and causes a more unequal land ownership pattern as large farms buy up small ones.

FIGURE 2: Costs and revenues from plantation, industrial forest



a point of reference for the total cost of the project as presently envisaged. Ecological or hybrid areas, the protection of native trees within industrial plantations, etc., give rise to certain financial benefits. Plantations become more resilient in regard to natural or societal calamities and native species serve as sources of genetic upgrading, which is of commercial value. However, it is primarily in the long run that the non-industrial activities provide benefits, meaning that they will not pay with a too high rate of discounting.

The use of pesticides or insecticides, the clearance of land and social investments such as the provision of basic education or the distribution of seeds among the local population, present related issues. For example, spreading poison from airplanes may be

the most effective for the short term, but will damage the ecology and productivity in the long term. The opposite should hold for poison contained tablets which are carefully designed not to leak. In the short-term it may be beneficial to use burning for the clearing of land. This is especially the case if labour costs are low, since handling burning tends to be labour intensive. In the longer run, burning diminishes the productivity of the soil. The financial benefits from investments in local involvement similarly rise over time as the enhanced population pressure accentuates the losses caused by social pressure.

Riocell in Gualba is an example of a private firm which manages to make financial profits from activities which consider long-term ecological and social consequences. Riocell is, however, "helped" by the relatively high labour cost of southern Brazil, and the availability of an exceptionally qualified work force. In addition, the strength of the company provides it with options to acquire financing abroad. As ecological and social investments generate economic returns in the long term, the pressure to make short-term profits rule them out as too expensive for most private firms. Moreover, educational and social programs must often be of a certain scale to affect general attitudes, which will make them even less viable for firms with considerable budget constraints.

Summing up, the production of wood generally pays only with a discount rate of 15 per cent or less. With the present scarcity of capital, discount rates are substantially higher. Moreover, forestry is damaged by various policies which, e.g., create a surge for cropped land as tax havens. For these reasons, plantations pay only when integrated with processing activities. Floram in its intended form is not viable in financial terms. The high rate of discount contributes to preventing a realization of the ecological and social investments which are planned to be part of it.

IV. National socio-economic analysis

For a socially relevant analysis, financial values must be adjusted for market and policy failures. Market failures concern both the fact that some markets are not operating efficiently, and the fact that some markets do not exist. The key concept is externalities: impacts on human welfare which fall outside the record of market transactions. Many of the costs of forest harvesting are not properly reflected in ordinary markets, and many of the benefits of standing forests do not receive their fair appreciation. In addition, there are

policy failures regarding, e.g., property rights definitions and enforcements, price regulations, taxation, public investments and bureaucratic sub-optimization.[3] Price distortions caused by policy failures can be said to emanate on three levels, the general policy level where links to environmental damage may be far from obvious, the environmental policy level and the project level.

The applicable method for environmental economic evaluations is the social cost-benefit analysis. This entails the tasks of i) identifying, quantifying and valuing social advantages and disadvantages in terms of a common monetary unit, ii) bringing the flow of monetary units together to a net present value, and iii) describing unvalued effects (intangibles) to enable a qualitative or quantitative consideration of these effects. Since the valuation entails the summing up of individuals' willingness to pay for items, marketed or not, it may also be necessary to apply income distribution weights to consider that the social value of income differs between individuals. For general references on the principles of cost-benefit analysis, see Little and Mirrlees (1974), Helmers (1979) or Bojö et al. (1990). For an application to forestry, see Andersson and Bojö (1990). As stated, I do not attempt any detailed cost-benefit analysis of Floram in this paper, but merely discuss what can be expected from such an undertaking. This section is concerned with the social valuation from the national perspective, while the next section turns to the international perspective.

In Brazil, the strong presence of both market and policy failures makes it extremely difficult to adjust market prices in an adequate manner. One of the most obvious distortions concerns wages. Due to minimum-wages and other regulations, the financial labour costs exceed the socio-economic ones. Another concerns taxation, where credits encourage exploitation of environmentally weak areas (cf. Mahar, 1989). A major subsidy is inherent in the establishment of identical fuel prices throughout the country. The subsidization of agriculture has already been commented on. In addition to federal laws, local authorities support agriculture and encourage the burning of forests. The problems are aggravated by the lack of property rights to standing forests, and that such rights are often conferred based on the clearance of land (cf. Repetto and Gillis, 1988).

A socio-economic evaluation of Floram requires first and foremost that private costs are adjusted for these imperfections. This is complicated by the fact that both wages,

3 The term 'policy failure' here denotes both inadvertent negative impacts and conscious pursuit of policies that serve vested interests at the expense of the general public ('government failure').

the excess supply of labour and public incentives vary between regions. Applying socially relevant labour costs and correcting for the subsidization of agriculture, in any case enhances the return to forestry. In addition, there are non-commercial or 'intangible' values pertaining to forests, which take the form of 'common goods'. Examples of such externalities in the present case are: desertification, prevention of soil erosion, water rehabilitation, and cooling of Sao Paulo in the case of State Central Park. These effects can, in principle, be quantified and valued in socio-economic terms. Here, it is sufficient to note that there exist external effects which raise the social value of the project above the financial value. Of these, the intended halting of deforestation in the Amazon is particularly important.

Planted forest is today the basis for pulp and paper production in Brazil, as well as fiberboard and particle board. Pulp and paper especially has expanded after the Second World War, reaching a production of 3.8 million tons in 1988. This makes Brazil the eighth largest producer of pulp in the world, but the potential for further expansion is great. The tropical native forests, on the other hand, supply most of the plywood, charcoal, sawnwood and veneer. In total, about two thirds of the total industrial wood requirements came from native forests in 1988, while the rest was provided by plantations. This meant the destruction of the equivalent of 1.8 million hectares of native forest per year (Ramos de Freitas, 1989).

Because planted trees are more easily available, located more favorably relative to industries and of more reliable quality, logging in native forests can generally not compete with them. The further expansion of planted forests will consequently replace the input provided by native forests. It is true that logging is not the major cause of deforestation, which is rather burning to clear land for cattle breeding or other agricultural activities. However, there is often a connection between the two. Infrastructure is, for example, developed for the purpose of logging, making forests accessible for small-holders. Plantations will also offer new employment opportunities outside the Amazon. If Floram were implemented in full scale, 1 million workers could be employed in forestry alone, with additional employment in agro-forestry. The excess supply of labor would be eased, at least regionally, although it can not be eliminated by Floram alone.

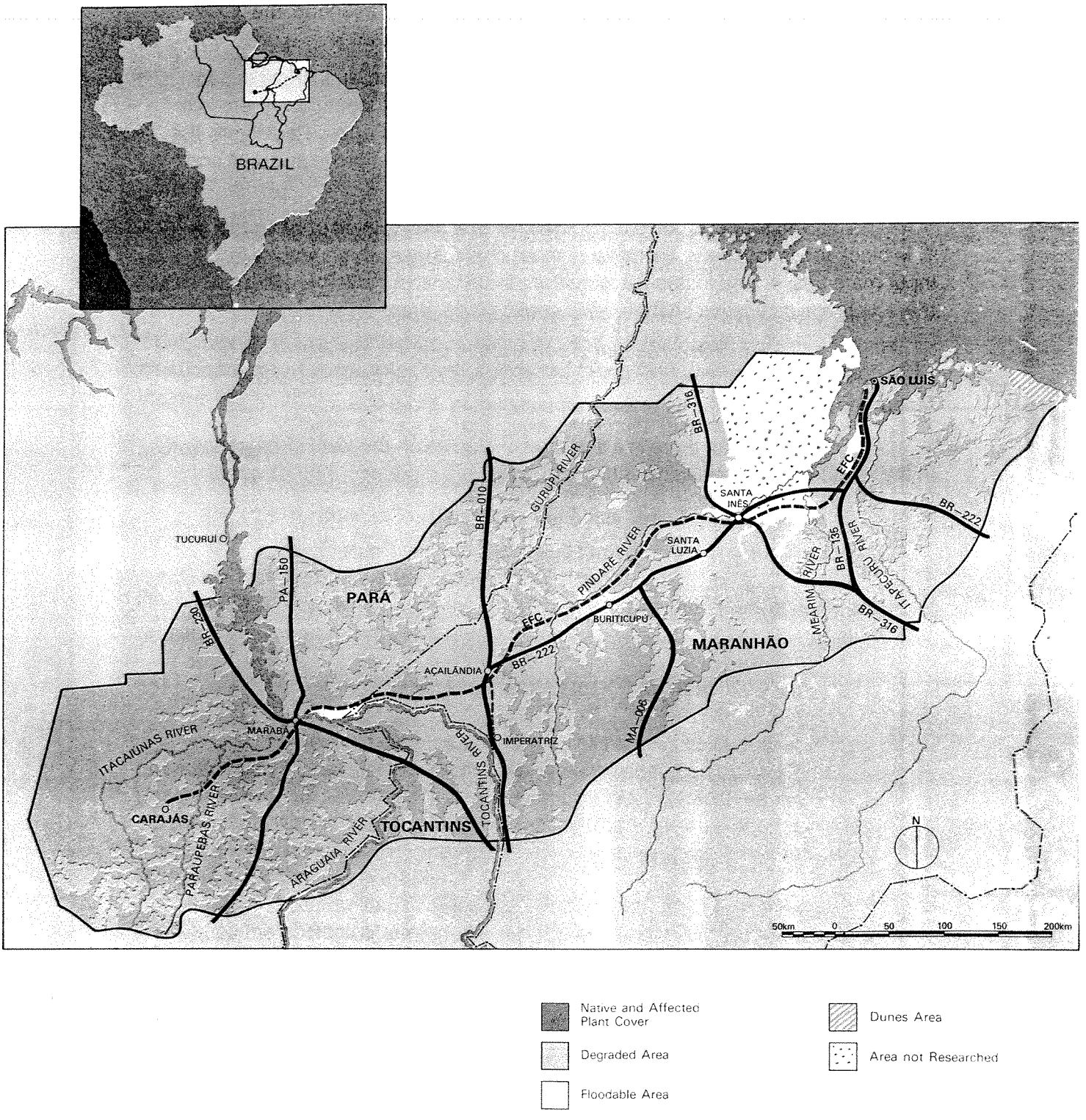
The process of deforestation may also be affected by impacts on general attitudes and policy objectives due to improved information about the value of forests, and the

development of distribution networks which enable locals to invest in forestry. Any major change in regard to the deforestation of the Amazon requires, in fact, that both taxation laws and ownership rights are corrected. An illustration is provided by Compania Vale do rio Doce, which is responsible for a forest management program around the Carajas - Sao Luis railway, where the Amazon is threatened from the East. The program includes both extensive research, and ecological as well as social investments throughout the 25 million hectares project area (CVRD, 1989). The project, which has already made a major difference for the protection of the local forest, has been taken up by the national authorities as a model for development. Still, their efforts can not match with the mounting pressure from the local population. The company's prognosis for the coming years is a considerable worsening of the situation throughout the project area. The reasons are mainly that new industries require forest input, strong incentives for cattle-breeding and rules for acquiring land titles based on the slashing of the forest. Figure 3 shows how far deforestation has already gone in the area, and how it spreads around the roads. The result is erosion, destroyed water supplies and the devastation of local tribes. Floram could make a major difference for projects such as that run by Compania Vale do rio Doce mainly by paving the way for a correction of present policies.

Thus, it is difficult to identify and quantify the impact of Floram on the Amazon, not to speak of the valuation. The possibility of reduced CO_2 emissions and preserved biological diversity is returned to in the next section, as such effects would strongly benefit the international community. For Brazil itself, the benefits of an improved environment, directly from plantations or indirectly from preservation of the Amazon, are mainly of a long-term nature. Moreover, they will hinge on the ecologically and socially motivated investments that are unlikely to pay for private companies, and on a revision of distortional policies. Brazil as a country is rationed in the international financial markets, however. Capital is scarce at the national level, accounting for a high rate of discount from the social perspective as well.

Another important socio-economic effect concerns the impact of Floram on the total supply of forest products and, hence, on prices. As the Amazon provides wood under all circumstances, plantations would not increase the supply in the short to medium term. Wood prices are already low and are unlikely to be further depressed. The price of processed products is similarly unlikely to be much affected. In the case of pulp, for

FIGURE 3: Land use in the area of influence of the Carajás Railroad



example, wood accounts for only about 10 per cent of the total cost in Brazilian industry. In the long run, extensive plantations will increase the supply of wood and, hence, may reduce prices. It may be argued, however, that the major problem for forestry in the long term is not over-supply, but the destruction of tropical forests. The substantial supply at the current time notwithstanding, average prices for logs, sawnwood and plywood became more firm in all regions (plywood only for Asian exporters) in 1990 (ITTO, 1991a). With tropical hardwood becoming scarce in the future, there will be excess demand and higher prices (Andersson and Bojö, 1990). In the end, consumers will develop substitutes, and the market for wood products shrink. Worries about the consequences of increased forest output may still represent a major stumbling-block for the international acceptance of Floram. It is also important for Brazil itself. Financing an expansion of forestry, Brazil would take on large economic risks.

Summing up the national perspective, correction for wage distortions, subsidies of agriculture and positive externalities raise the socio-economic value of Floram above the financial value. The industrial use of native forests would be scaled down, but a major impact on the deforestation of the Amazon would also require corrections of tax laws and property right acquisition laws. However, socially and ecologically motivated investments provide benefits primarily in the long run. Brazil is lacking capital on the national level, accounting for a high discount rate. A design of the project which is sound from the national perspective will, although less than in the financial case, lean towards short-term gains rather than long-term ones. Finally, it may be argued that Floram in itself would not reduce the prices of wood or processed forestry products. By financing Floram, Brazil would still take on substantial economic risks.

V. Global socio-economic analysis

Extending the national socio-economic analysis to the global level, two partly interrelated specifications need to be made. The first concerns the scarcity of capital caused by the accumulation of external debts and the subsequent cut-off from the international financial markets. The second concerns the diffusion of costs and benefits from forestry beyond national borders.

Beginning with the former, savings require that consumption is foregone, and consumption is low already in developing countries. This sets up limits to what can be saved domestically, which makes it natural that investment comes from abroad. Like

many other developing countries, Brazil borrowed extensively in the 1970s when interest rates were low. A great deal was used for consumption and conspicuous investments which served political rather than economic goals. When interest rates went up in the late 1970s and early 1980s, the international credit was rationed for the indebted developing countries. It is well-known that this need not have anything to do with the basic solvency of the economy. The explanations lie in, e.g., the risk of debt repudiation, limited taxing power of the governments in debtor countries, and imperfections related to the supply of loans - such as the risk of panic among creditors. Likewise, the risk of policies that interfere with the ownership of affiliates, expropriation or nationalization, may prevent direct investment (Andersson, 1991). Other factors contributing to scarce capital are: barriers to imports in industrialized countries; budget deficits and soaring inflation resulting in overvalued exchange rates; corruption; and capital flight due to the lack of credibility of the national exchange rate.

There has been some debate over the consequences of indebtedness and credit rationing for forestry. The traditional view is that the result is an increased exploitation of natural resources to achieve increased exports. Against this, Hansen (1989) argued that less capital is available for extraction of the renewable resource base. However, both these arguments fail to consider the intertemporal motives of foreign borrowing. Taking imperfections in the capital markets into account, the costs of indebtedness increase with the level of debt, so that activities suitable for reducing the debt are shifted from the future towards the present time. This upgrades the discount rate relative to the rest of the world, meaning the international capital markets or the industrialized countries. It becomes less urgent to implement a project such as Floram, which account for long-term benefits.

Turning to the diffusion of costs and benefits across borders, standing forests to some extent benefit wealthy temperate nations rather than poverty-stricken tropical ones. Here, I bring up the two most important international consequences of Floram, the absorption or prevented emissions of CO_2, and the preservation of genetic diversity. There have been efforts to evaluate such effects in monetary terms, and progress has been made for certain cases (Pearce, 1990; Dixon and Sherman, 1990; Barbier, 1991). Still, the monetary value of climatic stabilization or biodiversity is far from being accurately estimated. The uncertainty which pertains to the monetary valuation must not make us neglect it altogether.

Due to its long atmospheric life and radiative properties, CO_2 is believed to account for some 50 to 60 per cent of the greenhouse effect. Every hectare planted in Floram would absorbe some 36 tons of CO_2 in the first six years.[4] Beginning in the 6th year, a great deal would be returned to the atmosphere as wood is harvested, processed and burnt. On the other hand, new forests would then be planted. To obtain a point of reference for a valuation, I here make only a tentative estimate of how large re-emissions of CO_2 can be expected.

Assume that half of the CO_2 absorbed in industrial forests (70 per cent of Floram) is re-emitted in the year of harvesting. In the hybrid and ecological forests (30 per cent of Floram), the absorption gradually phases out over time as trees grow old. Think of this as occurring over the second decade after plantation.[5] Under such circumstances, and given that Floram involves the planting of 1 million hectares each year for 20 years, we obtain the time pattern of absorption depicted in Figure 4. The absorption increases as more and more hectares are planted, but the growing re-emissions from harvesting and the maturing of the ecological and hybrid forests finally reverses the trend. The maximum level of absorption is achieved in year 20, when about 430 million tons of CO_2 are absorbed. After 40 years, the level of absorption is stabilized at 200 million tons per year. The average annual absorption during the first cycle of plantation is 18 tons of CO_2 for every hectare, while the "steady state" level is about 10 tons.

In the long run, one must probably count on larger re-emissions from the industrial forests since paper is burnt, furniture thrown away, etc. There will then be a downward trend in the absorption over time, as indicated by the dotted line in Figure 4. The exact outcome will be affected by the design and operations of the program, from logging to industrial processing and recycling of paper, as well as the management of the standing forests. If burning is used for the clearance of land, for example, considerably more CO_2 would be re-emitted to the atmosphere.

The benefits of absorbing CO_2 are uncertain. However, many forecasts point toward severe consequences if the human emissions continue on a large scale. Countries such as the Netherlands, Denmark or Bangladesh, which would be the first to be hit by a

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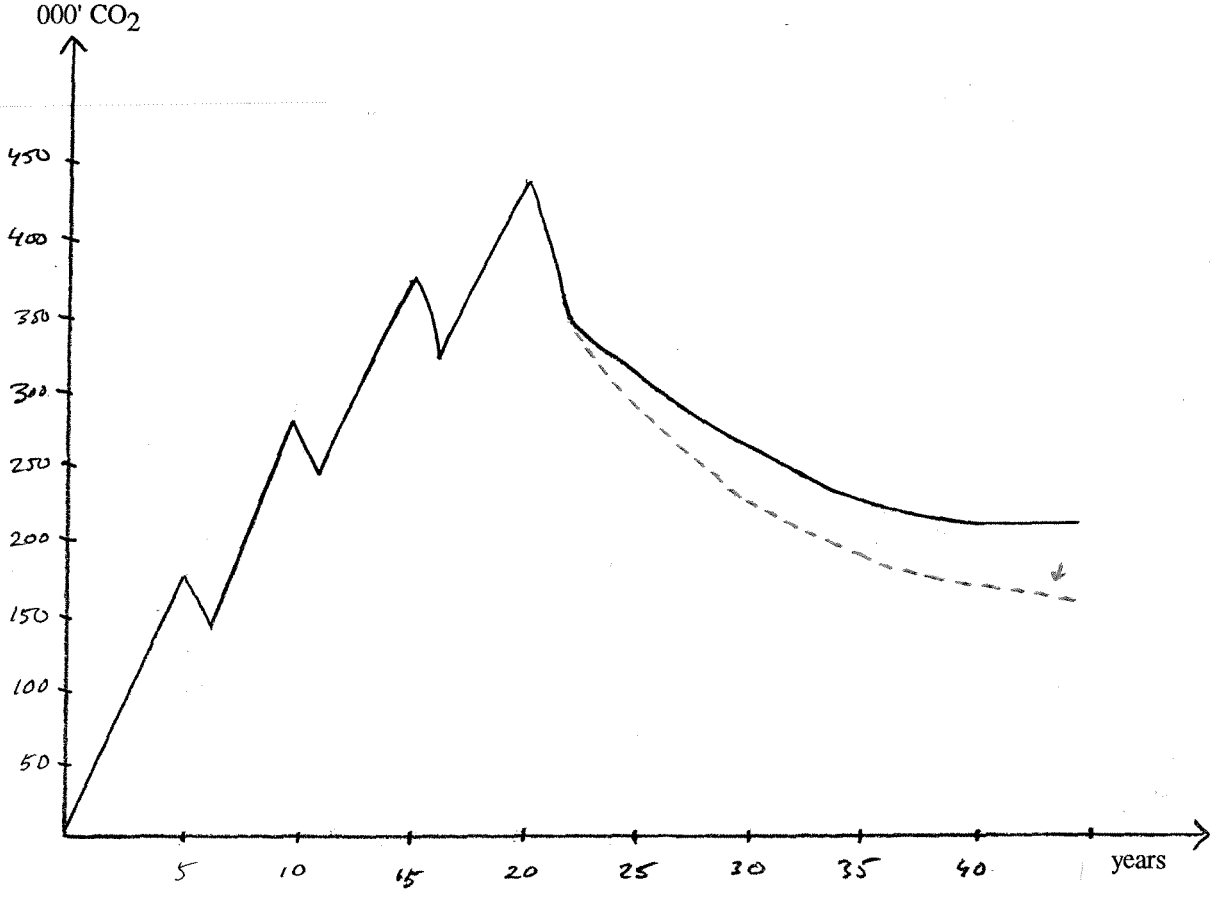
4 Every hectare produces 50 square meters of wood per year. This gives 20 square meters of dry wood, 36 tons of CO_2 and 26 tons of atmospheric oxygen.

5 Zero per cent of the annual absorption of CO_2 is thought of as re-emitted in the tenth year, and 100 per cent after 20 years. In the time between I assume a gradual increase in the re-emissions, meaning that 10 per cent of the annual absorption is re-emitted in the eleventh year, 20 per cent in the twelfth year, and so on.

FIGURE 4: Distribution of CO_2 absorption over time



rising sea level, may suffer the most. More and more countries now argue for tangible restrictions on fossil fuel emissions. The EC ministers for the environment, for example, agreed in October 1991 to impose a tax on energy to halt the increase in their emissions. The EC alone is presently responsible for about 13 per cent of the world's total emissions of CO_2. The United States, which accounts for more than 20 per cent, has not yet made any corresponding announcement, however. Estimates of regional and national contributions to greenhouse warming are given in Table 1. According to these figures, the present land use in Brazil as a whole contributes almost 15 per cent of the world's total emissions of CO_2, and some 9 per cent of total human contributions to global warming.

Given a maximum level of emissions, there have been various estimates of how this can be enacted most effectively. A target commonly used is 80 per cent of the emissions in 1990. Even in this case, the present CO_2 concentration will keep increasing well into the next century, and may cause substantial damage. Kverndokk (1991) finds that the most effective phasing out of emissions would require almost all reductions to be

TABLE 1: Distribution of human contributions to greenhouse warming, late 1980s
(CO_2 equivalent emissions from different sources, in per cent. Errors in summation due to aggregation)

	CO_2 Emissions			Methane	CFC	
Country	Fossil Fuel	Land Use	Total	Emissions	Emissions	Total
Europe	8.8	-	8.8	1.4	8.1	18.6
USA	9.0	0.5	9.5	2.2	5.9	17.1
USSR	7.6	-	7.6	1.0	3.0	11.7
Brazil	0.3	9.2	9.5	0.5	0.4	10.3
China	4.4	-	4.4	1.5	0.5	6.4
World	42.4	20.3	62.7	13.6	23.7	100.0

Source: Recalculated from World Resources Institute (1990-91)

made in industrialized countries. Some developing countries would be allowed to increase their emissions. This is not to say that the industrialized countries would carry the largest costs in all instances. China was found to suffer the greatest losses in terms of GDP.

Any possible target for the total emissions is an arbitrary one. In principle, however, a ton of CO_2 absorbed in Brazil could mean that a reduction of one ton is foregone somewhere else. It is less straightforward to halt deforestation than to cut fossil fuels. Floram could counteract or check increased emissions from deforestation, rather than substitute for cuts in energy production. This suggests that the CO_2 saved through Floram is worth as much as the cost of cutting the corresponding emissions from fossil fuels. Although it is extremely difficult to estimate this cost, it is more meaningful than trying to calculate the extremely uncertain benefits, as attempted by Nordhaus (1991a).

Among studies calculating the costs of cutting CO_2 emissions in certain industrialized countries, can be mentioned Hoeller et al. (1991), and Nordhaus (1991b). To estimate cost efficient international reductions, Manne and Richels (1990) undertake simulations in global growth models. Similarly, Kverndokk (1991) calculates cost efficient carbon taxes and tradable carbon emission permits. The principle is that a tax on an emission must be larger than the income associated with it, if the emission is to be cut. The uniform tax of emitted CO_2 and the uniform price of a permit correspond to the shadow price of emissions, which is equal for all countries in the cost efficient agreement. To reach 80 per cent of the emissions in 1990, Kverndokk obtains a shadow price of over

600 USD per ton carbon.[6] This can be interpreted as the cost required to reach a target which is likely to be politically determined. In this sense it measures a probable "price" on carbon.

Recalculating carbon to CO_2 (a factor of 0.273), the shadow price obtained is about 165 USD per ton CO_2. As made clear e.g. by Jorgenson and Wilcoxen (1991), however, this estimate is likely to be exaggerated for a number of reasons. Both producers and households would adjust to higher taxes on carbon in various ways, leading to substitution affects and changes in prices. In addition, there would be increased cuts over time as more energy efficient technologies were induced. Floram, on the other hand, results in a large initial absorption of CO_2, which later declines. Taking the dynamic effects of taxes into account, Jorgenson and Wilcoxen (1991) find that a tax of about 60 USD (in 1989 value) per ton carbon in the year 2050, would cut the emissions in 1990 by 20 per cent. The timing and stringency of the tax has then been designed so as to cause the smallest possible drop in income. In the internationally cost-effective reduction the US would have to reduce its emissions even more. Adjusting for this in accordance with the framework of Manne and Richels, and recalculating to CO_2, we obtain a value of about 30 USD per ton.

Under all circumstances, the literature suggests substantial benefits from CO_2 absorption, given that the total human emissions are to be reduced. Counting with an average annual absorption of 18 tons per hectare over the first cycle of plantation, and applying the estimate of 165 USD per ton, Floram would give rise to a global gain of almost 3,000 USD per hectare per year! A correction for substitution effects and technological progress which cuts the benefit to 30 USD per ton, renders a gain of 540 USD per hectare per year during the first cycle, and 300 USD in the long term. Even with this valuation, the initial absorption of 36 tons per year renders a monetary contribution of over 1,000 USD. The total cost is covered by the value of CO_2 absorption in the first year already.

Although the precision of these estimates leaves a great deal to ask for, they point towards the significance of global benefits. If deforestation in the Amazon would be hampered as well, they would be even greater. Of the current human emissions of CO_2, fossil fuels provide between two-thirds and three-fourths, and deforestation the remaining

6 The figure is in the same range as those obtained by Manne and Richels (1990).

TABLE 2: Amazon deforestation and CO_2 emissions

Year	Area 000'km^2	%	Annual increase 000'km^2	%	Annual emissions in 10^9t.	% of world
1988	378	7.7	22	9.5	0.31 - 0.45	4.4 - 6.2
1989	401	8.2	24	6.3	0.33 - 0.48	4.6 - 6.6
1990	415	8.5	14	3.4	0.19 - 0.27	2.7 - 3.8

Source: Reis (1991)

25-33 per cent.[7] A recent estimate of the deforestation in the Amazon is reported in Table 2. In 1988 and 1989, it accounted for about 5 per cent of the global emissions of CO_2. In 1990 the rate has slowed, but the contribution is still about 3 to 4 per cent of the world's total. According to Reis, the burning will speed up as soon as Brazil's economic growth catches up. As only 8.5 per cent of the Amazon has been deforested so far, there are immense potential emissions down the road, and even more so as the population pressure continues to grow. Based on simulations, Reis (1991) finds that a "restricted growth scenario" will cut 22 per cent of the Amazon by the year 2030, and 37 per cent by 2090. In the basic scenario, extending the present trend, almost 33 per cent of the Amazon would be gone by 2030, and 67 per cent by 2090. As seen in Table 2, the present deforestation involves emissions of about the same magnitude as the absorption foreseen by Floram.

In addition to atmospheric effects, we have the preservation of biological diversity. Although this provides some immediate commercial gains through the production of medicines, food, materials, recreation, etc., most benefits can be reaped in the distant future only, and by other countries than Brazil itself. With yet unborn generations unable to make their voices heard today, there is little incentive to undertake the investments which are necessary to acquire comprehensive information about biological diversity. Many species are extinct before their presence is even known, not to speak of their commercial value.

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7 The rain forest not only absorbs, but also produces, a great deal of CO_2 and methane. Deforestation causes large emissions primarily due to burning.

These difficulties make it necessary to look for alternative methods to obtain monetary estimates. One possibility is to use the costs needed for re-establishing ecosystems (cf. IUCN, 1988). This is seldom applicable, since it must first be determined whether such restoration would be worthwhile. Another more useful position is to look for the revealed willingness to pay for ecological conservation in various organizations. Such willingness to pay stems from tangible option or existence values for people who are not immediately related to a resource, but whose concern still constitutes a real value. Given that it is practically feasible, it should then be possible to channel their payments to the resource. Estimates based on this method show that biological diversity does account for substantial values (cf. Ruitenbeek, 1991). If Floram is properly designed, there could be considerable global benefits due to the preservation of biological diversity as well.

VI. Concluding remarks

Tentative valuations show that it makes a major difference whether the international community supports Floram. The policy distortions and high discount rate in Brazil prevent plantations from being profitable for private firms and individuals. In a socio-economic analysis for Brazil as a country, correction for distortions in labour costs and taxes, as well as positive externalities, lead to additional gains. Still, many investments oriented towards long-term gains would not be profitable, and the project would involve great risks for an individual country. Given that the total human emissions of CO_2 are to be reduced, Floram is clearly profitable from the global perspective, however. Under plausible assumptions, the benefits of absorbed CO_2 would outweigh the costs in the first year following plantation already.

If Floram hampers the deforestation of the Amazon, the benefits of halted CO_2-emissions and preserved biological diversity would be larger still. On the other hand, a major impact in this respect requires corrections of tax laws and property right definitions. It may be argued that the Amazon should be protected directly through policy reforms, rather than through support of Floram. The two should be viewed as complementary, however. Floram could help to check the deforestation of the Amazon by, e.g., making logging of native species uneconomic and offering new employment opportunities in other parts of the country. In addition, the social and educational investments which are

necessary for Floram to be undertaken as envisaged, could influence general attitudes towards the environment, and thereby pave the way for policy reform.

The work of Baumol (1971) and others, suggests that governments should be able to handle environmental problems through side payments. Floram may be viewed as a test case, since international support is necessary for a design which is optimal from the global perspective. Moreover, a cost-effective handling of the greenhouse effect requires that taxes on CO_2 emissions are coupled with incentives for plantations or efforts to curb deforestation. Why, then, would other countries not support Floram? One worry might be that vast plantations would reduce prices and hurt forestry elsewhere. Because inexpensive wood is available under all circumstances, however, planted trees will merely replace the cutting of native ones. Leaving Brazil without support for Floram will hardly curb the growth of forest industries,[8] but it will foster continued deforestation and the global calamities which go with it. Rather, there is great resistance on the part of some countries against the principle of accepting international transfers as a tool to deal with international environmental problems.

There are certainly problems with transfer payments, particularly related to moral hazard. If a country senses that foreign assistance can be obtained, it may pretend that its appreciation of the environment is lower than it actually is. In this way, transfers could lead to less pollution abatement than would otherwise come about. Applying this to Floram, the provision of support could attract people who tried to use it for their own private purposes. Moreover, Brazilian authorities could refrain from correcting the policies which promote deforestation. Finally, other countries could use Floram as an excuse for not halting their own deforestation, or not cutting their own emissions from fossil fuels. There are ways to handle these problems, however. International support can be connected to helpful monitoring, which ensures that funds are used as intended, as well as to a revision of distortional policies in Brazil. Particularly tax laws and property right definitions should be addressed, not least at the regional level. Concerning forestry elsewhere, Floram is likely to exert a positive demonstration effect in that other developing countries are induced to manage their own forests more cleverly. The way for

8 The current, low prices on pulp and paper are below the break-even point of many producers, while Brazilian industry can make profits at even lower prices. Still, prices are expected to rise. Stocks are now down to normal, demand will continue to grow - not least in developing countries - and bottlenecks in Brazil and other developing countries will prevent a drastic increase in output.

the global community to avoid Floram being used as an excuse not to cut emissions from fossil fuels, finally, is not to refute the project. That opens up the possibility that some countries use unilateral support for their own purposes. Floram represents an option to check the emissions of CO_2 from land-use, and can thereby complement other cuts.

Speaking more generally, there is a need to consider how transfers can be used to achieve a sound management of the environment. This concerns not only transfers of capital, but also of technology and know-how. With growing pressure on our global resource base, it will become increasingly important to deal with the situation in the most cost-effective way. There are many instances in which this will require that huge sums are spent in certain countries for the benefit of many others. The risks and opportunities encountered in Brazilian forests represent one important example. We had better start cooperating, for the good of all of us.

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