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The Social Dynamics of Deforestation in the Brazilian Amazon: An Overview

Discussion Paper No. 36, July 1992
Antonio Carlos Diegues with an appendix by Paul Kageyama and Vergilio Viana

Contents

Preface

The UNRISD research programme on the **Social Dynamics of Deforestation in** Developing **Countries** is concerned with analysing how deforestation processes are generated in different ecological and socio-economic settings and how they affect the livelihood of different social groups. The programme has included local level case studies in Brazil, Central America, Nepal and Tanzania, as well as eight studies of specific themes which cut across countries and regions.

This paper by the Brazilian social scientist Antonio Diegues presents a preliminary assessment of the social origins and impact of deforestation in Brazil's Amazon region, as well as ideas regarding practical alternatives to deforestation. The paper was also intended to provide a coherent conceptual and methodological framework for detailed case studies that followed. It is based on a wide body of secondary sources, consultations with key informants and visits to proposed research sites.

When analysing the causes of deforestation, the paper emphasizes the role played by processes of economic and social change associated with the unequal distribution of land, commercialization of agriculture, landloss and poverty. These conditions have resulted in the expulsion of poor peasants to the Amazon forest frontier areas. Other factors such as inflation and land speculation have also underpinned deforestation. The paper argues, however, that the chief responsibility for most of the massive deforestation lies principally with the government and its development strategy of the past three decades which, through credit, tax and other incentives, has enabled large scale agricultural and cattle raising schemes to be established. The promotion of mining and hydroelectric projects in the Amazon and efforts to increase exports to pay the huge external debt have also contributed to deforestation. The paper stresses that deforestation in the Amazon should be analysed in the context of Brazil's insertion in the world economy and its overall development style.

Many poorer and weaker social groups have been deeply affected by the deforestation processes in the Amazon. The paper refers to the case of the rubber tappers who have been dispossessed by large landowners, corporations and cattle ranchers. Another group which has suffered, partly because of the growth of gold mining in the Amazon, is the Amerindian population. There is an escalating level of violence in the Amazon, as these groups attempt to resist land invasions.

The paper goes on to identify different alternative forest or land use practices that have been adopted in the Amazon. It discusses the concept of "neo-extractivism" which has evolved from movements of the rubber tappers and other forest-based people. This resource management system seeks to protect the forest and provide secure, sustainable, forest-based employment for these different groups of people who are dependent on the Amazon forests. Furthermore, it attempts to maintain the socio-cultural identity of indigenous populations such as the Indians.

The paper concludes with an annex on the technical, forestry and agroforestry alternatives to combat deforestation. With limited scientific research available, much of the knowledge about this area rests with the local Amazonian population. More research at the local level is called for in order to find solutions to the problem of deforestation in the Brazilian Amazon.

Antonio Diegues is the Co-ordinator of the Programme of Research and Conservation of Wetlands in Brazil, of the University of Sao Paulo. The annex was prepared by Paulo Kageyama and Virgilio Viana, both forestry engineers and staff members of the University. The UNRISD project on the Social Dynamics of Deforestation is co-ordinated by Krishna Ghimire with Solon Barraclough as senior consultant.

July 1992

Dharam Ghai
Director

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Summary

The objectives of this paper are to review the main socio-economic relationships and processes leading to deforestation in the Brazilian Amazonia, to assess its apparent consequences for various groups of local inhabitants and to look at some of their collective responses.

The most important process underlying the deforestation of the region is the accelerating economic incorporation into the national economy of the largest remaining frontier of Brazil (Amazonia represents over half of the nation's territory). Capitalist investment has been taking place rapidly in the region. This process of investment and incorporation (the military speak of "occupation") is leading to certain patterns of land concentration and skewed income distribution similar to those that exist in other parts of the country.

The short period of time in which this most recent economic expansion in the region has been taking place, the relative absence of formal social institutions (including those of government) in this vast area, and the nature of the region's natural resources have all contributed to high levels of conflict and violence. There are many conflicts of interests between different actors and social groups. On the one hand, there are the traditional dwellers of Amazonia - the Amerindian tribes, the riverine population and the rubber tappers. On the other hand, there are many newcomers to the region: representatives of multinational interests such as mining; national investors in the region's resources and commerce; various public agencies as well as numerous landless low-income people from the south and north-east looking for ways to improve precarious livelihoods. The conflicts that ensue and their dynamics are closely reflected in changing patterns of land use and land tenure and of course have implications for the appropriation of natural resources by different groups.

Changes from traditional land use such as rubber tapping, fisheries and shifting agriculture, to so-called "modern ones" such as cattle raising, intensive agriculture, land settlements, logging and mining, have lead to deforestation and conflicts.

Government policy and strategy is another key element to understanding the deforestation of Amazonia. The policies have changed dramatically in the last 20 years, from promoting small-scale settlements to encouraging large agricultural livestock schemes and large mining projects. Every shift in government policy had a different impact on deforestation.

Deforestation processes and their social impacts have shown different patterns in regions dominated by large estates such as in south-east Para and in areas more dominated by organized rural settlements, as in Rondônia in western Amazonia (see map).

After examining the causes of recent deforestation, the paper looks at its impact on traditional population groups in the region as well as on new settlers. Their livelihoods have often been deeply and adversely affected. Their access to resources has been reduced or lost leading to increasing poverty and migration to new areas. As a result, there is an increasing disruption of their traditional ways of life and culture. The next section of the paper looks at some of the collective reactions of affected groups.

Information on the social dynamics of deforestation processes remains relatively scarce, although a lot has been written on deforestation, itself. This paper represents a preliminary effort to put together relevant information and a bibliography related to the social forces and processes subjacent to deforestation in Amazonia. This review should help in identifying the principal issues and to formulate hypotheses to investigate through further research.

Introduction

Brazil has approximately 3.5 million square kilometres of moist tropical forests, equivalent to 30 per cent of the world total. Most of Brazil's tropical forests are located in the Amazonian Basin, known as Amazonia.

There are two concepts used in Brazil to determine the boundaries of the Amazon region. This usually leads to confusion. The first one is Legal Amazonia which comprises an area of 5 million square kilometres, about 58 per cent of the Brazilian territory. For administrative and planning purposes it comprises seven states: Acre, Amapa, Amazonas, Mato Grosso, Para, Rondônia and Roraima as well as parts of Goias and Maranhao, and is bigger than western and eastern Europe combined, excluding the USSR. It is a region of crucial importance to Brazil from environmental and developmental points of view. The other concept is Classical Amazonia, covered in general with tropical forests. This is 1.5 million square kilometres smaller than the Legal Amazon (see map).

Dense forests (*terra firme*) occupy nearly 70 per cent of the area and 27 per cent is occupied by the *cerrado* (dry scrub savannah), mainly in the states of Mato Grosso, southern Para, Goias and part of east Rondônia (Fearnside, 1986). From 5 to 10 per cent of the area is occupied by wetland (*varzea, igapos*, lakes).

Amazonia has a critical importance for Brazil. It covers more than half the national territory and has a diversity of human groups including more than 140 indigenous tribes. It has been characterized as the "single richest region of the tropical biome. A single hectare of rain forest near Manaus, for example yields 235 tree species over 5 centimetres in diameter and 179 species over 15 centimetres in diameter" (Myers, 1984).

The variety of birds, fish and insects is also great. There are 2,000 known species of fish in the Amazonian rivers, eight times the number of species in the Mississippi river and 10 times the number found in the whole of Europe. Experts estimate that the real number of fish species might reach over 3,000. It is generally agreed that deforestation is rapidly reducing this natural variety of species. It is also depriving local populations of their livelihoods and mankind of as yet undiscovered medicinal plants and pest resistant genetic materials (Mahar, 1989).

> "Indeed, the great treasury to be found within the Amazon is the most obvious - the vast biological array of living organisms. There are many tens of thousands of plant, insect, fish and mammal species that inhabit this great tropical forest. Realistically accurate estimates of all the different kinds of organisms that live in the Amazon cannot be made, as many still remain to be discovered. Unfortunately, too few of us realize and appreciate this kind of wealth. Numbering among its treasures, the Amazon forest contains a plethora of plants that have great promise for economic utilization. Many of these plant species could be scientifically domesticated and used in agricultural programmes within the Amazon Valley and elsewhere in the tropics. Some possess specific advantages for cultivation, such as the ability to grow under harsh conditions with minimal care, current acceptability as a food, construction or fuel source by local peoples and superior content or quality of oils, proteins, drugs, insecticides, waxes or other products of importance to an industrialized society. Without such a verdant and diverse flora, the ability of humans to survive and indeed flourish in the Amazon Valley would be greatly diminished. In the statistics of IBGE, for 1979, there are 32 species of Amazonian plants used for gums, waxes, fibres, oils and food." (Balick, 1985)

1. The Magnitude and Rate of Deforestation

There is a great deal of discussion in Brazil about the extent and rate of deforestation in Amazonia. Much depends on the methodology utilized. The first estimates of deforestation

were made in the early 1970s by the Radam project using airborne side-looking radar, suggesting that little clearing of forest had taken place. Landsat images of 1975 have shown that only around 0.6 per cent of the forest of the Legal Amazon total area had been cleared (around 30,000 square kilometres). However, deforestation increased rapidly after the mid-1970s.

In 1980, according to Fearnside and World Bank estimates, over 125,000 square kilometres of forest had been cleared. Estimates vary considerably concerning the area deforested up to 1989.

The most recent deforestation measurements by the INPE (Space Research Institute of Brazil) show that by 1988, some 251,429 square kilometres of the Legal Amazonia had been deforested. This is equivalent to 5.12 per cent but does not include old deforestation in the states of Para and Maranhao. However, the same Institute now recognizes that the area might be larger, reaching by 1989 some 400,000 square kilometres, or 8 per cent of the Legal Amazon (Pinto, 1990). According to Fearnside (1989a), estimates based on linear projections show that the deforested area reached 7.2 per cent of the region during the same period. Up to 1988, Mahar estimated that almost 600,000 square kilometres had been cleared (12 per cent), which constitutes an area larger than France.

During 1987 alone, according to INPE, 20,000 square kilometres of forest were burned, 40 per cent of which were recently deforested areas (see, for example, Setzer, 1988). There are other estimates of 80,000 square kilometres of forests burned in the same year. Experts say that around 46,000 square kilometres of forests were burned in 1989. During the burning period, the smoke spread over millions of square kilometres, causing serious health problems and closing down important airports.

Deforestation has been concentrated in certain sub-regions. In Rondônia and Mato Grosso, for example, nearly one-fourth of the forest had already been cleared by 1988, whereas more than 99 per cent of the forest was still intact in Amapa (Mahar, 1989).

> "The proportionally greater advance of clearing in the *cerrado* (dry scrub savannah) areas, all located in the peripheral zone of Amazonia means that statistical data for the Legal Amazonia as a whole tend to reflect greater clearing than those for the rain forest area". One aspect of the clearing pattern counterbalances this bias to some extent within the transitional zone between rain forest and *cerrado*. Dicks examined Landsat images for 1975 and 1979 for a 10,322 square kilometres area in southern Para and found a strong tendency for preferential clearing of the more heavily forested patches within this transitional landscape i.e. smooth gradation from high forest to open scrub." (Fearnside, 1986)

One basic characteristic of the Amazonian region is the low fertility of the soils. According to Salati (1989), the largest part of the Amazonian soils have a low potential as far as nutrients for plants are concerned. Sanches et al. (1982) came to the conclusion that 90 per cent of the Amazonian soils have a phosphate deficiency, 73 per cent are toxic (aluminium), 50 per cent present a hydric deficit, and 24 per cent of the soils are subject to flooding. For agricultural purposes there remain only 7 per cent which are scattered all over the area.

Shifting cultivation, with long fallow periods, was a small factor of deforestation in Amazonia and was practised mainly by indigenous people and the *caboclo* local population. Slash and burn pioneer agriculture by small farmers has increased rapidly in the last decades, particularly in the settlement areas of Rondônia. Fallow periods have been shortened, causing serious problems for forest regeneration. However, large farms, some of them lacking financial and labour resources, also practise slash and burn in larger areas. Frequently, small

farmers, after having practised slash and burn agriculture, are forced to sell their land to larger farmers.

Although it may be difficult to estimate the present rate of deforestation in Brazil, it can be said with confidence that it is high and increasing rapidly and dangerously. As Fearnside says:

> "It matters little whether rain forests last a few decades more or less, given that ample evidence is available that probable trends, in the absence of swift changes in governmental policies and controls, would lead to a speedy end of the forest. Better understanding of the environmental effects of deforestation could or should move decision makers to set more rational policies regulating development in rain forest areas." (Fearnside, 1985)

2. History and Populations of Amazonia

Some authors (including Denevan, 1976) estimated that at the beginning of the sixteenth century (European discovery of Brazil and Amazonia), there were between 5 and 7 million Amerindians living in the region. Human occupation is believed to have been largely concentrated (around 28 inhabitants per square kilometre) in the "floodplains" (*varzeas*) along the main rivers.

Since the beginning of the Portuguese colonization, the main colonial settlements were also along the rivers in the *varzeas*. From those settlements, expeditions were organized to look for spices and drugs. In the nineteenth century, a new commercial product, rubber (latex), caused an economic boom in the region. There was an important migration from the drought-affected areas in the north-east of Brazil and the region benefited from an expanding rubber trade until 1910, when rubber plantations established in Malaysia began to capture markets previously supplied from Brazil.

In the early 1960s the first highway (Belem-Brasilia) linked Amazonia to the south. This promoted rural settlement schemes in Amazonia.

During the military régime (after 1964) the Programme of National Integration was launched (1970), including some important highways crossing the Amazon, such as the Transamazon, or BR-320 (see map). The idea was to attract drought-affected people from the north-east. In 1971, the government created "pro-terra" to stimulate agricultural settlements in the region.

In the late 1970s, the military government's strategy changed. Instead of agricultural settlements of small farmers, large development poles were planned (Polamazonis). A large mining pole (Grande Carajas), large dams and industrial centres based on mineral transformation were established as were several large agribusiness projects. State corporations, multinationals and private Brazilian firms greatly benefited from this programme. In order to counterbalance the heavy negative environmental impacts, some protected areas were also established, but their role in minimizing deforestation was modest.

The First Development Plan for Amazonia by the new civilian régime (1986-1989) basically reaffirmed the same development strategy, although environmental concerns began to receive more attention in these plans. The newly created IBAMA (Institute for Environment) which replaced SEMA (Secretary for Environment) was more active in the region, although it lacked sufficient funds and personnel as well as enough political support to stop deforestation in the region. After the heavy forest burning of 1987, the main government fiscal incentives to large projects were temporally discontinued. International pressures also played an important role in questioning recent patterns of Amazonia development.

3. "Causes" of Amazonian Deforestation

There is a general consensus among students and participants of the recent deforestation in Amazonia that it is the result of human interventions. Agreement ends there, however, as wide differences of opinion prevail concerning the roles of different actors, processes, institutions and policies. A brief review of the "causes" of the ecological and social disaster engulfing the Amazonian rain forests and the majority of their traditional inhabitants put forth by various analysts brings out the futility of proposing simplistic explanations or remedies. Assigning weights to the different factors "causing" the region's deforestation would be a chimerical exercise as these change according to each time and place, as well as depending on the "eye" (the conceptual framework) of the observer. The summary that follows of the principal "causes" of Amazonian deforestation is arbitrarily divided for greater clarity of exposition into the following three areas: structural factors; macro-economic factors; and the Amazonian development strategy, 1960s to 1980s.

Deforestation, like most social processes, is the outcome of interacting social (and natural) systems and processes at local, regional, national and global levels. This paper attempts to look at these interconnected processes and mechanisms and policies most directly resulting in the destruction of the rain forest and the impoverishment of many of its peoples.

3.1 Structural Factors

(a) The land tenure system

In Brazil, around 2 per cent of all agricultural landowners own about 60 per cent of the arable land and they fiercely resist any attempt at promoting agrarian reform.

While over half the agricultural labour force is landless, 1 per cent of the families engaged in agriculture controlled nearly two-thirds of the country's farmland. Landlessness contributed to an immense flow of poor rural people to the so-called "frontier" regions of the *cerrado* at first and then to the Amazonian region (Martins, 1982). In 1985, the government launched a modest process of agrarian reform. The programme aimed to provide access to land by some 1,400,000 of 12,000,000 landless people. In fact, only 77,000 received land titles.

The recent fierce opposition of big landowners to agrarian reform has worsened land distribution both outside and within Amazonia and also increased deforestation within the region. Many big landowners, fearing land reform, have burned large tracts of forest, particularly in 1987 when the land reform law was being discussed by the Congress (the New Constitution). They also claimed that agrarian reform should affect only public lands, especially in the Amazon region.

Until recently, huge parts of the Amazonian territory were considered "empty", even though this region was to a great extent the domain of the indigenous population. It was usual for a land speculator to buy thousands of hectares of land and to claim even more. The cheap price of land further stimulated such practices. Additionally, forest burning was regarded as a sign of land occupation facilitating legal possession of these large tracts.

Forest burning was just one method of securing possession. Forest clearing was another condition for receiving fiscal subsidies and incentives. It is important to note that most tax exemptions and subsidized credits went to well-off people with land titles. This contributed to skew further the distribution of wealth in the region. Property ownership is usually a precondition for obtaining investment credit in Brazil. As a result, Amazonia's many sharecroppers, tenants and squatters were effectively denied access to these credit subsidies (Mahar, 1989).

Small-scale squatters are often accused of being a major cause of deforestation in some regions, as in Rondônia. They are, in fact, less of a problem than are the larger ranchers and speculators. If small farmers want to claim a plot of land, they have no legal incentive to clear land beyond the area needed for their shifting cultivation. In Mato Grosso, Goias, Para and Maranhao, claims on public land (*terra devoluta*) have resulted in the allocation of most public land to individually owned ranches, speculators and to large corporations.

> "The reason is that corporations and large ranches have a major advantage over poor individuals in the rush for land: they have the capital to build their own access roads into the forest. This advantage enables them to lay claim on land much farther from major highways than could poor settlers. Small farmers have difficulties in finding land for squatting. They can typically only claim land a few kilometres from public roads, as they could neither market produce nor have access to health or education facilities if they ventured further. Often their only alternative is to invade land that already is clearly privately claimed, leading to land disputes." (Binswanger, 1989)

Another factor favouring deforestation was the subdivision of landholdings. According to Brazilian law, farmers are obliged to leave 50 per cent of their land under forest cover. However, they sell the forested part of their properties to other buyers. These, in turn, will clear half of the forest for pasture and crops, leaving the remaining 50 per cent of the land under forest, until a subsequent sale occurs. In this way, a law ostensibly designed to protect the forest encourages its destruction.

The inegalitarian land tenure system, and the fiscal incentives which backed up this system meant that Amazonia was treated as an escape valve for settling landless people. This very often resulted in destroying the forest and implanting non-sustainable forms of agriculture on a massive scale.

(b) Population dynamics

Brazil has a population density of 17 inhabitants per square kilometre, but it is unevenly distributed (more densely in the south/north-east and less densely in central and northern regions). The population growth rate for Brazil as a whole slowed after the 1960s. Total population continued to grow rapidly, but rural population actually decreased. In Amazonia, however, population growth accelerated sharply after the 1960s and while the region's rural population grew more slowly than urban, it increased by 50 per cent between 1970 and 1980 and by 36 per cent between 1980 and 1989 (see Table 1).

Table 1

Population growth in Legal Amazonia

	Rural	Urban	Total
1940	1,056,628 (72.2%)	405,792 (27.7%)	1,462,420
1950	1,263,788 (68.4%)	580,867 (31.6%)	1,844,655
1960	1,604,064 (62.6%)	957,718 (37.3%)	2,561,782
1970	1,977,260 (49.7%)	1,626,600 (50.3%)	3,603,860
1980	2,843,118 (48.4%)	3,037,150 (51.6%)	5,880,268
1989	3,835,900 (44.4%)	4,804,300 (55.6%)	8,640,200

Source: IBGE (Brazilian Geographic and Statistical Institute) census.

From Table 1, it can be seen that the population of Amazonia grew by some 60 per cent from 1970 to 1980 and even more rapidly during the 1980s. After the 1970s, however, urban population in the region exceeded that of rural areas. Although population growth is part of

the problem, it is not a main cause of deforestation. Population has increased in some areas of Amazonia (such as Rondônia and eastern Para), where deforestation was caused primarily by unsuitable agricultural practices and even more by expansion of large cattle ranches (Sawyer, 1986).

(c) Agricultural modernization in the rich southern provinces

The 1960s ushered in a rapid modernization of the agricultural sector in southern Brazil. This process, which was closely linked with the polarized land tenure system mentioned earlier, had profound consequences on the structure of production, land ownership, employment and the volume and directions of internal migrations. To a large extent, this modernization was induced by government policies that expanded the volume of subsidized credit for the purchase of improved seeds, farm implements, fertilizers and pesticides (Millikan, 1988), and by expanding markets.

Strong international demand for primary commodities such as soya and coffee gave an additional impetus to modernization. In the state of Parana, for instance, a colonization effort directed at small farmers had a very positive result in establishing a prosperous farming society based on coffee and food crops. In 1959/60, Parana had surpassed Sao Paulo as Brazil's top coffee-producing state. Shortly thereafter, however, a series of problems including soil depletion, plant diseases, over-production and lower producer prices precipitated an abrupt decline in the region's coffee economy. Many former coffee-growing areas were converted to a mechanized system of soybean cultivation that required larger farms and fewer labour inputs. Between 1970 and 1980 in Parana, the number of farms smaller than 50 hectares fell by 109,000 units with a combined loss of 890,000 hectares in this category. In contrast, farms larger than 1,000 hectares increased by 450 units with a gain of more than 1,000,000 hectares. During this period the area under soybeans rose from 172,000 to 2.3 million hectares. Many agricultural labourers, especially sharecroppers and other tenants, lost their only source of income. As a result, net migration from the rural areas of Parana reached 2.5 million during the 1970s compared with a net gain of 170,000 in the previous decade. Many of them migrated to the Amazonian state of Rondônia where they started clearing the forest (Mahar, 1989).

Agricultural credit has also played an important role in the modernization of agriculture.

> "While the amount of credit disbursed in the Amazon is small compared to the total agricultural credit volume, it is a significant factor accelerating deforestations. As the income tax preference for agriculture, subsidized rural credit tends to increase the demand for land leading to a more rapid expansion of crop and pasture land. In addition, subsidized credit by encouraging mechanization has reduced employment and tenancy opportunities in agriculture. The system thus increases the movement of settlers to frontier areas." (Binswanger, 1989)

The structural factors, i.e. the land tenure system, the underlying system of incentives, and the increased mechanization of agriculture combined to expel large numbers of agricultural labourers, seeking new sources of livelihood. Other factors affecting deforestation will now be examined.

3.2 Macro-Economic Factors

(a) Unemployment

Lack of employment and income opportunities are pushing large contingents of people to frontier areas and new economic activities, such as gold mining, in the Amazonian region. The number of independent gold miners exceeded 200,000 by 1990. The mining process generates very dangerous and poisonous mercury pollution (mercury is used to separate the

gold from other materials), and destroys aquatic and forest habitats. The local population whose diet depends on fish are now threatened by mercury poisoning, as are the miners themselves.

(b) Inflation

Extremely high rates of inflation in the 1980s induced the urban *bourgeoisie* from the southern states to buy land in Amazonia in order to speculate with and protect their capital. Many industrial and banking interests considered cheap land an excellent investment.

Land speculation explains the conversion of much forest area to pasture. The value of land in Amazonia has been steadily increasing at a rate higher than inflation. This assured high returns to any one who could hold on to a claim and sell it later to someone else. As there were practically no taxes on land and real interest rates were low or negative, land speculation was extremely attractive. An important reason for the increase in land values was the desire of investors to hold real property as a shelter from inflation, rather than as an input for production. Under existing legislation, replacement of the forest with pasture was the cheapest way to occupy the area legally and protect it from take-over by squatters, neighbouring ranches or government agrarian reform programmes. Pasture counted as an "improvement" (*benfeitoria*) to justify the granting of a definitive title (Fearnside, 1989a).

(c) External debt and deforestation

While all of the national-economic factors mentioned above contributing to deforestation were influenced by world markets and other external factors, there is an especially close link between the heavy Brazilian external debt and deforestation in Amazonia. Since the mid-1970s the government decided that Amazonia should contribute greatly to solve its problem of scarce foreign exchange. The export-oriented mining and some livestock projects that affect so much of the forest area, and the livelihood of the local population (mainly the Indians), are closely related to Brazil's external debt, which is the largest in Latin America.

(d) Commodity prices, cereal cultivation and deforestation

It is also important to assess the impacts of the rise and fall of commodity prices, especially of cereals, in the international market in different periods and its consequences on forest depletion. The study of Capistrano and Kiker (1990), although not specifically concerned with Brazil, analyses the impacts of commodity price fluctuations in world markets on developing countries with tropical forests and contributes to a better understanding of deforestation in Brazil.

In the period 1972-75, grain shortages and high international prices apparently had a significant and adverse impact on tropical forests. Forests were depleted as countries sought greater food self-sufficiency, particularly for cereals. The magnitude of the forest depletion of developing countries increased on average by 4.7 per cent to 5.1 per cent for every 1 per cent increase in a country's cereal self-sufficiency ratio, according to this study. For 60 per cent of the countries studied, average export prices of major agricultural crops increased during the first half of the 1970s. This increase may have contributed to forest depletion. In the period 1976-1985, even though world grain prices were falling, efforts to achieve greater cereal self-sufficiency, and the expansion of arable land for this reason, continued to deplete forests. According to the same study, in 1981-1985, every 1 per cent increase in "arable" land was associated on average with a 3.5 per cent increase in rates of forest depletion. Of course, co-variance does not necessarily imply cause and effect.

3.3 The Amazonian Development Strategy - 1960s to 1990s

Introduction

During the military régime (1964 to 1985), the military élite advocated that Amazonia should be occupied at any cost. Some important roads, such as the Belem-Brasilia and the Transamazonica, were built. Colonization schemes were planned and partially implemented along these highways. Other roads were planned and constructed linking several Amazonian capitals. Those roads attracted both large and small farmers. As a result, the extent and rate of deforestation increased significantly.

In the 1960s, the dominant government strategy for the region was based on road construction and human settlements around the newly built highways (Belem-Brasilia, Transamazonica). It was called PIN (Plan for National Integration). One of the main objectives of the Amazonian development programmes launched in 1967 by the military régime was to attract private enterprises to the region (Eglin and Thery, 1982).

This was to be achieved through increased public expenditures on infrastructure (roads, airports, telecommunications) and special fiscal incentives and credit lines for enterprises willing to invest in the region.

The package of fiscal benefits was extensive. It included holidays from the corporate income tax for 10 to 15 years, as well as exemptions from export taxes and import duties. Additional fiscal incentives were extended in 1967 to firms located in western Amazonia (Mahar, 1989). The strategy was to "occupy" the region rapidly, with the state providing support and incentives for investors and settlers willing to participate. The 1970s were an era of organized settlement in Rondônia, provoked in part by agricultural and livestock incentives.

However, by the end of the 1970s, the whole government strategy for the occupation of the Amazonian territory shifted from encouraging small-scale agricultural settlements to one of stimulating export-oriented growth poles based on mining and large cattle raising schemes. In this context, the largest iron project in the world (Grande Carajas) was established in the eastern part of Para. This mining area covers over 895,000 square kilometres, a region larger than France. Large tracts of forest are being cut to provide small and medium iron smelting plants with cheap charcoal.

(a) Road construction and organized rural settlements by INCRA

> "The first road to have a serious impact on the Amazonian forest was the Brasilia-Belem all-weather highway (1,800 kilometres), constructed in 1964. Official estimates suggest that the population jumped from 100,000 in 1960 to 2 million in 1970." (Rezende, 1973)
>
> "Large numbers of migrants in search of land and employment entered the area, as well as firms that wanted to establish cattle ranches. There is no doubt that extensive conversion of forest into cattle ranches took place." (Mahar, 1989)

Organized settlement schemes in Amazonia started in 1972 with the construction of the Transamazon highway under the Programme of National Integration. These were inspired by geopolitical reasoning during the military régime. The plans were to settle 70,000 families from the over-populated north-east where severe land tenure problems exist. Despite a large amount of subsidies and financial aid, at the end of the programme (1974), only 5,700 families had been effectively settled, and only 40 per cent of the settlers were from the north-east. By the end of the 1980s, some 8,000 families had been settled but later on many of them left the area because of difficulties in marketing their products, soil erosion and malaria.

Extensive stretches of the Transamazonian road had to be abandoned and were invaded by forest (Moran, 1988).

Native Amazonians cleared less forest per year than newcomers but they cultivated more of the land that they cleared. It was not uncommon for new immigrants to clear 10 hectares but plant only four or five, because the land had not been adequately burned or because the labour of weeding large fields had been underestimated. Gradually newcomers have learned to clear smaller fields, to manage them intensively, to rely more on manioc and bananas and less on corn and beans (Moran, 1988).

The most successful newcomers to the Amazon rain forest were those who sought advice from local *caboclos* (local backwoodsmen). These settlers diversified their production by planting manioc, peanuts and tobacco. Since the majority of the immigrants responded to the government incentives, there was a harvest-time oversupply of rice and corn and subsequent low prices. Bean production was low in all years due to plant disease. But manioc, the traditional Amazonian crop, could be made into flour, thereby providing a steady cash flow. Since it was relatively scarce, it fetched a prime price. Many successful newcomers also took wage-paying jobs. Frontier settlements everywhere are characterized by a scarcity of labour, particularly skilled labour, so that wages tend to be high relative to those in old settled areas. A third settler-family strategy that worked well was to adjust the workload to the amount of available household labour instead of relying on bank credit and hired hands. Although most rural settlements along the Transamazon highway were failures, the settlement programme by INCRA (Agrarian Reform Institute) in Rondônia was more successful in settling thousands of landless peasants from the south (Moran, 1988). During this same period, however, huge amounts of incentive payments were distributed by SUDAM (Amazonian Development Agency) to corporations and large farms to promote cattle raising in the region (Oliveira, 1988).

Another important organized settlement experience was the BR-364 linking Cuiaba to Porto Velho (see map). The soils of Rondônia are much better than those of the rest of Amazonia and attracted landless peasants from the southern states. In the 1960s, Rondônia had still been only sparsely populated by rubber tappers.

As with the earlier Belem-Brasilia highway, the completion of a dirt road linking Rondônia to the rest of Brazil caused a strong migratory flow. The National Institute of Agrarian Reform (INCRA) started a colonization programme to settle 28,000 people on 2.7 million hectares, between 1972 and 1975. By 1977 another 28,000 were waiting to be settled. Although the plans were for settlers to grow food crops and perennial trees, cattle ranching was extensively practised, causing serious problems. The ecological results of the massive influx of migrants to Rondônia was accelerated deforestation. Over 25 per cent of the state's tropical forest was cut by 1988.

The impacts of these two highways on the forest were very negative. The Transamazonian highway programme, however, was estimated to be responsible only for 4 per cent of Amazonian deforestation because many of these plans failed (Browder, 1988). The effects of highway construction on areas reserved for indigenous populations, and protected areas, were also devastating as these reserves were continuously invaded, especially by large ranchers.

Pasture for cattle is the main land use in deforested areas of Amazonia. It is much more important than the impact of small farmers on the forest. Although the incentives for cattle ranching have been temporarily discontinued, the impact of this land use promoted by previous decades of government financial assistance and other incentives is very large. Many studies have shown the non-sustainability of cattle ranching in the region (Hecht, 1985; Fearnside, 1989a). These studies showed that the initial enrichment of soils (from cutting and

burning of biomass) was at the expense of the total available nutrient stocks in the ecosystem, which gradually declined thereafter. Lacking the defenses of the diversified natural system, within a few years, many pastures were invaded by pests and weeds. These problems caused ranchers to overgraze and in some areas, such as Paragominas, to abandon degraded pastures.

The high costs of chemical fertilizers (the Amazon has no known phosphate deposits) and of weed control meant that ranchers found it more profitable to clear new forest than to recuperate old pastures.

Agribusinesses account for a small portion of the cleared area relative to pasture, but one that could expand significantly. There are large-scale plans for financing mechanized agriculture and associated industries in the Grande Carajas area (Fearnside, 1989a).

It is clear that large agricultural and cattle raising projects (combined with land speculation) were responsible for most of the deforestation if one compares them with the deforestation caused by small farmer settlement projects, as in Rondônia. Very often, the large projects have expanded their holdings by buying out or expelling small farmers from their lands. Frequently, small farmers were used by large companies to clear the forest, to plant food crops for one or two agricultural seasons and then to plant pasture. Gall (1978) describes this situation as follows:

> "The companies arrive in the jungle with airplanes, agronomists, lawyers, political connections, government money and hired thugs, known as capangas, whose job is to protect disputed land boundaries from invasion by new squatters and to evict families from land claimed by the company. The companies buy, at low prices, large tracts of forest in which some squatters may already be living; they also tend to buy land from the initial wave of pioneer settlers. Sometimes the squatters are paid to leave. Sometimes their houses are burned by the capangas and their subsistence plots sown with pasture grass seeds from overflying company planes to stop squatters from growing more food. Sometimes the capangas maim or kill recalcitrant squatters, and sometimes the squatters wait in ambush for the capangas and successfully resist eviction. Conflicts and violence have quickly become legendary to these regions." (Gall, 1978: 4)

(b) Investment tax credits and fiscal incentives for large-scale agricultural and cattle raising schemes

"Incentives" formed a very important part of the new development strategy, which was undertaken from the mid-1960s. Brazilian corporations could take up to 50 per cent credit against their federal income tax liabilities, if the resulting savings were invested in projects located in Amazonia and approved by SUDAM. The tax credit mechanism proved to be very attractive to investors and by late 1985, about 950 projects had been passed by SUDAM.

From 1966 until 1988, when formation of new subsidized projects was temporarily discontinued, 581 were in the field of agriculture and cattle raising, 40 agro-industrial, 274 industrial and 52 in the area of services (Oliveira, 1989). From these agricultural and cattle raising projects, 37 per cent were established in Para, 35 per cent in Mato Grosso, 9 per cent in Goias, 5 per cent in Amapa and the remaining 14 per cent in Maranhao, Amazonas, Acre, Rondônia and Roraima (Oliveira, 1989).

These projects occupied an area of over 9 million hectares. The average area per project was 7,000 hectares in Amazonas, 14,100 in Goias, 16,300 hectares in Para and 31,400 hectares in Mato Grosso (Oliveira, 1989). Many of these projects belonged to national groups and to international corporations or to multinational capital associated with national groups. One study (Eglin and Thery, 1982) identified 19 multinational groups in Amazonia, owning around 7,342,000 hectares of land for logging, cattle raising and agricultural projects. The Jari

Florestal alone (National Bulk Carriers), which by that time belonged to Daniel Ludwig-USA, owned around 3,200,000 hectares of land in Para and Amapa. Several groups owned over 300,000 hectares. Most of this land belonged to groups from the United States, Canada, Japan and the United Kingdom.

Most of the projects were subsidized through SUDAM and FINAM. Projects funded by FINAM were responsible for 21 per cent of the deforestation in the state of Mato Grosso. If all the planned projects were fully implemented, they would be responsible for 31.7 per cent of all deforestation in Mato Grosso and 9.8 per cent in the state of Para (Yokomizo, 1989). Fortunately, the degree of project implementation was low and some deforestation was at least temporarily averted. Of all agro-industrial and cattle raising projects, only 15 per cent were in fact fully implemented, 8 per cent were cancelled and 4 per cent did not even start. The majority of these projects (73 per cent according to Yokomizo), were in the process of being implemented in 1988. Of these 384 projects, 58 per cent had been receiving subsidies for over 15 years. The costs of implementation were much higher than foreseen in the beginning. Many projects on the verge of bankruptcy were resold to new owners who applied for additional fiscal incentives.

A survey undertaken in 1986 concluded that of 92 projects surveyed only three were profitable (Yokomizo, 1989).

(c) Fiscal incentives and logging

The Amazon basin is an enormous warehouse of tropical timber. An estimated 260 million hectares of the forested Amazon basin located in Brazil support some 50 billion cubic metres of standing wood, of which about 15 million cubic metres are currently marketable. The Brazilian government policy of fiscal incentives has also favoured industrial wood producers. The combination of subsidized programmes and the government financed road system stimulated a massive shift in logging investment from southern Brazil to the Amazon. Wood production grew 4,000 per cent in the 1970s in Para alone (Schmink, 1988).

Of several hundred commercially usable species, only about 20 are well known on the international market for sawn lumber. Industrial wood producers in Brazil respond to foreign demand by increasing specialization in a relatively small number of species, such as virola, cedar and mahogany. At the same time, there is a big waste of logs by sawmills. Moreover, the impact of logging on the forest should not be overlooked. Some 400,000 hectares of native forest are affected each year by the operations required to extract 20 cubic metres per hectare of commercial species (Schmink, 1988).

Millions of cubic metres of marketable wood were simply lost, either in the establishment of ranches or in the construction of large dams. As the demand for logs increased, particularly in the southern markets, logging was carried out in extensive areas. During the process, only a few cubic metres of selected wood were extracted, but disproportionate damage was done to the forest due to unsound logging practices (Capistrano and Kiker, 1990). Typically, at least half of the remaining stock, including immature trees of commercial value and harvestable stocks of less desirable varieties, were damaged beyond recovery (Repetto, 1990).

Lumbering is also becoming an important factor in incursions into indigenous areas in Rondônia, Acre and the western parts of Amazonia. Logging roads serve as entry routes for squatters who clear parcels in the hope of securing legal land claims. Indian reserves such as Pacaas Novas (in Rondônia) are being logged to supply saw mills in Ouro Preto.

Logging in *terra firme* is rapidly destroying species such as *cerejeira* (Amburana acreana) and *mogno* (Sweitenia macrophylla). In the flooded "*varzea* forests", the first to be affected, many commercial species are disappearing.

Timber resources also play a role in the struggle for land control. Land grabbers often sell off the valuable tree species from their properties first. They then sell the land itself. Conflicts also arise between sawmills competing for access to increasingly distant sources of valuable timber. Penetration into the forests of indigenous reserves may lead to confrontations with native groups or with the authorities.

Compared to other activities in the area, industrial wood production creates more stable jobs and better working conditions than do most other Amazonian businesses. Some settlements are created in a logging area, but as soon as the forest is logged, many of them disappear (Schmink, 1988).

> "With greater control and management there is a potential for sustainable forestry management and wood processing in Amazonia. Already two-thirds of Brazil's exported sawn wood comes from the Amazon and both domestic and international markets for wood products and derivatives are good. A new emphasis on sustained-yield tropical forestry, forest management and agroforestry is emerging as a priority in the region." (Schmink, 1988: 169)

(d) Large development projects in Amazonia (e.g. the mining project of Grande Carajas, south-east Para)

In the mid-1970s, the government essentially abandoned the strategy of organized settlements and created "Pol-Amazon" based on the creation of 15 growth poles. These poles are essentially based on mining operations and related activities, although they also include large agricultural and livestock schemes around these poles. Given the country's requirements for foreign exchange to pay growing external debts, the government felt that exports from Amazonia could greatly contribute to foreign exchange earnings. In 1980, the Great Carajas Programme was established to exploit the extensive reserves of iron, copper, manganese, cassiterite, nickel, bauxite and gold. The estimated reserves of iron in Serra dos Carajas, located 550 kilometres south of Belem, are 18 billion tons. The programme covers 895,000 square kilometres, more than 10 per cent of the total territory of Brazil (Valverde, 1989).

The first project was the exploitation of iron ore reserves by a state company - Companhia do Vale do Rio Doce. Besides the development of the mine site, the project included the construction of a 900 kilometre railroad to the harbour of S. Luis do Maranhao (already built) and the construction of a dam (Tucurui), flooding 2,435 square kilometres to provide cheap subsidized electricity to the aluminium producing facilities established by multinational companies along the Amazonian coast. The Vale do Rio Doce Company commissioned a series of studies on the environmental impacts of its activities. These attempted to estimate the effects the projects would have on soil erosion, the vegetation, regeneration of fauna, etc. The situation in the area around the mining projects has proved very problematic. There is accelerating forest degradation as well as conflicts over land rights. The county of Maraba, where Serra dos Carajas is located, doubled in population from 1980 and 1985, creating huge problems for the educational, health and employment sectors (Mahar, 1989).

In the electric energy sector the situation is also very serious. The government intends to build dams in several Amazonian regions, destroying 841,200 hectares of forest, and affecting the habitat of several Indian and riverine populations. Fish migration patterns will be seriously affected, and thus the main supply of protein for local populations will be limited.

In Grande Carajas, over 15 pig iron and manganese iron projects using charcoal have been approved. Although it is planned that these plants should use wood from forest plantations (eucalyptus), the plants, which are already operational, employ charcoal from virgin forests. These plants would require 12 million tons of charcoal per year. This implies that between 90,000 and 200,000 hectares of forest would be cut yearly to provide charcoal. As wood from

the proposed eucalyptus plantations would not be available until seven years after planting, the total deforestation would reach over 1 million hectares, that is some 12,000 square kilometres of forest (Fearnside, 1987). In fact, it is expected that small farmers will produce most of the charcoal, leading to serious environmental and health problems. In addition, farmers would be shifting from charcoal to food production. Accelerated erosion and land deterioration are expected from these devastating practices (IDESP, 1988).

Conclusion

The main objective of the Amazonian development strategy was to "occupy" the Amazon. In the early years, the policies focused on settling poor, landless farmers from the north-east and the south of Brazil in the "empty" forests of the Amazon. These policies only proved partially successful, for a variety of reasons, and therefore were not a major cause of deforestation.

The building of an extensive road network connecting the Amazon to the rest of the country, however, had a very negative impact on the Amazonian forests. Foreign "aid" and investments too played a key role: loans from the World Bank, IDB, and other financial institutions have funded roads and other infrastructure that have heavily contributed to deforestation.

The new settlers in the Amazon are not the main "cause" of recent deforestation. Incentives offered by the state to large-scale agricultural and cattle raising schemes have resulted in extensive deforestation.

One important condition for receiving fiscal incentives and subsidies is evidence that the land was actually being used. Use of the land was regarded by the authorities as basically synonymous with forest clearing.

> "The rules of land allocation encourage rapid deforestation on individually owned ranches, because the final amount of land that receives title under regularization is a multiple of the area converted to pastures. In addition, clearing land provides protection against small squatters and land invasions, as squatters do not invade land already converted to pasture." (Binswanger, 1989)

Cattle ranching, in many cases, has proved a non-sustainable activity, but cattle ranchers have preferred to abandon degraded pastures and expand their activities to other forest areas. State incentives to loggers have also resulted in massive deforestation. Even a superficial comparison would show the wide differences in the rates of deforestation. The settlement schemes of the 1970s aimed to settle 70,000 families from north-east Brazil, but eventually, only 8,000 families actually officially settled. There is no estimate of the unofficial settlers. Logging, however, affected 400,000 hectares in Amazonia annually; 800,000 hectares of forest land were taken over for the Grande Carajas project, and one study of multinational firms in the Amazon showed that over 7,000,000 hectares of land were appropriated for agricultural and cattle raising projects. It should be remembered that some of the land deforested by the cattle ranchers was originally cleared by new peasant settlers and small cultivators.

The remaining sections of the paper deal with the environmental and social impacts of this deforestation.

4. Environmental Impacts of Deforestation

Increasing deforestation in Amazonia has already had significant environmental impacts in the region. Its consequences will increase even more dramatically if the deforestation trends continue.

Two types of impacts, global impacts and regional/local impacts, can be observed:

4.1 Global and National Impacts

(a) The greenhouse effect

Atmospheric carbon dioxide worldwide has increased exponentially since the mid-nineteenth century. Most of the CO_2 increase has resulted from burning fossil fuel. It is now recognized that the burning of forests is also an important contributing factor to the increase of CO_2 in the atmosphere. Not enough information exists, at present, on how much the burning of the Amazonian forests contributes to this process. There is accumulating scientific evidence that increased atmospheric CO_2 is associated with a warming trend in the global climate because of the "greenhouse effect" produced by CO_2 and some other "greenhouse gases" in the atmosphere. Fearnside (1988) suggests that if all the Amazonian forests were converted to pasture, some 50 billion tons of CO_2 would be thrown into the atmosphere. If all the Amazonian forest were cut during a 50-year period, one billion tons of CO_2 would be thrown into the atmosphere annually. Some of this CO_2 would be recaptured by the natural regeneration of the forests. As some five to six billion tons of CO_2 are produced annually by the burning of fossil fuel, deforestation in the Amazon would represent around 20 per cent of total CO_2 emissions. The actual rate of deforestation would represent a contribution of five to six per cent of the total. One additional aggravating factor is the construction of huge hydroelectric dams in the region. As the flooding of the reservoir is usually made without removing the trees, large quantities of gases from decaying vegetation are thrown into the atmosphere.

(b) Changes in the hydrological cycles

Forests play an essential role in the maintenance of the hydrological balance of the Amazonian region and of the Brazilian territory as a whole. They play an important part in maintaining the high rainfall pattern of the region as forests retain the run-off of the water from rainfall. When large tracts of forest land are converted to pasture, the run-off of the waters into the rivers and *igarape*s (streams) is much higher. The forest plays an essential role in the transportation of water vapour through cloud movements into the agricultural areas of southern Brazil. This phenomenon has been investigated by the Goder Institute of New York (Fearnside, 1988). Less water transported to the agricultural regions in southern Brazil may be already changing the rainfall patterns in that area and damaging harvests.

The situation may become even more dramatic during the dry season in the Amazonian region. Fearnside (1985) states that there is already a hydrological stress in some areas during the dry period. According to this scientist, the dry season already poses severe limits on many agricultural activities in the region. During the 1979 dry season, Manaus had 73 days without a single drop of rain. Ground water levels fell precipitously both in the open and under forest cover, where trees continued to transport water vapour to the air from their large leaf areas.

"Bare soils as under pasture conditions absorb water at less than a tenth the rate, with consequent major runoff (and erosion). The water simply is not available under deforested conditions to be returned to the atmosphere. This carries the serious implication that beyond a certain point, deforestation in the Amazon would trigger an irreversible drying trend." Salati and Vose (1984) estimate that total deforestation of Amazonia would lead to a 600 mm reduction in annual average precipitation. In the central Amazon, as in the Manaus area, a considerably smaller reduction in rainfall could have severe consequences on the local biological landscape. Obviously, a combination of forest and tree cover over a certain area is necessary to maintain the integrity of the hydrological cycle. The amount necessary is not known, and will depend in part on the contributions (currently unknown) of various forms of land use to the hydrological cycle.

Again, it is of interest to note that "the forms of land-use most likely to sustain the hydrological cycle are those that most closely approximate the natural vegetation" (Lovejoy, 1985).

4.2 Regional/Local Impacts

Other ecological consequences of deforestation are primarily local. A few of these are mentioned below.

(a) Impacts on soils and agricultural land

People not familiar with the Amazon region have the illusion that the area is flat. Although some parts of the basin are quite level, there are many steep slopes. With deforestation, erosion starts to become a serious problem as it causes significant soil losses when soils are exposed by cultivation (Fearnside, 1985).

After the forest is cleared, the nutrient stock in the soil usually declines unless replaced by fertilizers. The balance of nutrient losses and inputs may have a link also with the proximity of natural stands of vegetation. Nutrients may be transported in the air from forest edges into adjacent areas. If vast areas of forest are cleared, this transportation of nutrients from adjacent areas may not occur (Fearnside, 1985). Moreover, forest clearing leads to soil nutrient losses through leaching; the fixation of many of the nutrients originally present, or added from ash when forest is burned, constitutes a serious problem.

(b) Impact of deforestation on traditional shifting agriculture

The traditional shifting agriculture which has been practised for centuries in the region had little effect on the environmental balance: the cultivated areas were small; the fallow periods were very long, normally between 10 to 15 years; and usually only patches with relatively good soils were cultivated. The whole situation changed when large tracts of forest were cleared and the land was occupied by pasture. Forms of agriculture which require regeneration of second growth, such as shifting cultivation, are likely to be modified when the surrounding forest has been cleared. These changes often involve shortening the fallow period to a point where vegetation and soil quality are degraded, jeopardizing the system's sustainability. Uhl (1989) has thoroughly studied the impact of shifting agriculture on the forest. He concluded that in traditional shifting agriculture, cultivated areas were small and surrounded by forest, the transportation of seeds from surrounding trees was high and regeneration of the forest cover started soon after harvesting. This regeneration does not take place in the same way when large tracts of forest are converted into pasture.

> "Autoregeneration of the forest is a forest management long employed by shifting agriculturists (Indian and indigenous people). After deforestation, an area is immediately planted with small subsistence crops (e.g., rice, beans, corn and manioc). After two or three years, and a decrease in soil fertility, the site is abandoned and a new one prepared for subsistence agriculture. In the deserted location, a regeneration of forest begins with a secondary forest called capoeira. In this type of forest, small clearings are formed in the middle of the forest. All have the genetic potential for regeneration of the original forest ... After some decades, the "capoeira", when viewed from above has the appearance of a continuous forest but the trees are of less girth than in the original forest. ... Deforestation of large areas is quite different from that of shifting agriculture and natural regeneration is problematic. First, some species may be totally destroyed and with no chance of remaining trees assisting in the regeneration of the vegetation. Secondly, there may be a high level of erosion with very great disturbance in the biogeochemical cycles hampering vegetation growth. ... When permanent agriculture is established, there is a total modification of the ecosystem. There is no recycling of nutrients and productivity will only be maintained through continuous application of fertilizers. Water and energy cycles will also be affected." (See Lovejoy, 1985, p. 45.)

(c) Impact on traditional floodplain agriculture

The floodplains of Amazonia, which represent some 5 per cent of the whole territory, have been traditionally used for cultivation of species such as rice, cassava, and more recently for jute fibre. This kind of agriculture has been practised by indigenous and riverine populations for centuries (Meggers, 1987). *Varzea* (floodplain) agriculture is likely to become more risky with continued deforestation of watersheds, because it may alter the flooding cycles. Watershed deforestation usually results in faster run-off after rain, as less water is retained by the vegetation and its associated porous soils (Diegues, 1989).

(d) Impact of deforestation on traditional inland fisheries

Most of the settlements of Amazonia were until recently concentrated along the watercourses which serve the region as a natural highway system. The *varzea* and *igapo* are a current focus of development interest because they enjoy an annual replenishment of nutrients in the alluvium. Recent studies by Goulding (1980) have considerably expanded our understanding and appreciation of this relationship whereby, often, the major component in the diet of many fish species is organic matter (fruits, seeds, etc.) which falls into the water during high water periods of the year. Indeed, this is common knowledge among *caboclos* and indigenous people such as the Tukano. The latter deliberately retained forests close to water sources in order to protect this relationship and thus their fisheries (Lovejoy, 1985).

Around 75 per cent of the commercial fishing of Amazonia depends on this forest-river relationship. Among the poorest residents of Manaus, for instance, fish supplies a third of the protein in people's diets. Several species of fish, such as *tambaqui* (Colossoma macropomum) spend part of the year in inundated *varzea* forest of white water rivers consuming fruit produced by a variety of tree species. Goulding (1983) has shown how *tambaqui* and 34 other fish species utilize 40 different fruit seeds in flooded forest areas of Rondônia. This is most remarkable biologically as carnivora is the overwhelming dominant mode for fish and Amazon fish must have descended from carnivorous ones.

If the rice and fish yields are compared, the volume of rice is greater but the fish provide more protein. Certain areas could, therefore, be designated for rice, while others could be set aside to provide fishery support and could also serve as sites for fish culture (Lovejoy, 1985).

(e) Impact on forest productivity

Deforestation eliminates the production of Brazil nuts (Bertholletia excelsa), natural rubber (Hevea brasiliensis), rosewood oil (Aniba dickel) and timber. Areas with concentrations of these potentially renewable resources are, in many cases, deforested and converted to pasture. Brazil nut trees in the state of Para have, since the nineteenth century, been granted to *castanhistas* (Brazil nut barons), who enjoy legal title to them. This has raised the value of the land for sale to speculators. Clearing the rain forest closes forever different options for sustainable management of forest resources (Fearnside, 1989b). Many pharmaceutical uses of these products have barely begun to be tapped. Loss of the rain forest, for example, is considered a major setback in the effort to find anti-cancer drugs (Myers, 1976).

(f) Impact on biological diversity

> "A high degree of endemism exists among Amazonian species: many species occur in limited ranges. The potential loss of genetic diversity from deforestation in the Amazonia has been a major concern of biologists worldwide. Some reasons for conserving genetic diversity include the potential for discovery of new organisms of economic value, or finding new uses for already known organisms; this includes new crop plants and variety. Ecological diversity, as well as genetic diversity in the strict sense is quickly destroyed by deforestation. Often complex, convolved associations go extinct long before the lost individuals of the species involved disappear." (Fearnside, 1985)

5. Social Consequences of Deforestation

The social impacts of deforestation are different for the region's various socio-occupational groups. Some of these differential consequences are summarized below.

(a) Traditional riverine populations

The occupation of Amazonia, which has been described earlier, took place before the 1970s, primarily along its numerous navigable rivers. Most of the population lived along these rivers in the *varzeas* (floodplains), gaining their livelihoods from fishing, extractive activities and hunting. Recent development programmes which concentrate on *terra firme* areas, have tended to neglect this population.

Rivers and lakes have suffered negative impacts from large development projects (siltation, decreases in productivity, etc.) and dangerous pollution from gold-mining activities. The same processes have affected the Indian communities living along the *igapos* and *igarapes*. This riverine population, which has one of the highest rates of fish consumption per capita in the world, derives most of its protein from fishing. It has also suffered from the impact of industrial fishing. Bloody conflicts ensue between traditional fishermen from many Amazonian lakes and outsider commercial fishermen who arrive in large motorized boats to fish in the lakes (Hartman, 1989). Over-fishing has been reported for many species (Junk, 1983).

The construction of big dams is also changing the migration patterns of many Amazonian fish as they are now confined in the reservoirs (Petrere, 1989).

The deforestation of floodplain forests also contributes to the decrease of fish resources as many species feed on tropical fruits and seeds, as described earlier.

As a result of these impacts, traditional riverine populations are losing income and employment opportunities. Their health conditions, too, have deteriorated, particularly due to mercury pollution.

The construction of roads parallel to rivers has diverted many health and education facilities to new population centres in *terra firme*, thereby depriving the riverine population of these basic services. As a result, out-migration from the *varzeas* is severe (Diegues, 1989).

(b) Consequences of deforestation for the "extractivist" population (rubber tappers, Brazil nut gatherers, etc.)

In Amazonia a large rural population relies on the forest and its products for survival. According to Alegretti (1987), around 1,500,000 persons (32.9 per cent of Amazonian rural population) harvest forest products, combining this activity with subsistence agriculture and fishing. This calculation does not take into account the Amerindian population of around 220,000 persons who also rely on forest products, such as rubber, oils, fruits and fibre.

While extractive production has declined in terms of the share of the total dollar value income generated in Acre, Amazonas and Rondônia from 1970-1980, it is still of substantial economic importance and its value continues to increase in absolute terms. In Acre, while the area occupied for extraction decreased from 1970-1980, and the areas of cattle ranching and agriculture increased dramatically, the per hectare value of extraction increased much more than either meat or crop production. At the same time, rubber exports increased as a share of overall exports from the state. An increasing export value with a decreasing area of exploitation and an increasing per hectare cash value, suggest that extraction is a very attractive development alternative, compared to cattle or agriculture. The greater sustainability of extractive activities and the fact that they do not destroy forests makes it an even more attractive long-term alternative from a social viewpoint.

> "Despite rapid transformation of large parts of Amazonia and massive incentives offered to cattle ranching and agriculture, extractive production has continued to be economically significant. ... In 1970, total vegetal production (extraction, agriculture and wood) for the states of Acre, Amazonas and Rondônia was worth approximately $72,439,780. Rubber (Hevea) alone accounted for 17.9 per cent of this value and extractive products (rubber, Brazil nuts and a few other nuts, oil and fibres) as a whole for 23 per cent. Manioc is the single most valuable crop, accounting for about 28 per cent of the total value in the three states. By 1980, the percentage of extraction falls to about 14.9 per cent. If wood production, insignificant in the three states in 1970, is counted, wood and extraction account for 21.5 per cent of the total value. This change is because of the change in production in Rondônia, which is in turn related to migration to Rondônia in the decade (where the population increased from 111,064 to 491,069 or 342 per cent). In the same period, manioc falls to 18.6 per cent of the total value. Rubber and manioc still account for about a third of the total production of vegetable products and manioc remains basically a subsistence crop. In Acre and Amazonas, rubber actually increases as a share of the total value of vegetal production over the decade." (Schwartzman, 1988)

From 1970 to 1980, extractive production was worth more than cattle production in all three states.

Assuming that a hectare of land held for cattle ranching in Acre in 1980 lasts 10 years and yields the same output throughout, and then becomes unusable after 20 years, a hectare of this land will yield $37.20, while a hectare in extractive production will yield $179.80 (Schwartzman, 1988).

At present, there are two principal systems for production of rubber tapping. The first is a traditional system, in which the *seringalista* (rubber baron) is the owner of the land. Under these conditions the *seringueiros* (rubber tappers) are forced to deliver all of their production to a single patron, who usually provides tools on credit and who has total control over and access to the market. He provides merchandise (sugar, salt, kerosene, etc.) in advance and collects the rubber at the end of the season. Debt peonage was the common result of this system, since patrons controlled prices both of the rubber and the merchandise. The bonded *seringueiro* was always in debt with the *barracao* (warehouse), because of this peonage system, locally called *aviamento*.

In the second system, "free *seringueiros*" have some control over the land they use and are not dependent on the "*aviamento* system". Since the 1960s, entrepreneurs from the south have arrived in Amazonia, buying large farms for cattle raising. They bought large tracts of forest with rubber trees. At the same time, some traditional patrons (*seringalistas*) withdrew from several regions and the remaining rubber tappers felt free to sell their production to independent middlemen or *marreteiros regatoes*. Autonomy for rubber tappers, however, did not mean prosperity or security on the land. Autonomous rubber tappers were, in fact, frequently in debt to the middlemen who bought their rubber and sold them goods. Also they were subject to expulsion from the lands they occupied without title (Schwartzman, 1988).

The *seringueiros* traditionally live in *colocacoes*, which are both areas and productive units in the forest. In the centre of his *colocacoe*, the *seringueiro* family builds a house made of *paixiuba* (a palm tree). Most of the *colocacoes* are established at the side of a *igarape* (small river). This production unit is customarily around 300 to 600 hectares in area. The latex is collected from the rubber trees and transformed into rubber through smoking over a fire. In the *colocacao*, shifting agriculture, hunting and fishing are also essential livelihood activities.

Every day, the *seringueiro* walks several kilometres through a path called *estrada da seringa*. In order to earn a minimum income, the *seringueiro* has to extract latex from 100 to 150 trees

daily, producing around 500 kilograms of rubber. In order to survive, each *seringueiro* has to work some 200 to 300 rubber trees (Allegretti, 1990).

There is no division of labour in the rubber extraction process. The tapping and transformation into latex is done individually by the *seringueiro*, who stays the whole day in the forest. Under these conditions, each *seringueiro* family is very isolated as *seringueiros* are dispersed throughout the forest. As explained above, the main outside contact of the *seringueiro* is with the *barracao*, a warehouse belonging to the rubber baron, where he buys what he needs at a high price. The free *seringueiro* deals with the middleman (*regatao*) from whom he buys the goods he needs.

The impact of deforestation on the *seringueiros* is frequently disastrous. From the beginning of the 1970s, with the state policies of encouraging occupation of Amazonia based on cattle raising and fiscal incentives, the situation of the rubber tappers worsened dramatically. These policies contributed to changes in land ownership and use that deprived the rubber tappers of access to their traditional sources of livelihood.

Since the 1970s, there has been an increasing concentration of land in the hands of a few large owners, most of them coming from the south. At the same time, the number of smaller holdings has increased. In Acre, for instance, between 1960 and 1970, the area predominantly devoted to extraction fell by 65 per cent, while the area devoted to agriculture increased 410 per cent and cattle ranching by 132 per cent. During the same period, the number of holdings devoted to extraction increased by over 1,000 per cent, implying that the traditional rubber-producing estates were fragmented as rubber barons withdrew or sold out and independent rubber production was taken by free rubber tappers. In 1970, the number of holdings smaller than 500 hectares represented 57 per cent of the total number of holdings while in 1960, these were only 9.5 per cent of the holdings (Schwartzman, 1988). However, the number of small producers, particularly renters and occupants, increased. This reflects the emergence of autonomous rubber tappers who are largely occupants with precarious tenure or, in some cases, renters.

Many large rubber tree and Brazil nut tree areas are being quickly transformed into cattle ranches. Although these trees are protected by law and should not be cut, all other trees are usually cut and burned. This hinders the survival of the protected trees which remain semi-burned and isolated in the middle of new pastures.

One of the areas of widespread destruction of Brazil nut and rubber trees is the southern part of Para where many large cattle-raising farms have been established. In the same area, pig iron plants are being developed and, as a consequence, large areas of those valuable trees are being cut and burned for charcoal. At the same time, logging activities are increasing dramatically which is another activity responsible for the destruction of Brazil nut trees (Allegretti, 1987).

The expansion of cattle ranches and other large (usually speculative) holdings is responsible for the expulsion of the *seringueiros* from their traditional lands and activities. Many of them became wage earners on the ranches or have migrated to the outskirts of the new towns of Amazonia. Often they become temporary workers, migrating from one place to another, or have entered gold-mining activities as *garimpeiros* (small artisanal miners). The shift of many *seringueiros* from being “captive rubber tappers” to “autonomous” ones led to their becoming main actors in the resistance to deforestation. Their struggle will be analysed in a later section of this paper.

As a result of the increasing deforestation, the access of the rubber tappers to the natural resources on which they depend is decreasing. Not only are the rubber tapping areas being

reduced but deforestation is also affecting the availability of fish in the *igarapes* and game from the forest which deprives traditional residents of their main sources of protein. Many rivers are also being polluted by mercury used by the *garimpeiros* (Petrere, 1989), as noted earlier.

As a consequence of losing traditional livelihoods, many *seringueiros* have moved to Bolivia and Peru. According to estimates by rubber tapper leaders, some 50,000 *seringueiros* crossed the border to Bolivia during the 1970s and 1980s after being expelled in land conflicts. Many others are now living in slum areas of Rio Branco and Porto Velho. Capital cities, such as Rio Branco, registered population increases of over 10 per cent annually between 1970 and 1980.

Urbanization is rapid in the whole region, but most of the newly created cities (and the old ones) lack the basic facilities for health, education and employment. As most of the new migrants lack expertise in urban activities, they join the increasing number of underemployed and unemployed people of the region.

(c) Consequences of deforestation for the Indian population

The Indian population in Amazonia is the single human group suffering most from deforestation and related large development projects such as mining, dams and road construction.

Since the European colonization of Brazil began 500 years ago, the number of indigenous people is estimated to have declined from 5 to 6 million people (some authorities have estimated many more) to its current level of around 220,000. These survivors speak over 140 languages and dialects. Prior to the arrival of the Europeans, the indigenous population was widely distributed across Brazil, It consisted primarily of hunter-gatherers, many of them living in the Amazon Forest. These Amazonian peoples were the last indigenous groups to be destroyed by contact with the colonizers, mainly because they lived in isolated forested areas. The progressive displacement of indigenous people resulted from physical extermination, enslavement and especially the spread of new diseases to which they had no resistance. Some 70 per cent of the remaining indigenous population lives in the north and central-west regions where Western style “civilization” has only recently appeared (CEDI, 1987).

After 1910, the Brazilian authorities adopted measures designed to protect native people from the most extreme forms of violence and other conditions leading to long-term population decline. Some institutions like FUNAI (previously SPI) were created to protect the Indian communities but their activities were often ineffective in checking continuous aggression by outsiders and sometimes even abetted it. It is estimated that during the first half of the twentieth century alone, some 87 distinct Indian groups were exterminated (Farren, 1989).

The main policy to protect Indians has been to establish “reserves”. By 1990, some 27,000,000 hectares of land had been set aside as “reserves”, almost half of this area was included in the last four years. However, many of these reserves have not been physically delineated. As their limits are not clear, invasions by loggers, *garimpeiros*, large companies, ranchers, speculators and others are easy and frequently lead to open conflicts. The extension of these reserves is often criticized by large agricultural and mining interests with the argument that too much land has been allocated to too few Indians. Other Brazilians, however, suggest that these Indians have inhabited those areas for centuries and that they require access to large areas of forest in order to survive. Moreover, they point out that in Brazil, the land controlled by only a few *latifundiarios* is far more than all that has been set aside as Indian reserves.

There are four main immediate threats to the Indian lands. These are mentioned below:

(i) The invasion of *garimpeiros* in gold and cassiterite mining operations is the single most important threat to the Indian reserves today. Amazonia has one of the largest mining regions in the world. In the Indian reserves one finds gold, bauxite, cassiterite, etc. Many Indian areas have already been recently invaded by the *garimpeiros*. The most well-known example is the invasion of the Ianomami land, along the Brazilian border with Venezuela. These invasions started in 1974, during the initial phase of the Perimetral Norte highway which crossed these lands. In 1984, there was a massive invasion by some 2,000 *garimpeiros* in the Surucucu Mountains. Since then, thousands of Ianomami have died either from direct violence or from diseases transmitted by the *garimpeiros*. Over 80 airfields have been constructed illegally in the Ianomami region to bring in *garimpeiros* and supplies. In a controversial decision, the government has recently decided that the Inanomami reserve should be a discontinuous territory, allowing for mining and logging in the "buffer zones". This decision will contribute to the disintegration of the traditional Inanomami culture (Cunha, 1989). The situation is complicated by the fact that, legally, subsoil resources remain the property of the state in Brazil even in lands set aside as reserves.

There are now around 22 Indian reserves invaded by *garimpeiros* according to the CEDI Report (1989). An additional 560 mining concessions had been granted and over 1,600 other petitions for mining concessions are awaiting approval. Over 77 of these concessions would be located in Indian land.

Mining operations in the Indian territories are leading to the destruction of the riverine forests which nourish fish which are the main protein resource of the Indian communities. In addition, hundreds of kilos of mercury are being thrown into the rivers, *igapos* and *igarapes*, contaminating fish and Indians alike.

(ii) Commercial logging is becoming increasingly frequent in the Indian reserves. In 1987, the Kampa, Kulina and Jaminaua Indians denounced to IBDF (the Brazilian Institute for Forestry Development) and FUNAI (National Foundation for Indians) the invasion of their lands of Rio Envira of the state of Amazonas, but nothing has been done to force the invaders to quit the area. As a result, the Indians destroyed the sawmill (Cunha, M., 1989). In the Alto Solimoes, loggers invaded the reserve of the Tikuna Indians in 1988 and killed 11 Indians. Also in Rondônia, loggers invaded the land of six Indian groups. The Indians organized and forced 100 loggers' families to leave the Zoro area.

(iii) Invasions by landless peasants constitute another menace for the Indian reserves. Peasants expelled from large *latifundia* frequently invade Indian areas in search of cultivable lands. In Rondônia, this process has led to many conflicts with the Indians. Frequently these landless peasants are used by loggers to create a *de facto* situation in which logging of Indian forests can start.

(iv) Dam construction and other large government projects pose a serious threat to many Indian reserves. Several dams are planned in the Amazonian region, including some inside Indian territories. In south-east Para, over 72,000 hectares of land have been taken by the government for infrastructure projects and more than 408,000 additional hectares will be taken from the Indians in case the hydroelectric dams planned for The Xingu river are constructed (Santos and Andrade, 1988). Numerous Indian communities have already been affected by the construction of dams flooding large forest areas, such as Balbina in Amazonas.

(d) Growing land conflicts

Amazonia is, at present, the region with the highest rate of land conflicts in Brazil. The unplanned occupation of the area has led to many heated and often violent disputes

throughout the region between squatters or other occupants with precarious tenure and landholders. Those claiming legal titles to the land are often the much feared *grileiros* (land speculators) who commonly engage *pistoleiros* (hired gunmen) in order to drive small farmers off the land they occupy. Land tenure, especially access to land for cultivation and housing, is currently the most conflictive social and political issue in that region. These conflicts have been aggravated by the government's retreat in 1988 from proposing long promised programmes of agrarian reform. Human rights abuses in the Amazon region are all particularly centred around land tenure issues (Farren, 1989).

Violence, however, is not limited strictly to land title issues but is also used by landlords to obtain cheap labour. Most of the workers in the *fazendas* (livestock and agricultural estates) are hired through middlemen called *gatos* to clear the forest. Most of the workers are financed by the gatos and as a result are in debt to them. In many cases they are stuck in the *fazendas* without being able to leave as they are not in a position to pay their debt. This debt peonage is made effective through use of force.

Many rural union and Indian leaders have been killed in conflicts over land and labour. So too have several progressive Catholic priests who took positions in favour of the rural poor.

During the last 20 years, some 1,100 rural workers have been killed as a consequence of land conflicts in Brazil. Half of the cases occurred in Amazonia, mainly in the states of Para, Maranhao and Goias. Table 2 shows the number of land conflicts in Amazonia recorded in 1985 alone.

Table 2

Land conflicts and numbers of participants in Amazonia, by state, during 1985

State	Number of conflicts	Persons involved
Roraima	3	8,500
Acre	6	16,995
Roraima	24	12,995
Amazonas	14	26,485
Para	84	65,393
Maranhao	71	62,464
Goias	61	14,183
Mato Grosso	43	14,289
Total Amazonia	352	221,304

Source: Oliveira, 1989.

6. Social Responses to Deforestation

Until the 1960s, social conflicts in the region were not as acute as they have been since, and local populations were not organized to oppose domination and exploitation. During the last two decades, however, the local population has been deeply affected by the violent processes of land and natural resources expropriation reviewed above. Many negatively affected groups started to react and to organize. Some examples of these reactions are mentioned below.

6.1 Social Movements of People Displaced by Dam Construction

Over 8,000 families have been affected by the construction of the Tucurui dam on the river Tocantins. The Electric Company (Eletronorte) has done very little to resettle these people under acceptable conditions. The large Cachoeira Porteira dam, planned in an old settlement

of black people and Indian reserves, such as Nhamuda-Mapuera, will affect about 8,000 families. The Ji-Parana dam will displace over 2,500 families. The Waimiri-Atroari indigenous people were affected by the extensive shallow flooding from the Balbina dam.

Those being affected by the construction of large dams are now nationally organized to fight for better living conditions. They were very active during the Meeting of Forest People, in Altamira, in February, 1989. They campaigned against the construction of dams in the Xingu river where many Indian reserves are located (CEDI, 1989).

6.2 Social Movements of the Indigenous Population

In the past, Indians frequently accepted rather passively the taking over of their land by outside groups or reacted sporadically and ineffectively. Recently, however, their resistance has begun to be better organized and stronger.

In 1982, the Tikuna Indians created a General Council of the Tikuna Tribe, formed by 68 community leaders. Later, the Indigenous People's Union (Uniao dos Povos Indigenas) was created and it has an important role in the defence of Indian interests. In 1985, the Indigenous Union joined with the Rubber Tappers National Council to create the Alliance of the Forest People.

For the first time, Indian tribes such as the Caiapos are negotiating to receive a share of the money generated by mining activities on their lands such as by the *garimpeiro*. At the same time, with the help of NGOs, the Uniao dos Povos Ingigenas has created a Centre for Indian Research where Indian students are being trained (Cunha, 1989).

6.3 The National Movement of Rubber Tappers and the Forest People and their Proposal for Extractive Reserves

In the 1960s, the capitalists from the southern part of Brazil started buying land from the old *seringalistas* (owners of rubber areas). In order to guarantee their legal titles to these lands they started burning the forest and expelling the rubber tappers. In 1975 the Rural Workers' Union of Basileia was created. In the following years, the Union started legal actions to prevent the *seringueiros* being evicted from their traditional lands. The *seringueiros* commenced the so-called sit-down strikes (*empates*) in front of the workers who had been sent in to cut the forest. After 1976 there were 45 *empates*. In 15 *empates* the *seringueiros* stopped the deforestation, but in 30 they were defeated. They succeeded, however, in stopping deforestation of over 1,200,000 hectares. In 1985, the first national meeting of *seringueiros* was held and the National Council of Rubber Tappers was created. The reaction of UDR (Rural Democratic Union that represented the most conservative groups of large landowners) was immediate and in December of 1988 the national leader of the *seringueiros*, Chico Mendes, was murdered. A new development of this social movement took place when Indian groups joined their traditional rivals, the *seringueiros*, in a newly born Movement of the Forest People. Several *empates* included Indian representatives together with the *seringueiros*.

The National Council of Seringueiros is well organized in Acre and Rondônia. In Acre, there are committees of the Movement in several towns such as Basiléia, Assis Brasil, Tarauaca and Cruzeiro do Sul. Similar committees are being created in the states of Amazonas and Amapa.

The National Council of Seringueiros receives support from various NGOs and environmentalist groups such as the Institute of Amazonian Studies, CNDDA-National Council for the Defence and Development of Amazonia, Oxfam, the Ford Foundation, Christian Aid, IDRC, and several Brazilian universities.

The main strategy of the National Council of Seringueiros is the creation of extractive reserves. The concept of extractive reserves is more than ecological. The *seringueiros* are

fighting for continual access to the forest, not necessarily because of the forest itself but because it is the source of their livelihood and the basis of their very way of life. Without the forest there would be no latex, nuts and other forest products on which they depend in order to survive. The implementation of these extractive reserves requires a profound agrarian reform in the region which is presently blocked by the conservative forces in Brazil.

> "The extractive reserves, as proposed, are to be communally run, with the Government retaining land ownership in a manner similar to Amerindian reserves or parks. By this system, an extractive reserve is not a form of resource collectivization. Although not issued separate deeds, individual families retain their rights to tap in their traditional collecting territories (colocacoes) within the reserves. The land cannot be sold or converted to non-forest uses, although small clearings for subsistence crops are permitted (usually not exceeding 5 hectares per family or approximately 1-2% of a reserve." (Fearnside, 1989b)

The proposal for extractive reserves responds to five urgent necessities, both for the protection of traditional forest inhabitants and for the region's longer-term sustainable development.

(a) The need for forest conservation in these parts of Amazonia undergoing rapid transformation

The states of Rondônia and Acre, where conversion of forest to cattle pasture or for annual cropping is proceeding rapidly, are the two most likely candidates for initial creation of extractive reserves. This is, in part, because the rubber tappers of these regions have made a strong appeal for forest protection. Particularly in the state of Acre, the rubber tappers' organizations have become highly visible and are generating considerable support for the idea of extractive reserves. The idea is supported by local groups that depend on sustainable forest productivity for their livelihood, namely rubber tappers, Brazil nut gatherers and other extractive producers. There could be a real possibility of preserving large areas of forest in the long-term if this local constituency were directly involved in the management of extractive reserves and responsible for their use and conservation (Schwarzman, 1988).

(b) The need for secure land rights and responsibilities

The proposal for extractive reserves is in general most strongly supported by autonomous or free rubber tappers. Free *seringueiros* are central to the success of the proposal, since they have a keen interest of their own in sustainable rubber production, as well as the organizational capacity to protect reserves (Schwarzman, 1988).

(c) The need for locally controlled development

The extractive reserve could be a basis for locally controlled development that includes legal protection of land rights, education, health care and improved marketing of rubber production through producers' and consumers' co-operatives. Extractive reserves democratically controlled by the local people traditionally depending on the forest could be a means for free rubber tappers to stay on the land permanently with reasonable prospects for the future (Allegretti, 1990).

(d) The need for economically productive uses of forest lands

Extractive reserves may represent a more economically productive use of the forest land than the alternatives that are now displacing native rubber and other forms of extractive production. Pastures soon become unproductive, as seen above, on most of the region's soils, while sustainable agriculture frequently implies expensive purchased inputs. Logging, unless carefully executed and controlled, soon destroys the forest.

The extractive reserve proposal, however, should not be viewed as a means of supporting a dense population or of absorbing people migrating from other regions. Even for experienced rubber tappers, only a sparse population can be supported (currently 1 to 1.7 persons/square kilometre). Great care must be taken for the term "extractivist projects" or "extractivist reserves" not to become a mere euphemism for the type of settlement that has already become common along the Transamazonian highway and in Rondônia. The latter have already been discredited, and the legitimate extractivism should not suffer the same fate (Fearnside, 1989b).

Economic self-sufficiency is an important goal of the extractivists. It will require maximizing the variety and value of products sold, limiting the loss of surplus to middlemen and minimizing the cost of establishing and maintaining the reserves (Fearnside, 1989b).

(e) The need for better social organization

The extractive reserves respond also to a need for social organization among autonomous rubber tappers and others whose livelihoods depend on extraction of forest production. The idea of co-operatives within the extractive reserves is to counteract exploitation of the *seringueiros* by rubber traders or *regatoes*. According to the traditional system, the indebted rubber tappers are dependent on a *seringalista* who buys their production and provides food and other consumption goods. The values of these supplies are deducted from the value of their rubber. This marketing system is one main reason for the high cost of natural rubber in Brazil compared to rubber from south-east Asian plantations as the middlemen are virtually monopolists in their respective areas and can charge the rubber tappers high mark-ups for their consumption goods as well as high interest rates on accumulated debts.

Sudhevea (the national rubber company) bases its calculation of costs of production (and hence of official prices) entirely on traditional patron-client relations in native rubber production, explicitly leaving free rubber tappers out of account. The most detailed recent study (Fealq, 1983) finds that the single greatest cost in rubber production is purchased consumption goods by rubber tappers' families. The patron's (*seringalista's*) costs are passed on to his clients, the rubber tappers, through high prices of supplies. This study concludes that the only possibility for lowering the cost of production of natural Brazilian rubber would be along the lines of free rubber tappers' organizations, since these can claim a higher price for their rubber and buy consumer goods at lower prices. Eliminating exploitive middlemen is a crucial prerequisite for making native rubber more competitive and for improving the incomes of rubber tappers (Schwarztman, 1988).

If the *seringueiros* manage to establish their own co-operative societies and small latex processing units, they will be able to solve one of their main problems: the low price of their product and high price of what they have to buy. Moreover, marketing mechanisms for new products have to be developed if extractivists are ever to enjoy a reasonable standard of living. As the poverty of the rubber tappers during the rubber boom has shown, when most of the value of their product is retained by intermediaries, extractivists remain poor, regardless of the amount of wealth they generate.

> "The rubber-tappers are now making a major effort to diversify the products they extract and sell. This strategy would require collaboration with researchers (such as pharmacologists, chemists and botanists), who could develop new products, and also with economists and marketing specialists." (Fearnside, 1989b)

In order to diversify economic activities within the extractive reserves, the National Council of Rubber Tappers has recently created a Training and Research Centre. They have recruited forest engineers who are studying ways of increasing the number of rubber trees in the *colocacoes* (Diegues, 1989).

The Council is also continuing to develop the Projeto Seringueiro which is a popular education programme developed in several *seringais*. Around 18 schools have been created in the Xapuri Region, in Acre.

Between 1981 and 1985, Projeto Seringueiro organized six schools and two producers' and consumers' co-operatives as well as a programme for the training and support of community health monitors through the Acre State Secretariat of Health. By 1983, Projeto Seringueiro held its first teachers' training course and the schools were turned over to the local communities, with literate community members doing the teaching. The co-operatives initially functioned well. For the first harvests, the capital was maintained and consumption goods were bought out of the profit from rubber production. In 1984, however, with hyperinflation, the co-operatives failed. This coincided with an attempt to turn the co-operatives over to strictly local control. The experience of rubber tappers with Projeto Seringueiro, as well as with local unions and other similar initiatives in other parts of Amazonia, was an important impetus behind the first national meeting (of the National Council of Rubber Tappers) in Brasilia in October 1985 (Schwartzman, 1988).

7. Alternatives to Deforestation in Amazonia

Numerous proposals are being made by different agencies, organizations and individuals to stop Amazonian deforestation. Many, understandably, focus on national policies and development strategies. Others stress the urgency for international action, controls, sanctions and financial support. Still others emphasize local level initiatives and alternatives. Proposals range from strict public controls, rewards and penalties to freer play of market forces, from adjustments within the country's present development strategy to a radically different strategy, and from massive international aid and pressures to fierce opposition (including by many who are fully committed to saving the forest) to any infringement on national sovereignty. No matter how sincere advocates of these different approaches may be, they usually have little to say about what social forces can be mobilized to implement them.

The preceding review of interacting processes, policies and institutions at local, national and international levels leading to accelerating Amazonian deforestation suggest that there are no simple remedies. Systemic problems require systemic solutions. Existing social science paradigms are rather vague about what specific social actors in particular situations should do to bring about desirable social change, or how to cope with their unanticipated implications when they occur.

Further research on the social dynamics of deforestation in the Amazon region could help in identifying opportunities and obstacles in pursuing alternatives. Such research would be directed initially at analysing local level alternatives with emphasis not only on their impact on deforestation but also on the livelihood of those groups living in or near and depending on the forest. Ultimately, solutions have to reach the local level where the tropical rain forest is being cut and burned. Therefore, this is the logical place to begin analysis of alternatives. Regional, national and international implications of these alternatives, however, will have to be taken into account as well as examining their local level possibilities, obstacles, costs and benefits.

An obvious alternative to deforestation for the lands traditionally exploited by rubber tappers, Brazil nut gatherers, river dwellers and indigenous populations would be the extractive reserves discussed in the last section. But these proposals should be analysed in more detail. How many extractive reserves are being proposed? What areas and populations would they cover? Have any yet been established? Who benefits and who pays? How are they actually managed - how are decisions taken? Whose lands were affected? Could they become a significant regional alternative without profound agrarian reform and supporting changes in

economic policies and social relationships regionally or nationally? Would they, and under what circumstances, be economically attractive in comparison to other alternative land uses?

Related issues for further research would be the technical and economic possibility of extractive reserves and associated agroforestry systems. Are they technically sound and economically feasible under present conditions? Why has forestry research neglected to explore the technical alternatives to deforestation? What technical improvements in the proposed alternatives could make them more attractive? A few of these issues are discussed in Appendix A.

Similar questions arise with respect to the environmental destruction associated with expanding cattle ranching and land clearing for speculation. What are the probable costs and benefits for those controlling the forest land and for the Brazilian economy of these land uses compared to leaving them as forest? What changes in regional, national and international policies and institutions would have to be brought about to make environmentally damaging conversion of forests to other land uses unattractive for large ranchers and speculators? Related questions arise concerning forest destruction for reservoirs and mining. How could the pollution and forest destruction associated with the expansion of mining and commercial timber exploitation be checked? Who would benefit and who would pay?

There is an urgent need for more research into such questions in Amazonia.[1] The researchers should take into account, however, that public policy, like socially induced deforestation itself, is an output of social systems locally, nationally and internationally. They should not limit the scope of their investigations to identifying "policy recommendations" but should also consider how these recommendations might become realities.

Appendix: Finding Technical Alternatives that could help in Halting Deforestation (some Forest Research Priorities)

by Paulo Kageyama and Virgilio Viana

A.1 The Need of Alternative Production Systems

The low productivity of current shifting agriculture and forest management practices undermines the socio-economic sustainability of the Indian extractive reserves and of the riverine populations in the Brazilian Amazon. An example of this problem is the negative consequences of increasing production of cheaper rubber from plantations in southern Brazil for the extractive economies. At present, the income level of *seringueiros* is already too low to withstand further deterioration (Allegretti, 1990). Since the extractive reserves are

[1] As a follow-up to this review, two case studies are being undertaken aiming at analysing the changes in the livelihood strategies of the local population most affected by deforestation in the State of Rondônia and in the south-east region of Para. These studies aim also at studying the changes in social reactions of affected populations as a consequence of deforestation, in particular, the riverine people, Indians, rubber tappers, small farmers and squatters.

The two regions represent different types of land occupation and natural resources uses. Rondônia was first opened to colonization in the early 1960s, through the completion of the Cuiaba-Porto Velho highway. Part of the soils of that state are more fertile when compared to other areas of Amazonia and attracted thousands of settlers from other Brazilian provinces. The main characteristics of the occupation of Rondônia is the establishment of organized rural settlements by INCRA, the National Institute for Colonization and Agrarian Reform. In this case, small plots of land were allocated to poor farmers.

The south-east region of Para was occupied mainly by large farms for agricultural and cattle raising purposes as well as by large mining projects. The large Carajas mining complex is located in this area.

surrounded by pastures, even the *seringueiros* are tempted to clear land for pastures if they see no other economic alternative.

Current land use systems have low productivity and underutilize shrub and tree species with high economic potential. They are risky because they are based on too few crops. They imply extensive forest clearing for cultivation. There is a need of alternative forestry and agroforestry systems leading to an increase in the standard of living of traditional populations. These alternative systems imply increasing productivity and reducing economic risk while at the same time conserving biological diversity through the maintenance of the forest cover. This need has already been perceived by many grassroots organizations. The Brazilian National Council of Rubber Tappers, for example, created a Centre for Information and Research with the objectives of identifying research priorities and supporting participative research programmes.

Forestry and agroforestry research in the Amazon have more often than not favoured unsustainable land use systems that lead to inappropriate deforestation in the Amazon. Forestry and agroforestry research have given too much attention to exotic monoculture systems and too little attention to the use of natural biological diversity and to improving traditional land use systems. This has reinforced other processes expelling traditional populations from their homelands into urban areas.

Although there is a legitimate claim for more research funds in the Amazon, there is also an urgent need of redefining forestry research priorities in the region. Forestry research should abandon its historic emphasis on exotic monoculture systems and focus increasingly on improving traditional land use systems and developing new agroforestry systems that are sustainable and more appropriate for traditional populations as well as for new colonists.

Forestry and agroforestry research in the Amazon should have not only scientific goals but also educational objectives (Fals Borda, 1982). Research findings need to have a strong technical, scientific and economic basis to counter the pressure towards cattle farming and plantations in Amazonia, by providing viable alternatives for sustainable economic production in extractive reserves. On the other hand, participative research has also the objective of training *seringueiros* to carry out their own research and become more independent (Fals Borda, 1982). This last objective was proposed by Osmarino, a prominent *seringueiro* leader, as a central goal of the Centre for Information and Research of the Brazilian National Council of Rubber Tappers.

A.2 Forestry and Agroforestry Alternatives

Sustainable development in the Amazon has to be based on a delicate balance of economic, social, ecological and genetic objectives and constraints. The region requires a development style that results in economic growth, social welfare, ecological stability and maintenance of its immense genetic variability. There are a few technical alternatives that may help achieve a desirable equilibrium among these objectives. Here we will discuss some of these forestry and agroforestry alternatives. These alternatives can be adapted to various forms of land use and ownership.

(a) Natural forest management

For the purpose of this discussion, natural forest management will be considered as the management of forests directed mainly towards production of wood products. Forest management, however, should aim at both wood and non-wood products. Therefore, the division here between natural forest management and neo-extractivism is used only to facilitate the discussion.

There are several million hectares in the Brazilian Amazon in National Forests, Indian Reserves and Extractive Reserves that should, by law, have to be maintained under forest cover. There are also large areas of poor soils, still forested and not in protected reserves, that should be maintained under forest cover. There is an urgent need for management systems that result in an improvement of the standard of living in those areas for both traditional and non-traditional populations. These systems have to be socio-economically and ecologically sound (Gomez-Pompa, Vazquez-Yanes and Sada, 1982; Dubois, 1974; Viana, 1990).

There are a number of problems that have resulted in the failure of numerous efforts to manage heterogeneous tropical forests (Hartshorn, 1990; Viana, 1990). However, significant changes in the markets for tropical forest products and recent advances in our understanding of tropical forest regeneration ecology, have created new technical possibilities for sustainable management of tropical forests in the Amazon. At the same time, political pressure from various sources may eventually contribute to making sustainable forest management increasingly attractive for those controlling forest resources.

Among these developments, the following four seem particularly relevant for Amazonia: (i) Under pressure from environmental groups, consumers in industrial consumer countries are beginning to demand that timber imports be certified that they come from forests being sustainably managed. (ii) The increase in the domestic market for species other than traditional premium timber species provide new possibilities for sustainable forest management (as well as new temptations for deforestation). (iii) The increase in the demand of non-wood forest products for cosmetics, medicine, juices, etc. provides opportunities for new markets for forest products. (iv) The pressure of local and international environmental groups to curb destructive logging by a more efficient system of law enforcement may eventually lead to effective regulation.

There are a few critical issues that have to be addressed in order to implement sustainable forest management in the Amazon. Perhaps one of the most important is the fragility of forest institutions in defining and implementing long-term forest policies. These problems include (i) the scarcity of funds for basic activities; (ii) better use of local level forestry expertise, and the need to recycle human resources; (iii) the lack of a political environment conducive to long-term planning; (iv) the lack of effective forest extension services, and (v) the distance of professional foresters from the concerns of popular social movements. Another issue is the technology available for sustainable forest management in the Amazon. A central problem of forestry research in Brazilian Amazonia is the lack of continuity of most research programmes. Research programmes often begin with abundant funds but, after a few years, become increasingly limited by a lack of financial support.

Tropical forestry research is also plagued by a lack of concern with social and ecological issues. Traditionally, forestry research in the tropics was focused on producing export timber rather than on promoting the socio-economic development of local populations. This was an obstacle to the development of realistic alternatives for sustainable forest management. Foresters failed to deal with problems such as the reasons for invasions of forest lands by squatters (Wyatt-Smith, 1987), or the generation of sustainable agroforestry economies which would improve the livelihoods of local inhabitants.

Today, there are great challenges to be explored in the management of tropical forests. First, let us consider the social components. Forest management has to become an integral component of sustainable development of Amazonian rural areas. Up to now, forest production is non-sustainable and migratory, has low productivity and employs non-qualified and poorly paid labour. However, if forests are managed in a sustainable fashion, there is a need for highly qualified labour to identify, select and harvest trees. These tasks are very complex, especially if management incorporates critical ecological information. This

ecological information (e.g., regeneration habits, tree phenology, seed dispersal patterns) is often available - at least partially - in the folk knowledge of traditional populations (Posey, 1983; Clay, 1989; Anderson, 1990). In a sense, these groups, that are most marginalized by the current development pattern, are those that may be the best suited for promoting sustainable forest management. Their specialized skills should be remunerated, not penalized, by society.

Secondly, let us consider some ecological issues. Among the greatest obstacles to forest management are (i) the lack of understanding of the "dynamic" nature of most tropical forests; (ii) a general lack of information about the regeneration requirements of canopy tree species (Hartshorn, 1990); (iii) the low predictability of forest composition after logging; and (iv) the low density of economic species in Amazonian forests (Viana, 1990). These problems, however, can be minimized by incorporating simple ecological information into forest management. In the last decade or so, it has become increasingly clear that canopy gaps play an important role in natural forest regeneration and that there are different ecological groups, with adaptations to colonize gaps of different sizes (Brokaw, 1987; Viana, 1989). Forest renewal through gap-phase regeneration is the key to managing natural tropical forests (Hartshorn, 1990). In a sense, forest management is the science and art of managing the process of gap formation and gap regeneration through careful logging and thinning operations. Forest management should not consider general girth parameters for defining logging and thinning operations for all species. Instead, it should consider girth parameters for groups of species with similar life histories. This would add an important "ecological vitamin" to tropical forestry (Beard, 1953). Although this ecological perspective may be easily accepted by most biologists, traditional foresters often see it as either too complex or disconnected from practical management operations.

Thirdly, let us consider economic issues. Economic sustainability is a requirement for biological forest sustainability (Leslie, 1987). A critical problem of Amazonian forests is their high diversity and low density of economically viable species. Management can either go towards a drastic reduction of biodiversity in production strips - surrounded by biological refuges - or towards an integration with a more diversified forest industry. A diversified forest industry may be a key element for increasing the economic viability of forest management through a more intensified use of forest products - wood and non-wood. This may make viable the management of forests in smaller land holdings and employ more and better paid labour in rural areas.

Finally, it should be noted that there are a few ongoing field experiences that seem promising. These may help provide a basis for sustainable forest production in the Amazon in the future (e.g., Graaf, 1990; Hartshorn, 1990).

(b) Agroforestry

Agroforestry is the combination of trees with agriculture or pasture or both, either simultaneously or sequentially. Agroforestry is not a new concept but rather a new term to describe land use systems that have been used for many centuries by traditional populations in Latin America and other regions of the world (Gomez-Pompa and Kaus, 1990). Agroforestry offers a number of economic, social and ecological advantages. These include higher productivity through a more efficient use of light, water and nutrients; lower economic risk; lower losses due to pests and diseases; more efficient use of labour throughout the year; lower requirements of purchased inputs and capital and better conservation of soils and watersheds (Copjin, 1988; Nair, 1990).

Agroforestry systems are particularly suited to low fertility and/or steep topography soils and to populations with low availability of capital. Agroforestry systems were successfully used

by many traditional populations in the Amazon (Posey, 1983; Anderson, 1990) long before the Europeans arrived.

The relationship between agroforestry and research institutions and development agencies is paradoxical. Despite the fact that agroforestry represents one of the most promising land uses in the Amazon, it has received very little or no attention from research institutions and development agencies. Research institutions have focused more on monocultures, largely due to the history of agronomic and forestry research itself, based on models imported from temperate countries and designed to increase profits of commercial forest industries. Development agencies have often financed only monocultures. Even today, many funding agencies exclude mixed cropping from their scope of action.

There is a need for a joint effort on the part of both research institutions and development agencies in promoting agroforestry. This effort should begin by a characterization of existing forms of agroforestry being used by riverine populations, Indians, rubber tappers and colonists. These provide an important starting point for developing greater productivity and sustainability of agroforestry systems.

Agroforestry systems may be used in Indian reserves, extractive reserves, new settler colonies and by riverine populations. A promising effort to develop improved agroforestry systems may come out of the Extractive Reserve Chico Mendes, formed as a result of a joint effort of the Brazilian National Council of Rubber Tappers Centre for Information and Research, the Department of Forest Sciences of the University of Sao Paulo and the Woods Hole Research Centre (USA). The plan is to create agroforestry alternatives for current shifting practices and thus create small areas of high and diversified production, within the extractive reserves, for both subsistence and market products.

These are great challenges for agroforestry in Amazonia. Firstly, there is a need to characterize current production systems from socio-economic, cultural, agronomic and ecological perspectives. Secondly, there is a need to evaluate future market trends for products that will be harvested from trees in the next 5, 10, 20 and more years. Thirdly, there is the challenge of finding species mixtures, in time and space, that minimize competition and maximize compensatory effects (leading to greater productivity in mixtures than in monocultures), and thus increase the productivity and sustainability of land uses in the Amazon.

(c) Neo-extractivism

The extraction of non-wood products has been practised for a long time by traditional populations of Amazonia (*seringueiros*, *ribeirinhos* and “Indians”). It is a model of an extensive use of the forest, with little environmental disturbance. The very low productivity in this type of land use, in its traditional form, has not permitted the full use of these resources for the benefit of local populations, even where institutional management would have allowed them to retain such benefits.

The low competitive nature of the extractivism, compared to the same species intensively cultivated in other regions and countries, has been pointed out as the main limitation of this land use. The low technological level in extractivism, the difficulties of transport and commercialization of the products, exploitative marketing, and other problems, all limit the sustainability of the traditional extractivism. The improvement of extractivism, aimed at turning it into an economic alternative for Amazonia, has been criticized by those who are searching for technical solutions to sustained development that are socially just, benefiting the majority of the Amazonian population, and ecologically suitable for the ecosystem (Anderson,1990; Hadley and Schreckenberg, 1989).

The use of advanced appropriate techniques, with the objective of increasing the number of products being extracted from the forest, could help make extractive systems economic, while maintaining the principle of sustained use could help make neo-extractivism competitive. The enrichment of species in the region, while increasing the density of useful species and preserving the principles of minimal disturbance to the ecosystem should be a research priority.

The association in extractivism of *seringueira* (Hevea brasiliensis) and *castanheira* (Bertolethia excelsa), mainly in southeastern Brazilian Amazonia, is one promising alternative. It could support social, environmental and genetic conservation goals. The consolidation of such systems in extractive reserves is the aim of neo-extractivism (Allegretti,1990).

The benefits of extractivism through the preservation of physical, chemical, biological and genetic resources should be adequately evaluated and the costs borne by ultimate beneficiaries in a position to pay. For example, benefits of diminishing CO_2 emissions and of maintaining biodiversity in Amazonia eventually accrue to societies throughout the world. These benefits should be taken into account and beneficiaries in rich countries should share the costs of promoting land use systems that generate them. Facing up to this delicate issue is fundamental for the full success of neo-extractivism in Amazonia.

It is important to note that, although there is a big gap in formal scientific knowledge, a great number of appropriate technologies are available, scattered throughout Amazonia. The organization of this knowledge, from individual experiences in many points in Amazonia, could help to improve extractivism and to consolidate this form of land use as a viable alternative for sustained development of the region. This presents a challenge for researchers.

(d) Genetic conservation

Extractive reserves, which involve low levels of human intervention in the ecosystem, permit the exploitation of forest resources to be compatible with the conservation of genetic resources. This can be facilitated by taking special care in quantifying and genetically monitoring the species under conservation in order to guarantee their conservation *in situ*.

The preservation of the natural variability of a species necessary for the continuity of its evolution in the ecosystem is the most suitable form of genetic conservation. This is the case of many species of primary tropical forests, notably those in the final stage of succession for which conservation ex situ through traditional germplasm banks is not feasible. Furthermore, in genetic conservation in situ, not only the gene pool of species under conservation is preserved, but also that of populations of associated organisms in the natural ecosystem, which are essential for the continuity of evolution (Kageyama, 1987). The high genetic variability existing in natural populations is gradually eroded in the process of domestication and improvement of the species. It is now being destroyed by the continued and increasing rate of forest devastation in the Amazon region. It is worth mentioning that this natural variability is often indispensable for solving many problems, mainly those of a sanitary nature, of intensive agriculture. The genes producing resistance to pests and diseases of intensive crops normally exist in the diversity of species in natural forests.

The Amazon region represents an immeasurable genetic source. We should consider the resources represented by the populations of thousands of species of the Amazon ecosystems. One should recall Amazonian species which are presently economically important, such as the rubber tree, Brazil nut trees and the cacao tree. The important source of genetic material for these three species lies in the southwest Amazon region of Brazil, mainly the states of Acre and Rondônia. Furthermore, the state of Acre is related with an area of the Pleistocene Refuge

(Prance, 1984) and, therefore, is a region of high endemism and variability. Many other species may become even more important for humankind in the future if Amazonian ecosystems can be preserved.

The extractive reserves of the state of Acre may perform an important role by preserving variability to be used in intensive cultivation outside the Amazon region of the three species mentioned. Care must be taken for the genetic variability not to be eroded in the extractivism process. Also, the genetic material used in the reserve should be improved starting from local populations themselves.

Specific technologies and institutions have to be created to make rational extractivism compatible with the pragmatic conservation of genetic resources. These considerations should be taken into account when designing and evaluating alternatives to deforestation.

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