The Impact of Deforestation in the Brazilian Amazonia
— Change on Ecosystem and Social Environment —

ブラジル・アマゾンの開発による森林減少問題
—森林伐採が生態系と地域社会に及ぼす影響—

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CONTENTS

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Chapter 1 General introduction and objective of the study

1.1 General introduction

Amazonia is the biggest continuous tropical forest of the world, occupying almost 6,500,000 km² of the northern area of South America, and 63% of it belongs to Brazil (8,511,965 km²). The Brazilian Amazonia is known as Amazonia Legal in Brazil. The climate is equatorial, with high temperature and humidity. Average temperature during the dry season (June to November) is 27.9°C and during the rainy season (December to May) is 25.8°C. Annual rainfall in its central region ranges from 2000 to 3000 mm, in the east Andean slopes it exceeds 5000 mm and toward the north and the south of the region it decreases to about 1500 mm (Junk 1989).

There are three types of Hylea (rainforest) in Legal Amazonia: Terra firme (98%) - unflooded tropical rainforest, Várzea (62,000 km²)-alluvial zone forest flooded during the rainy season, and Igapó-flooded forest. The *Dipterocarpaceae*, a very common botanical family in Southeastern Asia does not exist in the forests of Brazilian Amazonia. The dominant botanical families are *Leguminosae*, *Lecythidaceae* and *Sapotaceae* in the terra-firme forest and *Myristicaceae* in the várzea forest (MCT-INPA/DFID 1997). Commercially speaking, mahogany (*Swietenia macrophylla*), commonly known as mogno in that region, is the most valuable wood in Amazonia, and Brazilian nut (castanha do Pará) (*Bertholletia excelsa*) and latex extracted from rubber tree (*Hevea* sp.) are important non-wood products of that region.

Legal Amazonia is drained by Amazonian Basin and the stem river of the Basin is the Amazon (6,450 km) that issues from the glacial lakes of Andes in Peru, 5,600 m above the sea level and flows towards the Atlantic Ocean, passing through the Amazonian Rainforest. According to the most recent geomorphic divisions of Brazil, the Amazonian plain corresponds to three geomorphic units. The first one is the "Planície do Rio Amazonas e alguns afluentes" that corresponds to a thin belt along the Amazon and some of its tributaries, including Marajó Island. The second is the depression with 100 to 200 meters high, the "Depressão da Amazônia Ocidental", the biggest geomorphic unit of that region. The third is the 400 to 500 meters highland covered with deep forest, the "Planalto da Amazônia Oriental" that extends from Manaus to the Atlantic Ocean.

According to 1997's FAO report, 130,000 km² of the world natural forests is cleared each year. The tropical forests seriously affected by deforestation are in the region of Southeastern Asia and Pacific. Deforestation is taking place also in Brazilian Amazonia, with many foreign logging companies establishing there, recently. There are many reasons for clearance, mainly for farming, mining and population growth.

Since 1992's United Nations Conference on Environment and Development held in Rio de Janeiro, Brazilian government is making attempts for better usage of the Amazonian forests, encouraging the introduction of sustainable management of the forests. However, it is still uncommon in the states of the Brazilian Amazonia, and few studies have reported on this area.

1.2 Deforestation in the Brazilian Amazonia

In Brazil, Legal Amazonia has been cleared each year since the development project took place in the 1970's, and deforested area within it was 460,000 km² in 1988 (Fearnside 1990). After the Global Environmental Meeting held in Rio de Janeiro in 1992, deforestation rate in Amazonia seemed to slow down, but biomass burning intensified again, recently. The Amazonia, once called the "green hell", is actually seen as a big economical resource of mine, timber and cattle beef, threatening not only the fauna, flora and indigenous people of that region, but also, global environment.

Nine states among 26 Brazilian states form the Legal Amazonia: Amazonas, Pará, Rondônia, Acre, Roraima, Amapá, Mato Grosso, Maranhão and Tocantins, and the last three states belong to the Legal Amazonia only partially. Among these states, Pará, Rondônia, Mato Grosso and Maranhão are the most deforested states. Causes of deforestation vary in different places of Amazonia. In Rondônia and in eastern Acre, migration of small farmers is the main cause of conversion, however deforestastion for cattle pasture is the most frequent agent elsewhere in the Brazilian Amazonia. Rondônia was the last one that the Brazilian government implemented the development project, but deforestation rate was the most accentuated compared to the other states of Legal Amazonia, over the past 20 years.

Today, tropical forest is seen as an important resource of biodiversity rather than that of a commercial timber. Also, tropical forest plays an important role as being a vast sink of carbon being captured from the atmosphere through photosynthesis. On the other hand, increased burning caused by slash-and-burn is resulting in a big scale CO_2 emission into the atmosphere, on the order of 0.3 gigaton/year, only in the Brazilian Am-

azonia (Fearnside 1996a). This fact is likely to be affecting the world climate, causing global warming.

This study is focused on the impact of deforestation in the Brazilian Amazonia upon the ecosystem and social environment. The Amazonian environment is changing very rapidly. In 1995, Brazil's population was 162,497,250 inhabitants (IBGE 1998) and it is still expected to continue to increase (Fig. 1.2-1).

Population pressure is one of the most serious reasons for the deforestation in Brazilian Amazonia. Average deforestation rate in that region is estimated to be 21,000 km²/year. Total deforested area presents different values depending on the researcher, since when development projects took place in that region in the 1970's. They are: 12% (Mahar 1989), 11.5% (INPE 1998) and 8% (Fearnside *et al.* 1990). Deforested area before the 1970's were very small and it is not yet known. Deforestation estimates demand a very hard task, both remote sensing analysis and ground truth in different seasons. The cause for large-scale clearance in the Brazilian Amazonia is a result of economic, social and political perspectives (Dale *et al.* 1994).

1.3 Researches carried out in the Brazilian Amazonia

There are some important projects that are actually taking place at the universities or institutes of the United States of America, Germay and Brazil: EOS-Amazon Project (NASA's Earth Observing System Interdisciplinary Investigation, University of Washington), EOSRAM (EOS Regional Amazon Model, University of Washington and the Brazilian National Institute for Space Research (INPE), LBA-The Large Scale Biosphere-Atmosphere Experiment in Amazonia (CPTEC-INPE, Center for Weather Forecasting and Climate Research-Brazilian Space Research Institute), INPA-Brazilian National Institute for Amazonian Studies, Max Planck Institute-Department of Tropical Studies, and Limnology.

Because of its hugeness, followed by the lack of transport facilities, researches concerned with that region have been limited in the past, but today, the development of technology has enabled the access by aircraft and satellite. The "Projeto RADAM" (1968-1977), succeeded to overcome these difficulties, covering the whole area of Legal Amazonia by radar, using aircraft in 1960's and satellite since 1970's. This Project enabled to make an inventory of mine ores of bauxite, lead, copper, cassiterite, iron, manganese, niobium, nickel, gold, asbestos, quartz, salt, phosphate, diamond, uranium and petroleum, laying under the deep forest. The Big Development Projects as for example, Carajás Project occupying a cleared area of 900,000 km², began its activity with the discovery of iron mine of 18 billion ton, by the satellite imagery.

Today, the "Projeto RADAM" covers the whole Brazilian territory and is called "RADAM Brasil". The LANDSAT scenes that cover Legal Amazonia totalizes 229, each scene sweeping the area of 185×185 km (34,225 km²), and digital information of each imagery can be obtained in a 300MB CD-ROM. Brazil, the second main user of LANDSAT data next to its host country, the United States, has the reception center in Cuiabá (Mato Grosso State) and processes the data at INPE, National Institute for Space Research in Cachoeira Paulista and in São José dos Campos, São Paulo.

The ABRACOS (Anglo-Brazilian Amazonian Climate Observation Study) project initiated at the end of

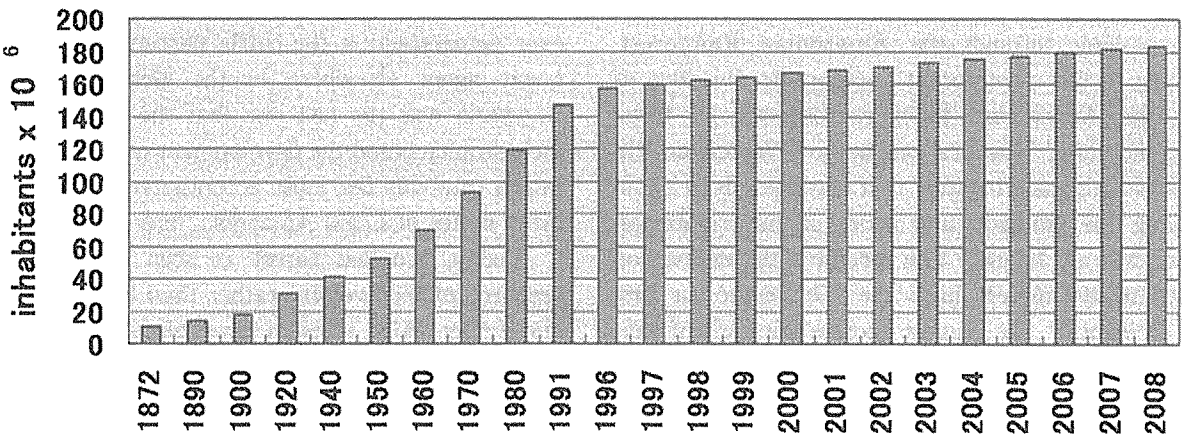


Fig. 1.2-1 Brazil's population growth (projection from 1997)
Source: IBGE 1998

the nineteen eighties had the objective of discovering how the soil and vegetation of Amazonia interacted with the atmosphere to affect climate (Gash *et al.* 1996). The primary objective of ABRACOS was to improve climate model predictions of how Amazonian deforestation might affect climate, and new field data collected during this project were used to calibrate land surface sub-models of the GCM (General Circulation Models). The most recent model results indicated a substantial response to deforestation which varies regionally: annual rainfall changes were predicted to be up to 20 per cent, with a tendency for NW-SE orientation of rainfall changes extending SE of the deforested area especially in December-February. The ABRACOS data were used to calibrate different GCMs and all of them were very sensitive to the representation of the land surface characteristics.

The LBA (Large-Scale Biosphere-Atmosphere Experiment of Amazonia) project (LBA 1997) is a multi disciplinary scientific investigation of the Amazon Basin being carried out by INPE-CPTEC. The LBA main scientific thema are Physical Climate, Land Surface Hydrology and Water Chemistry, Atmospheric Chemistry, Remote Sensing: Land Use and Cover Change, and Biogeochemistry/Carbon. Apart from INPE, there are researchers from NASA, USA, UK, The Netherlands, Germany, France, Puerto Rico and USP engaged in this project.

The BIONTE (Forest Biomass and Nutrients) project executed by MCT (Brazilian Ministery of Science and Tecnology), INPA (Brazilian Institute for Amazonian Research) and DFID (UK Department for International Development, ex-ODA) was carried out in order to ascertain the right indication for the sustainability of forest management in the Amazonian terra-firme rainforests. This project gave continuity to the research on forest management carried out in 1980, under the grant aid of CNPq-INPA/BID/FINEP and was executed in ZF-2 Forest of INPA, 90 km North from Manaus, in the Amazonas State. The field study was initiated in June 1992 and finished in December 1997 (Pic. 1.3-1).

This project had the aim to define selective timber exploitation without affecting the ecosystem, to study sustainability under the forest management, and to develop the Brazilian capacity to execute researches concerned with forest management in different levels, in order to achieve the sustainable development of that region. Also, this project was incorporated in the last phase of the LBA project.

Independently, many studies have been executed on climatology (Gentry *et al.* 1980; Nobre *et al.* 1991; Richey *et al.* 1989; Salati *et al.* 1984; Shukla *et al.* 1990), sustainable forest management (Silva 1996; Higuchi 1997) and ecology (Sioli 1984; Fearnside 1996b; Fearnside 1996c; Fearnside and Guimarães 1996; Fearnside and Barbosa 1996a; Fearnside 1997) for better understanding of that region. However, little literature has been published on climatic influence of deforestation upon the small catchments of Brazilian Amazonia. Although much work has been done to date, more studies need to be conducted in order to clarify the effects of deforestation on regional and global climate and to ascertain the role of sustainable forest management applied in the tropics.

1.4 Objectives and the basic structure of the research work

The primary objective of the present research was to make clear the *status quo* of the Amazonian forests in the light of ecological point of view. The questions raised were:

1. Is the Brazilian Amazonia really shrinking too fast ?
2. Is the Amazonian deforestation really affecting the climate ?
3. What is the main cause of Amazonian deforestation ?
4. At what extent is deforestation affecting the environment and local people ?
5. What measures are taken from the Brazilian government concerned with the conservation of forest ecosystem ?
6. Does Sustainable Forest Management function in the Brazilian Amazonia as it does in the temperate forest ?
7. Is it possible to maintain the indigenous people culture with development ?
8. What is the most efficient measure for the advanced countries to assist developing countries concerned with the conservation of tropical forest ecosystem ?

The purpose of this paper was to give the most direct answer possible to these questions that motivated the author to carry out the present research. Many researchers have been working on different aspects of the Brazilian Amazonia, and the present work is composed of three main thema: sustainable forest management, influence of deforestation on local people and regional climatic change.

As for sustainable forest management, many studies have been presented to date, mainly related to Pará State, the biggest Amazonian log producing state (Silva 1996). This paper shows the situation of other Amazonian states in the light of sustainability.

Deforestation affected not only the Amazonian fauna and flora but also the indigenous people. Although there are some literature on Amazonian indigenous people in the light of linguistics, quite few studies have been done on the indigenous people in the area of forestry. As it is impossible to think on Brazilian Amazon without their presence, this paper dealt with their actual situation concerned with their culture, history and human rights.

Another main objective of the research was to analyze how change of vegetation cover was affecting the local climate of Brazilian Amazonia. The GCM (General Circulation Models) had been used to predict climate change with the hypothesis that the whole Amazonian Forest was converted into pastures (LBA 1997). However, as 100% conversion is not realistic, the present paper tried to grasp the local climate change, using the observed hydrometeorological data from a small catchment including developed and non-developed areas, in order to compare mainly the evapotranspiration gradient which well demonstrate the influence of land cover change. The results indicated that developed areas showed decrease in evapotranspiration and rainfall, and increase in discharge rate, as the GCM simulation predicted.

Finally, the main goal of this paper was to make clear the current forest situation of the Brazilian Amazonia to find the better method for decision making on land-uses and forestry in order to satisfy both local people subsistence and global needs concerned with the sustainability of the ecosystem.

In Chapter 1, history on Amazonian exploitation and research, importance and world concern on Brazilian Amazonia were discussed, while Chapter 2 was devoted to the Amazonian development and land-uses over the last thirty years, sustainable forest management and actual logging situation. In Chapter 3, Amazonian development projects, remote sensing analysis on the recent Amazonian land-uses were discussed. Chapter 4 dealt with the development influences to the Amazonian people who had always been neglected in the course of the Amazonian development. The influence of big scale deforestation on the local climate was discussed in Chapter 5. The observed hydrological data were analyzed in the small catchments of Rondônia, in Southwestern Amazonia. Finally, Chapter 6 mainly covered the general conclusions of the whole work.

Chapter 2 The Amazonian forests and development

2.1 Actual situation of the Brazilian Amazonia

Large-scale clearance in the Brazilian Amazonia occurred as a result of economic, social and political influences. Deforested area registered by INPE (National Institute for Spatial Research) since 1978 achieved the peak of 29,059 km^2 in 1995, decreasing to 13,037 km^2 in 1997. Average deforestation in Legal Amazonia was 21,000 (+/−2,000) km^2 /year in 1975-1990 (Fearnside *et al.* 1990). In the present paper, the LANDSAT-based estimates are used, as being the most reliable values at present (Fig. 2.1-1).

According to Institut of Weltwirtschaft (IFW), causes of Brazilian deforestation in 1981-1990 were derived from: a) forestry 2%, b) agriculture 91% (shifting cultivation 15%, pastures 40%, permanent cultivation 4%, others 32%) and c) industry 7% (mining 3%, hydroelectric power stations 2%, others 2%).

Conversion of forest into pasture and farming has been the main cause for degrading the Amazonian environment in the last two decades, however fertile soil of Amazonia is 6.11% in terra firme and 5.61% in varzea. This fact indicates that almost 90% of Amazonian soil are inappropriate for raising crops. The 11.72% of Amazonian rich soil correspond to 50 million ha, equivalent to the whole area for farming of the country. Pasture is a very common land-use style of Amazonia, however it quickly degrades the soil.

In the early 1970's, government tax incentives for ranchers attracted many rich farmers from the south, and this fact brought a big-scale clearance in the Brazilian Amazonia. There were 22 million heads

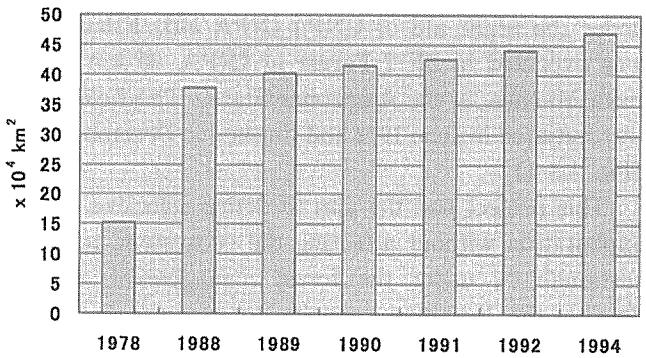


Fig. 2.1-1 Deforestation in the Brazilian Amazonia
Source: INPE

spreading over the 5 million ha of land within Amazonia in 1989. Compaction of soil by cattle breeding, transformed the poor soil much more infertile, making the conversion irreversible. Also, for each 1000 ha of pasture, only five laborers were demanded. If the same area were used for farming, 1500 local laborers could be absorbed. Tax incentives do not apply for cattle ranching, and instead, logging has increased dramatically in recent years.

The rainforests of Brazilian Amazonia have been controlled by the forest management plans since 1990. Nevertheless, during the field work, it was revealed that more than 50% of logging was from non-managed forests. It was explained that due to the vastness of the area (6,500,000 km^2), the lack of government inspectors, and the insufficient expertise regarding rainforests conservation on the part of new settlers coming from other regions of the country, deforestation remains uncontrolled. In Rondônia, the over-exploitation of mahogany, the mogno (*Swietenia macrophylla* King., *Meliaceae*) led to the insolvency of many logging companies founded in the 1980's.

2.2 History of the Amazonian development

In 1940, President Vargas visited Amazonia for the first time with political perspectives, and since then many development projects have been implemented in that region.

In 1953, Legal Amazonia was created officially, adding to the North Region of Brazil, part of the states of Maranhão, Goiás and Mato Grosso, administered by SPVEA, occupying 60% of the country. The "First Five Years Plan" was held by SPVEA, however it failed due to the fragile economic background.

In 1960's, Peru and Venezuela began their development projects in Amazonia.

In 1966, the government of President Castelo Branco created the "Amazonian Operation" and with this, SUDAM (Department of the Development of Amazonia), BASA (Bank of Amazonas) and SUFRAMA (Department of Administration for the Free Market) were founded. The operation offered several facilities to the companies that had the development projects in Amazonia.

From 1968 to 1977, Projeto Radam was settled, mainly for mineral ores search under the deep forest by radar and satellite imagery, with 1,000 ground monitoring points. With this Project, a mine of $600{,}000 \times 10^3$ ton of bauxite was found in Trombetas, to the northwest of Santarém, in Pará State.

In 1970, the government of President Médici created the PIN (Plan for National Integration) to integrate the most poor people of the northeast region of Brazil and to specially assure the National Security in the borderland of Legal Amazonia. With this Plan, many highway construction projects were executed.

In 1972, migration and colonization took place at the crossing point limited by "Transamazônica" (BR230), "Belém-Brasília" (BR10) and "Santarém-Cuiabá" (BR163) highways, partially paved. The land was to be peopled by 70,000 families, *i.e.*, 500,000 people and to them, INCRA (Instituto Nacional de Colonização e Reforma Agrária) offered house, 2 ha of reclaimed land and 100 ha of natural forest with 50% concession for conversion, financed by Bank of Brazil and Bank of Northeast.

During 1972 to 1974, the IPND (First Plan for the National Development) and PDAm (Plan for the Development of Amazônia) were created for the integration and development of Legal Amazonia.

In 1974, the plan for the colonization of Amazonia was suddenly stopped by the government, and President Geisel created the IIPND (Second Plan for the National Development) in order to explore Amazonia as a source of timber, mining and create pasture for cattle raising and farmlands for exporting crops to pay the déficit since the Oil Shock in 1973.

From 1975 to 1979, INCRA sold one million and seven hundred thousand ha of land to non-governmental companies.

To date, many development projects within Amazonia have been established in order to solve the following socio-economical problems of Brazil: 1-political solution for overpopulation, offering land to the landless peasants and jobless urban poor, 2-reduction of foreign debt, converting the rain forest into crop field, 3-defense of border regions against encroachment by the adjoining country.

The discovery of mine ores by the Projeto Radam, accelerated the establishment of mining factories within Amazonia and with implementation of big projects, construction of dams and highways was also encouraged. Following mine ores can be listed in the Brazilian Amazonia, among others: a) lignite 35.5 million ton (Benjamin Constant), b) niobium 2.9 billion ton (São Gabriel da Cachoeira), c) natural gas 100 billion m^3 (Tefé-Caruari), d) tin (cassiterite) 392,000 ton (Brumadinho, Bom Futuro, Novo Paraíso, Pitinga and Presidente Figueiredo), e) bauxite (aluminium) 200 million ton (Rio Trombetas and Nhamundá), f) lime 50

million ton (Nhamundá), g) Potassium 560 million ton (Nova Olinda do Norte) and h) gold 40 ton (Rio Maués) and 150 ton (Curionopolis). Besides, in Carajás, Pará State, a big ore of 18.4 billion ton of gold, copper, manganese and nickel led to a creation of Big Carajás Project.

The Brazilian Amazonia has suffered a big scale clearance lately due to the anthropogenic factors. In some Amazonian regions, it is really hard to find native forests as we used to have before. Among the nine Brazilian states that form Brazilian Amazonia, deforestation rate in the states of Rondônia and Mato Grosso indicated an exponential curve since 1970. The population growth accompanied the deforestation in Rondônia (Fig. 2.2-1).

2.3 Land-uses in the Brazilian Amazonia

In the Brazilian Amazonia, main activities have been resumed to the extraction of non-timber products as for latex and Brazilian nuts, in the past. Timber was only cut at riverside and population pressure was insignificant as to degrade the forest. However, in the 1970's, colonization projects introduced agriculture to the new settlers along the highways, converting the forest in large-scale.

The traditional agricultural areas of the Brazilian Amazonia are located in the eastern part of the state of Pará, in mid and low Amazon. Main crops are cacao, cassava, coffee, maize and rice in that region.

Rich ranchers from the southern country came also for opening pastures, attracted by the governmental tax incentives in that region. They are expanding their lands buying lands from the poor settlers who can not continue their subsistence in their impoverished soil after the conversion.

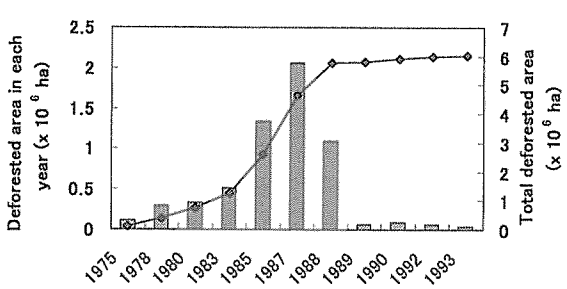
Also, gold prospectors are proliferating throughout the Brazilian Amazonia, often working under severe conditions. Among the mineral resources discovered by the RADAM Project, the following ores can be listed: the bauxite mines, at the Trombetas River, near Almerim and Paragominas, the iron fields in the Carajás range, the cassiterite fieds in the south of the State of Pará and in the State of Rondônia. The Amazonian mineral resources are very rich and varied, and almost of them can be extracted by open-air mining.

Population in Brazilian Amazonia has increased in the last decades, however, even today, the population density of the region is very low, less than 2 inhabitants per square kilometer. The urban centers are few and spread throughout the area.

2.4 Land-uses in Rondônia State

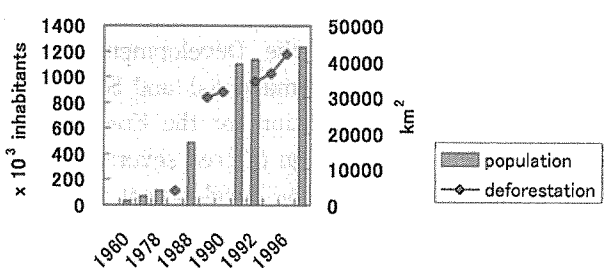
The development of Rondônia State was very fast due to the colonization project along the BR-364 highway and the process of land occupation generated the curious fishbone pattern. In Rondônia State, the first demographic data of 1940's registered 36,935 inhabitants and in 1991 it was 1,130,874 inhabitants. The population still continues to increase, reaching 1,231,007 inhabitants in 1996. This increase in population has resulted in deforestation, which, at present, is a matter of great concern (Fig. 2.4-1).

The first INCRA (National Institute for Colonization and Agrarian Reform)'s project of settlement in Rondônia began in 1970, which substituted the traditional forest activity which exploited trees for the production of latex with a more conservation oriented method. At that time, geometrically divided lots of 500 m by 2 km were distributed along the BR-364 highway and vicinal roads to the settlers. Later, the Brazilian



Extent of deforestation in Rondonia state
Total deforested area till 1993:
6.024 x 10^6ha (24.78 % of the state area)

Fig. 2.2-1 Deforestation in Rondônia
Source: INPE



Population (IBGE) x Deforestation (INPE)
(Rondonia)

Fig. 2.4-1 Population increase and deforestation in Rondônia State
Source: IBGE, INPE

government created the Polonoroeste Program under the Decree no. 86,029 of May 27, 1981, which had as the main goal, the paving of the BR-364 highway (1,456 km) between Cuiabá (capital city of Mato Grosso state) and Porto Velho (capital city of Rondônia), to integrate this remote region to the developed states of the southern country.

The city of Ouro Preto d'Oeste was founded to that aim, and it was located along the BR-364 highway. The place coincided just with the occurrence of an excellent soil type for raising crops, the "terra roxa" (*Chromic Luvisol FAO*).

However, peasants settled in other lands had to abandon the place after some years. At that time, lots of 500 m by 2 km each had been distributed geometrically along the BR-364 highway, independent of the local high or low relief. The settlers could convert 50% of the forest into farmland, but this figure had always been neglected. Most part of the lots of the Project Tancredo Neves in Ji-Paraná presented less than 50% of the remaining natural forest in 1997 (Pic. 2.4-1).

There were 90,000 landowners in the state in 1990, being 60,000 from settlements of the 1970's and 30,000 from those of the 1980's. Governmental financial incentives for the new settlers and development projects followed by the implementation of infrastructure have led to a clearance of at least 21% (about 5,100 thousand ha) of the natural forests within the state.

Converted land with reaped economic value became the most common style of land-use, and it was explored only for a short period. Abandonment of 63% of it, *i.e.*, 3,200 thousand ha was registered. Although the main objective had been successful, the Polonoroeste Program was not satisfactory in relation to the ecological aspects. Conversion of the forests into degraded cattle pastures with little economic value became the most common style of land-use, and in Jiparaná alone there were 128,316 head of cattle in 1980. There were no sufficient and qualified agents for monitoring the forests and protection reserves, leading to an environmental degradation.

Among various approaches to improving the forest management, Rondônia State introduced the zoning strategy (Table 2.4-1) with the intention of addressing ecological problems with the social and economic benefits gained from proper land use.

2.5 Amazonian timber and sustainable forest management

2.5.1 Amazonian timber

Amazonian botanic dominant families are *Leguminosae*, *Lecythidaceae* and *Sapotaceae* in terra firme (dry land) and *Myristicaceae* in várzea (periodically flooded plain). Main species of lumber exported from Brazilian Amazon in 1994 were *Carapa guianensis, Dinizia excelsa, Bagassa guianensis, Cedrella* spp., *Amburana cearensis, Hymenaea courbali, Cordia goeldiana, Astronium* spp., *Ocotea porosa, Tabebuia* spp., *Swietenia*

Table 2.4-1 Zoning of Rondônia State defined by PLANAFLORO (1990)

Zone	Area (ha)	Objective
1	6,195,000	Intensification of farming, installation and recovery of agriculture, cattle breeding and agroforestry.
2	3,015,000	Installation, recovery, development of farming and cultivation of perennial crops of small producers working in a social community.
3	589,000	Encouragement of the utilization of lowland and plateau alongside the watercourse and firm land by the farmers of the river-bank, developing the agroforestry and fishery.
4	3,500,000	Ordering and developing the exploitation of the forest products as Brazilian nut, latex, oil, fruit and roots.
5	2,435,000	Logging of valuable tree species according to the rules of forest management, taking in account the slightly fragile forest ecosystem, typical of ombrophyllus forest.
6	6,400,000	Conservation and permanent preservation of the fragile forest ecosystem, including Indian reserve and legal conservation units.

macrophylla, Bowdichia nitida, Cedrelinga catenaeformis and *Virola surinamensis* (ITTO 1997). Among these species, the hardwood mahogany "mogno" (*Swietenia macrophylla*) is commercially the most valuable, followed by virola (*Virola surinamensis*). In 1990-1996, 743, 840 m^3 of mahogany was exported from Brazilian Amazon (AIMEX 1997).

In the Brazilian Amazonia, timber is classified as "madeira nobre", a valuable wood as mogno, virola (*Virola Surinamensis*), cerejeira (*Torresea cearensis*), and "madeira branca", less valuable wood such as Ipê (*Tabebuia impetiginosa*), angelin (*Hymenolobium patraeum*), Cedro (*Cedrela fissilis* Vell., *Meliaceae*), Faveiras (*Parkia* spp.), Sucupira (*Ormosia coccinea* and *Ormosia coarctata*), Maracatiara (*Astronium Lecoentei*) and others (IBAMA 1997). Intensive exploitation of "madeira nobre" in the 1980's led to a scarcity of mogno and virola in that region and the Brazilian government provided a two year ban on new concessions for harvesting these species in the Amazon regions under Decree number 1963, published on July 26th, 1996.

2.5.2 Amazonian timber in the world market

Amazonian tree species are extremely heterogeneous and the average commercial tree yield is one m^3/ha/year in a natural forest (Silva 1996). Among the ITTO (International Tropical Timber Organization) members, the top 4 round wood producers in 1995-1997 were Brazil, India, Indonesia and Malaysia. Production of Indonesia and Malaysia is decreasing gradually (Fig. 2.5.2-1), and reflecting this fact, logging companies from these countries are advancing in the Brazilian Amazonia.

Among 4000 to 5000 tree species registered by INPA, less than 100 species are absorbed in the international market. An average of 300 species are usually found in a typical stand of one hectare of Amazonian terra firme forest. Exported Amazonian lumber in 1993 was mogno (*Swietenia macrophylla*) 14.21%, jatobá (*Hymenaea courbaril* L.) 5.94%, curupixá (*Micropholis venulosa*) 5.76% and cedro (*Cedrella* spp.) 5.02%, summing up to 395,272 m^3. The total Amazonian timber exports including lumber, veneer, plywood and secondary processed wood products were 665,663 m^3 in the same year.

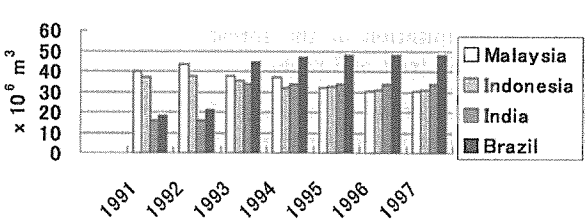


Fig. 2.5.2-1 The 1991-1997 top four tropical log producers
Source: ITTO (1997)

Tax incentives to carry out the farming projects in Amazonia were extinct in 1990, and instead, felling and selective exploitation of timber turned to be more intensive, mainly in southern Pará State (MCT-INPA/DFID 1997). The demand of Amazonian timber is increasing not only for national market but also for exports. In 1997, Brazilian production of logs was 48,000,000 m^3, being 26,000,000 m^3 from non-conifers (Amazonian hardwoods). The big four log producers among ITTO members are Brazil, India, Indonesia and Malaysia, at present (ITTO 1997).

The forest resources of southeastern Asia achieved its peak in the 1990's (Grainger 1987) and, some of Asian tropical timber companies are advancing in Amazon. Philippines and Thailand, the big tropical timber exporters in the past, turned to be importers in this decade because of depletion of timber in their countries. Tropical timber market has been stable in recent years, being the average 136 millions m^3/year.

Most part of Brazilian timber export profit comes from paper and pulp production obtained from Eucalyptus or other planted species (conifers) of the southern country at present, however finished manufactures originate from Amazonian hardwoods (Fig. 2.5.2-2).

Amazonian log production is increasing (Fig. 2.5.2-3), and predatory harvesting of commercial timber from natural forest is a matter of concern, recently.

2.5.3 Sustainable forest management in the Brazilian Amazonia

There are two important forest management researches within Brazilian Amazonia: One is carried out in National Forest of Tapajós (EMBRAPA-CPATU-The Brazilian Agricultural Research Organiza-

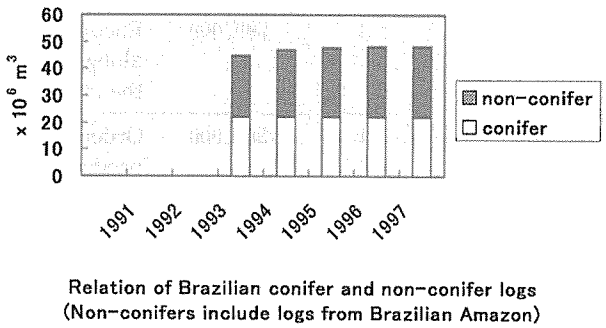


Fig. 2.5.2-2 Brazilian lumber production ($\times 10^3 m^3$)
Source: ITTO (1997)

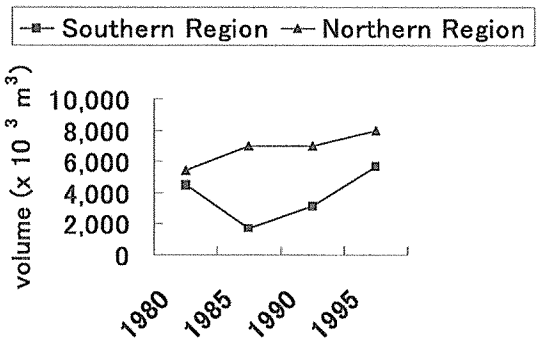


Fig. 2.5.2-3 Brazilian lumber production from Southern region and Northern region. The great part of the Northern log production comes from Amazonia.
Source: Brazilian Wood Profile (1994)

tion-Agroforestry Research Center for the Eastern Amazonia) and another one in Manaus (INPA-National Institute for Amazonian Research), since 1980. The purpose of this study was to ascertain whether conservation of ecosystem could work with tropical log production. Theoretically, sustainable management of the forests in Brazilian Amazon enables to maintain the infinitely renewable forest resources. If the forest were properly managed, as a condition for granting logging permits by IBAMA (Brazilian Institute for the Environment and Renewable Natural Resources), not only deforestation rate can become lower permitting the sustainability of ecosystem but also bring economic and social benefits to the local people (Table 2.5.3-1). However, quite a few projects are properly monitored due to lack of experts and surveyors in the forests. This situation does not correspond to the main goal of ITTO-2000 target: all tropical timber exports should originate from forests under sustainable management till 2000.

Usually, Amazonian hardwoods are harvested predatorily, however some of them are produced from the plantation: Teca (*Tectona grandis*), Albizia (*Albzia falcata*), Balsa (*Ochroma pyramidale*), Gmelina (*Gmelina arborea*) and Seringueira (*Hevea brasiliensis*).

The Brazilian Amazonian timber stock is estimated to be 50 billion m^3, being the viable volume yield only 10% of it (Higuchi 1997). The volume and height of commercial trees in the Amazonian terra firme forest (dense rainforest nearby Manaus) are calculated as follows (Higuchi *et al.* 1985):

Volume $V = a(DBH)^b H^c$

Where the regression coefficients are

$a = 3.2919$, $b = 2.1572$ and $c = 0.4202$

DBH = diameter at breast height

Table 2.5.3-1 Area and number of Plan for Sustainable Management of Forests in the Brazilian Amazonia. Source: DIREN/DEREF 1997, SUPES/Zachow 1998.

States	Average Area (ha)	Maximum Area (ha)	Number
Acre	6,277.39	66,168.00	31
Amazonas	7,481.23	50,000.00	61
Amapá	266.53	2,000.00	19
Maranhao	1,561.45	14,294.00	66
Mato Grosso	1,348.78	21,291.00	1609
Para	2,068.78	60,000.00	740
Rondônia	1,454.26	15,832.00	73
Tocantins	308.27	1,048.00	11
	*2,5689.59		**2610

*General Average by Plan for Sustainable Management of Forests
**Total of Plan for Sustainable Management of Forests
Note: Roraima excluded.

Height $\log H = a + b\ (1/DBH)$

Where the regression coefficients are

$a = 1.2419$ and $b = -0.0365$

H = total height

In Amazonian managed forest of Pará State, an ideal cutting cycle should be around 30 years. Average exploitation of 40 cubic meter/ha is recommended for each cycle and 20 trees/ha with DBH = 20 cm should be left within the stand till the next harvesting without damaging the sustainability (Silva 1996). Inventory should be periodically updated during the harvesting cycle, in order to be informed about the growth and mortality of different commercial trees, for each 200 ha, according to the governmental decree no. 48/95.

Brazilian Amazon Forest area is 3,648,000 km^2 (364,800,000 ha) (Higuchi 1997) and deforested area till 1989 summed up to approximately 500,000 km^2. Deforestation rate from 1990 to 1995 was 127,720 km^2 (12,772,000 ha) (ITTO 1997). The area of transition of forest to savanna is the most deforested area, due to the local people over exploitation of fuel woods, irregular forest clearing and forest exploitation. Among the Amazonian nine states, the most deforested were Pará, Mato Grosso, Maranhão and Rondônia.

The study forest ZF-2 of INPA was formed with six stands of 4 ha each: control natural forest, and others with cutting rate of 70%, 60%, 50%, 40% and 30%. Researchers were periodically monitoring the area in order to study about the microclimate, CO_2 absorption, volume and DBH increment, mortality of trees, litter, soil moisture and others (Pic. 2.5.3-1). This study gives

an indication for silviculture to ascertain the sustainability of managed forest. From the experiments, it was understood that harvesting of 8 trees/ha every 25 years of cutting cycle was sustainable, in the stands with 40% and 30% cutting, the rate encouraged to accomplish the sustainable management. Researches on nursery of Amazonian quick raising species for silviculture were executed in ZF-2, and main species of INPA arboretum were andiroba (*Carapa guianensis* Aubl., *Meliaceae*), copaíba (*Copaifera* spp.-*Leguminosae Caesalpinoideae*), cedro (*Cedrella* spp.), cumaru (*Dipteryx odorata* (Aubl.) Willd. *Leguminosae Papilionoideae*), faveira (*Parkia* spp.-*Leguminosae Mimosoideae*), ipê (*Tabebuia* spp.-*Bignoniaceae*), jatobá (*Hymenaea courbali*), mahogany (*Swietenia macrophylla*), parapará (Jacaranda copaia (Aubl.) D. Don.-*Bignoniaceae*), sapucaia (*Lecyyjos pisonis* Cambess. Subsp. *usitata* (Miers) *Lecythidaceae*), virola (*Virola* spp.), among others.

Generally speaking, Amazonian tree species raise very quickly and some of them get 8-10 m height with annual DBH increment at a rate of one centimeter to three centimeter in the first two or three years, after seedling. The average DBH increment increases of Amazonian species are indicated in the Table 2.5.3-2.

The most valuable Amazonian timber is mogno (*Swietenia macrophylla*) and the occurrence of this specie corresponds to the area of 1,518,964 km^2, and its stock is 18,209,093.9 m^3 of volume. More than 70% of the Brazilian export timber was mahogany before the government regulation was implemented in 1990. The mahogany quota system allowances began with the harvesting limit of 150,000 m^3/year and it was 70,000 m^3/year in 1996, when two years moratorium were established by the government, due to the scarcity of this specie.

In the Brazilian Amazonia, harvesting is usually done with practice of "correntão". This method disturbs the forest badly due to the felling executed by two bulldozers connected with a thick chain. Also, as mahogany trees are usually distributed in widely scattered patches, compaction of soil during the locomotion of the bulldozers and harvesting machines not only fell innumerable non-commercial trees but also disturb the biodiversity of the Amazonian fauna and flora. Regional deforestation occurs for each mahogany tree harvest.

Forest management was not introduced until recently in the Brazilian Amazonia, however, researches carried out by INPA and EMBRAPA made the management of tropical forests possible, making an adaptation of European style to the Brazilian Amazonia. Forest management in tropical forests demands some different methods compared to the temperate ones. Removal of lianas, cutting them at least a year before harvesting the commercial wood is a very important task in the Brazilian Amazonia, in order to avoid forest degradation (Pic. 2.5.3-2).

According to Decree no. 1282 of October 19th, 1995, modern definition of forest management in the Brazilian Amazon is: Forest administration for obtaining economic and social benefits, respecting the mechanism of ecosystem sustainability. If the forest management is economically viable, ecologically correct and socially just, sustainability is possible.

Forest exploitation degrades directly the forest if it is not practiced with proper management. Logging in the Brazilian Amazon gives damage to 60% of the vegetation cover or, it destructs an average of two cubic meters of trees for each cubic meter of timber, at present. In Tailandia, Pará State, in eastern Brazilian Amazon, 1.4 m^3/ha loss of non-commercial trees was observed for each one m^3 logging of commercial trees.

Table 2.5.3-2 Growth of main commercial tree species of Brazilian Amazonia

Species	Diametric increment (mm/year)
Andiroba, *Carapa guianensis* Aubl. -*Meliaceae*	6
Tauari, *Couratari*, spp -*Lecythidaceae*	3
Maçaranduba, *Manilkara* spp. -*Sapotaceae*	4
Breu, *Trattinnickia burseraefolia* (Mart.) Willd. -*Burseraceae*	4
Ucuúba-da-terra-firme, *Virola* spp.	6
Freijó-branco, *Cordia goeldiana*	5
Parapará, *Jacaranda copaia* (Aubl.) D. Don. -Bignoniaceae	8
Cupiúba, *Goupia glabra* Aubl. -*Goupiaceae*	7

Source: Silva (1996)

Management efficiency is reflected at the end of the cutting cycle, and liana removal before a year of harvesting is essential for the exploitation of valuable trees in that region.

This study gives an indication for silviculture to ascertain the sustainability of managed forest. From the experiments, it was understood that harvesting of 8 trees/ha every 25 years of cutting cycle was sustainable, in the stands with 40% and 30% cutting, the rate encouraged to accomplish the sustainable management. Researches on nursery of Amazonian quick raising species for silviculture were executed in ZF-2 and main species of INPA *arboretum* were andiroba (*Carapa guianensis* Aubl., *Meliaceae*), copaíba (*Copaifera* spp.-*Leguminosae Caesalpinoideae*), cedro (*Cedrella* spp.), cumaru (*Dipteryx odorata* (Aubl.) Willd. *Leguminosae Papilionoideae*), faveira (*Parkia* spp.-*Leguminosae Mimosoideae*), ipê (Tabebuia spp.-*Bignoniaceae*), jatobá (*Hymenaea courbali*), mahogany (Swietenia macrophylla), parapará (Jacaranda copaia (Aubl.) D. Don.-*Bignoniaceae*), sapucaia (*Lecyyjos pisonis Cambess.* Subsp. *usitata* (Miers) *Lecythidaceae*), virola (Virola spp.), among others.

2.5.4 Suggestions

Sustainable management of tropical forests is economically viable and this technique brings the enrichment of the explored area without losing the biodiversity. However, from the field study in the Brazilian Amazonia, it could be concluded that the governmental decision on land-uses seldom responded the needs of local people, and did not respect the ecosystem. INCRA continues to plan new settlements within virgin forests instead of making good use of the large cleared lands, in order to avoid conflicts with squatters. Sawn mills are exempt from taxation while IBAMA (Brazilian Institute for the Environment and Renewable Natural Resources) inspectors are paid for protecting the forest. These controversial organs work with the same economic source, the public tax. An organ which is expert only in surveying and analyzing the Amazonian big projects environmental impact should be created to make governmental decisions. Settlements in virgin forests are causing frequent uncontrollable forest burning, as happened recently in Roraima State, spreading from the settlement area as far as the Yanomani Indian Reserve.

Deforestation from logging was insignificant till 1990 in Amazonia, however, today it turned to be an important source of income for the local people. Lumberjacks are generally poor people and valuable trees are cut whenever and wherever are found in the forest. Local people should be technically and economically assisted by the government to accomplish the sustainability of forests. For that purpose, experiment results should be applied in Amazonian remaining forests. Also, agroforestry play an important role for that goal, enabling the optimization of rational and economic utilization of the soil, producing timber and food continually, without disturbing the ecosystem of the soil.

Chapter 3 Amazonian development and land uses

3.1 Development projects in the Brazilian Amazonia

Economic exploitation of Amazonia began in 1966. SUDAM, the Superintendência do Desenvolvimento da Amazônia, was a regional authority of planning the development of that region. The measure was to provide communication and socio-economic infrastructure and investments by means of financial incentives mainly in mining, establishment of industries and cattle-breeding projects. The roads were to serve as guidelines for migration into Amazonia, and INCRA, the Instituto Nacional de Colonização e Reforma Agrária formulated projects for agrarian colonization and models for developing settlements. The 'Programme for National Integration' initiated in 1970, provided for establishing 200 km wide corridors along the highways, removing a total of 2.2 million km^2 of virgin forest. With the discovery of mine ores by RADAM project within Amazonia, mining industries were settled in the forest. Also, having more than 11,000 km of frontier extension with neighboring countries, by geo-political motives, questions of internal security and increasing tension in the border region, road-building was accelerated. By August 1982, SUDAM approved 658 private development projects in Amazonia: 404 (61.4%) for cattle-breeding projects and 206 (31.3%) for industry and mining. In 1980, the number of cattles of Rondônia was 2,510,000 heads, five times the population of the state and this figure is increasing each year.

Among the big Projects within Amazonia, it can be listed :

1- Grande Carajás Project: iron ores (18 billion tons), timber, pulp industry complex occupying an area of 900,000 km^2.

2- Calha Norte Project: construction of Perimetral Norte Highway in the Amazonian forest along the border lines with Surinam, Guiana, Venezuela, Colombia and Peru (2,300 km). This project failed due to the

government deficit.

3- Jari Project: Daniel Ludwig's private rubber plantation, cattle raising and the first pulp industry complex in Legal Amazonia (failed and sold to the Brazilian Government).

4- Polo Noroeste Project: construction and paving of BR-364 Highway, financed by the World Bank, and INCRA's colonization project mainly in Rondônia.

Governmental big development projects were responsible for vast clearance in the Brazilian Amazonia. In Rondônia, the Polonoroeste Project contributed widely to the development of the state and consequently, increased population was the main factor for the new clearance (Table 3.1-1). The main aim of the Polonoroeste Project was paving the BR-364 highway. This road served as a link of circulation of the crops of the state to the big cities and brought immigrants from the industrialized cities of the southern country. Also, governmental programs granting special loans and tax incentives for agriculture and cattle-ranching activities requiring felling, resulted in a widespread deforestation. Peasants driven from the drought of northeast came also to settle in the farms of INCRA. Both immigrants were not used to manage the different soil condition of Amazonia. The only thing they knew was slash-and-burn and they were rapidly cutting the forest to establish farms. Some years after, leaching of the soil led them to convert the farmland into degraded pasture. This fact became the most common type of land-use in that region, accelerating the deforestation even more.

Also, opening of new highways was always accompanied by the deforestation in Rondônia. Samuel Hydroelectric Powered Dams flooded a big amount of vegetation cover and another one is being built in Ji-Paraná.

On the other hand, Rondônia became one of the main producer of the crops for exportation and also supplier of the basic crops to the nearby region. In 1988, the PLANAFLORO program substituted the POLONOROESTE, adding the ecological aspects. Today, more than 25% of Rondônia, is preserved officially as a protection area. For that purpose, zoning played an

Table 3.1-1 List of Amazonian Development Projects and Plans applied to Rondônia

① **INCRA (National Institute for Colonization and Agrarian Reform).** Colonization project created in 1970 in order to execute the settlement of poor people coming from northeastern and southern country.
② **Polonoroeste Project (Northwest pole project).** Created under Decree no. 86,029 on May 27th, 1981. Program to intensify the integration of Rondonia by paving the BR-364 highway from Cuiabá to Porto Velho, bringing colonists from other regions, developing agriculture, providing the conservation of ecosystem and protection of indigenous people. It was mainly funded by the World Bank.
③ **Planafloro (Plan for environment and forest of Rondônia).** Created the first Socio-Economic-Ecologic Zoning of Rondônia under the Decree no. 3782 of June 14th, 1988. Maps of 1 : 1,000,000 were elaborated for different theme : soil, vegetation, fauna, relief, hydrography, geology, geomorphology, mining ore, agrarian situation and agrarian structure of the state. It was the Brazilian Plan of the United Nations Program for the Development of Rondônia, funded by the World Bank and Brazilian Government, in order to put the management of natural resources of Rondônia into practice, as a strategy to harmonize socio-economic aspects of human occupation in that region, introducing the sustainable forest exploitation. Zoning was planned to execute proper manipulation of forestry and agriculture, assuring the conservation of fragile ecosystem of the state.
④ **Plan of Forest Management in Amazonia.** Created according to the Brazilian Forest Law and executed since 1900. It was officially ruled under Decree no. 1282, on October 19th, 1994. This plan follows the ITTO (International Tropical Timber Organization)-2000 goal which determines that the tropical timber export must be executed only from managed forests respecting the sustainability of the ecosystem.
⑤ **PIN (Program of National Integration).** Created by Decree law no. 1106 of June 16th, 1970. Program to integrate the remote regions of Amazonia to the developed regions of Brazil.
⑥ **Machadinho d'Oeste Project (second phase of Planafloro)** New settling model of INCRA's colonization project in order to grant less destructive form of land-use, allowing the sustainability of agroforestry.
⑦ **Urupá Project 1996 (second phase of Planafloro).** New settling model of INCRA's colonization project in order to grant less destructive form of land-use, allowing the sustainability of agroforestry.

important role. The program established a rule for the better use of the converted lands and encouragement of the utilization of forests in the ecological point of view. However, it is to blame that irregularities do exist still today. Many lots are completely cleared and abandoned.

To run the development projects, construction of infrastructures as hydroelectric power plant and highways was also accelerated.

3.2 Hydroelectric projects and highways

The Plan 2010 was held to implement the construction of 136 high dams in Brazilian territory (80 in Amazonia) untill 2010. In Rondônia, increased population has led to a building of Samuel hydroelectric powered plant and its first generator unit started operations in July 1989. It flooded 560 km^2 of the forest, including indigenous tribes' village. It is located on the Jamari River, 52 km east from Porto Velho, the capital city of Rondônia. The reservoir's volume is 3.2 billion m^3 and a normal maximum operating level is 87.00 m. It has a maximum generation capacity of 216 MW and supplies electricity to the cities of Porto Velho, Abunã, Guajará Mirim, Ariquemes, Ji-Paraná in Rondônia and also Rio Branco in the neighbor state of Acre. It attended the demand of industrial sector that increased 38% during the period of 1981-86 in that region. In the years to come, untill 2010, another one, Ji-Paraná hydroelectric powered dam with maximum generation capacity of 512 MW will be built on the Ji-Paraná River, nearby Ji-Paraná city. Untill 2000, following hydroelectrics are planned to be constructed within Amazonia (Table 3.2-1).

Complete removal of biomass in the dam reservoir was never contemplated throughout the construction. Some few months are too short for removal before filling the reservoir, and inventory has never been done effectively. It is evident that the urgency of identifying and implementing better mechanisms for assuring that environmental concerns are reflected in development decisions.

Construction of highways began since the late 1960's in Legal Amazonia (Table 3.2-2), and this fact brought development and destruction in Amazonia, at the same time.

3.3 Remote sensing analysis of Amazonian deforestation

The total area of Rondônia is 243,044 km^2 and until 1970's, the forest area was almost intact. Since the Polo Noroeste Plan began, cleared forest area has increased annually (Table 3.3-1).

Deforested area of Jiparaná in Rondônia was analysed using the following data:

Data: CD-ROM Base 231 Ponto 067 Data 930728 INPE 140

Format: IBM-DOS

Type: High resolution satellite data: 2563 colors used (8 bits for each RGB, indicating each pixel with 24 bits) = 16,777,216 colors.

Data source: Landsat5-TM processed by INPE, Cachoeira Paulista, São Paulo.

Orbital characteristics: Sun-synchronous polar orbit

Image identification: Path: numbered westward, with path number 001 passing through eastern Greenland and South America.

Row: numbered southward, from 81°N to 81°S

Table 3.2-1 Hydroelectric dams of Brazilian Amazonia

Dam	location (State)	power (MW)	flooded forest area (km^2)
Tucuruí*	Pará	7,960	24,300
Balbina*	Amazonas	250	23,600
Samuel*	Rondônia	216	656
Coaracy Nunes*	Amapá	70	
Belo Monte	Pará	11,000	7,365
Porteira	Pará	1,400	
Ji-Paraná	Rondônia	512	
Manso	Mato Grosso	210	
Couto Magalhães	Mato Grosso	220	
Barra do Peixe	Mato Grosso	450	

*in operation, the others are under construction.
Source: Eletronorte (1990)

Table 3.2-2 Main highways of the Brazilian Amazonia

Name of the highway	Extension (km)/ Width (m)	Implemented/ asphalted
Perimetral Norte	2,300	1973/1975 (stopped)
BR 230 Transamazônica	5,600/7.0	1973/1974 (partially, 832.1 km)
BR 163 Santarém-Cuiabá	2,363.2/7.0	1973/1974
BR 174 Manaus-Boa Vista	972.0/7.0	1974/1994
BR 364 Cuiabá-Porto Velho	1,872.5/7.0	1968/1992
BR 010 Brasília-Belém	1,424.4/7.0	

Source: DNER

Rondônia's Path-Row 233-66, 232-66, 231-66, 001-67, 233-67, 232-67, 231-67, 233-69, 232-68, 231-68, 230-68, 229-68, 232-69, 231-69, 230-69 and 229-69.

Size of the scene: 185 km×185 km, 6400 (5728) lines×7020 pixels, 281.5 MB-300MB

Resolution: (28.5 m×28.5 m)/pixel, bands 1, 2, 3, 4, 5 and 7).

Central coordinate: Latitude -10°8′2″S, Longitude -62°7′9″W (line: 3201, pixel: 3511)

1- The cleared area resulted from the INCRA's Colonization Project was detected as a fish-bone pattern, presenting the following size in pixels:

width of the cleared area:

060 pixels×28.5 m=1,710 m (1.71 km)

080 pixels×28.5 m=2,280 m (2.28 km)

spacing between each cleared area :

120 pixels×28.5 m=3,420 m (3.42 km)

130 pixels×28.5 m=3,705 m (3.705 km)

132 pixels×28.5 m=3,762 m (3.762 km)

135 pixels×28.5 m=3,847 m (3.847 km)

154 pixels×28.5 m=4,389 m (4.389 km)

length of corridors of cleared area: 10 km to 100 km on both sides of the trunk road.

In accordance with the INCRA's plan, 100 ha (1 km²) of woodland was distributed to each peasant family and only 50% of the farmland was allowed to be cleared in order to avoid ecological disturbance. Analyzing the CD-ROM data, the cleared area was bigger than the size predicted by INCRA (40% of the State), corresponding to 17,483.136 km² of cleared area, representing 51% of the total area of the scene (34,225 km²).

Table 3.3-1 Cleared forest area of the Rondônia State since 1975

year	cleared forest area (km²)	source
1975	1,216.5	Tardin *et al.* 1980
1978	4,184.5	Tardin *et al.* 1980
1980	7,579.3	Carneiro *et al.* 1982
1983	13,955.2	Brazil, Ministério da Agricultura 1985; Fearnside and Salati 1985
1988	30,000.0	INPE 1992
1989	31,800.0	INPE 1992
1990	33,500.0	INPE 1992
1991	34,600.0	INPE 1992
1993	40,057.9	SEDAM 1995

3.4 Field study in the Amazonian deforested areas

3.4.1 Study area

The field study was carried out in the Brazilian Amazonia, visiting the settlement lots administered by INCRA (National Institute for Colonization and Agrarian Reform) Jiparaná of Rondônia State (Pic. 3.4.1-1), pastures along the BR-364 highway nearby Rio Branco city, and Zoobotanic Park of Federal University of Acre and INPA Study Forest ZF-2 located 90 km to the north of Manaus, in Amazonas State.

3.4.2 An outline of the Rondônia State

Rondônia state is in the southwestern Brazilian Amazonia and its geographical coordinates are Latitude 7°58′S-13°43′S and Longitude 59°50′W-66°48′W. It is limited in the North with Amazonas State, in the Northwest with Acre State, in the West with Bolivia and in the East and South with Mato Grosso State (Fig. 3.4.2-1).

The area of Rondônia is 243,044 km² (approximately 24.3 million ha). According to the climate classification of Köppen, the climate of Rondônia is Am (Equatorial) and Aw (Tropical). The feature of Rondônia's climate is rainy and hot and the variation of temperature throughout the year does not exceed 6°C. Yearly average temperature is around 24°C with relative humidity between 80% to 85%. Rainy season begins in October and lasts until June. Yearly average rainfall varies between 1750 mm/year to 2750 mm/year. Insolation is about 1908 hours/year (SEDAM 1996). July to September is the burning season and burnings concentrate usually in the end of dry season, in September. During this season, traffic accidents become frequent in the roads, airport is suspended for several days and many people get sick, because of the smoke (Pic. 3.4.2-1).

The soil type of Rondônia is represented by Oxisol-USDA (Ferrasols-FAO/UNESCO). Generally speaking, it can be classified as acid with concentration of Fe and Al. In acid soils, the pH may drop to a point where the clay minerals are attacked. This may result in the release of Fe and Al serve as cementing materials for hardpan and concretion formation. Usually, a soil with a pH below 5.5 may be regarded as a potential carrier of soluble Fe and Al. Although Fe is an essential element, a concentration of Fe above the necessary for plant growth is injurious. Also, Al alone is usually blamed for toxicity. (Joffe 1949). The acid soil is hard to transform to a fertile soil, even using modern methods. In Rondônia, only 18% of the area are considered good for farmlands, composed of "terra roxa", the *Luvisol*. This

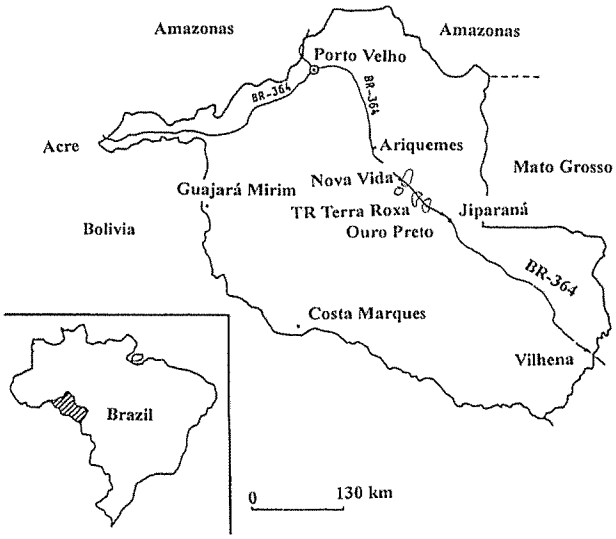


Fig. 3.4.2-1 Map of the Rondônia State

area is located along the BR-364 highway just where the Ouro Preto d'Oeste and some of other 23 cities created for the settlement were implanted in the 1970's. Agriculture (rice, cocoa, coffee, maize, cotton) and cattle raising (Pic. 3.4.2-3), mining (cassiterite, niobium, gold), extraction (timber, rubber) are the main economic activities of Rondônia.

3.4.3 Rondônia's zoning strategy

During the period of 1986-1988, the first attempt on economic zoning was done by PLANAFLORO (Plan for the Environment and Forest of Rondônia), substituting the POLONOROESTE.

The first Socio-Economic-Ecologic Zoning of Rondônia was executed in June 14, 1988, by PLANAFLORO, under the Decree no. 3782 of the government of the state. According to the recent zoning done in the state, 7.5 million ha was destined to Indian Reserve, Biological Reserve and Permanent Conservation National Park.

Many attempts were done during the first stage of zoning, integrating real data with an overlay of all the proposed land-uses in order to ensure that economic development and environmental preservation could be compatible.

According to the recent zoning, 7.5 million ha was designated for an Indian Reserve, a Biological Reserve and a Permanent Conservation National Park. Today, more than 25% of Rondônia is officially preserved as a protected area, implying the important role of zoning in such cases.

The program also established the rules for better usage of converted lands and encouraged the utilization of forests from an ecological point of view.

According to zonal policy, lands in Rondônia can be distributed as shown in the Table 2.4-1 and a total of 9,200 thousand ha of farmland in Rondônia will be in full operation until the end of 2010. Sustainability is the main objective of zoning, and efforts to ensure this end are expected.

According to INCRA Porto Velho, the size of the lots distributed to the settlers has suffered continuous decrease: till 1988, it was 100 ha/colonist; 1987-1988, 50 ha/colonist; in 1991, the average was 30 ha/colonist. In the recent Project, Machadinho do Oeste, the lots are 25 ha/colonist. According to PLANAFLORO, a total of 9,200 thousand ha of farmlands in Rondônia will be fully occupied till the end of 2010.

At the beginning of 1970's, Rondônia was a remote region covered with dense rainforest. In the last two decades, activities such as agriculture, mining, and industries have developed quickly in Rondônia. More than two thousand new establishments have formed an industrial complex. The industries have been founded mainly to process timber and to supply food products and public building materials.

The state is the main supplier of crops for that region, today. In 1997, production of crops was 77,201,000 ton, corresponding to 88% of the total crop production of mid-west region. In Rondônia, deforested area summed up to 6.024 million ha, corresponding to 24.78% of the total area of the state. Clearing was only conducted with official authorization from 1991 to 1993, and authorized area for clearing was 110,252 ha (0.45%), for burning was 284,532 ha (1.17%) and for selective logging

was 12,278 ha (0.05%) in 1992-1993.

Forest converted to different land-uses in Rondônia resulted mainly from settlement, mining and hydroelectric powered plant.

3.4.4 Settlement

In this study, the practice of land-use of Rondônia State were analyzed, based on a survey done in the lots of farmers in Ji-Paraná, in August 97. The field study was carried out in each lot of two farmers who belong to the INCRA, TN29 Lot 142 and TN33 Lot 112, respectively, to analyze the conversion method of rainforest to farmland (Pic. 3.4.4-1).

Within the past two decades, 100 thousand families settled in Rondônia, occupying four million ha of total agricultural land of six million ha. Most of them were poor peasants that came from South and Northeast region of Brazil.

According to INCRA Porto Velho, federal land destined to the new settlers is distributed in different loans, depending on the condition of the lots, varying from R$10/ha (bad land condition) to R$80/ha (excellent land condition), being the mean price R$40 to R$50 per hectare (R$=US$1.073, in August 1997; minimum monthly wages in Brazil=R$112, in March, 1998), paid up by the colonists in 5 to 10 years. In general, they begin to pay their loan in the second year after purchasing the lot.

Actually, 20% of the settlers continue in the lot since the first settlement. The typical pattern of land-use practiced by the settlers is slash-and-burn. During the first years after the burning (less than four years), the colonists plant annual crops such as rice, corn, beans or manioc, and perennial crops such as coffee, cocoa and rubber. As soil quality decreases and crops become more susceptible to pests and disease, production of these crops becomes infeasible. Also, planting perennial crops demand a much larger labor and capital investment leading the farmers to convert farms into pastures, degrading the land in an irreversible manner. After the conversion, pasture grasses last not more than 8 years. Settlers who migrated in the poor soil have no choice as to abandon it after few years, after burning 50% of the forest. According to the agent of INCRA, the mean time of the families' stay in the lots is around four years.

The colonists who keep their lives in the lot have as their subsistence, apiculture, fish culture and cattle breeding to compensate the impoverished soil for crops. Actually, the Project Machadinho d'Oeste is being run by INCRA in Ji-Paraná. This project is the new settling model and the lots are not divided geometrically. It respects the water system and this results in an irregular shape of the lots, called "blocos" (blocks). There are 8 blocks within the Project Machadinho d'Oeste, contouring the fountain, accordingly. Another one is the Project Urupa with a block with 20,000 ha. This block has been invaded seriously by the neighbor land grabbers, recently.

3.4.5 Mining

Rondônia has a rich cassiterite (tin) ore (70% of the country) besides copper, diamond, gold, graphite, iron, manganese, niobium and titanium ores under the dense forest. Open-air mining contributes to an irreversible conversion of the forests, however it is the most common style of exploitation in that region. Some of the mining companies collect a thin superficial layer of soil of the cleared land and put it back to the primary place after the mining is completed. However, quite few industries put this into practice and not always the preserved soil keeps the characteristic of months or years before the excavation.

The cassiterite ore Brumadinho in Rondônia, cleared 12% of the natural forest cover of that region. In Bom Futuro, the cassiterite ore, located 280 km from Porto Velho, has an extent of 112 thousand ha. Usually, in cassiterite ore, thousands of ha of the forest is cleared and excavated. The cassiterite rock is washed from the clay on the waterside, polluting the river and degrading the nearby forest.

In Rondônia, gold ore is heavily polluting the river with mercury. Gold extraction in Amazonia, uses mercury for the amalgamation process, thus polluting the river with the mercury excess during the washing process and also the atmosphere during the evaporation process while separating pure gold from the amalgam. The Madeira River (Pic. 3.4.5-1) is polluted with mercury and, in its 500 km flow between the cities of Guajará Mirim and Porto Velho, eight ton of mercury was used to extract 15 ton of gold, in 1988. In Porto Velho, 70% of the fishes sold at the market is polluted with mercury. Not only in the rivers of Rondônia but also in innumerable rivers of Brazilian Amazonia, proliferation of mercury is affecting the environment.

However, mineral ore is absorbing a large amount of poor peasants who abandoned their barren land of the failed settlement. Proliferation of pollutants in the environment resulting from the mineral exploitation is a matter of great concern in the Brazilian Amazonia, at present.

3.4.6 Logging

Main tree species of Rondônia are palms (*Palmaceae*), mahogany (*Swietenia macrophylla*), cerejeira (*Torresea cearensis*), ipê (*Tabebuia* spp., *Bignoniaceae*), angelim (*Hymenolobium* spp., *Leguminosae Papilionoideae*), cedro (*Cedrella* spp.), faveiras (*Parkia pencula* (Willd.) Benth. ex Walp. *Leguminosae Mimosoidae*), Sucupira (*Bowdichia nitida* Spruce, *Leguminosae Papilionoidae*), maracatiara (*Astronium Lecoentei*), and in Jiparaná there were many natural stands of cacao.

In Rondônia, forest site with occurrence of mahogany is shrinking each year and loggers are shifting bigger distances than before, recently.

Forestry is the main industry of Zone 5 of the state and it is densely covered with Palm trees (*Palmaceae*) as well as other species such as are cited above. There were 1500 lumber mills in the state, producing 5 million m^3/year of sawn wood, and timber was a source of 35% of the state's economic income in 1990. There were 784 lumber mills registered in IBAMA (Institute for the Environment and Renewable Natural Resources) in 1993, of which, 735 were sawn mills, 43 veneer mills and 6 plywood mills. Logging was executed by 491 small logging companies registered by IBAMA, in all 22 districts of Rondônia State in 1993 (Table 3.4.6-1).

Logging in Rondônia was possible only along the river bank before the implementation of highways led by the development projects in the decade of 1970. Deforested area was 0.50% in 1975, however, the average deforestation reached 239,000 ha/year during the 1978-1993. More than 76.02% of deforestation concentrated between 1984-1988.

This period coincided with the peak of harvesting mahogany and virola. Today, ipê and jatobá (*hymenaea* spp.) are used as substitute for them. As Amazonian valuable timber has only been predatorily exploited without reforestation over the decades, harvesting stand is becoming each time distant from the mills. In Rondônia State, average distance for harvesting is 65.8 km. This figure varies according to the species, and for companies working only with "madeira branca" (less valuable commercial timber for domestic use), the distance is 57.3 km and for those who include exportable timber it becomes 87.9 km. If the company works only with export timber as mahogany, the distance stretches 161.0 km from the base point. This fact makes the logging activity more expensive and locomotion of machinery in the forest gives damage to the ecosystem.

Log production of Rondônia was 60,000 m^3, 307,000 m^3 and 1,320,000 m^3 in 1975,1980 and 1985, respectively (Fig. 3.4.6-2).

Table 3.4.6-1 Lumber mills of Rondônia State registered in IBAMA. Source: IBAMA/DICOFE, NGO of Rondônia (1993)

Districts	No. of lumber mills	%
Ariquemes	243	49.5
Paraná	99	20.2
Ouro Preto d'Oeste	39	7.9
Porto Velho	16	3.3
Pimenta Bueno	11	2.2
Vilhena	11	2.2
Rolim de Moura	9	1.8
Costa Marques	9	1.8
Jarú	7	1.4
Alvorada do Oeste	6	1.2
Monte Negro	6	1.2
Alto Paraíso	6	1.2
Other districts*	29	5.9
Total	491	100.0

*Cacaulândia (5), Cerejeiras (3), Alta Floresta d'Oeste (3), Guajará Mirim (3), Espigão d'Oeste (3), Presidente Médici (3), Campo Novo (3), Cacoal (2), Colorado d'Oeste (2), Machadinho d'Oeste (2).

Most part of the loggers of the state concentrates in Ariquemes and 70-80% of these loggers are farmers of subsistence. Ninety percent of them have only one truck for logging and fifty percent of them have no other suitable logging machinery. This city is also a hotbed of malaria and 47% of the 102 thousand inhabitants contracted the disease in 1989.

3.4.7 Sustainable management of forests in Rondônia State

In Rondônia, there are 73 plans for sustainable management of forests (Table 2.5.3-1). It is crucial to widen these plans in order to protect the fragile ecosystem of Amazonian rainforest, and for that purpose, zoning will play an important role (Table 2.4-1). If forest management is to benefit local people and to function effectively to avert global warming, decision-making must give proper weight to socio-economic factors.

During the field study, abandoned cleared area was very common and inconsistent management was observed in the remaining forests. More profitable utilization of converted land, silvicultural plantations and sustainable timber management are urged in order to minimize deforestation. Implementing better mechanisms for assuring these environmental concerns is evident in development decisions.

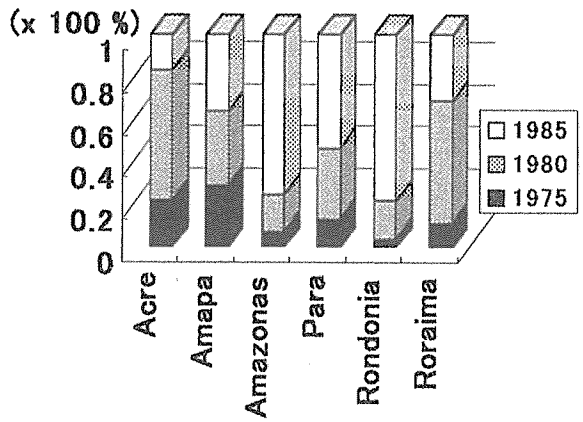


Fig. 3.4.6-2 Log production ratio by state in Brazilian Amazonia: in Rondônia State - 60,000 m³ (1975), 307,000 m³(1980), 1,320,000 m³ (1985)
Source: BIONTE (1997)

In Rondônia, although efforts for sustainable management of the forests by the governmental institutions do exist, it was found that farmers were converting more than 50% of their forests illegally, thus disregarding the government's ecological intentions.

3.5 Main problems raised from deforestation

In 1982, there were only 8 agents of IBDF (Brazilian Institute for Forestry Development) to patrol the forest, and consequently, the manipulation of the forests was not done properly.

Today, forests are monitored by the agents of both SEDAM (Secretariat for the Environmental Development) and IBAMA. The inspection is done once a year and if the farmer does not meet the inspector requirements, the inspector will not renew the registration of the land. If the logging is not done from properly managed forests, the inspector cancels the authorization for that purpose. However, irregularities still exist at present. Many lots were completely cleared and were left abandoned. Also, more than half of logging activity was not properly registered due to the ignorance of loggers and high tax charged for obtaining license for that purpose. Decrees prohibiting deforestation have minimal effect on land clearing decisions made by farmers or ranchers living far from major roads and cities and spread over the state.

In order to decrease the deforestation rate in the Brazilian Amazonia, the government restricted farmers to convert only 20% of their lands, recently. As a result, the incursion of loggers into the lands of the Amazonian indigenous people has become more frequent, as they still have an abundant stock of mahogany. In addition, ecological progress is disturbed by the lack of adequate education among the indigenous people, who are enjoying the material benefits of selling their valuable wood.

INCRA's settlement project provides an example of a series of barriers to properly occupying cleared areas. The lack of infrastructure, education and health care for the new settlers coming from other states lead to the abandonment of reclaimed land after few years of use.

Impoverished soil can not be used for cultivation of crops, and deforestation of the virgin forest is the only way left for the people to continue their lives. The assistance they get from the government after the settlement is not enough for their subsistence.

Local people usually depend on fuel wood and poverty does not permit land in fallow, which is the best way for regenerating the soil for cultivation of crops. Land-use change in Rondônia was dominated by transformation of forest to cattle pasture. Usually, impoverished soils after two or three years of utilization for raising crops are soon abandoned or converted into pasture in Amazon, and that was the reason why there were so many pastures and abandoned lands in Rondônia State.

Settlers often plant annual crops for one to three years before planting pasture, whereas large ranchers plant pasture directly after felling. The rapidly increasing rate of forest loss in Rondônia means that vegetation replacing the region is crucial in determining the impact of deforestation. Degraded cattle pastures regenerate secondary forests more slowly than do fallow in shifting cultivation. Efforts in lay land fallow are urged in this region.

Today, Rondônia supplies 88% of basic crops of all mid-west Brazilian region. In 1975-1985, log production in Rondônia registered an increase, however, due to the scarcity of mahogany after intensive exploitation of the wood, different timber is harvested at present. Timber was a source of 35% of the economic income of the state in 1990, but among 1600 lumber mills established in Rondônia in 1982-1988, only 50% of them are in activity today. With the development projects of the 1970's, Rondônia was transformed into a big agricultural nucleus, yet left many social and ecological problems behind.

Chapter 4 Influence of development to the local people

4.1 History and present situation

In 1500, there lived more than five million indios in Brazil, but with the colonization, they were killed, captured to slavery or even died from diseases they never had before, taken from the Europeans. Today, they are only 217,778 and 136,000 of them are living within Legal Amazonia.

In late 19th century, with the invention of automobiles, big demand of rubber attracted a lot of rubber-tappers (seringueiros) in Legal Amazonia, coming from the northeast region of Brazil. Conflicts between rubber-tappers and indigenous people have been frequent since then.

The gold rush in Amazonia left many victims in different Indian groups, in this century. In August 1993, a group of gold prospectors massacred 19 men, 16 women, 18 boys and 17 girls in two villages Haximu of Yanomami group in Roraima state, near the Venezuela border. The chief Antonio Yanomami walked two days to reach the nearest FUNAI post to tell about the massacre. This is one of the many facts that happen frequently in the deep Amazonian rainforest. On the other hand, gold prospectors are also victims of the poverty driven from the drought of the northeastern country. There were 20,000 gold prospectors in that region before the official delimitation of Yanomami Indian reserve (94,000 km^2) and today they are about 600. They are clandestinely in that reserve, and this fact is beyond Federal police control.

4.1.1 People who live in Amazonia at present

In Amazonia, most part of people who live in the cities are "mamelucos" or "caboclos". Mamelucos are sons of an Indian and a white man. Caboclos are civilized Brazilian Indian of pure blood or a Brazilian half-breed of white and Indian.

Migrants who came from the southern country attracted by the governmental tax incentives are whites, the European descendants. Migrants who came from the northeastern country are mestiços (half-breed of white and black people) and caboclos. There are also "mulatos" who are African descendants brought by the Portugueses as slaves, in the 19th century to Brazil to work in sugar cane plantations.

Miscigenation is very common in all over the country and due to the concentration of indigenous people in this region, there live many caboclos in Amazonia. However, there also live many millenary groups with different cultures and languages who are semi-civilized or isolated within the forest.

There also live Japanese descendants who immigrated to work out in agriculture, in Pará State and in Rondônia State, fifty years ago. Jute and pepper are the results of their efforts after many years of trial to make them as the main export products from Amazonia.

In the early 20th century, Amazonian indigenous people suffered intrusion by the "seringueiros" (rubber-tappers) who came mainly from the northeastern country, a very poor region with grave drought. They worked very hard collecting latex mainly for exportation to manufacture tires to be used for the first invented automobile by mankind. Lately, these rubber-tappers took the initial lead in resisting the forest destruction brought by the BR-364 highway. One of the first protesters against the deforestation driving rubber-tappers from their homes was Wilson Pinheiro. After his murder by the hired guns of the invading ranchers in 1980, the rubber-tappers of Acre leadered by Francisco Alves Mendes Filho (Chico Mendes) pursued a policy of non-violence which involved unarmed "empates" (human blockades) with ranchers' deforestation gangs. In the lawless state of Acre, the gunmen could not always be shamed into forswearing force when confronted by barriers of women and children; more "empates" were lost than were won. However, those that were won saved three million hectares of forest. Finally, Chico Mendes was gunned down in the remote western Amazon state of Acre on December 22, 1988. He died opposing a road: Federal Highway BR-364, running east/west across the states of Rondônia and Acre, in his struggle for extractive reserves and sustainable economic alternatives.

4.1.2 The Indigenous people of the Brazilian Amazonia

In 1500, Brazil were populated by approximately five to six million indigenous people, composed of 700 ethnic groups. However, today, there are only 217,778, corresponding to 146 ethnic groups. The indigenous people live in 500 Indian reserves within Amazonia, administered by FUNAI and many of them do not speak their own language, today. Many Indian groups have been driven off their land by the big development projects within Amazonia. Surveillance by satellite since the 1960's has revealed the existence of large mineral resources of iron, bauxite, gold, cassiterite and uranium under the Amazonian forest (IBGE 1975). Since then, thousands

of gold prospectors and mining companies began exploration within the forest.

There are almost 136,000 Indians in Brazilian Amazonia living in their "malocas", a traditional village scattered in 82 million ha of rainforest. One of the biggest group is Yanomamis with 10,000 people living in northern Amazonian state of Roraima. They were invaded by 20,000 gold prospectors (garimpeiros) in 1987-1988 and 1,500 of the people died by malaria and violence. They are victims of violence due to the existence of rich mine ore within their reserve. There is only one FUNAI agent in each 1000 km^2 and they have two airplanes in Boa Vista, capital city of Roraima to attend 10,000 Yanomami people living in the following villages: Ajarani, Ajuricaba, Araca, Auaris, A. Catrimani (I), B. Mucajaí, Catrimani (II), Demini, Ericó, Haximu, Homoche, Marauiá, Maturacá, Mucajaí, Nova Demini, Olomai, Paapiú, Padauaris, Palimiu-There, Parafuri, Surucucu, Toototobi, Uaiacás, Uraricoera, Xidea, Xikoi and Xiriana. There also live 15,000 Yanomamis in the Venezuelan side.

In Rondônia State, the Uru-Eu-Wau-Wau group had their village passed over by the BR-364 and intrusions to their land became frequent since then.

This highway brought many problems, specialy diseases the Indians never had before. In 1990, the Surui people were dying from measles, malaria and tuberculosis, loggers were stripping their reserve of the last of its mahogany, and the Federal Indian agency, FUNAI, had closed its local post to sick Indians on the grounds that it had no money for food or medicines. The groups within Rondônia that suffered from invasion to their traditional lands are: Arara, Zoró, Tubarão Latunde, Cinta-Larga, Sakirabiar, Suruí, Tupari, Uru-Eu-Wau-Wau, Makurap and Gavião (Karitiana 1996).

At least 85% of Rondônia's indigenous population was estimated to have died from violence and new diseases by the time the BR-364 was paved from Cuiabá as far as Porto Velho in 1984. This highway continued to spread westwards after reaching Porto Velho, and in Acre state, the indigenous groups on BR-364's path suffered as badly as the Indians of Rondônia had done.

The Kaxarari of the Rondônia/Acre border were devastated by epidemics after the construction company, Mendes Júnior, dug a huge gravel pit on their territory, providing a perfect breeding-ground for malarial mosquitoes. In November 1992, chief Alberto César Kaxarari claimed that only 177 of his 3,000 people had survived the epidemics, and 70 percent of the survivors were suffering from malaria and tuberculosis. The Katukina, a group living on the BR-364 near Cruzeiro do Sul, have seen their village turned into a roadside stop and suffer problems of alcoholism, malaria and abuse of women (Shankland 1993).

The increasing population of Amazonia has led to the building of many hydroelectric powered dams which have flooded the lands of many indigenous groups (Caufield 1984).

The Samuel Hydroelectric Power Plant supplies electricity to the cities of Porto Velho, Abunã, Guajará-Mirim, Ariquemes, Ji-Paraná in Rondônia State and Rio Branco in Acre State. It is located on the Jamari river, in Rondônia, 52 km from Porto Velho. The construction took place in 1982 and the operation began in July 1989, completing the full capacity generation of 216 MW in 1990. With the construction, an area equivalent to 656 km^2 of forest was flooded, driving away three tribes of that area: Rio Machado, Araras and Gaviao, who lived along the Rio Machado (Jiparaná River) for thousands of years (Karitiana 1996).

The Cotingo Dam has been proposed for construction in the Raposa Serra do Sol Indigenous Area in Roraima State, and the main tribe in the area was the Macuxi, with smaller contingents of Ingariko and Taurepang/Wapixana. The catchment basin of Cotingo River is a 3380 km^2 area bounded on the north by the continental divide that forms the border of Brazil with Venezuela and Guyana. As dam construction approached, Macuxi Indians were isolated and expelled from their own land by military police of the Roraima state government. Although Brazil's 1988 constitution makes clear that traditional occupation is the basis of protection (Article 231, Paragraph 3), royal payments are not specified for hydroelectric dams as mentioned for mining on indigenous lands (Fearnside and Barbosa 1996b).

The Caiapó group confronts with another type of problem. They live in Caiapó Reserve, however, since the 1980's, they have suffered intrusion from the loggers to explore mahogany. The loggers are not only using corrupt measures to illegally buy the Indian mahoganies, but also are making use of the cheap Indian labor to its logging. The group, however, are totally dependent on the income from their mahogany to purchase the white's goods as cars and tape-recorders, at present. In 1993, the Caiapó representatives went to Brasilia to ask the government the indemnity for the prohibition to exploit mahogany in their own land.

Depending on the location of their village, the indigenous people suffer different grade of influence from the development. The people who were sent to the Indian

reserve near the cities, faced the white's way of life more directly, after their removal from their forest to give way to the development projects. The profound social changes have resulted in alcoholism, misery and depression, increasing the suicide rate among indigenous people. In the last ten years, 206 deaths by suicide of Guaranis-kaiowás were registered among the Indian groups.

Little literature has been published on the situation of indigenous people of Brazilian Amazonia. The problems of suicide among indigenous youngsters of Southern Amazonia can be related to the influence of development (Ishi 1994). Problems of indigenous tribes of Brazilian Amazonia derived from the development projects are reported by Gheerbrant, 1988. Removal of indigenous villages from dam sites in the Brazilian Amazonia is described by Caufield 1984. Some interesting information is available on the specific indigenous groups within Rondônia State (Hugo 1991). The present study was based on the field work carried out in the Karitiana village located in northern Rondônia, in August, 1997.

4.2 Field work

Among different groups of Rondônia that have contact with white people, the Karitiana was chosen for study because this group suffered particularly from influence of development and had the tragic past. The Karitiana village has 207 people. Eleven of them are from other ethnic groups and 24 are living in Porto Velho city. Almost 70% of the people are composed of children and youngsters (Pic. 4.2-1). There are very few old people in this group. Before the first contact, there were 3 to 5 thousand people, with many clans.

Their village, occupying 89,698 ha, is located 97 km southwest of Porto Velho, the capital city of Rondônia (Fig. 4.2-1, Pic. 4.2-2). This land was delimited in June 1976 and was promulgated under decree No. 93,068, on August 6, 1986. The delimitation excluded the best part of their lands. The river Candeias' bank, where they lived before, was their traditional land with their cemetery and old villages of their ancestors, but now, a road passes over it.

This study began in September 1996, when the first contact was made with the leader of the Karitiana Group, at the Symposium on Environment of JBN (Japan-Brazil Network), held in Tokyo. Since then, through correspondence, newspaper clippings and copies of reports of the indigenous representatives' meetings sent by the leader, information concerning with their problems was collected. In August 1997, a visit was made to the Karitiana's village, NGO (Nongovernmental Organization) of Rondônia and CIMI (Missionary Council of Indigens) of Porto Velho city of Rondônia, to add substance to the research. The representatives of Karitiana village, the House of the Indios of FUNAI, CIMI and NGO were asked about their actual situation, attitudes, thoughts and problems from their different points of view.

According to the leader of the Karitiana group, they still suffer from incursion by farmers and miners, even living within the Indian reserves. There is a law to protect their rights but there are few inspectors to patrol or enforce it. There are so many incursions that it is almost impossible for the inspectors to defend the indigenous people effectively. One agent has to inspect some thousands of square kilometers of the forest, and many accidents happen behind him (Karitiana 1996).

Within the Karitiana group, deaths due to disease are a routine. There are no doctors in the community, nor do doctors visit. They are occasionaly attended by four health-care agents, but that is not enough. They have two shamans (pajés) who know much about medicinal plants. However, the Karitiana people are very vulnerable to the contagious diseases brought by the white people. They have sufficient food, but some have the problem of alcoholism. They use a filter to drink water from the river (Rio das Garças), but the water is polluted (Pic. 4.2-3).

They have only eight bathrooms in the village. In order to be attended legally by the public health care center in the city, they use a microscope so that they can

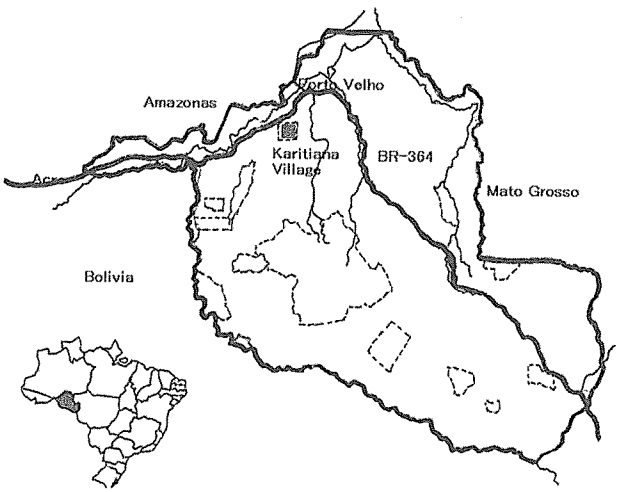


Fig. 4.2-1 Karitiana village and Indian reserve of Rondonia State
Source: IBGE

justify the disease to be treated free of charge. Illness due to snake's bite is very common in Amazonia and for that reason they need the means of urgent communication. In 1997, there was a sick indio in the village who died because there was no means of transporting him to the city. They also need medicines to treat malaria.

Assistance for health care and hygiene is the most important priority to help the indigenous people at present. More qualified staff of governmental institution are also required to protect their lands.

In the beginning, FUNAI concentrated their efforts on assimilating the índios to the whites' lifestyle. Today, missionaries of CIMI do not try to convert them as before, and instead help them to keep their culture, religion, language and custom, encouraging them to retain their identity. For that purpose, they try to accompany the people, living in the village whenever possible, and train them to produce their own teachers and health care agents within the community.

Education of the Karitiana people began regularly in 1982, in the village. The school (named August 4) has two classrooms, with 95 children, youngsters and adults. Four white teachers and three indigenous teachers are working there. The languages used for teaching are Karitiana and Portuguese, and they learn mainly Mathematics and Portuguese so as to facilitate interchange and trade with the non- indigenous people. There is a lack of textbooks in the Karitiana language. However, they are using the first such book to learn Karitiana's orthography and grammar with some ancient stories of the Karitiana people.

The official organizations that assist them include FUNAI (National Indian Foundation), and Projeto Planafloro. From 1991 to 1992 the international NGO worked on a project named APARAI (Association for Environmental Protection and Recovery of Indigenous Lands) and helped them to train laboratory technicians. Unfortunatelly, in 1997 an agent of FUNAI abused two indigenous girls and people of the village, no longer trust the FUNAI agents.

In the Karitiana group, some youngsters living in Porto Velho city are studying to be lawyers in order to defend their rights. The main problem is lack of financial aid for their studies. Help for their education is very important and qualified agents are needed urgently to assist the Karitiana people.

According to the Uirapuru Association of the Indigenous Group, after the delimitation of their land, the Karitiana group suffered incursions in 1977 and in 1982. The mining company "Mineradora Jacundá" explored for ore and timber, and left a degraded forest behind them. Even in 1997, some prospectors tried to explore for gold. However, the Karitiana community did not permit that incursion on their land.

Today, they seldom hunt because the size of their remaining forest does not permit it, and they have good manioc and corn fields. Besides, they plant cará potato, rice, zucchini (macaxeira), sweet-potato and beans. Their orchards bear guava, jaca (jack fruit, durian), caju (cashew), cacao, banana, avocado, lemon and orange trees. They also breed some chickens, ducks, pigs and parrots. Their traditional craft products of head ornaments (cocares), earrings, pierces, bracelets, bows and arrows are an important source of income. They have a small work- shop in Porto Velho City. Economic independence is very important to their subsistence life-style.

The Karitiana village is a relatively modern one, with electricity. There are some bicycles, an old Toyota truck, an old tractor, two chain-saws, an electric motor, a mill-house and two chicken-houses. The people wear simple clothes, but they also wear their traditional ornaments (cocares) occasionally. Before the delimitation, they lived in a bigger land between the rivers Candeias and Jamari, and could hunt whenever they needed. That is now not possible due to the decline in wildlife, and they only have cassava, corn and fruits to eat.

To help meet their food needs, FUNAI constructed two chicken houses in the middle of their area, in 1996. However, there are no chickens because of lack of funds and the houses are being destroyed by termites.

The leader's parents were killed by the whites when he was very young. Since then, he studied Portuguese and now he can speak both languages fluently. The group leader is the representive of Uirapuru, and CUNPIR, organization of different indigenous groups, and Portuguese is a tool he uses to understand other groups and to negotiate with government organizations in order to claim the rights of his people.

In Porto Velho, there is a House of the Índios of FUNAI (Pic. 4.2-4). The house accommodates children who go to school in Porto Velho, sick people who need medical care, and representatives of different groups who work for the community, going back to their village once a month in turns, to help their families and keep informed. The groups living together at the time of my visit on August 17, 1997 at the House, comprised the Karitiana, Tenharim, Diahoi and Parintintin. Their villages are located far from each other and trucks are

needed to patrol their lands, to transport sick people and fruit and crops to sell in Porto Velho. However, they still have no trucks, or only broken ones. Assistance for transport is an important need.

The Karitiana group consists of indigenous people who have not assimilated completely to the white population. They wish to preserve their culture, of which they are very proud. They need the help of FUNAI, ONG and CIMI, but they seek dialog at first. According to the leaders of the group, the first priority for aid is on health care, followed by children's education and transport. They prefer to be economically independent and are looking for sources income, particularly through selling their crops and craftworks. Also, in order to achieve rights at the level of Brazilian citizen, they are organizing a committee in alliance with other groups. From my contact with the Karitiana people, it was clear that they love their family, their forest and above all, peace. Other groups, however, are more militant and attack white trespassers on their lands. Sometimes, these groups also attack rubber-tappers who are working lawfully.

It is ironic that Rondônia State, named after Marshal Rondon who first created this organ to protect the dignity of the indios, is one of the most deforested states in the Brazilian Amazonia, with so many suffering Indian groups. Recently, the Brazilian government revised the law relating to agrarian reform and proclaimed decree No. 1775/96 to delimit the Indian lands. This decree resulted in contraction of many Indian lands, making way for farmers and colonization projects. In the last two decades, 100,000 peasant families from southern Brazil migrated to occupy four million ha of the six million ha of the agrarian lands of Rondônia State. The production of crops in Rondônia was 77,201,000 ton in 1997 (IBGE 1998), corresponding to 88% of the whole crop production of the Brazilian Mid-West region. The development projects in Rondônia State transformed the most remote region of Brazil to a major supplier of crops and minerals in a very short time. The development, however, had serious consequences for the indigenous people.

4.3 Problems and suggestions

The most fertile land of Brazilian Amazonia concentrates in Acre State in Western Amazonia, and rich ranchers and farmers coming from the Southern country are being a menace to the local people. Commercial crops do not help the subsistence of the local people, however paving of the BR-364 is accelerated in order to enable circulation of the crops. The construction of BR-364 highway in the middle of the forest is advancing the clearance along the road, and rubber-tappers are being driven from their forest. There are 40 thousand of them in Acre, at present. They are forming an alliance to protect their forest, in order to continue their activity of rubber extraction. They uses a tactics of "empate", a peaceful method created by Chico Mendes, the leader of Acrean rubber-tapper's alliance, to hold the intruders in the forest. In December 1988, however, Chico Mendes was murdered by the gunman of a rich rancher. The government should protect and assist legally the life of the rubber-tappers who know the best way of utilizing the forest in a sustainable way.

In Amazonia and also in other Brazilian states, fighting between the squatters and land grabbers has been a serious problem, recently. In Brazilian Amazonia there are a lot of places where law doesn't work and murder is frequent in the conflict of lands.

On the day the author visited INCRA Porto Velho, there were many representatives of landless people outside the gate, asking for the land, accusing for the big ranchers who live in big cities, keeping the guard of their unproductive lands with gunmen. Redistribution of land in Amazonia is urged to put an end to the unfair status of the poor peasants.

Not only in the Brazilian Amazonia but also in whole Amazonia, indigenous groups live in their "malocas" scattered all over the region. The government created indigenous reserves in the area where concentrate their villages, except for the isolated groups or unknown groups. Some of them are: Yanomami (9468 people) in Roraima State and in Venezuela; Vale do Javari (3000 people), Kulina of mid-Juruá (800 people), Kanamari (700 people), Deni (750 people), Zuruahã (130 people), Kayapó (1743 people), Mundurucu (688 people) in Amazonas State; Karitiana (207 people), Uru-Eu-Wau-Wau (1200 people), Aripuanã (565 people) in Rondônia State; Nambikwara (533 people) in Mato Grosso State; Xingu (2773 people), Kararaô (252 people) in Pará State; Kraolândia (1198 people) in Tocantins State and Araribóia (278 people) in Maranhão State, among others.

They have many problems, including their economic independence, health and education of their children. The relationship between the índios and FUNAI (National Indian Foundation) is very complex and leaves much room for improvement. Preservation of their language and their traditional lifestyle is of crucial importance to maintain their identity.

This study suggests that the most effective way to assist the local people is to help them to be economically independent, send or form teachers to study within their community. To achieve that goal, it will be desirable to provide a nurse and a teacher who can speak their language. It is also important to provide a truck to each group and also a periodical doctor's visit in their village, until they can achieve their autonomy.

Maintaining their identity is crucial to their existence, and working together with different groups with similar objectives is a wise strategy. We can conclude with certainty that the role of FUNAI and CIMI is vital for their success.

4.4 Role of the Brazilian government

Efforts to control the deforestation by the Rondônia State resulted from the establishment of the Program of National Integration (PIN). Rules were created to encourage the implementation of basic infrastructure, widening the boundaries for economic activity and allowing for the colonization of huge areas not yet occupied in the most remote region of Brazilian Amazonia.

The next step for development was the Polonoroeste Project. Within the past two decades, about 100 thousand families have settled in Rondônia, occupying four of the six million ha of the allotted for agricultural land.

The actual stage of the evolution of the state is a reflex of the political strategy established by the Program of National Integration (PIN) created by the Decree law no. 1106 of June 16, 1970. This rule was created to encourage the implementation of basic infrastructure, enabling the amplification of the economic boundary and the colonization of huge areas not yet occupied in the most remote region of the Brazilian Amazonia. Between the consensus of 1970 and 1980, the population increased at 14.9%/year and deforested area grew at a rate of 37%/year between 1975 and 1980 (Fearnside 1990).

The Amazonian region has changed and developed compared to the past thirty years. The Brazilian government had the strategy to do so, however now it is time to create the rules to protect the fauna, flora and the people who live there, urgently. Health care, education and minimum infrastructure are needed to assist the local people and to protect the fragile ecosystem. Amazonian forest is really being destroyed anthropogenically.

Economic assistance from the developed countries is expected specially in the education of the foresters and local people, offering know how concerned with sustainable management of tropical forests. Also, helping Brazilian experts in forestry to patrol periodically the forest and give assistance to the local people is very much appreciated.

Chapter 5 Influence of Amazonian development on the environment

5.1 Forest decrease

Deforestation of Legal Amazonia in 1970-1996 was 517,069 km^2 and annual deforestation rate achieved the peak of 29,059 km^2 in 1995, decreasing to 13,037 km^2 in 1997 (Table 5.1-1). In Pará State, Paragominas is the most deforested area by logging, the biggest spot of Amazonian tropical log production. Also, Carajás Project deforested 900,000 km^2 of rainforest for iron, bauxite mining, non-metal mining, timber exploitation and farming, including the construction of railway to transport the products to Ponta de Madeira harbor, São Luís in Maranhão State.

This project also built one of the Brazilian biggest hydroelectric dam, the Tucuruí, flooding 2,430 km^2 of rainforest to produce 8 million Kw of electricity.

Rondônia, one of the nine states of Brazilian Amazonia, suffered another big deforestation by conversion, registering the highest rate of population growth of all the Brazilian states in the last twenty years.

Deforestation accompanied population growth in Rondônia with deforested area as much as 24.78% of the total area of the state in 1993. Deforestation along the highways BR-364 and BR-429 is clearly aligned in the Landsat imagery. The former links this region to the most developed southern states and the latter penetrates the half of Rondônia represented by the Guaporé River valley, which was deeply covered with dense forest, until recently.

The present forest situation of Rondônia State was analysed based on the fieldwork done in August 1997.

5.2 Geomorphology and climate of Rondônia State

Rondônia is in the southwestern Amazonia (Latitude 8°S-16°S, Longitude 60°W-68°W), its area is 243,044 km^2 and is limited by Bolivia, Acre State, Amazonas State and Mato Grosso State. The northwestern region, bordering with the Acre State and Amazonas State, is formed by the depression, the "Depressão da Amazônia Ocidental" (100 to 500 m a.s.l.), the western region, bordering with Bolivia, is formed by a plane along the Guaporé River, the "Planicie e Pantanal do Rio Gua-

Table 5.1-1 Deforestation in the Brazilian Amazonian States since 1970 (km²). Deforestation is very little and unknown before the 1970's.

States	Area	Population	Deforested area (Aug. 1996)
Acre	153,149.9	483,726	13,742
Amapá	143,453.7	379,479	1,782
Amazonas	1,577,820.2	2,389,279	27,434
Maranhão*	333,365.6	5,222,565	99,338
Mato Grosso	906,806.9	2,235,832	119,141
Pará	1,253,164.5	5,510,849	176,138
Rondônia	238,512.8	1,231,007	48,648
Roraima	225,116.1	247,131	5,361
Tocantins	278,420.7	1,048,642	25,483
Legal Amazonia (Total)	5,109,810.4	18,748,510	517,069

*Only 50% of the state is in Legal Amazonian region.
Source: INPE (1998), IBGE (1998)

poré" (0 to 99 m a.s.l.), the northern part is formed by the depression, the "Depressão Marginal Sul-Amazônica" (100 to 500 m a.s.l.) with scattered highlands within it, the "Planaltos Residuais Sul-Amazônicos" (up to 300 m a.s.l.) and the southern part is formed by continuous highlands and plateau, the "Planalto e Chapada dos Parecis" (300 to 800 m a.s.l.).

The climate is wet and warm, and the annual average temperature is around 24°C with relative humidity between 80% to 85%. Rainy season begins in October and lasts until next June. Annual average rainfall varies between 1750 mm to 2750 mm, with a burning season usually at the end of dry season, in September.

In Rondônia, soils are varied in their characteristics. The soil type in Rondônia is mainly *latosol*, Latosolo Vermelho-Amarelo, álico *i.e.*, orthic Ferralsols (FAO), or Haplorthox (US Soil Taxonomy), followed next by *podzol* and Terra Roxa Estruturada, i.e., eutric Nitosols (FAO) and rhodic Paleudalfs (US Soil Taxonomy) (Sombroek, 1984). This soil is also known as *luvisol* and, it's occurrence is between Seringal Nova Vida and Ouro Preto d'Oeste along the BR-364 highway, which is a very rich soil, good for raising crops. Today, it is known that 83% of the soil of the state is unfertile, although one of the reason that so many farmers were attracted in this state was the existence of "Terra Roxa", with high percentage of active iron oxides, proper for agriculture. Later, it was revealed that the occurrence of the "Terra Roxa" was very little within the state and the best ground was already taken by the rich farmers from the southern country, when the migrants reached the land.

Rondônia's vegetation is represented by the transition species that occur in the edge of the rain forest and savanna. In many places, big scale clearance (more than 50%) can be noted, along the highways. The dense forest does not exist as much as before, due to the vast clearance occurred in the last decade.

5.3 Change on hydrologic regimes and climate

Global climate change brought by the development of Amazonian basin is a matter of concern, recently (Gash *et al.* 1996). Conversion of rainforest into farmland and pasture is the main development style in the Brazilian Amazonia. It is known that deforestation may affect the microclimate of the region, altering the albedo, water and surface-energy balance (Nobre *et al.* 1991; Salati *et al.* 1984). Amazonian forest is highly efficient in recycling water vapor back into the atmosphere, and modification of microclimates is the most immediate effects of forest clearing (Bosch *et al.* 1982; Meher-Homji 1991). However, observational analysis of historical series of precipitation and stream flow in the Amazon basin has not shown any trend in the basin's hydrological cycle that could be attributed to changes in the vegetation cover (Salati *et al.* 1991), till recently. Rainfall interception is a component peculiar to the rainforest, and forest felling as well as forest burning cause decrease in evapotranspiration, affecting the local water budget (Kuraji 1996). In the present study, the relationship between decline in forest cover and alteration in hydrological regime in Rondônia State was analyzed. As a result, increase in runoff ratio, and decrease in rainfall and evapotranspiration were

obtained from developing catchments. On the other hand, decrease in runoff ratio, and increase in rainfall and evapotranspiration were obtained from undisturbed forest catchment. From the regression lines, we can say that deforestation is causing changes in rainfall regime, in the sense that the climate is tending to be dry and hot in that region.

The following data were used for analysis:

1) A long term hydrological records of following meteorological stations (ANEEL-Brazilian National Agency of Electric Energy):
   Runoff: Ji-Paraná river, Tabajara (Lat-08°56′00″S Long-62°03′03″, Drainage 60,212 km²); Ji-Paraná (Lat-10°52′26″S Long-61°56′56″W, Drainage 32,806 km²); Jamari river, Ariquemes (Lat-09°56′00″S Long-63°04′04″, Drainage 7,295 km²); Guaporé river, Pedras Negras (Lat-12°51′05″S Long-62°53′53″W, Drainage 116,731 km²)
   Rainfall: Tabajara (Lat-08°55′00″S Long-62°06′00″W), Ji-Paraná (Lat-10°50′57″ S Long-61°55′55″ W), Ariquemes (Lat-09°56′05″ S Long-63°03′03″ W) and Pimenteiras (Lat-13°28′55″ S Long-61°02′02″ W)
2) Landsat 5 TM imagery (processed by INPE-Brazilian National Institute for Space Research) of different dates, Bands 5, 4 and 3 (RGB, respectively)
3) Digital map (IBGE-Brazilian National Institute for Geography and Statistics, and OCN-USA Air Force).

There are eight sub-basins of the Madeira Basin in Rondônia State, which are the following: Guaporé, Mamoré, Abunã, Mutum-Paraná, Jaci-Paraná, Jamari, Aripuanã and Ji-Paraná. The analysis was made to Guaporé (natural forest), Jamari (developed) and Ji-Paraná (developed) sub-basins.

Pedras Negras is located in a riparian area of Guaporé sub-basin, and borders with Bolivia. The natural rainforest is almost intact and there are also savanna and Parecis Mountain Range to the edge of Ji-Paraná basin. During the rainy season (October-May) large area is flooded along the Guaporé River and affluents.

Tabajara and Ji-Paraná are located in Ji-Paraná basin downstream and upstream respectively. Tabajara is less developed than Ariquemes and Ji-Paraná, and till the 1970's, all of these sites were deep rainforest.

Ji-Paraná was strongly developed with the colonization project of INCRA (National Institute for Colonization and Agrarian Reform) since 1970. The city is located where the Ji-Paraná river (or Machado river) crosses the BR-364 highway (Pic. 5.3-1).

Ariquemes is the city where many logging companies of the State concentrate. It is at the Jamari river bank, where the BR-364 highway crosses.

In a long-term observation, evapotranspiration can be calculated from precipitation and discharge on a drainage basis. Following equation was used for calculation.

$$\frac{dS}{dt} = P - Q - E$$

Where, S is the catchment storage, t is time, P is precipitation, Q is discharge and E is evapotranspiration.

Using the observed rainfall, runoff and evaporation values, monthly evapotranspiration of each catchment was calculated.

Using the simple model for evapotranspiration, following results were obtained from the calculation (Table 5.3-1).

Amazonian deforestation may affect the global climate as is predicted by the General Circulation Models, which is a matter of concern, recently. The present study described the effect of agricultural development upon the local climate, analyzing the hydrological responses of that region. Four watersheds including a non-developed forest area were chosen for study in Rondônia State. In developed watersheds, decrease in evapotranspiration and precipitation, and increase in runoff ratio were observed. In these areas, 30 to 50% of the watershed had been converted into agricultural field. At Tabajara in Ji-Paraná watershed, runoff ratio increased from 0.4 to 0.5, while the evapotranspiration decreased from 1300 mm/year to 600 mm/year. Moreover, precipitation decreased in developed watershed, correlating the evapotranspiration. This trend suggests that climate change in Rondônia is likely to indicate the transition of forest into savanna, as a result of the anthropogenic activity in that region.

If the conversion of forest is reflecting the development level of the watershed, we can say that it is progressing in the following order: Pedras Negras, Ariquemes, Tabajara, and Ji-Paraná (Fig. 5.3-1).

Using the water balance method, hydrometeorological analysis was made to each of these four catchments with different level of development.

At Pedras Negras station in Guaporé catchment, forest is almost intact, presenting high evapotranspiration (1448 mm) and low runoff ratio (0.15), characteristic of the sound forested watershed. Discharge is increasing and, rainfall and evapotranspiration are

Table 5.3-1 Results of the calculation from water balance method

Meteorological Station	Period	Precipitation (mm/y)	Discharge (mm/y)	Evapotranspiration (mm/y)	Runoff Ratio
Tabajara	1978-88	1621	706	915	0.438
Ji-Parana	1992-96	2352	700	1653	0.303
Ariquemes	1991-96	1859	738	1121	0.397
Pedras Negras	1983-94	1692	243	1448	0.145

decreasing, in the watershed with land cover changes.

At Tabajara station in Ji-Paraná catchment, one third of the forest was converted into farmland. Evapotranspiration is low (yearly average 915 mm) and runoff ratio is high (0.44). Decrease was noted in both rainfall and evapotranspiration values.

At Ariquemes station in Jamari catchment, one third of the forest was deforested and runoff ratio is high. However, increase in precipitation and evapotranspiration was noted.

At Ji-Paraná station in Ji-Paraná catchment, as much as half of the forest was deforested. As precipitation is abundant (yearly average 2352 mm) , evapotranspiration is high (1653 mm). This catchment presented an accentuated decrease in precipitation and evapotranspiration, and increase in runoff ratio.

Summarizing, deforestation leads to a decrease in rainfall and evapotranspiration, and an increase in runoff ratio. A strong correlation was observed between the variation of rainfall and evapotranspiration values. This fact predicts that Amazonian deforestation can result in precipitation decrease in the future, and the effect of climate change upon the local ecosystem is a matter of concern.

The Amazonian State of Rondônia became internationally notorious for the environmental degradation. The first influence of deforestation can be perceived in terms of water balance change. The variation of runoff ratio reflects the precipitation and discharge, and runoff ratio can be translated in a variation of land cover rate. The forest runoff ratio can be thought as being 0.1-0.2 and therefore, runoff ratio of 0.3-0.5 can be interpreted as deforestation rate of 30-50%.

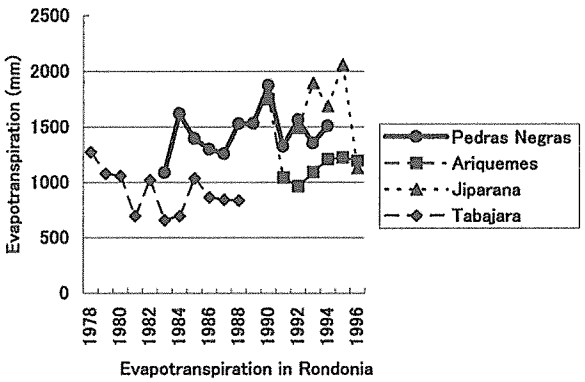


Fig. 5.3-1 Evapotranspiration at Tabajara, Ariquemes, Ji-Paraná and Pedras Negras
Source: ANEEL

The main problem for maintaining the ecosystem is the proper utilization of cleared area after felling the forest. Farmland, pasture and abandonment are the three main conversion style of the felled forest in Rondônia. If the forest is converted into farmland, crops will grow as a new vegetation type and it will hardly degrade the ecosystem. In the case of pasture, if proper management is not done, soil compaction will inhibit the vegetation growth, leading to desertification, as many cases indicated in the past. In the case of abandonment, pioneer species will gradually cover the primary area, advancing to secondary species. Decrease in precipitation and evapotranspiration in developing regions will limit the growth of original vegetation, making the conversion irreversible. If evapotranspiration does not achieve 1000 mm per year, the tropical rainforest can not keep its sound growth. The accentuated decrease of evapotranspiration in Tabajara is likely to indicate the transition of typical forest climate to that of savanna.

During the field study, many abandoned farmlands after few years of use were observed within the INCRA (National Institute for Colonization and Agrarian Reform) Ji-Paraná settling lands. Remaining forests were rare in the lots and land use after felling was mainly for raising perennial crops as coffee, cacao, and annual crops as rice, beans and cassava. There were also colonists raising fishes and working in apiculture. However, the most common type of land use was pasture. This fact can be seen in the Landsat5 TM imagery, with the "fishbones" being gradually substituted by the square shaped pastures.

Using the water balance method, correlation of evapotranspiration, precipitation and discharge gave the

regression lines of each catchment, showing different responses between developed and non-developed catchments. Following results were observed in developed catchments from the analysis of water balance:

(1) Increase of runoff ratio: 0.15 to 0.5.
(2) Decrease of evapotranspiration: 1500 to 1000 mm.
(3) Decrease of precipitation: 2000 to 1500 mm.

5.4 Research to be carried out from now on

Taking in account that great scale deforestation is occurring in the study area, the results above indicate that forest clearing is affecting the water regime in small catchment scales. Decrease of 500 mm evapotranspiration obtained in the analysis seems to be very significant. Evapotranspiration of 1000 mm is a limit for the rainforest sound growth and this result is a matter of concern in the near future. The present analysis done in Rondônia should be applied to other small catchments of the Amazonian Basin, with more than one thousand affluents, many of them affected by deforestation.

Chapter 6 General conclusions

Based on the field study and on the analysis of data gathered since 1994, many new findings and problems could be aligned in the course of the present study on Amazonian deforestation.

Sustainability-Governmental efforts concerned with forest management carried out in this region, are oriented to the conservation of ecosystem. Timber exploitation was regulated in 1994 through the Resolution 48/94 of IBAMA. Foreign logging companies possessing forests bigger than 2500 ha have a legal obligation to register them and get National Congress warranty.

International demand for tropical timber has been stable in the last decades. However, Malaysian timber will deplete around the year 2005 (MCT-INPA/DFID 1997), after an intensive exploitation, and other Southeastern Asian countries that were big tropical timber exporters in the past, are gradually turning to be importers. Logging companies of Malaysia, China and Switzerland are buying vast forest areas in Itacoatiara, Amazonas State, and in other Brazilian Amazonian states, recently. There were 22 foreign logging companies operating in Legal Amazonia in 1997, and they were irregular owners of almost two million ha in that region. Five of them were asiatic companies and were operating near Solimões River and Madeira River so that they might transport valuable woods passing through Peru and Bolivia, where patrol is not restrict for timber exploited from non-sustainable forest.

Eighty percent of the Amazonian timber is exploited illegally according to IBAMA, and patrol is beyond their capacity. The Brazilian organs as military police, INCRA, FUNAI and others will have to concentrate their efforts to watch for the Amazonian forests.

If predatory harvesting would continue in the Brazilian Amazonia, forest resources will deplete in a near future, following the example of the Southeastern Asia. The opening of the BR-317 highway between Acre State and Peru, stretching from the BR-364 highway, will facilitate the circulation of Amazonian logs directly to Pacific, and consequently to Japan and other Asian countries, in the next century.

Deforestation from logging was insignificant till 1990 in Amazonia, however, today it turned to be an important source of income for the local people. Lumberjacks are generally poor people and valuable trees are cut whenever and wherever are found in the forest. The ideal cutting cycle is 30-35 years in the managed forests of Brazilian Amazon of Pará State, and logging should be executed, respecting this cycle, or at least 25 years according to the results of INPA's ZF-2 forests in Amazonas State. It is important also to cut not more than eight trees/ha and they must not include more than two or three trees of the same species during the harvest. Amazonian commercial species have an average diametric increment as shown in Table 2.5.3-2, and based on this information, cutting cycle can be established respecting the ecosystem of the forest. Reforestation is just in its starting point in the Brazilian Amazonia, and the success for sustainability depends on the governmental policy.

Local people should be technically and economically assisted by the government to accomplish the sustainability of forests. For that purpose, experiment results should be applied in Amazonian remaining forests. If cleared area should be used properly by the local people with substantial assistance from the part of government, virgin forest can be preserved. Also, agroforestry plays an important role for that goal, enabling the optimization of rational and economic utilization of the soil, producing timber and food continually, without disturbing the ecosystem of the soil. In Pará State, there is a Japanese farmer who succeeded in raising crops in the forest. Choosing the crops that prefer shade in the forest as for example coffee, passion fruit, pepper, papaya, melon among others, he could maintain the sustainability of the forest without degrad-

ing the soil for crops. Experiments combining the plantation of pioneer and climax vegetation in the same stand and raising crops and chickens in the shade are an important means for the local people's subsistence.

Sustainable management of tropical forests is economically viable and this method brings the enrichment of the explored area without losing the biodiversity.

From the field study in the Brazilian Amazonia, it could be concluded that the governmental decision on land-uses seldom responded the needs of local people, and did not respect the ecosystem. INCRA continues to plan new settlements within virgin forests instead of making good use of the large cleared lands, in order to avoid conflicts with squatters. Converted lands into pasture gain higher price at the time the colonists sell them and this fact has led to a large-scale deforestation. Degraded pasture results from loss of soil fertility through erosion and leaching. Also, soil compaction inhibits growth of pasture grasses and vegetation regrowth in abandoned pasture is much more slowly if it has been heavily used. Forest recovery in highly degraded pasture is extremely slow unless special methods are taken. Sawn mills are exempt from taxation while IBAMA (Brazilian Institute for the Environment and Renewable Natural Resources) inspectors are paid for protecting the forest. These controversial organs work with the same economic source, the public tax.

An organ which is expert only in surveying and analyzing the Amazonian big projects' environmental impact should be created to make governmental decisions. Developed countries should assist Brazilian foresters and provide substantial help and interchange in academic organs in forestry. Research results should be applied in forest management promptly, and economic aid in this area from the part of developed countries is expected.

Local people-The ecologic-economic zoning project executed by the Brazilian government (Decree No. 96944 of October 12, 1988) was a means of avoiding inappropriate development projects causing environmental damage. In order to make the manipulation of forests compatible with the local people subsistence, zoning is playing an important role in Amazonia. Limiting the zone for conservation, logging can be executed in a more disciplined way, and settlers will not clear virgin forests. Rubber-tappers can live in a sustainable way, making good use of the forest, and indigenous people also can continue in their reserves without intrusion.

However, if local people is not oriented about the zoning, conflicts will not end, and the government should assist them more directly, disposing qualified agents in all over the Amazonia. Opening up indigenous and other protected areas to exploitation was often seen during the field study.

Settlements in virgin forests are causing frequent uncontrollable forest burning, as happened recently in Roraima State, spreading from the settlement area as far as the Yanomani Indian Reserve. Indigenous lands represent a sort of last frontier for exploiting timber, minerals and other resources. Indians need a source of financial independence if they are to enjoy any benefits of the white's way of life. This fact has led leaders of a number of tribes to strike deals with loggers and miners to illegally allow exploitation in indigenous areas. These deals were often unfavorable financial terms and had negative impacts on the environment, health and culture of the tribe.

There are many cases in which indigenous groups are split into fractions, as happened with Macuxi group, at one side in favor to the government developing projects and at other opposing to them. The former is favored with benefits as health centers, running water, electricity and telephone posts. Thus, the gap between "good Indians" and oppositionists will increase as the development process goes on.

Indigenous land is frequently considered as mere obstacle for exploiting timber, minerals, and for dam and highway constructions. Indigenous people are passive for development decisions because of lack of knowledge and are often deceived by the white people. Very few of them are putting into practice what they learned from the discrimination and hostility from the part of the whites. Young people who are aware of the problem are trying to be lawyers, teachers and politicians. They really wish to preserve their culture, language and identity, and education is the only way to raise them from misery. Economic assistance in education is urged specially to youngsters, in order to assure their future benefits.

For instance, health care assistance and communication improvement are their first needs. It is very important to understand the needs and thinking of different indigenous people, and to respect their identity. A modest attitude from our side is essential to lead with the indigenous people. There are a lot of civilized groups for different reasons: ones were driven away from the forest, others wanted to assimilate the white's civilization.

The fact that there exist a lot of groups living in

their own style within the forest, demonstrates that they would like to preserve their lifestyle and, we have to respect their ideology and culture.

In the Brazilian Amazonia, environmental impact assessment is not properly executed even for large development projects as for dam building and road construction. However, it is required by Brazil's environmental legislation since 1986, under Law no. 6938 of August 31, 1981, articles 9 and 10 which was regulated by resolution 001 of January 26, 1986 of the National Council of the Environment.

Local Climate-Clear cutting affects the microclimate of the converted land and hydrologic regime of the region, as well. Concentration of chemical elements in the forest's water system can be noted after deforestation due to the following factors: first, the temperature of the soil increases, accelerating the decomposition of organic matter of the soil of Ao layer, increasing the concentration of NO_3-N and positive ion of the soil water; secondly, evapotranspiration and absorbance of nutrients decrease, resulting in increase of the surface flow; third, absorbance of the nutrients from the trees stops.

According to the agent of INCRA Ji-Paraná, who lives there for more than twenty years, flooding of Ji-Paraná River are becoming a serious problem in the rainy season. As a result of widespread conversion of forest into pasture, the climate became more dry and warm than before, recently. This fact was analyzed in the Chapter 5.

Suggestions-Many efforts have been done concerned with the sustainability of the Amazonian forests, however, they failed because of lack of patrol and awareness of the local people and loggers who came from non-Amazonian region. There are a lot of means to encourage the practice of good use of the tropical forest. Some international companies are getting good results from tests in silviculture, enabling the same or more economical yield from that of direct natural forest timber exploitation.

In the course of the present study, it could be concluded that there are many ways to help the Amazonian people. The main tool for the sustainability should be the education of local people and foresters directly engaged to forest activities, giving proper assistance. Establishing the fallow and respecting the cutting cycle, soil potential can be conserved eternally and government should concentrate the assistance as far as this cycle might be assimilated naturally by the local people. Economical assistance is also important, however without making them conscientious to sustainability, it will be only a palliative method. Also, facing the population pressure, it is important to the government to assist new settlers in the sense that they should obtain the minimum subsistence in order that they do not need to convert and degrade new portion of virgin forest. Considering the Amazonian vastness, lack of patrol is unavoidable, and local people should be oriented to watch for the forest by themselves, protecting their own forest, thus discovering their important role and their forest value. The government should act urgently to contain the deforestation process. If rubber-tappers and indigenous people can no longer live in the forest, it means that we also are put into a crucial situation to continue our lives on the Earth.

Amazonian deforestation will continue unless fundamental changes are made in the structure of the system underlying forest clearing. The Brazilian government is urged to take a measure to meet the situation and, there is also much room to the developed countries to help economically and academically, concerned with the sustainability of the Amazonian tropical forests.

Researchers of Amazonian studies need much help in technology transfer, as for example in remote sensing analysis, using different satellites. The result of this study can be applied to plan proper land-uses, viewing the sustainability of forests and defining strategic areas for substantial patrol of forests.

Forest management projects are still badly formulated and they are not carried out properly in the Brazilian Amazonia. There is much room for the developed countries to execute technology transfer in this aspect. Not only researchers of developed countries, but also researchers of tropical regions should gather their know how in tropical forest management, as well.

National projects are needed to train foresters, loggers, technicians who are directly engaged in forestry, to improve less degrading logging system and to disseminate the know how all over the Brazilian Amazonia. It is also important to improve nursery and seedling bank and to support taxonomists, biologists, zoologists, limnologists, climatologists and other researchers working to achieve the same goal to maintain the biodiversity and sustainability of Amazonian ecosystem.

Amazonia is our common Earth's heritage and we are responsible to preserve it. Nature has been changing all over the Earth's history, however mankind accelerated that process against the nature's time flow. It is time to stop degrading Amazonia before the anthropogenic influences affect its ecosystem in an irreversible man-

ner.

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Summary

Most part of the world's tropical forest is located in the developing countries, and conversion is spreading each year. Colonization project is also advancing in the Brazilian Amazonia, and forests are converted at an average rate of 21,000 km²/year. The purpose of this thesis was to examine how recent large-scale clearance affected the regional climate, environment and local people, and make suggestions for preserving the Amazonian fragile ecosystem.

The present study dealt with hydrological analysis in Rondônia State, a remote region that accomplished a very fast development in the last two decades. A multi-temporal hydrological data of ANEEL were used for the water balance method, to find the effects of deforestation on water regime within developed and non-developed catchments. Land-uses were analyzed using the Landsat5 TM imagery processed by INPE. As a result of hydrological data analysis of small catchments in Rondônia State, runoff ratio increase of 0.15 to 0.5, evapotranspiration decrease of 1500 to 1000 mm and precipitation decrease of 2000 to 1500 mm were observed in the developed area of Ariquemes, Jiparaná and Tabajara. On the other hand, high rate of evapotranspiration was observed in undisturbed catchment, in Pedras Negras. Rondônia State was one of the most remote regions of Legal Amazonia, however, this state suffered a large-scale clearance in the last decades, with the implementation of Brazilian development projects, specially in the late 1970's. This fact was reflected in the hydrologic analysis. In developed cachment of Tabajara, evapotranspiration was up to 1000 mm till 1980, however it decreased to an average of 700 mm since 1981. This figure indicated that the vegetation map of this area was altered from rainforest to savanna. Also, hydrological analysis registered the runoff rate of 0.3 to 0.5, thus reflecting the result obtained from the remote sensing analysis, registering 30 to 50% clearing in that region.

As for the Brazilian government policy, concerned with the preservation of the Amazonian rainforest, zoning strategy was implemented, in order to make a clear division for land-uses, thus preserving the fragile tropical ecosystem and protecting local people's life. The field study was carried out in three districts among 6 zones, to examine the real function of that strategy. As a result, in a farmland of the Jiparaná's colonization project, the rule for 50% clearing was not obeyed, and in Karitiana village, intrusion was still common.

As for the Amazonian local people, Karitiana village was visited in Rondônia State, in order to examine their traditional lifestyle and problems faced by the Karitiana people. As a result of the field study in Karitiana village, it could be noted that development was affecting their lifestyle. The Karitiana people suffered an abrupt decrease of its population from 5000 to 12 people in the early 1970's, due to the development projects implemented in Rondônia State, in the last decades. In August 1997, they were 207 people, 11 from other ethnic groups and 24 living in the House of Indios, in Porto Velho. There were few old people and 70% of them were composed of children. Two or three of them were dying every year, contracting diseases brought by the white people, and there were many sick people in the House of Indios in Porto Velho, without proper doctor care. Health assistance, transport means and education were the first aid they needed.

Finally, the main goal of this paper was to make clear the current forest situation of the Brazilian Amazonia to find better method for decision making on land-uses and forestry in order to satisfy both local people subsistence and global needs concerned with the sustainability of the ecosystem. As a whole, the Brazilian Amazonia presented many negative influences of development. Zoning strategy should function properly to allow the conservation of ecosystem. In order to accomplish that purpose, financial aid in academic activities concerned with forestry, including the formation of rangers among the local people is expected, not only from the Brazilian government but also from the developed countries.

Key words: Brazilian Amazonia, deforestation, ecosystem, zoning, Indian reserve

ブラジル・アマゾンの開発による森林減少問題
―森林伐採が生態系と地域社会に及ぼす影響―

丸山めぐみ

世界で最大の連続した熱帯多雨林を有するブラジル・アマゾンでは，現在，開発プロジェクトによる森林伐採が進行中であり，年間約3億トンの二酸化炭素が大気中に排出されているが，具体的な森林破壊による影響を表す実証データは意外に少ない。そこで，本研究は，ブラジル・アマゾンを対象として，最近の大規模な森林伐採による気候と環境，地域社会への影響を，現地調査をふまえて検討したものである。本研究で用いた研究方法と結果は，以下の通りである。

(1) 森林伐採の気候への影響

気候に関しては，Nobreら（1991）による，ブラジル・アマゾン全体が放牧地になったと仮定した場合のGCM（大気循環モデル）予測が広く流布されているが，熱帯雨林の全域が100%放牧地になるという仮定は，現実的ではないと思われる。そこで，開発による森林伐採が，気候変化にどのように影響するものであるかを実証するため，熱帯林からの蒸発散量を指標として用いることとし，開発の度合いが異なるアマゾンの複数の小流域を対象に，水収支法に基づく水文解析を行った。対象地域として，法定アマゾン（ブラジル・アマゾンを形成する9つの州）の中で開発が最も遅れており，最近になって非常に大規模な森林伐採が行われたロンドニア州を選定した。土地の改変の分析には，INPE（ブラジル国立宇宙局）により直接入手した，ロンドニア州の5つの衛星画像データを用いて，リモート・センシング解析を行った。また，水文解析には，ANEEL（ブラジル水源エネルギー省）から直接入手した，流量データと雨量データを用いた。水文データ解析の結果から，開発地域であるTabajara, Ariquemes, Jiparanáの3流域における流量は増加傾向にあり，雨量は減少傾向にあること，また，未開発地域のPedras Negras流域では，蒸発散量が多く，雨量も多いことが明らかになった。ブラジル・アマゾンで一般的に受け入れられている植物地理帯基準では，年間蒸発散量が1000 mmを切ると，熱帯林の生育に必要な水分量が不足して森林の成立は困難になるため，植生はCerradoと呼ばれるサバンナに分類される。開発地域のTabajaraにおける蒸発散量について見てみると，1980年以前には1000 mm以上あったものが，1981年以降は平均700 mm台に低下している。これは，この地域が，植物地理帯での熱帯林からサバンナに移行していることを意味するものである。この結果は，この地域で1970年代後半に植民計画プロジェクトが大規模に展開されるようになったこと

と照応しており，開発の影響が具体的に蒸発散量の数値に反映した形で示されていることになる。また，水文学的には，アマゾンの熱帯林での流出率は一般に0.1とされているが，今回の水文解析の結果では，開発地域での流出率は0.3〜0.5という値となった。これは，この地域が30〜50%の土地の改変を受けたことを示唆している。他方，衛星画像データの解析では，開発地域において30〜50%の森林が消滅しているという結果が示されており，水文解析の結果と対応していた。以上の結果から，従来のGCMモデルに基づく解析方法では感知しえなかった，森林伐採率の異なる小流域において，それぞれ異なった開発状況が生態系と気候に及ぼす影響が具体的に明らかになった。

(2) ブラジル政府による森林保全政策の実態

熱帯林保全政策として，ブラジル政府は，アマゾンの森林を保全地域と農業用地に分け，生態系と地域住民の生活を守ることを意図して，ゾーニング計画を打ち出している。しかし，この政策に関する報告は，海外ではほとんど知られていないため，本研究では，ロンドニア州で行われているゾーニングについて，その実施状況を把握するため，Porto Velho市，Jiparaná市，及びKaritiana村の3箇所を現地調査した。ロンドニア州の場合，州全域が，a）市街地を含む集約的な商業用農産物生産農地，牧畜とアグロフォレストリー，b）小規模の農業用地，c）川辺の住民の季節農地及び魚の養殖地，d）林産物奨励地域，e）商業木生産地，そしてf）永久森林として保全される区域と先住民保護区，の6ゾーンに分けられていた。現地調査した対象地は，それぞれPorto Velho市(市街地)：aゾーンとJiparaná市(農地：Tancredo Neves植民プロジェクトの農地)：aゾーン，及びKaritiana村(先住民保護区)：fゾーンの指定地域であった。現地調査の結果，aとfのゾーン内では，森林保全に関しては機能しておらず，細かい取り決めは守られていないことが明らかとなった。すなわち，開拓農民がブラジル政府から開墾のために許可されている森林伐採率(50%)は，aゾーン内のJiparaná市ではほとんど守られていなかった。また，fゾーン内にあるKaritiana村では，ブラジル政府公認の先住民保護地区であるにもかかわらず，1997年にも盗伐や砂金採りによる不法侵入を受けていた。

(3) 森林伐採が地域社会へ及ぼす影響

ブラジルが16世紀にポルトガル人によって「発見」された当時，700部族，500万人の先住民がいたと推定されている。それが，現在では146部族，21万人に激減し，そのほとんどがアマゾンに住んでいる。最近では，アマゾン開発によって多くの部族が消滅し，白人がもたらした病気によって亡くなったり，心無い人々によって村を焼き払われたり，殺されたりしている。ロンドニア州では，先住民の85%がブラジルの幹線国道BR-364号線の建設によって，直接的または間接的に殺されてしまった。このように，つい最近まで，アマゾンの先住民は，ブラジルのなかで人間としての扱いを受けてこなかったのであるが，近年，ようやく彼らの人権や土地所有権をめぐり，広く論議が行われるようになってきた。森林伐採が地域社会へ及ぼす影響の如何に関しては，FUNAI（国立インデイオ基金）やNGO（非政府組織）などの活動報告と，Karitiana部族のリーダーとの私信などを通じて，ロンドニア州では，1991年にCUNPIR（南西アマゾンの先住民部族からなる組織）が結成されており，彼らの人権，土地所有権，及び森林の保全の必要性に関する見解に関して，ブラジル政府に意見書を送っていることを知った。そこで，CUNPIRのそれら森林の所有権や森林環境に関する考え方が現実にはどのように機能しているのか，また，Karitiana部族が，開発による森林伐採によって伝統的な生活様式にどのような影響を受けているのか，という点について実証するため，1997年8月に，ロンドニア州Porto Velho市から西へ95 kmの位置にあるKaritiana村を，2日間にわたって現地調査した。その結果，以下のことが明らかになった。CUNPIRに関しては，現地調査した時点では，大地主との間に利害関係が絡んだため，いくつかの部族が，白人の大農場主に買収され，組織の内部に亀裂が入り始めていた。Karitiana村に関しては，開発の始まる前の1971年時点で5000人いた部族は，アマゾンの主要幹線道路である国道BR-364号線の建設などの開発のために，一時期はその人口が12人にまで減少してしまったが，1997年現在では207人にまで回復していた。そのうち11人が他の部族の者であり，また24人は，Porto Velho市にあるFUNAIの「インデイオの家」に住んでいた。村の人口の約70%が子供たちで占められており，年寄りは殺されたか，病気で亡くなってしまっていた。彼ら先住民が現在かかえている，一番切実で大きな問題点は，経済的自立，交通手段，及び医療に関するものであった。彼らは，現在では，もともと住んでいた，豊かな森林に囲まれた，肥沃で広大な土地を追われ，近くにある錫採掘場によって汚染されたガルサス川が流れる，小さな先住民保護地区に移され，以前の伝統的なライフスタイルである，狩猟と焼畑の生活はできなくなっている。さらに，彼らの先祖が眠っているとされる，彼らにとっての聖地の上を高速道路が走っており，部族にとって最も大事な精神的な拠り所が奪われた状態に置かれている。現在では，開発プロジェクトを遂行する際に，先住民側とブラジル政府側との間で，環境アセスメントが行われるようになってきたが，最終的な開発プロジェクトの実施に関する決定権は，未だ政府側が握っている。また，1996年にブラジル政府が発令した法令1775/96によって，アマゾンの先住民の土地が新たに区画整理された結果，保護区は一層縮小され，小さい部族は消滅の危機にあることが明らかになった。

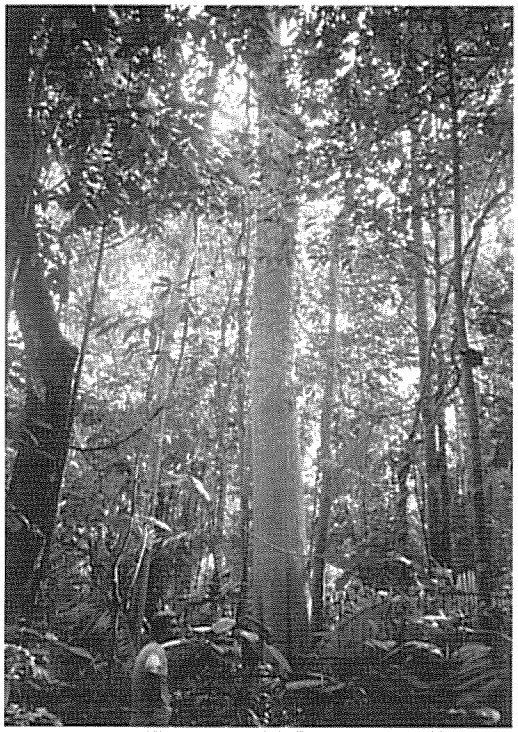
キーワード：ブラジルアマゾン，森林伐採，生態系，ゾーニング，先住民保護区

Pic. 1.3-1. ZF-2 Rainforest seen from the 45 m observation tower.
Picture taken by the author on August 21, 1997

Pic. 2.4-1. The settler Paulo Gromico Filho (right) of TN29, lot 142 and INCRA's agent Mr. Eduardo de Conceição de Lacerda with 20% of remaining forest on the back, in Jiparaná, Rondônia.
Picture taken by the author on August 19, 1997

Pic. 2.5.3-1. INPA's 45m Observation Tower of ZF-2 Forest in Amazonas State.
Picture taken by the author on August 20, 1997

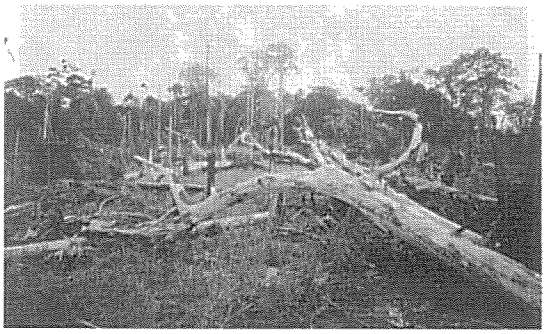
Pic. 3.4.1-1. INCRA's Settlement lots in Jiparaná, Rondônia State.
Picture taken by the author on August 11, 1997



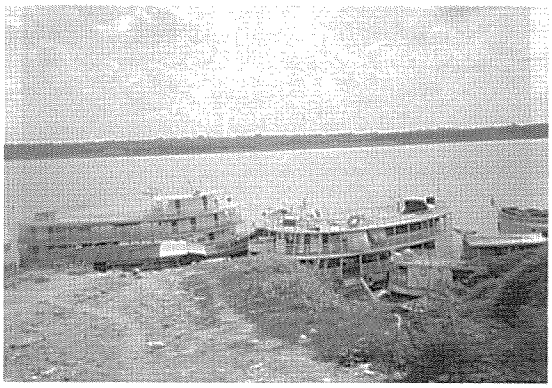
Pic. 2.5.3-2. Lianas in the remaining forest of the settler Paulo Gromico Filho of TN29, lot 142, in Jiparaná, Rondônia State.
Picture taken by the author on August 19, 1997

Pic. 3.4.2-1. Burning of forest nearby Porto Velho in Rondônia State
Picture taken by the author on August 17, 1997

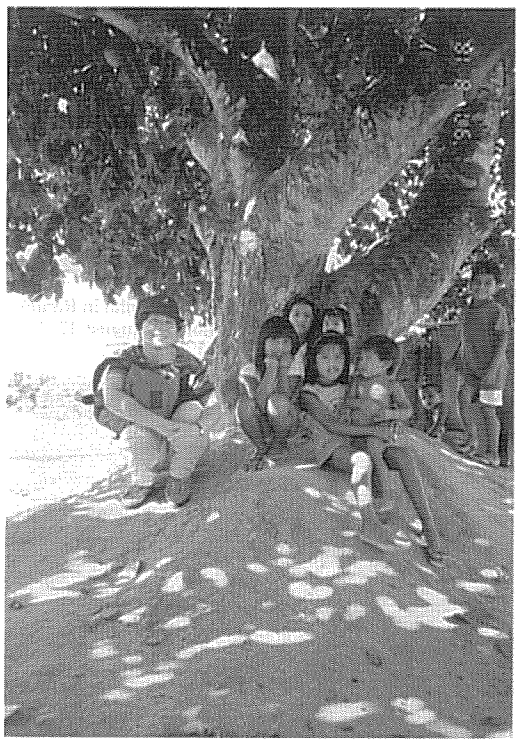
Pic. 3.4.2-3. Pasture in Jiparaná, Rondônia State.
Picture taken by the author on August 19, 1997



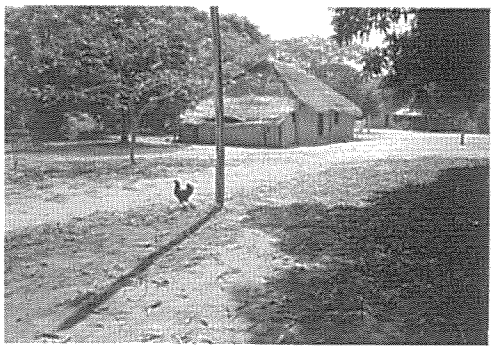
Pic. 3.4.4-1. Burnt forest after a year in a lot of the INCRA's settler Paulo Gromico Filho of TN29, lot 142 in Jiparaná, Rondônia.
Picture taken by the author on August 19, 1997



Pic. 3.4.5-1. Madeira River in Porto Velho city.
Picture taken by the author on August 20, 1997

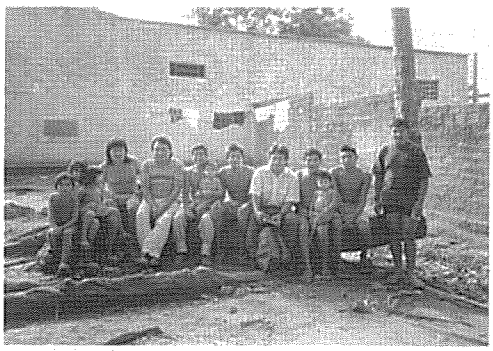


Pic. 4.2-1. Karitiana's children under the jack fruit tree in Karitiana village.
Picture taken by Antenor Karitiana on August 18, 1997



Pic. 4.2-2. Karitiana village.
Picture taken by the author on August 18, 1997

Pic. 4.2-3. Karitiana child playing in the Rio das Garças river in Karitiana village.
Picture taken by the author on August 18, 1997



Pic. 4.2-4. House of the Índios of FUNAI in Porto Velho. They are families of Karitiana, Tenharim, Diahoi and Parintintin groups.
Picture taken by the author on August 17, 1997

Pic. 5.3-1. Ji-Paraná river (or Machado river) in Ji-Paraná.
Picture taken by the author on August 19, 1997