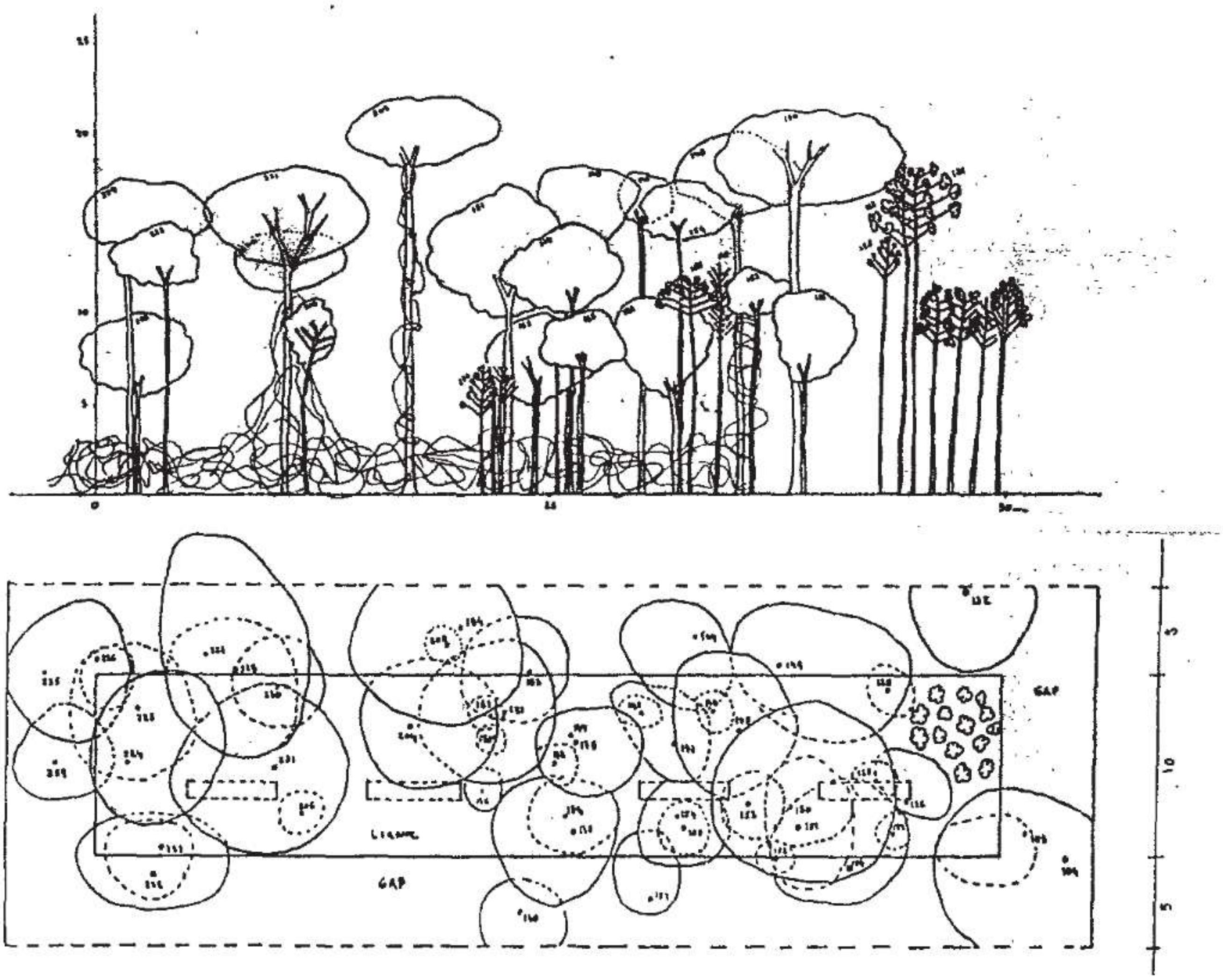
FORMS OF FOREST EXPLOITATION AND NATURAL REGENERATION IN CARAJAS (BRAZIL)



BY
NEY PINTO FRANÇA
JUNE 1990

FORESTRY DEPARTMENT - WAU
SECTION OF SILVICULTURE AND FOREST ECOLOGY

WAGENINGEN AGRICULTURAL UNIVERSITY
MSc TROPICAL FORESTRY COURSE

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Preface

The conservation of the Tropical Rain Forest is one of the most world wide discussed topics in these days, and solving the problem of deforestation in the Tropics has become an important issue.
Brazil's Grande Carajas Program is the largest development scheme in the World, covering 10% of Brazil's territory. It is located in the eastern Amazon region.

There are plans to consume large tracks of Tropical Rain Forest as raw material for charcoal which will be used in the smelting of pig-iron. Deforestation will also serve to implement agro-industrial projects. Both activities are supported by the government by special fiscal incentives.

This study deals with forms of Tropical Forest exploitation in the region of the Program Grande Carajas (PGC). This subject was chosen because of:

* The complex land use pattern which includes: Indians Reserves, Biologic Reserve, Forest Reserves, Selective logging areas, Large cattle farmers, Settlers and squatters (posseiros), and their relationship;

* The high degree of land degradation caused by the actual way of exploitation;

* The replacement of tropical forest by other land uses without a preliminary and deep study of possible sustainable forest management.

Herein I discuss some general aspects of the land use pattern of the Carajas/Buriticupu region with help of satellite image interpretation, and as a fitting detail the feasibility of a sustainable forest management on a natural regeneration basis taking into account some important characteristics of the region.

The main objective is to find out who is doing what with their forest areas and how could we improve existing knowledge on forest management at Carajas region.

This MSc thesis was done as part of the Tropical Forestry MSc course of the Wageningen Agricultural University,The Netherlands.

The author is a forester with a 10 years experience in the eastern Amazon region, who intends to give a contribution with some scientific information in the search of solutions for the deforestation problem in the region.

I would like to take this opportunity to express my especial grateful to many people and institutions who helped me to carry out this research:

- First of all I very much appreciate the continued support of the Tropenbos Programme, with the provision of first year scholarship, especially Dr. W.G. Sombroek, who encouraged me to carry out this research.

I also thank very much:

- To the financial support from Brazilian Research Council - CNPq, for the gnawed year scholarship.
- To UNESCO - Division of Ecological Science by the support in the field-work realization through Dr. Malcolm Hadley.
- To IBAMA - Instituto Brasileiro do Meio Ambiente, to which I work, for the institutional support.
- Professor R.A.A. Oldeman, head of the Department of Silviculture and Forest Ecology, for the enthusiastic support and guidance.
- Dr. N.R. de Graaf as my main supervisor during two years study, to whom I am very grateful for gave me the main lines and guidance to setting up the study.
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- Dr. van Wyk for help with the statistical analysis.
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- Last but not least to the Compania Vale do Rio Doce - CVRD by its fundamental logistic support at field level, through SUMEI-Rio and FRDSA-Acailandia.

1. INTRODUCTION

1.1 Recent history of Carajas/Buriticupu Region

Until the early 1950's, the Carajas/Buriticupu region was almost entire cover with tropical rain forest. The region started to be occupied in the 50's by landless from the dry areas of northeast states. They were farming under shifting cultivation system and officially those lands were owned by the state.

Since the 1970's the occupation pattern changed and become characterized by the violent expulsion of landless families by cattle ranchers ,logging companies, and land speculators (Gistelinck,1988). Murders are quite frequent ,specially of landless leaders, presidents of rural syndicates and priests.

Population of Maranhao State (IBGE,1970)

1970	3.081.000	inh.	75% in rural areas
1980	4.200.000	inh.	68% in rural areas
1988	5.000.000	inh.	64% in rural areas

Nowadays this region belongs to the Program Grande Carajas (PGC) region, a national development scheme program (see section 1.5)
Its land use occupation pattern may characterize a typical development scheme region in Brazilian Amazon. Land uses such as

* Indians Reserves
* Biological Reserves
* Forest Reserves
* Large Cattle Farms
* Colonization Schemes
* Encroachment Areas

are present treat each other as a result of the actual increase of land speculation.

1.2 Physical Environment

Geology

Geographically the region is characterized by the headwaters of the rivers Gurupi, Caru, Buriticupu, and the upper part of the Pindare river.

According to the geologic map of Maranhao (DNPM,1986) this region belongs to two geological formations:

* Itapecuru Formation - Chronologically located in the Upper Cretaceous Period. Lithologically it is formed mainly reddish sandstone (arenito), composed of medium to coarse grains cemented by heavy clay and pockets of kaolin interlayed of silt and clay.

* Barreiras Formation - Chronologically located in Tertiary Period. Lithologically it is formed mainly by low consolidated sediments with predominance of reddish colour, composed by sandstone siltic-clayish, bad selected with clayish bed, and conglomeration and intercalation of kaolin.

* Hollocenic Alluvium -Chronologically located in Hollocene Period. litologically it is formed by sand, silt, clay and gravel.

Geomorphology

The geomorphology is characterized by:

* Sedimentary Plateau Para-Maranhao, which appears continuous (e.g. Tiracambu Plateau) or isolated , associated with Barreiras Formation, overlaying by depositional clay surface also known as a Belterra plateau (Klammer,1984)

* Hilly lands - Pediplain surfaces, or strongly dissected in hills, with or without incised valleys between hills.

* Alluvial Plain - The case of Pindare river.

Soils

The study region has a soil survey carried out by the Consulting and Planning Agency CDN on request of PGC, included in the paper called "Planning of the Carajas Railway Corridor".
The main soil units which predominate in the Buriticupu region are:

PV3 - The association of:
- Red yellow podzolic, medium texture
- Red yellow podzolic latosolic, medium texture
- Red yellow latosol , medium texture

This unit is associated with sloping terrain.

PV1 - Red yellow podzolic, heavy texture
This unit is associated with gently undulating terrain.

LA2 - The association of:
- Yellow latosol, clayey and medium texture
- Red yellow latosol, clayey and medium texture

This unit is associated with gently sloping terrain.

LA1 - Yellow latosol, heavy texture
Associated with flat to gently sloping terrain (Belterra Plateau)

LV4 - Red yellow latosol, clayey and medium texture
Associated with gently sloping terrain

A2 - Association of alluvial soils, variable in texture, and plinthosols, variable texture; associated with flat terrain.

Climate

Golfari (1980) divided the study area in two main bio-climatic regions:

	Region 2	Region 4
Annual mean temperature ('C)	24.5 - 26.0	24.5 - 26.0
Annual mean precipitation (mm)	1600 - 2000	1400 - 1800
Water deficit (mm/year) according Thornthwait	100 - 200	150 - 300
Dry period (month)	4 - 6	5 - 6
Climate type	Sub-humid	Trop.Sub-humid
Vegetation type	Evergreen Hygrophile Forest of Gurupi River	Mesophile Forest of Pindare River

(See Map 1 - Bio-climatic Map of Carajas Region)

1.3 Vegetation cover

Two main vegetation type are present in the study area (Golfari,1980)

* Evergreen Hygrophile Forest of Gurupi River:

Occurs from the right fluvial terrace of the Gurupi river to Tiracambu hills. Dense forest with high trees (50 m) , high biomass, some time alternated with less dense forest patches, altitude between 100 to 300 m above sea level.

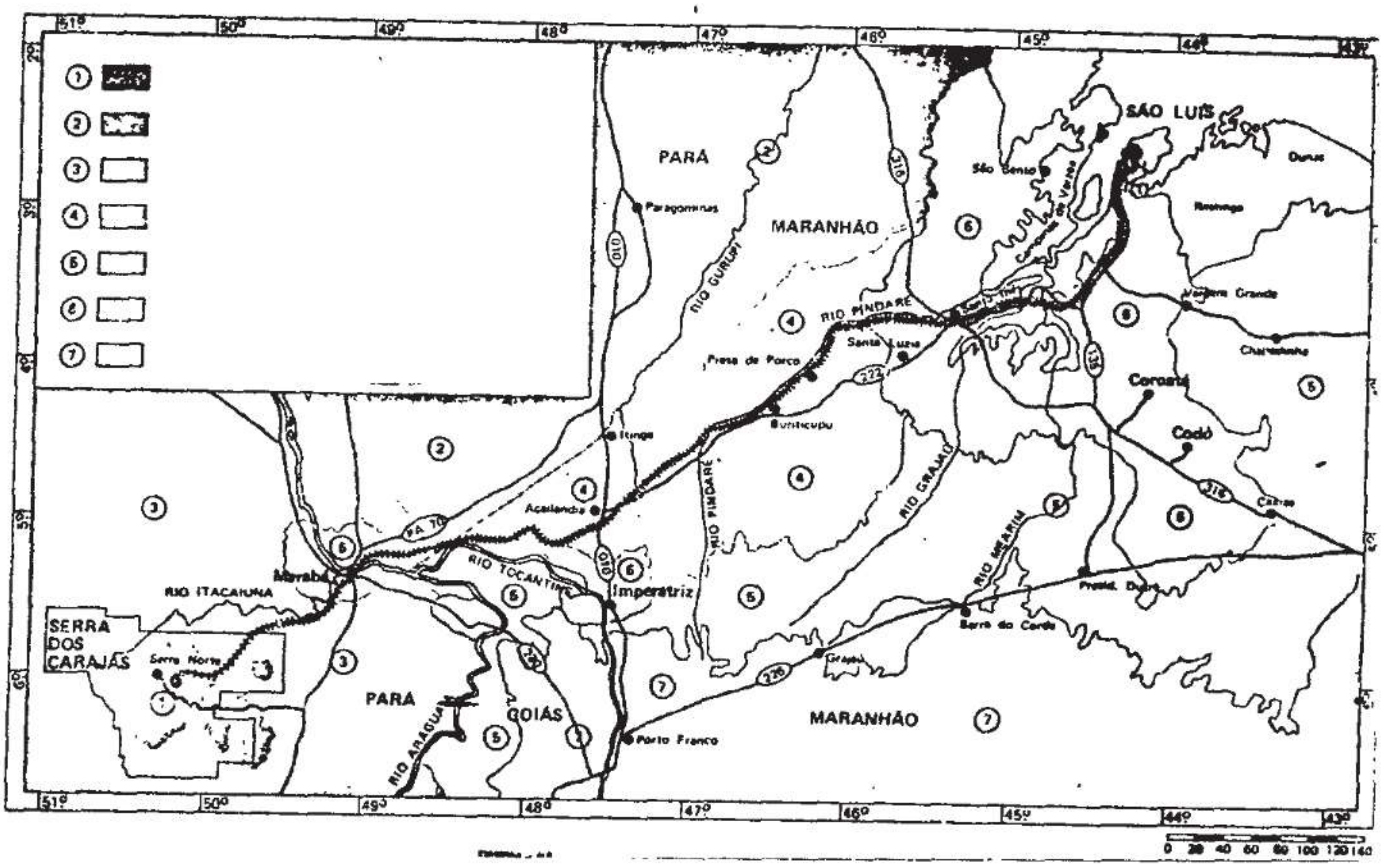
Main species are: *Pouteria spp*, *Dinizia spp*, *Manilkara spp*, *Carapa spp*, *Vochysia spp*, *Lecythis spp*, *Carimana spp*, *Parkia spp*.

* Evergreen Mesophile Forest of Pindare River:

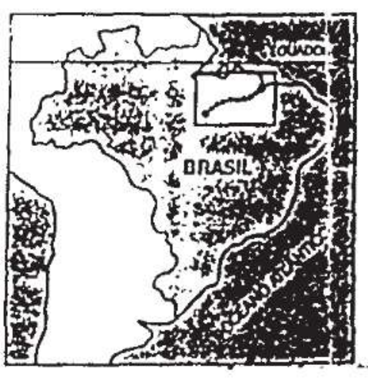
Occurs on the upper Pindare and on the lower Buriticupu catchments areas, is a forest formation less homogeneous than Hygrophile Forest type, with alternation of dense forest and open forest; with presence of lianas, with a medium biomass and a timber volume of approx. 120 to 150 m3 (Radam Brasil,1973) and (Salomao et alii, in press), normally found on plateaus. Main species are:

Cenostigma spp, *Dialium spp*, *Ocotea spp*, *Tabebuia spp*, *Zollernia spp*.

ZONEAMENTO ECOLOGICO - REGIÕES BIOCLIMÁTICAS



ESTRADA DE FERRO CARAJÁS



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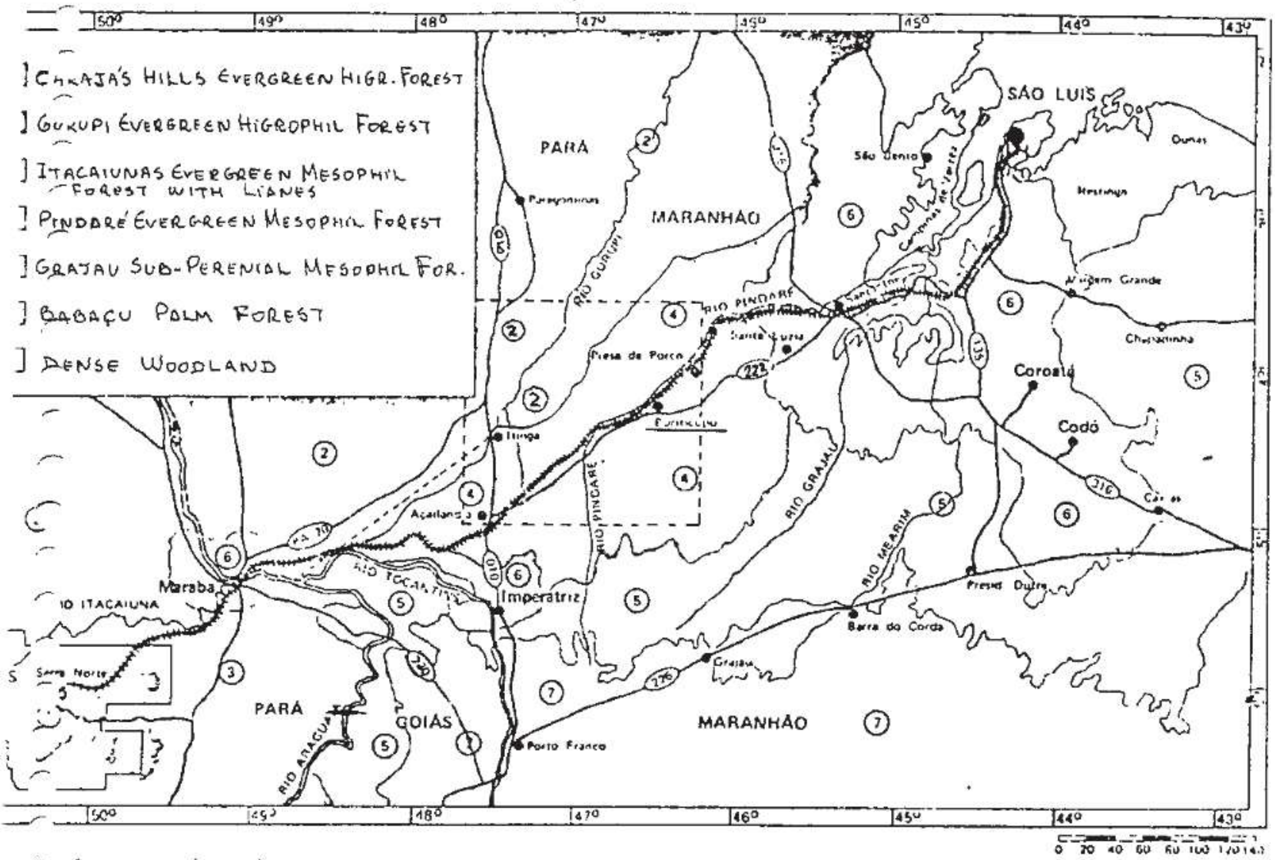


GOLFARI (1980)

- - - STUDY AREA

ESTRADA DE FERRO CARAJÁS

1.4 Land-use and Socio-economic aspects of the study area

The study area has a quite interesting occupation pattern, many kinds of land-uses are present due to the special character of the Amazon occupation strategies.
Three main facts determined changes in the socio-economic context:

* the building of the highway Br-010 from Brasilia to Belem in the early 1960's
* the building of the highway Br-222 from Sta. Ines to Acailandia in the early 70's
* the building of the Carajas railway in the early 80's

Main land-uses in the study area are:

1. Large cattle ranches
2. Colonization scheme - ITERMA / COMARCO in Buriticupu
3. Invasion areas - Pindare region
4. Biological Reserve - Gurupi
5. Indians Reserves - Arariboia, Caru
6. Private Forest Reserves - e.g. CVRD-Buriticupu

1.4.1 Large cattle areas

Most cattle farms have areas between 1000 and 10.000 ha, where cattle are bred for meat export and internal market.
Cattle ranchers started to occupy the area in the early 60's with the construction of the Br-010 highway and later with the construction of the Br-222. Cattle farmers are largely supported by the National Government in the form of special loans and tax incentives.

In the Pindare region, COMARCO (Maranhao Colonization Company) carried out, in 1972, a scheme in which more than 500.000 ha of forest land were allocated and distributed (25.000 ha each) among cattle farmers.

The total deforested area for pasture on east Amazonia is 10 million ha, an area two times the whole surface of Costa Rica. From this area, 80% are degraded and/or abandoned.

1.4.2. Colonization scheme

The Buriticupu colonization scheme started in 1972, under administration of COMARCO which the objective was to solve land conflicts in the area by distributing 300.000 ha of land among 10.000 of landless families .
In fact, only 50.000 ha (20% of the initial 300.000) were allocated to 2.000 poor families . The remaining area was distributed to cattle farmers.
These 50.000 are situated in the most arid part of the region with a topography characterized by slopes.

The scheme was doomed to fail from the beginning as lack of water made farm management for the peasants almost impossible. Those who manage to survive cultivate rice, maize, been and cassava by means of shifting cultivation. Only 65% of the original families still participate in the original scheme.

1.4.3. Invasion areas by posseiros(squatters)

In the last 20 years, land policy was characterized by fast concentration of land in the hands of powerful groups who proceed to the expulsion of the posseiros (original land "owners") from the rural areas.
The municipality of Sta. Luzia, which is crossed by the Carajas railway is a typical example: between the period of 1975 to 1980 the number of small peasants decreased by 20% and the land area occupied by them decreased by 74% .
In whole Amazon region, 2% of the farms occupy 60% of the total area,(Cerri,1989)
After the construction of the Carajas railway, groups associated with local politicians took over even more land from the posseiros, who as pioneers cleared the forest.

Numbers of landless families in the surrounding municipalities of Buriticupu village (Gistelinck,1988):

municipality	posseiros families
Sta. Ines	2.400
Sta. Luzia	11.200
Bom Jardim	4.900
Acailandia	4.900
Imperatriz	17.500
Total	40.900

In spite of expulsions, the process of invasion by landless increased again in the last 5 years, especially in abandoned grazing areas of the cattle farms and in their forest reserves as well. This had been possible because the President of Brazil in this period, Mr.Sarney, himself is from Maranhao state and he did not want to take measures against the rural population of his own state.

In most of the big "abandoned" cattle farms there have been invasions. The Cacique Agropecuaria (100.000 ha), for example, was invaded by more than 1.000 poor families where today we find Presa de Porco village. Others examples are Fazenda Ciquel, Fazenda Verona (in which landless families are building the Tancredo Village), Fazenda Terra Bela, Fazenda Lagoa Azul, Fazenda Matary, Fazenda SIT, Fazenda Sta. Inacia and Fazenda Seringal.

Commonest practices of these posseiros are:

* felling of commercial trees followed by slash and burning
* planting of annual crops during one to three years
* planting pasture to sell the land to other cattle farmers
* or when the area is large enough they practice shifting cultivation.

1.4.4. Biological Reserve of Gurupi (341.000 ha)

Created in 1988 this reserve is located in one of the last forest areas of the Maranhao amazonian region, which has almost the same characteristics as the humid forest of the Amazon basin. This area, north-west of the state Maranhao(see map 2 with overvieuw of the protect areas),is one of the least studied biogeographical areas of Brazil. Main causes for this lack of scientific knowledge are (Oren,1988):

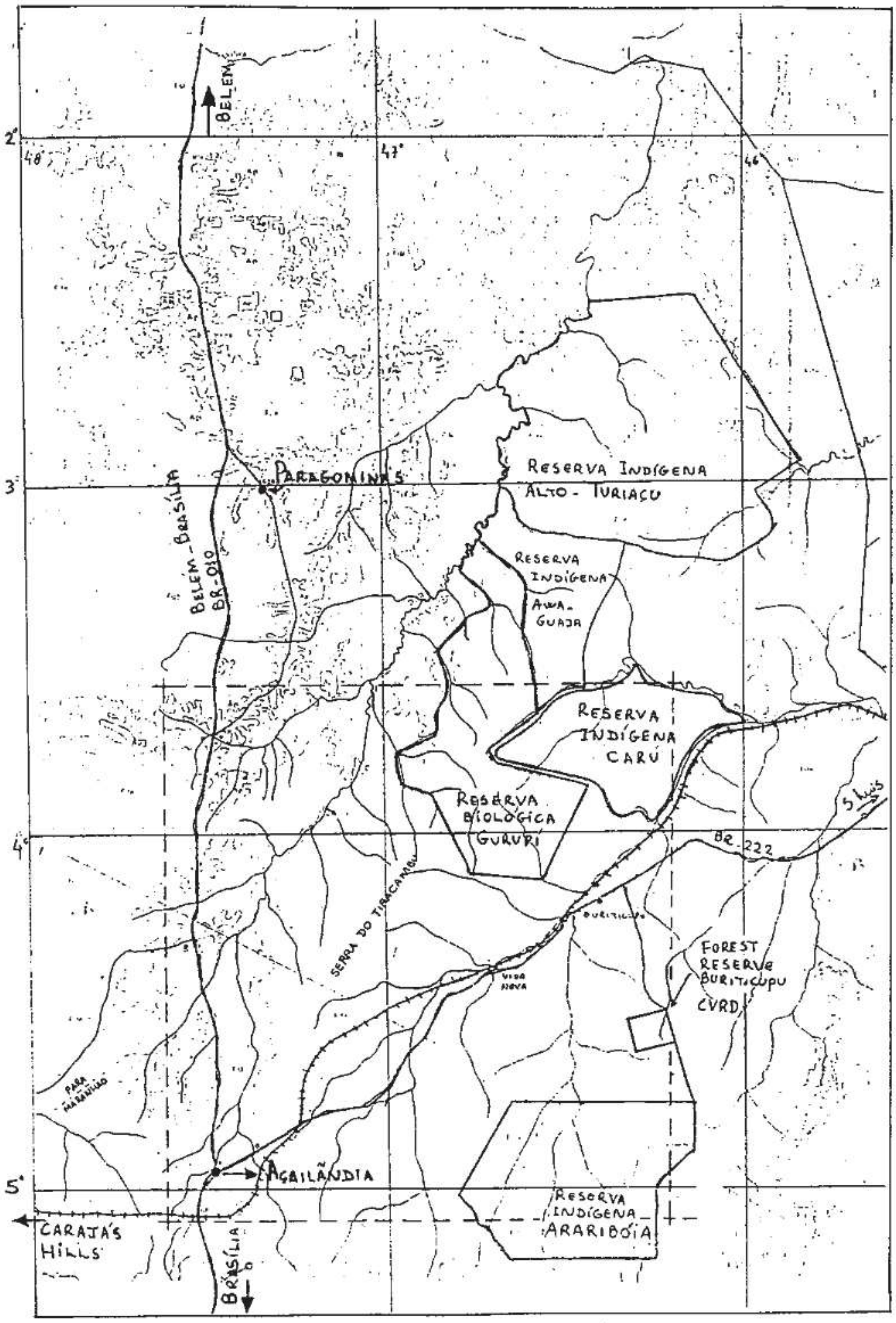
* researchers believed that the pre-amazonian forest has less relevant biota, because of its transitional character;
* difficult access;
* presence of indians (Guaja and Guajajara) who have been obstructing all exploration activities.

In 1981 researchers of the Museu Paraense Emilio Goeldi carried out studies in which the importance of the local fauna was established.

Species endangered by extinction are:

Birds:

Tinamus tao - Azulona
Tinamus guttatus - Inhambu galinha
Cripturellus cinereus - Inhambu preto
Cripturellus variegatus - Chororao
Harpia harpyja - Gaviao real
Morphnus guianensis - Gaviao de penacho
Penelope pileata - Jacu de cocuruco branco
Mitu - Mutun cavalo
Crax fasciolata pinima - Mutun pinima
Psophia viridis - Jacamim de costas verde
Ara macao - Araracanga
Aratinga guarouba - Ararajuba
Neomorphus geoffroyi - Jacu queixada
Ramphastos tucanus - Tucano grande de papo branco
Phoenicircus carnifex - Raio de sol
Xipholena lamellipennis - Anabe de rabo branco
Galbula dea - Ariramba do paraiso
Jacamerops aurea - Ariramba grande da mata virgem
Platyrinchus platyrhynchos - patinho de pileo branco
Microcerculus marginatus - Uirapuru veado
Periporphyrus erythrometas - Bicudo encarnado



MAP 2 OVERVIEW OF PROTECT AREAS

Mammals:

Chiropotes satanas - Cuxiu
Felis onca - Onca pintada
Tapirus terrestis - Anta
Tayassu pecari - Queixada

To justify such a large reserve area, researchers have pointed out that only a large area can effectively protect the vegetation and some animal spp as Felis onca, Harpia harpyja, Aratinga guaruba, endangered of extinction.

1.4.5. Indians reserves

There are two indian reserves within the study area.(see Map 2 and Map 3 Carajas region and its Indians territories)

Reserve	Area	Tribe
* Caru Indian reserve	172.667 ha	Guaja and Guajajara
* Arariboia reserve	413.589 ha	Guajajara

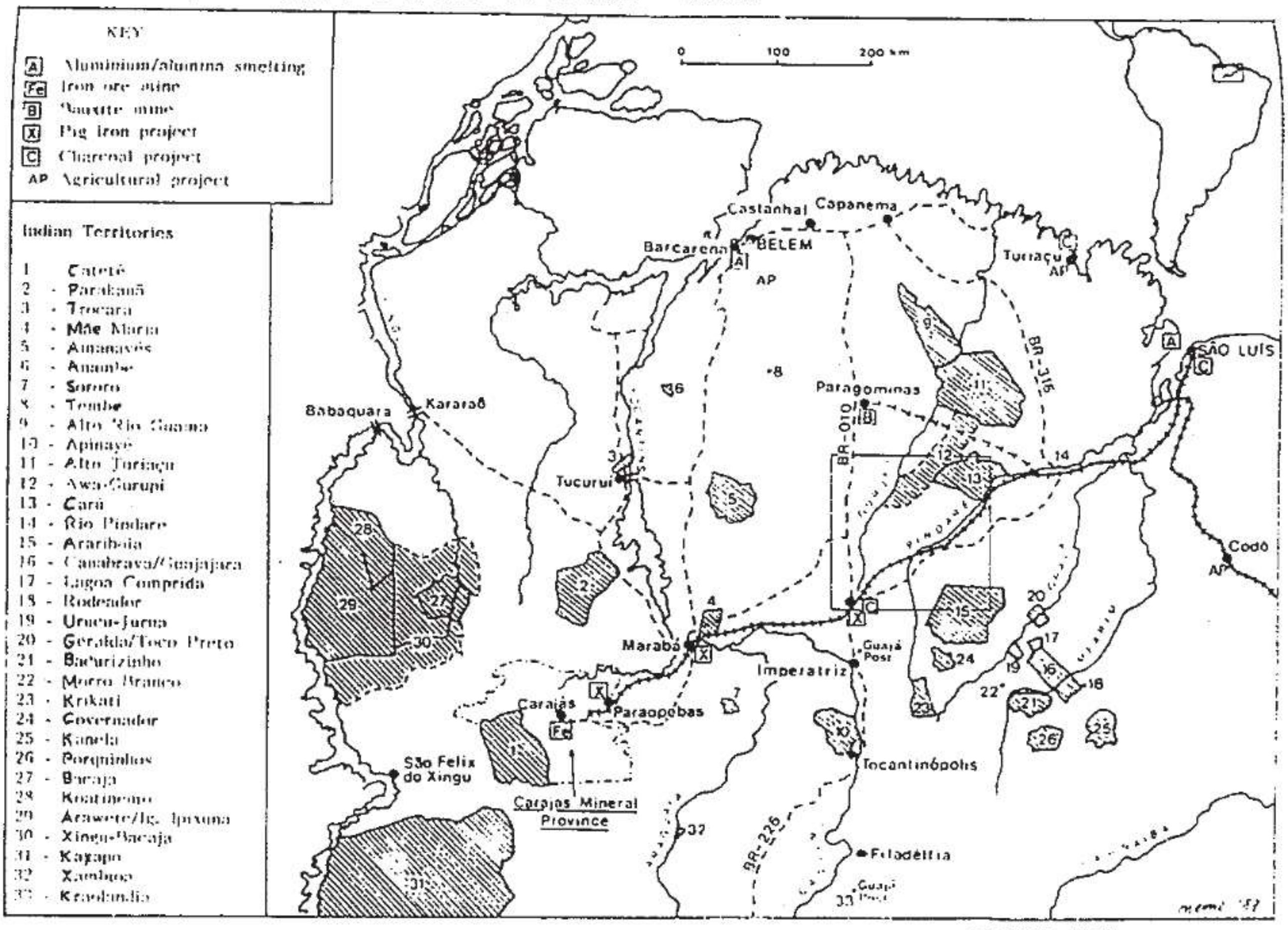
These areas are constantly threatened by cattle farmers, landless, mining companies and gold diggers.
These tribes can be considered the region communities which are most affected by the changes in the socio-economic context.

The Guajajara constitute the largest single tribal nation with 6.500 inhabitants and although divided into a number of sub-groups and territories located north and south of the railway, they still maintain their characteristic tupi language and consider themselves as one people. They are the original inhabitants of the Pindare river valley and by their strong cultural resistance they could preserve their own identity in spite of 400 years of contact with white people.

The Guaja tribe has as a very peculiar characteristic: they are the last purely hunter and gatherer nomad tribe of Brasil and their existence is strongly threatened by outsider's activities. In the last 10 years they have been reduced to 25% of the original population.

The indigenous knowledge of the forest resources has been largely ignored. Studies of a neighbor tribe, Urubu Kaapor, has been carried out by William Balee of the Museu Emilio Goeldi who made an inventory of their forest land use. According to the research (Balee,1986) the Urubu Kaapor of the Alto Turiacu Reserve (which has a boundary with the Gurupi Biological reserve in the north) have a very well defined forest management system. In an sampling area of 1 ha they recognized at least one utility for each of tree species encountered (food, medicine, construction, etc...).

MAP 3 OVERVIEW OF INDIANS TERRITORIES AT CARAJÁS REGION



TREECE, 1983

☐ STUDY AREA

1.4.6. Private Forest reserves

By law all farm in the Amazom region should have at least 50% of its area cover by natural forest , which is usually called as a private forest reserve.
Some owners of large farms are trying to keep their forest reserves despite the risk of invasion.
A good example is the CVRD (Compania Vale do Rio Doce) who owns two forest reserves in the study area:

1. The Buriticupu forest reserve (10.000 ha) in which the company has been making efforts in protection and management. There are some experimental plots (6 years old) under different treatments. The company normally offers support to researchers who want to carry out research in the reserve, especially in topics like forest ecology and management.

2. Acailandia Forestry Center, an experimental forest farm (Fazenda Itabaiana - 1.800 ha) with several experimental plots under agroforestry systems, specially annual crops mixed with amazon timber or fruit trees. Most commonly used species are:

timber trees:
* Tabebuia spp (Ipe)
* Cordia ssp (Freijo)
* Simaruba spp (marupa)
* Coumarouma spp (cumaru)
* Paiquia spp (parica)

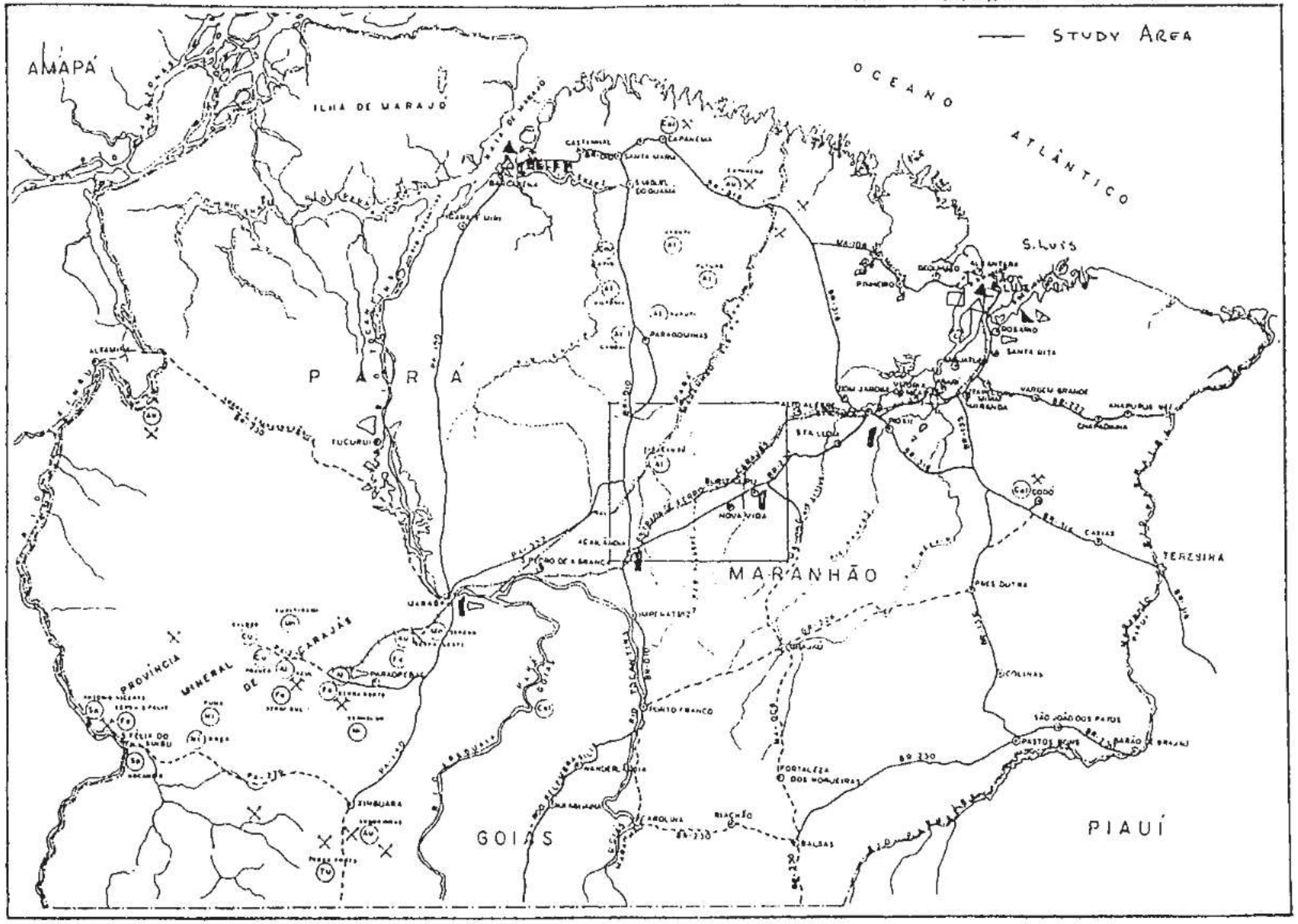
fruit trees:
* Malphia punicifolia (acerola)
* Byrsonia crassifolia (murici)
* Achras sapota (sapoti)
* Artocarpus altins (fruta-pao)
* Anacardium spp (caju)
* Paullinia cupana (guarana)

1.5 Grande Carajas Programme - PGC

This programme is considered one of the largest development schemes of the world embodying an area of million square kilometers (10% of the country area), an area equivalent of two times West Germany.
Implementation started in 1980, the main goal being the export of minerals.

Estimates of the mineral reserves are (Breno dos Santos,1982):
18 million tons of iron ore, by far the largest mine of the world
60 million tons of manganese ore
48 million tons of aluminum ore
88 million tons of nickel ore
02 million tons of copper ore
100 tons of gold ore
100 million tons of tin ore

MAP 4 CARAJA'S REGION



☐ STUDY AREA

Also included in the programme are the implementation of industries and agro-industries on large farms supported by special loans and tax incentives.
The exploitation of natural resources and the primary production will be all aimed at export making use of the export corridor formed by the Carajas railway and surrounding area.

The products with large potential for export are :

from agro-industries(Ferreira,1986):

rubber	medicine essence
palm oil	resin
cassava pellets	timber
babacu oil	charcoal
cocoa	fish
pepper	meat
guarana	plywood
brazil nuts	rice
tropical fruits	maize
cellulose and pulp	cassava
cashew nuts	cotton
soya beans	

from industry:

Twenty pig-iron plants are scheduled for financial incentives from PGC which will demand 2.4 millions metric tons of charcoal/year, an amount equivalent to 100.000 ha of forest/year. This will bring a new land-use type to the region which is Eucalyptus plantations.

Preliminary estimates reveal that 700.000 ha of Eucalyptus plantations would be needed, equivalent almost 10 times the area of the unsuccessful managed plantations at Jari Project, (Fearnside,1989).
The budget of the PGC includes only for infra-structure US$ 22.5 billion and US$ 39.2 billion for direct financial input.

To meet these objectives the government has already built:

* 900 km of the Carajas railway
* Tucurui hydroelectric dam with a lake area of 216.000 ha
* Hydroway Araguaia-Tocantins: 2.600 km (not yet ready)
* Marine harbour Porto da Madeira: one of the largest in the world with a capacity to receive ships with 300.000 tons

1.6 Addressed problem

Many different groups of the rural population of the Amazon region are dealing with forest resources in accordance with their perception of the environment. Indians, posseiros, settlers, cattle farmers, foresters, etc..., each of them with completely different backgrounds concern to rural activities.
Many discussions have been taking place lately about land utilization in the PGC region, as a consequence of the actual forest land degradation. In my opinion, this discussions miss a

deep knowledge about several aspects of the forest ecosystem as well as the knowledge about the behaviour of the rural population related to their use of the forest resources. To know the way they manage these resources is important for the evaluation of the long term availability of these resources.
There also is an urgent need to carry out research in Brazilian Amazon in order to study the response of different logging intensities and silvicultural treatments on the development of the forest , to support future forecasting studies (Silva and Whitmore,1989) as well as knowledge of the natural regeneration processes of the Amazon rain forest.

1.7 Specific problem

The subject to be investigated in following chapter in this study is the feasibility of a natural regeneration system as an option of land use, taking into account the following aspects of the area:

* availability of forest areas;
* uses of the forest resources by the local population;
* available data of the CVRD experimental natural regeneration system.

This study is important, considering the extent of forest degradation in the area due to the strong changes in land use. The interest in the sustainable management of the tropical rain forest is growing among forest owners, but knowledge about the responses of the forest under different kinds of intervention is still missing.

1.8 Scientific questions

Some important question are presented, althouth we do not intend to answer all of them.

On regional level:

1. Are there sufficient forest areas in condition to be managed on a natural regeneration basis?

2. To which extent is the forest degraded? and what are the causes of such degradation?

3. What is the situation of the protected areas in respect to the surrounding land-use?

On farm level:

1. How important is the forest for different local groups such as
   large farmers,
   small farmers and posseiros, and
   indians

2. What is their knowledge about forest management?

3. What are the existing plans for forest use?

On site level:

1. Was the forest too open after intervention ? (regarding the quality of the natural regeneration).

2.
A. Is there any relation between treatments and type of natural regeneration (pioneers and other spp)? (regarding to species and frequencies)
B. Ditto between treatment and forest structure?
C. Ditto between treatment and tree architecture?

3. Are silvicultural treatments needed to improve the actual forest structure, increment, and natural regeneration processes?

1.9 Objectives

The general objective of this study, is to assess the feasibility of a forest management system (with enphasis to natural regeration) in the PGC region, especially in the Buriticupu area. This objective can be split in two:

A. Assess the potential of a natural regeneration system as a land use option for the local population.

B. Assess the potentialities of such a system taking into account the forest structure under different exploitation intensities in the experimental plots of the Buriticupu Forest Reserve (CVRD).

2. SILVICULTURE AND FOREST MANAGEMENT

2.1 Aspects of a silvicultural system with natural regeneration

In this study, natural regeneration as a silvicultural system is defined as: "favouring the spontaneously occurring regeneration of species of known value to man and those likely to be acceptable in the future" (Wyatt-Smith,1987). Also to preserve the regeneration of the species which participate indirectly in the regeneration process, by offering shelter, sleeping quarters to living agents essential in the natural regeneration processes of the valuable spp. (e.g. pollinators, seed dispersers, etc.) Here it may be important to clarify the concepts of valuable species and desirable species.
Valuable species are those of economic interest, also called commercial species. Desirable species are those which may have economic interest but should have ecological importance to the process of natural regeneration.

2.1.1. Processes of tree regeneration

According to Schmidt (1990) and Boerboom (1982), the most important processes to take into account to guarantee natural regeneration are:

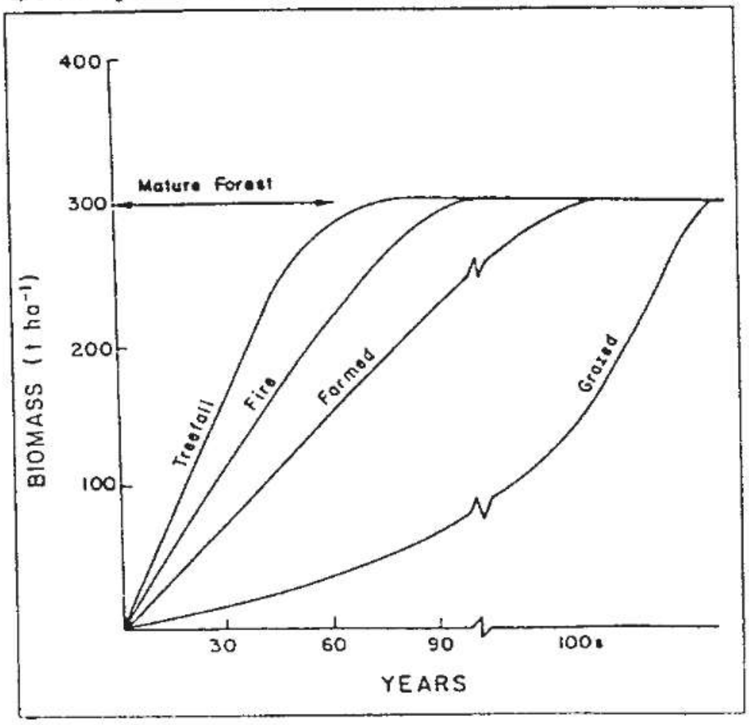
* flowering and pollinization
* fruiting
* seed dispersal
* seed preparation
* dormancy and germination
* growth and mortality of seedlings

The forest manager should take care of the ecological conditions which lead to the above processes, moreover promote them, by e.g. changing light intensity at ground level.

In respect to biological conditions, it is important to conserve large tracts of untouched forest, dispersed over the area to be treated (Pannel, 1989) in order to guarantee the preservation of the above living agents from which we yet do not know enough. (Schmidt, 1990). It might be possible to use forest areas unsuited to machine movements or with very few valuable trees to fulfill the above requirement (Jonkers,1987).

As far as site conditions are conserned, it may be important to mention the finding of Uhl and Vieira (1989) , who has been studing natural regeneration process after several kinds of disturbed /abandoned sites, in the north of the study area (Paragominas Municipality).
They present an interesting graph in which the speed of forest regeneration is estimated according to differences in site condition. (see figure no.1). It is clear how forest can recover faster in a tree fall gap than in a large gap of aboandoned pasture, due to the higher availability of nutrients.

Figure 1 (below): *Both the availability of nutrients and regeneration mechanisms influence the speed of forest regeneration after disturbed sites are abandoned. Recovery is relatively rapid following natural disturbances when compared to anthropogenic disturbances.*



UHL ET ALLI, 1989

2.1.2 Silvicultural objectives

In order to promote conditions for natural regeneration, silvicultural measures may be concentrated on: (Boerboom, 1982)

A. Improve conditions for seeding and seedlings establishment (e.g. liberation of seed trees, opening of canopy, scarifying of soil, etc...).

B. Restriction of the regeneration of undesirable species, by e.g. eliminating seed trees and climber cutting well in advance.

C. Improving conditions in the lowest strata for growth of seedlings and saplings of desirable species, by e.g. elimination of trees and other forest components (mainly climbers). Light plays the most important role here usually.

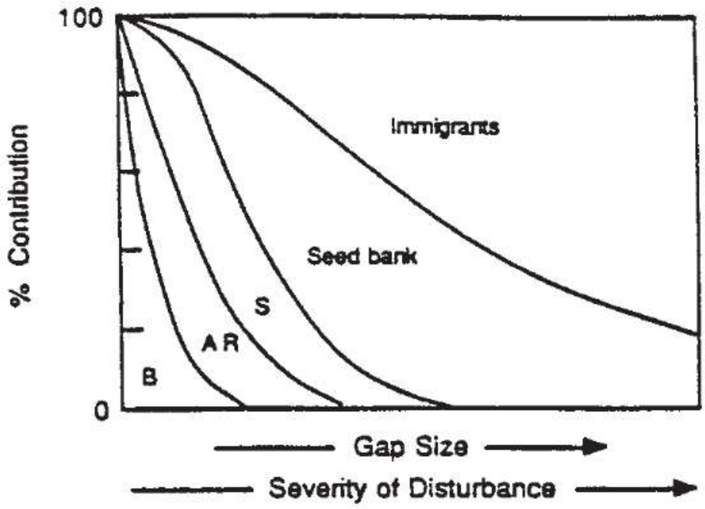
D. Improving conditions for survival and growth of individual desirable trees, by individual treatments e.g. liberation.

E. Change forest structure to a certain extent.
An example is the elimination of very large and/or malformed and partly rotted individuals of undesirable species, to make the structure more homogeneous.

In relation to the above measures various questions be considered:
In measure (A) the improving conditions mainly mean opening of canopy.In this respect we may mention a interesting relationship between gap size and the relative contribution of various guilds of organism gap filling (Bazzaz, 1984). See figure no.2

Figure 2.

Relationship between gap size and the relative contribution of various guilds to gap filling. Increased severity of disturbance during gap creation moves the time axis to the right. B = branches, AR = advance regeneration, S = sprouts. From Bazzaz (1984)



One of the major important factors in the characteristics of natural regeneration is the size of gaps. In small gaps, advance regeneration is most important while a seed bank becomes more important in larger gaps.

A crude distinction may be made between forest regeneration on small and large surfaces, in small and large gaps respectively, with recruitment from various sources of propagules varying in respect to gap size and severity of disturbance. (Bazzaz,in press).

According to Whitmore (1986) this means that in a canopy gap created by the death of one or a few trees, seedlings already present in the undergrowth (normally primary spp) are released and grow up into building phase (saplings and poles).
In a big gap by contrast ,pre-existing seedlings may die, as there is a major shift in microclimate near and below the ground. The gap is then filled by new seedlings (mostly pioneer spp) which were not present below the previous canopy.

Thus we have two sorts of tree species, those with shade-tolerance seedlings and those with light-demanding seedlings. The latter can not regenerat under any shade, including their own.
These two species classes are often roughly addressed/indicated also as climax or primary and pioneer or secondary species respectively.

This leads to a discussion of the measure (E) Changing forest structure. The extent that the forest structure should be modified has to be related with the forest eco-units already present in the undisturbed forest, which can be done by forest transect analysis. Forest structure and eco-units will be treated in the next paragraphs.

2.1.3 Forest interferences

Interference should also be practiced taking into account the optimization of the natural regeneration process (Boerboom,1982).

A. Timber/wood felling
Although harvesting of the wood is the usual main objective, the interference has important silvicultural effects. With timber stand improvement felling, seed trees of desirable species are given extra space for increasing their growth and seed production.

B. Refining
Forest components (mainly trees and climbers) that are considered undesirable, are eliminated from the stand. Specification of the undesirable criteria of forest components needs attention, also with respect to the ecological functioning of the forest without these components.(see differences between economic species and desirable species).

C. Liberation
By elimination of forest components around desirable individual trees these are liberated.

D. Soil scarification
Soil, under or near seed trees and also on skid trail, is tilled to promote seedling establishment.

The above mentioned silvicultural measures should be evaluated under the light of some aspects which are relevant for a successful management such as (Neil,1981):

A. the nature of the residual stand left after logging and in particular the species and vigour of the seed trees;

B. the growth ,stocking and distribution of seedling and advanced sapling growth both before and after felling;

C. the damaging effect of logging on the residual seedlings , saplings and trees and of logging tracks and extraction roads on the environment , particulary on natural water drainage pattern and soil physical conditions;

D. damage to the residual stand by secondary fungal and insect attack following logging damage and by wind and bark scorch;

E. the likelihood of weed growth , invasion by pioneer trees and increased luxuriance of climbers.

In addition we could include other aspects which should be present in successful management as well: maintenance of the status of the nutrient cycle, avoiding nutrient export from the treated areas . Undesirable species should be left there , rotting, in order to let nutrients perform their complete cycle within the forest ecosystem.
In this respect application of arboricides play an important role, avoiding leaching, when trees will die slowly, spread the dying over a period of one or two years ,which facilitates the

absorption of nutrients from the biomass, instead of promoting leaching by killing instantaneously an huge amount of living biomass (Schmidt, 1990).
The preservation of a large amount of living biomass during all stages of a rotation is of at most importance. The nutrient capital will remain safely stored in this biomass, which is capable of catching nutrients loosened from decaying tissues (Boxman et al, 1985)

2.2 Forest structure

For a complete study of forest structure the following two factors are important:

A. Forest components, such as:

* trees of the canopy;
* understorey trees;
* shrubs;
* lianas or woody climbers;
* understorey herbs.

Lianas, though not as abundant in mature primary forest as in secondary forest and gaps, form an important part of the structure. E.g. in Mixed Dipterocarp forest (Malaysia) lianas contribute to the foliage in 1/3 (Kira, 1978).

B. Stratification of forest components:

Stratum is defined by both the set of trees at a certain level and the set of environmental factors at this level (Bourgeron and Guillaumet, 1981).
It has been suggested (Bourgeron, 1983) that there is a clear relationship between the stratification in the forest and bio-climate factors such as: CO2 rate, humidity, temperature, evaporation, light and brightness.
The following situations are observed in the first stratum (above ground level):
* CO2 rate and humidity are higher than in the canopy above;
* Temperature is lower than in canopy above ;
* Strong nocturnal temperature inversion;
* Light intensity is lower than in the canopy above.

Forest structure determines the internal microclimate which controls the distribution of smaller plants and the distribution and activities of animals (Richards, 1983).
Variation in the structural elements are associated with differences in site conditions, dynamics of regeneration, growth, succession and biotic impacts (Brünig, 1979).

In a study of forest structure it is important to look at the different phases of growth related to forest dynamics by the analysis of forest eco-units and profile diagrams. Forest profile diagrams provide a qualitative tool in the analysis of forest stratification (Bourgeron, 1983), and they are valuable in comparing types of forest with widely different structures.

Forest eco-units

A forest consists of a mosaic of patches in different phases of the forest life-cycle (Oldeman, 1990)
The Tropical Rain Forest may be referred to as silvatic mosaic, composed by eco-units of different sizes and shapes, built of different species groups (Oldeman, 1983).
Forest eco-units are defined as: every surface on which at one moment in time a vegetation development has begun, of which the architecture, ecophysiological functioning and species composition are ordained by one set of trees until the end. (Oldeman, 1986)

Five eco-units can be identified according to their phases of development:
1. Innovation: new gap composed mainly by seedlings;
2. Aggrading gap: composed mainly by saplings;
3. Aggrading tree: composed mainly by trees of the future;
4. Biostatic: composed mainly by trees of the present;
5. Degrading: composed mainly by trees of the past.

In order to be able to identify these phases, some definitions related to forest architecture are needed (Oldeman,1983):

* Trees of the future are those which still have a potential for height growth, crown expansion or both, but which may also die young.

* Trees of the present are those which have a potential to extension and expansion left, their size being the maximal one at the given site, but their sustenance being very durable because of an ability to replace lost parts.

* Trees of the past are those which have been damaged or died back beyond the point of no return, and which are dead, dying, decaying or a combination of this states.

The architecture analysis of the forest was developed by Halle and Oldeman (Hallé et al., 1978)

2.3 Existing Systems in Latin America

Trinidad

In 1927, a shelterwood system was applied on sandy soils, with emphasis on the regeneration of the aggressive lighter hardwoods, usually light demanders.
Location: Arena Forest Reserve on the well drained sites, where the forest is typically Carapa-Eschweilera seasonal evergreen rain-forest (Neil,1981).
Objective: charcoal production
Rotation cycle: 60 years
In the late 1950's widespread electrification and the change to oil fuel, lead to decrease in fuelwood demand, and consequently the silvicultural treatments could only be applied in the original form envisaged occasionally.

Puerto Rico

In 1943 following the success of Trinidad, Puerto Rico started with about the same objectives (charcoal and timber) and stopped with the activities also because of the same reason, lack of market.

In both countries management was implemented successfully, although it was in a very small and localised scale.

Location : Luquillo Mountains

Surinam

This country started with its experiments on natural forest management in 1960 with J.P. Schulz; continuous in 1965 with J.H.A. Boerboom and again in 1978 with N.R.de Graaf. It is called Celos Silvicultural Systems, and is implemented with the objective to produce timber (de Graaf, 1986).

De Graaf formulated a treatment schedule consisting of three refinements, the fist shortly after logging , the second eight years later, and the third 16 years after exploitation, with the second harvest foreseen after twenty years.

Since 1982 improvements were added and a harvesting system was included. Celos Silvicultural System and Celos Harvesting System were integrated into the Celos Management System, which has the following basic principles (De Graaf and Hendrison, 1987):

1. harvesting operation and silvicultural treatments are integrated;

2. forest inventory is the basis for planning of harvesting operations as well as silvicultural treatments and for control of stock development, logging impact and treatment effects;

3. timber extraction is restricted in order to maintain the ecological functions of the forest at the highest level possible, reducing logging damage and export of nutrients;

4. the system is polycyclic, using felling cycles of 25 years,depending on the increment reached and timber dimensions expected;

5. management units have to function as forest districts, maintaining an infrastructure of multipurpose roads and settlements for forest labour;

6. a solid forest law has to safeguard the legal position of management zones and forest districts.

French Guyana

In 1982 , CTFT (Centre Technique Forestier Tropical) started a silvicultural research project in an exploited forest area within the coastal zone of forest. Commercial volumes and harvesting costs were calculated and the economic implications of the scenarios with varying levels of harvesting for timber or fuelwood were presented.(Schmidt,1987)

Peru
Since 1982 a timber management plan is carried out in an area of 140 ha , with a estimated felling cycle of 30 years. The experimental design is based on clear-cut strips (20-50 m wide) with protection strips of about 200 m wide, as a source of seeds for natural regeneration (Higushi et al,1987).

Brazil

Brazil has by far the largest tropical forest area of the world. However it is not the most active country in forest management systems research.
Since 1958 Brazil has some experiments in forest management located at Curua-Una - PARA (Pitt, 1969), but government agencies did not support properly this type of research.
Up to now very few areas are under management, and those are just experimental plots carried out with efforts of a small group of researchers.
Only four institutions are dealing with forest management research:

1. SUDAM (Superintendency for the Development of Amazonia)has some experiments on forest exploitation as well as on the recovering of forest mechanically exploited in Curua-una region (Pitt, 1969) (Dubois, no/date) (Jankauskis, 1983)

2. EMBRAPA (Brazilian Enterprise of Agricultural Research) started with forest management research in 1975 in the Tapajos National Forest, and later others researches were implemented in the Jari Project area(Carvalho,1987).

* Tapajos experimental plots include:
1975 - commercial inventories, potential of natural regeneration, structural studies, forest exploitation, silvicultural treatments and studies of growth rates (area of 64 ha);

1981 - several types of inventories, vegetation composition, intensity of exploitation, silvicultural treatments for sustainable management (area of 144 ha);

1982 - secondary forest management, forest structure and natural regeneration at Belterra village (area of 132 ha);

* Jari experimental plots include:
1983 - intensity of exploitation and primary forest grows rates (500 ha of primary forest and 1500 ha of secondary forest).

3. INPA - (National Institute of Amazonia Researches)
A multidisciplinary project has been implemented since 1979, involving about all departments of the institute such as Ecology, Botany, Technology of forest products and Silviculture.
The project is called Ecological Exploitation and Management of the Tropical Humid Forest (Area of 96 ha). The specific project of the Silviculture department is "Woody Biomass Evaluation and Forest Management for Energy"(Higushi et al, 1987).

4. CVRD (Companhia Vale do Rio Doce)
The brazilian state mining company, which through its subsidiary Florestas Rio Doce implemented several experiments on forest management in different parts of Brazil, mostly with objective to harvest timber and biomass for charcoal by testing different intensities of exploitation and monitoring the natural regeneration. The location of the experiments are (Jesus et al.,1989):

a. Forest Reserve of Linhares
Area of the experimental plots (22,5 ha) in the Atlantic Forest type;

b. Buriticupu Forest Reserve
Area of the experimental plots (10 ha) in the Evergreen Mesophyl Forest type of the Pindare river;

c. Maraba Forest Reserve
Area of the experimental plots (8 ha) in the Evergreen Mesophyl Forest type of the Itacaiaunas river;

d. Porto Trombetas Forest Reserve
Area of the experimental plots (10 ha) in the Dense forest of the Oriximina region.

3.0 METHODOLOGY

This research has the aim to study the feasibility of natural regeneration systems, although not only focussing on the silvicultural level but also at the regional level in respect to land owners and their land use options. The reason for that choice was that natural regeneration system as a land use should function not only at site level but also be in harmony with the other land uses of the region and with social factors. For that reason a study at these 3 levels was carried out in looking to forest exploitation issues.

* Regional land use level: remote sensing data;
* Land owner level: attitudes towards land use;
* On site level: description of forest structure and natural regeneration.

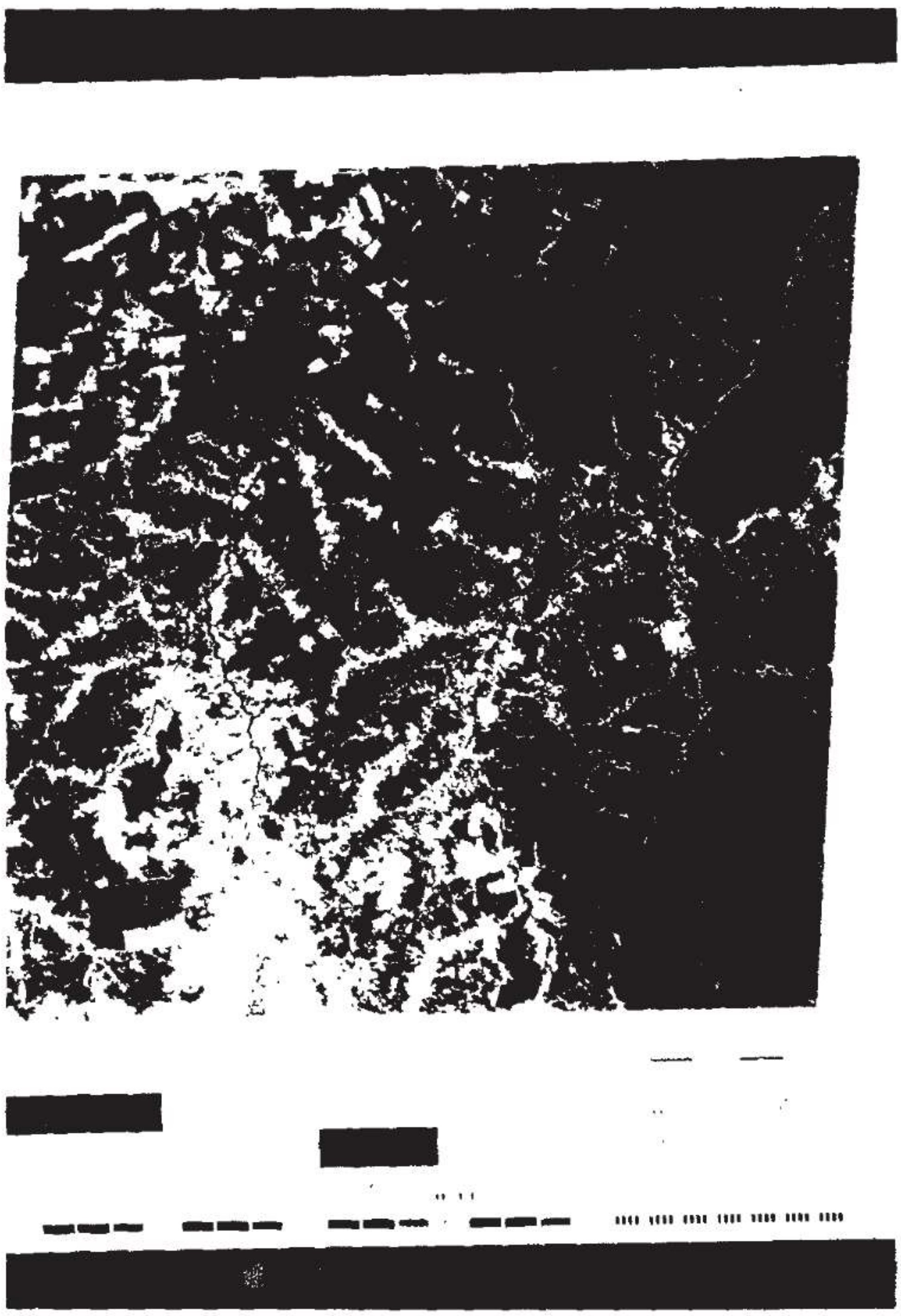
3.1 Regional Land Use Level

A Thematic Mapper (TM) Satellite Image from Landsat 5 was used to evaluate the pattern of forest exploitation and to get a description of the regional land use with emphasis to the remain forest areas.
The reasons of the choice of the Landsat 5 - TM was because this kind of image allows analyses of forest cover and geomorphology, through its bands 3, 4 and 7.

The analysis of such aspects is not only important from the point of view of forestry (timber production, etc.) or wildlife management (monitoring their natural habitat,etc.), it is also relevant for more general conservation aspects.
Deforestation in catchment areas (in our case the Tiracambu hills) may disturb the water regime downstream, lead to erosion and consequent silting-up of reservoirs and even bring about climatological changes.
The interpretation was done visually and the map compilation was done with the use of computer and digitizer, applying the Monoplot program in order to calculate areas of the land use units.
A Final Land Use Map is presented at scale 1:1.000.000, which shows infrastructure , drainage pattern , and land use units. (See fold-out map 6)

Characteristics of the image:

Scale: 1: 250.000
Surface area : 3.404.000 ha
Date : 31. 07.88
Cloud cover : 0%
Colour composition :
Band 3 (blue) gives a good contrast between:
  * areas with and without vegetation;
  * dense vegetation and open vegetation;
  * savannah, woodland, forest and agriculture fields



Band 4 (green):
* sensitivity to the coarse texture of the forest canopy
* sensitivity to geomorphology
* sensitivity to burned areas

Band 7 (red):
* good for analysis of geomorphology, soils and geology
* sensitivity to terrain morphology

3.2 Land Owner Level

The different types of land owners or users were interviewed and bibliography retrieval was made, in order to collect land user opinion on the following topics:
. Importance of the forest areas
. Use of the forest resources
. Knowledge on forest management
. Existing plans for forest use

Unfortunately it was not possible to do the interviews systematically due to time constraint and lack of transport. Data could not be tested statistically, although applicable in gathering an idea of the forest resources use as well as the perception of the forest owners in respect to forest.
A literature survey was made to complete the data.

3.3 On Site Level

This part of the research took place at the Buriticupu Forest Reserve owned by the Companhia Vale do Rio Doce - CVRD , which is carrying out some experiments related with intensity of forest exploitation with the objective of harvesting charcoal and timber.
In 1983, an experiment with five treatments in four replications each was set up in Evergreen Mesophile Forest type of Pindare River (alternation of dense and open forest with lianes) , situated at 350 m above sea level on plateau terrain, with similar characteristics of the land unit Itinga type (Sombroek,1962). See map 2, map 5 and forest profile location paragraph 5.2.

Geographic Coordinates: 04 32 30 south
46 15 00 west

Area of each treatment plot: 0.5 ha (100 * 50 m) surrounding by a wide buffer zone.

The following logging and silvicultural treatments were carried out:

<u>Treatment 1</u> - Control (zero treatment)

<u>Treatment 2</u> - Only cutting of lianes

<u>Treatment 3</u> - Clear cut

Treatment 4 - Harvesting all trees with DBH > 45 cm and cutting of lianes

Treatment 5 - Harvesting all trees with DBH < 10 cm and > 60 cm and cutting all malformed, standing dead and non-commercial trees.

In this study only the treatments 1, 4 and 5 were analyzed because the others were not considered as real natural regeneration treatments, for e.g.:
- Treatment 2 may not be considered as a logging treatment, but just a forest interference like liberation which may be part of a silvicultural treatment;
- Treatment 3 may not be considered as a treatment because it was just a clear cut.

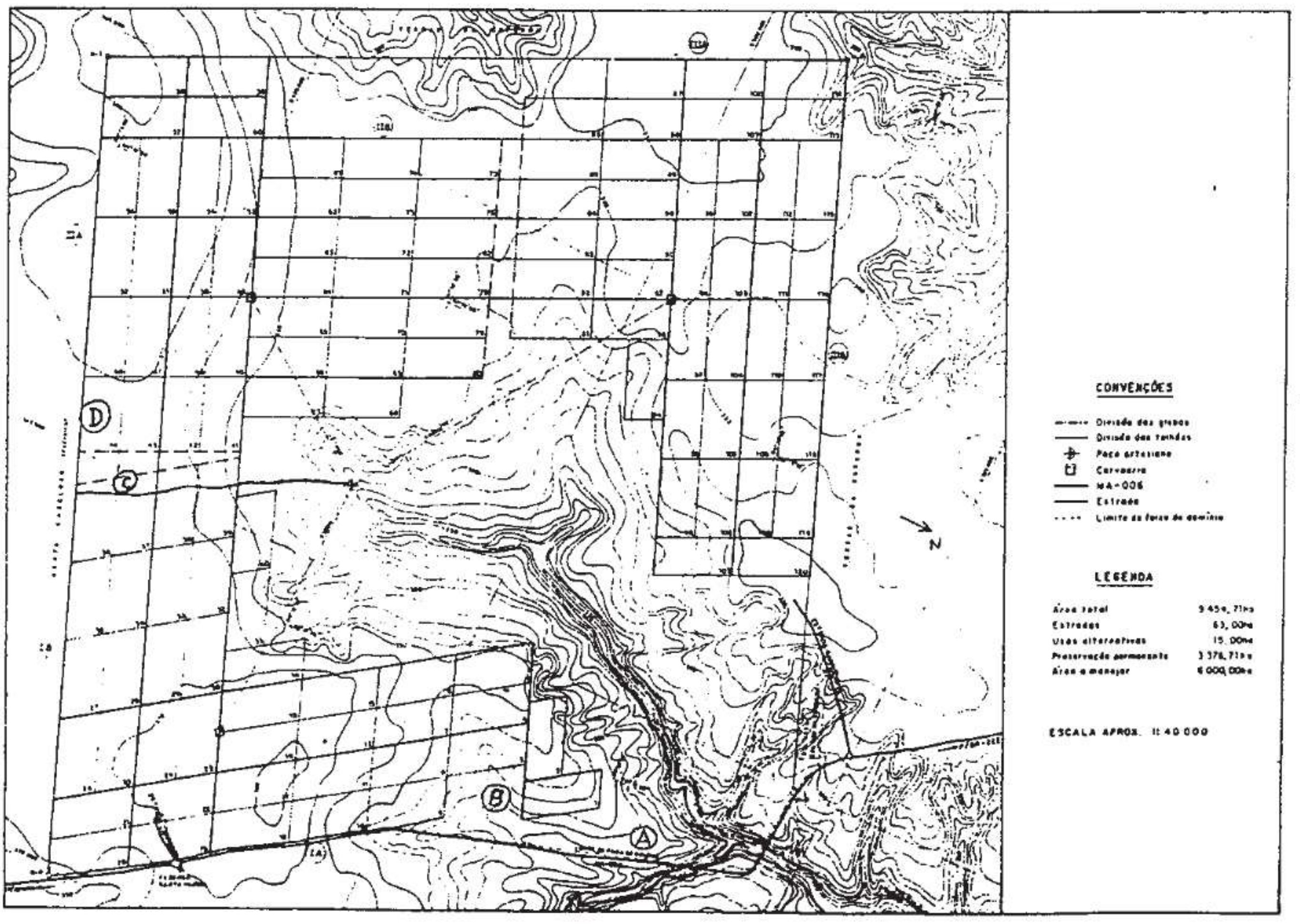
With the objective to describe forest structure and natural regeneration, transect techniques as well as profile diagram making were carried out in replication A for the treatments 1, 4 and 5.

Only one replication was studied because of time constraints, thus replication A was chosen because it had a basal area somewhere in between the basal areas values of the other replications:

	Repl. A	Repl. B	Repl. C	Repl. D
Basal area (m2/ha)	28.0	32.5	19.1	19.1

MAP 5

BURITICUPU FOREST RESERVE - CVRD



– *Plano de exploração e manejo florestal.* Ⓐ TRANSECTS LOCATION

3.3.1 Forest Structure

The study recorded:
* Type of trees : ecological and commercial characteristics of the stand in respect to timber production:
  - pioneer species.
  - primary species of commercial value
  - primary species of no commercial value.

* Categories of trees according to tree architecture - tree life phase (Halle and Oldeman,1978)
  - trees of future
  - trees of present
  - trees of past

The Transect
For each treatment one transect was made out and every tree with DBH = or " 10 cm was recorded within the transect area of 20 * 60m . The objective was to analyze horizontal crown distribution as well as eco-units formation.
Recorded were: The exact location of individual trees, crown projection and tree base.

The Profile Diagrams
To analyze the structural aspects at vertical plane , like crown distribution, stratification of forest components (especially lianes) and categories of tree architecture, one profile diagram was made per/in each treatment with dimension 10 * 50 m, recording all trees with DBH = or " 10 cm.
Recorded were: DBH, total height, height of the branch free trunk, crown diameter and crown form.

The structural data analysis was done with the use of the statistical test CHI-Square, to check if there was systematic difference between treatments. Observed frequencies and expected frequencies of tree categories (architecture criteria), were considered in the calculations, as well as type of trees (ecological and commercial criteria).

Histograms for types of tree are presented (ecological and commercial criteria) as well as a histogram combining the previous criteria with architecture criteria.

3.3.2 Natural Regeneration

The potentiality of natural regeneration was evaluated with following proceeding:

For each treatment, 4 sub-samples with 1 * 5 m were plotted on each profile in a systematic way, with equal distance between them (see fig. 8, 9 and 10), in order to correlate natural regeneration with respective forest structure of each treatment. Numbers of plants were counted and divided in two classes and in two types:

Seedlings class 1 - plants = or < 30 cm
Seedlings class 2 - plants > 30 cm , but < 2,5 cm DBH

Tree species type
Liane species type

Analysis was done by estimating the Population Median of no. plants from sample median, per class and per category for each treatment.
We also show histograms with total no. of plants per class and per category .

List of commercial species as defined by the CVRD management: (Braga, 1986)

1 - Jatoba	Hymenaea spp	Leg.Caes.
2 - Pau Santo	Zollernia spp	Leg.Caes.
3 - Copaiba	Copaifera spp	Leg.Caes.
4 - Massaranduba	Manilkara spp	Sapot.
5 - Muiracatiara	Astronium spp	Anac.
6 - Pau d°arco	Tabebuia spp	Bign.
7 - Pau roxo	Peltogyne spp	Leg.Caes.
8 - Cumaru	Dipteryx spp	Leg.Caes.
9 - Sapucaia	Lecythis spp	Lecyth.
10 - Inhauba	Eschweilera spp	Lecyth.
11 - Tauari	Couatari spp	Lecyth.

4. RESULTS

4.1 Regional land use level

Impact of current practices on land

An important output of the satellite image interpretation is the table presented in the legend of the land use map of Acailandia-Buriticupu region (map 6).
The land use unit called Complex of Selective Logging and Secondary Forest seems to be the predominant land use of the region, occupying the largest area among the units, estimated in 1.469.114 ha, equivalent to 41,8 % of the whole area of the satellite image.
This may indicate how uncontrolled forest exploitation is practiced at the region, specially if we add to this figure more 33.1 % of the area (1.149.927 ha) today used by cattle ranches which were also cover by forest, as well as an unknown area within the Biologic Reserve limits which is also exploited by logging companies as testified by us during the field work.

The map also shows cattle ranches as a second predominant land use in the region occupying 33,1 % of the total area of the satellite image.
The option for this kind of land use was adopted by large land owners and speculators, especially because of the economical attractiveness on short term, the benefits of fiscal incentives and subsidized credits and finally because planting pasture is the most common method used by grileiros (land grabbers) to obtain the rights of ownership of any deforested piece of land.

Cattle ranging leads to land degradation in 10 or 20 years, depending on the efforts of the land owner in combatting invading weeds and secondary forest vegetation (Fearnside, 1989).

Nowadays, the government suppressed most of the subsidized credits and fiscal incentives for cattle ranging. The solution farmers found to finance the maintenance of old pastures (replanting and fertilizing) is to rent forest areas to logging companies. Four ha of forest are needed to maintain 1 ha of pasture (Cerri,1989).

An other important practice is cleaning pasture by chopping down the bush, burning and fertilizing, which can give pastures a new, albeit short, lease on life, although the economics of maintaining pasture versus clearing new ones works against managing existing cleared land (Serrao, in press).
At the moment, 80% of these pastures are degraded and/or abandoned (Cerri, 1989) characterizing the ill-considered land use policy.
Main causes of pasture degradation as pointed out by Fearnside (1989) are the loss of soil fertility through erosion and leaching and the fixation of phosphorus in forms not available to plants.
Serrao (1989) calculated that if 25% of the existing pastures were properly managed, 75 % could be allocated to other land uses with the same meat production.

On the other hand, foresters from EMBRAPA (Brazilian Institute for Agricultural Research) state that if the equivalent area now occupied by cattle (10 million ha or 3% of the Amazon Forest) were exploited for timber in a polycyclic sustained managed way (30 years), it would be enough to supply the Brazilian needs for wood production.
The above data translates, at least, the enormous contradiction of the government policy for the development of the Amazon region. If 75% of the forest areas (today occupied by cattle) were saved and put under management, both problems could be solved: the production of meat (with the efficient use of 25% of the grazing land) and the wood production.
Now the situation is really disastrous, taking into account that selective logging also promotes forest land degradation in this region. The percentage of gaps found in the canopy after selective logging was 50% or more, compared with 10 to 20% normally found in Amazon forest (Uhl and Vieira,1989). An other strong indication of the extent of forest degradation by selective logging, are the number of the sawmill operating in the study region (321 according CDN survey,1987) and the area affected by logging.

Some consequences of this disastrous policy are:

A. Land ownership problems;

B. Large amount of abandoned and degraded grazing areas, sometimes in an irreversible process of erosion, estimated in 920.000 ha (see map 6);

C. Large degraded forest areas due to the selective logging activities in stead of sustainable forest management, estimated in 1.470.000 ha (see map 6);

D. Thousands of landless families living on strips of land, between the road and fences of abandoned pastures or invading large farms (e.g. Presa de porco village, see map 6) ;

E. Invasion of protected areas by posseiros , cattle farmers and logging companies, looking for timber and forest soils where fertility is still present (e.g. Gurupi Biological Reserve which lost at least 15.000 ha of forest cover, see map 6);

F. Invasion of Indian Reserves by peasants and cattle farmers while no measures against this are taken by authorities (e.g. Caru Indian Reserve which lost at least 9.000 ha of forest cover).
Indians stand alone, despite an agreement between CVRD/FUNAI in which US$ 13,6 million were allocated by CVRD, and supposed to be spent by FUNAI in a "Supporting Project" lasting 5 years (1982-1986). Almost nothing was done in relation to the protection of the Indian Reserves. Only 0,06% of the original budget was intended to land demarcation which by pressure of anthropologists was reversed to 10%, which was still insufficient. The remaining 90% was spent by FUNAI on infrastructure, equipment and maintenance of infrastructure.(Ferraz and Castro,1987)

4.2 Land owner level: attitudes towards land use

4.2.1. Large Farm owners

Some farmers are trying to protect their forest reserves, by buying timber from other areas instead of cutting their own. Typical examples are Fazenda Cacique and also Fazenda of Rosa Madeireira Ltda , a farm owned by Mr. Jorge Rosa with the largest sawmill of the Paragominas region. He has 30.000 ha of forest reserves but prefers not to exploit these at the moment.
Timber entrepreneurs also state:" We know forest management could be an interesting option, but it is cheaper, right now, to rent 1 ha of forest for logging (between US$ 50 and US$250 which is cheaper than one cubic meter of Tabebuia) than to manage our own forest.
Forest management for most of them means clear cutting or selective logging and after this the area is left to natural regeneration.
However most of the larger farm owners prefer to promote clear cut in their forest areas , then plant pastures just because they are afraid of invasions by posseiros which prefer always to get in forest areas rather than pastures.

4.2.2. Posseiros (squatters)

Squatters are landless people who came from Maranhao or from other states of the North-east region.
Many of them were driven away from their own possession because they lack land titles, despite the fact of living there in some cases, for more than 20 years.
The importance posseiros see in forest lies in the supply of "fertile soils" and wood for fuel and construction. Others see it as a source of cash by selling trees in periods of need.

Because it is easy to invade new areas, some posseiros exploit the forest and sometimes plant crops or grass during one or two seasons, then sell the land to large farmers or speculators. But we may not say that it is a common behaviour, most posseiros invade land as a survival necessity.

They use to plant under the shifting cultivation system if they have enough land. Normally they divide the invaded area in lots of 50 ha for each family what is according to them enough to promote shifting cultivation.
They may have their own strategies to manage forest resources but this was not identified in this research.

Their main problem is to get from the government land agencies (INCRA AND ITERMA) the certainty of the land ownership, through the agrarian reform implementation. If not, they will be driven away again, and would invade new areas, causing more deforestation.

There is some evidence that logging companies support posseiros in the process of forest land invasion, under the condition that posseiros sell logs to them .

4.2.3 Settlers of the Buriticupu Colonization Scheme

Most settlers have about the same behaviour as posseiros in respect to the forest resources.
They look at the forest as a source of 'fertile soils' and wood for fuel and construction, moreover they have the disadvantage of the smaller lots (25 ha) than the posseiros (50 ha).
Since 1972 they cut their forest, and many of them did clear cut the entire lot already in the first years, in order to sell logs.
In the conception of the project the introduction of agroforestry was foreseen, but this was not the track followed by the settlers. In the deforested areas just subsistence agriculture was done in 1 or 2 ha of annual crops, due to the lack of extension support (Miranda,1988).
Because of the small size of the lot (25 ha) and the slope characteristics of the terrain they did not have that much area to cultivate under the usual shifting cultivation system.
Therefore they have to return to the same site after a short period of time, leading in general to decreased nutrient availability as well as soil degradation and erosion (Schubart,1985).
Very few settlers have plantations of permanent crops, such as pepper, cocoa, orange, rubber.
The Extension Service (Emater) attend only 78 settlers, with a total area of 107 ha (Miranda,1988) which represent 3.9% of the settlers and 0.2 % of the total area.

4.2.4. Indians

The Guajajaras - Arariboia Reserve

According to the Guajajara chief, J.Sapural , forest is an essential element of their culture and subsistence. They intend to keep the area under the original vegetation cover , but they have difficulties in controlling the whole area from invasions.
Guajajara indians live nowadays from:

* Agriculture - manioc, maize, beans.
* Hunting and gathering forest fruits
* Fishing - they have a lake with 18 km length
* Selling crafts - made of palm fibers (Babassu, Buriti, Guarima)
* Collecting and selling leaves of a forest shrub called jaborandi (Pilocarpus microphyllus) to the pharmaceutical industry.
* Selling water to neighboring farmers.

The Guajajara indians have a religion with many divine beings. Among them is the creator of the world , Maira, a cultural hero to whom they attribute the creation of man, agriculture, the forest and the cosmos.
The forest and the waters have divine owners, those who take care of them and may cause illness for those which destroy them (Barros and Zannoni,1988).
Guajajaras have two important festivities:

* Moqueado party - in the beginning of the rainy season
* Honey party - to grant the abundance of hunting

During the First General Assembly of the Guajajara Nation (October,1986) representing six communities, 100 leaders expressed their opinion in respect to the Program Grande Carajas: "This Program leads us to pernicious consequences within the group, such as divisions, rivalries, mutual suspicion and weakening of the authority of the chiefs" (Treece,1987).

The Guajas - Caru Reserve

According Balee (1988) the Guaja group is one of the last foraging (non-horticultural) people of South-America, and some of them are not yet contacted by non-indians.
They depend on Babassu palms in their subsistence, traditionally foraged in bands of 5 to 15 people across primary forest of trees of families Lecytidaceae, Burseraceae, Sapotaceae and Leguminosae. Never felling and burning forest for horticulture,the Guaja always made camp only in enclaves of Babassu palm forest.

They obtain much of their dietary protein from the kernel and many of their calories from mesocarp of Babassu nuts, and supplement this diet by hunting, fishing and gathering. (Balee,1988).
Especially to this tribe, forest resources are of fundamental importance since they have no agricultural habits, but in contrast are dependent on minor forest products, with a nomadic way of life, which is used as a survival strategy.
The Guaja group has no demarcated area (nowadays they share with Guajajaras the Caru Reserve) although the interministry decree no. 76 (1988) prescribed that 147.000 ha should be demarcated to them. Economic groups are pressing the government to postpone the demarcation of the area while they encroach it.

4.3 On Site Level

Forest structure

The original propose for establishing the experimental plots used in CVRD's research, was to derive a method for harvesting wood for charcoal and timber in a ten years cycle. Harvesting intensity was fully determined by the minimum felling diameter. No attention had been paid to the remaining forest structure after logging, as well as the process of new eco-units formation. Logging treatments and silvicultural treatments were implemented at the same time, which probably lead to an unsuitable structural ensemble. Forest components and their stratification were also not properly considered.

Treatment 1 - (Control - Zero treatment)

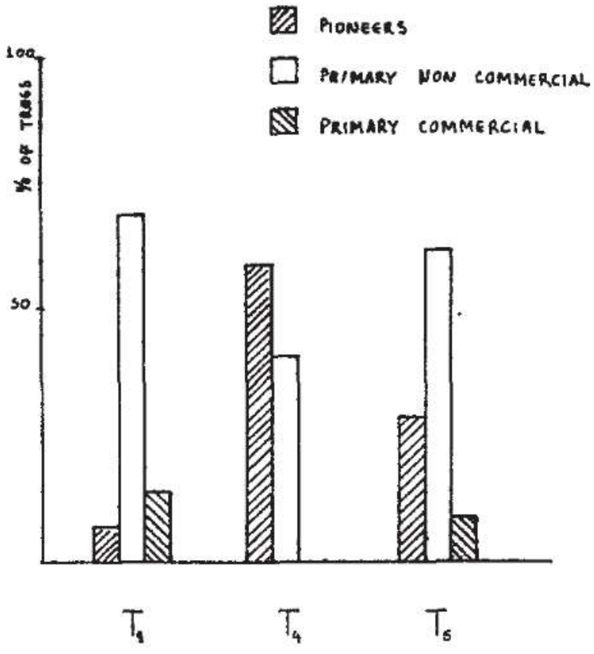
Figure 8, transect and profile diagram of T1, as well as figures 4, show the expected relation between type of trees, in a no treated forest. Only few pioneers are present (7%), while primary commercial as well as primary non commercial species occurs much more. See table 1.
In respect to architecture criteria, again T1 shows a expected relation of tree categories, considering a natural forest,in which there are 52% of trees of future, 34% of trees of present and 14% of trees of past. See figure 5.
The Control treatment can also be analyzed in the figure 11 (Eco-units formation). Note that most of area of the transect is dominated by Biostatic eco-units type (67%).

Treatment T4 - (Heavy treatment)

Figure 9 shows the transect and profile diagram of T4, which present a clearly strong structural changes.
When compared with treatment T1 (no treatment), pioneer trees (Cecropia sp) and lianes had increased in number, much more than expected. This occurred as a consequence of the lack of observation on the eco-units dynamic processes, specially size of gaps left after logging.
Figure 11 shows that most of area of the transect is dominated by eco-units in the aggrading gap phase (52%),, as a result of the heavy treatment.
The tendency of these eco-units in aggrading tree phase is to develop three more phases, that is, aggrading tree, biostatic and a degrading phase, which will take at least twenty more years. Only after this phases have been completed can the primary tree species start to take over the pioneer species by fragmenting the degrading phase. Probably will need fifty more years to reach again the biostatic phase of the primary species.

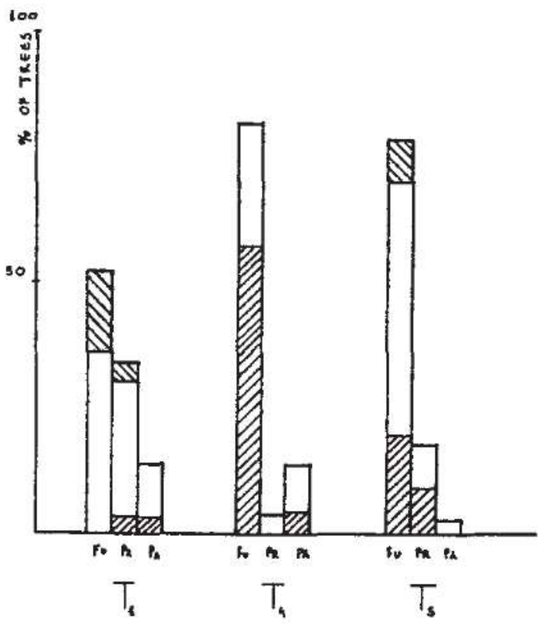
Figure 4, based on the ecological and commercial criteria, show T4 with a clear dominance of the pioneers species (59%) over the primary non commercial species (41%), which use to be the dominant type of tree, and no primary commercial species at all (0%) characterising a low potential for charcoal and any potential for timber to the next harvesting (within 4 years).
So, summed up the treatment T4 may not be a 10 years cycle, but probably a 70 years cycle.

FIGURE 4



T1 → CONTROL . ZERO TREATMENT
T4 → CUT ALL TREES > 45 cm DBH AND LIANES
T5 → CUT ALL TREES < 10 cm AND > 60 cm DBH AND IN THE RESIDUAL STAND CUT ALL MALFORMED STANDING DEAD AND NON COMMERCIAL TREES

FIGURE 5



FU = TREE OF FUTURE

PR = TREE OF PRESENT

PA = TREE OF PAST

Table 1 - Forest Structure.
Analyses of forest components > 10 cm DBH Table Percentage of tree type under the three treatments.

Ecological associated with commercial criteria.

Type of tree	T 1	T 4	T 5
Pioneers	7%	59%	29%
Primary commercial	14%	0	9%
Primary non comm.	79%	41%	62%
Total	100%	100%	100%

Treatment 1 (zero treatment) shows forest with its reasonable distribution of tree type, where pioneers occurs with small values and primary species with high values.

Treatment 4 shows how strong has been the exploitation intensity when we look at the higher values of the pioneer species and at the lower values of primary species in relation to the values of T1 as well as T5.

Treatment 5 shows a more acceptable values for both type of trees due to the more soft exploitation.

The graph of fig. 5 also compares the three treatments in terms of tree architecture (combined with ecological and commercial criteria), and their participation in the transect.
In T4, there were 82% of trees of future, from which 71% are pioneer species, 29% are of non-commercial species and there are no commercial trees. Nowadays, 6 years after felling, when we look at table 2, the categories tree of present (4%) and tree of past (14%) and their respective composition (table 4), we may conclude that there will be a very low biomass available for charcoal production in the stipulated time (ten years) out the category of non-commercial trees, and nothing to be harvested for timber from primary commercial species.

Treatment T5 (moderated treatment)

The intervention intensity in this plot was not so strong as in T4, here only trees with DBH ` than 10 cm and " 60 cm were felling.
Comparison of transect and profile diagrams between treatments 1, 4 and 5 (figures 8, 9 and 10), shows the moderated treatment T5 as a stand of a reasonable structural ensemble, with less pioneers than T4, whereas lianes occurs in the same intensity as in T4.
The graph of figure 4 shows that T5 has a better potential on primary commercial species (9%)than T4 (0%), as well as much less pioneers (29%) and a reasonable potential for charcoal (62% of primary non commercial species).

In respect to tree architecture, comparison of treatments on figure 5 shows:
* 79% of trees of future from which 63% are non-commercial species, which indicates also a greater availability of biomass for charcoal production than in T4, and still some potential for timber, with 11% of primary commercial species. In respect to pioneers trees of the future, it occurs much less (26%) than in the heavy treatment T4 (71%), which may indicates a better logging intensity option.

* 18% of trees of present from which 50% are pioneers and 50% non-commercial which gives an indication that some biomass will be available for charcoal production to the next harvesting, when non-commercial species would be already in a mature phase, although there will be no primary commercial species for timber.

When compared with T4, there are less gaps in T5, which gives a better balance between the eco-units by avoiding large aggrading gaps composed mainly of pioneers and lianes.
Figure 11 shows that most of area of the T5 transect is dominated by eco-units in aggrading tree phase (52%), which confirm the superiority of T5 over T4 treatment.

This structural ensemble leads to a better natural regeneration condition for desirable species than in T4. Such conditions are:
- less changes in microclimate;
- less changes in soil temperature;
- less changes in soil moisture changed less than in T4.
- light intensity is also better controlled which leads to less pioneers.

Table 2 - Percentage of categories of trees considering their life phases. Architecture criteria.

	T 1	T 4	T 5
Tree of future	52%	82%	79%
Tree of present	34%	4%	18%
Tree of past	14%	14%	3%
Total	100%	100%	100%

Treatment 1 (zero treatment) shows the natural forest stand .

Treatment 4 shows that 6 years after exploitation we find a very low potentiality for exploitation within 4 years like it was expected in the experimental design. 4% of trees of present, composed of non commercial species and 14% of trees of past in which 67% are pioneers species what can not be use neither for charcoal nor for timber production.

Treatment 5 shows a better distribution between the categories, where tree of future (79%) are composed of 11% of primary commercial trees and 63% of primary non commercial, which is a reasonable potential for further exploitations , but not to the next one. For the next exploitation (4 years time) trees of present and of past have higher values than treatment 4
but still the biomass available for charcoal is not high.

Table 3 - Treatment 1. Type of trees within each tree category.

type cat.	Pioneers	Prim.Comm.	Prim.non Comm.
Future	0%	29%	71%
Present	10%	10%	80%
Past	25%	0%	75%

Table 4 - Treatment 4. Type of trees within each tree category.

type cat.	Pioneers	Prim.Comm.	Prim.non Comm.
Future	71%	0%	29%
Present	0%	0%	100%
Past	33%	0%	67%

Table 5 - Treatment 5. Type of trees within each tree category.

type cat.	Pioneers	Prim.Comm.	Prim.non Comm.
Future	26%	63%	11%
Present	50%	50%	0%
Past	0%	100%	0%

Note: this tables should be readed together with figure 5.

Natural regeneration

Manipulation of natural regeneration in this forest type (Evergreen Mesophil Forest, open forest with lianes), should be very carefully conducted specially because of the local environment conditions.
The Buriticupu region is a transition zone between the tropical amazon forest and the semi-arid north-east region of Brazil, with a very peculiar climate:

* average temperature 26'C.
* mean rainfall 1500 mm/year
* mean water deficit 250 mm/year
* dry period 5 to 6 months

Under such circumstances strong interventions in the forest structure will affect natural regeneration more than in areas with a true rain forest climate. This because changes in microclimate at soil level and soil moisture will be stronger.

A. Water stress has a strong effect on germination and seedlings. Synnott (1973) states that drought caused *Entandrophragma utile* seedlings aged 10-14 months to wilt, some failed to recover and died. Many tropical trees (e.g. *Cedrela odorata*, *Mansonia altissima*) have plenty seedlings during the wet part of the year or after a heavy seed fall, but in the dry period of the year most seedlings die. This appears to be the case of the Buriticupu plots where we can see in T1 (zero treatment) a large amount of seedlings in the first class and a small amount in the second class (sapling).
See figure 7a and 7b.

B. Nutrient stress : rainfall also bring nutrients to the ecosystem (Richards,1973a) so that at the Buriticupu plot the water deficit probably leads to less fertile soils.
Other aspect which may have affected the natural regeneration was the strong change in the nutrient status. According to de Graaf (1986), the only way to maintain the nutrient store in the original ecosystem seems to be to maintain a large biomass, which slowly releases and recycles its nutrients and which has a high filtering activity. This is the concept of biomass-dependent site quality, which did not occur in Buriticupu plots because of the high amount of biomass exploited for charcoal.

C. Mortality : survival probability is higher at germination if adequate soil moisture is available and temperature equable (Whitmore, 1975; Richards, 1979).
Liew and Wang (1973) state that natural regeneration depends to a great extent on whether enough seedlings survive until the time the forester wants to operate.
Unfavorable soil properties may result in a marked deficiency of commercial species in the canopy. Areas with adverse physical conditions seem to impede the development of a sound commercial stand (Jonkers, 1987).
A general tendency seems to be that sandy soils favour natural regeneration more than heavier clay soils (Ayliffe, 1952).
In the Buriticupu plots heavy clay soils are predominant, which lead to unfavorable conditions to natural regeneration of

commercial species.
An other important aspect is that higher temperatures combined with low soil moisture can be cause wilting or death by scorch (Fox, 1972). This situation normally occurs in too open canopies after interventions, which is also the case of Buriticupu plots.

Light intensity also seems to play a important role in natural regeneration processes. After interventions, gaps are created and the larger the gap the more light reaches the undergrowth and ground and the more intense will be the competition between pioneers and primary species. The ability to survive lengthy periods while making negligible growth and then to respond rapidly to improved growing conditions is a major silvicultural characteristic of the most desirable rain forest trees but it is also found in many lianes spp (Neil, 1981).
Fortunately, light is a controllable factor which can be managed by foresters by regulating the intensity of intervention.

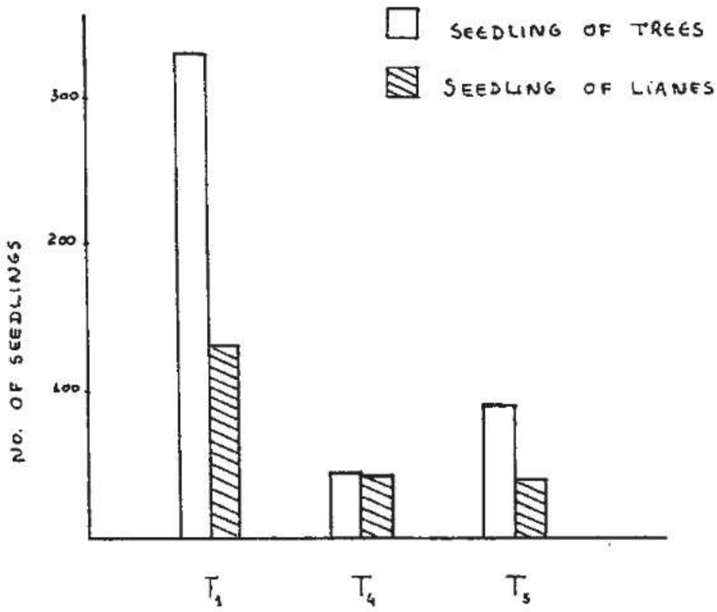


Figure 6 shows effect of each treatment on natural regeneration, considering seedlings of trees and seedlings of lianes, six years after exploitation.

Figure 7a. Figure 7b.

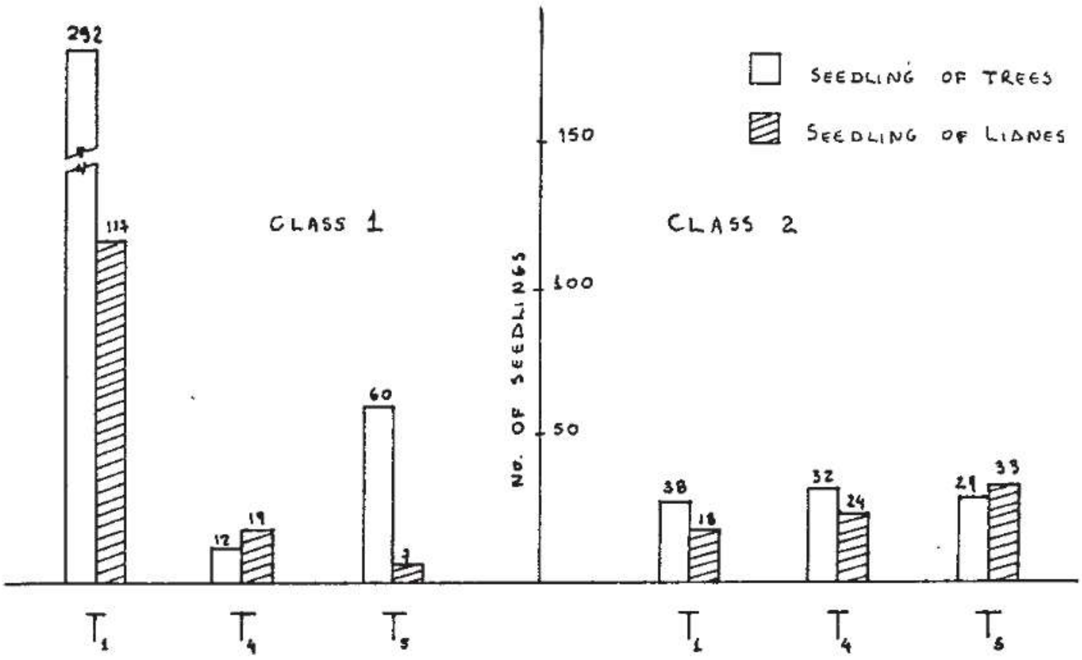


Figure 7a and 7b show effects of treatments on natural regeneration split up in two classes :
class 1 - recently established seedlings ` 30 cm height;
class 2 - large established seedlings " 30 cm height,
but ` 2.5 cm DBH.

In relation to the Buriticupu plots the following observations may be mentioned:

There was a obvious shortage of commercial seedlings and saplings in the treated plots (see fig.7a and 7b), because all seed trees had been felled during exploitation. The treatments would have been more successful if at least some vigorous mature trees of commercial species had been left. The same could be done for those trees ` than 10 cm DBH in the treatment T5, which were the sapling and the poles stock of the stand, but have been felled during the exploitation.

Treatment T1 - Control or Zero treatment.
Figures 6 and 7, and tables 6 and 7, show the behaviour of natural regeneration in untreated plot, where tree seedlings appear always with values at least two times bigger than lianes seedlings. Reasons for that are mention by Caballe (1986) which state that lianes invasion in forest occurs only if forest present marked dynamic instability, such as a low structural organization degree. Other reason is the low light intensity in the understorey when compared with treated plots.

Treatment T4 - Heavy treatment.
One of the most important aspect in natural regeneration was not properly considered in this treatment: the likelihood of weed growth, invasion by pioneers and increased luxuriance of climbers.

The invasion by lianes and pioneers in T4 was really very intense due to the large gaps formed by exploitation.
Nowadays many advanced saplings, poles and small trees of pioneers species are still found, although not always recorded in the natural regeneration counting, neither in the profiles because many of them have DBH between 2.5 cm and 10 cm, range not cover by this study (see par. 3.3).
In respect to lianes regeneration, even today (six years after exploitation), it seems to play a important role in spaces occupation. Figure 6 shows that number of liane seedlings have about the same value of tree seedlings, characterising a strong competition between seedlings type. However the liane growth strategy, also called by Caballe (1986) as opportunist strategy, is much more efficient than tree growth strategy, which takes more time to occupy spaces. It means that tree seedlings will be dominated by a blanket formed by lianes, causing the retarding of further development of tree seedlings by years, or even will render the soil unfit for seed germination (Oldeman,1986 and Kahn, 1982).
Looking at the fig. 9 (profile diagram of the heavy treatment 4), we see the large amount of biomass created by the blanket of lianes, probably formed after the forest exploitation.
Other consequence of the heavy treatment was the decrease in regeneration rates compared with T1 zero treatment (see fig.6). In T4 both types of seedlings presented smaller values than in T1, most probably due to decrease in soil moisture content, still as a consequence of large gap formations.

When we split up the seedling counting in two classes (see fig. 7 - T4), lianes occurs more than tree seedlings in class 1 but in class 2 tree seedlings present the biggest value, which appears to be a interesting unexpected result.
This regeneration class, mostly belongs to the previous situation, when forest structure were recently modified, and number of liane seedlings were supposed to be bigger than number of tree seedlings.
One plausible explanation for this unexpected result, is that in these study the sub-samples in which natural regeneration were recorded, were plotted in a systematic way, with equal distance between them, without considering possible differences in sub-sample sites, like the existence of gaps or residual forest at the sub-sample spot.

Treatment 5 - Moderated treatment.
In this treatment the appearance of the advanced saplings, poles and small trees of pioneers were much less than those in the T4. In respect to lianes regeneration, it appears to be better controlled with this kind of treatment, although at moment just after the exploitation the existing lianes had occupied the new spaces created. Figure 6 and table 6 show tree seedlings with values more than two times bigger than liane seedlings, which maintain the same proportion of T1. This seems to be a very good relation as well as a very good result, although the number of seedlings are rather smaller compared with T1.
When we split up the counting in two class (see fig.7 and table 7), class 1, the recently established seedlings, shows a quite good relation for tree seedling/ liane seedling, due the better structural ensemble of T5 when compared with T4, but also because

this recently established seedlings belongs to the actual structure situation, already a bit recomposed from the forest exploitation interference.
Class 2, large established seedlings, shows about the same values for trees and lianes seedlings, which may indicate that they were consequence of the previous structural ensemble, say 2 or 3 years after exploitation, when the effect of treatment were still marked.

Table 6 - Percentage of tree and liane seedlings under the three treatments.

	trees	lianes	total
treatment 1	71%	29%	100%
treatment 4	51%	49%	100%
treatment 5	69%	31%	100%

Treatment 1 shows the zero treatment with tree seedlings presenting a value more than two times bigger than lianes seedlings.

Treatment 4 shows about the same % for trees and lianes seedlings what indicate dominance of lianes because of its efficient growth strategy.

Treatment 5 shows % of tree seedlings with a value about 2 times bigger than lianes seedlings which maintain the same proportionality found in T1.

Table 7 - No.and type of seedlings under the three treatments
Class 1 - seedlings = or < 30 cm
Class 2 - seedlings > 30 cm, but < 2,5 DBH

	class 1		class 2		total	
	trees	lianes	trees	lianes	trees	lianes
treatment 1	292	117	38	18	330	135
treatment 4	12	19	32	24	44	43
treatment 5	60	7	29	33	89	40

Treatment 1 (zero treatment) shows a well defined difference between type of seedlings in both class. Although class 2 present smaller values than class 1 (caused by death in the competition process), tree seedlings still keep the dominance over liane seedlings .

Treatment 4 shows liane seedlings dominating tree seedlings in the class 1, but in class 2 an unexpected opposite situation occurs.

Treatment 5 shows tree seedlings already dominating liane seedlings in class 1, but for class 2 about the same values occur, may be due to the preliminary effects of forest exploitation, or even to possible differences in site conditions.

5. DISCUSSION AND CONCLUSION

5.1. Regional land use

Considering the results of the land-use map, the predominant land use types of the study area are:

A. Cattle Ranches are showing the highest degree of degradation, mainly caused by changes in vegetation cover with use of fire, from forest to degraded grazing areas, in general with a high C-factor.
Degradation of the vegetation cover will affect its protecting and regulating functions and may trigger various processes of soil and land degradation (Boerboom,1990).
This is the case in most pasture land in the study area .
This land use type should be restricted to the existing areas, and even so, the 80 % already degraded areas should be transformed in well managed pastures or if the owner fail to do so, it should be transformed to a sustainable land-use type such as agro-forestry for small farmers.
The actual tendency is to plant Eucalyptus for charcoal production which will neither solve the ecological problems nor the social conflicts,and on the contrary, will degrade land even more and maintain the actual land ownership policy, which is characterized by very large farms owned by few people (Shiva, w/o date).

B. Selective Logging is a land use type which leads to a vegetation dominated by secondary forest species (with poor biological diversity) depending on the degree of exploitation and on the ability of loggers to avoid forest damage.
Most of the logging companies have no trained workers who would be able to exploit forest with low damage to the residual stand. Uhl and Vieira (1989) show that, in a study carried out in Paragominas region (north of the study area), although only less than 2 % of the trees were harvested , 26 % of the trees were killed or damaged.It means that 16% of the basal area was harvested , with an additional 28% of the stand basal area destroyed or damaged.
The main consequences are:
- a strong change in forest structure, which leads to lianes and pioneer species invasion of the artificial gaps and decreasing ability of the forest to regenerate to the original stand.
- selectively logged forest became susceptible to fire because of increased fuel loads and by promoting microclimate changes to more dry conditions. (Uhl and Vieira,1989).

This land-use type should receive more attention from the government, because of its economic and ecologic influence in the region.
There is a strong timber industry working specially in Acailandia, which appears to be one of the most active in Brazil. The study of the PGC (Planning of the Carajas Railway Corridor,1988) state that 321 saw-mills are working in the study area ,offering 10.000 jobs, with a consumption of 984.600 m3 of logs for timber and 111.540 m3 of logs for veneer production. This makes clear how economically important the forestry industry is to the region.

However when we look at the legend of map 6 we may realise that, although 41.8 % of the area are under forest exploitation, only 0,2 % of it is occupied by forest plantation and none area under sustainable forest management.

This also shows the importance of the 3 levels research, when forest management systems (exploitation systems + natural regeneration systems) appear to be a feasible solution to the sustainability of the timber industry, but is not practiced at all.
If forest resources were managed with sustainable yields, these industries could have a long term production plan, without the actual need to move to other areas, where more forest and land degradation will take place.

According to the satellite image interpretation, there are still some areas in the study area where forest management systems could be applied (estimated in about 50.000 ha), but not enough to supply the existing industries for long time. Especially the areas in the surrounding of the Gurupi Biologic Reserve where the hygrophile forest type of the Gurupi river is present, may be suitable, but more detailed survey would be needed to define the appropriated site.
Logging companies should be persuaded and taught, with extension programmes, to apply rational methods in exploitation activities, associated with natural regeneration silvicultural systems. Otherwise this degradation process will be repeated in the whole Amazonian region.

Positive results on forest management systems are available from experimental plots in Surinam (CELOS Management System) and Tapajos (EMBRAPA), as well as the preliminary results from INPA and CVRD.

Forest Institute (IBAMA) should be more efficient in controlling and monitoring logging activities, and implement forest management systems, where new laws and rules would be needed because the present legislation is too general in respect to forest management.

C. Protect Areas are the others land use types present on a representative scale (01 Biologic Reserve and 02 Indians Reserve). Their situation is very much vulnerable by the fact that cattle farmers need more land to plant more pastures with low input in forestry soils. Landless may find it more easy to invade government land (normally without any control) than to invade lands of cattle farmers lands who regularly react with para-military groups.

Both the Biologic Reserve of Gurupi and Indian Reserves (CARU and ARARIBOIA) are a very important test to the "Programa Grande Carajas" in respect of the real concern to the ecological problems in the Amazon region.
The protection of these specific areas and especially the survival of their populations (Indians) with their deep knowledge in forest resources will be the greatest challenge for the Brazilian government.

D. Small Farmers :

Colonization scheme as well as posseiros areas, in terms of area, occupy a very small part of the study area, which may indicate how little support they receive from government authorities. When we look at the financial facilities cattle farms get, we may think that government act as if settlers and posseiros does not exist. But in reality many of them were already in this region before any cattle farm, even before the roads construction.

By right they should be allowed and supported to occupy certain zones in the PGC region by a real agrarian reform, and not only so, but they should have much more attention from government agencies, with special supporting programme for legalizing their possession as well as for specific extension campaigns aiming at the use of forest resources. Otherwise, much more conflicts will come up with the increasing rates of population pressure. More forest land will be invaded leading to more deforestation and ultimately to ecological disasters.
Companhia Vale do Rio Doce has made many efforts to support some small villages along the railway, by construction of schools, dispensaries, as well as starting a railway service for transport of passengers and farm products. But this should be the responsibility of PGC, which is the responsible for coordination, implementation and monitoring of any development activity at the region.

It is clear that this coordination is lacking. A lot of institutions are working in the region and almost any relationship between these are recorded:

* Examples of government institutions:
-INCRA and ITERMA (National and State Land Reform Institute) which were expected to promote land reform;
-IBAMA (National Environment Institute) which was supposed to take care of the forest areas and set up an adequate and specific forest policy;
-SMEMA (State Environmental Office), which has about the same tasks as IBAMA, but at state level;
-SAGRIMA - State Agricultural Office;
-EMATER - State Extension Office;
-FUNAI - National Indian Foundation;
-CVRD - Companhia Vale do Rio Doce.

* Examples of non government organizations:
-CIMI - Indigenous Missionary Council;
-CPT - Land Pastoral Commission;
- Land Workers Syndicate;
- Many village associations.

Most of the decisions are take in the capital, Brasilia, very far from local reality and without any consultation of the target groups, or even to the local institutions.

As a conclusion we may have a look in the land use map (map 6), and interpret the actual tendency of the landless people to invade to indians reserves, mainly caused by the lack of official settlement programmes.

The other clear tendency is the gradual encroachment of the Biologic Reserve by cattle ranches, which may characterize the inconsistent work done by IBAMA in combating the deforestation process.

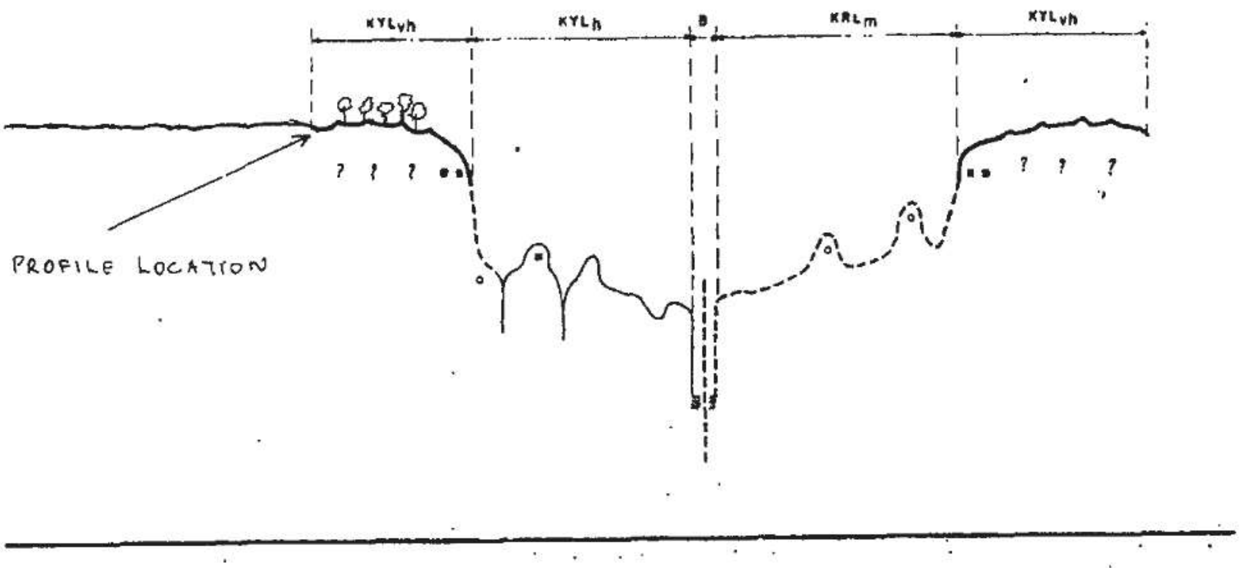
5.2. On Site Level

In spite of this analysis cover only one replication (repl. A), cause by time constraints, and the size of replication (50 * 100m) as well as the transects (20 * 60m) been small, interesting conclusions can be drawn, although more detailed studies should be done.
CVRD research appears to be in the right track with its natural regeneration experiments, although the expectation of the rotation cycle was too optimistic (10 years) and improvements of the treatments are needed. Treatment 5 seems to be the more promising because of the better forest structure when compared with T4.

The Chi-Square test proved that there is significant difference between treatments in respect to forest structure. T5 treatment shows a better structural ensemble characteristics which is more like T1 (control).
Chi-Square tests were also used to compare the distribution of pioneer, primary commercial and primary non-commercial trees within each treatment. The results were that treatment differ in distribution of tree category. And again T5 appears to be the best in respect to the crop for the next harvest with 11% of primary commercial species.
The forest really was too open after treatments, especially in T4, but also in T5. This statement is supported by the comparison among transects and its eco-units formation.(See figure 11).
If exploitation have been done paying attention to the eco-units formation, its structure would probably be better, with less lianes and less pioneers, leaving room to primary commercial and non-commercial species.
The strategy used in the experiment as stated by Thibau (1986) was to make tropical forest sustainable yield feasible by utilising its large amount of wood volume. This is not feasible especially in this forest type of evergreen mesophil forest of Pindare river (open forest with lianes) where the natural forest has low timber volume (150 m3/ha) when compared with other forest types in Amazon Region, where timber volumes may reach 271 m3/ha (Caxiuana - PARA; Sombroek,1966 and Smit,1960).
In this forest type, felling operations should not harvest in one time large amount of wood volume, but on the contrary, would have been better if more slight exploitation were tested.

Other important point mentioned by Sombroek (1962) for this specific area, is the influence of relief on the composition of the vegetation. There is a striking difference between the vegetative cover on the totally flat, central part of the plateau (case of Buriticupu replication C and D) and that on the very gentle sloping edges of the plateau (case of Buriticupu replication A and B, see fig. 3 and 12). The former bear a open forest with dense understorey with many thick creepers and vines, with relatively few big trees, often in small groups and mostly laden with climbers (cipoalic forest with climber towers). The latter bears a heavy forest, consisting of many big trees above an open understorey, almost without creepers and vines.

ITINGA LAND-UNIT



SOMBROEK, 1962

This difference in vegetation between edge and central part of plateau (land unit Itinga), according Sombroek occurs probably due to a drier microclimate in the central part of the plateau. It may be that the gentle sloping edges have a better moisture supply throughout the year than the flat central parts.
Considering that the majority of the Buriticupu Forest Reserve area is located at the central part of the plateau, improvements in silvicultural systems should take into account the above considerations about site differences.
According to this theory natural regeneration of commercial species would be less vigorous in central part of the plateau than in the very gentle sloping edges of plateau, case of the replication A analyzed by this study.
The experimental plots location at Buriticupu Reserve is other point which may influenced natural regeneration precess. Replication A, B and D were plotted very close to the boundaries of the Forest Reserve (about 100 m), after what vegetation changes are marked.This change in vegetation cover probably affected the dispersal mechanism of many commercial species, such as living agents like mammals.
The intensity and the way treatments were planned affected natural regeneration potential. Secondary species are better adapted to hot and dry conditions than primary species (Oldeman, 1983). Because of the large gaps such conditions were created in both treatments, seeds of primary species were suppressed by the vigorously growing trees of secondary species, lianes and herbs.

Although lianes are not an unstable factor, it only invade forest which present a marked unbalanced dynamic (Caballe, 1986). Number and type of seedling were compared in all treatments, using the chi-square test, which proved the domination of lianes especially in treatment 4.
The conclusion is that there are systematic differences between treatments in respect to the distribution of seedling types, which was expected but not to the extent of T4 treatment, where the amount of seedlings of lianes were very high.
In the CELOS Management System (Surinam) three silvicultural treatments are prescribed along the rotation cycle (25-30 years). In Buriticupu, silvicultural treatments could also be applied to improve the experimental design especially because of the high amount of lianes.
In respect to the definition of rotation cycle, it is to early for a meaningful conclusion.

6. RECOMMENDATIONS

- More research should be carried out in the P.G. Carajas Region considering the changes in land use pattern;

- A specific monitoring programme using remote sensing techniques should be implemented in the whole Carajas Region, as a tool for agro-ecological zonation and an environment master plan;

- Buffer zone management (research and implementation) should be considered for all Protected Areas. Special attention should be given to the environmental extension program.

- More studies about indigenous knowledge on forest resources are needed not only to reinforce their cultural value, but also in order to translate it in scientific terms, to apply in silvicultural design and transfer such knowledge to the local population especially to the posseiros and settlers who could optimize their use of forest resources.

- Agro-forestry systems should be developed for the Carajas Region having as a target group settlers, posseiros and small farmers.

- Research on forest management system should be more supported by government agencies especially at Carajas region. Improvement in both, harvesting and silvicultural systems are urgently needed not only in the Carajas region but for the whole Amazonian. Several thousands of hectares would be needed for a representative experimental/demonstration area, in which not only timber and charcoal production would be studied, but also minor forest products, especially those already exploited by the extractivismo activities like edible fruits, oils, latex, fibers and medicines (case of Jaborandi at Buriticupu reserve).

- The research on pasture land reclamation should be supported and intensified with special attention to silvo-pastoral systems in order to avoid the expansion of the present pasture areas.

- Development projects should be on a site-specific basis, where local conditions will determine the shape of the project.

- Land reform and extension programmes should be initiated to provide posseiros legal rights to land and sufficient knowledge in a sustainable way.

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Annex 1: Profile Diagrams.

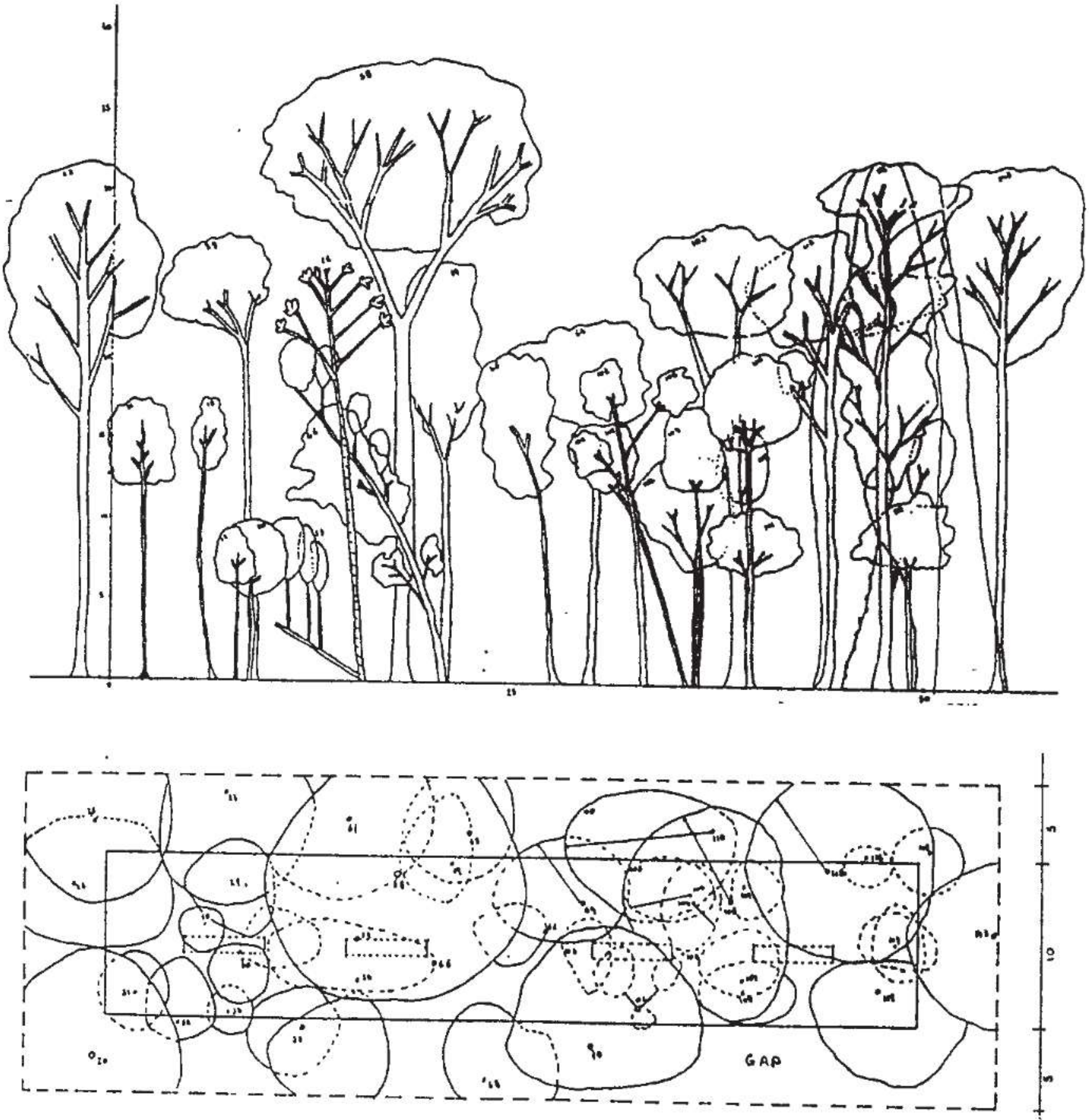


FIGURE: 8 TREATMENT 1

TRANSECT AND PROFILE DIAGRAM

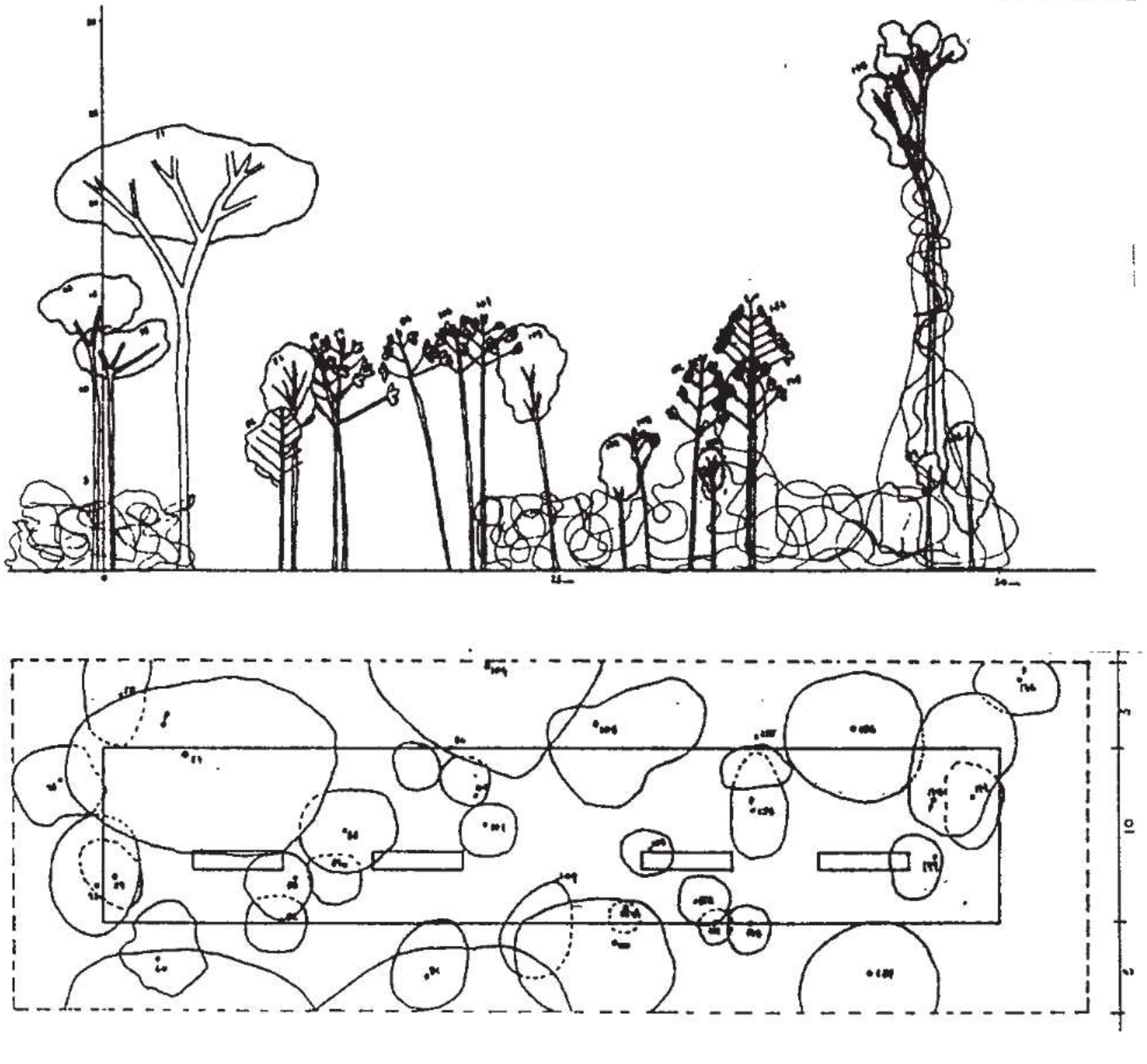


FIGURE 9: TREATMENT 4

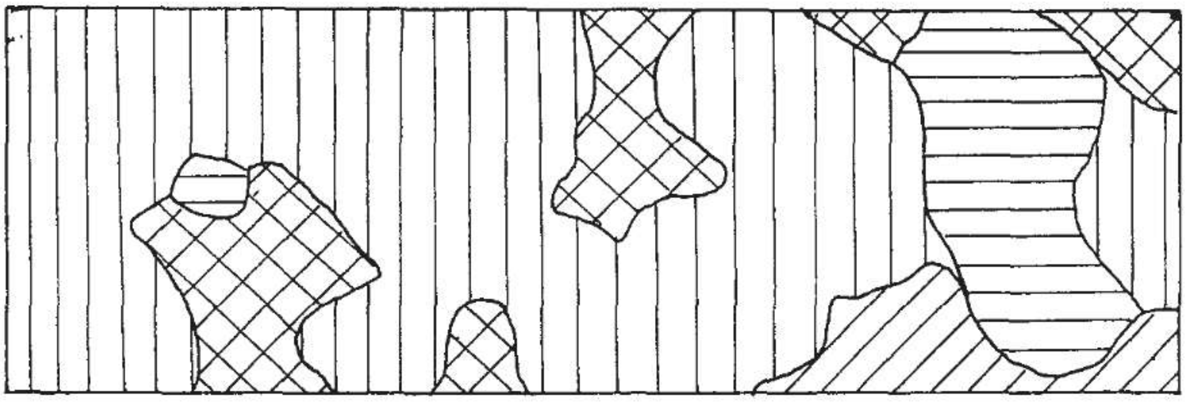
PROFILE DIAGRAM AND TRANSECT

FIGURE 11: ECO-UNITS FORMATIONS

SEE THE DIFFERENCES IN TREATMENT SHOWED BY THE ECO-UNIT FORMATION OF EACH TRANSECT. (%)

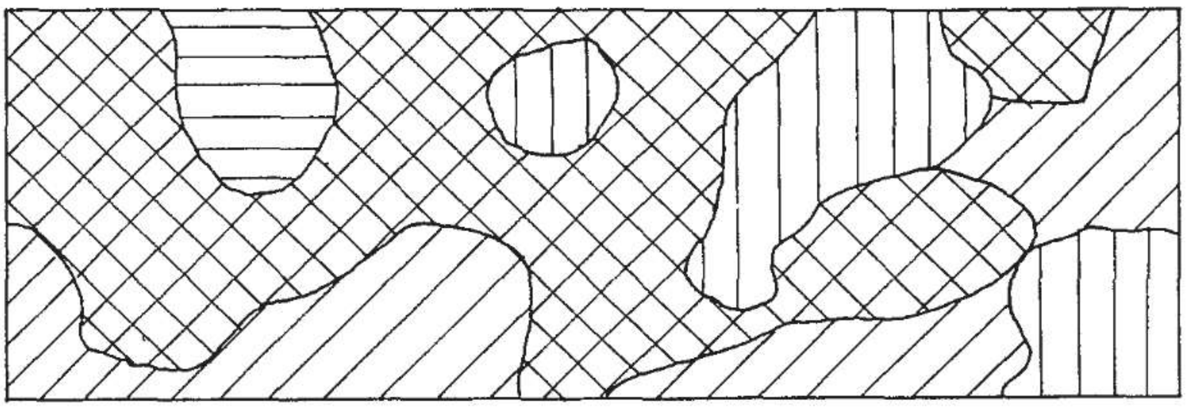
	T_1	T_4	T_5
☐ INNOVATION	0	0	0
▨ AGGRADING GAP	06	52	26
⊠ AGGRADING TREE	14	14	52
▥ BIOSTATIC	67	23	16
☰ DEGRADING	13	11	06

T_1



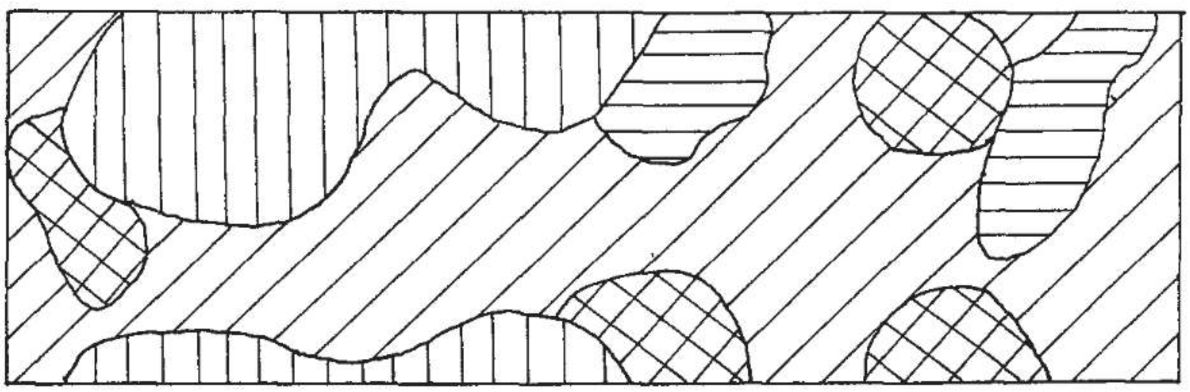
ZERO TREATMENT

T_5



MODERATED TREATMENT = CUT ALL < 10 cm AND > 60 cm DBH

T_4



HEAVY TREATMENT CUT ALL TREES > 45 cm DBH

Annex II

List of trees, found in the transects - Buriticupu Forest Reserve

Transect A1-2-02-----07

Label	Local name	dbh	Total high	1st branch	Arquitecture
23	sacopemba	42	33	16	present
25	sacopemba	45	34	18	present
31	pitonba de leite	14	17	11	future
29	pau brasil	25	26	16	future
28	mamui	31	18	08	past
30	copaiba	11	09	07	future
33	sacopemba	14	09	06	future
56	imbauba	37	27	17	present
57	cafe bravo	13	10	03	past
58	sacopemba	83	38	20	present
59	goiabarana	19	26	16	future
63	sacopemba	37	35	25	present
66	copaiba	25	16	05	future
64	sacopemba	23	20	16	future
65	pitaica	21	20	12	future
102	copaiba	15	20	12	future
106	sacopemba	22	13	07	future
104	sacopemba	16	17	17	future
105	pau santo	47	28	12	persent
107	sacopemba	15	16	11	future
103	pau branco	19	16	13	future
101	sacopemba	12	11	07	future
100	sacopemba	25	19	15	future
115	sacopemba	77	28	18	past
116	cariperana	14	17	09	future
118	sacopemba	33	28	18	present
117	cascudinho	11	07	05	future
119	sacopemba	70	31	20	past
148	sacopemba	54	32	20	present

Transect A4-1-03-----08

Label	Local name	dbh	Total high	1st branch	Arquitecture
43	sacopemba	21	15	12	future
59	abiu seco	24	12	10	future
57	sacopemba	42	24	14	present
83	papo de mutum	15	12	08	future
82	mamui	20	08	05	future
84	imbauba	12	11	08	future
85	imbauba	14	12	09	future
86	imbauba	13	13	11	future
106	imbauba	18	14	11	future
107	imbauba	15	14	10	future
109	tambuca	18	12	08	future
105	sacopemba	35	32	12	past
108	mamui	16	08	06	future
154	mamui	10	07	04	future
152	imbauba	14	14	11	future
151	mamui	15	06	05	past
148	imbauba	13	13	11	future
153	imbauba	12	15	13	future
155	imbauba	19	15	13	future
156	caneleira	26	23	10	future
178	umiri	40	30	18	past
177	cafe bravo	15	08	02	past
179	envira taia	10	06	05	past

Transect A5-1-02-----07

Label	Local name	dbh	total high	1st branch	Arquitecture
223	caneleiro	29	15	12	future
224	jatoba de fava	21	17	14	future
225	cafe bravo	16	10	05	present
226	espeturana	19	12	06	present
227	caneleiro	54	21	15	past
228	abiu seco	21	14	07	future
230	abiu branco	21	14	11	future
231	abiu seco	25	18	12	future
206	mamui	14	06	05	future
204	amesca	23	22	18	future
182	mamui	12	08	06	future
181	abiu seco	28	17	09	future
180	mamui	12	08	07	future
176	mamui	15	08	06	future
183	cafe bravo	24	10	06	present
179	amesca	19	18	05	future
178	pau brasil	21	18	15	future
177	mamui	17	12	06	present
174	pau roxo	24	15	10	future
175	abiu seco	11	11	07	future
145	pau brasil	13	18	16	future
146	mamui	17	13	10	present
147	envira taia	12	09	08	future
154	espeturana	19	19	16	present
155	abiu seco	12	13	10	future
149	murici da mata	25	18	14	present
148	espeturana	29	20	16	present
153	envira taia	13	13	10	future
150	jacaranda	31	21	17	future
151	abiu seco	32	19	07	future
125	mamui	19	16	13	present
128	imbauba	13	18	16	future
126	imbauba	18	19	17	future
127	imbauba	18	19	16	future

ANNEX III

Number of seedlings per Sub-Sample per Treatment
e.g.:Replication A , Treatment 1 , Sub-sample 1 = A11

A11

Local name	Classe 1	Classe 2
TREE spp		
Sacopemba	9	1
Cafezinho	2	-
Canela de velha	1	-
Gema de ovo	1	-
Mirindiba doce	1	-
Breu vermelho	-	1
Inga vermelho	-	1
Tachi vermelho	-	1
Sub-total	14	4
LIANES spp		
Escada de jaboti	67	1
Garaxama	1	10
Arabideia conjugata	-	1
Sub-total	68	12

A12

TREE spp		
Sacopemba	8	1
Envira	3	-
Goiabao	2	-
Cafezinho	2	-
Breu vermelho	1	-
Abiurana	-	2
Pitomba	-	5
Muiraximbe	-	1
Envira branca	-	1
Gema de ovo	-	1
Barrote	-	1
Sub-total	16	12
LIANES spp		
Escada de jaboti	53	-
Garaxama	4	2
Sub-total	57	2

A13

Local name	Classe 1	Classe 2
TREE spp		
Sacopemba	82	5
Clarizia	18	-
Envira branca	2	-
Miconia	1	-
Ingarana	1	-
Cafezinho	1	-
Envira preta	1	-
Conduru de sangue	-	2
Goiaba de anta	-	1
Goiabao	-	2
Abiu cutite	-	1
Canela de velha	-	1
Sub-total	106	12
LIANES spp		
Escada de jaboti	10	-
Garaxama	7	1
Arabideia conjugata	1	1
Sub-total	18	2

A14

TREE spp		
Sacopemba	139	2
Janita	12	-
Cafezinho	2	-
Envira branca	1	2
Inga vermelho	1	-
Abiu folha fina	1	-
Ingarana	-	3
Taruma	-	1
Abiu peludo	-	1
Goiaba de anta	-	1
Tachi vermelho	-	1
Sub-total	156	11
LIANES spp		
Escada de jaboti	28	-
Garaxama	-	1
Sub- total	28	1

A41

Local name	Classe 1	Classe 2
TREE spp		
Ingarana	2	1
Inga vermelho	1	2
Goiabarana	1	2
Janita	1	1
Tachi vermelho	-	1
Cafezinho	1	1
Pau branco	1	4
Sub-total	7	12
LIANES spp		
Escada de jaboti	7	4
Garaxama	-	2
Sub-total	7	6

A42

TREE spp		
Goiabarana	-	3
Janita	-	1
Envira branca	-	1
Sacopemba	-	1
Sub-total	0	5
LIANES spp		
Escada de jaboti	4	1
Garaxama	1	3
Inga cipo	1	-
Arabideia conjugata	-	1
Sub-total	6	5

A43

TREE spp

Inga vermelho	2	-
Ingarana	2	-
Sacopemba	1	-
Cafezinho	1	1
Marupa	1	-
Pau branco	-	5
Jatoba	-	2
Amescao	-	1
Goiabarana	-	1
Breu	-	1
Sub-total	5	11

LIANES spp

Garaxama	2	4
Escada de jaboti	1	-
Arabideia conjugata	1	-
Sub total	4	4

A44

TREE spp

Local Name	Classe 1	Classe 2
Breu branco	-	2
Ingarana	-	1
Cafe bravo	-	1
Abiu folha peluda	-	1
Sub-total	0	5

LIANES

Escada de jaboti	3	3
Garaxama	-	3
Arabideia conjugata	-	3
Sub-total	3	9

A51

TREE spp		
Abiu seco	41	-
Cariperana	1	-
Gema de ovo	-	2
Ingarana	-	1
Tachi preto	-	1
Cafezinho	-	1
Cafe bravo	-	1
Sub-total	42	6
LIANES spp		
Garaxama	-	9
Arabideia conjugata	1	-
Sub-total	1	9

A52

TREE spp	Class 1	Class 2
Abiu seco	5	4
Pau branco	1	1
Cafezinho	5	-
Envira branca	1	-
Sacopemba	1	-
Cafe bravo	-	3
Envira taia	-	2
Pitaica	-	1
Tachi preto	-	1
Imbauba	-	1
Sub-total	13	13
LIANES spp		
Garaxama	2	1
Escada de jaboti	2	3
Arabideia cojugata	-	1
Sub-total	4	5

A53

TREE spp	Classe 1	Classe 2
Envira taia	1	-
Janita	1	-
Abiu branco	-	2
Tento	-	1
Cafe bravo	-	1
Imbauba	-	1
Pente de macaco	-	1
Sub-total	2	6

LIANES spp		
Garaxama	1	6
Escada de jaboti	-	3
Arabideia conjugata	-	1
Sub-total	1	10

A54

TREE spp

Inga vermelho	1	-
Cafezinho	1	-
Tento	1	1
Pau branco	-	1
Cajussara	-	1
Imbauba	-	1
Sub-total	3	4

LIANES		
Garaxama	1	6
Arabideia conjugata	-	1
Escada de jaboti	-	2
Sub-total	1	9

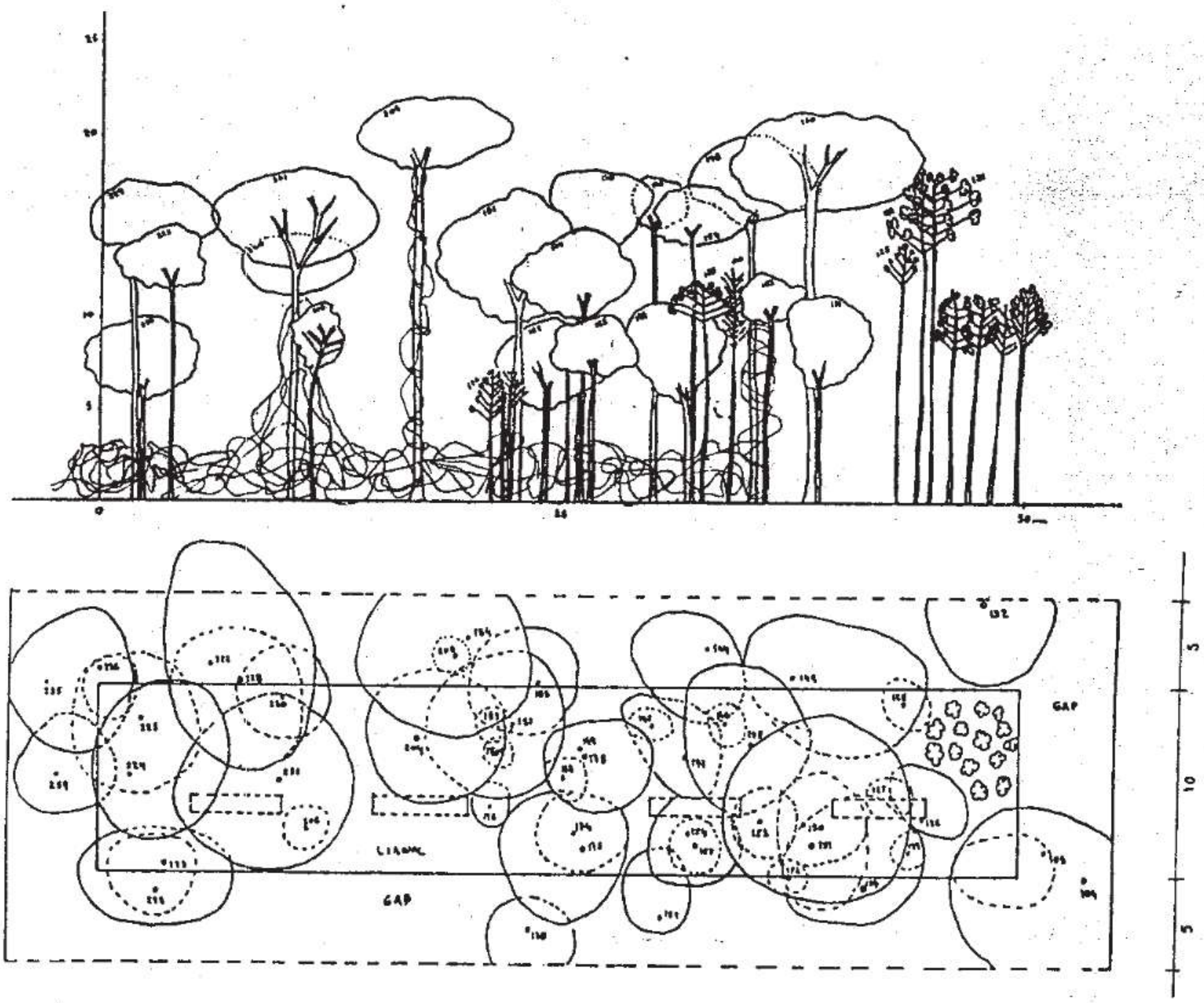
ANNEX IV

List of species - Buriticupu Reserve - Replication A

Codes: 1. small trees 2. lianas 3. big trees

Local name	Scientific name	
1. Abiu branco	Pouteria spp	3
2. Abiu cutite	Richardella macrophylla	3
3. Abiu folha fina	Micropholis venulosa	3
4. Abui peludo	Pouteria hispida	3
5. Abui seco	Pouperia laurifolia	3
6. Abiurana	Micropholis williamii	3
7. Almesclao	Protium spp	3
8. Arrabideia	Arrabideia conjugata	2
9. Barrote	Tetragastris altissima	3
10. Breu almescla	Protium decandrum	3
11. Breu vermelho	Protium Puncticulatum	3
12. Cafe bravo	Metrodora flavida	1
13. Cajussara	? ? ?	
14. Conduru de sangue	Mirocarpus frondosus	3
15. Canela de velha	Rinorea neglecta	1
16. Caneleiro	Cenostinga tocantinum	3
17. Cariperana	Licania micrantha	3
18. Cascudinho	Coupia spp	3
19. Clarizia	Clarizia ilicifolia	1
20. Copaiba	Copaifera nitida	3
21. Envira branca	Xilopia nitida	3
22. Envira preta	Guateria poeppigiana	3
23. Escada de jaboti	Bauhinia guienensis	2
24. Garaxama	Memora flavida	2
25. Gema de ovo	Poecilanthe effusa	1
26. Goiaba de anta	? ? ?	
27. Goiabao	Richardella macrocarpa	3
28. Goiabarana	? ? ?	
29. Imbauba	Cecropia obtusifolia	3
30. Inga cipo	Inga edulis	2
31. Inga vermelho	Inga alba	3
32. Ingarana	Pithecelloium cochleatum	1
33. Jacaranda de veado	Swartzia spp	
34. Janita	? ? ?	
35. Jatoba	Himenaea courbaril	3
36. Mamui	Jacaratia spinoso	1
37. Marupa	Simauba amara	3
38. Mirindiba	Glycidendron amazonicum	3
39. Muiraximbe	Emmotum fagifoloium	1
40. Murici da mata	Byrsonima crispa	1
41. Papo de mutum	? ? ?	
42. Pau branco	? ? ?	
43. Pau brasil	Mirocarpus frondosus	3
44. Pau roxo	Peltogyne catingae	3
45. Pau santo	Zollernia paraensis	3
46. Pente de macaco	Apeiba burchellei	3
47. Pitaica	Swartzia cardiosperma	1
48. Pitomba de leite	Talisia esculenta	1
49. Piturana	Cassia apoucouita	3

50. Sacopemba	Galipea jasminiflora	3
51. Tachi preto	Tachigalia myrmecophila	3
52. Tachi vermelho	Tachigalia paniculata	3
53. Tanimbuca	Terminalia guianensis	3
54. Taruma	Vitex triflora	1
55. Tento	Ormonia holerythra	1
56. Tinteiro	Miconia minutiflora	1
57. Umiri	Humiria balsamifera	3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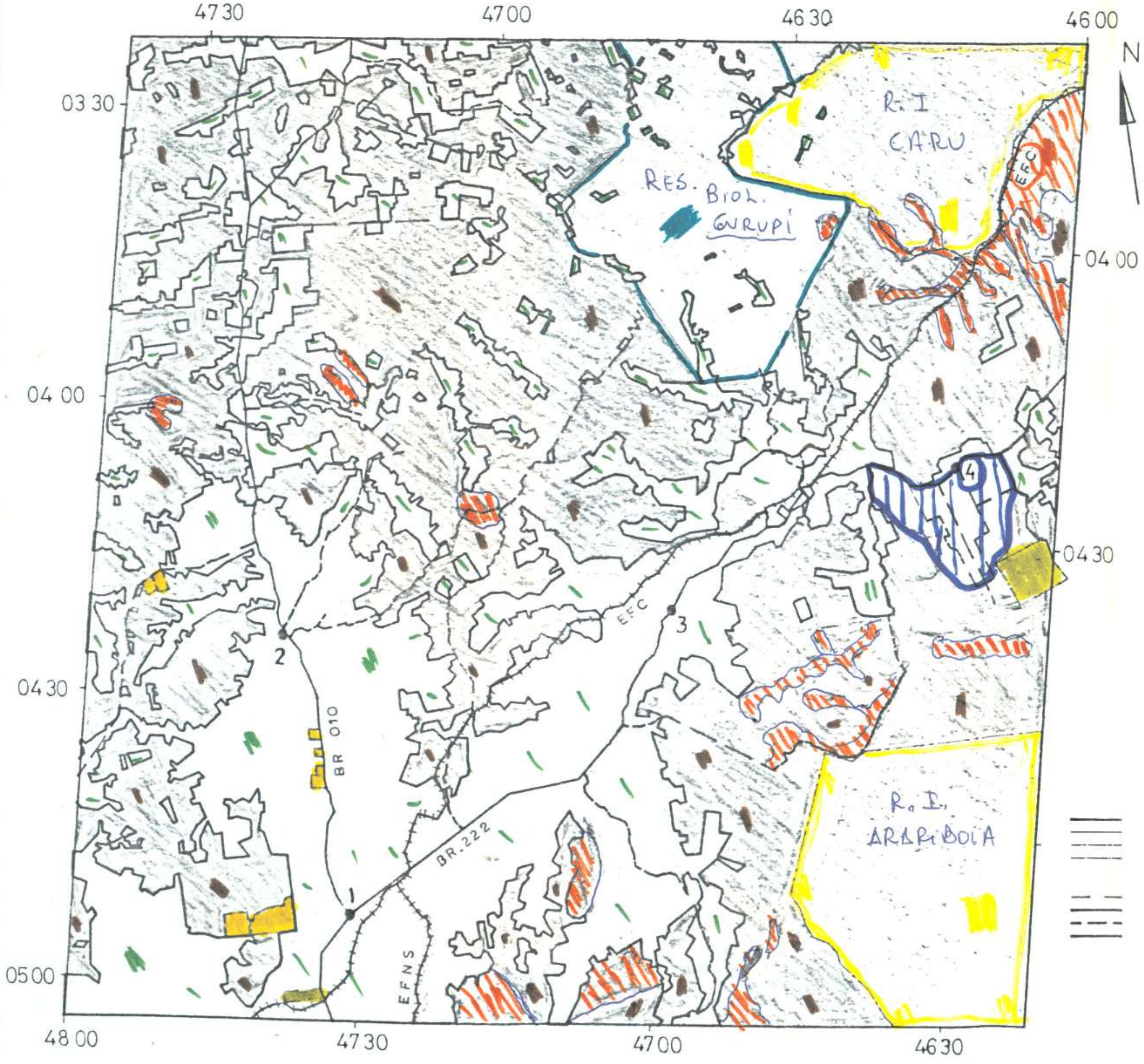
LAND USE MAP OF CARAJÁS REGION

AÇAILÂNDIA - BURITICUPU MA



LEGEND OF LAND USE MAP OF CARAJÁS

AÇAILÂNDIA - BURITICUPU REGION

based on satellite image
Landsat 5 TM from 31. july. 1988

	LAND USE UNITS	AREA (ha)	%
	COMPLEX OF SELECTIVE LOGGING AND SECUNDARY FOREST	1.469.114	41,8
	CATTLE RANCHES	1.149.927	33,1
	INDIAN RESERVE	400.587	11,6
	BIOLOGIC RESERVE	202.702	5,8
	SQUATTERS - POSSEIROS	169.1 20	4,9
	COLONIZATION SCHEME	45.217	1,3
	FOREST RESERVE - CVRD	10.873	0,3
	FOREST PLANTATION	9.200	0,2
	TOTAL AREA	3.456.740	100

SCALE 1:1.000.000

0 50 100 km

CITIES
1. Açailândia
2. Itinga
3. Bom Jesus
4. Buriticupu

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Tropical Forestry Master Course 1988 - 1990
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Forest Monitoring Program