CHAPTER 8

PROBLEMS, LIMITING FACTORS AND POTENTIALS FOR RECUPERATION OF DEGRADED AREAS

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8.1 Conditions of Recuperation of the Degraded Areas

8.1.1 Necessity of Recuperating Degraded Areas

The Brazilian Amazon tropical rain forest represents approximately 30% of the whole world tropical forest and its functions exert a great influence on the maintenance of not only the Brazilian environment but also of the whole Planet. As long as the deforestation is taking place in a fast pace during the last decades, the degraded areas are spreading out in the whole Amazon region. Unless appropriate measures are immediately implemented to cope with this situation, the expansion of deforestation and degraded areas is inevitable. The expansion of degraded areas exerts a negative influence on the Amazon region natural conditions, as well as on the local population lives and on their economic activities. Furthermore, this will affect the global environment balance to which the Amazon region forests and environment give a great contribution. In other words, the impact of the natural forests reduction and of the degraded areas increase will not be limited only to Brazil but will affect the whole world.

The Study Area population depends in a large extent on the surrounding forests, at the same time that they carry out agricultural, animal husbandry and/or silvicultural activities as basis for their survival. The increase of degraded areas limits the production to the land use restriction, what makes difficult the local population lives and economic activities. Therefore, the immediate implementation of the Plan for the Recuperation of Degraded Areas is considered necessary, aiming at the improvement of productivity and at the sustainable land use, through the inclusion in the productive system of degraded areas, that suffer from the decline of productivity and of their economic value, and of abandoned areas without use.

The Plan for Recuperation of Degraded Areas shall be elaborated in such a manner that the recuperation models can be applied practically for each type of degraded areas, taking into consideration the region's traditional familiar technologies and the new imported technologies. It is also important to analyse the activities and organization of the concerned organizations and the possible sources of financial resources necessary for the execution of the degraded areas recuperation. The elaboration of the Plan for the Recuperation of Degraded Areas shall allow the improvement of residents lives quality through the improvement of their income and through the generation of job opportunities, as well as through the land use in a sustainable manner, and consequently avoiding the deforestation and improving the forest functions, thus contributing to the Amazon region natural forests preservation and to the stability of the global environment.

8.1.2 Characteristics of Distribution of Degraded Areas

According to the satellite images analysis (as of 2000) and the field surveys, the distribution of degraded areas in the Study Area was identified as follows.

Table 8.1-1 Distribution of Degraded Areas (km^2)

Degraded Areas / Municipality	Marabá	São João do Araguaia	São Domingos do Araguaia	Brejo Grande do Araguaia	Palestina do Pará	Micro region of Marabá
Juquira	196	7	35	22	29	289
Capoeira	505	11	50	15	23	604
Capoeirão	806	21	102	28	42	999
Babaçu area	382	640	64	343	50	1,479
Bare land	0	0	0	0	0	0
Total	1,889 (12.5%)	679 (53.7%)	251 (17.9%)	408 (35.3%)	144 (14.3%)	3,371 (16.9%)
Total Area	15,105	1,265	1,400	1,156	1,008	19,933

In the Study Area, the degraded areas represent approximately 17% of the total. The juquira and capoeira areas occupy around 1 to 4% of the total area of each municipality. The capoeirão represents approximately 7% in the municipality of São Domingos do Araguaia, while in the other 4 municipalities it represents 2 to 5%. Babaçu is present in a higher proportion in the municipalities of São João do Araguaia and Brejo Grande do Araguaia, specially occupying more than half of the total area of São João do Araguaia. The bare land is almost inexistent, except for the sand beaches along the rivers.

In the municipality of Marabá, the degraded area represents approximately 13% of the total area, and most of it is concentrated along the Carajás railway and the State road PA-150. In special, large portions of babaçu and capoeirão areas are distributed along the PA-150. The degraded areas are sparsely distributed between the railway and the road. On the other hand, in the municipality of São João do Araguaia, the degraded area represents approximately 54% of the municipal total extension. In the areas between the Araguaia river and the federal road BR-230, that connects the city of Marabá to the city of Estreito by the federal road BR-10, the degraded areas punctually distributed along the north-south road in the form of a fish spine. This region is mainly dominated by the babaçu. In the municipality of Brejo Grande do Araguaia, similar to the municipality of São João do Araguaia, the babaçu dominated degraded areas are spread out on the northern portion between the Araguaia river and the federal road BR-230, occupying approximately 35% of the whole municipal territory.

As a general view, the degraded areas occupy, in large blocks, the center-south of the municipality of Marabá, most of the municipality of São João do Araguaia and the northern part of the municipality of Brejo Grande do Araguaia. The total degraded area in these 3 municipalities corresponds to 2,976 km^2 (14.9% of the total area).

8.1.3 Basic Guidelines of Recuperation of the Degraded Areas

The recuperation of degraded areas shall promote the stability of the productive system and the permanence of producers, with the land use being carried out in an economic and environmentally sustainable manner. This shall contribute for the pressure exert by the deforestation and forest fires on the remaining natural forests.

The recuperation of degraded areas can be accomplished through the introduction of the agrosilvipastoral system, i.e. the inter-cropping among agriculture, animal husbandry and silviculture, replacing the traditional monoculture system of agriculture and animal husbandry.

The inter-cropping system is more efficient for the tropical rain forest region ecology than the monoculture. The animal husbandry, however, can not be eliminated considering that represents an attractive (easy and safe) activity to the small-scale farmers.

The basic guidelines for the recuperation of degraded areas not used in economic terms are as follows:

a. Consider the vegetal succession, valuing the vegetation potential (biomass).

b. Analyze alternatives for the sustainable and rational use of degraded areas, searching for measures that can generate the highest effect with the lowest input, and allowing the permanence of small-scale producers on the land.

c. Analyze measures that can allow the utilization of manpower and capital with the highest economic effect, considering that the fight against poverty can contribute to avoid the expansion of degraded areas.

d. Analyze sustainable and adaptable measures and land use to the region's environment from a broad interdisciplinary point of view.

e. Analyze actions that can add value in the inter-cropping of several agricultural activity components with the use of native forest species with commercial value.

f. Analyze the fostering of the forest products' exploitation activity that can also make use of the remaining forests.

g. Analyze compatible measures with the higher plans actions, in a way that they can be incorporated to the local governments policies and be supported by them, and also incorporating the results of researches already carried out by institutions, also counting on their collaboration.

h. The participation of local social actors and beneficiaries is indispensable for that the Recuperation Plan is implemented and exploited in a sustainable way.

i. Analyze measures that take into consideration the vocation and stimulate in some way each executing organization and/or sector in need, such as the familiar farmer, the animal raiser or the lumber-mill since the projects need this motivation to be carried out.

j. Analyze systems through which the federal and State governments can take measures to assume their responsibilities, considering that the recuperation of the Amazon region degraded areas is an important issue at the federal level.

8.2 Problems and Limiting Factors in the Recuperation of Degraded Areas

8.2.1 Natural Conditions

The Study Area natural conditions are controlled by three main natural factors, i.e., topography, soil and rainfall, which are possibly the responsible for the natural environmental and for the vegetation distribution, including forests, agriculture and pastures.

(1) Topography

Several forms of topography are found in the micro region of Marabá, with altitudes varying between 100 m near the rivers and 800 m at the Cinzento Mountain Range. Marabá, Brejo Grande do Araguaia and Palestina do Pará are the municipalities with the higher percentage of steep topography which, depending on the gradient degree, can become a limiting factor to the development of, for instance, agricultural activities in large areas, mainly if managed through the traditional way.

(2) Soil

1) Classes and Characteristics of Soils

The main soil types in the Study Area are the Red Yellow Clayey Soils, followed by the Red Yellow Latosols, the Litholic Neosols, and the Quartzose Neosols.

These soils are extremely acid and weathered, having a strong granulate structure and being well drained. Except for the nutrients recycled in the organic matter, these soils are very poor in nutrients and soon a careful fertilization becomes necessary for the agricultural production, with the need of a long period to recover their fertility. The predominant restrains of these soils for cultivation are deficiency of P, toxicity of Al and low reserves of nutrients.

Although the production can increase with an appropriate management and the application of correctives and nutrients to the soil, the conversion of large extensions of land into agricultural production areas is not promising due to the high costs of fertilizers, including transports, to the traditional agricultural system and to the lack of capital.

2) Soil Degradation Caused by Deforestation and Pastures Formation

The removal of the primary forest for the formation of pastures not only destroys the original mechanisms of nutrients conservation, but also causes the soil compaction with the destruction of its porosity and the reduction of its water holding capacity, also disturbing the delicate balance of vegetation, soil and climate of the forest ecosystem. Although the mineral nutrients remain in the soil after deforestation and forest fire, the vegetation only absorbs part of these nutrients. Therefore, the exotic pastures largely planted in the Study Area suffer a gradual decline of productivity due to the low soil fertility.

The phosphorus in the soil is the most critical nutrient for the pastures stabilization. The soil organic matter is capable of maintaining for some time an acceptable supply of nitrogen for the pastures growth. However, as time passes the nitrogen availability becomes deficient. The use of a fertilization with high contents of phosphorus and nitrogen besides the use of herbicide is extremely efficient. However, due to the high costs the pastures management is

carried out using fire what can cause their degradation.

As a consequence, usually after 3 to 4 years of pastures' utilization by meat cattle, the pastures' growth and the soil coverage rate start to decline. Besides, the topography with strong undulations increases the erosion and, in many cases, the degraded pasture areas are abandoned, followed by the appearance of a vegetal succession of juquira, capoeira and capoeirão.

(3) Rainfall (Climate)

The differences in plants distribution in the Study Area are related not only to the climatic conditions but also to the physical characteristics of soil, mainly the water balance and the plants water requirements, as well as their resistance to the drought.

The dependency of the blossoming and fructification phenology in regard to the rainfall seasonal pattern is also important in the reproduction of several vegetal species. Other aspects such as soil nutrients, shadowing rate and soil temperatures also affect the development of vegetal species.

According to the Köppen classification, the Study Area is in a transition band between Aw and Am with a rainfall of approximately 1,500-2,000 mm/year. Most of the Study Area, mainly the four municipalities and the eastern portion of Marabá, present a water deficiency of 400-500 mm/year.

8.2.2 Socioeconomic Conditions

(1) Land Ownership Issue

The historic attitude towards the agrarian issues reveals the lack of interest of the public managers in the past in regard to the appropriate land use and to the conservation of the natural patrimony. The action without technical criteria, since no measurement nor demarcation of land were demanded once they were considered endless, today is reflected in a complex land ownership identification system.

The information collected in the concerning organizations such as INCRA, ITERPA, Real Estates Registration Offices and Municipal Secretariats of Land although rich are dissociated, hindering a current and actual view of the agrarian situation, inhibiting a better planning of the productive spaces in the Study Area.

(2) Strategy of Zoning Development

In planning the social, economic and ecological actions, a development strategy based on the region zoning is fundamental. This zoning though was not carried out yet. Meanwhile, the advances in the new frontiers continue to reproduce the same occupation models already experimented in the previously occupied regions.

The issue of sustainable use of renewable natural resources is intrinsically related to the ecosystem. However, since this is also related to the forms of utilization of productive spaces, a development strategy based on a zoning is extremely important in the definition of the best utilization alternatives for the physical spaces and their natural resources.

(3) Infrastructure

The precariousness of the physical infrastructure, mainly the local roads network that actually only operates from June to December, represents a problem that has to be surpassed in order to assure an efficient flow to the commodities circulation.

Other physical infrastructure deficiencies observed in the rural environment are the lack of electrification and communication means. Consequently, the few industries installed in these regions are those directly dependent on the natural resources exploitation based raw material such as the mining companies, lumber-mills and fruits' pulp industries.

Another usual complaint in these agricultural frontier areas is about the social infrastructure, mainly the education and health ones. In the education sector, the precariousness is not only reflected in the small number of schools but mainly in the education quality, almost always only providing the first basic grade (1^{st} to 4^{th} series). Another problem is the lack of classrooms and teachers, something that became very common in the rural zones. The students from several different grades receive their classes at the same time, from the same teacher, in the same classroom. This so called "multi-serial" system is inefficient to assure the education quality and has to be fought and eradicated, specially considering the great amount of financial resources invested in education by the Federal Government through the FUNDEF[1].

The deficiencies of the health sector are also observed in the rural environment, mainly in the locations more distant from the urban centers. The complains about the lack of professionals and medicines are repetitive, and to the people the only alternative is to search for more equipped centers. Since the water supply, basic sanitation and environmental education programs are also precarious in the distant locations and sometimes even in the urban centers of the municipalities, there is a high incidence of typical diseases of low social development level, such as respiratory diseases, parasites, diarrhea and several infections. However, the main morbidity in the region is by far the malaria with approximately 40% of the cases treated through the Health Only System – SUS.

(4) Credit System

There are still many obstacles for the small-scale producers to access the credit institutions. Such obstacles are listed below:

a. Lack of information: Despite the efforts carried out by the small-scale producers associations, cooperatives and other forms of organization, the small-scale farmers still face difficulties to interact with and to be duly benefited by the financing agents.

b. No debt repayment: The financial items are determined by the financing agent. However, there is frequently a difference in pace among the managerial capacity of farmers, the access to production inputs (including technology) and the expectance of the investment return from the subsistence production carried out by the small-scale farmers.

c. Accomplishment of Targets: The financing agents frequently demand the

[1] FUNDEF – Fund for the Maintenance and Development of the Fundamental Education and Valuing of the Educators' Formation.

accomplishment of contract targets after the release of the financial resources, even when this is late in relation to the cultivation plan. This fact has occurred in the Marabá micro region in regard to the expansion of the cupuaçu cultivation. The delay in releasing the contracted amounts lead the farmers, in order to accomplish the schedule fixed by the bank, to plant the seedlings during the dry season what resulted in the loss of 95% of the planted seedlings.

d. Technical Assistance: The low knowledge level of the farmers, above all about the adoption of new technologies and new crops, also compromises the products quality and reduces the prices paid to the producer.

e. Verticalization: The small installed industrial capacity together with the precariousness of the local road network strongly restrains the products prices, not allowing the remuneration of the invested capital.

The frequent alterations in the FNO conditions are bringing uncertainties and fears to the small-scale farmers as for contracting financing. The economic instability and the successive financial plans to contain the inflation, what caused several adjustments and the raise of financial charges to unsustainable levels, lead many borrowers to insolvency and to loose their properties. Although the charges were reduced and only from 1998 on some positive reaction was observed in the volume of contracted loans, the recent trauma was not entirely overcome by the small-scale farmers.

(5) Market

Still now the most practiced activity is the predatory monoculture. The opportunities for the exporting markets are still oriented towards products such as castanha-do-brasil, fruits pulp, palm heart and other raw materials such as ore, tropical wood, vegetal oils and essences. New markets can be only reached through good investments in all the production levels, as well as through the differentiation of products, besides the overcome of the bureaucratic demands in the exporting sector.

For the domestic market, there is the perspective of commercialization of some products such as tropical wood, dairy products, meat, palm heart, fruits pulp and açaí. However, the prices competitiveness of most of the products is hindered by, among other factors, the low quality, high cost of transportation freight established according to the long distances and the petroleum price.

8.2.3 Production Aspects

(1) Agriculture

In the subsistence familiar agriculture, when the number of persons in the domicile increases, the reduction of the fallow period is necessary due to the lack of cultivation areas. This causes the degradation of some areas and consequently the poverty and destruction of environment.

The agricultural production is focused on the cultivation of annual crops such as rice, maize, cassava and feijão beans through the slash-and-burn cultivation system. The tropical fruits cultivation is being experimented by some farmers, however they are still facing several problems due to the precariousness of their productive basis.

Most of the farmers arrived from other regions of the Country in the last 30 years and do not know agriculture and animal husbandry technology nor the natural environment of the Amazon region. The technical and financial assistance rendered by the governments and NGOs only covers part of the farmers. Therefore, the organization of farmers is indispensable for the improvement of the productivity. However, the organization of colonizer farmers is not an easy task. Besides, there are several fire occurrences caused by the improper management what causes the loss of the planted fruit species. In general, these farmers do not have the basic conditions for the agricultural production.

As problems regarding to the agricultural production in the Study Area we can mention the following items:

a. Deficiency on the technological knowledge about agriculture in general, in special about fruits cultivation.

b. Lack of awareness about the sustainable use of cultivation areas.

c. Deficiency on the technical assistance carried out by the governmental organizations.

d. Lack of confidence on the associations.

e. Inconveniences in the service rendered by the credit institutions.

(2) Animal Husbandry

The animal husbandry activity is being developed through the extensive system, and the pressure for the occupation of forest areas, legal reservations or not, is increasing.

At first, the pastures were formed in small areas for the animals' troops and for the breeding cattle. The pastures in large areas were formed through the occupation of forest areas in the surroundings through the slash-and-burn system. The main problems of the animal husbandry activity in the Study Area are as follows:

a. Lack of guidance about the proper use of fire that ends up reaching indiscriminately forest and pasture areas.

b. Low level of technological knowledge on the part of the small-scale producers about the reproduction and genetic improvement of the cattle.

c. High incidence of zoonosis.

d. Deterioration of pastures due to overgrazing and to the use of fire.

e. Instability of the agrarian sector due to the intense pressure over the land ownership.

(3) Silviculture

Despite the economic importance of the wood sector for the Pará State economy, the native sources of forest-wood raw material are being treated in a predatory way at the frontier region.

The intensive use of the forest resources in the Study Area and the tendency of their depletion occur due to several factors described as follows:

a. Non sustainable forest management due to the inexistence of appropriate organizations for the qualification in silvicultural activities.

b. The technological sector of the tropical silviculture is not structured.

c. Degradation of forests through the use of fire largely carried out by small-scale up to the large-scale producers in their production areas, which causes the fire of the surrounding forest reservation area. Sometimes, the reservation area itself is fired for the expansion of the productive area.

d. Lack of an efficient structure of forest control and patrolling.

e. Lack of people awareness about the environmental issues and the sustainable management of silviculture.

f. Lack or deficiency of credit lines for the forestry sector.

8.2.4 Institutional Aspects

(1) Inter-institutional Action

The concerned organizations are not always well articulated. Since the Constitution assures certain levels of autonomy, there is a difference between the Federal and State governments concept about the environment preservation and the region's development. The State, in turn, overlaps the municipal actions, executing projects which could be otherwise carried out in a decentralized manner by the municipalities. The reverse also happens and in this case the municipalities take the initiative of promoting actions, projects and programs which were to be executed at the State or Federal spheres. The consequences of this lack of articulation are observed in the increase of public investments, in the dissipation of efforts and, above all, in the inefficiency in accomplishing the programs' targets.

(2) Technological Diffusion and Rural Extension

Although EMBRAPA carries out an indispensable work in the field of agricultural research, it does not have an effective diffusion system to take to the rural population the available technology. Besides that, the financial resources destined to the rural extension as well as to the universities and to the research institutes are not meeting the demand.

On the other hand, EMATER, which is the organization responsible for the transference of technology to the Pará State producers, does not keep a direct channel with EMBRAPA, besides having an insufficient technical staff to meet the demand. In the micro region of Marabá, only about 10% of the rural producers are served by EMATER, and the other farmers count on the support of the also few technicians of the municipal secretariats and State regional offices, besides the NGOs installed in the region such as CEPASP and Extensão Amazônia. However, all these organizations have few technicians and most of the small-scale farmers who need the technical assistance are not being properly served.

8.2.5 Executive Aspect

The public organizations responsible for the recuperation of degraded areas do not present conditions for the accomplishment of their responsibility in executing projects and/or supervising services due to the insufficiency of personnel and budget. In this fashion, even with a structured legislation and systems, there are difficulties in the projects and/or services execution step. In order to carry them out, these public organizations have to justify the utilization of human resources and budget in a sound way in order to carry out the planning and execution of degraded areas recuperation projects.

8.3 Potentials for the Recuperation of Degraded Areas

The degraded areas typified as Juquira, Capoeira and Capoeirão, when abandoned, start the process of vegetal recuperation through the formation of the secondary vegetation. To economically recuperate these areas, the promotion of productive activities in the agrosilvipastoral system is necessary. Forestry production and fruits cultivation through the combination of reforestation, agroforestry and silvopastoral activities, as well as through the reform of pastures, aim at the recuperation of degraded areas.

As concrete measures we can mention the following: the cultivation of forest species with commercial value (fruit species, species to be used as roughage, shadowing trees) in the degraded pastures / juquira; the improvement of pastures management including the silvopastoral system; the reforestation with fast growth forest species; the reforestation in the intercropped heterogeneous system; and the reforestation in the homogeneous and uniform system with exotic species. We can also mention: the inter-cropping cultivation of fruit species through the utilization of the biomass potential in the capoeira and capoeirão areas; the reforestation and enrichment with forest species with commercial value, among others. It is worthy to mention that the babaçu areas will be treated and classified as Juquira, Capoeira and Capoeirão due to their peculiarity as degraded areas in the Study Area. On the other hand, the capoeira and the capoeirão will be, in general, treated jointly due to their similarity in terms of recuperation measures, except special cases.

8.3.1 Potentials for Recuperation through the Agricultural Development

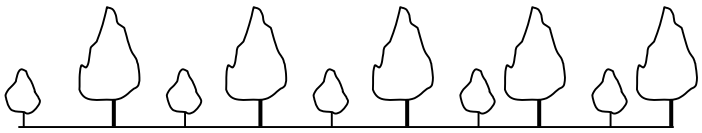
In the Study Area, the main activities are the agricultural cultivation through the slash-and-burn system and the animal husbandry. In order to promote a more sustainable land use, the agriculture carried out utilizing forest species, i.e., the agroforestry system is efficient since allows the generation of economic value in the form of wood, wood for the production of firewood and charcoal, fruits, roughage, products that can be industrialized, also through the introduction of fruit species. As ecological effects, we can mention the soil improvement and fertilization, the mitigation of the microclimate, the reduction of erosion, the improvement of the soil water holding capacity, as well as the shadowing of animals and agricultural products, among others. The inter-cropping cultivation of various forest and fruit species controls the attack of diseases and pests possible through the homogeneous cultivation, offering a diversification of agricultural products and thus the stabilization of income.

The agrosilvipastoral activities, through the introduction of the agroforestry system, in a similar way to the development of the natural forests' ecosystem, allow a highly economic

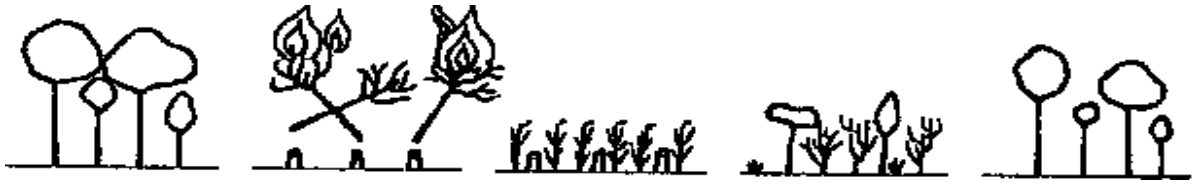
and ecological sustainable productive system.

The agriculture broadly practiced in the Study Area is carried out through the slash-and-burn system in order mainly to produce cassava, maize, rice, etc. The traditional slash-and-burn system is a measure that allows the addition of the nutrients accumulated within the trees to the soil. However, the uncontrolled fires that are today carried out in several locations can induce to the abandonment of areas due to the decline in productivity, and can also cause a harmful cycle of deforestation and expansion of degraded areas. Although the planed use of fire is allowed according to the legislation in force[2], the reduction of the fire use pressure is an important issue. At the long term, the implementation of a sustainable productive system in these degraded and abandoned areas such as capoeira after their use for cultivation through the slash-and-burn system is possible through the cultivation of high economic value forest species and of perennial crops such as fruit species.

System of Inter-cropping Cultivation (Cultivation in the Spaces between Trees)



Rotation System of Biomass Utilization (Improved Rotation System of Slash-and-Burn)



Capoeira – Slash-and-Burn – Cultivation of Annual Products – Planting of Commercial species – Renewal of Forests with Commercial species.

(1) Juquira

Inter-cropping Cultivation of Fruit Species

In the juquira found mainly in degraded pastures, the soil presents low fertility, and the nutrients necessary for the cultivation of agricultural species are depleted, thus a long time is necessary for the vegetal recuperation. For this reason, a possible alternative is to wait for the soil natural recuperation through the vegetal succession in capoeira and capoeirão. However, the inter-cropping cultivation of aligned fruit species after a soil preparation that can be carried out manually or through the use of agricultural equipment such as tractor is possible to be carried out. Juquira requires the use of fertilizers and the elimination of weeds, what results in high management costs. Therefore, the juquira can be utilized for the large-scale cultivation carried out by big companies, while in general the familiar agriculture does not utilize the juquira due to the financial limitations.

[2] According to the alteration of the New Forestry Code (Law No. 2661, July 08/1998), the planed use of fire is allowed in case the objective is the development of an agrosivopastoral activity, since the SISNAMA (National System of Environment) examination and other conditions are fulfilled.

(2) Capoeira and Capoeirão

Cultivation of Shadowing Fruit Species in Capoeira

In capoeira, where the natural regeneration of commercial species is observed, the cultivation of fruits and forest species after the partial preparation of soil is possible. In this case, the opening is carried out in approximately 2 m of width and with a spacing of approximately 10 m in order to plant in line. The species that can be adopted are shadowing fruit species such as cupuaçu, and forest species such as andiroba. The remaining capoeira can be partially logged for the complementary cultivation of forest species after the appropriate establishment of luminosity conditions. This methodology is being utilized in settlements such as the PA Araras through PRONAF projects, and 60 familiar farmers are taking part.

Cultivation of Fruits and Forest Species combined with the Cultivation through the Slash-and-Burn System

The cultivation of commercial value fruits and forest species in capoeira and capoeirão, during or after the cultivation of annual crops such as cassava with the utilization of the nutrients accumulated in the biomass through the slash-and-burn system is possible. The species to be planted, making use of the multiple layers structure, are the perennial fruit species of short cycle (ex. banana) as shadow at the initial stage, and shadowing fruit species (ex. cupuaçu). For the long term shadowing, relatively tall fruit species such as açaí and forest species such as castanha-do-brasil tree can also be inter-cropped. This production system is applicable for the small-scale familiar agriculture that carries out the slash-and-burn system. The slash-and-burn cultivation is carried out during 2 to 3 years. In the 1st year, only the annual crops are produced, then the harvest of fruits starts in the 2nd year when the traditional production drops. After this period, the forests are in process of formation including the commercial species.

Fruits Cultivation in the Capoeira through the “Mulch” System

In the project SHIFT carried out through the technical cooperation with Germany, the “mulch” system is being experimented (this method consists in covering the plants with vegetal matter layers) in capoeira with the use of tractor, in the attempt to reduce the negative impacts caused by the slash-and-burn cultivation, and to promote the permanency of farmers on the land. Comparing the slash-and-burn system with the “mulch” system with the use of tractor, in the 1st year the slash-and-burn system presents a better yield due to the immediate supply of nutrition, although in the 2nd year this system yield presents a considerable drop being surpassed by the “mulch” system yield. In the 3rd year, the traditional system yield records a drop equivalent to half of the 1st year yield. On the other hand, in the “mulch” system 90% of the vegetal matter is lost due to tropical conditions in which the decomposition is accelerated, thus the cultivation is not carried out. The “mulch” system with the use of tractor was not practically introduced since demands a high cost for the heavy machinery and for the application of fertilizers in the 1st year.

Babaçu Control

Babaçu grows in regions where the rainy season extends for at least 5 to 6 months with an annual rainfall between 1,200 and 2,000 mm (Kass *et al.*, 1993). Babaçu is found at the eastern portion of the Study Area that presents such climatic conditions. The repeated use of

fire finally burns the hard peel of the babaçu fruit, thus promoting germination. In the corrected acid soil, the babaçu grows vigorously, affecting the ecosystem (Anderson *et al.*, 1991). In the Study Area, the most popularly used control method is the injection of pesticide mixed with diesel oil directly into the roots. Another method is to uproot the plant using a mechanic excavator, usually used to install the fence, and fill the opened hole with water to promote the decomposition of the main root. These control practices can be easily carried out in 1 to 2 ha areas, but are not economically feasible for areas larger than 5 ha. A large babaçu area can be utilized by the silvipastoril system with the introduction of goats and buffaloes which rather eat young babaçu leaves. For controlling babaçu, the elimination of all plant's seeds without using fire is important.

8.3.2 Potentials for the Recuperation of Degraded Areas Through the Animal Husbandry Activity

The methodology proposed for the recuperation of degraded pastures is the mechanized plowing, the application of manure and the re-planting of pastures (Veiga, J.B. 1995). However, in case of the degradation of large pasture areas utilized through the extensive system, such as in the Study Area, the reform of pastures is economically difficult.

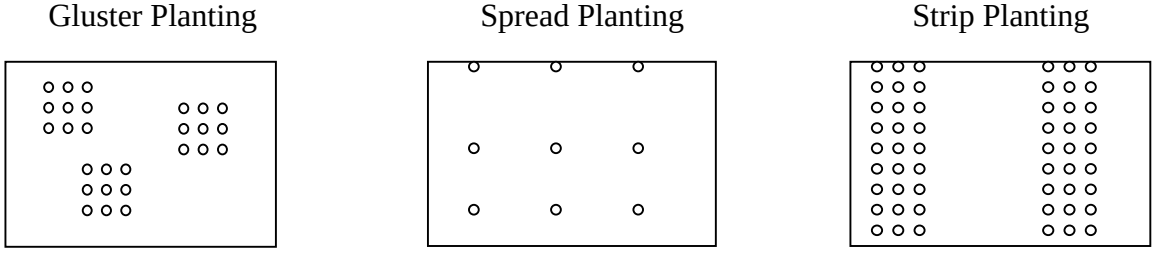
However, the silvopastoral system, with the introduction of forest species in the animal husbandry activity, induces the increase of the soil organic matter through the forest species planted in the pastures, raises the nutrition level of the soil utilized by the trees roots system and offers shadow to the animals, as well as contributes for the mitigation of the microclimate and for the reduction of the attack of diseases and pests.

(1) Juquira

The pastures degraded due to the long term utilization tend to be dominated by juquira. Since the soil is very much deteriorated, the cattle has to be removed for the re-planting of pastures after the soil preparation and the application of fertilizers. At this moment, the silvopastoral activity can be started, also by planting native and exotic forest species.

Establishment of the Silvopastoral Activity

At the medium- and large-scale farms, the cattle has to be partially removed from the pasture for the planting of forest species, and the animal husbandry can start again in this area after 1 to 2 years when the planted trees are already grown. The planting methods can be in clusters, spread planting, in strips, etc. In the Study Area, the appropriate method is the planting in strips which demands few cultural treatments. The appropriate species to be adopted are the large size ones that allows the penetration of luminosity such as the arboreous species such as Paricá, palm tree species with commercial value such as Coconut, and leguminous species that can be used as manure such as Eritrina (*Erythrina spp).*



(2) Capoeira / Capoeirão

Application of the Rotation System of Biomass Utilization for Animal Husbandry

The capoeira/capoeirão is utilized for the cultivation of annual products, after the soil preparation using fire. After the continuous cultivation during some years, pastures are planted. Then the extensive animal husbandry is carried out for another years, and when the soil nutrition is reduced and the control of weeds becomes difficult, the area starts to fallow. When a new forest is formed in the fallow land, the soil preparation is carried out using heavy machinery for once more cultivating annual products. In this system, leguminous plants are introduced at the initial stage for the soil improvement, what allows the increase of sustainability. The fallow period can also be used for the production of forest species with commercial value.

8.3.3 Potentials of Recuperation through the Development of Silviculture

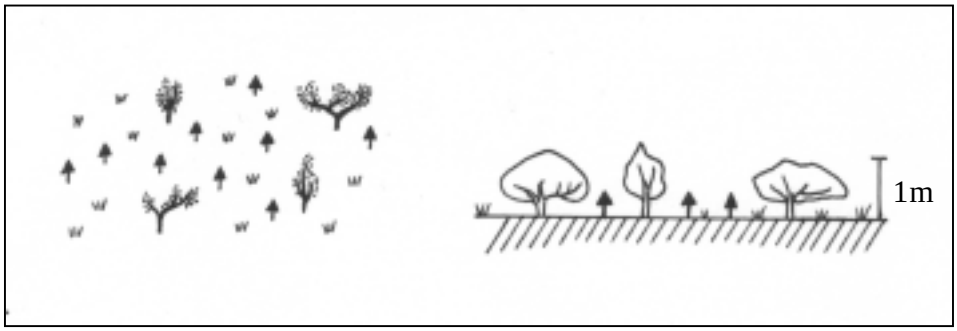
The degraded areas include several forest species from bushes to big trees that usually do not produce any economic value in the form of wood or fruits. As an alternative to economically recuperate these degraded areas, the development of silviculture through the selective use of high economic value native and exotic forest species is possible.

(1) Juquira

Reforestation can be carried out with fast growth native species and through the heterogeneous system inter-cropped with some commercial value forest species regularly planted, after the simple soil preparation. The homogeneous reforestation with exotic species after the mechanized soil preparation is also possible.

Reforestation with Fast Growth Species

When juquira appears, the soil productivity is already deteriorated although there are good luminosity conditions and the vegetation is sparse. These characteristics can be utilized for the free planting of fast growth native species with high renewal capacity. Depending on the species, this planting method does not require high soil preparation costs. Paricá that present a high renewal capacity can be adopted, as well as leguminous and other fast growth species such as Faveira. This simple and low cost technological method is applicable to small-scale producers as well as to large-scale ones.



Inter-cropping Heterogeneous Reforestation

As a method that aims at the reduction of ecological hazards and the diversification of productive species, the inter-cropping line planting of commercial species, including the fast growth ones, after a simple manual soil preparation is possible. Although in the Amazon region there are still few experiments in this sector, this shall be the main reforestation method using native species. In pastures presenting a declining productive capacity, the reforestation carried out in a demarcated area where the animal husbandry is suspended for a determined period of time represents the first step of the silvopastoral activity.

Homogeneous Reforestation using Exotic Species

Exotic forest species which production technological system is already established in a certain level such as eucalyptus can be planted after the mechanized preparation of soil. Since juquira presents low soil fertility level, the soil correction and the application of fertilizers are very important for the homogeneous system reforestation. At the COSIPAR forest station, the *Eucalyptus urograndes* is the promising genetically improved species.

(2) Capoeira / Capoeirão

In comparison with juquira, the capoeira and capoeirão vegetation presents a higher biomass productive function and better soil physical characteristics. The most limiting factors for the planting of native forest species in these areas are the luminosity conditions at the soil superficial layer and the competition with other species as for the absorption of nutrients. At the capoeira initial stage, there is still enough condition to plant in the forest bed. In the case of capoeirão, the most effective method is to make the enrichment through the planting of commercial value native species after partially cutting the vegetation. This method facilitates the regular growth of species difficult to grow straightly and of species that demand shadowing. Capoeira and Capoeirão can also be used through the method of reduction to the soil of nutritive minerals accumulated in the vegetal biomass for the cultivation of agricultural products. This is possible to be carried out through the mechanized biomass “mulch” or the soil preparation. After the soil preparation, the reforestation of native and exotic species is possible, the Taunya system reforestation starting from the cultivation of annual products as well as the cultivation of agricultural products that can be industrialized.

(3) Transition Zones

The frontier areas between the legal reservations and pastures in large-scale farms or the frontier areas with the agricultural cultivation areas in properties of small-scale farmers tend to be transformed into capoeira, 20 to 40 m wide, forming a transition zone. In these areas, the reforestation with fast growth species in the enrichment regimen or through the heterogeneous system is highly executable, which is also effective in terms of improving the capoeira economic qualities.

8.4 Feasibility of Applicable Technologies

8.4.1 Application of Agricultural Technologies

(1) Selection of Species for the Agroforestry System

Annual products, short cycle perennial products and intercropped arboreous forest species shall be planted, creating a multiple layers structure. The products adopted in the Study Area are presented in the following table according to their heights.

Table 8.4-1 Classification of Agricultural Products, Fruit and Forest Species according to their Height

1st Layer	Annual crops with maximum height of 1 meter	Feijão beans, Pineapple, Rice, etc.
2nd Layer	Annual crops with an approximate height of 1 meter	Cassava, Maize, etc.
3rd Layer	Short cycle perennial fruit species with maximum height of 2 to 3 meters	Banana, Papaya, Passion Fruit, etc.
4th Layer	Perennial fruit species with maximum height of 6 meters	Cupuaçu, Orange, Acerola, etc.
5th Layer	Palm trees	Açaí, Pupunha, Coconut, etc.
6th Layer	Fruit and Arboreous Species	Castanha-do-Brasil, Mahogany, Paricá, etc.

Source: Sistema Agroflorestal. 2000. P. S. Miranda.

Cupuaçu is a native species in the Study Area, being a perennial fruit species with good commercialization and production conditions. The cupuaçu cultivation is increasing in the last few years. The inter-cropping cultivation, being the cupuaçu the main species, presents a high application feasibility. In this case, the annual crops and the short cycle perennial fruit species are removed after harvest, finally remaining the cupuaçu, other fruit species and the forest species.

The plants physiological functions such as metabolism ways (C_3, C_4, CAM), tolerance to shadow, circulation of nutrients, growth of the rooting system, among others, shall be taken into consideration when deciding the planting density. The formation of a diversified ecosystem contributes for the reduction of damages caused by the attack of diseases and pests, as well as for the improvement of nitrogen and carbon circulation, etc.

1) Fruit species (tri-annual) x Shadowing Perennial Fruit Species (Passion fruit [Gliricidia from the 7th year] x Cupuaçu)

Passion fruit is planted in a spacing of 6 m x 3 m (555 plants/ha) and Cupuaçu in a spacing of 6 m x 6 m (277 plants/ha). Passion fruit is planted in the inter-spaces of the Cupuaçu plantation where the irrigation system is installed. Passion fruit which is a plant that grows under the sun will be planted twice in a 3 years period until the soil surface is covered by the Cupuaçu. The leguminous Gliricidia will be planted from the 7th year on to avoid the problem caused by the continuous cultivation which contributes for the reduction of nitrogen in the soil, thus allowing the continuous harvest of Cupuaçu.

2) Annual Products x Short Cycle Perennial Fruit Species x Arboreous Forest Species (Rice, Maize, Feijão Beans x Banana, Cupuaçu, Castanha-do-Brasil)

The planting spacing is 20 m x 20 m (25 plants/ha) for Castanha-do-Brasil, 6 m x 6 m (208 plants/ha) for Cupuaçu, and 3 m x 3 m (867 plants/ha) for Banana. In the inter-spaces of these species cultivation, annual products are cultivated in the sequence of Rice, Maize and Feijão beans, through the system of 3 harvests per year during 2 years. In order to carry out 3 harvests per year, leguminous plants shall be introduced for the retention of nitrogen. The Banana and Cupuaçu harvests take place in the 3rd and 4th years, respectively.

3) Annual Products x Short Cycle Perennial Fruit Species x Forest Species utilizable as Roughage x Forest Species (Rice, Maize, Feijão Beans, Banana, Pineapple x Banana, Cupuaçu, Gliricidia, Castanha-do-Brasil)

The agricultural products are cultivated in the inter-spaces of the forest species utilizable as roughage. The system of 3 harvests per year is carried out in the agroforestry activities. The forest species such as Castanha-do-Brasil and Gliricidia are planted in spacing of 10 m x 10 m (100 plants/ha) and in the inter-spaces of these species Rice, Maize, Feijão Bean, Banana and Pineapple are cultivated for 3 harvests per year. The Pineapple is planted in spacing of 0.4 m x 0.3 m (1000 plants/ha) in the inter-spaces of the forest species planted in spacing of 10 m x 10 m. Pineapple starts to produce from the 2nd year on. To carry out 3 harvests per year, the leguminous plant (Gliricidia) shall be introduced in order to promote the retention of nitrogen. Cupuaçu is planted in the 2nd year. The harvests of Banana and Cupuaçu start from the 3rd and 5th years, respectively.

4) Intercropped Silvopastoral System with Coconut, etc. (Coconut, Neem, Gliricidia x Braquiária)

Braquária (*Brachiaria brizantha*) is seeded 6 months after, in the inter-spaces of Coconut, Neem and forest species utilizable as roughage planted with spacing of 8 m x 8 m (52 plants/ha). Animals are introduced in the pasture only when the Coconut and Neem are taller than 2 meters so that the animal does not eat the seedlings. The pasture growth which is usually fast is controlled under the shadow supplied by Coconut and Neem. The Coconut harvest starts from the 4th year on.

5) Silvopastoral System Utilizing Babaçu, etc. (Babaçu, Leucenas x Braquiária)

The Babaçu cultivation density is 100 plants/ha. After the soil preparation using an excavator tractor, trees utilizable as roughage are planted. The pasture is seeded 6 months after when the trees are taller than 2 meters. Fire is not used because it deteriorates the soil and promotes the germination of buried Babaçu seeds, although burning is temporarily useful in terms of alkaline nutrients increase. The pasture growth is controlled under shadow, similarly to the previous item.

(2) Selection of Forest Species that can be Industrialized

1) Rubber tree

Brazil has an annual demand of natural rubber of 120,000 t. In order to meet this demand, the country produces 80,000 t, besides importing 40,000 t. In the Marabá micro region, there are

wild rubber trees, but they are not planted. The main limiting factors for the cultivation of natural rubber in the Amazon region are as follows: attack of diseases, credit conditions, and commercialization channel. The intercropped reforestation with rubber trees presents the following advantages:

a. Being a renewed species that appears in the 5th phase of the vegetal succession, it presents a good adaptability to the region.

b. Technology in the field of genetic improvement is available.

c. The young forest environment favors the success of native forest species reforestation.

d. The relatively dry climate (Aw) can reduce the damages caused by diseases.

e. A latex processing plant can be installed with a relatively small investment, what facilitates the project execution.

The experiences of large-scale rubber trees plantation carried out in the Amazon region were not successful due to the damages caused by the attack of diseases and pests. However, the introduction of rubber trees through the agroforestry system by medium-scale producers is considered feasible (Smith et al., 1995).

2) Dendê

The dendê market is expanding, and Brazil imports this product. 50 millions ha are said to have aptitude for the dendê cultivation in the whole Amazon region, presenting a great potential for its cultivation (Smith et al. 1995). In Pará State, the dendê is being largely planted in the regions of Bragantina and Tailândia. For the dendê growth, the annual rainfall must be over 2,000, therefore this cultivation is not feasible at the Study Area where there is a well defined dry season.

8.4.2 Application of Animal Husbandry Technologies

(1) Characterization of the Silvopastoral System

At the Amazon region, there are few experiments of the silvopastoral system. In the demonstrative researches carried out by EMBRAPA-CPATU, the cultivation of 3 strips of paricá, tatajuba, and eucalyptus (*Eucalyptus tereticornis)* in several combinations with braquiarão and quicuio-da-amazônia was tested. The experiments are showing good growth results (Tavares Marques L. C. E Brienza, Jr. S. 1991).

There are experiments of the silvopastoral system in combinations such as rubber tree x puerária, and mango tree x wild plants. There are also silvopastoral experiments with coconut. The coconut palm tree is feasible for the silvopastoral system since allows the penetration of luminosity. Data as for the animal husbandry results are not available. In Acará, at the south of Belém, 160 trees/ha of coconut palm tree were planted in 3,600 ha of pastures, where the coconut palm trees with 8 years old produce approximately 10,000 fruits/ha/year.

At the Study Area, COSIPAR that is carrying out reforestation with eucalyptus, is experimenting the extensive cattle husbandry in eucalyptus reforestation areas. The eucalyptus is planted in the spacing 3 x 4m and are 1.5 to 2 years old, and the pasture has a

supporting capacity of 0.5 heads/ha.

(2) Planting for the Formation of a Living Fence at the Farm

The farm fences used to control the cattle management, made of wooden poles and wire, have an useful life of 4 to 15 years, thus needing a periodic renewal. This fence replacement by another formed by living plants allows the maintenance cost reduction, and besides this there are some species that can contribute to generate economic value in the form of food and roughage.

(3) Introduction of Forest Species Utilized as Roughage

In the Amazon region animal husbandry, experiments with forest species that can be used as roughage are difficult to find. The utilization of this type of species complements the roughage with proteins and also assures the supply of food even during the dry season, thus contributing to the development of the intensive animal husbandry and to the production sustainability. The possible leguminous species for this purpose are hereinafter listed.

Table 8.4-2 Leguminous Species for Roughage in the Amazon Region

Popular Name	Scientific Name	Origin	Leguminous	Characteristics
Caliandra	*Caliandra calothyrsus*	Native	*	Good for roughage. Grows in capoeira.
Cassia	*Cassia siamea*	Exotic	*	Good for roughage despite the low contents of protein.
Gliricidia	*Gliricidia sepium*	Exotic	*	Largely used for living fence.
Guandu	*Cajanun cajan*	Exotic	*	Good for roughage. Largely used in Central America.
Leucenas	*Leucaena leucocephala*	Native Exotic	*	Originating at the Occidental Amazon. Does not grow in acidic soil.
Leucenas	*Leucaena hibridos**	Exotic	*	A variety of the *Leucaena Leucocephala,* adapted to acidic soil.
Erythrina	*Erythrina spp.*	Native Exotic	*	Mainly utilized for fertilization. The toxic species requires special care to be utilized as roughage.

Source: Manual Agroflorestal para Amazônia. Instituto Rede Brasileira Agroflorestal. (REBRAF) 1996.

8.4.3 Application of Silviculture Technologies

(1) Selection of Forest Commercial Species

The commercial value forest species planted in the Amazon region until now include exotic species such as Eucalyptus, Pine tree, Caribaea, Gmelina, and recently Teak and African Mahogany. On the other hand, the native forest species are very assorted and more than 60 species are being utilized at the lumber-mills as commercial species. These species are classified into 5 groups according to the growth rate and the specific gravity in dry environment.

Table 8.4-3 Classification of Commercial species in the Amazon Region

Group	No. of Species	Specific Gravity in dry environment	Characteristics
A	10	0.4 ~ 0.5	Fast growth species.
B	8	0.5 ~ 0.7	Produces good quality wood for construction material and for furniture making.
C	6	0.7 ~ 0.9	Produces commercial value fruits besides good quality wood.
D	10	0.8 ~ 1.0	Produces wood for heavy structures presenting a high regional demand.
E	12	0.8 ~ 1.0	Produces high quality wood also with a beautiful texture. Also serves for heavy structures.

Group A: Fast Growth Forest Species

Most of these species such as Açacu, Sumaúma, Morototó, Parapará, etc. present a volume growth at a rate of 20m^3/ha/year, the tree canopy represents less than 50% of the whole tree, and more than half of the height is formed by straight trunk with high commercial value (SUDAM, 1977). Paricá, the species introduced in industrial reforestation by EIDAI and other companies, presents a good growth rate and is considered one of the most important species for reforestation among the fast growth species. The Paricá survival is confirmed at the frontier areas with forest species, and at the recently deforested areas in the Study Area.

Group B: Species that Produce Good Quality Wood for Construction in general and for Furniture Making

This group is represented by Andiroba, Mahogany and Red Cedar which are being largely planted. These species of *Meliaceae* present a relatively fast growth although tend not to grow straightly, being possible the attack of "broca", when planted in homogeneous and uniform system in open areas. In strongly deteriorated soil areas, the cultivation of Tachi Branco is efficient, being a leguminous with high nitrogen storage capacity.

Group C: Species that Produce Commercial Value Fruits besides Good Quality Wood

Castanha-do-Brasil is appropriate for the reforestation aiming at the recuperation of degraded areas since presents excellent characteristics in terms of straight growth, besides presenting a good volume growth of 24m^3/ha/year (SUDAM, 1977). Bacuri and Piquiá are utilizable for subsistence fruit cultivation or for landscaping, being useful for the capoeira enrichment and for the intercropped cultivation of forest species that can be industrialized such as rubber tree when the goal is the wood production.

Groups D and E: Species with High Specific Gravity in dry environment and that Produce Wood for Heavy Structures

In comparison to the other groups, these groups' species present a slow growth rate. These groups include several leguminous species, as well as the species of *Moraceae* and of *Sapotaceae*, among others. These species are important from the ecosystem preservation point of view since their seeds and fruits many times serve as food for birds, primates and small animals that live on the forest bed. It is thus efficient to introduce these groups' species, even in small amounts, in the enrichment system or in the heterogeneous reforestation system. As a

species presenting a relatively fast growth, an excellent straight growth and good for reforestation, we can mention the Tatajuba.

Taking into consideration the growth results and the access to commercial species seeds, the following 30 species shall be adopted for reforestation in the Study Area.

Table 8.4-4 Selection of Species for Reforestation in the Study Area

	Characteristics	Species Name
Native Species	Group A (fast growth rate)	Paricá, Faveira, Morototó, Parapará, Cuaruba, Sumaúma, Ucuúba
	Group B (produces good quality wood)	Andiroba, Red Cedar, Freijó, Mahogany, Tachi Branco
	Group C (produces fruits besides good quality wood)	Bacuri, Castanha-do-Brasil, Copaíba, Piquiá
	Group D (produces wood for heavy structures)	Angelim Pedra, Jutaí-Açu, Maçaranduba
	Group E (produces good quality wood)	Cumaru, Ipê Amarelo, Ipê Roxo, Jacarandá-do-Pará, Muirapiranga, Sucupira, Tatajuba
Exotic Species	Good for homogeneous reforestation	Eucalyptus
	Produces good quality wood	African Mahogany, Teak
	Produces wood and fruits	Jack fruit Tree

(2) Reforestation with Fast Growth Species and of the Uniform and Homogeneous System

The reforestation using fast growth native species present the following advantages: 1) costs for soil preparation are not high; and 2) large amounts of cheap seedlings can be produced from matrix trees within the object area. The species which seeds present a high germination rate can be submitted to the sod seeding in the rainy season. In case of juquira and sparse capoeira, they can be freely planted. In case of planting in large areas, care has to be taken in regard to the possible attack of diseases and pests. In this case, the planting area has to be divided into blocks up to tens of ha, far from each other. The adopted species can be selected from the group A, and can be utilized both in the homogeneous and the heterogeneous systems. Few species shall be selected for each block, and the reforestation shall be carried out in a planed and continuous fashion according to the goals established for a good yield in terms of wood volume. The reforestation using fast growth native species demands an easier technology, being the method that allows the recuperation of degraded areas without the need of many cultural treatments or high investments, besides not depending on the scale nor on the financial capacity of the executing agencies.

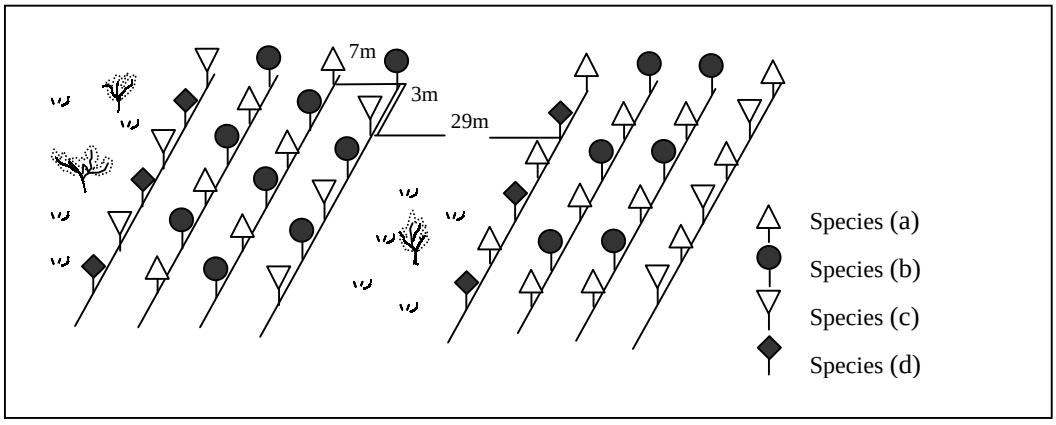
While the reforestation using fast growth native species is carried out in many cases such as in the communal silviculture, the uniform and homogeneous reforestation using exotic species such as Eucalyptus is propitious for large-scale enterprises. The uniform reforestation using Eucalyptus is being carried out for many years in the Study Area by the COSIPAR metallurgical company among others. The large amount of Eucalyptus seedlings are being produced in the forest nursery center with an installed equipment for the automatic control of humidity, while in parallel the selective genetic improvement is being carried out with technologies brought from the south of the Country in order to carry out the reforestation in the scale of thousands of hectares. The species planted as experiment, *Eucalyptus grandis*, can

suffer the attack of diseases and pests, and the improved species, *Eucalyptus urograndes* (hybrid of *Eucalyptus grandis* and *Eucalyptus urophylla*) presents a fast growth and is being considered a promising species. The COSIPAR reforestation objective is to produce vegetal charcoal necessary for the production of pig iron. There is however the future possibility of exporting wood through the Carajás railway.

The technology applied in the reforestation using fast growth native species and that one applied in the uniform reforestation using eucalyptus present a strong contract. The first one aims at the improvement of forest quality through the planting in degraded areas, and the second one represents an advanced intensive silviculture, that demands the mechanized soil preparation, the soil correction including its acidity correction using lime, the application of fertilizers, the elimination of weeds, the elimination of ants, and the installation of fire prevention corridors, what results in a high cost per hectare. However, the invested capital can be recovered when the logging time comes, after 7 to 8 years.

(3) Heterogeneous System Reforestation and Taunya System

The cultivation is carried out in strips, utilizing species selected from the native species groups A to E, as well as from the group of exotic species with good quality wood. The species combination is determined according to the number of each species seedlings to be planted. In degraded pastures and juquira, the proportion between the pastures strip (juquira strip) and the forest strip can vary, in accordance with the animal husbandry activity. In capoeira and capoeirão, the reforestation of the enrichment system through the cultivation in lines can be introduced. This cultivation method, feasible for small- up to large-scale producers, will be the main option for the heterogeneous reforestation. According to the following Figure, the forest species (a) in order to be planted in large amounts can be selected among the fast growth species, (b) and (c) among the commercial species that produce good quality wood, and (d), in smaller amounts, among the slow growth species or the experimental species.



Some examples of native species combinations that can be adopted are presented as follows.

	Species (a)	Species (b)	Species (c)	Species (d)
Example 1	Paricá	Mahogany	Castanha-do-Brasil	Tatajuba
Example 2	Paricá	Faveira	Mahogany	Castanha-do-Brasil
Example 3	Faveira	Mahogany	Cedar	Tatajuba
Example 4	Faveira	Paricá	Teak	Mahogany

When this method is applied in capoeira, the native vegetation has to be cut in a width of 1 to 2 m along the planting line, as well as the simple preparation of soil has do be done. The species shall be selected taking into consideration the luminosity conditions. Where the capoeirão phase is clearly seen, trails 2 to 3 m wide have to be opened and rings of bark shall be taken of the trunk (girdling) in order to form an appropriate environment for planting, what allows the plating in lines.

In this system, in the first years of the project, the cultivation of annual products in the inter-spaces of the planted forest species is carried out. For this, soil preparation including soil correction is carried out utilizing machinery, before planting the forest species. The main objective of introducing annual crops is the establishment of the agrosilvipastoral system through the soil improvement. The pastures reform is possible to be concretized through their implementation carried out together with maize cultivation in the third and forth years, after the cultivation of mainly leguminous species. It is proved that the pastures reformed in this fashion acquire a cattle supporting capacity more than the double of the usual one. The Taunya system reforestation is applicable to medium- and large-scale producers having conditions to carry out the mechanized cultivation.

(4) Inter-cropping Heterogeneous Reforestation using Rubber tree

The rubber tree, an Amazon region's native species which is being widely planted in this region, is selected to implement rubber tree plantations. Although there is no experience of rubber tree plantation in the Study Area, the implementation of such plantations in small-scale would be efficient in order to promote the organization and the permanence of settled small-scale farmers. The planting of native forest species will be carried out in different periods, considering that the forest environment of the rubber tree plantation after 5 to 6 years of its cultivation propitiates the growth of native forest species. The heterogeneous reforestation intercropped with rubber trees aims at the collection of latex while the introduction of forest species aims at the shadowing of agricultural products and the reduction of ecological hazards, besides wood production.

8.5 Models for the Recuperation of Degraded Areas

8.5.1 Typification of Models according the Agricultural Activity Manner and Scale

The Study Area producers develop activities that vary in manner and scale. The measures to be adopted for the recuperation of degraded areas are thus also various. In order to concretize the sustainable land use, recuperating the degraded areas, the alternatives for an adaptable land use for each manner and scale of agricultural activity have to be analyzed. The land use in the Amazon region according to the scale and financial capacity is classified as follows.

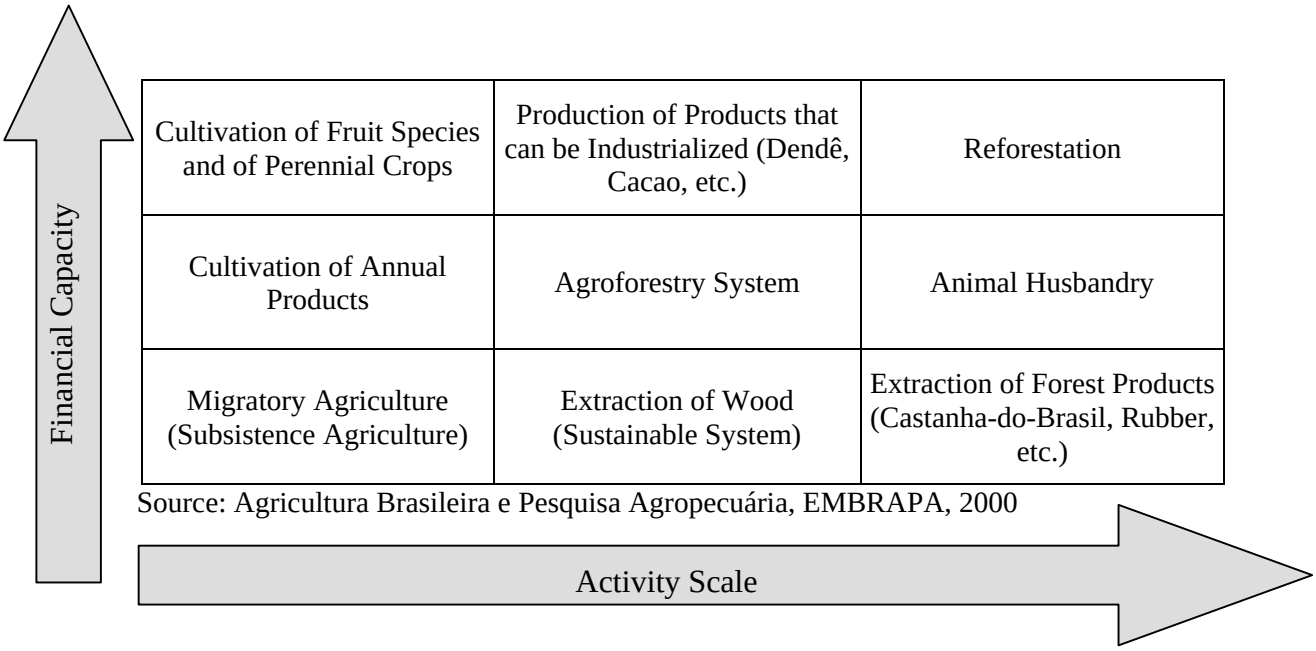


Figure 8.5-1 Land Use according to the Financial Capacity and the Activity Scale

The applicable models for the recuperation of degraded areas in different activities are herein on listed.

(1) Model 1: Inter-cropping Cultivation of Fruit Species using Irrigation (Cupuaçu x Passion Fruit) (From the 7th year on, the reforestation of shadowing forest species which are utilizable as roughage is carried out)

In the inter-spaces among the Cupuaçu plants and where the irrigation facilities are placed, the Passion fruit is cultivated, being adopted for shadowing the Cupuaçu. Passion fruit requires a high initial investment once, being a herbaceous plant, needs poles and wire, although its profitability is also high. The 555 plants/ha of Passion fruit produce approximately 15,000 kg/ha/year of fruits. The 277 plants/ha of Cupuaçu produce 3,575 kg/ha/year. The total gross revenue is R$ 1,475/ha/year. The initial investment and the annual operation and maintenance costs are R$ 728/ha and R$ 380/ha/year, respectively.

(2) Model 2: Cultivation of Agricultural Products Inter-cropped with Fruit and Arboreous Forest Species (Rice, Maize, Feijão bean x Banana, Cupuaçu, Castanha-do-Brasil)

This is a model composed by 3 harvests per year of agricultural products cultivated in the inter-spaces of shadowing trees which are utilizable as roughage. As for the arboreous forest species, considering the shadowing of Cupuaçu, the Castanha-do-Brasil is adopted. The Castanha-do-Brasil is a native species at the Study Area and tends to become scarce in the region. This tree's trunk grows straightly and its produces fruits. The planting spacing is 20 m for Castanha-do-Brasil, 6 m for Cupuaçu, and 3 m for Banana. A gross revenue of R$ 580/ha/year for the agricultural products and R$ 470/ha/year for fruits is expected. The total gross revenue is R$ 1,050/ha/year. The initial investment and the annual operation and maintenance costs are R$ 236/ha and R$ 380/ha/year, respectively.

(3) Model 3: Agricultural Products Inter-cropped with Trees Utilizable as Roughage (Rice, Maize, Feijão bean, Pineapple x Cupuaçu)

This is a model with 3 harvests a year of agricultural products cultivated in the inter-spaces among the shadowing trees which are utilizable as roughage, and its target-public are the small-scale farmers. The agricultural production is 150 kg/ha of Rice, 1,800 kg/ha of Maize, and 450 kg/ha of Feijão bean. As for fruit species, the Pineapple yield is 10,000 kg/ha and the Cupuaçu yield is 3,575 kg/ha. The gross revenue of the agricultural products is R$ 580/ha/year, and of the fruits is R$ 380/ha/year. The total revenue is R$ 960/ha/year. The initial investment and the annual operation and maintenance costs are R$ 184/ha and R$ 380/ha/year, respectively.

(4) Model 4: Silvopastoral System Inter-cropped with Coconut, etc. (Coconut, Neem, Trees Utilizable as Roughage x Braquiária)

The pasture is implemented in the inter-spaces among Coconut, Neem and trees utilizable as roughage. As silvopastoral system inter-cropped with fruit species, being the target public the medium- and large-scale producers, the combination of pasture and coconut plantation with good commercialization conditions is adopted. The Coconut production, starting from the 4th year on, is of 6,760 fruits from 52 plants/ha, generating a gross revenue of R$ 676/ha. On the other hand, the gross revenue from the Nelore cattle is of R$ 150/ha. The initial investment and the annual operation and maintenance costs are R$ 127/ha and R$ 300/ha/year, respectively.

(5) Model 5: Reform of Pastures using Babaçu, etc. (Babaçu, Trees Utilizable as Roughage x Braquiária)

The pasture is implemented in the inter-spaces among the Babaçu and the trees utilizable as roughage, then the Buffalo who eats the young babaçu is introduced. At the eastern portion of the Study Area, large areas of pastures are degraded, being transformed into babaçu areas. The babaçu area is utilized for the silvopastoral system through the reduction of babaçu palm trees without utilizing fire. The babaçu is cut using a mechanic excavator in order to attain a density of 100 plants/ha, then the pasture is seeded when the trees utilizable as roughage are taller than 2 meters. The gross revenue is R$400/ha/year of which revenue from Buffaloes is of R$ 150/ha. The initial investment and the annual costs of maintenance are R$ 71/ha and R$ 300/ha/year, respectively.

(6) Model 6: Reforestation using Fast Growth Species (Reforestation with Parika)

Parika is planted as the most viable native species for the reforestation using fast growth species. There are several cultivation methods, from the free cultivation without any soil preparation cost until the regular spacing cultivation, for instance 5 m x 4 m. 500 plants/ha of Parika shall be planted in juquira or sparse capoeira. Half of the planted trees will be exploited at 13 years in order to get a gross revenue of R$ 2,275 with 91 m^3/ha of extracted wood. At 20 years, all the trees will be cut in order to obtain a gross revenue of R$ 4,275 with the extraction of 171 m^3/ha of wood. The annual average gross revenue is of R$ 328. The initial investment, annual operation and maintenance costs, as well as the wood extraction costs are R$ 44/ha, R$ 43/ha/year and R$ 105/ha/year, respectively.

(7) Model 7: Heterogeneous Inter-cropped Reforestation (Several Manners of Strip Planting)

The heterogeneous reforestation in strips is applicable from the introduction of the silvopastoral system to the enrichment of capoeira and capoeirão. Forest species are planted in 4 strips 7 m wide each and with spacing of 3 m, establishing a forest strip 21 m wide and a fallow area 29 m wide (pastures/juquira). The number of trees to be planted per hectare is 98 plants for the forest species (a), 82 plants for the species (b), 51 plants for the species (c), 33 plants for the species (d), amounting to 264 plants/ha.

The extraction of Paricá takes place 13 years after planting, together with the logging of 50% of the Castanha-do-Brasil trees. 25 years later, the partial logging of Mahogany and Tatajuba is carried out for regeneration together with the total logging of the Castanha-do-Brasil trees. A loss of 30% of all the species is expected. The length of the extracted wood is 7 meters for all the species. The gross revenue is of R$ 377/ha/year. The initial investment, the annual costs of operation and maintenance and the wood extraction costs will be of R$ 21/ha, R$ 50/ha/year and R$ 94/ha/year, respectively. On the other hand, the gross revenue with livestock husbandry will be of R$ 46/ha/year and the initial investment and the annual costs of management will be of R$ 12/ha and R$ 31/ha/year, respectively.

(8) Model 8: Heterogeneous Reforestation in the Taunya System

The cultivation manner will be in accordance with the heterogeneous inter-cropped reforestation. Soil preparation is carried out using machinery for the cultivation of forest species and the mechanized cultivation of annual crops in the inter-spaces of planted trees and in the forest strips. The introduction of annual products aims at not only a complementary income but also at the soil improvement effect. Soybean is cultivated in the 1st a 2nd years, Feijão Caupi in the 3rd year, Maize in the 4th year together with the implementation of pastures, putting the cattle on the pastures from the 5th year on. The volume of extractable wood is equal to the model 7. Besides this, this model also includes a gross revenue from annual products and livestock husbandry. The gross revenue from wood will be of R$ 377/ha/year and the initial investment, the annual operation and maintenance costs as well as the wood extraction costs will be of R$ 17/ha, R$ 47/ha/year and R$ 94/ha/year, respectively. The agricultural products will generate a gross revenue of R$ 112 $\pm$ 37/ha/year, with an initial investment and annual operation and maintenance costs of R$ 82/ha and R$ 38/ha/year, respectively. As for livestock husbandry, the gross revenue will be of R$ 89/ha/year and the initial investment and the annual operation and maintenance costs will be of R$ 24/ha and R$ 49/ha/year, respectively.

(9) Model 9: Heterogeneous Intercropped Reforestation using Rubber Tree

The heterogeneous inter-cropped reforestation using rubber trees is carried out. At first, the rubber trees seedlings are planted in a spacing of 7 x 3 m, in the proportion of 476 plants/ha, and 5 years later the forest species (a) and (b) are planted in the inter-spaces among the rubber trees, obtaining 119 plants/ha for each, amounting to 238 plants/ha. From the 6th year on, the small-scale latex processing is started, which is operated by a group of 30 producers. A lower quality rubber (“cernambi”) is also produced since it is easy to be processed in the producer’s own property. As forest species, Faveira will be adopted as species (a) and Andiroba as the species (b). In case the total logging is carried out 20 years later, a gross revenue of R$ 4,956

from 99 m^3/ha of Faveira and R$ 3,040 from 60 m^3/ha of Andiroba is obtained. The annual average gross revenue is of R$ 320. The initial expenses, the annual operation and maintenance costs as well as the wood extraction costs will be of R$ 15/ha, R$ 6/ha/year and R$ 102/ha/year, respectively. As for rubber, the gross revenue from latex will be of R$ 1,027/ha/year and the initial expenses as well as the operation and maintenance costs will be of R$ 34/ha and R$ 69/ha/year, respectively. The gross revenue from "cernambi" will be of R$ 504/ha/year, and the initial expenses and the annual costs of operation will be of R$ 34/ha and R$ 69/ha/year, respectively.

(10) Model 10: Uniform and Homogeneous Reforestation using Exotic Species (Reforestation using Eucalyptus)

The uniform and homogeneous reforestation, mainly using Eucalyptus, will be carried out mainly by companies and large-scale producers. After soil preparation using tractors and other heavy machinery, 1,111 plants/ha of Eucalyptus will be planted. In the homogeneous and uniformed reforestation experiences carried out in the Study Area, an improved species *Eucalyptus urograndes* (hybrid of *Eucalyptus grandis* and *Eucalyptus urophylla*) is utilized. This species, which presents a fast growth, will be also adopted for the present model. Although the expenses per hectare are relatively high, the investment return is possible in a short term of 7 to 8 years when the logging point is reached. The reforestation using Eucalyptus in the Study Area supplies raw material for vegetal charcoal necessary for the metallurgical companies. When completely logging at 7 years, a gross revenue of R$ 2,632 from 300 m^3/ha of extracted wood is expected. The average gross revenue is of R$ 376/ha/year. The initial expenses, the annual operation and maintenance costs, and the wood extraction costs will be of R$ 166/ha, R$ 48/ha/year and R$ 105/ha/year, respectively.

The general table of the degraded areas recuperation models, the target producers, and the type of degraded areas is presented as follows.

Table 8.5-1 Models of Degraded Areas Recuperation and the Target Public

Model	Measures for Recuperation	Producer Scale			Type of Degraded Area			
		S	M	L	Juquira	Capoeira	Capoeirão	Babaçuzal
1	Cultivation of Inter-cropped Fruit Species with Irrigation	○	◎		◎	○		
2	Cultivation of Agricultural Products Inter-cropped with Fruit and Forest Species	○	◎		◎	○		△
3	Cultivation of Agricultural Products Inter-cropped with Forest Species Utilizable as Roughage	◎	◎			◎	◎	○
4	Silvopastoral System Inter-cropped with Coconut, etc.	○	◎	◎	◎			
5	Silvopastoral System Utilizing Babaçu, etc.	◎	◎	○		○	○	◎
6	Reforestation using Fast Growth Species and of the Silvopastoral System	○	○	○	◎	○		
7	Heterogeneous Inter-cropped Reforestation and of the Silvopastoral System	○	○	◎	◎	◎	○	△
8	Heterogeneous Reforestation of the Taunya and Silvopastoral Systems		○	◎	◎	◎	○	○
9	Heterogeneous Inter-cropped Reforestation using Rubber Tree	◎			○	○		

10	Homogeneous and Uniformed Reforestation using Exotic Species			○	○	○		

Remark: ◎ very much applicable, ○ very applicable, △ applicable

8.5.2 Supporting Technologies for the Implementation of Recuperation Models

(1) Improvement of Soil Conditions

In the Study Area, fertilizers have to be applied to the soil due to the low fertility, what hinders the implementation of models due to the high costs. In Tomé-açu, residues of processed fruits at the agroindustrial unit are used for the production of organic compost aiming at the reduction of the fertilization cost. The small-scale producers of the Study Area generally carry out several activities from the cultivation of annual crops in the slash-and-burn system to the animal husbandry, thus they can use animal manure as organic fertilizer.

(2) Leguminous Plants and Fertilization

In the humid tropical region, the soil is easily deteriorated through the lixiviation of nutrients contained in the soil caused by the large amount of rainfall. On the other hand, the Amazon region's soil is, in general, extremely acid. In order to recuperate the degraded areas in this region, the introduction of leguminous plants that contribute for the retention of nitrogen and have leaves and fruits utilizable as roughage is efficient. The leguminous plants have the functions of storing the nitrogen contained in the environment by means of bacteria of the rooting system symbiotic nodules, improving the nutrients contained in the soil. Apart from this, the leguminous plants manage to provide protein and essential amino acid, scarce substances in herbaceous plants, thus supplying an essential source of nutrients for livestock husbandry. Upon the introduction of leguminous plants, the nitrogen shall be reduced as much as possible (NPK: 4 – 30 – 16 + Zn), and the increase of phosphorus quantity is important. The utilization of chicken manure is efficient since it contains lots of phosphorus. The application of 2 ton/ha of lime is also important to correct the soil pH level about 30 days before planting.

(3) Irrigation during the Dry Season

In the whole Study Area, mainly at the eastern region, the water deficiency is remarkable, thus the cultivation during the dry season requires irrigation. There are farmers that do not utilize irrigation, but in general the irrigated cultivation of fruit species shows better results. The irrigation system usually utilized in the Study Area is simple, using pipelines and a pump.

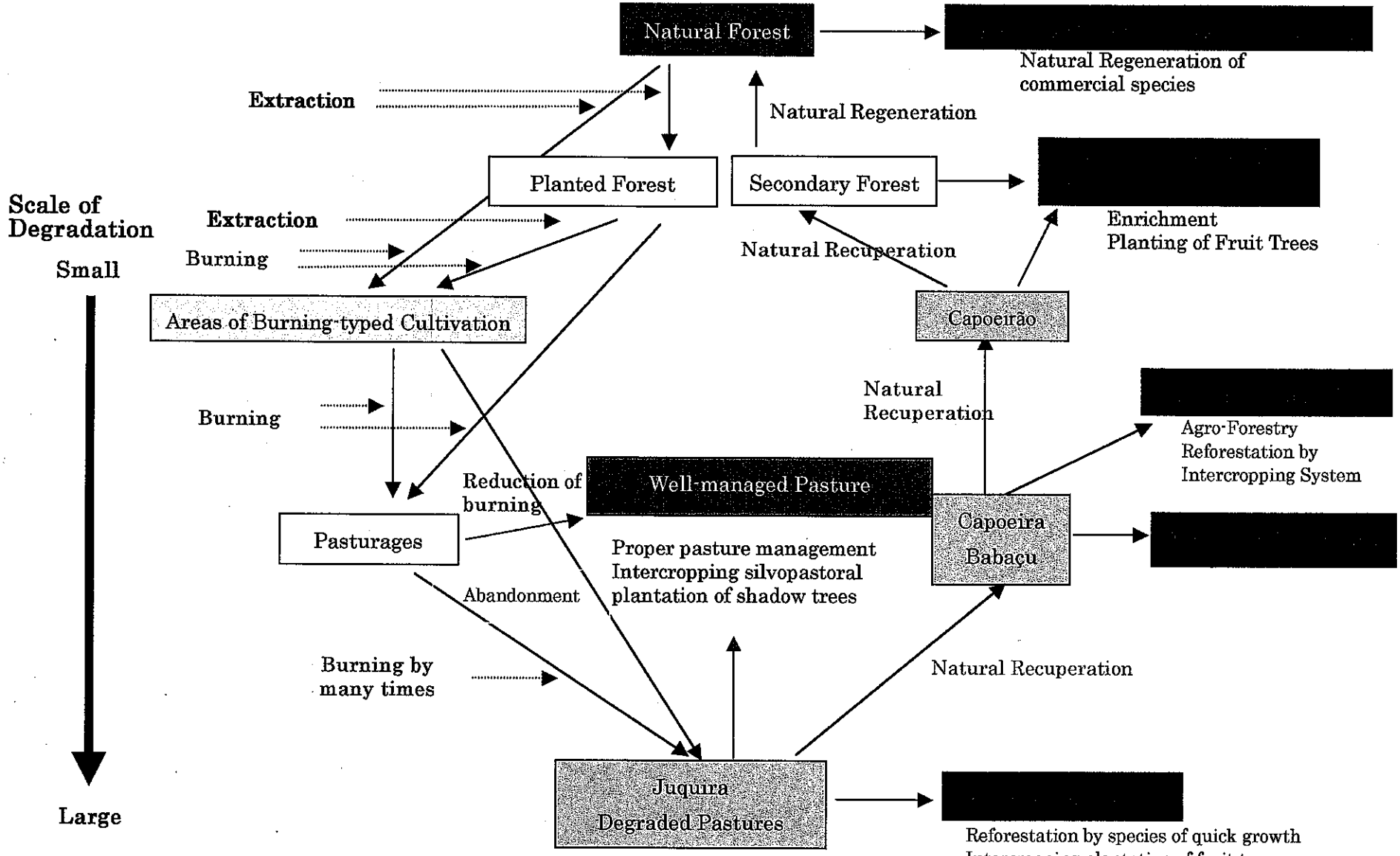


Fig. 8.3-1 Basic Concept of Degradation Process and Recuperation of Degraded Areas