

Cirad-forêt/Forêts Naturelles



Centre
de coopération
internationale
en recherche
agronomique
pour le
développement

Département
des forêts
Cirad-forêt

Programme
forêts naturelles

Rapport de mission au Brésil Du 24 février au 03 mars 2000

Projet de coopération Cirad-forêt - EMBRAPA

Plinio Sist

03 avril 2000

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Cette mission avait pour but d'assister à l'atelier d'ouverture du projet Dendrogene et de finaliser la proposition de coopération Cirad-Forêt-Embrapa rédigée en Novembre 1999 lors de ma dernière mission à Belem. Un premier rapport concernant l'atelier Dendrogene a été rédigé conjointement à J-M. Bouvet et L. Maggia. Ce document concerne donc uniquement la seconde partie de ma mission (24/02 au 03/03).

La proposition de projet appelée PCT (Proposição de Cooperação Técnica) a été revue et commentée par les chercheurs de l'EMBRAPA. Cette coopération a pour vocation de définir et développer des actions de recherche dans le domaine de l'écologie forestière et la sylviculture s'insérant au sein de projets déjà existants de l'EMBRAPA. Les principaux commentaires et suggestions des chercheurs de l'Embrapa portaient essentiellement sur les points suivants :

1. Préciser dans les détails les modalités d'intégration du projet au sein des autres projets de l'Embrapa
2. Développer des activités de recherches en relation avec le projet Dendrogene dans le domaine de la génétique des populations et de l'écologie des populations (notamment la définition des groupes écologiques)
3. Tenir compte de la nouvelle structuration du département forestier de l'Embrapa et des différents projets en cours.

En tenant compte de ces remarques, de nouveaux paragraphes concernant notamment l'étude de la génétique des populations ont été rajoutés à la version de novembre 1999 (en caractères gras sur le document, voir Annexe 1). Lors de la première journée de l'atelier concernant la restructuration du département forestier, il m'a été demandé de présenter le projet oralement (voir annexe 2).

Le premier objectif du projet est d'étudier l'impact des pratiques sylvicoles sur la composition et la diversité spécifique des espèces d'arbres au cours de la dynamique forestière après exploitation et traitements sylvicoles. Cette étude s'appuiera sur le concept des groupes écologiques basés sur le comportement des espèces (par exemple, espèces héliophiles pionnières ou espèces héliophiles primaires etc..). Ce concept a d'ailleurs été largement discuté lors de l'atelier du projet dendrogene pour la sélection d'espèces commerciales représentatives. Il existe une littérature très abondante sur ce sujet et une revue bibliographique s'avère donc nécessaire. Le second objectif est d'étudier l'impact de l'exploitation et des traitements sylvicoles sur l'écologie et la structure génétique des populations des espèces d'arbres à intérêt commercial. Le projet Dendrogene ayant défini 10 espèces prioritaires, les espèces à étudier seront en premier lieu choisies au sein de cette liste.

La proposition de projet devra être approuvée par la direction de l'Embrapa Belem puis envoyée à son Secrétariat de Coopération Internationale (SCI) à Brasilia. Enfin le SCI devra transmettre cette proposition à l'ABC (Agencia Brasileira de Cooperação) instance gouvernementale seule habilitée à officialiser cette coopération entre le Cirad-Forêt et l'Embrapa.

Annexe 1**PROJETO DE COOPERAÇÃO TÉCNICA EMBRAPA/CIRAD****1. Identificação do Projeto**

1.1. *Título:* **Improving harvesting techniques and silviculture of terra firme forests in Eastern Amazon**

1.2. *Duração prevista:* 3 Anos

1.3. *Fonte externa:* Cirad-Forêt, França

1.4. *Custo estimado*

| | |
|------------------------|--------------|
| Recursos externos: | US\$ 457,200 |
| Contrapartida nacional | US\$ 335,000 |
| TOTAL | US\$ |

1.5. *Entidade Proponente*

Embrapa Amazônia Oriental
Trav. Dr. Enéas Pinheiro s/n
66.095-100 Belém – Pará - Brasil
Tel: 0XX 91 276-6333
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1.6. *Entidades co-participantes*

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2. Justificativa

2.1. Diagnóstico da situação

Harvesting techniques and silviculture treatments have a major impact on forest structure, dynamic processes and productivity (Uhl and Veira 1989, Bertault and Sist, 1995, 1997, Pinard and Putz 1996, Johns *et al.* 1996, Sist *et al.* 1998). Mechanised harvesting, if uncontrolled, can have the high damaging effect on forest structure, composition and regenerating capacity (Nicholson 1979). Forests are not only a valuable source of timber but also provide a wide range of non-timber forest products as well as major environmental services. The principle of sustainable forest management is to harvest the natural forest resource without compromising its social and ecological value. Minimising the effect of harvesting damage must be therefore one of the main requirement for achieving sustainable forest management. It is now recognised that reducing harvesting damage to both forest and soil can shorten the felling cycle length because it ensures better natural regeneration and growth of the desired commercial species (Putz 1994). Because of their tremendous consequences on future forest dynamics processes and, therefore on future production, harvesting is now considered as the first most important stage of natural forest silviculture.

Forest dynamics studies conducted in neotropical forests showed that few years after harvesting, growth of commercial species decrease dramatically making post harvesting silvicultural treatments necessary (De Graaf, 1986, Silva 1989, Silva *et al.* 1995, Finegan *et al.* 1999). For this reason, combination of both RIL and silvicultural treatments are likely to be promising tools to reduce in a more significant way the rotation cycle than RIL alone.

Research carried out by Cirad-Forêt in French Guiana and by Embrapa in Eastern Amazon led to set up Growth and Yield models able to predict the forest production and productivity for future cycles (Favrichon 1998, Silva *et al.* 1995). In tropical lowland forests, a very large number of tree species occur together (150 to more than 200 species / ha, for tree > 10 cm DBH, Whitmore 1984, Richards, 1996) and the responses to forest disturbance are very variable from one species to another. The majority of these species are generally represented by few individuals within a limited area such as in permanent sample plots. Several authors attempted to group tree species according to their ecological behaviour or so called temperament by Oldeman and van Dijk (1991). Van Steenis (1958) distinguished "biological nomads" species which need gap to regenerate and thus are continuously moving and growing in scattered gaps, and, by contrast with "dryads" able to remain permanently in high forests. Swaine and Whitmore (1988) differentiated two main groups: pioneer species which require full penetration of sunlight to the forest floor for the germination of seed and establishment of seedlings and non-pioneer shade tolerant species called also climax species which are able to germinate and establish under closed canopy. However, this contrasting and broad classification of tree species are too simple to reflect the ecological behaviour of trees in tropical forests. Temperaments of trees are not simple categories linked to light requirement or gap size, but result from complex strategies adapted to broad environmental changes during their time life. In the pioneer or nomads groups, it is now accepted to distinguished short and long life pioneer species (Van Steenis, 1958). Within the climax species group, light requirements of trees are ranged along an increasing gradient, from the most shade-tolerant species (mainly small understorey trees never reaching the canopy) to semi-tolerant climax species, which need substantial solar radiation for release and growth. Taking this into consideration, several authors proposed more detailed classifications. Favrichon (1998) distinguished five groups: 1. Shade-tolerant trees of the understorey or inferior strata, 2. Shade-tolerant trees of the canopy, 3. Partly shade-tolerant emergent trees, 4. Light demanding canopy trees, 5. Pioneer trees. The analysis of architectural patterns of trees is also a promising approach to understand tree temperament (Hallé and Oldeman, 1970, Hallé *et al.* 1978). However, in primary forest environmental conditions, particularly light intensity and soil exposure, are not always constant and change, sometimes in a drastic way. For this reason tree architectures alone cannot reflect tree adaptability to these environmental changes during their development (Oldeman and van Dijk, 1991). Oldeman and van Dijk, therefore proposed 6 different groups of temperaments, taking into account both architectural modelas and spatial arrangement of leaves and shoots. Those groups are: 1. Hard

strugglers (highly shade tolerant), 2. Strugglers (shade-tolerant), 3. Gambling strugglers (partly shade-tolerant), 4. Struggling gamblers (light demanding), 5. Gamblers (Pioneer tolerating some shade in late development stages) and 6. Hard gamblers (strictly pioneer). *Although light is recognised as the main factor in the growth of trees, soil properties, such as drainage and fertility, play as well a very important role that must be considered.*

The goal of silvicultural treatments is to promote the growth of selected commercial species. However, these treatments have been, so far, applied in a very global approach considering trees as a whole population rather than based on our knowledge of the temperament of the species to be favoured. Improving our knowledge on tree temperament will undoubtedly lead to define high performance silvicultural treatments (Oldeman and van Dijk, 1991).

The genetic structure and diversity of a given tree population is maintained mainly by the reproductive pattern of the species which ensure migration of genes through pollination and seed dispersal. Any modifications of the ecosystems such as those occurring after logging will have important consequences on the population genetic structure of the species (Namkoong et al. 1996). This, of course, will depend on the intensity of changes and how the reproductive patterns of the species can be adapted to its new environmental conditions. Selective logging removes only the biggest trees of commercial interest which are, in a biological point of view, adult trees ensuring the reproduction of the species. After logging, distances between adult trees may be increased in such a way that pollen dispersal become inefficient. This will result in a decreasing of outcrossing rates and, therefore, a reduction of genetic diversity. Seed dispersal is another important mechanism of genetic exchange between populations. In neotropical primary forests, 80 % of the trees depend on animal for their seed dispersal. Logging, is likely to affect, for example, moving of animals living in the canopy, such as monkeys. To understand the impact of logging on population genetic structure, it is important to analyse and to monitor the temporal and spatial dynamic of genetic structure. The last decade has seen rapid advances in molecular biology leading to set up new methods to study population genetic structure and dynamics. However, our knowledge of the impact of logging on the intraspecific genetic diversity of trees is still very poor and more research on case study species is needed.

Our knowledge on how forest harvesting operations and silviculture affect tree species composition during forest dynamics phases is still very poor. Because of the extremely high species diversity of tropical forests, guild of species or group of species may be the most practical taxonomic unit to be used in this field of research (Stork et al. 1997). It is therefore expected that this research co-operation between Cirad and Embrapa could be extended to assess in a practical way the impact of forest management practices on forest biodiversity. This study is likely to provide an important contribution for the definition of verifiers of criteria and indicators for assessing sustainability of forest management in eastern Amazon.

2.2. Situação esperada ao término do Projeto

- *Concept of ecological groups reviewed*
- Knowledge of the ecological behaviour and *population genetic structure* of the selected commercial tree species is improved.
- Sustainable silvicultural practices are proposed and tested in the field based on the results of the research
- Research co-operation between Cirad and Embrapa strengthened
- *Financial supports other than those provided by Cirad and Embrapa are found*

2.3. Descrição do projeto

This project aims to provide research support to existing projects carried out by EMBRAPA. For this reason, each research activity is related with the objectives of these projects.

Cirad-Forêt in French Guiana and EMBRAPA in Eastern Amazon, have developed an important tree data base from their respective experimental plots. Ecological groups will be defined based on the analysis of these available data, through the ordination of variables such as, tolerance to light during development, growth rates, maximum diameter size, and mortality rates. For each group the ecology of one or two representative species will be studied in the field (regeneration, demography, seed dispersion and predation, reproductive biology). The main criteria for selecting a species will be as follows:

- ◆ Species with commercial interest
- ◆ Species representative of one functional group in regards to the group variables (light requirement, mortality rates, growth rates, maximum diameter, diameter distribution of tree population, *architectural models*)
- ◆ Scarce data on ecology not or poorly available
- ◆ Linkage with other project

An important criterion for selecting the species will be a linkage with other projects (last one in the list). *During the opening workshop of the DENDROGENE project, participants agreed on a list of ten commercial species representing three ecological groups (pioneers, climax shade tolerant and climax light demanding species, see annex). These species, which are also included in other projects carried out by EMBRAPA such as the project "Structure and growth of natural forests in Amazon", will be therefore considered in priority for this study. The concept of ecological groups was largely discussed during this workshop and more research is certainly needed to define appropriate guild species. The literature review and definition of ecological groups proposed in this research proposal is therefore very relevant to Dendrogene project.* This literature review aims to 1) synthesise our knowledge in this research area and 2) to identify relevant problematic to be answered in this project. This literature review will also lead to define suitable ecological groups integrating silvicultural, ecological and architectural approach.

The impact of logging and silviculture on the genetic structure of the population of the selected commercial species will benefit from the experience of genetic research carried out in collaboration French Guiana by Cirad-Forêt in the experimental site of Paracou. It is planned that geneticists from Cirad-Forêt based in French Guiana will realise short-term visits to collaborate in this project.

Potential areas for this research are in priority existing experimental sites of EMBRAPA where harvesting techniques and silvicultural treatments have been tested. A good knowledge of the forest composition and conditions before and after harvesting is a pre-requisite for this study. Those sites are: Moju, Tapajos, Jari, Tailandia and Cauaxi. It means that the research proposed here will be carried out in the framework of existing EMBRAPA's projects.

Embrapa and Cirad-Forêt agreed that this project is also a preliminary phase which should be partly dedicated to strength and develop this research co-operation program according to new opportunities which may arise during this period. In Brazil, eco-certification of wood has called the attention of several harvesting companies which are now interested to involve forestry research institutes in the assessment and the improvement of their forest management systems. These new opportunities to develop research activities in on going Embrapa projects will be actively investigated during this phase. This project also aims to address the preoccupation of many organisations regarding the impact of forest harvesting operations on forest biodiversity. It is therefore expected that this research could be extended and applied at a larger scale (experimental scale to operational/industrial scale) with the financial support of organisations such as FFEM, French Ministry of Foreign Affair, French Embassy.

The results of this research must lead to define appropriate silvicultural practices for the studied species, in natural terra firme forests of Eastern Amazon. Forestry sector, policy makers and

harvesting companies are therefore one of the main beneficiaries of this research. The scientific community will benefit from the publication of the results as well as the organisation of a seminar/workshop at the completion of this first phase of the project.

2.4. *Quadro institucional*

This project of research co-operation is proposed under the agreement of the Memorandum of Understanding (MoU) signed between EMBRAPA and Cirad. A Cirad office is already available within the premises of EMBRAPA Amazonia Oriental Research Center. EMBRAPA's infrastructure will be offered to achieve the objectives of the co-operation project.

At least one scientist of EMBRAPA will be assigned as counterpart to Cirad scientist designated to the project. Three other Embrapa's scientists are also expected to contribute for the development of the present cooperation project (see list). Dr. Plinio Sist will be assigned as a permanent scientist of Cirad-Forêt and coordinator of the project (see CV attached). Specific technical support missions of researchers from Cirad-Forêt based in French Guiana or in Montpellier as well as visit of EMBRAPA scientists from Brazil to French Guiana or France will be organised to strengthen collaboration and promote scientific exchange between EMBRAPA and Cirad-Forêt.

As it was stated above, this project aims to develop activity research within on-going projects of Embrapa. Several projects have been already identified as potential frameworks to develop the research activities proposed in this document. These projects are:

Dendrogene

Jurua Project (Embrapa/Cifor/ITTO)

Structure

"Estrutura e crescimento de florestas naturais na Amazônia"

Mahogany project

Dendrogene project aims to develop simulation models able to assess the impact of forest management practices on genetic diversity at the species level. The ecological and genetic approach proposed in the PCT has been recognised as a complementary research for this project. *Study on the impact of logging and silviculture on the population genetic structure of case study could be carried out in cooperation with the dendrogene project. In French Guiana, Cirad-Forêt has set up laboratory infrastructure integrating new molecular techniques of investigation (RAPD and micro-satellite). Research cooperation between researchers based in French Guiana and scientists from Embrapa involved in Dendrogene project is therefore expected to be strengthened by scientific exchanges and short-term missions in French Guiana and Brasil. Dendrogene project also aims to improve forest management decision and techniques by improving our knowledge on the ecology of commercial species. Studies on the impact of logging and silviculture proposed in the present project will therefore provide complementary information to Dendrogene database.*

The present proposed research co-operation is as well be an important contribution to the research activities carried out in Embrapa projects on the impact of logging and post-harvest silviculture. This is the case of the recent Jurua project, carried out jointly by Embrapa and Cifor in Tailandia and funded by ITTO. This project aims to develop viable Criteria and Indicators suitable for monitoring and auditing forest management practices. As it was mentioned above, important information on the impact of silvicultural systems on biodiversity may be obtained at the guild level. Because of its ecological species groups approach, the Cirad/Embrapa research cooperation proposed here, can strongly contribute to the achievement of the objectives of the Jurua project. For this reason Cirad-Forêt has been already identified by both Embrapa and Cifor as a potential partner.

Studies on the ecology of the selected commercial species are relevant to the project of Embrapa "Estrutura e crescimento de florestas naturais na Amazônia" which gathers 6 sub-projects. The main objective of this project is to improve our knowledge of the structure and growth of natural forest in Amazonia to implement models of rational use of the forest resources (= da estrutura e do crescimento de florestas naturais na Amazônia, para implementar modelos de utilização dos recursos florestais). The present research proposal will complete those of the following subprojects:

Estudo de práticas de manejo e produção de florestas naturais no Estado do Amazonas

Modelos demonstrativos de sistemas silviculturais em manejo de florestas naturais no Estado de Mato Grosso

Estrutura e crescimento como base para o desenvolvimento de sistemas silviculturais para florestas naturais da Amazônia oriental.

EMBRAPA is also carrying out research on the ecology and silviculture of Mahogany (Swietenia macrophylla). This species being included in the species priority list of the Dendrogene project, it is likely that the research cooperation presented here will take into account this species.

As it was stated above, beside light factor, soil characteristics (drainage and fertility) play also an important role in plant growth. Research centers and universities developing research in this issue (LBA, FCAP) would be therefore potential cooperators of this proposal.

3. Objetivos e Resultados

3.1. Objetivo de Desenvolvimento

To establish appropriate silvicultural practices, including harvesting techniques in terra firme forests of the Eastern Amazon based on knowledge of commercial species ecology, population dynamics and **population genetic structure**.

3.2. Objetivos imediatos

1. **Definition of appropriate ecological groups to assess forest diversity**
2. To assess the impact of forest silvicultural practices on the ecology and population genetic structure of some commercial tree species
3. To improve knowledge on the ecology of important commercial species in the Eastern Amazon

3.3. Resultados

1. Literature review of the concept of ecological groups
2. Case study on the ecology and **population genetic structure** of some commercial species studied
3. Harvesting and silvicultural practices of the studied species recommended
4. Research on methods to assess impact of harvesting on species diversity at an operational scale **based on the concept of ecological groups** is initiated
5. **Research supported by external donors (FFEM, French Cooperation Ministry, PPG7)**

4. Plano de Trabalho

4.1. Plano de Trabalho

Resultado 1: Assessment of the concept of ecological groups

- Literature review
- Review of the internal report

Resultado 2 : Ecology and genetic structure of some commercial species studied

- Working meetings with Embrapa counterparts and field visits to select study sites and species
- Definition of ecological groups
- Case studies on specific species representative of each ecological groups
- Data analysis

Resultado 3: Silvicultural practices of the studied species recommended

- Publication of the main results
- Seminar/Workshop
- Publication of a synthesis in a scientific journal

Resultado 4: Research on methods to assess the impact of silvicultural practices, including logging, on species diversity at an operational scale initiated

- Make contact with private sector interested in eco-certification
- Selection of the study area
- Literature review

Resultado 5: Research supported by external donors (FFEM, French Cooperation Ministry, PPG7)

- ***Research Proposal written in cooperation with Embrapa***
- ***Research proposal document submitted to donors***

4.2. Indicadores e Meios de Verificação

Resultado 1: Literature review on the concept of ecological groups

- Internal Report published and reviewed internally
- Publication in a scientific journal

Resultado 2 : Ecology and genetic structure of some commercial species studied

- Field studies started
- Publication of reports and scientific papers submitted to international scientific journals
- Data base gathering all the information on the ecology of the studied species

Resultado 3: Silvicultural practices of the studied species recommended

- Internal report and publication in a scientific journal
- Seminar/Workshop organised

Resultado 4: Research on methods to assess the impact of silvicultural practices on species diversity at an operational scale initiated

- Study area selected
- Partnership with a forest company established
- Literature review

Resultado 5: Research supported by external donors (FFEM, French Cooperation Ministry, PPG7)

- Research proposal document written and submitted to donors
- Research funded

5. Cooperação externa solicitada

5.1. Justificativa para Escolha de Fonte Externa

EMBRAPA Amazônia Oriental was one of the pioneer research institution to establish low impact harvesting experiments in the Brazilian Amazon, back to 1979 in Tapajós Forest. The silvicultural experiments conducted by Embrapa in Eastern Amazon served as the basis to the Brazilian Silvicultural System for terra firme forests which is indicated in the country's forest management regulations.

Since the last fifty years, Cirad-forêt has been involved in forest management issues in tropical forest in the three main continents Africa, South East Asia and South America. One of the main objective of Natural Forest Programme in Cirad-forêt is to develop management tools to achieve long-term sustainable use of tropical forests. Cirad-forêt has been also involved in the implementation at the experimental scale of Reduced-Impact Logging (RIL) in South East Asia (STREK Project and Bulungan Research Forest in East Kalimantan, Indonesia) and Africa (Cameroun). These studies compared the impact of different logging techniques on the forest dynamics processes. In 1984, Cirad-forêt set up an experimental site in French Guiana (Paracou) to test various logging intensities followed by different post-logging silvicultural treatments. In French Guiana, Cirad-Forêt has also recently started research on the impact of logging on the genetic structure of some commercial species tree population. This research has been clearly identified by both institutions as an important field of cooperation with Dendrogene project. In the late 80s, Cirad-forêt also carried out research on silviculture in the Amazon in cooperation with INPA.

Gathering the experience of both Embrapa and CIRAD in the field of tropical silviculture, will strengthen technical co-operation between the two institutions and will contribute to improve scientific knowledge in the field of tropical forest management.

5.2. Custo estimado da Cooperação Solicitada

One permanent researcher: 36 men/month @ 9200 US\$

Salary, medical insurance, home renting, home leaves transportation fees..... 331,200 US \$

Operational costs 30,000 US \$

3 Technical missions and visits..... 27,000 US \$

Equipment (computers, furniture).....24,000 US \$

Seminar.....15,000 US \$

Vehicle.....30,000 US \$

TOTAL..... 457,200 US \$

4.3. Cronograma de Execução

[illegible]

6. Contrapartida oferecida

6.1 Pessoal

José Natalino Macedo Silva, 4 H/M
 José Carmo Alves Lopes, 2 H/M
 Milton Kanashiro, 2 H/M
 João Olegário Pereira de Carvalho, 2 H/M

6.2 Treinamento

The project will offer training opportunities for forestry students from Faculdade de Ciências Agrárias do Pará

- a: Subject: tropical silviculture
- b: Localisation: Embrapa Amazonia Oriental and its field research stations
- c: Duration: 1 year, renewable for 1 year

6.3 Material permanente

Embrapa Amazonia Oriental will put at disposal of the project, vehicles, office equipment, a local computer network and communication facilities such as FAX, e-mail, and telephone lines.

6.4 Obras e instalações

CIRAD Forêt has got office installations provided by Embrapa Amazônia Oriental. Beside an office building, laboratories, workshops and other facilities will but provided by Embrapa

6.5 Custo Estimado da Contrapartida oferecida: US\$ 335,000

6.6 Demonstrativo das Contribuições Financeiras (em US\$)

Embrapa Amazônia Oriental

| | |
|----------------------------|----------------|
| Pessoal | 86,000 |
| Material de Consumo | 6,000 |
| Material permanente | 80,000 |
| Serviços de Terceiros | 5,000 |
| Equipamentos e instalações | 150,000 |
| Viagens e Estadas | 8,000 |
| TOTAL | 335,000 |

CIRAD FORÊT

| | |
|---------------------|----------------|
| Personnel: | 331,200 |
| Consumables | 30,000 |
| Technical mission | 27,000 |
| Equipment | 24,000 |
| Vehicle | 30,000 |
| Third part services | 15,000 |
| Total | 457,200 |

7. Referências

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ANNEXE 2: Transparents présentés lors de l'atelier de reprogrammation du département forestier de l'EMBRAPA.

PROJETO DE COOPERAÇÃO TÉCNICA EMBRAPA-CIRAD-FORÊT

**Titulo: Melhoria das técnicas de exploração e silvicultura
nas florestas de terra firme da Amazônia oriental
Improving harvesting techniques and silviculture of
terra firme forests in Eastern Amazon**

Duração prevista: 3 Anos

**Custo estimado: 792 200 US\$
457 200 (Cirad)
335 000 (EMBRAPA)**

THE CONTEXT

Impact of logging and silviculture on forest species diversity and future species composition is still poorly known

Studies on the impact of logging on population genetic structure must be developed and promoted

Embrapa in Eastern Amazon and Cirad-Forêt, in French Guiana have given priority to these research issues



THE NEEDS

Set up research co-operation between Cirad and Embrapa

Develop research activities within Embrapa on-going projects

THE OBJECTIVES

OBJECTIVE OF DEVELOPMENT

To establish appropriate silviculture, including harvesting techniques in terra firme forest of Eastern Amazon based on the knowledge of commercial species ecology, population dynamics and population genetic structure

SPECIFIC OBJECTIVES

- To assess the impact of forest silviculture practices on forest species diversity**
- To assess the impact of forest silviculture practices on the ecology and population genetic structure of selected commercial species**

THE APPROACH

Ecological groups (Literature Review and definition)

Case study on the ecology of some commercial species (10)

Case study on the population genetic structure of some commercial species (5)

