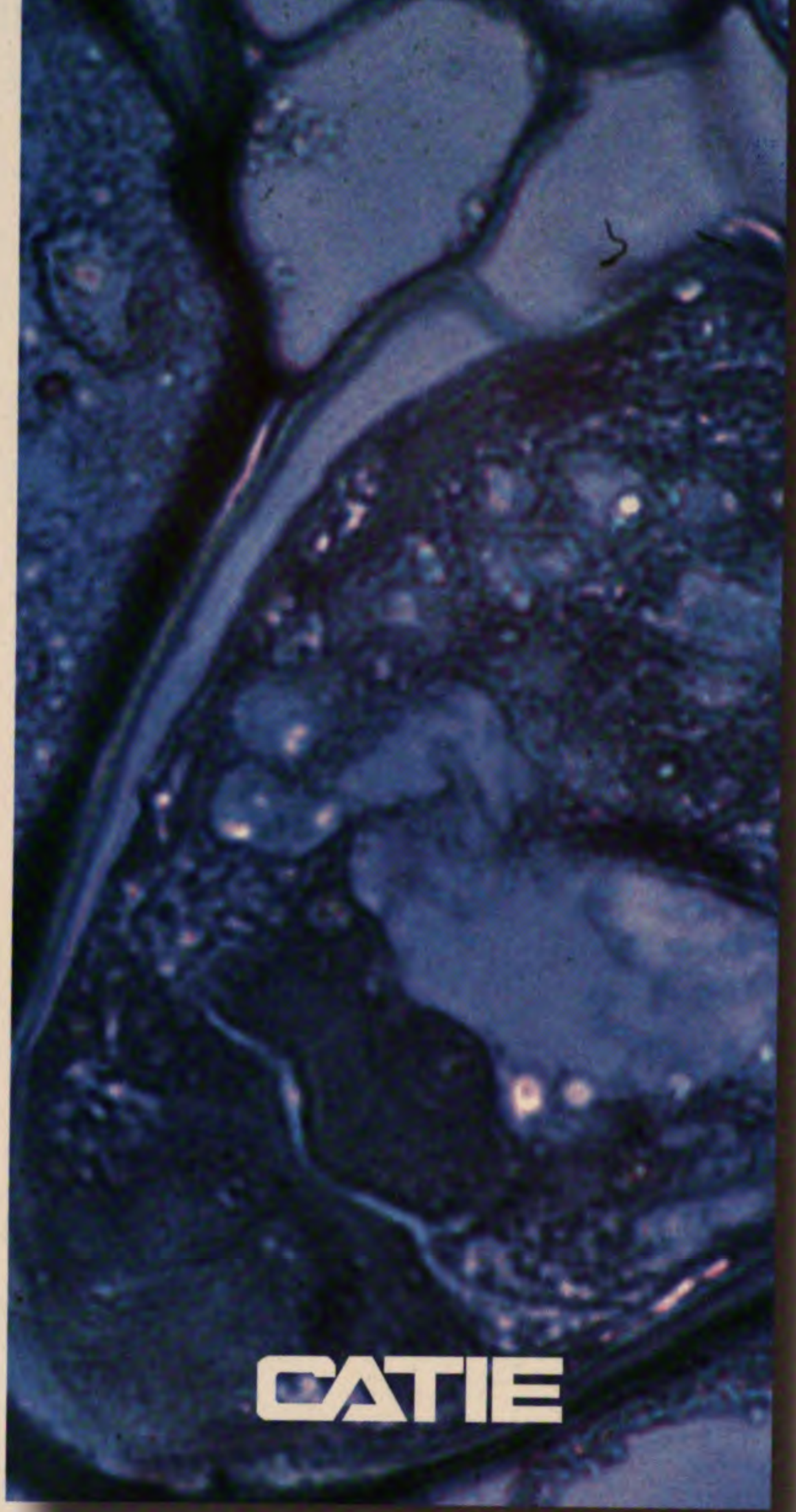

RESEARCH LINES

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RESEARCH LINES

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Tropical Agriculture Research and Higher Education Center

Turrialba, Costa Rica
1999

CATIE 's Mission

To improve the well-being of humankind by applying scientific research and higher education to the development, conservation and sustainable use of natural resources in the American Tropics.

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3. CATIE - Políticas y programas I. Título II. Serie

This document contains information presented to the Board of Directors in April 1997.

Contents

1. Introduction

1.1 Main problems and challenges

In a world of increasing population and diminishing natural resources, agriculture has become one of the production sectors that most affects the environment and natural resources. Population growth has resulted in a constantly growing demand for food which, combined with an inappropriate use of natural resources, the application of environmentally harmful production technologies, and a lack of alternative employment in rural areas, has intensified the conflict between agricultural production and the conservation of natural resources.

The challenge of efforts seeking to resolve this conflict lies in increasing agricultural and forestry production while at the same time conserving natural resources. CATIE believes that these objectives constitute two distinct, yet complementary and inseparable, facets of the same aim to "produce while conserving and conserve while producing."

In tropical Latin American countries, **rural poverty** and food security continue to represent major challenges for the agricultural sector. Some 65% of the inhabitants of CATIE's member countries live in poverty and more than half of these poor live in rural areas. With the current rate of population growth, food production has at least grow apace in order to meet the burgeoning demands of future generations.

In many countries of the American tropics, the agricultural sector plays an important role in national economies and social development. Now, with the opening of world markets and economies, the **competitiveness** of agriculture and food production will be key to the future of harmonized economic and equitable social development in these countries. This issue is closely linked to the fact that the agricultural sector of the American tropics is presently characterized by low levels of technology.

Degradation of natural resources, deforestation and the loss of biological diversity are threatening the functioning of our life-support systems. As a result, the diversity of benefits associated with the conservation and sustainable management of these resources is being dissipated.

Certain trends indicate the emergence of possible critical areas for research in the future. The degradation of soil productivity and water resources is already affecting the health and living conditions of thousands of people in the American tropics. Global climatic change, a consequence of the anthropogenic alteration of the chemical composition of the atmosphere, is affecting biogeochemical cycles and having a further impact on agriculture, forestry and natural resource-related sectors. The mitigation of and adaptation to such possible changes are new challenges for agriculture and natural resource management in the American tropics.

Overall, some critical challenges for development can be summarized as: a) increasing social and economic welfare and equity, b) developing measures that boost the efficiency of agricultural production while minimizing costs and adverse impact on the environment, and c) contributing to environmental integrity and conserving biological diversity and natural resources.

1.2 The mission and objectives of CATIE

According to its Strategic Plan, the mission of CATIE is "research and education in agriculture and related sciences for the development, conservation and sustainable use of natural resources in the American tropics to improve the well-being of humankind."

CATIE's general objectives are to:

- generate and validate technological practices for agricultural production and natural resource management which are economically feasible, socially and culturally acceptable, and environmentally sustainable;
- prepare professionals at the postgraduate level to contribute to the development of knowledge and the execution of programs that will contribute to the solution of socio-economic and agroecological problems in tropical America;
- promote proficiency in technological practices developed through institutional collaboration and diffusion of these practices to end users; and
- disseminate the information generated and foster the adoption of new technological practices.

CATIE's research program aims to produce:

- increased knowledge on biophysical, ecological and socioeconomic mechanisms and dynamics of different production systems and their components;
- improved technologies and management systems for integrated sustainable agriculture and natural resource management and conservation; and
- information, scenarios, and options for sustainable development based on agriculture and natural resource conservation and management.

2. Strategic Considerations for Future Development

2.1 The baseline of research in 1996

CATIE has a long history of research in the areas of agriculture and natural resources management. Although its activities in research, education, and technology transfer have produced outputs of considerable impact in the development of these sectors, especially in Central America, there is still room for improvement in all lines of action. The situation of research at CATIE in 1996 can be characterized as follows:

Strengths

- Regional coverage through partners, networks, and collaborative research projects
- Competent personnel in research and education
- Experience in working with multidisciplinary and interdisciplinary groups
- Physical infrastructure (laboratories, computer facilities, etc.)
- Strong program in education and training that complements research activities
- Budget structure that will allow it to develop its own research agenda in the future

Weaknesses

- Low output of quality articles published in international scientific journals
- Low output of strategic research and low impact in developing measures for sustainable development in the region
- Few genuine research projects - research funding mainly through development projects
- Research mainly targeting biophysical topics; more research needed on human dimensions
- Little communication between CATIE areas and research groups

2.2. Expected status by the year 2003

In terms of research areas and lines:

- CATIE is at the vanguard of the development of technologies and sustainable production systems for integrated agriculture, agroforestry, forestry and natural resources management.
- CATIE is filling the vacuum of strategic research in natural resources management in the region, addressing issues ranging from global changes and markets to the regional status of natural resources to the well-being of the population at the local level.
- CATIE collects, analyzes and disseminates information relevant to the long-term planning of sustainable development in its member countries. This information is produced using advanced technologies and means (GIS, data banks, expert systems, Internet, etc.).

- CATIE is a leading institution in the utilization of biotechnology for the conservation and improvement plant genetic resources of selected crop and forest tree species.

In terms of institutional performance:
- Research findings of international importance are published in peer-reviewed international journals (at the rate of 20 publications of this caliber per year).
- Publications (books, manuals, CD-ROMs, etc.) synthesizing research findings are produced for Latin American and Caribbean audiences.
- Research findings from different areas and disciplines are integrated through modelling and the development of expert systems and data bases.

2.3 Immediate actions in research

Research at CATIE is organized into research areas and lines, as described below. The current description is based mainly on the institutional situation and resources available in 1997; needs for new resources are indicated below. In the short term (through the end of 1999), the development of CATIE's Research Program is based on the following:
- Increased strategic research efforts on questions relevant to member countries, for example, information on the status of and trends in natural resources.
- Increased research efforts on policy issues and measures for sustainable management and natural resource conservation.
- Increased research efforts in economic and social aspects of all research areas.
- Refocusing of efforts in the area of watershed management, protected areas and land use; new focus on land-use change and its implications for local land-use policies and global environment.
- Refocusing of efforts in the area of food crops and agriculture; food production and security will be an essential part of the research on sustainable production systems. The research on crops and agricultural techniques is carried out mainly through collaboration with national and international institutions and through regional research networks.
- In all research areas, activities focus on problem-solving research, carried out by interdisciplinary research teams.
- Increased emphasis is placed on the publication and dissemination of research findings, especially in peer-reviewed journals of international standing.
- Improved collaboration with national institutions, the private sector and NGOs, including collaborative research projects with institutions in the developed world receiving international funding.
- Development and application of techniques such as GIS-based information systems, modelling and databases in order to produce and transfer relevant information to the member countries.
- Allocation of new resources for: a) forestry and natural resource economics, b) plant genetic resources, c) biotechnology, d) geographic information systems, and e) development of models, expert systems and databases.

3. Research Lines at CATIE

3.1 Research portfolio

CATIE's research activities can be grouped thematically into three main research areas. They are:
- Area I. Genetic resources and integrated pest management for agriculture and natural resource management
- Area II. Sustainable production systems in agroforestry and forestry
- Area III. Socio-economic and policy analysis of natural resources and production systems.

Each area, in turn, consists of **research lines**. CATIE's five research lines are:

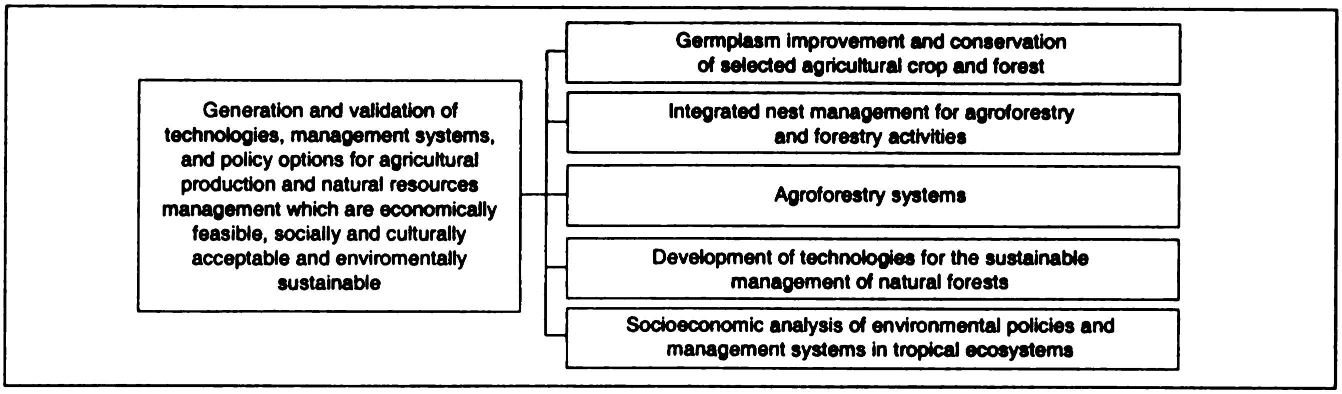
Line 1. Germplasm improvement and conservation for selected agricultural crops and forest species

Line 2. Integrated pest management for agroforestry and forestry activities

Line 3. Agroforestry systems

Line 4. Development of technologies for the sustainable management of forests and their biodiversity

Line 5. Socioeconomic analysis of enviromental policies and management systems in tropical ecosystems



3.2 Summary of research lines

Research line	General objective	Sub-lines/components
1. Germplasm improvement and conservation for selected agricultural crops and forest species	To contribute to agricultural and forestry development through the conservation and rational use of genetic diversity.	1a: Agricultural crops component 1b: Forestry component
2. Integrated pest management for agroforestry and forestry activities	To reduce pesticide use by adopting ecologically oriented alternatives and to reduce losses caused by pests	2a: Shade-grown perennial crop systems 2b: Hillside mixed food crop/ agroforestry systems 2c: Mahogany growing in plantations.
3. Agroforestry systems	To conduct both basic and applied research on promising agroforestry technologies that increase production of agricultural, livestock and forestry products with a view to improving rural well being without adversely affecting the natural resource base and environmental quality.	3a: Agroforestry systems for the production of annual crops on humid hillsides 3b: Agroforestry systems for perennial crops (mainly coffee) 3c: Silvopastoral systems for degraded pasture lands in the humid tropics 3d: Plantation forestry silviculture for private farms
4. Development of technologies for the sustainable management of forests and their biodiversity	To develop strategies and technologies that contribute to the sustainable diversified management of neotropical humid forests, through the determination and modelling of the impact of different internal and external factors on the dynamics of the society-forest system.	4a: Development of technologies for the sustainable management of natural forests 4b: Conservation of biodiversity in natural forests managed for production
5. Socioeconomic analysis of environmental policies and management systems in tropical ecosystems	To identify, develop and use techniques and information that contribute to a more rational and sustainable use of natural resources through the calculation of direct and indirect economic, environmental and social costs and benefits of different land-use schemes, and through the evaluation of policies and other types interventions to promote it.	5a: Economic valuation and analysis of environmental goods and services from tropical ecosystems. 5b: Socioeconomic assessment of policies affecting the utilization and management of tropical ecosystems 5c: Socioeconomic analysis of the processes of technological change occurring in tropical ecosystems

A detailed description of the five research lines is given in the Appendices of this document.

4. Resources

Table1. Estimate of current resources available for research activities (annual averages)

Type of Resource	Line 1	2	3	4	5	Total
A. CATIE resources						
1. Human resources [1]	**11.70**	**20.50**	**16.08**	**20.75**	**15.60**	**84.63**
Ph. D.	2.50	3.20	3.08	1.65	1.35	11.78
M.Sc.	3.00	3.70	0.90	4.75	2.50	14.85
Other professional staff	1.10	1.60	1.10	6.35	0.75	10.9
Post-docs/visiting scientists	0.10					0.1
Ph.D. students	1	1	1	1	1	5
M.Sc. students	4	11	10	7	10	42
2. Funding (operational) (kUS$/year)	**22**	**133**	**85**	**170**	**20**	**430**
Equipment and materials	13	85	63	75	10	246
Travel and other expenses	9	48	22	95	10	184
3. Infrastructure (equipment, etc.)	**2**		**80**	**100**	**5**	**187**
4. Other resources	**19**		**20**			**39**
B. Partner Institution Resources						
1. Human resources [1]	**2.12**	**13.67**	**6.52**	**4.60**	**0.02**	**26.93**
Ph. D.	1.52	0.02	0.92	1.10	0.02	3.58
M.Sc.	0.60	5.65	2.10	1.50		9.85
Other professional staff			1.5	1.0		2.50
Post-docs/visiting scientists						
Ph.D. students						
M.Sc. students		8	2	1		11
2. Funding (operational) (kUS$/year)	**158**	**79**	**45**	**8**	**20**	**310**
Equipment and materials			16	5	10	31
Travel and other expenses			29	3	10	42
3. Infrastructure (equipment, etc.)			**140**	**50**		**190**
4. Other resources			**5**	**2**		**7**
Total human resources [1]	**13.80**	**34.17**	**22.60**	**25.35**	**15.62**	**111.54**
Human resources excluding students [1]	**8.82**	**14.17**	**9.60**	**16.35**	**4.62**	**53.56**
CATIE researchers	**14**	**21**	**19**	**20**	**9**	**83**
Partners' researchers	**5**	**10**	**13**	**2**	**0**	**30**
Total researchers	**19**	**31**	**32**	**22**	**9**	**113**
Funding (operational) (kUS$/year)	**180**	**212**	**130**	**178**	**40**	**740**
Infrastructure	**2**		**220**	**150**	**5**	**377**
Other resources	**19**		**25**	**2**		**46**

[1] Calculated as person/years allocated to the research work.
See Appendix 6 for detailed information on human resources.

5. Linkages

5.1 Linkages with other CATIE programs

- The research at the postgraduate school, which is carried out mainly by M.Sc. and Ph.D. students, should be fully integrated with the strategic research lines of the research program. This may require re-engineering the curricula and educational structure.
- In the medium term, the Ph.D. program can play an important role in enhancing the research efforts of the Center. New and innovative mechanisms for funding the Ph.D. program should be developed for this purpose.
- Dissemination of research results will be carried out in collaboration with the outreach program. Here, the emphasis will be on the production of synthesis reports, GIS-based databases and information accessible through Internet.
- In CATIE's collaborative efforts with national institutions and organizations, the mechanisms developed by all of its programs through various regional networks and projects will be fully utilized.

5.2 Linkages with other institutions and organizations

- In order to ensure the relevance of CATIE's research efforts, linkages are enhanced with member country feedback mechanisms. For this purpose, various mechanisms, including regional networks, are utilized.
- Collaborative research projects will be developed with international research institutions.
- Research cooperation with advanced Latin American, North American, European and other institutions and organizations is enhanced through joint research projects, exchange of researchers and postgraduate students, and other mechanisms (sabbaticals, etc.).

6. Management, Planning and Evaluation

The definition of the research lines introduces a new working environment at CATIE. The activities of each research line are carried out by a interdisciplinary research group lead by senior scientist. Each research line prepares its annual work plan, including an individual annual work plan for each of its researchers. Progress made in executing the annual work plan is monitored and the results and impact evaluated.

- Monitoring of research progress will be carried out annually by the research program. Indicators will be established for measuring progress and performance.
- Evaluation of the impact of the research program as a whole, or of its research lines, will be conducted periodically, by way of external evaluations.
- An internal Scientific Advisory Council, consisting of CATIE's leading scientists, will be established to coordinate the planning, management, monitoring and evaluation of CATIE's research activities.

Appendix 1

Research Line 1

Germplasm Improvement and Conservation for Selected Agricultural Crops and Forest Species

Germplasm Improvement and Conservation for Selected Agricultural Crops and Forest Species

Agricultural crops component

1. Justification

Central America is characterized as a region where species of worldwide importance originated and/or were domesticated. The economies of the countries of the region are based on agricultural systems dependent on introduced species (coffee and banana), the genetic base of which is very narrow.

Central America's population of 33 million inhabitants is linked, either directly or indirectly, to agricultural activities. Insufficiently developed production systems and plant health problems result in low production levels and a high-inputs agriculture.

The region's urban development, the substitution of traditional crops with improved cultivars, and high deforestation rates are accelerating the process of genetic erosion. The loss of genetic diversity of actual or potential use will have a very high cost if appropriate measures are not taken to mitigate it in the near future.

Production systems using high inputs increase production costs and rural poverty levels.

Research activities that address genetic erosion are concerned primarily with germplasm collection and preservation, and aim to rescue *genetically diverse* species of actual or potential use. Mechanisms must be developed for introducing *genetically diversity species* for use in genetic improvement programs on staple crops of key importance to the region's economies.

Germplasm characterization should contribute to reinforcing preservation actions by valuating germplasm and promoting its utilization, thus supporting genetic improvement programs. CATIE's actions in the areas of germplasm preservation and characterization, under its Phytogenetic Resources and Biotechnology Units, are mainly funded by the Center's core budget. International cooperation also exists, but for very specific purposes, as in the cases of ACRI, which provides annual funding toward the preservation of cocoa germplasm; in addition, IPGRI supports Sapotaceae germplasm characterization and conservation activities. A project financed by USDA to evaluate, regenerate and increase the data base management of genetic resources in Middle America was implemented very recently. French cooperation (ORSTON-CIRAD-MAE) also supports the Biotechnology Unit with technical personnel and funding to develop activities under the *Musa* and coffee programs.

Mechanisms to acquire mid-term financing resources are not very clear; thus, it is critical to maintain and increase existing relationships and strategic alliances with institutions such as FAO, IPGRI, etc., in order to facilitate the securing of funds for maintaining and strengthening the development of phytogenetic resources and biotechnology activities.

The accelerated rate of genetic erosion is a great concern in the region. The most outstanding action undertaken in recent years in this area was the establishment of the Mesoamerican Phytogenetic Resources Network (REMERFI) of which CATIE, IICA, IPGRI and FAO are active members. There is great interest and political determination in the region regarding the establishment of this system. Network actions are being developed in each country and one person represents each country in the Network.

CATIE has comparative advantages in the region in this regard. Its Phytogenetic Resources and Biotechnology Units have the infrastructure necessary to preserve germplasm and both are recognized at the regional level for their support to human resources training and the development of activities, in addition for the genetic wealth they hold in custody. The development of phytogenetic resources and biotechnology activities in the region's countries is very incipient and no significant levels of development have been achieved.

There are international centers operating in the region, but they focus exclusively on maize , wheat, beans and cassava crops.

Due to its considerable experience managing autochthonous phytogenetic resources, CATIE possesses comparative advantages for developing strategic links with worldwide level institutions directly or indirectly involved in phytogenetic resources actions.

CATIE should interact on an ongoing basis with actions developed elsewhere; it should also maintain direct communication with national programs in order to expand the scope of their action. In addition, it should adopt a firm attitude regarding germplasm increase and preservation, as it is a depository of the region's genetic wealth.

Research activities developed by the Phytogenetic Resources and Biotechnology Units will be closely linked to educational activities through the master's degree program in biotechnology and phytogenetic resources.

CATIE should strengthen its training actions at the regional level as there are a number of international institutions which have resources available to cover short courses or in-service training in areas where CATIE has and should exploit its regional comparative advantages.

CATIE's influence will depend on the results of its research; the support given to germplasm preservation, utilization and distribution for strengthening genetic improvement programs; and its contribution to training human resources in the region.

2. Beneficiaries

The direct beneficiaries of germ plasm preservation and characterization activities are the countries, genetic improvement programs and producers.

3. Objectives

General objective

To increase, preserve, characterize, document and make available to users the genetic diversity of species of actual or potential use kept in the germplasm bank or in in vitro conditions.

Specific objectives

- To characterize/evaluate preserved genetic diversity in order to promote utilization of selected germplasm or its application in genetic improvement programs.
- To establish and manage data bases containing genetic and phenotypic information on materials preserved.
- To distribute germplasm that has superior characteristics.

4. Current Status

As part of CATIE's germplasm conservation activities, it is necessary to increase actions to rejuvenate orthodox seed collections (*Capsicum, cucurbita*, etc.), as well as the field collections of cocoa, coffee and fruits, because of their age.

Actions developed by others are very isolated and most of them contribute to germ plasm preservation, as in the case of ACRI and IPGRI, which support the characterization and maintenance of these collections through the Sapotaceae Project (Tropical America Native Fruits Project).

5. Goals

The goals of germplasm preservation and improvement are to:

- Improve conventional preservation techniques, adapt and/or develop new long-term (cryopreservation) germplasm preservation technologies.

- Rejuvenate high priority field collections: coffee, cocoa and fruits and low germination percentage orthodox seeds.
- Develop morphological and molecular characterization activities of important germplasm for the region (coffee, cocoa, sapotaceae, musaceae, cucurbitaceae, capsicum, bactris and tree species).
- Strengthen cooperation links with regional and worldwide institutions with a view to developing joint activities in the areas of phytogenetic resources and biotechnology.
- Disseminate information from data bases generated through characterization activities.
- Support distribution of germplasm with superior characteristics to be used in genetic improvement programs or by farmers.

6. Relationship with CATIE's Education and Outreach Areas

Activities to rejuvenate collections and characterize germplasm will strengthen the area of education through students' direct involvement in these efforts as part of their assistant research hours or their graduation projects.

With regard to outreach, the Phytogenetic Resources and Biotechnology Units will promote the development and strengthening of genetic and phenotypic data bases. The information generated will serve as the basis for promoting and assessing existing genetic diversity and for enhancing its use to strengthen the search of solutions to the problems faced by the agricultural sector of CATIE's member countries.

7. Human Resource Development

The human resources available to the Phytogenetic Resources Unit has been weakened and in order to develop its activities, it will be necessary to strengthen this area.

Staff training is an area CATIE should strengthen to improve its employees' research capabilities.

Motivated staff with a good understanding of their jobs and the desire to acquire new knowledge will boost their work capacity and the quality of the Center's research products. CATIE should reintroduce this view and promote it among its staff.

Loss of trained human resources results in a deterioration of the quality of CATIE's work and products.

8. Partners

Work partners

Inter-institutional efforts are being developed within the region to strengthen phytogenetic resources and biotechnology activities. Although the institutional reorganization processes underway in the countries make it difficult to implement such efforts, liaisons have bee identified in each country. CATIE's participation will be direct or indirect, depending on the policies to be implemented and the negotiations with present and potential donors.

Resources are scarce and a high percentage of them will be earmarked for concrete actions in the countries. The countries' institutional capacity to offer services and assume certain responsibilities within the process being implemented will determine the likelihood of obtaining more resources in the future.

Funding partners

CATIE should consider incrementing funds allocated to the Phytogenetic Resources and Biotechnology Units in order to hire qualified personnel, purchase new equipment and install new facilities. It is also fundamental to promote closer relations with the Forest Seeds Project (PROSEFOR), particularly with a view to the sharing of laboratory facilities. At this moment, the Phytogenetic Resources Unit has a long-term (-17 oC) preservation chamber and one seed drying room.

No facilities are available for routine activities such as determining humidity and seed viability. This undermines the effectiveness of activities and results in a loss of information on stored germplasm.

Resources can be obtained from donors, but the donors must be identified, proposals prepared and negotiation processes undertaken. Some unfruitful efforts were conducted with GTZ in the past.

The success of efforts to secure funding will depend mainly on strategic alliances developed in the future with institutions working in the region and on the Unit's impact at both the regional and international levels.

9. Approach and Methodologies

Phytogenetic resources and biotechnology actions should concentrate on managing and preserving autochthonous germplasm from Mesoamerica with actual and potential use, and on increasing the genetic diversity of exotic species of economic importance.

The methodology makes use of conventional techniques and biotechnological tools for germplasm preservation and characterization.

The Phytogenetic Resources Unit has the infrastructure and capacity necessary for medium- and long-term (cold chambers) preservation of orthodox and recalcitrant field collection species. It also has trained personnel to conduct rejuvenation and germplasm morphological characterization.

The Biotechnology Unit has the infrastructure needed to develop biotechnological techniques for:

- *Micropropagation:* There is good mastery of *in vitro* regeneration systems (microshoots, somatic embriogenesis and studies underway on cellular suspensions). These activities receive important support from the histology laboratory.
- *Preservation:* There is a good command of medium-term preservation techniques and prior experience with cryopreservation.
- *Molecular characterization:* This laboratory has mastery of one type of marker: RRPDs.
- *Genetic transformation:* This is an emerging topic for the laboratory. It will be necessary to add complementary equipment in order to be able to conduct studies on gene transference (plasmids preparation and molecular analysis of plants).

It is relevant to incorporate important economic species and their wild relatives, such as:

- *Native:* (*Capsicum, Cucurbita, Bactris, Sapota-ceae, Lycopersicom, Theobroma* and forest tree species).
- *Introduced:* (*Coffea, Musa*)

Methodologies

Conservation methods will primarily use conventional techniques and will implement and/or develop biotechnological tools suitable for the aforementioned species.

Molecular and morphological characterization activities of preserved germplasm should be strengthened.

Sub-lines of research

- Conservation and management of phytogenetic resources maintained in germplasm and *in vitro* (cryopreservation) banks.
- The Phytogenetic Resources and Biotechnology Units will continue to preserve and manage the existing collection.
- Germplasm characterization/evaluation (conventional and molecular techniques).
- The following species are subject to characterization because of their high priority and representation in the germplasm bank, and their importance in the region: *Coffea, Capsicum, Cucurbita, Lycopersicon, Bactris* and *Sapotaceas*. Research activities on *Theobroma cacao* and *Pachyrrizus* sp. are in a two-year phasing out period (1997-98). Forest species subject to characterization are: *Swietenia machrophylla, Cedrella* sp., *Cordia* sp., *Pinus* sp.
- Evaluation of superior genotypes
- Production and distribution of superior genotype seeds.
- Management, updating and projection of genetic and phenotypic data bases.

10. Resources

The following tables show available resources and those required by the Phytogenetic Resources and Biotechnology Units.

Table 1. Estimated resource needs of the Phytogenetic Resources Unit (annual averages)

Type of resource	Current	Optimistic
A. CATIE resources		
1. Human resources (number of person/years)		
1.1. Ph. D.		1
1.2. M.Sc.	1	3
1.3. Other professional staff	4	6
1.4. Post-docs/visiting scientists		
1.5. Ph.D. students		
1.6. M.Sc. students		4
2. Funding (kUS$/year)	17.452	62
2.1. Equipment and materials	9.568	25
2.2. Travel and other expenses	6.184	12
3. Infrastructure (equipment, etc.)	1.7	25
4. Other resources		
B. Partner institution resources		
1. Human resources (number of person/years)		
1.1. Ph. D.		
1.2. M.Sc.		1
1.3. Other professional staff	1	2
1.4. Post-docs/visiting scientists		2
1.5. Ph.D. students		
1.6. M.Sc. students		
2. Funding (kUS$/year)	73	
2.1. Equipment and materials	47	
2.2. Travel and other expenses	8	
3. Infrastructure (equipment, etc.)	15	
4. Other resources	3	
C. New resources		
1. Human resources (number of person/years)		
1.1. Ph. D.		
1.2. M.Sc.		
1.3. Other professional staff		
1.4. Post-docs/visiting scientists		
1.5. Ph.D. students		
1.6. M.Sc. students		
2. Funding (kUS$/year)		
2.1. Equipment and materials		
2.2. Travel and other expenses		
3. Infrastructure (equipment, etc.)		
4. Other resources		

Table 2. Estimated resource needs of the Biotechnology Unit (annual averages)

Type of resource	Current	Optimistic
A. CATIE resources		
1. Human resources (number of person/years)		
1.1. Ph. D.		2
1.2. M.Sc.	3	5
1.3. Other professional staff	7	10
1.4. Post-docs/visiting scientists		
1.5. Ph.D. students		
1.6. M.Sc. students		4
2. Funding (kUS$/year)	25	200
2.1. Equipment and materials		
2.2. Travel and other expenses		
3. Infrastructure (equipment, etc.)		
4. Other resources	19	
B. Partner institution resources		
1. Human resources (number of person/years)		
1.1. Ph. D.	3.5	4
1.2. M.Sc.		
1.3. Other professional staff	3	
1.4. Post-docs/visiting scientists		
1.5. Ph.D. students		
1.6. M.Sc. students		
2. Funding (kUS$/year)	85	85
2.1. Equipment and materials		
2.2. Travel and other expenses		
3. Infrastructure (equipment, etc.)		
4. Other resources		
C. New resources		
1. Human resources (number of person/years)		
1.1. Ph. D.		
1.2. M.Sc.		
1.3. Other professional staff		
1.4. Post-docs/visiting scientists		2
1.5. Ph.D. students		
1.6. M.Sc. students		
2. Funding (kUS$/year)		30
2.1. Equipment and materials		
2.2. Travel and other expenses		
3. Infrastructure (equipment, etc.)		
4. Other resources		

Table 3. General research lines of the Biotechnology Unit

	Activities	Coffee	Musa	Forest species	Sapotaceae
Molecular characterization	Markers	+			
	Markers assisted selection	+			
Preservation	Medium term			+	+
	Cryopreservation	+	+	+	+ (IPGRI)
Micropropagation	Medium scale		+	+	+
	Massive	+	+		
Genetic transformation			+	+ (ITTO)	
Sources		CIRAD ORSTOM MAE PROMECAFE	CIRAD MAE INIBAP	Core ITTO	Core IPGRI
Expected products and obtention dates		- Initiation of distribution of improved hybrids 1997 - Utilization diversity strategies and databases 1998	- Structure and distribution of *vitro* plantlets starting 1998 - Pilot production unit 1999 - 2000 - Gene transference method 2000	- *In vitro* culture method and conservation 1999-2000 - Diversity characterization 2000 - Gene transference method 2002	- *In vitro* culture method conservation 1999
Principal partners		CIRAD ORSTOM MAE PROMECAFE	CIRAD MAE + Mexico? Cuba? Honduras?	ITTO project counterparts	IPGRI REMERFI

Forestry component

1. Justification

Tree planting, natural forest management and the conservation and use of biodiversity are recognized as key elements of sustainable development in Central America, neighboring regions, and in most parts of the developed and developing worlds. The careful management (i.e., characterization, conservation, improvement and use) of forest genetic resources is an important component of all three activities. Without effective management of forest genetic resources, the following negative consequences will ensue:

- Productivity of forest plantations, including the arboreal component of agroforestry systems, will be sub-optimal. While germplasm selected for industrial production systems will increasingly resemble that available for domesticated crops, forest germplasm available for smallholder production systems will remain undomesticated. Use of inappropriate seed sources will result, at best, in financial losses and, at worst, in plantation failure.
- Important opportunities (i.e., the possibility of resolving the *Hypsipyla* problem) will be lost.
- Natural forest management regimes will be formulated without an understanding of their genetic consequences.
- It will be impossible to formulate scientifically-based guidelines for *in situ* genetic conservation, particularly for many species that currently subsist primarily within agricultural landscapes.
- Because erosion of genetic diversity impacts on species viability, biodiversity at all three levels will be threatened.

Area and population affected

The need for effective management of forest genetic resources is acute in all CATIE member countries. The nature of the problem varies according to the different ecological zones, but on balance, it is probably equally serious in the Pacific and Atlantic watersheds of Central America. Unavailability of appropriate forest seed directly affects smallholder tree planters. Similarly, uncertainty over the genetic implications of natural forest management may translate into sub-optimal silviculture and, consequently, losses in profitability. Loss of genetic diversity and the impact of this loss on higher-level biodiversity (species, ecosystems) will negatively affect both forest owners and society in general.

Cost of the problem and its relation to rural poverty

Tree improvement on an appropriate scale is relatively cheap and can be highly profitable. The opportunity cost of not implementing tree improvement programs is proportional to the area to be planted. Marginal gross discounted revenue from tree improvement ranged from US$23ha-1 (20% discount rate) to US$93ha^{-1} (5% interest rate) for *Gmelina arborea*[1]. A full analysis would take into account the effect on technology adoption of the availability of visibly superior germplasm. The contribution of tree improvement to combating rural poverty is identical to that of tree planting as a whole, i.e., it increases and diversifies income and contributes to a greater sustainability of production systems.

The impact of improved levels of knowledge of genetic aspects of natural forest silviculture is more difficult to assess. However, conservation of the genetic diversity of species within managed forests is a prerequisite for success of this type of land use, and, if the 'use it or lose it' rationale is accepted, it is, by extension, also a prerequisite for saving much of the Central American forest from destruction. As a vital component of natural forest management, the relationship of improved genetic knowledge to the mitigation of rural poverty is the same as that of natural forest management as a whole.

Probability of success

Forest genetic research techniques are well developed, and in general there should be no technical obstacles to meeting the objectives described below. It should be recognized, however, that the specific

1 Data from Hamilton, Brodie, Chandler and Cornelius. 1996. A financial analysis of samll-scale Gmelina arborea Roxb. improvement program in Costa Rica.

problem of the mahogany shoot borer may prove to be intractable.

Current and expected levels of funding

At present, CATIE's activities in forest genetics are funded entirely by external donors through specific projects. Funding for 1997 amounted to approximately US$800K: (CIFOR/IPGRI (genetic effects of fragmentation) - US$100K; DANIDA (PROSEFOR) - US$600K; European Union (mahogany) - $100K. Beyond 1997, funds are not assured, but it seems likely that funding will increase to approximately US$1,290K per annum by 1998-99 (PROSEFOR: US$720K; CIFOR/IPGRI US$100,000; EU US$70K; ITTO US$400K). Beyond 1999, prospects are uncertain, except for PROSEFOR.

Forest genetics research, and particularly tree improvement, is badly affected by the discontinuities (of both funding and emphasis) inherent to project funding. At present, no support is received from the core budget. A Forest Genetic Resources Unit was established in 1993 within the Forestry Area (see Strategic Plan 1993-2002), but no coordinator was appointed and, in effect, the Unit exists only on paper. Consequently, intra-institutional coordination of forest genetics work at CATIE has suffered.

Comparative advantages of CATIE

CATIE possesses a clear competitive advantage in this field. It is the only institution in Central America with experienced doctoral-level forest genetics specialists, and the only Central American institution whose human resources include experienced tree breeders, population and quantitative geneticists, ecologists and molecular biologists. Additionally, only CATIE has the mandate, region-wide contacts and infrastructure necessary to carry out activities framed by ecological rather than political boundaries.

Extra-regional organizations are involved in forest genetics research in Central America, particularly in Belize and Costa Rica (genetics in natural forest), but these efforts tend to be oriented more towards scientific than developmental goals.

2. Beneficiaries

CATIE's work in this field is aimed primarily at smallholder forest owners (of planted and natural forests) and, through its impact on biodiversity conservation, at the population of CATIE member countries as a whole. In addition, the work on strategies for genetic conservation in fragmented forests, be these managed or unmanaged, and the work on resistance in mahogany, also have global relevance.

3. Objectives

This research line aims to contribute to agricultural and forestry development in the region through the conservation and rational use of its genetic diversity. Work is planned under three main categories which, together with their associated specific objectives, are listed below:

Forest genetic conservation

- Develop strategies for the conservation of forest genetic resources within fragmented and/or managed natural forests, based on the characterization of genetic processes (forest fragmentation project).
- Generate information on genetic diversity and the processes that affect it in mahogany and other (model/ecologically important/economically important) species (forest fragmentation project /mahogany project (EU) / ITTO project).

Tree improvement

- Improve the production, supply and utilization of genetically and physiologically improved planting material (PROSEFOR)
- In collaboration with other groups within CATIE (Biotechnology, MIP) and outside it (Bolivia, Honduras, ITE), work towards the development of an IPM strategy for mahogany-*Hypsipyla* (ITTO project)
- Strengthen the capacity of national institutions to carry out tree improvement on a sustainable basis (PROSEFOR).
- In general, raise awareness about the importance of genetics in silviculture (PROSEFOR)

Utilization

- Foster the exchange of information and materials among different groups and institutions interested in forest genetic resources (PROSEFOR).
- Produce guidelines for the conservation of forest genetic resources within fragmented and/or man-

aged natural forests, based on the characterization of genetic processes (forest fragmentation project / EU-mahogany project) .

4. Current Status

At CATIE

CATIE has a longstanding program of genetic improvement of forest trees, which is beginning to expand from Costa Rica to the rest of Central America and the Dominican Republic. To date, activities outside of Costa Rica have been confined to the establishment of interim seed sources, training and institutional support.

In the past, the potential for intra-institutional collaboration at CATIE (biotechnology-forest genetics-forest ecology-biodiversity-domestication) has not been fully tapped. More recently, joint initiatives (biotechnology-forest genetics, ITTO project) have begun. On an institutional level, CATIE's technical and infrastructural capacity for research in forest genetics is probably unmatched in Latin America.

Others

In Central America, CATIE is unrivalled in tree improvement expertise. However, in regard to the application of molecular techniques in forestry problems, CATIE lags behind institutions such as the University of Costa Rica and the Organization for Tropical Studies. This is essentially because all three relevant groups at CATIE have been concentrating on other problems: the forest geneticists on tree breeding; the biotechnologists on strictly agronomic problems and the natural forest management specialists on the effects of management on growth and floristics, etc. Only recently have all three recognized the importance of genetic studies of natural populations.

5. Goals

- Guidelines for the *in situ* conservation of forest genetic resources (managed/fragmented forests), based on a predictive model.
- A range of seed sources/conservation units established in all participating countries, serving a wide variety of purposes including genetic evaluation, provision of material for advanced selections, improved seed production and conservation of valuable genotypes.
- Technicians trained, able to understand, implement and develop tree improvement activities in their own organizations.
- Seed certification schemes officially implemented by forestry authorities and accepted by tree planters and forestry organizations. Certified seed being routinely used in reforestation programs with fiscal incentives.
- Consolidated regional and national working groups making significant contributions to the forestry sector in general.
- National seed banks upgraded and well equipped, increasingly supplying the needs for high quality seed.
- Scientific and technical papers, manuals, bulletins, seed catalogs, etc., produced and distributed among a wide variety of users throughout the region.
- Quantification of the level and distribution of genetic diversity within a range of economically and ecologically important tree species.
- Candidate IPM strategies for control of the *Hypsipyla* problem.

6. Relationship with CATIE's Education and Outreach Areas

Forest genetics research at CATIE continues to require the inputs of M.Sc. and Ph.D. level students. To date, students have generally worked on problems associated with vegetative propagation, seed, and quantitative genetics. As CATIE's forest genetics personnel acquire experience with molecular techniques, the range of options will grow.

PROSEFOR can reasonably be considered as much an 'outreach' project as a research project. Its programs of dissemination and training will make a significant contribution to the Outreach Program's agenda for dissemination of technical/scientific information and technical cooperation.

7. Human Resource Development

CATIE's current staff capacity in forest genetics is broadly in accordance with its needs. One M.Sc. level specialist is currently undergoing doctoral-level training in population genetics and molecular applications. Additional personnel will be required for implementation of the ITTO project, but this is covered in the project budget.

8. Partners

CATIE's current research partners in forest genetics are CIFOR, IPGRI, ITE (Scotland) and the DANIDA Forest Seed Centre. CIFOR and IPGRI support CATIE forest genetics activities both directly, through their core budgets, and through the CG SGRP (system-wide genetic resources programs). The link with ITE provides access to EU funds.

9. Approach and Methodology

PROSEFOR

The principal strategy of PROSEFOR is to support and service major seed producers/users in the countries of the region in connection with seed source selection and management, and seed procurement. This support service is provided through a national lead agency in each country, in close coordination with the relevant government agency (which in most cases assumes the lead agency role). The program has three corner stones for implement this strategy: gathering knowledge on seed procurement and tree improvement; establishment of national working groups in beneficiary countries; and provision of technical and financial support and services to these national groups, including training, technical assistance, formal education at CATIE, distribution of information, and provision of basic equipment to selected seed banks.

Genetic effects of the forest fragmentation project

This project aims to develop a predictive model of the effect of forest fragmentation. Currently, work is focused on four species in seasonally-dry Costa Rica. However, the work is not species- or ecosystem-specific.

Genetic diversity of mahogany

This project, in its final year, is working to develop conservation guidelines for mahogany, based on distribution of RAPDs variation. The emphasis is on *Swietenia macrophylla* in the Atlantic watershed, from Quintana Roo to Panama.

In general, drawing up 'species lists' for forest genetic conservation cannot be done in the same way as for food crops, because ex situ conservation is suitable only for a few species, and is, in any case, fraught with problems. We feel strongly that the way to secure genetic diversity of forest species is through their utilization in, or at least coexistence with, agricultural systems; this must be based partly on sound genetic principles.

10. Resources

PROSEFOR

Infrastructure: Rehabilitated seed bank and offices; in the countries, LOAs with national institutions in support of training and development activities.

Human resources: Two Ph.D., two M.Sc., plus support staff. The national institutions have assigned a counterpart in each country; the project does not maintain staff in the countries.

Ideally, the project should be augmented by a communications specialist based at CATIE and a work team in each country comprised at least by one professional, a field assistant and a secretary, with adequate transportation, equipment, materials and operating funds.

Fragmentation Project

The project has skeletal but adequate staffing (one M.Sc. plus support staff in each project). Although there is no special infrastructure, fulfillment of objectives will depend to some extent on access to other CATIE infrastructure (biotechnology lab).

Mahogany project

The project has just one professional (M.Sc.), complemented by a highly experienced research assistant. The current staffing level is in accord with the planned activities. Infrastructure includes the CATIE forest nursery.

11. Work program

PROSEFOR

The work program aims principally at strengthening the seed banks and the regional and national networks, supporting tree improvement and seed research, holding training courses and seminars, disseminating information (including the project bulletin), and developing seed sources.

Forest fragmentation project

During 1997, work will focus on population mapping and collection of samples. Laboratory analysis will begin in 1997, to be completed by late 1998.

Mahogany project (EU)

RAPDs variation is currently being examined by project collaborators at ITE and guidelines on genetic conservation will subsequently be prepared. In addition, a series of field trials is being established, to be taken over later by the ITTO mahogany project.

ITTO project

During the first two years, the activities of the Forest Genetic Resources Unit will be directed principally at the establishment of field tests.

Table 4. Estimate of resource needs for the research component of the Genetic Improvement and Conservation of Forest Tree Species Unit (annual averages)

Type of resource	Current	Optimistic
A. CATIE resources		
1. Human resources (number of person/years)		
1.1. Ph. D.	2	6
1.2. M.Sc.	4	6
1.3. Other professional staff		8
1.4. Post-docs/visiting scientists		2
1.5. Ph.D. students		4
1.6. M.Sc. students	4	8
2. Funding (kUS$/year)		
2.1. Equipment and materials	15	100
2.2. Travel and other expenses	18	94
3. Infrastructure (equipment, etc.)	0	300
4. Other resources (communications, training, research costs, etc.)	400	400
B. Partner institution resources (2)		
1. Human resources (number of person/years)		
1.1. Ph. D.		
1.2. M.Sc.		
1.3. Other professional staff	7 (part time)	7 (full time)
1.4. Post-docs/visiting scientists		
1.5. Ph.D. students		
1.6. M.Sc. students		
2. Funding (kUS$/year)		
2.1. Equipment and materials		18
2.2. Travel and other expenses		18
3. Infrastructure (equipment, etc.)		300
4. Other resources		
C. New resources (3)* **		
1. Human resources (number of person/years)		
1.1. Ph. D.		
1.2. M.Sc.		
1.3. Other professional staff		
1.4. Post-docs/visiting scientists		
1.5. Ph.D. students		
1.6. M.Sc. students		
2. Funding (kUS$/year)		
2.1. Equipment and materials		
2.2. Travel and other expenses		
3. Infrastructure (equipment, etc.)		
4. Other resources		

*** In 1998, PROSEFOR funds and staff are likely to be similar to those indicated for 1997. The only likely new resources are those of ITTO, estimated at US$400,000 per year.

Table 5. Details on current professional staff of the Genetic Improvement and Conservation of Forest Tree Species Unit

Expertise	Expert	Education Level
Forest genetics and tree improvement	Rodolfo Salazar	Ph.D.
	Francisco Mesén	Ph.D.
	Jonathan Cornelius	M.Sc. (Ph.D. student)
	Luis F. Jara	M.Sc.
Silviculture	William Vásquez	M.Sc.
	Carlos Navarro	M.Sc.

Table 6. List of current and potential new partner institutions for the research component of the Genetic Improvement and Conservation of Forest Tree Species Unit.

Current partner institutions	Country
Ministry of Environment and Energy (MINAE)	Costa Rica
National Seed Office (ONS)	Costa Rica
Technological Institute of Costa Rica (ITCR)	Costa Rica
General Directorate of Natural Resources	El Salvador
General Directorate of Forests	Guatemala
National School of Forest Sciences (ESNACIFOR)	Honduras
Ministry of Natural Resources	Nicaragua
National Institute of Natural Renewable Resources (INRENARE)	Panama
General Forestry Directorate (DGF)	Dominican Republic
Potential new partner institutions	**Country**
Atlantic Coast Regional University Center (CURLA)	Honduras
Seed Certification Office	Honduras
Seed Certification Office (CENTA)	El Salvador
Universidad Evangélica	El Salvador
ECOFOREST	Guatemala
Seed Export	Guatemala
National Autonomous University	Nicaragua
Technical Forestry Institute (INTECFOR)	Nicaragua
Center for Sustainable Development (CEMARE)	Panama
National Association of Tree Planters (ANARAP)	Panama
Enda-Caribe	Dominican Republic
Pedro Henriquez Ureña University	Dominican Republic
Asocc. of Forestry and Agroindustrial Producers (APAIFO)	Costa Rica
Hojancha Agricultural Regional Center (CACH)	Costa Rica
Jicaral Agricultural Regional Center (CACP-J)	Costa Rica
Esparza Agricultural Regional Center (CACE)	Costa Rica

Appendix 2

Research Line 2

Integrated Pest Management for Agroforestry and Forestry Activities

Integrated Pest Management (IPM) for Agroforestry and Forestry Activities

1. Justification

Integrated pest management (used throughout in the broad sense to mean insects, weeds, diseases and nematodes) provides low-input, multidisciplinary solutions for the management of the whole pest complex in the context of a cropping system. It is an approach that enhances decision-making regarding pests and production systems through a knowledge of what, how and when to use ecologically-based technologies.

To be successful, IPM must be interdependent with the management of the whole system, meaning that IPM options are developed in intimate relation with other actors in the system. This document should therefore be read in conjunction with those pertaining the other Research Lines, particularly Agroforestry Systems, in which the IPM collaboration is likely to be greatest.

The primary target systems for IPM outputs and research collaboration will be shade-grown perennial crop systems (SGPCS), hillside mixed food crop/agroforestry systems (HAFS1) and mahogany growing in plantations (plantation forestry systems -PFS-). The corresponding geographic target area will depend on the exact sites and systems selected for multidisciplinary implementation-oriented research (MIOR) and development activities, but results and outputs will be applicable wherever such systems occur in the Central American region2. Due to their strategic nature, systems in which the same crops occur will be frequent. Thus the target for SGPCS-related activities is 852,000 ha (4% of the total agricultural area), affecting 712,000 people (6.1% of the agricultural population). HAFS-related activities target 520,000 ha and 339,000 people. Data are currently not available for the targets of IPM-related activities.

Results will also be generally applicable throughout tropical America where similar conditions prevail; in some cases they will have worldwide potential. Since all target systems primarily involve small, resource-poor producers, the direct impact on rural poverty is likely to be significant. When outputs of this and associated activities carried out by other technical areas and partners are massively implemented, the results will include more stable sources of employment for men and women, increased farm income, and better quality of life as a result of health, environment and (in the case of HAFS) nutritional gains.

1 Data for HAFs systems assumes cultivation of only beans, cabbages, peppers and tomatoes.

2 Defined as Belize, El Salvador, Costa Rica, Guatemala, Honduras, Nicaragua and Panama, for which the data presented in the rest of this document apply. Most data presented in this document are extracted from or calcutated on the basis of data in FAOSTAT database (http//:aoos.fao.org). Data for land area from 1994, for population 1995, for production 1996, and for pesticide use 1993. Crop values and crop losses are author's estimates and probably conservative (per kg values and loss % were US$0.55 and 20% for beans, US$0.29 and 20% for cabbages, US$11.91 and 30% for peppers, US$0.77 and 30% for tomatoes and US$2.43 and 15% for coffee) Pesticides costs data assumes an average 40% i.a./l c.p. and US$15.oo /l p.c. value. Pesticide use data assumes annual average use/ha of agricultural land * multiplier to take a account of different intensities of pesticide use (multipliers used: beans = 0.4, cabbage = 4, pepers = 7, tomatoes = 5, coffee = 1).

The major goals of IPM in SGPCS and HAFS are the reduction of pesticide use through substitution of ecologically oriented alternatives, reduction of losses caused by pests, and enhancement of farmer pest management decision-making capacity. The combined annual economic value of pesticides and losses, based on 1996 production figures and 1993 pesticide use data, are US$341 million in SGPCS and US$108 million in HAFS. Data for PFS are not available but informed opinion suggests that losses may be very high.

Earlier experience in IPM research and implementation suggests that 50% reductions of both pesticide costs and losses are realistic goals, resulting in combined annual savings to Central American agriculture of US$112 million (conservatively assuming only 25% adoption). These direct savings alone would justify the program, but when the non-monetary benefits of improved health, reduced environmental contamination, improved soil fertility, reduced soil erosion and generally improved sustainability that result to varying degrees from IPM practices are taken into account, the justification becomes overwhelming. Of particular interest in this context is the contribution of improved sustainability in productive systems to slowing the emigration to urban and particularly agricultural frontier areas, where additional pressure is placed on remaining natural forests.

The existing CATIE budget supports a core group of four Ph.D. (including the head of the Sustainable Tropical Agriculture Area) and five M.Sc. IPM professionals at headquarters that achieves a significant multiplier effect in research output through a cadre of highly trained support staff. Current research efforts are largely directed toward the generation of strategic technologies that, in large part, would feed seamlessly into the new focus. External donor support finances an additional three Ph.D. and four M.Sc. IPM professionals plus support staff whose work focuses on both strategic technology generation (largely at headquarters) and predominantly MIOR and implementation activities (largely in Nicaragua), which have considerable technical overlap with this proposal and will provide an experience base for implementation activities.

The strong emphasis on biointensive IPM, microbial control technologies, and their implementation in production systems designed to increase sustainability and target small farmers in ecologically sensitive areas should be attractive to new donors. New emphases on pest management and ecology in agroforestry systems are also likely to stimulate donor interest. In addition, considerable potential exists for synergizing the program through alliances with partners that have their own funding sources. Several new projects, that would primarily support the strategic technology generation component of the program, have already been submitted or have high potential for success when submitted.

The IPM line clearly addresses the call made by Central American presidents on October 12, 1994 in Managua, Nicaragua, in the "Alliance for Sustainable Development" agreement, to "stimulate the use of biological controls and avoid excesses in the use of pesticides and herbicides". It is also in full accord with two significant international agreements to which the Central American nations are signatories. Agenda 21, that resulted from the 1992 UNCED Conference held in Rio de Janeiro, states that "agriculture has to meet this challenge --food demands of a rising population and uncertain capacity of available resources and technologies to meet them-- mainly by increasing production on land already in use and by avoiding encroachment on land that is only marginally suitable for cultivation..." and "...integrated pest management ... is the best option for the future, as it guarantees yields, reduces costs, is environmentally friendly and contributes to the sustainability of agriculture." The World Food Summit in Rome (1996) agreed that "we recognize the importance for food security of sustainable agriculture, fisheries, forestry and rural development in low- as well as high-potential areas ..." and "... promote ... regional collaboration in plant pests and animal disease control and the widespread development and use of integrated pest management practices." Studies on pest management and ecology in agroforestry systems were identified a decade ago as a high priority by ICRAF, but was not followed up on because of a lack of resources.

CATIE has a major comparative advantage in generating and disseminating producer-oriented technologies as a result of its accumulated experience over two decades in farming systems and IPM research. IPM's inherent systems focus suits it to play a major role in the development of sustainable agroforestry production systems and in the development of novel planting systems for plantation trees. During recent years, when the MIOR focus at CATIE/Turrialba largely gave way to disciplinary research on strategic technology inputs, priorities were set with reference to the prioritization of a small number of major food production systems (mainly tomato-based, low-input musaceous crop-based, coffee systems and maize-based systems). There has been a concentration on pests or approaches in these systems that impact a wide range of environments and other systems; in any event, the broad approach and general component activities applied in IPM are similar regardless of the system.

In the CATIE IPM group working in Nicaragua, the multidisciplinary, systems-oriented approach has been retained and expanded to include research into IPM implementation methods, with a strong emphasis on enabling national institutions. Significantly, IPM/Nicaragua has several years experience working in shade coffee systems. Although the efforts of other institutes and initiatives in the region might overlap with some aspects of the program, none can match CATIE's multidisciplinary, fully integrated, applied IPM and agroforestry approach, which is backed by original, high-level research into the strategic components needed to fill the technological vacuum that currently limits the supply of scientifically-based sustainable alternatives. National, regional and international centers and programs should be seen as contributors, users and partners, not as competitors or as agencies supplanting the role that CATIE will play.

The research program will feed into and benefit from CATIE's current and future M.Sc. and Ph.D. educational programs in integrated pest management, ecological agriculture, tropical horticulture and agroforestry studies. Because of their direct involvement in research that addresses the challenge of the transition to sustainable production through agroforestry, staff and students will contribute to CATIE's "green" image and will provide information-oriented inputs for CATIE's outreach efforts.

2. Beneficiaries

Direct beneficiaries are national institutions in the public, private and NGO sectors involved in research, extension and implementation of IPM and/or agroforestry activities who will receive novel, scientifically-evaluated technological inputs, materials and research planning tools, as well as experience in collaborative development of improved sustainable systems and implementation methods. Indirect beneficiaries are producers of crops and trees in target systems, consumers, and rural communities as a whole through increased or more stable employment opportunities, greater incomes, reduced pollution and improved health. The world's scientific community will benefit from inputs of scientific knowledge in the field of sustainable agriculture. Society as a whole will benefit from reduced rural migration to cities and marginal forest areas and less encroachment on natural forests for agriculture and timber extraction.

3. Objectives

General objective

To reduce pesticide use through the substitution of ecologically oriented alternatives and to reduce losses caused by pests.

Specific objectives

- Using a multidisciplinary collaborative approach with other contributors, to integrate biointensive IPM practices into target production systems.
- Based on current research strengths and the needs identified for integrated systems implementation activities, to generate, develop and test biointensive IPM technology inputs for use in target production systems.
- To generate knowledge on how to effectively mass implement IPM in target agroforestry systems, and how to enhance producers' pest management decision-making capabilities.
- To provide responses to immediate plant protection demands of other groups working in target systems through short-term, problem-solving research. To provide pest-related research support services to

internal and external users working in the areas of agroforestry, plantation forestry and natural forest management, including pest identification, phytosanitary characterization, methods development, and network coordination.

4. Current Status

As outlined above in the analysis of CATIE's competitive advantage, much of the current activity in IPM research and development already generates knowledge, develops technologies and works on implementation methods that are applicable to the new, broader research focus in HAFS. Reorientation of staff time or additional personnel will be required to strengthen inputs to SGPCS and PF systems, areas currently with weak resources (with the exception of coffee in Nicaragua).

In IPM, the only significant activity in HAFS being carried out by other institutes in Central America is at Zamorano (EAP), particularly the Zamorano IPM-COSUDE Hillsides Project in Honduras and Nicaragua, and soon to begin work in El Salvador. The CATIE program will complement these activities by providing outputs not covered by their program, primarily in the development of certain strategic inputs (including microbial control, whitefly management technologies and possibly cover crops) that are not strong points of this largely applied, on-farm project, and by introducing agroforestry components into the production systems. The CATIE program could offer much more but this will depend on demand and availability of additional resources.

The AVDRC will be a valuable partner through its vegetable crops initiative, which has an IPM component. However this project is neither large enough to be construed as "covering this area" (in fact, it hopes to rely to some extent on CATIE expertise in this field), nor does it specifically target hillside farmers or contemplate the introduction of IPM within an agroforestry approach. Similarly, the level of activity in national IPM programs tends to be uneven, short-term, highly applied and crop- or single pest species-focused, rather than system-focused as proposed herein. In the broader context of Hillsides, there exist a wide range of NGO, governmental and internationally-funded initiatives that are described in the sister document on Agroforestry Systems. None of these has a strong IPM component and the demand for inputs can be presumed to be very high if current, limited contacts are a valid guide.

5. Goals

This section is limited specifically to IPM objectives. Insofar as IPM will carry out much of its activity within system-focused research lines, this section should be read in conjunction with sister documents for those lines where, for example, information on milestones for collaborator and area selection can be found.

- **End-1997** IPM/agricultural systems expert contracted as coordinator. System-based IPM groups working in close coordination with institute-wide working groups for system-focused research lines. Two IPM research proposals developed in support of HAFS and SGPCS. Whitefly Network coordination transferred to another institute. Program initiated for development of microbial control for coffee pathogens.
- **End-1998** Ecologically adapted and characterized cover crop species for SGPCS and HAFS selected and available for mass implementation. One Ph.D. and three M.Sc. theses initiated in SGPCS on shade-fertility-pest-natural enemies-technology interactions or microbial control of key pests. Microbial control applied for coffee berry borer control in mass implementation program in Nicaragua. Two IPM research proposals developed in support of HAFS, SGPCS or PFS. Effective training models identified for mass implementation of IPM. Monitoring system available for key natural enemies of *Hypsipyla*. Research programs initiated on soil-borne pathogens of timber species, and soil fertility-OM-pests in HAFS.
- **End-1999** Final phase-out of externally-funded non-priority research (April 1999). Field-tested microbial control technology for *Phyllophaga* available for wide-scale evaluation in HAFS. Additional three M.Sc. theses initiated on SGPCS topics and five on HAFS topics. Optimal utilization methods developed for commercially-available microbial control products against key HAFS insect

pests. Biointensive management system for whitefly/geminivirus demonstrated and mass implementation with partners begun. Proposal presented for introduction of biological control agents for itchgrass.

- **End-2000** Partner programs established in all C.A. countries for dissemination of improved cover crop technologies for SGPCS and HAFS. Field-evaluated technologies for microbial control of coffee pathogens available for wide-scale testing. Candidate *Hypsipyla*-tolerant silvicultural systems under evaluation; role of natural enemies in such systems characterized.
- **End-2001** Ecological principles for improved coffee/shade system management elucidated, published and applied in pilot areas. Success of different models for mass implementation of IPM determined and in process of application with partners. Coffee lines with horizontal disease resistance identified and available for large-scale evaluation.

6. Relationship to CATIE's Education and Outreach Areas

The research program will benefit CATIE's current and future M.Sc. and Ph.D. educational programs (Integrated Pest Management, Ecological Agriculture, Tropical Horticulture and Agroforestry) by ensuring that professors are constantly exposed to fresh knowledge in their respective fields and also have a broad vision of the context in which their specialties are applied. It will also provide the arena in which thesis research will be done, thus additionally ensuring that students are (and, equally important, feel that they are) making a contribution to real problems rather than performing academically-interesting but ultimately inapplicable research. Because of their direct involvement in research that addresses the challenge of the transition to sustainable production, participating staff and students will be well placed to generate state-of-the-art syntheses on topics of real-world relevance, expert systems, contributions to local and world scientific literature; they will also be able to provide the raw material for knowledge bases and data bases.

7. Human Resource Development

- Refresher course in experimental design and data analysis geared to specific types of research.
- Intensive training in: a) Agroforestry - CATIE M.Sc. courses "Agroforestry Systems" and "Agroforestry Systems with Coffee and Cocoa"; b) Coffee IPM - CATIE coffee IPM short course April 3-6, 1997; c) IPM in plantation forests; d) participatory research and development, including gender and minorities focus - IPM Nicaragua and Environmental Socioeconomics Area
- Training for support staff (mainly M.Sc.) in project proposal writing - PPP staff to execute
- Continued English-language training for support staff; the aim is fluency.
- Incorporation of participatory decision-making mechanisms at CATIE
- Redesign of staff evaluation procedures to emphasize individuals' goals and success in achieving them, in place of accomplishment of "average" institutional goals.
- Encourage Ph.D. study for exceptional M.Sc. staff
- Free up staff time for productive activities and improve quality of products by streamlining reporting procedures and information provision, with particular emphasis on flexibility of format (place responsibility for extraction of relevant information and harmonization of presentation on person/unit requiring the information) and improved coordination between deadlines and major activities at the Institute level.
- Provide salary incentives to national staff based on real responsibilities and performance.

8. Partners

Because of the necessity of an interdisciplinary approach, many of the institutional linkages for IPM research will be the same as those identified for the system-focused research lines. As these are not listed here, reference can be made to the descriptions of those lines. Independent linkages may be developed for some IPM activities, primarily, but not exclusively, for development of strategic IPM technologies. In these cases, the IPM group will look for effective and efficient collaborative relations in different member countries based on shared vision, common goals and compatible interests. Relationships will be developed, strengthened and maintained through effective joint planning, execution and evaluation processes based on common needs and strengths. Although the institutions listed in the following table are possible working partners, the definitive selection will depend on logistic and budgetary constraints. Emphasis will be placed on seeking an equitable distribution of efforts among all member countries. When the aforementioned constraints result in experimental locations being biased toward one country or another, prioritization of specific research topics according to regional criteria will ensure relevance and applicability across a range of countries.

Most of these institutions or projects already have their own funding as well as varying degrees of other operating resources. Insofar as CATIE's offer is consistent with the specific objectives of these organizations, greater or lesser proportions of these resources would be immediately available as counterpart funding. Past experience suggests, however, that in the absence of additional funding sources (CATIE, donors), achievement of CATIE's broader objectives would encounter organizational obstacles even when

Table 1. Candidate partner institutions for IPM collaboration in, or with a presence in, target countries

System	Country	Regional partner	Public Institutions	Private Institutions	Egos	Universities
SGPCS	Costa Rica Nicaragua Honduras Guatemala	PROMECAFE PROMECAFE PROMECAFE PROMECAFE	MAG MARENA	ICAFE UNICAFE IHCAFE	Various Various Various	UNA/UCR UNA/UNAN- León
HAFS	Costa Rica Nicaragua Honduras Guatemala El Salvador	AVRDC PASOLAC EAP/ COSUDE CIAT PRIAG	MAG/MINAE INTA SRN CENTA	ASOCODE UNAG-PCAC FHIA	ACA Project ALTERTEC CIDDICO	UNA/UCR UNA/UNAN- León CURLA U. del Valle
PFS	Costa Rica Honduras Panama El Salvador Bolivia	MINAE SRN/ ESNACIFOR RENARE CENTA Bolivian institutions				UNA/ITCR
Natural forests						
Research support services	Costa Rica Nicaragua El Salvador Honduras Guatemala Panama Belize	 EAP-Zamorano USFS	MAG / SPN INTA CENTA IHTA ICTA IDIAP MAG	InBio	Various	UNA/UCR/ITCR UNA/UNAN-León

there is full agreement between CATIE and its partners on general objectives.

On the CATIE side, funding proposals should be submitted jointly by the technical areas working in the system-focused research lines; this will make it possible to avoid a continued fragmentation of efforts which could easily persist even within the context of supposedly integrated research lines. Such proposals should be drawn up in close cooperation with the proposed regional partners. Consideration should also be given to redrafting proposals already under development by individual technical areas to determine whether improved interaction with other areas can be built in without endangering their chances of success. Internationally, current and high-potential partners already identified for component-oriented work include ODA (UK), USDA (USA), DANIDA (Denmark), EU-DGXII (European Union) and ITTO.

9. Approach and Methodology

The research activities will be carried out in all of CATIE's member countries, and will be based on the needs, strength and opportunities for collaboration with CATIE's other technical areas and its partners. However, a major concentration of activities in the next few years is likely to take place in Costa Rica and Nicaragua because of the collaboration opportunities already identified.

The primary target systems for IPM outputs and research collaboration will be shade-grown perennial crop systems (SGPCS), hillside mixed food crop/agroforestry systems (HAFS) and mahogany growing in plantations (PFS). The main agroecological zone for the SGPCS and HAFS is expected to be humid tropical environments (defined as areas receiving 1250mm of rainfall or more). The exact tree or crop/tree species focus in these systems will depend on detailed, often site-specific analysis of strengths and opportunities, conducted by the whole target system team.

The case of HAFS merits special advance consideration. Because of the inherent variability of these systems and the lack of a single, unifying crop or tree species component, the focus will be on widely applicable practices and principles for the overall system. In the case of IPM, this will likely mean a dominant research focus on topics such as microbial control and management principles for generalist pests, organic and plant nutrition approaches to pest management, cover crops for weed suppression and fertility improvement, and pest interactions between tree and crop system components. **Rather than be uniquely crop-based, it is considered that the target of this line of research should be the entire system.** The characteristics of the system, rather than predefined crop priority criteria, will determine what research is required because crops and agroforestry species form part of an integrated system and management practices need to be compatible across the full range of crops and rotations the farmer wishes to practice. Nonetheless, the most common vegetable crops in these types of systems are beans, tomatoes, crucifers, green maize/sweetcorn and sweet peppers and will thus almost certainly self-select in many cases. While the research focus is clearly compatible with stimulating organic vegetable production, and will address such systems when appropriate, the IPM group's approach will be to reduce rather than eliminate the use of agrochemicals.

Overall, the IPM research line will combine original disciplinary and multidisciplinary IPM research, and multidisciplinary implementation-oriented research (MIOR) developed with other actors in the target systems. A balance will be struck between the competing demands of new research activities (major thrusts, readily identifiable in advance as keys to success in the system-focused approach), responsive research (demand-lead or problem solving) designed to address problems or opportunities that arise during the MIOR activities, and research in areas of historic strength reoriented to produce outputs applicable to the new targeted systems, as well as research essential to ensure production of outputs prior to the phasing out of redundant sub-lines. This latter group of activities is not considered further in this discussion and will be the subject of another study.

Although every situation will need a specific methodological focus, a generalized scheme is proposed for IPM research activities (Figure 1) that can also be applied to research in other technical areas. For problem identification and integration studies in

Table 2. Summary of systems, crops and possible sub-lines for IPM experimental activities

Target production systems	Target crops	Secondary research lines
SGPCS	Coffee Cocoa?	- Use of natural covers for pest management - Interaction shade-fertility- pests- natural controls-technology - Biological control of key pests, e.g., coffee berry borer, coffee rust, *Rosellinia* - Genetic resistance for disease management - IPM mass implementation methods
HAFS	Vegetables Beans Other crop/tree components as required	- Biological control of key pests: e.g., whiteflies, whitegrubs, foliar & soil pathogens, itchgrass - Use of natural covers for pest management - Soil fertility-OM-pests interactions - IPM mass implementation methods
PFS	Mahogany Other tree species as required	- Impact of silvicultural practices on damage and natural control of *Hypsipyla* - Soil-borne pathogen management studies (also for timber trees in HAFS and SGPCS)
Natural forest systems		All activities in these systems will be carried out as research support services
All systems	Various species	RESEARCH SUPPORT SERVICES - Pest and natural enemy identification - Phytosanitary diagnostics - Agroecological surveys - Mass production of microbial control agents for research needs

the priority systems, the IPM group must work together with other technical areas. The priorities of the work to develop strategic IPM technologies will depend on the problems and demand identified in these stages. To this end, it is proposed that multidisciplinary working groups be established for the target systems (Figure 2). Interest has already been expressed by other technical areas, and SGPCS and HAFS working groups have already been formed. To ensure a systems-based focus, rather than a fragmented approach based on the research interests of individual technical areas, similar groups must be formed in the other systems. The detailed nature of strategic technology development and relevant agroecological studies would remain the primary responsibility of the IPM group. A more detailed breakdown of major research topics and their relation to actual and potential resources is given in Table 6.

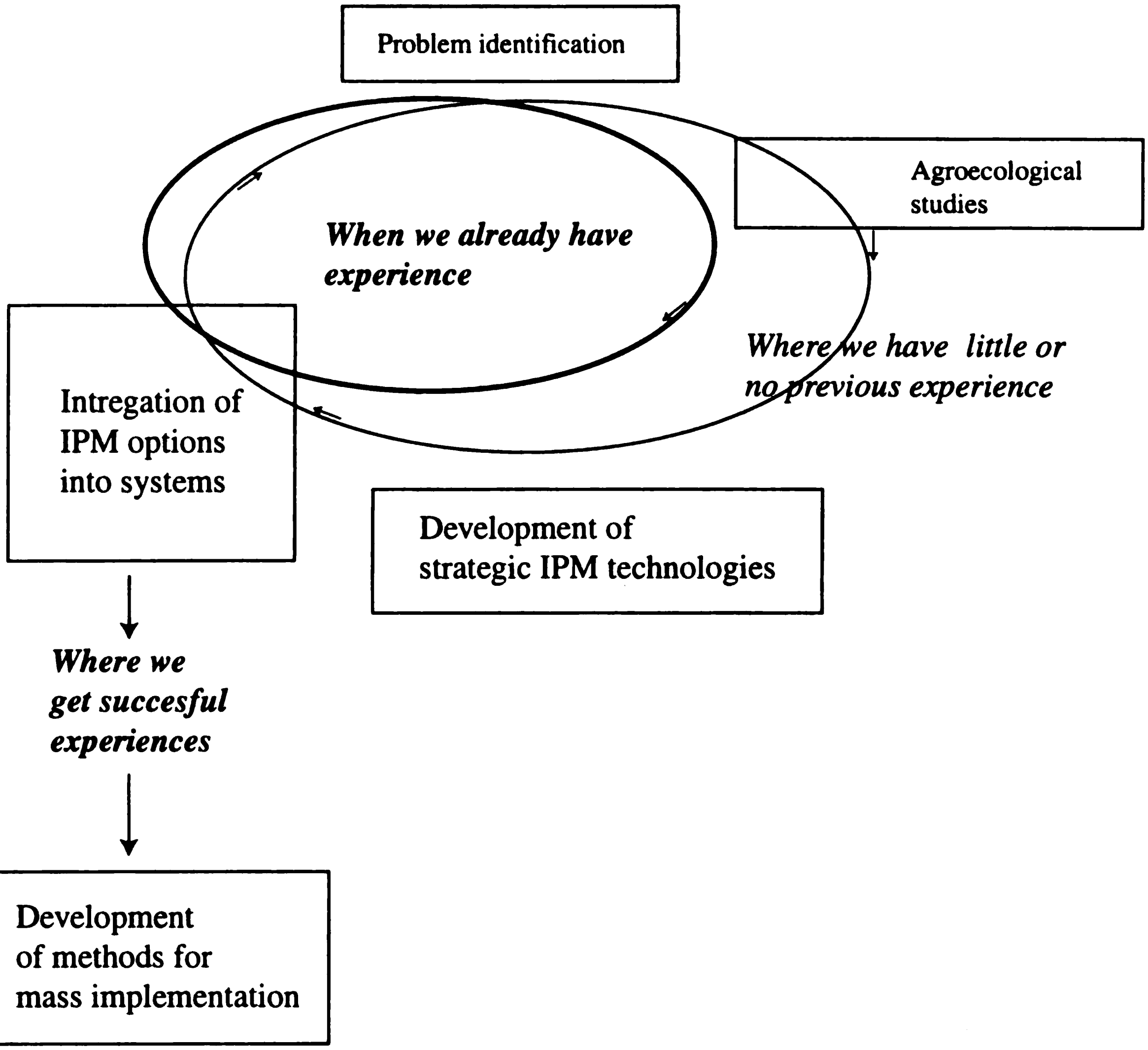


Figure 1. Representation of key phases in the IPM research cycles where prior experience and new areas exist

	Technical Area				
System Working Group	**Agroforestry**	**IPM**	**ATS**	**Socioeconomics**	**Natural Forests**
SGPCS	**	**	**	*	
HAFS	**	**	**	*	
PFS		*	**	*	*
NatFor				*	**

Figure2. Cross-area functioning of system-focused working groups.

Table 3. Estimate of resource needs (annual averages)[1]

Type of resource	Current	Optimistic
A. CATIE resources [2]		
1. Human resources		
1.1. Ph. D.	3.2	5
1.2. M.Sc.	3.7	7
1.3. Other professional staff	1.6	10
1.4. Post-docs/visiting scientists	0	3
1.5. Ph.D. students	1	1
1.6. M.Sc. students	11	15
2. Funding (kUS$/year) Total	133	800
2.1. Equipment and materials	85	200
2.2. Travel and other expenses	48	120
3. Infrastructure (equipment, etc.)		
4. Other resources		
B. Local Partner Institution Resources		
1. Human resources		
1.1. Ph. D.	0.02	5
1.2. M.Sc.	5.65	10
1.3. Other professional staff	10	20
1.4. Post-docs/visiting scientists		3
1.5. Ph.D. students		4
1.6. M.Sc. students	8	15
2. Funding (kUS$/year) (Total)	79	400
2.1. Equipment and materials	2?	100
2.2. Travel and other expenses	1?	60
3. Infrastructure (equipment, etc.)		
4. Other resources		
C. New resources		
1. Human resources		
1.1. Ph. D.		
1.2. M.Sc.		
1.3. Other professional staff		
1.4. Post-docs/visiting scientists		
1.5. Ph.D. students		
1.6. M.Sc. students		
2. Funding (kUS$/year)		
2.1. Equipment and materials		
2.2. Travel and other expenses		
3. Infrastructure (equipment, etc.)		
4. Other resources		

1 Resource estimates include needs for continuing or expanded activities in IPM -Nicaragua project. Current funding is due to end at the end of 1997 and it is proposed that responsibility for subsequent phases be transferred to national institutions. "Optimistic" scenario is therefore likely to be inflated. (Sections A3, A4, B3 and B4 are included as Table 1.) Estimates take no account of the fact that personnel are only partially dedicated to research.

2 Includes externally funded projects.

Table 4. CATIE and partners' infrastructure and other resources

CATIE

Current

- Laboratories (Microbial Control & Entomopathogen Collection, Insect Rearing Unit, Diagnostics & Taxonomic Collections, Entomology and Nematology, Phytopathology, Weeds Workshop and Spray Chamber).
- Screen houses (one in good condition, one in average condition, two in poor condition)
- Computer facilities (1x Pentium, 1 x 486 network server, 3 x 386, 2 x notebooks (386-no battery & 486), several 286 & AT in poor repair, 2 laser printers, one b/w scanner, one slide maker).
- Vehicles (2 pickups: one new, one three years old)
- Space in "La Montaña" Experiment Station for trials
- Office space for 17 persons

Changes required for proposed program

- Backup power supply to laboratories (very urgent); re-equipping and some remodeling (for operational and safety reasons) for Diagnostics, Entomology and Nematology and Phytopathology laboratories. Access for vehicles to Microbial Control and Entomopathogen Collection, Insect Rearing Unit, Diagnostics & Taxonomic Collections.
- Two new screen houses to replace the three in average-to-poor condition
- 13 x Pentium; new network server and infrastructure; Pentium notebook to replace 386; 2 x color laser printer, 5 x b/w laser printer; 6 x Epson LQ dot matrix printers; color scanner.
- Five 4WD vehicles
- Secure sites in target zones for SGPCS and HAFS research
- Additional office space for 9 persons

Partners

Current

- Entomopathogenic fungus commercial production facility and support laboratory, one vehicle, field labor (DIECA and sugar mills).
- Molecular biology laboratory (UCR)
- Laboratories and plots for banana research (EARTH)

Table 5. Five-year work program

System	Crop Componen	Research activity	1997	1998	1999	2000	2001
Shade-grown coffee systems (SGPCS)	Shaded coffee Cocoa?	Use of natural covers for pest management	—	—	—	—	—
		Shade-fertility-pest-natural enemies-technology interactions		—	—	—	—
		Biological control of key pests	—	—	—	—	—
		Mass IPM implementation methods	—	—	—	—	—
		Coffee disease/nematode resistance studies		—	—	—	—
Hillsides mixed food crop /agroforestry systems (HAFS)	Vegetables/ Beans Other crop/tree components as required	Biological control of key pests	—	—	—	—	—
		Use of natural covers for pest management	—	—	—		
		Mass IPM implementation methods			—	—	—
		Soil fertility-OM-pests interactions		—	—	—	—
Planted forests (MP)	Mahogany Other tree species as required	Impact of silvicultural practices on *Hypsipyla* damage and natural enemies	—	—	—	—	—
		Soil-borne pathogen management studies (also for timber trees in HAFS and SGPCS)		—	—	—	—
Natural forests	Various species	All activities in these systems will be carried out as research support services	—	—	—	—	—
Research Support Services	Various species	Pest and natural enemy identification	—	—	—	—	—
		Phytosanitary diagnostics	—	—	—	—	—
		Agroecological surveys	—	—	—	—	—
		Mass production methods for microbial control agents	—	—	—	—	—
		Whitefly Network	—	—			

Table 6. Major research topics in Line 2: IPM for Agroforestry and Forestry Systems

Main Sub-line	Research Topic	Resource Origin		Resources[1]
		Core	Project	
System targeted				
Hillsides Agroforestry Systems (HAFS) • **vegetables** • **beans** • **other crop/tree components as needed**	**Biological control - strategic research** • tactics for deployment of entomopathogenic fungi (EPF) against whiteflies		X	• No current resources: dependent on new project. Project submitted to USDA Jan97. Possible component of Phase III IPM -Nicaragua proposal to NORAD (Jul 97?)
	• tactics for deployment of EPF against key limiting insect pests of HAFS systems		X	• No current resources. Use of core resources dependent on demand defined in context of HAFS working group. Possible component of Phase III IPM -Nicaragua proposal to NORAD (Jul 97?)
	• development and field testing of EPF and bacteria against whitegrubs		X	• ODA-*Phyllophaga* project until Mar 1999. Limited core support required currently for testing in HAFS. Good perspectives for new projects.
	• development and field testing of microbial control agents for tomato blight and bean pathogens		X	• No current resources: dependent on new project. Project on tomato pathogens ready for submission to USDA Mar 1997
	• ecology of arthropod and microbial biological agents in HAFS production systems, and system design for optimizing natural biological control		X	• No current resources. Project under development with RAVC-Denmark for work on arthropod agents. New project required for microbial agents component: no current prospects.
	Systems focused research • IPM inputs to HAFS systems design. Research agenda defined in context of HAFS working group (primarily composed of Agroforestry, Crop Protection and Socioeconomics) in response to system needs	X	X	• Principal topic for core resources deployment in HAFS (mid-late1997 onwards?) High priority for project preparation. Possible component of Phase III IPM-Nicaragua proposal to NORAD (Jul 97?)
	Pest/system management interactions - strategic research		X	• Limited current resources. Priority for project preparation.
	• Studies of interactions between soil fertility enhancing and erosion control measures and pest abundance and damage		X	• No current resources: dependent on new project. Project submitted to USDA

Main Sub-line	Research Topic	Resource Origin		Resources[1]
		Core	Project	
HAFS (cont.)	• Impact of soil covers and cultural practices on whitefly-geminivirus incidence			Jan97. Possible component of Phase III IPM-Nicaragua proposal to NORAD (Jul 97?)
	Methodologies for mass IPM implementation • Research agenda set according to needs determined by the HAFS working group. Additional collaboration with Outreach Program.		X	• Current resources in Crop Protection limited to Phase II IPM-Nicaragua project. Likely component of Phase III IPM-Nicaragua project. Additional resources in Socioeconomics Area and Outreach Program.
Shade-Grown Perennial Crops Systems (SGPCS)	**Biological control - strategic research** • strategies for deployment of entomopathogenic fungi (EPF) against coffee berry borer		X	• Current resources depend on Phase II IPM-Nicaragua Project. Possible component of Phase III IPM-Nicaragua proposal to NORAD (Jul 97?)
• **coffee** • **timber trees**	• development and field testing of microbial control agents for coffee rust and *Rosellinia* in coffee and timber trees.	X	X	• No current resources. Use of core resources projected from mid-late 1997. Full development dependent on new project funding.
	Systems focused research • IPM inputs to SGPCS systems design. Research agenda defined in context of SGCPS working group (primarily composed of Agroforestry, Crop Protection and Socioeconomics) in response to system needs	X		• Major topic for core resources deployment in SGCPS (mid-late 1997 onwards?). High priority for project preparation. Possible component of Phase III IPM-Nicaragua proposal to NORAD (Jul 97?)
	Pest/system management interactions - strategic research • Studies of interactions between pests (particularly coffee berry borer), diseases (particularly coffee rust), shade trees, timber trees, coffee and management. Emphasis in Line 2 on effects on pest and disease abundance and damage. Both independent pest- and disease- oriented work and collaborative research with Agroforestry are foreseen.		X	• Current resources exclusively in Phase II of IPM-Nicaragua Project. High priority for project preparation. Possible component or stand-alone project of Phase III IPM-Nicaragua proposal to NORAD
	• Impact of soil covers and cultural practices on weed problems in coffee.	X		• Exclusively core-funded activity.

Main Sub-line	Research Topic	Resource Origin		Resources[1]
		Core	Project	
SGPCS (cont.)	**Methodologies for mass IPM implementation** • Research agenda set according to needs determined by the SGPCS working group. Additional collaboration with Outreach Program		X	• Current resources in Crop Protection limited to Phase II IPM-Nicaragua project. Likely component of Phase III IPM-Nicaragua project. Additional core resources in Socioeconomics Area and Outreach Program.
Plantation Forestry Systems (PFS) • **Mahogany** • **Laurel**	**Strategic research on key limiting pest problems.** • Impact of silvicultural practices on damage and natural control of *Hypsipyla*		X	• No current resources except small trust fund support for maintenance of *Hypsipyla* laboratory colony and entomopathogen identification (until July 1997). Future resources dependent on ITTO Project being funded.
	• Soil-borne pathogen management studies (see pest/system management interactions and biological control components of SGPCS)	X		• No independent resources required in foreseeable future: results of work in pest/system management interactions and biological control components of SGPCS will be extrapolated to these systems. Possible requirement for new resources from 1999? onwards.
Research Support Services	• Pest and natural enemy identification for timber, agroforestry and agricultural crop species	X		• Current resources adequate
	• Phytosanitary diagnostics for timber, agroforestry and agricultural crop systems	X		• Current resources permit minimum level of activities necessary. Possible USDA-funded project for improving dissemination (also current Outreach Program). Inputs for specific activities in projects /core activities in HAFS, SGPCS and PF systems activities are possible.
	• Agroecological surveys with emphasis on SGPCS systems			• Limited current resources . Resources likely to be available within activities planned for HAFS and SGPCS

Main Sub-line	Research Topic	Resource Origin		Resources[1]
		Core	Project	
Non-system focused biological control activities	• Mass production of microbial control agents for research needs and research on production methods for technology transfer		X	• Current resources within ODA-*Phyllophaga* project and Phase II IPM -Nicaragua for production for research purposes. New resources for research on technology for transfer are possible within Phase III IPM-Nicaragua project.
	• Development of native pathogens and classical biological control studies on itchgrass.		X	• Current resources (until 1999) within NRI-*Rottboellia* project. Possible continuation subject to new funding and agreement on introduction of exotics
Stand-alone socioeconomic studies	• Plant protection information studies for decision-makers and policy makers	X		• Core inputs of staff time for collaboration with Socioeconomics Area from which additional resources are expected

[1] "No current resources" means that no core or project funds or personnel will be dedicated to this topic after 1997. M.Sc. theses may enable limited progress until further funding is achieved. For the purposes of this table, M.Sc. thesis resources have not been considered as core resources.

Appendix 3

Research Line 3

Agroforestry Systems

Agroforestry systems

1. Introduction

This executive summary describes the four sub-lines of research considered for improving sustainable agricultural and forestry production. Separate documents are available on each of the sub-lines. The sub-lines are:

- agroforestry systems for the production of annual crops on humid hillsides (AFS-ANNUALS),
- agroforestry systems for perennial crops (mainly coffee) (AFS-PERENNIALS),
- silvipastoral systems for degraded pasture lands in the humid tropics (SPS), and
- plantation forestry silviculture for private farms (PF).

The unifying elements of the four sub-lines are:

- Introduction of trees into agricultural systems on farms (including pastures) rather than introduction of agriculture (including animals) into forests.
- Emphasis will be given to timber producing and multi-purpose species, with special attention to the effects of the tree component on the environment (micro-climate, pests, soils). General principles will be developed on the basis of solid scientific data, making it possible to valuate externalities. In the short-term, fruit trees will be given low priority.
- Second generation agroforestry research, that is, studies of how the systems function (bio-physical and socio-economic interactions) and how they respond to interventions, rather than characterization and productivity evaluations. The latter may continue, but as a basis for financial evaluations.
- Development of descriptive, empirical and eventually process-based models for identifying limiting factors, gaps in knowledge, extrapolating/interpolating site/species results, developing selection criteria and expert systems or other guiding principles that facilitate widespread implementation of results.

These general approaches will ensure complementary and integrated work in the four agroforestry sub-lines, as for example when comparing the performance (e.g., production, nutrient cycling, disease susceptibility) of a given tree species in plantations, with and without annual crops during the establishment phase, or in combination with perennial crops.

2. Justification

2.1 Areas (x 106 ha) and population (x 106) to be affected by research results

Variable	AFS-annuals	AFS-perennial	SPS	PF	Total
Area 0.2	0.8	6.0	1.0	8.0	
Population	2.0	1.7	0.6	___*	4.3

* If firewood is considered, a significant proportion of the 60 million rural inhabitants in the target region will benefit.

2.2 Cost of the problem

Soil erosion is cited as the main example:

- Soil erosion in annual crop systems on hillsides amounts to 150 t/ha/yr, equivalent to 3 t/ha/yr of N, and 1.5 t/ha/yr of P. Cost of replacing N and P in 190000 ha amounts to over US$50 million/yr (by means of inorganic fertilizers).
- Soil erosion in coffee plantations averages 40 t/ha/yr. Including environmental costs, organic coffee in Costa Rica produced a profit of *16,000/ha while conventional coffee gave a net loss of *49,000/ha (1992-93, when coffee prices were at their lowest).
- Soil erosion in degraded pastures amounts to up to 200 t/ha/yr, equivalent to 4 t/ha/yr of N and 2 t/ha/yr of P.
- At least one million ha of plantations have been established. If it is assumed that half this area is inadequately managed, resulting in a 25% lose of productivity of the conservative potential yield estimate of 20 m3/ha/yr, 2.5 million m3 of wood products (timber poles, fuel wood, etc.) are lost every year.

2.3 Rural poverty

- Maintaining and improving soil quality on hillsides and utilization of technologies which require less agrochemicals will improve farm incomes by reducing production costs. Organic products receive higher prices.
- Timber, firewood, and fruit production from coffee plantations will increase farm income and reduce financial risk without reducing coffee profitability. Proper shade management may partially substitute fertilizer application, reduce production costs, reduce pollution and increase product prices ("forest" and/or organic coffee).
- Increasing animal stocking rates in restored pastures will result in higher farm incomes and timber production will reduce economic risk.
- Fuel wood production from thinnings/branches will benefit rural families in member countries where the total rural population is estimated at 60 million people. Proportional benefits for women and children, generally responsible for fuel wood collection, are high.

2.4 Probability of success

There is a high probability of success because:

- there is little ongoing research on these topics
- site-specific CATIE experience shows the potential of these agroforestry systems
- limitations, such as tree-crop, tree-tree competition, are easily identifiable and experience from other disciplines can contribute to overcoming them
- farmers, technicians, international scientists/organizations, institute directors and politicians support these initiatives
- considerable amounts of national resources are available to contribute to generating and transferring results
- specialized markets offer premium prices for sustainably produced and organic products

2.5 Financial and human resources (see Table 1)

CATIE personnel: Based on an estimate of proportional time dedicated to different CATIE programs, agroforestry research presently has 3.15 person/years annually (Ph.D. and M.Sc.), with an optimistic estimate of 9.8 available per year in the future.

Postgraduate research: Between 10-20 M.Sc. students are normally involved in CATIE agroforestry research each year. Students are divided somewhat equally among the four agroforestry research lines. Financial resources earmarked for M.Sc. students during their second year (research phase) amount to US$16,000/student/year; that is, at least US$160,000/year for agroforestry (assuming only 10 students/year).

Staff projects: Current research activities by staff members include US$40,000 in Belize (SPS, AFS-ANNUALS and AFS-COCOA), US$15,000/yr in Costa Rica and Panama (CATIE/GTZ), US$50,000/yr in Costa Rica (timber-coffee root competition; includes two Ph.D. grants); US$50,000/yr for regional modeling studies of plantation silviculture; US$15,000 in CATIE's miscellaneous accounts for research in AFS-annuals and SPS.

Several research proposals have been submitted to support research on AFS-coffee and SPS. Funds are being requested (EU/DG XII -ECU 850,000- and others including DANIDA, and German foundations with the University of Bonn).

2.6 Political interest

Sustainable agriculture, ecological marketing, organic production, reduced pollution, prevention of environmental degradation, and agricultural systems integrating crop, livestock and forestry production are becoming topics of significant weight in Central American policy making. In addition, many countries have modified their forest and incentive policies with a view to stimulating widespread participation in plantation establishment programs.

2.7 Comparative advantages of CATIE

CATIE is the leading research institution in Central America with over 20 years experience in integrated research, post-graduate education (M.Sc. and Ph.D.), and training in agroforestry, natural resource management and conservation, and integrated pest management. In addition to reaching technical staff through its networks and other long-standing collaborative activities, CATIE serves as a natural link between international organizations that address natural resources (research and funding) and national policy groups.

2.8 Relation to education, outreach and other CATIE research lines

Post-graduate higher education, short-term training (both at CATIE and in member and collaborating countries), and technical cooperation in Central American countries are fully integrated with the AFS-Annuals, AFS-Perennials, SPS and PF research lines. The resources of proposed partners have the potential of achieving a major impact on land use, agrochemical use and new income options for rural communities. The work on genetics, biotechnology and seeds of key crops and timber trees (line 1) provides a framework for selecting the most promising species, varieties, provenances, etc. The IPM techniques for agro-silvicultural and forest plantations (line 2) are an essential aspect of the management of trees and associated components. The work on tree growth and modeling in secondary forests (line 4) is closely related. CATIE's economic and policy-related research (line 5) will be developed in coordination with these activities.

3. Beneficiaries

Research results have an impact on rural families, vegetable consumers in the cities, policy and decision makers, students and technical staff from government and non-governmental organizations in the natural resources, agriculture, livestock and forestry sectors, private forest companies, and the global scientific and technical community working on sustainable development in the tropics.

4. Objectives

General objective

To generate both basic and applied information on promising agroforestry technologies that will increase production of agricultural, livestock and forestry products and thus improve rural well-being, without adversely affecting the natural resources base and environmental quality.

Specific objectives

- To develop and validate economically viable and ecologically sound alternatives for the introduction and utilization of woody species in pastures on small- and medium-sized farms in the humid areas of Central America
- To evaluate and model the bio-physical and socioeconomic interactions between timber and/or "service" trees and perennial crops
- To develop agroforestry technologies for the sustainable production of vegetables on humid hillsides of Central America
- To improve the management of forest plantations in tropical America through modeling, testing and the validation of appropriate silvicultural techniques

5. Current Status

Agroforestry systems (AFS) for the production of annual crops on humid hillsides

Although there is considerable interest in problems of hillside agriculture in Central America (IFPRI, CIAT, IICA), all focus on basic grain production in dry areas of Nicaragua, Honduras and El Salvador. Programs fostering organic vegetable production have begun in Honduras and Costa Rica, although without a soil conservation component. CATIE has considerable experience in IPM for major vegetable crops, watershed management, soil conservation on hillsides, and agroforestry technologies, and can therefore fill an important niche at the regional level in the area of sustainable vegetable production.

Agroforestry systems for perennial crops

No other major international organization is conducting basic research on agroforestry with perennial crops. Small-scale, relevant applied research programs are carried out by many government and non-governmental organizations (e.g., ICAFE in Costa Rica, CENICAFE in Colombia). CATIE has considerable experience in bio-physical research in this topic. Bio-physical and productivity research continues in Costa Rica (GTZ), Panama (GTZ) and Nicaragua (IPM). Participatory approaches have been developed in Nicaragua.

Silvipastoral systems (SPS) for degraded pasture lands in the humid tropics

A major CATIE research effort has been made to identify native legume and non-legume woody perennials that can produce large quantities of protein and energy-rich forages for animal feed, and which have a positive impact on soil properties, thus contributing to making sustained production possible. Although timber trees are often found in pastures, they are not managed; moreover, regeneration is poor and growth is stunted. CATIE has studied regeneration of native species, growth rates, biomass productivity in pastures and silvicultural options for producing timber along pasture boundaries. Through these research efforts, CATIE has become the leading institution for silvipastoral systems in Central America.

Plantation forestry silviculture for private farms

Since 1980, CATIE's researchers have established a network of experimental areas and demonstration tree plantations in six countries of the Central American region. The coordinated use of standardized data collection procedures has made it possible to establish a data base system with the information collected from this plantation network. In this research line, the modeling of stand dynamics will be based on methodologies and models developed in Europe. The process-based stand and tree-growth model (SIMFORG) that has been successfully used to predict tree growth in Europe will be validated against the field data and subsequently parametrized to fit Central American conditions. Sensitivity analyses of key financial indicators will be carried out using special methodologies and software.

6. Five-year Goals

Agroforestry systems (AFS) for the production of annual crops on humid hillsides

Integrated pest control and soil management systems developed for the production of major vegetable crops on humid hillsides; production of organic vegetables increased in all participating countries; models developed for predicting effects of management activities on vegetable production and income.

Agroforestry systems for perennial crops

Traditional shaded-coffee systems quantified; process research conducted on exemplary trees and coffee plants at a limited number of sites, potential of trees to substitute chemical fertilizers determined; ecophysiological and financial models developed; participatory methods for testing alternatives developed and tested with farmers.

Silvipastoral systems (SPS) for degraded pasture lands in the humid tropics

Silvipastoral alternatives developed for increased timber and animal production; increased income on cattle farms and restoration of degraded pastures demonstrated; quantitative data generated on the role of SPS in conservation of soil, water and CO_2.

Plantation forestry silviculture for private farms

Growth and yield tables developed for main plantation species under different forest management regimes; process-based physiological models, computer-based management systems, and economic models developed, validated and in use in member countries; synthesis reports prepared and disseminated; regional networks and data bases for growth and yield data and plantation management established and in operation; partner institutions interacting.

7. Human Resource Development

Training on organic vegetable production and methodologies for field and on-farm research modeling, GIS and data bases is required for present staff.

Modelers familiar with constraints and possibilities of plantation silviculture, agroforestry and silvipastoral technologies, organic vegetable production, and hillside agriculture are required. An expert in root studies has been requested. High-level research assistants (Ph.D. candidates or post-doctoral fellows) are required for strategic research.

8. Partners (see Table 2)

Agroforestry systems (AFS) for the production of annual crops on humid hillsides
Hillside consortium in Honduras (CIAT, CIMMYT, IFPRI), UCR and GTZ-IICA in Costa Rica; German, United States and Canadian universities.

Agroforestry systems for perennial crops (mainly coffee)
National coffee institutes in Central America, PROMECAFE, national universities in Central America, European universities (Wales, Bayreuth, Bonn).

Silvipastoral systems (SPS) for degraded pasture lands in the humid tropics
CENTA, ICTA, IDIAP, ministries of agriculture and livestock in Central American countries, ICRAF; European, United States and Canadian universities.

Plantation forestry silviculture for private farms
National forestry and agroforestry research and extension committees of Central America and Panama, European universities, CIFOR, private forestry companies, MARENA, INTA, COHDEFOR, CENTA.

9. Approach and Methodology

All four lines will have a similar program, summarized below:

- On-station and on-farm (including participatory) research.
- Bio-physical and socioeconomic research.
- Applied research with (by) collaborating national institutes.
- Establishment of some medium-, long-term instrumented sites at key locations for strategic ecological research.
- Studies of traditional practices as a basis for the design and testing of improvements.
- Development of a conceptual model to help guide/select research priorities.
- Understanding of the physiological basis of stand and/or system dynamics, including studies of below-ground interactions.
- Growth and yield studies of key species grown in plantations and/or in combinations.
- Quantification of the relationships between the principle factors governing tree/crop growth and individual tree/crop and stand development, as a basis for process models.
- Development of data bases for storing and analyzing experimental data in a user-friendly format.
- Modeling of the interaction between management interventions and the ability to generate desired products (in terms of products and values).
- On-site validation of the applicability of the models and agricultural-silvicultural recommendations, in terms of technical and financial feasibility.

The specific characteristics of each sub-line, including target zones and components, are :

Agroforestry systems (AFS) for the production of annual crops on humid hillsides

- Humid (>1250 mm/yr) slopes in Central America, slopes >15%-<40%, N-fixing trees, several vegetable species, sub-line in organic agriculture.

Agroforestry systems for perennial crops (mainly coffee)

- Humid tropics but avoiding marginal zones; e.g., less priority to higher altitude zones (lower tree growth). Principal species is coffee but cocoa, plantain and peach palm (pejivalle) are examples of potentially important components. Top emphasis on timber, followed by services (e.g., mulch); fruits are low priority.

Silvipastoral systems (SPS) for degraded pasture lands in the humid tropics

- Humid areas, particularly with sloping land. Timber trees in improved grass-legume pastures. Grazing under forestry plantations.

Plantation forestry silviculture for private farms

- Main emphasis on lowland zones (humid and semi-arid); later also high-medium plateau (especially pines). Native species and/or species with high potential to produce high quality timber (*Tectona, Gmelina, Pinus, Swietenia, Cordia*).

10. Work Plan

Agroforestry systems (AFS) for the production of annual crops on humid hillsides

Year 1 (1997):

- Formulate more specific action plan
- Identify and contact potential collaborators
- Define sub-lines of research
- Define activities at CATIE and in countries
- Seek donor support.

Year 2 (1998):

- Hire modeler
- Identify knowledge gaps
- Design activities at CATIE and in countries that may give a theoretical framework
- Identify and contact potential donors
- Develop data base of present knowledge and experience
- Develop network of hillside organic vegetable collaborators
- Conduct strategic research in areas identified as knowledge gaps

Year 3 (1999):

- Consider possibility of expanding organic vegetable production in collaborating countries

Year 4 (2000):

- Identify most promising solutions
- Begin validation studies

Year 5 (2001):

- Validation
- Evaluation
- Extension

Agroforestry systems for perennial crops (mainly coffee)

Year 1 (1997):

- Initiate studies of traditional practices in five countries (1 yr)*
- Develop model concept (1 yr)
- Establish principal applied research trials in Costa Rica (evaluation 10 yr)
- Train national staff and complete planning and agreements (2 yr)
- Publish existing cocoa trial results in international journals (2 yr) (phasing out)
- Valuate natural resources benefited by shade-coffee technologies (5 yr)

Year 2 (1998):

- Establish satellite-applied research trials in five countries (evaluation 10 yr)
- Develop process-based models (2 yr)
- Conduct tightly focused research on specific issues like crop physiology (2 yr) and nutrient cycling in the soil (3 yr)
- Financial modeling of exemplary combinations (3 yr)

Silvipastoral systems (SPS) for degraded pasture lands in the humid tropics

Year 1 (1997):

- Elaborate detailed work plan
- Contact collaborators
- Define research activities and projects for funding purposes
- Strategic research (all five years)
- Research networking and development of data bases
- Training and postgraduate education (all five years).

Year 2 (1998):

- Develop projects for funding purposes
- Develop process models
- Publish research results in international journals (years 2-5).

Year 3 (1999):

- Develop process models
- Prepare extension bulletins

Years 4 and 5 (2001):

- Validate and evaluate technologies
- Publish results in extension bulletins and scientific journals

* Numbers in parenthesis refer to number of years required to complete activity.

Plantation forestry silviculture for private farms

Year 1 (1997):

- Fully develop user-friendly version of MIRA database for Windows environment; test and distribute to partners in member countries
- In collaboration with CIFOR, harmonize plantation-related data bases for global use
- Develop the process-based stand growth and yield model and parametrize for two main species in the region
- Two M.Sc. theses at CATIE on economic and financial aspects (in collaboration with research line 5) and one on stand productivity

Year 2 (1998):

- Develop growth and yield tables for main plantation species under different forest management regimes
- Validate the process-based stand growth and yield model and parametrize for additional species in the region
- Conduct financial analysis of costs and benefits of various strategies of silvicultural interventions
- Three M.Sc. theses at CATIE and one in Europe

Year 5 (2001):

- Develop growth and yield tables for main plantations species managed under different forest silvicultural regimes and growing in diverse site qualities
- Develop process-based physiological models, computer-based management systems and economic models; validate and implement in member countries
- Prepare and disseminate synthesis reports
- Establish and implement regional networks and data bases for growth and yield data and plantation management; partner institutions interacting
- Four M.Sc. theses prepared annually; two Ph.D.s completed.

Tabla 1. Resources

Type of resource	Current			Optimistic
A. CATIE resources	**C**	**P**	**T**	
1. Human resources 1 (number of person/years)				
1.1. Ph. D.	1.9	0.8	2.7	6.55
1.2. M.Sc.	0	0.45	0.45	3.25
1.3. Other professional staff	0	0	0	1.5
1.4. Post-docs/visiting scientists	0	0	0	2.6
1.5. Ph.D. students	1	0	1.0	9
1.6. M.Sc. students	10	0	10	20
1.7. Field/laboratory assistants	2	0	2	3
1.8 Laborers	2	2	4	6
2. Funding (kUS$/year)	185	0	185	390
2.1. Equipment and materials	63	0	63	125
2.2. Travel and other expenses	22	0	22	70
3. Infrastructure (equipment, etc.)	80	0	80	140
4. Other resources	20	0	20	55
B. Partner Institution Resources (Section 8)				
1. Human resources 1 (number of person/years)				
1.1. Ph. D.	0.85	3		
1.2. M.Sc.	2.2	7		
1.3. Other professional staff (Ag.Eng./Forest)	1.5	14.5		
1.4. Post-docs/visiting scientists	0	6		
1.5. Ph.D. students	0.5	3		
1.6. M.Sc. students	2	9		
2. Funding (kUS$/year)	190	519		
2.1. Equipment and materials	16	134		
2.2. Travel and other expenses	29	66		
3. Infrastructure (equipment, transport, etc.)	140	235		
4. Other resources Labor	5	84		
C. New Resources (New projects/partners)				
1. Human resources (number of person/years)				
1.1. Ph.D.		3.75		
1.2. M.Sc.		1.5		
1.3. Other professional staff		2		
1.4. Post-docs/visiting scientists		1		
1.5. Ph.D. students		6		
1.6. M.Sc. students		6		
2. Funding (kUS$/year)		552		
2.1. Equipment and materials		293		
2.2. Travel and other expenses		104		
3. Infrastructure (equipment, etc.)		106		
4. Other resources Labor		49		

[1] See Table 1. C= Core; P= Project; T= Total

All resources in sections B and C can be considered "project resources" as they are covered by CATIE's core budget.

Table 2. Personnel

	Current	Optimistic
A.1.1.	C John Beer 20% P Reinhold Muschler 20% C Francisco Jiménez 15% C Eduardo Somarriba 30% C Donald L. Kass 25% C Andrea Schlönvoigt 40% C Jorge Faustino 10% C Muhammad Ibrahim 20% C María Kass 10% C Markku Kanninen 20% P Luis Ugalde 50% P Glen Galloway 10%	John Beer 30% Reinhold Muschler 30% Francisco Jiménez 50% Eduardo Somarriba 40% Donald L. Kass 40% Andrea Schlönvoigt 50% Jorge Faustino 15% Muhammad Ibrahim 40% María Kass 25% Modeler 70% M.Kanninen 20% Hans Jansen 15% Luis Ugalde 50% Glen Galloway 10% New staff 10%
A.1.2.	P Alberto Camero 5% P Jorge Benavides 20% P Gustavo Calvo 10% P Silke Westphal 10%	Alberto Camero 5% Gustavo Calvo 20% Rossana Lok 20% Forest.Eng. 50% (DANIDA Coordination) Silke Westphal 30% Horticulture specialist 50% Org. agr. spec. 50%
A.1.3.		CATIE reps. in countries, 5; 10% each
A.1.4.		Sabbatical Profs. 3, 20% each
A.1.5	1 joint Wageningen/CATIE	CATIE, Ph.D. program
A.1.8.	Core and GTZ	
B.1.1	Martha Rosemeyer University of California 5% Ken Schlather, USDA 5% Erick Fernández, Cornell 5% GSchroth, Univ.Bayreuth 5% Frank Berninger, U. Helsinki 25% (*) Eero Nikinmaa, U. Helsinki 20%(*) Annikki Mäkelä, U. Helsinki 10%(*) Risto Sievänen, U. Helsinki 10%(*)	More time of same 50% 2 University of Wales Total 75% 1 University of Reading 25% 1 University of Hohenheim 25% 1 ICRAF 25% Frank Berninger, U. Helsinki 25% (*) Eero Nikinmaa, U. Helsinki 20%(*) Annikki Mäkelä, U. Helsinki 10%(*) Risto Sievänen, U. Helsinki 10%(*)
B.1.2.	Lucy Fisher, Cornell 5% Jon Hellin, ODA 15% Ricardo Morataya, Univ. Helsinki Marcelino Montero, Univ. Helsinki	From collaborating NGOs/universities in the region 100% 100%
B.1.3	5 Agric. eng. 20% (1 per coffee institute)	5 Agric. eng. 100%

	Current	Optimistic
	MAG, etc. Costa Rica 50%	(1 per coffee institute) Government and non-government agencies in collaborating countries 300% 1 Agricultural engineer ICTA, 100% 1 Agricultural engineer, IDIAP,100% 1 Livestock engineer, CENTA, 100% 1 Livestock engineer, MAF, 100% 1 Livestock engineer, ICRAF, 100% 1 Agricultural engineer, MAG, 50%
B.1.4.		3 Post.doc. 100%
B.1.5.	Karen Lowell, Cornell 50% (to arrive May, 1997)	Students US and German universities
B.1.6.	Univ. Laval/Alberta 100% Univ. Helsinki 100%	Students US/Canadian/European universities
C.1.1.		1 Ph.D., 50% (EU funding) 1 Ph.D., 25% (ICRAF project) Dr. Goetz Schroth 100% (EU funding) 1 Modeler 100%
C.1.2.		1 Organic agriculture/horticultural specialist 50%
C.1.3.		Forestry eng. 100% (EU funding) 1 Agricultural engineer, 100% (EU funding)
C.1.5.		1 University of Bayreuth 100% (GTZ funding) US/European exchange students 400%
C.1.6.		US/European exchange students 500%

C.2. Includes (among others) the proposals:

1) "Quantification and management of shoot and root interactions between coffee and timber trees in shaded plantations in Central America." Submitted to DG XII, EU.

2) "Quantification and management of root interactions between fast-growing timber tree species and coffee in plantations in Central America." TUP/GTZ (Approved for 1997-1999)

3) "Stand dynamics and management of fast growing tree species in Central America." FINNIDA (Approved for 1997-1999)

(*) Full-time researcher; values refer to the amount of time allocated to this research line.
C = Core budget funding; P= Project funding (CATIE staff only)

Table 3. Partners

AA	AP	SP	PF	Current Partner Institutions and Organizations	Country
				In CATIE's member countries:	
		X		MAF	Belize
			X	The following private companies and NGOs: Macori, Los Nacientes, OTS, Raigosa, Coseforma, Canateca, Cabsa, Colgate-Palmolive, Chord-FAO, Fundecor, Agrosima, Stone Forestal, CODEFORSA	Costa Rica
			X	JUNAFORCA	Costa Rica
			X	SINAC	Costa Rica
			X	ITCR	Costa Rica
	X		X	National University (UNA)	Costa Rica
X				University of Costa Rica (UCR)	Costa Rica
X				GTZ-IICA Sustainable Hillside Agriculture Project	Costa Rica
X				Cornell mulch group	Costa Rica
X		X		MAG	Costa Rica
X		X	X	CENTA	El Salvador
			X	COHDEFOR	Honduras
X				CIDICCCO, Hillslope Consortium (CIAT; CIMMYT, IFPRI, IICA, LUPE),	Honduras
X				NRI Soil Conservation Project	Honduras
X		X	X	ICTA	Guatemala
	X			Universidad del Valle	Guatemala
X				CARE Agroforestry Project	Guatemala
			X	MARENA	Nicaragua
			X	INTA	Nicaragua
			X	Agrarian National University (UNA)	Nicaragua
X				UCA Soil Conservation Project	Nicaragua
X				Promundo Humano	Nicaragua
X				GTZ-Ngobe Project	Panama
X				ECO	Panama
X				FCAP	Panama
		X		IDIAP	Panama
	X			National coffee institutes in five Central American countries (ICAFE, UNICAFE, IHCAFE, PROCAFE, ANACAFE) and their member organizations	Guatemala, El Salvador, Honduras, Nicaragua, and Costa Rica
X		X	X	National Forestry and Agroforestry Research and Extension Commissions (providing an important channel for disseminating research results to a wide audience)	Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama
	X			PROMECAFE	Regional
				Elsewhere:	
X				University of Göttingen	Germany
X				University of Hohenheim	Germany

AA	AP	SP	PF	Current Partner Institutions and Organizations	Country
				In CATIE's member countries:	
X	X			University of Bayreuth	Germany
	X			University of Bonn	Germany
X				University of Cornell	USA
X				University of Alberta	Canada
X				University of Laval	Canada
	X	X		University of Wales	UK
			X	University of Helsinki	Finland
			X	The Finnish Forest Research Institute	Finland
		X		ICRAF	Kenya
			X	CIFOR	Indonesia
				Potential New Partner Institutions and Organizations	**Country**
				In CATIE's member countries:	
			X	INIFAP	Mexico
				Elsewhere:	
			X	EMBRAPA	Brazil
			X	University of Freiburg	Germany
			X	University of Wales	UK
			X	Dorschkamp Forest Institute	Netherlands
			X	ENSO Forest Development Ltd.	Finland

AA = Agroforestry systems for the production of annual crops on humid hillsides
AP = Agroforestry systems for perennial crops
SP = Silvipastoral systems
PF = Plantation forestry

Appendix 4

Research Line 4

Development of technologies for the sustainable management of forests and their biodiversity

Development of technologies for the sustainable management of forests and, their biodiversity

1. Justification

Natural forests fulfil basic functions of primary importance for sustainable development, providing society a unique combination of biodiversity conservation, protection of the environmental equilibrium, and production of goods.

The area under natural forests in Central America has been steadily shrinking as a result of the growing human population and their greater their influence on the forest. Starting with a nearly complete forest cover in prehistoric times, the extent of forest area has been reduced to 28% of the land mass in 1990. At the national level, this figure varies from 6% in El Salvador, the country with the highest population density in Central America, to 50% in Nicaragua.

The often fruitless desire of farmers to use the land to fulfil their immediate human needs results in a serious deterioration of the protective and conservation functions of the forest, and reduces its potential to produce sustainably. If annual rates at which forests are transformed into other types of land use continue, between 100,000 and 400,000 species may be lost in Latin America over the next 40 years. Year after year, Central American newspapers report about floods, which are increasing in severity as the forest cover of upper watersheds is reduced. Moreover, all too few people seem to take heed of the cause-effect relation between these two phenomena. At the planet-wide level, global warming is linked to the carbon cycle, in which forests play an essential role. The disappearance of forests is thus a problem of society as a whole, with costs that cannot be objectively calculated: what is the value of a species that becomes extinct?

Probably no more than 10% of tropical forests will ever be conserved in strictly protected areas, and economically attractive forest management with a view to producing goods (wood and other plant products) appears to be the most viable option for maintaining a forest cover that continues to provide the services needed by society. Sustainable management for production purposes --the activity that translates CATIE's *leitmotif* into action-- is technically possible in many humid neotropical forests. The possibility of successfully implementing forest management, however, is hampered by a lack of information necessary to guide the formulation and execution of production plans. What are the most appropriate techniques for controlled tree harvesting in a given forest? How much wood may be harvested from a forest, of which species, and how often? What proportion of the original biodiversity is conserved if the forest is managed for production? What financial and economic benefits does natural forest management provide to all stakeholders? The answer to these questions will contribute greatly to fostering the view that forest management for production purposes can be an attractive and permanent alternative type of land use.

Besides providing benefits to society, forest management practices for diversified production will contribute markedly to improving family economies of

Central American farmers living in agricultural frontier zones and organized to work at a family or community level, as recent studies in Costa Rica and Guatemala have shown.

CATIE has a large professional staff working on these issues. It controls a network of key research sites throughout the lowland broadleafed forests of Central America and is particularly well-equipped to find pragmatic answers to the above questions, for which reason it should continue to play a leading role in this research area. The success of the research will be demonstrated by the level of adoption of technologies and strategies validated. CATIE, which combines research, education and training in one institute, has the internal organization necessary for assuring that the knowledge it generates is transferred to member countries. With established roots in each country, it combines a regional approach with a sensitivity to national differences.

The governments of tropical America have demonstrated their commitment to environmental issues and sustainable development in various fora (i.e., Agenda 21, Alliance for Sustainable Development). Efforts aiming to improve the quality of the environment can count on the support of the international community, which is prepared, for example, to pay for proven carbon dioxide fixation.

2. General Objective of the Natural Forest Management Unit (NFMU)

- To develop strategies and technologies that contribute to the sustainable diversified management of humid neotropical forests, through the determination and modeling of the impact of different internal and external factors on the dynamics of the society-forest system.

Integrated approach to research in line 4

The overall approach to this research line is integrated and cross-disciplinary. It is proposed that work continue simultaneously on biophysical, technical, social, organizational, financial and economic aspects of forest management, in the same forests at selected study sites called "key sites." In this fashion, rather than obtaining products from research on forest biodiversity from one site and on social and financial aspects from another, cross-disciplinary research products on different facets --biophysical, operational, social and financial-- will be obtained from the *same* forests. Such an approach is facilitated by the structure of CATIE's research program and, we believe, will generate unique research products and unique opportunities for the exploration of forest management concepts through models integrating biophysical, social, economic and other considerations.

A second component of the integrated approach is the creation of a CATIE-coordinated cross-disciplinary research network on sustainable natural forest management. This approach is facilitated by CATIE's mandate and its prestige as a regional institution. The first steps toward creating the network have already been taken in the development of work plans for the CATIE-CIFOR Secondary Forest Management Project, and in the development of agreements with national institutions in Nicaragua, Guatemala and Costa Rica. Formalization and expansion of the network is considered one of the most important aspects of the present work plan.

Research network

Objective

- To consolidate a CATIE-coordinated research network uniting institutions and researchers in Nicaragua (Universidad Centroamericana), Honduras (CURLA and ESNACIFOR), Guatemala (CONAP/USAC, at least one national university), Belize (Forest Department), Peru (UNALM), Brazil (EMBRAPA/CPATU), at least two additional South American countries (probably Bolivia, with CIMAR/Universidad Autónoma Gabriel René Moreno and CIAT --both in Santa Cruz-- and Ecuador) and at least two European research institutions.

Goals (products)

- *Year 1 (by December 1997):* First stage for consolidating research network concluded, with UCA (Nicaragua), CURLA and ESNACIFOR (Honduras), CONAP/USAC (Guatemala), Forestry Department (Belize), EMBRAPA/CPATU (Brazil) and UNALM (Peru) incorporated.

- *Year 2 (by December 1998):* National institutions from at least two additional South American countries and at least two European countries incorporated into research network.

3. Sub-line 4a: Development of Technologies

Justification

Sustainable forest management is a centuries-old concept, and work on the application of this concept to natural tropical forests began under European colonial regimes during the last century. Nonetheless, there are no proven systems of natural tropical forest management that take into account the needs and realities of society on the eve of the 21st century; are integrated with different strata of society with an interest in the forest and the goods and services it provides; and ensure profitable productive activity while specifically taking measures to maximize biodiversity conservation. The development of such systems remains a challenge which CATIE, due to its long tradition of interest in the management of natural tropical forests, is uniquely equipped to address.

Sustainable diversified management based partly on an ecological understanding of stand dynamics...

Traditional ecology sought to describe "mature" forests and their relationships to soils and climates. Natural disturbances, however, are ubiquitous in tropical forests, and therefore large areas of tropical lands are covered by forests that are undergoing a process of recovery following disturbance; in other words, they are in a dynamic state. The study of forest stand dynamics, therefore, is as important to the understanding and sound management of tropical forests (if not more important) as the concerns of traditional ecology.

- In ecological terms, forest management operations are another disturbance; the speed and direction of forest recovery after disturbance caused by management determines the speed with which a further harvestable crop is produced. From this stems the research and monitoring activities that are key to answering some of the most important questions faced by forest managers: how much timber (or fruit, or fibre, etc.) can be harvested from the forest, of which species, how often? Is it profitable to harvest from forests within a framework of social/organizational and ecological sustainability? Which post-harvest silvicultural interventions are both financially and organizationally feasible and effective in increasing forest productivity?
- The study of stand dynamics in managed forests is one of the most important strategies for determining the ecological sustainability of the forest; it can also contribute enormously to understanding the sustainability of the earth system of which the forest is part, for example, in relation to fluxes of atmospheric CO_2 in the context of global warming. Rates of recruitment of new trees and of mortality of old ones, and trends in tree growth rates (= stand productivity) over time and in relation to different intensities of intervention are indicators both of the capacity of the forest to recover from management disturbances and of the nature and magnitude of CO_2 fluxes.

In spite of the importance of these questions, most studies of stand dynamics in neotropical forests are carried out --like most studies of forest biodiversity (see Research Line 8)-- in a small number of intensively studied sites, from which human disturbance is excluded. Information on stand dynamics of disturbed forests in general, and of managed production forests in particular, is therefore scarce and generation of such information is a top priority.

... but mainly on relevance to society

Forest management, however, is not merely a process of understanding and manipulating the forest ecosystem, and may only be justified if it benefits specific stakeholders (forest owners, indigenous forest peoples, rural populations at forest margins, the state, industry, recreational visitors, etc.). Forest management systems, therefore, must deal not only with the complex interactions taking place within forest ecosystems, but also with the equally complex, and perhaps less well understood, interactions between those ecosystems, different strata of society, and the earth system of which ecosystem and society are both part.

Without a good understanding of these interactions, the mere ability to manipulate forest dynamics

--however successfully-- will not result in sustainable forest management. Forest management systems that satisfy the needs of direct stakeholders and society as a whole, while remaining within the limits of ecological sustainability, must be developed. This necessity remains in spite of (or perhaps because of) the long periods of research on management of natural tropical forests in the colonies of European nations. Most of the literature of that era is purely technical. The technical achievements of colonial forestry have been incorporated, where appropriate, into modern-day approaches to forest management, but society and the global environment were not of overriding importance during that era and the literature handed down is almost silent on these subjects. Even some of today's major research and development efforts in tropical forest management are of a distinctly technical nature. For the next five years, then, the NFMU proposes a significant integrated, multidisciplinary approach to the development of management systems for natural tropical forests.

Objectives

Output 1: Understanding of Stand Dynamics of Tropical Forests

General objective

- Broaden and deepen knowledge of the growth, commercial yield and natural regeneration (i.e., the stand dynamics) of both old-growth and secondary forests, in relation to both sustainable management for production and the recovery and maintenance of the ecological functions of forests.

Specific objectives

- To determine rates of recruitment, growth and mortality of saplings and trees of both commercial and non-commercial species, and their relationships to the characteristics of trees (including their taxonomic identity and the functional group or guild to which they belong), their biotic environments, substrate variation, management interventions, climatic perturbations and forest life zone.
- To contribute to the development and validation of stand dynamic models, and the evaluation and modification of forest management practices on the basis of the use of these models, through: a) the provision of data for validation of existing models; b) the refinement, on the basis of more detailed modeling studies (see objectives below), of the structure, assumptions and algorithms of said model; and c), the development and use of new models as research tools.
- To make, refine and validate financial and economic projections for forest management on the basis of the results obtained from stand dynamic research, with particular emphasis on the use and comparison of models.

Output 2: Improved Management Strategies and Technologies for Sustainable and Multiple Use Management of Natural Forests

General objective

- To identify, develop and validate strategies and technologies for sustainable forest management using modeling techniques that incorporate the available knowledge of stand and species dynamics as well as algorithms predicting a range of alternative financial, economic and social consequences of their implementation in different socioeconomic and ecological settings.

Specific objectives

- In collaboration with CATIE's research on financial and economic aspects of sustainable land use, to identify and implement promising management interventions for effective and more sustainable use of forest resources, and determine their financial and economic effects on the society-forest system.
- To contribute to the development and validation of existing decision-supporting models, developed by partners for purposes of operational forest management, through a), the provision of data for model validation and b) the refinement, on the basis of more detailed modeling studies, of the structure, assumptions and algorithms of said models
- To evaluate the principles, hypotheses and assumptions of forest management practices, and of decision-supporting models developed for operational management, using the model identified in the above objective; to develop recommendations for

refining or changing said principles, hypotheses and assumptions.

- To identify and evaluate the potential effect of external factors, at both the micro- (e.g., the immigration of communities unsympathetic to the aims of forest management) and macro- (climatic change, politics, legislative changes, international market changes) levels, on the performance of the model predictions

Output 3: Tools for the Formulation of Policies

General objective

- To identify and develop marketing and monitoring tools for the formulation of policies that promote sustainable, diversified forest management.

Specific objectives

- To contribute to the development and validation of criteria and indicators for use in guiding planning, monitoring and control of forest management operations
- To forge links with appropriate institutions for the identification of new markets, and to contribute to the marketing of non-traditional forest products by providing information on sustainably available quantity and quality of such products
- Partly on the basis of the work carried out in relation to the above objective, analyze markets, incentives and legal aspects related to forest and land use for their potential in fomenting more sustainable forest management practices.

Current status

Recent trends in research on stand dynamics and forest management systems in neotropical forests

The outstanding scientific studies on stand dynamics of neotropical forests have, unsurprisingly, been carried out in forests at biological stations and have not focused on the effects of human intervention; only one such study has treated secondary forest. Little information on disturbed or managed neotropical forests is found in international literature and the analyses have been basic, even from the two most important cases of medium-term research on stand dynamics of managed neotropical forest: the Paracou experiment in French Guyana and the Tapajós National Forest in the Brazilian Amazon.

This is not to say that no research on stand dynamics has been done in the context of development projects or by regional and national institutions. In many cases, however, research plots set up have been poorly coordinated, with insufficient or non-existent definition of objectives and weak follow-up in terms of remeasurement, data management and reporting of results. Data quality in permanent sample plot studies is notoriously difficult to maintain even in ideal circumstances, and in such situations the value of the data gathered is extremely questionable.

Numerous stand dynamic models have been developed for logged and silviculturally treated tropical rain forests. Although a basic necessity for such models is that the data used cover as long a time period as possible, for as wide a range of forest conditions (in terms of site and intervention) as possible, some of these models are based on very limited data sets --for reasons mentioned above-- and on very simple assumptions about forest stand dynamics.

While simplicity of assumptions may in fact be desirable, most of the models proposed require validation and refinement on the basis of more complete data sets. A critically important gap in the development of models stems from the relative lack of field data on silvicultural treatments and their effects. Turning to the particular case of disturbed or managed neotropical forests, the general lack of significant medium- or long-term work on their stand dynamics means, obviously, that modeling work has been limited and that all the preceding comments about the need to refine and validate models are particularly relevant to the neotropics.

The lack of data from silviculturally-treated forest is especially evident in the modeling work carried out on stand dynamics of managed neotropical forests, where the most complete data set available --that for Tapajós National Forest in the Brazilian Amazon-- does not include such forest. Finally, no modeling work whatsoever appears to have been carried out on secondary forests.

Moreover, all these efforts have concentrated on forests, without paying too much attention to the social, organizational and economic environment in which stand dynamics takes place, which in many cases had a clear influence on the course of development of forest stands. As a result, no forest management systems based on integrated cross-disciplinary research have been developed. The CELOS management system, which is based on 20 years of research in Suriname, combines a silvicultural system with a tree harvesting system, the impact of which on the forest ecosystem is very well documented. Currently, the system is being validated in an industrial operation in Brazil, and plans are under way to implement different adaptations to the system in a network of operational demonstration sites in five Amazonian countries yet to be identified.

Although the economics of the operation and its potential for incorporating local communities into its silvicultural activities are discussed, it remains a technical system for which the social, cultural, religious, political and economic implications are insufficiently known. Work under way at Paracou and at other sites in neighbouring French Guiana and at Tapajós National Forest in Brasil is similarly orientated and therefore has similar defects. The Palcazu experiments in Peru are an outstanding example of an attempt to develop a forest management system for local communities. It includes a silvicultural system with tree harvesting and further processing within the setting of a local community organization. Unfortunately, the political environment did not allow the project to develop successfully, and the project was forced to work only with indigenous groups, having failed to link up with the settlers responsible for most of the land conversion in the area.

Research and development at CATIE: towards diversified forest management

During the 1985-1990 period, permanent sample plots for the study of stand dynamics were installed during the first phase of research at all current key sites. In all cases, experimental designs have facilitated the comparison of silviculturally-treated forest and forest with timber harvesting only; in some cases, virgin forest plots are also monitored as an important point of reference. This work has produced several reports published in national, regional and international conference proceedings and substantial publications are currently in preparation. The Natural Forest Management Unit database on stand dynamics is the most significant in Central America and projected consolidation of a research network will ensure that this situation is maintained; it will also contribute to strengthening participating national institutions. Because of the long time periods during which the work has been sustained, and the simultaneous work on socio-economic issues and forest plant biodiversity, the database should also be considered one of the three most important in the whole of tropical America, alongside those for Tapajós National Forest, held by EMBRAPA/CPATU at Belem, Brazil, and the multi-institutional database recording work at Paracou.

In collaboration with CIFOR and national institutions in Brazil, Peru and Nicaragua, CATIE has now initiated a cross-disciplinary research project on the management of secondary forests on farms. The short first phase, it is hoped, will lead into a significant second phase in which management activity will be initiated by farmers while parallel research on socio-economic and biophysical aspects of management go on.

The NFMU has identified several promising non-traditional species in Central American forests. Growth, yield and regeneration of these species, as well as of traditional timber species, are studied under different management conditions. At the same time, technologies and management models are developed that aim to increase the sustainability of forest management. The possibilities and constraints of markets for non-traditional forest products are being analyzed.

Thus, through its NFMU, CATIE stands out in the neotropical region as one of the few, if not the only, institutions with experience in cross-disciplinary research directed at developing forest management systems. In order to streamline the research activities and make the results available to a wider public, the NFMU is developing an information system that will make the information more accessible to different stakeholders and also through Internet in the near future.

Five-year goals (products)

One year (by December 1997):

- Two articles on stand dynamics research to date accepted for publication by international journals; internal reports on status of research in Nicaragua, Guatemala and Belize (Output 1) .
- SIRENA model, developed for operational forest management in northern Costa Rica by CODEFORSA/ODA, validated and refined using data from NFMU database; implications of different model scenarios for forest management in that geographic area published in national journal (Output 1)
- Preliminary individual-tree, spatially explicit stand dynamics model developed and parameterized on the basis of data from key sites in Costa Rica (Output 1).
- Cross-disciplinary research proposal developed and submitted to potential donors, integrating research into the ecological, technical, social and economic aspects of forest management, based on activities in key study sites in Honduras and Nicaragua (Output 1).

2 years (by December 1998):

- Article on financial (costs and benefits of management for timber production) and economic (valuation of fixation and storage of atmospheric CO_2) projections, based on different management scenarios as projected by the stand dynamics model, submitted to international journal (Output 1).
- Articles on stand dynamics research to date in Nicaragua and Guatemala published in regional journal or CATIE series (Output 1).
- Article on financial aspects and marketing of at least two non-timber forest products (e.g., *Reinhardtia* and *Quassia*) submitted to regional journal or CATIE series (Output 2).
- Article on socio-economic aspects (alternative business organizations, production logics) of at least one production system (e.g., Peten, Baja Talamanca) submitted to regional journal or CATIE series (Output 2).
- Article on a case study in diversified forest management (ecology and economics of production) of at least one production system (e.g., Peten, Baja Talamanca) submitted to regional journal or CATIE series (Output 2).
- Model for operational management (probably based on SIRENA) *and* individual-tree, spatially explicit stand dynamics model, both parameterized for forests at Nicaraguan and Guatemalan key sites (Output 1).
- Criteria, indicators and parameters for monitoring diversified forest management under conditions of key study sites in Honduras and Nicaragua identified and validated (Outputs 2 and 3)

3 years (by December 1999):

- Articles on stand dynamics of secondary forests on farms in Nicaragua, Peru and Brazil accepted in regional or national journals; synthetic publication on same subject for these countries and Costa Rica accepted by international journal (Output 1).
- Individual-tree, spatially explicit stand dynamics model refined and validated for Costa Rican key sites; article on model accepted in international journal and recommendations for management practice derived from its use accepted by regional journal (Output 1).

4 years (by December 2000):

- Article on financial (costs and benefits of management for timber production) and economic (valuation of fixation and storage of atmospheric CO_2) projections, based on different management scenarios as projected by the stand dynamics model for Nicaragua and Guatemala, submitted to international journal (Ouputs 1-3).
- Article on three forest-based production systems (community based, traditional commercial, improved commercial) and their ecological and socio-economic effect on the society-forest system (costs and benefits, organization, employment, diversification of production), based on different management activities in key sites in Honduras and Nicaragua submitted to a regional journal or CATIE series (Output 2).

5 years (by December 2001):

- Model for operational management (probably based on SIRENA) *and* individual-tree, spatially explicit stand dynamics model, both parameterized for forests at key sites in additional countries (Outputs 1 and 2).

- Article on a forest management system model for at least one production system, based on the cross-disciplinary research in key sites in Honduras and Nicaragua submitted to an international journal (Output 2).

4. Sub-line 4b: Conservation of Biodiversity

Justification

Conservation in production forests: necessary but not well understood

Few people readily link the conservation of humid tropical forest biodiversity with the harvesting of timber. Probably no more than 10% of tropical forests will ever be conserved in strictly protected areas. However, optimization of the conservation value of forests which are managed for sustainable production of timber and other products should be sought. Sustainable management for production is technically possible in many humid neotropical forests and the information on how to do it is now being widely distributed. Very little information exists, however, on what exactly is conserved in managed forests; by far the greater part of the information concerns vertebrates and only in very exceptional cases have researchers examined insect or plant biodiversity.

As far as plants are concerned, some of the ways in which the composition of tropical forest vegetation changes as a result of the harvesting of timber are intuitively obvious, for example, in increases in the abundance of light-demanding species. Intuition and experience, coupled with general ecological understanding of the effects of disturbance on ecosystems, has resulted in the preparation of guidelines for biodiversity conservation in managed forests, such as those of ITTO. These guidelines could and should be applied now. However, the lack of detailed empirical information on the effects of management means that some of the principles on which the guidelines are based are strictly hypothetical.

Hypotheses regarding the medium- and long-term effects of management for timber production on the composition and diversity of humid tropical forests do not appear to have been tested in the neotropics. Thus, although immediate action is needed on all fronts to ensure the conservation of some of the remaining forest, it is still necessary to establish a more scientific basis for conservation action in managed forest. In any case, the guidelines are so general that forest behavior must be monitored on an individual basis in order to provide the more detailed information necessary to orient management.

As far as monitoring is concerned, the challenge of developing economically acceptable techniques in the face of the enormous biodiversity of humid tropical forest has been taken up, but little progress has been made. Any monitoring techniques, whether they involve biological indicators or remote-sensing studies, require validation by detailed research before they can be widely applied, and this requirement appears to be one of the most difficult obstacles to overcome.

Secondary forests: a natural option for recovering tropical ecosystems

Large areas of land deforested for agriculture or cattle raising in the humid tropics are subsequently abandoned, sometimes almost immediately. A secondary succession begins that may lead to the development of a new, secondary, forest. This fact is sometimes overlooked in the tropical forest debate -- perhaps for good reasons-- but it is nevertheless clear that secondary forests offer the prospect that in some cases it may be possible to recover some of the ecological functions of the original old-growth forests. Secondary tropical successions have attracted increasing interest from scientists and land managers in recent years, but much of the scientific information on which management schemes could be based is limited to the first decade of a process that may last for centuries. Long-term research, emphasising processes occurring in older forests, is urgently needed if the true potential of secondary forests in sustainable land management is to be evaluated, and such forests adequately managed.

Conclusions

In view of the above, it can be affirmed that:

- humid tropical forests managed for sustainable production can and must make a contribution to the conservation of tropical forest biodiversity;
- although guidelines for biodiversity conservation in production forests exist and must be applied, a complete scientific basis for action remains to be established;
- although techniques for monitoring biodiversity in forests, including those under management, have begun to be developed, the need for validation through detailed pilot studies of forest response to intervention is yet to be met for neotropical forests;
- the true potential of secondary forests for recovering the production, protection and biodiversity conservation functions lost with the destruction of old-growth forests remains to be established; and
- understanding of the long-term mechanisms of ecosystem change in tropical secondary successions is incomplete and must be developed if these successions are to be managed in an optimal way.

Objectives

General

- To contribute to the scientifically-based conservation of biodiversity in humid neotropical forest lands, through the determination and modeling of the medium- and long-term effects of management for timber production on the composition, species richness and diversity (floristic parameters) of mature forests, and of spatial and temporal trends in the floristic parameters of secondary forests, at sites in at least two different Holdridge life zones and two general biogeographical regions.

Specific

- To determine the spatial and medium-term temporal trends shown by the floristic parameters of old-growth and secondary humid neotropical forests managed for timber production and identify the contributions made to those trends by the main field operations of forest management, by substrate variation, by successional time, by Holdridge life zone, and by climatic perturbations
- To define and identify rare species on the basis of the plot-based study and develop a preliminary classification of reasons for rarity in managed and secondary forests, and determine the effects of management on populations of rare species selected from each category of rarity
- To develop computer simulation models of the response of forest plant biodiversity to management, successional development and climatic perturbations
- To determine the implications of the above for plant conservation in the study forests, and for the implementation of cost-effective monitoring within the framework of operational management

Current status

Recent trends in studies of plant biodiversity of neotropical forests

It has been long known that tropical forests are the most diverse of the planet's terrestrial ecosystems. Detailed inventories of tropical biological diversity, however, have only begun to be published in significant numbers in the past two decades. Classic general texts on tropical forests, such as those of Richards and Whitmore, were written before this detailed information began to appear, and, in any case, they focus on the forests of Asia and Africa. A very great majority of the studies of plant biodiversity of neotropical forests published recently in international literature concern forests free of human intervention; many of the questions that preoccupy academic researchers do not concern human influence, or at least, not human influence during the 20th century. Many come from a very small number of intensively studied sites, usually biological stations supported by international organizations.

On the basis of this work, it is now possible to discuss, with a certain degree of confidence, similarities and differences between forests in different regions of tropical America, the contributions of different categories of plant life-form to total plant biodiversity, and the effects of factors such as annual precipitation, natural disturbance and geological history on plant biodiversity at the local and regional levels. In the conservation and preservation context, this work has contributed to the important identification of so-called biodiversity "hot spots" in the neotropics. The single major exception to the general emphasis on landscapes or sites undisturbed by humans in research on biodiversity of mature tropical forest has been the visionary project on the effects of forest fragmentation in the Brazilian Amazon. None of the other works cited, however, indicate how plant biodiversity in mature forests changes in response to human intervention in general, or to forest management for production in particular, nor why it changes and what practical measures can be taken to optimize the conservation value of disturbed and managed forests.

As far as secondary forests are concerned, greater interest has been placed on the recovery of plant biodiversity during secondary succession than on its status in disturbed mature forests. Most studies, however, have concentrated on the first few years of a process which may last for centuries, and have employed small sample plots that present difficult problems of scale in the interpretation of trends in floristic parameters. Only one study of a neotropical secondary succession has determined changes over time in the floristic parameters of a given forest, so that understanding of the causes of change is still hypothetical.

Research on biodiversity of production forests at CATIE

CATIE's orientation to foster simultaneous production and conservation through wise land-use led inevitably to the development of research on biodiversity conservation in natural forests managed for production. Due to CATIE's unique combination of research and technology transfer activities, practical forest management operations, research on forest management techniques and research on plant biodiversity are carried out in parallel in the same forests at key research sites.

In line with the Center's current drive to integrate research lines with postgraduate education, research on plant biodiversity in managed forests began with two student theses. These student research projects facilitated the establishment of permanent sample plots for long-term monitoring of changes in plant biodiversity at two of CATIE's key sites in Costa Rica; they also contributed to answering questions concerning changes in forest plant biodiversity in the first few years after the implementation of management. For example, NFMU and student researchers have seen how the only detectable short-term effects of management operations on plant biodiversity are caused by two operations: road construction and silvicultural treatment. Regeneration in felling gaps is of high diversity and its composition is much more similar to that of patches of untouched forest than to that of roads. These research plots have now been incorporated into the long-term research activities of the NFMU.

Research on plant biodiversity in secondary forests is currently in progress at three of the Costa Rican key sites. In one case, this work was implemented in 1987 and in all three, forests have undergone silvicultural treatment. The unique database generated by this work is currently being used for writing a manuscript to be submitted to an international journal. The new project on secondary forest management carried out in collaboration with CIFOR and national institutions is making it possible to extend this work to Nicaragua, Peru and Brazil.

Research on biodiversity in production forests is intimately linked to the development of criteria and indicators for biodiversity conservation in forest impacted by human activity. The meeting of the Conference of the Parties (COP) of the Convention on Biological Diversity (CBD) in Buenos Aires (November 1996) identified this as one of the top priorities for forest biodiversity research in coming years. A NFMU researcher was invited to participate in drafting a working document by CIFOR on the subject during 1997. It is hoped that participation in this type of activity, which stems from CATIE's involvement in biodiversity research, may increase in the next five years.

Five-year goals (products)

1 year (by December 1997):

- Article on results of first stage of research submitted to international journal.

2 years (by December 1998):

- Detailed studies of selected rare species implemented at two key sites in Costa Rica; module for data management for rare species research introduced in NFMU system.
- Plot-based studies on community biodiversity incorporated into existing growth and yield research plots carried out by partner institutions in managed mature and secondary forests in Nicaragua, Guatemala, Peru and Brazil.
- Plot-based studies on community biodiversity implemented in new research plots in managed mature forests in at least two additional South American countries.
- Proposals for practical monitoring techniques for operational management developed and reported in internal documents.

3 years (by December 1999):
- Practical monitoring techniques validated and article reporting results submitted to international journal.

4 years (by December 2000):
- Detailed studies of selected rare species implemented at one key site each in Nicaragua, Guatemala and Bolivia; module for data management for rare species research inserted into national database management systems.

5 years (by December 2001):
- Model for simulation and prediction of plant biodiversity change in managed forests developed and validated; report on model submitted to international journal.
- Article on results of first stage of research in Nicaragua, Guatemala, Peru, Brazil and Bolivia submitted to international journal.

5. Approach and Methodology

Research activities of the NFMU will build on the extensive experience obtained at its key sites in Costa Rica, Nicaragua and Guatemala. Current activities will continue and be complemented with more in-depth studies. The NFMU will extend its activities in the fields of applied and adaptive research initially to the broad-leafed tropical forests of Honduras and later to other countries according to their needs.

Regarding research activities in secondary forests, NFMU will continue activities in the current key sites in Costa Rica and expand its activities in coordination with CIFOR and local research organizations to Peru, Brazil and Nicaragua.

In all study sites the research strategy will follow five steps:

1. Implement forest management in full collaboration with the forest owner and within the framework of the dynamics of the people-forest system of each key site.
2. Understand the impact that these interventions have on the biophysical component of the system, and how constraints at the biophysical level limit management options for the forest owner. This involves extensive monitoring of the system in networks of permanent sample plots and the translation of the information into different (sub)models (e.g., growth models, yield projection, trends of plant biodiversity) and the providing informational feed back to decision makers.
3. Understand the socio-economic effects and constraints on options for forest management at each key site.
4. On the basis of 2 and 3 above, develop preliminary cross-disciplinary systems for the diversified management of forests similar to those of the key sites.
5. Validate the strategies and technologies developed

6. Human Resource Development

Scientific

- Motivate existing staff to obtain M.Sc. and Ph.D. degrees with a view to filling the requirements of the proposed chairs.
- Upgrade staff's ability to use common database and GIS.
- Enhance communication skills and participation in inter-disciplinary research and working groups.
- Improve quantity and quality of productive activities.
- Upgrade planning skills of staff, with special emphasis on project proposal writing.

Operational

- Provide further training for support staff in the planning and execution of forest management activities at key study sites, including methods for recording technical, biophysical and socio-economic data in the field.

Policy

- Encourage staff involvement in participatory policy decision-making processes.

Resource requirements

Table 1 details the resources needed to implement the proposed plan. The concept of "chairs" was considered for CATIE's own human resources, with each chair being comprised of one research professor, two research and teaching assistants, three Ph.D. students and four M.Sc. students carrying out research work. The proposed chairs are:

- Ecology of diversified forestry production systems
- Silviculture of tropical forestry biodiversity
- Diversified management of natural forests
- Economy of diversified forestry production systems
- Sociology and gender aspects of diversified forestry production systems
- Ecology and management of mangroves

An expert on management information systems (M.Sc. level) is also needed.

Table 1. Estimate of resource needs for the research component of the Natural Forest Management Unit (annual averages)[1]

Type of resource	Current			Optimistic		
A. CATIE resources	**C**	**P**	**T**	**C**	**P**	**T**
1. Human resources (number of person/years)						
1.1. Ph.D.	0.5	1.15	1.65	3.0	1.0	4.0
1.2. M.Sc.	0.8	3.95	4.75	6.5	2.0	8.5
1.3. Other professional staff	0.0	6.35	6.35	3.0	3.0	6.0
1.4. Post-docs/visiting scientists					2.0	2.0
1.5. Ph.D. students	1.0	1.0	18	8		
1.6. M.Sc. students	7.0	7.0	24	24		
2. Funding (kUS$/year						
2.1. Equipment and materials	5	70	75	50	15	65
2.2. Travel and other expenses	5	90	95	50	10	60
3. Infrastructure (equipment, etc.)	90	10	100	100	10	110
4. Other resources (specify)						
B. Partner Institution Resources						
1. Human resources (number of person/years)						
1.1. Ph.D.	1.1			2.5		
1.2. M.Sc.	1.5			4.0		
1.4. Other professional staff	1.0			3.0		
1.5. Post-docs/visiting scientists				1.0		
1.4. Ph.D. students				2.0		
1.6. M.Sc. students	1.0			4.0		
2. Funding (kUS$/year)						
2.1. Equipment and materials	5			15		
2.2. Travel and other expenses	3			10		
3. Infrastructure (equipment, research sites, etc.)	50			100		
4. Other resources (specify)	2			5		
C. New Resources						
1. Human resources (number of person/years)						
1.1. Ph.D.				1		
1.2. M.Sc.				3		
1.4. Other professional staff				3		
1.5. Post-docs/visiting scientists				1		
1.4. Ph.D. students				1		
1.6. M.Sc. students				2		
2. Funding (kUS$/year)						
2.1. Equipment and materials				30		
2.2. Travel and other expenses				15		
3. Infrastructure (equipment, research sites, etc.)				100		
4. Other resources (specify)						

[1]The estimate was carried out using two scenarios: a) current level of resources and b) optimistic (increase in resources). See Table 2 for details on staff and Table 3 for a list of partner institutions.
Includes the "chairs" proposed on the previous page.
C=core, P=project, T=total

Table 2. Current professional staff available for research at the Natural Forest Management Unit, including the OLAFO Project

Expertise	Expert	Education level research	Time for (%)	Source of funding
Economic evaluat. of ecosystems	Ammour, Tania	Ph.D.	20	OLAFO
Marketing of forest products	Bianco, Luis	M.B.A.	60	OLAFO
Information management	Brenes, Hugo	Assist.	100	Prosibona
Growth and yield	Camacho, Marlen	M.Sc.	80	Prosibona
Forest management, site quality	Campos, José J.	Ph.D.	20	Prosibona
Diversified forest management	Chang, Yorleny	Bach.	60	OLAFO
Information management	Chávez, Alvaro	Dipl.	50	Prosibona
Applied forest ecology	Delgado, Diego	M.Sc.	80	Core
Applied forest ecology	Finegan, Bryan	Ph.D.	50	Core
Applied forest ecology	Guariguata, Manuel [1]	Ph.D.	75	CIFOR
Silviculture of secondary forests	Guillén, Lucrecia	Lic.	80	Prosibona
Computer operator	Hernández, Xinia		100	Prosibona
Site quality	Herrera, Bernal [2]	M.Sc.	90	
CATIE/CIA				
Forest economics	Kent, Justine	M.Sc.	40	OLAFO
Forest management, logging	Louman, Bastiaan	M.Sc.	20	Netherl.
Diversified forest management	Marmillod, Daniel	Ph.D.	75	OLAFO
Community organization	Oduber, José	Lic.	40	OLAFO
Applied ecology and silviculture	Orozco, Lorena	Lic.	80	Prosibona
Silviculture and logging	Quirós, David	Dipl.	75	Prosibona
Applied ecology and silviculture	Quirós, Ligia [3]	M.Sc.	50	MINAE
Non-timber forest products	Robles, Gabriel	M.Sc.	40	OLAFO
Natural regeneration	Sáenz, Grace	M.Sc.	80	Prosibona
Logging	Venegas, Geoffrey	Bach.	50	Prosibona
Non-timber forest products	Villalobos, Róger	M.Sc.	75	OLAFO

Table 3. Current and potential new partner institutions for the research component of the Natural Forest Management Unit

Current partner institutions	**Country**
Central American University (UCA)	Nicaragua
Center for Agricultural Research (CIA) - Univ. of Costa Rica	Costa Rica
Centre for International Forestry Research (CIFOR)	Indonesia
Commission for Forestry Development in San Carlos (CODEFORSA)	Costa Rica
Ministry of the Environment and Energy (MINAE)	Costa Rica
National Institute of Biodiversity (InBio)	Costa Rica
University of Edinburgh	U.K.
Potential new partner institutions	**Country**
Agricultural Research Centre for the Humid Tropics (CPATU/EMBRAPA)	Brazil
Atlantic Coast Regional University Center (CURLA)	Honduras
Gabriel René Moreno Autonomous University (UAGRM)	Bolivia
Belize Forest Service	Belize
Center for Tropical Agricultural Research (CIAT)	Bolivia
La Molina Agrarian University (UNALM)	Peru
National School of Forest Sciences (ESNACIFOR)	Honduras
Union of Concerned Scientists (UCS)	USA
University of San Carlos (USAC)	Guatemala
2 European research institutions	Europe

Table 4. Current and potential new donors for the research component of the Natural Forest Management Unit

Current donors	• Swiss Development Cooperation (SDC - COSUDE) • Inter-American Development Bank (IDB)
Potential new donors	• European Union (EU) • Consultative Group for International Agricultural Research (CGIAR-CIFOR) (for criteria and indicators of biodiversity in managed forests) • GTZ • International Tropical Timber Organization (ITTO)

Appendix 5

Research Line 5

Socioeconomic analysis of environmental policies and management systems in tropical ecosystems

Socioeconomic analysis of environmental policies and management systems in tropical ecosystems

1. Justification

A more sustainable, environmentally sound management of tropical ecosystems depends on four key factors:

- Development of more sustainable, environmentally sound production and management practices
- Knowledge of the direct and indirect (external) economic value of the goods and services provided by the ecosystems, and of how this could be affected by the implementation of improved technologies/practices
- Understanding of the how the processes of technological change occur, given the human dimensions of the tropical ecosystems, through a comprehensive assessment of the socioeconomic factors that influence technology adoption, including gender issues and extension strategies and methods.
- Analysis of current and potential policies (incentives and disincentives) that influence tropical ecosystem management, in terms of their impact and cost-benefit efficiency, based on the information described above.

This research line will focus on the last three issues through interdisciplinary work in select prototypical (case-study) agro-ecosystems in which the biophysical research lines are also at work. These include plantation forestry, agroforestry systems for coffee production, agroforestry systems for the production of annual crops on hill-sides, managed (currently or potentially) forests in the humid tropics, and parks and biodiversity (forest) reserves.

This research line is comprised of three specific sub-lines:

- Economic valuation and analysis of environmental goods and services from tropical ecosystems.
- Socioeconomic evaluation of policies affecting the utilization and management of tropical ecosystems
- Socioeconomic analysis of the processes of technological change occurring in tropical ecosystems

It is expected that, within a five-year period, CATIE will make significant advances in each of the three aforementioned research sub-lines, and will have:

- estimated the economic value of the main environmental goods and services of the prototypical agro-ecosystems in which CATIE has focused its work;
- assessed the financial and economic feasibility and performance of the technological innovations proposed by CATIE, at least at the farm/natural resource use system and agro-ecosystems levels;
- evaluated the key aspects of the policy environment in terms of their influence on the former, and thus, on the adoption and dissemination of such innovations; and
- evaluated the other key socioeconomic aspects that influence the adoption and dissemination of such innovations, including the extension strategies and methods more commonly used in the member countries.

The resulting knowledge and information should be of obvious interest to policy and opinion makers, public and private sector research and development administrators (including the donor community), and members of the international and regional scientific and technical community as a whole (including CATIE).

CATIE's advantages for developing this line of work are clear in comparison with, for example, institutes specializing in economic and/or sociological issues but that do not conduct pioneering research or have any expertise in sustainable agriculture and/or environmental/ natural resources management technologies; and others that do not have the internal structures and working mechanisms necessary for truly interdisciplinary work. Furthermore, the kind of issues embodied in this research line (non-market valuation, policy analysis, adoption and diffusion processes, extension strategies/methods) are particularly relevant within the context of the agro-ecosystems and types of technologies CATIE research is currently addressing.

2. Beneficiaries

This research line works primarily to support CATIE's technology development efforts in agroforestry systems (both for shaded coffee production and sustainable hillside farming), plantation forestry, secondary forest management and biodiversity conservation. Accordingly, the end beneficiaries include the population of farmers and natural resource users that could eventually adopt some of the resulting innovations.

It is roughly estimated that the economic and sociological/anthropological information and knowledge gained through research in these prototypical agroecosystems can be generalized and applied to at least 20% of the area of most member countries. In terms of population, the livelihood of about 20% of the rural population of these countries is believed to be linked in a direct and permanent manner to production/resource utilization in areas that are socioeconomically and agroecologically similar to the case-study sites; nearly 50% is estimated to be linked in an indirect or temporary fashion. The work on this research line, as a whole, is expected to contribute to improving the potential and actual adoption of the technologies developed and promoted by CATIE, and should therefore have an impact on alleviating rural poverty, because:

- A key objective of CATIE's future biophysical and socioeconomic research will be to improve selected agro-ecosystems so that they provide enough income and internally consumed goods and services to secure a relatively decent standard of living (including environmental considerations) for their inhabitants, on a sustainable basis. The prototypical agro-ecosystems have been chosen, in part, because of their likelihood to meet that criteria.
- Another main objective of CATIE's research, which is to increase productivity on a long-term basis while reversing the current process of natural resource and environmental degradation, is also closely linked to the issue of rural poverty because it is well documented that these phenomena particularly affect the poorest of the rural population, and women in particular.

3. Objectives

General objective

- To identify, develop and use techniques and information that contribute to making a more rational and sustainable use of natural resources, through the calculation of direct and indirect economic, environmental, and social costs and benefits of different land-use schemes, and through the evaluation of policies and other types interventions that promote it

Specific objectives

- To assess the financial performance of improved sustainable agriculture and natural resource management technologies being researched and developed by CATIE.
- To evaluate how the implementation of these technologies can affect the value of the environmental goods and services (including positive and negative externalities) resulting from such agro-ecosystems, and thus their total (direct and indirect) socioeconomic impact.
- To foster public and private support for sustainable development and environmental initiatives, by means of the dissemination of information.
- To determine what socioeconomic and policy factors need to be addressed before a significant adoption of sustainable and environmentally sound technologies can be achieved.

- To determine what technology transfer/diffusion strategies and methods are most effective from the cost-benefit standpoint, given the socioeconomic and cultural conditions of CATIE's member countries.
- To evaluate key agricultural, natural resource and environmental policies in regards to their cost-efficiency and consistency with official policy objectives and other governmental and NGO actions.
- As a result of all of the above, to increase the levels of adoption and diffusion of the sustainable agriculture, environmental and natural resources management technologies being developed by CATIE for the benefit of its member countries.

Not having the aforementioned information carries a relatively high implicit cost. Because of its very nature, a relatively precise estimate of the magnitude of the problem can only be produced after such data has been collected and analyzed. On the other hand, if it is assumed that the factors discussed above are indeed the key constraints to adoption, the value of resources invested to date in research and extension activities for the above mentioned agro-ecosystems could be used as a very rough but minimum-bound estimate of this (opportunity) cost.

4. Current Status

Although the type of economic and social-science research to be conducted is not expected to require the development of new methods, validation and/or substantial adaptations may be needed in certain cases (Contingent Valuation -CVM-- being a primary example). Most of these methods have been used for analyzing similar issues/problems in developed and developing countries, somewhat less in tropical America as a whole, and seldom in Central America and the Caribbean.

The table below summarizes the situation in CATIE's member countries:

Area or System	Agroforestry systems	Plantation forestry	Natural forest management	Biodiversity management
Method or Issue				
Financial analysis	M/A/C*	M/A/C	M/A/C	M/A/C
Non-market valuation	M/V/A	M/A/C/V-A	M/A/V-A	M/V-A
Economic analysis	M/V-A	M/A/C/V-A	M/A/V-A	M/V-A
Policy assessment	M/V-A	M/A/V-A	M/A/V-A	M/A/V-A
Adoption analysis	M/C/V-A	M/C/V-A	M/V-A	M/V-A
Technology transfer strategies and methods	M/V-A	M/V-A	M/V-A	M/C/V-A

* M = Methodologies exist; A = Some of these methodologies have been applied in CATIE's member countries; C = CATIE experts have applied some of those methodologies; V-A = Some of the methodologies may need validation and/or adaptation.

5. Goals

This research line aims to accomplish the following in five years of work:

- Assess the financial performance of the most outstanding sustainable agriculture and natural resource management technologies researched and developed by CATIE.
- Estimate how much the implementation of these technologies affects the value of the environmental goods and services rendered by prototype agro-ecosystems, and thus evaluate their total (direct and indirect) socioeconomic impact.
- Identify the key socioeconomic and policy factors that need to be addressed before a significant adoption of these technologies can be achieved in CATIE's member countries.
- Determine what technology transfer/diffusion strategies and methods are most effective from the cost-benefit standpoint, given the socioeconomic and cultural conditions of CATIE's member countries.
- As pertains CATIE's technological agenda, identify policies that are cost-inefficient and/or that run contrary to official policy objectives and other governmental and NGO actions.

6. Linkages with CATIE's Postgraduate Education and Outreach Programs

It is expected that at least 75% of the research agenda contemplated within this line will be carried out by means of M.Sc. and Ph.D. theses, mostly by students of environmental economics and sociology. If the current trend continues of students from other areas also selecting environmental economics and sociology as thesis research topics, this may become a significant input for the aforementioned agenda. Furthermore, the proposed research sub-lines, topics, and interdisciplinary work strategies involve the application of the key skills, methodologies and attitudes making up the exit profile for Master Degree students in this area. Thus, the educational experience provided through course work will be appropriately complemented by the graduate thesis process.

Linkage with the Outreach Program will mainly develop through the implementation of a research strategy centered on the concept of prototype, case-study agro-ecosystems. As technology development and socioeconomic evaluation efforts begin in these agro-ecosystems, the Outreach Program will be strengthened by the training, technology diffusion and public relations opportunities they provide. This research strategy will also foster the strong and timely feedback originally envisioned as a key function of the Outreach Program. Finally, some research sub-lines and topics bear a special relevance to outreach, including the socioeconomic evaluation of technology adoption processes and of extension/diffusion strategies and methods.

7. Human Resources

This line of research assumes the following human resources availability during the next five years:

Area of Expertise	Name	Educational Level	% of Time in Research*
Forest resources economist	Aguirre, Juan Antonio	PhD	25%
Natural resources economist	Ramírez, Octavio	PhD	25%
Environmental economist	Shultz, Steven	PhD	50%
Rural sociologist	Prins, Cornelius	MSc	25%
Rural anthropologist	Lok, Roxana	MSc	25%
Gender and development	Fassaert, Cecile	MSc	25%
Biodiversity management Socioeconomics	Ammour, Tania	MSc	25%
Assistant researcher in economics	Gómez, Manuel	MSc	50%
Assistant researcher in economics	Ortíz, Rosalba	MSc	75%
Community participation and extension	Oduber, José	MSc	25%
Marketing of forest products	Bianco, Luis	MBA	25%
Research assistant in economics	Calvo, Gustavo	Lic.	25%
Assistant researcher in socioeconomics	Hidalgo, Andrea	BA	50%

Although a certain degree of substitution is allowable between types of expertise and the specific experts available, the general magnitudes of Ph.D. (100%-time) and M.Sc. (300%-time) research time availability must be maintained in order to achieve the goals outlined above.

8. Partners

The key external research partners for implementation of the aforementioned agenda will be:

- The Environmental Economics Unit of the University of Goteborg, Sweden, specifically Dr. Thomas Sterner and Dr. Jorge Rogat. Their main inputs will include methodological expertise and external funding for M.Sc. theses and small case-study research projects on critical environmental economic issues.
- The International Center for Forestry Research (CIFOR), through Dr. David Kaimowitz, who will mainly provide information, knowledge, and empirical and methodological expertise by means of his participation as a committee member in M.Sc. theses on topics concerning forestry socioeconomics issues.
- The Department of Horticultural Economics of the University of Hanover, Germany, through Dr. Hermann Waibel and Dr. Stefan Agne, who will conduct externally funded joint research projects in the fields of economic evaluation of pesticide use and policies.
- The Institute for Environmental Technology of London's Imperial College, Great Britain, through Dr. John Mumford, who will conduct externally funded joint research projects in the fields of economic evaluation of pesticide use and policies.
- The El Zamorano Pan American School of Agriculture in Honduras, through Dr. Allan Hruska, who will conduct externally funded joint research projects in the fields of economic evaluation of pesticide use and policies.
- A number of national-level public and/or private sector research institutions and organizations will be more precisely defined as the prototype (case-study) agro-ecosystems for the work to be conducted. Possibilities at this point include the National University (UNA) and the DRIP Project (Costa Rica), INTA and UNICAFE (Nicaragua), COHDEFOR (Honduras), CENTA and PROCAFE (El Salvador) and ICTA and CONAP (Guatemala).

9. Approach and Methodologies

The main research/analysis methods to be used in the development of this line include:

- Standard financial analysis, simulation and forecasting methods, with special emphasis on those that can jointly assess both expected profitability and risk.
- Production economic theories and methods, including multivariate production and cost function analysis.
- Non-market valuation methods, including Contingent Valuation (CVM), Travel Cost and Hedonic Pricing, as well as complementary econometric techniques.
- When required, standard and specialized economic assessment methodologies (as in the case of agroforestry systems).
- Specialized qualitative and quantitative methods for the analysis of adoption processes (ranging from Rapid Appraisals of Agricultural Knowledge Systems (RAAKS) to multivariate Poisson Count Regressions).
- Auxiliary econometric and statistical techniques (standard multivariate OLS regressions, time-series models, multiple equation and simultaneous equation models, limited dependent variable models, etc.)

As mentioned earlier, the approach will focus on the socioeconomic analysis and valuation of policies and management as well as of the environmental goods and services of tropical ecosystems through interdisciplinary work in select prototypical (case-study) agro-ecosystems in which the biophysical research lines are also at work. This includes plantation forestry, agroforestry systems for coffee production, agroforestry systems for the production of annual crops on hillsides, managed (currently or potentially) forests in the humid tropics and parks and biodiversity (forest) reserves.

Table 1. Estimate of resource needs (annual averages)1

Type of resource	Current	Optimistic
A. CATIE resources		
1. Human resources (number of person/years)	15.00	25.00
1.1. Ph. D.	1.00	1.50
1.2. M.Sc.	2.00	2.75
1.4. Other professional staff	1.00	1.75
1.5. Post-docs/visiting scientists	0.00	1.00
1.4. Ph.D. students	1.00	2.00
1.6. M.Sc. students	10.00	16.00
2. Funding (kUS$/year)	20.00	40.00
2.1. Equipment and materials	10.00	20.00
2.2. Travel and other expenses	10.00	20.00
3. Infrastructure (equipment, etc.)	5.00	10.00
4. Other resources (specify)	-	-
B. Partner Institution Resources		
1. Human resources (number of person/years)	1.00	6.50
1.1. Ph.D.	0.25	0.50
1.2. M.Sc.	0.75	1.00
1.4. Other professional staff	0.00	1.00
1.5. Post-docs/visiting scientists	0.00	1.00
1.4. Ph.D. students	0.00	1.00
1.6. M.Sc. students	0.00	2.00
2. Funding (kUS$/year)	20.00	40.00
2.1. Equipment and materials	10.00	20.00
2.2. Travel and other expenses	10.00	20.00
3. Infrastructure (equipment, etc.)	-	-
4. Other resources (specify)	-	-
C. New Resources		
1. Human resources (number of person/years)	-	8.00
1.1. Ph.D.	-	1.00
1.2. M.Sc.	-	1.00
1.4. Other professional staff	-	2.00
1.5. Post-docs/visiting scientists	-	1.00
1.4. Ph.D. students	-	1.00
1.6. M.Sc. students	-	2.00
2. Funding (kUS$/year)	-	
2.1. Equipment and materials	-	20.00
2.2. Travel and other expenses	-	20.00
3. Infrastructure (equipment, etc.)	-	5
4. Other resources (specify)	-	-

[1] Estimate carried out using two scenarios: a) current level of resources, b) optimistic (increase in resources). Details on the information included in this table are provided in the narrative sections of the proposal.

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