Annual Report

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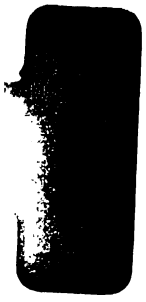

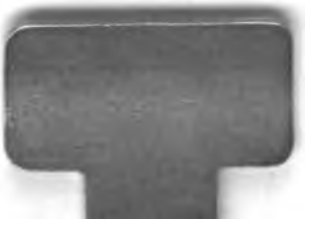

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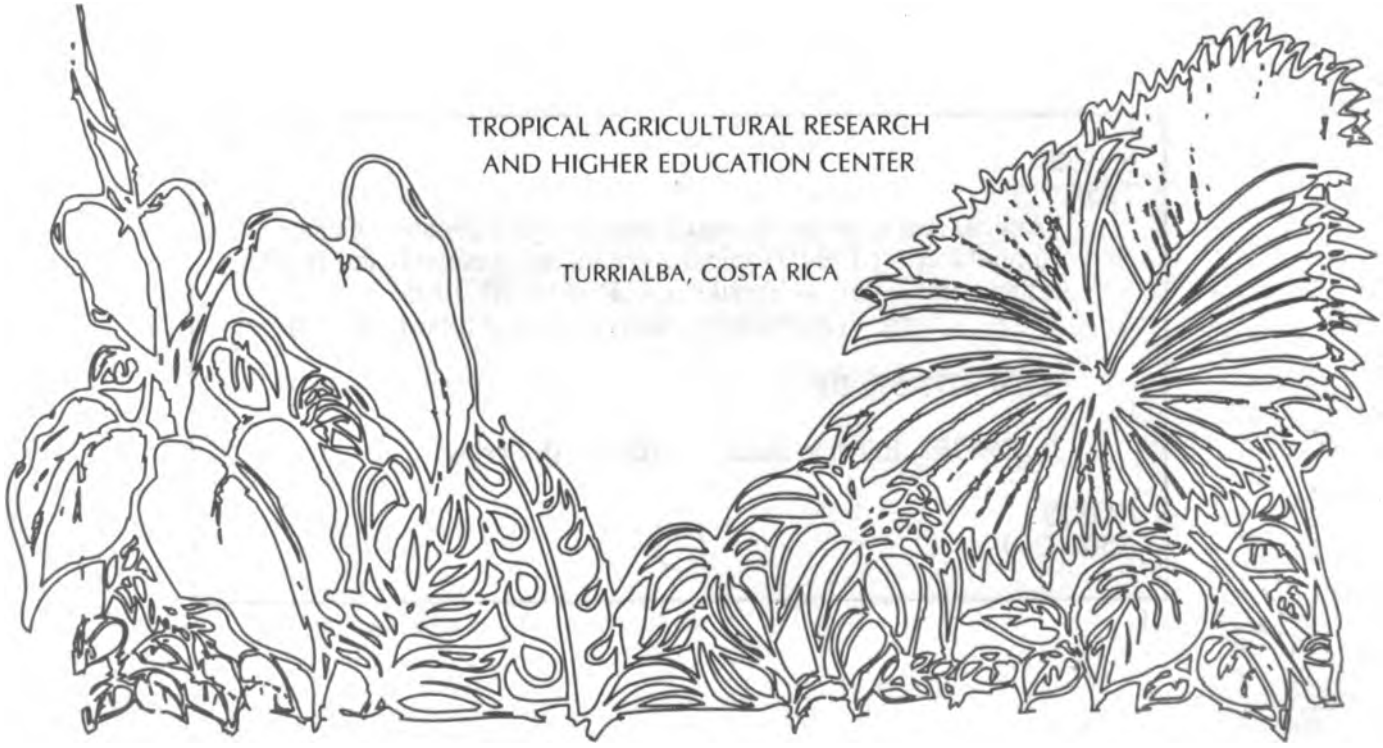
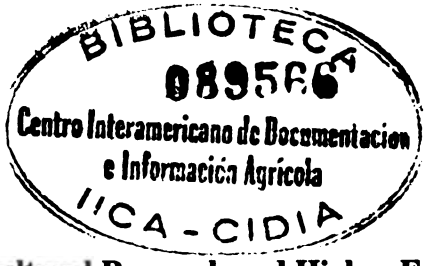


CATIE is an international, non-profit, regional, scientific and educational institution. Its main purpose is research and education in agricultural sciences, natural resources and related subjects in the American Tropics, with emphasis on Central America and the Caribbean.



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FOREWORD

This year is the first time that our Annual Report is presented in English, with an Executive Summary in Spanish. We want to establish better communications with our peers and the international community, and still maintain contact with our Latin American audience.

Communication and dissemination of information in Spanish, to our Latin American beneficiaries and clients occur through more than 400 technical publications per year containing CATIE's findings for research and validation revealing some of the most important experiences in sustainable development in the American Tropics.

The report shows results that are the by products of the synergy among higher education, research-validation, and outreach. In the last few years, CATIE has been refocusing on the link between its education and the research/outreach programs with the aim of enhancing its effectiveness in addressing the most urgent problems encountered today by the people we serve. We are concentrating on the themes of sustainable agriculture and integrated natural resource management in the American Tropics, always alert to the impact of these activities on the environment, on productivity and on human welfare. These are fields in which our knowledge base is strong and where CATIE has a comparative advantage in the region.

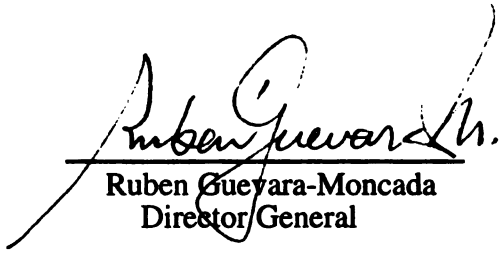
Our efforts in 1994, in strategic planning and management, were focused on the search for innovative ways to augment CATIE's core budget. As a result of streamlining in activities such as the operation of productive farms in Turrialba, the sale of technical services, and the rental of housing and other types of accommodation, self-generated income from these sources was increased considerably. Earnings generated by the CATIE Foundation's trust fund are also making a positive impact in our finances. Negotiations with main donors, and in particular with Sweden, Switzerland, and Denmark, aimed at supporting our core budget, are advancing well.

We are continuing to establish strategic alliances at the national and international levels. New ones for 1994 were: those with CIFOR, ICRAF, and ISNAR in the CGIAR; Colorado State University, to start doctoral studies at CATIE in 1996; Université de Laval and the University of Alberta in Canada to offer a joint master's degree in agroforestry systems for temperate regions; CIAT and IICA, with the financial support of the Inter-American Development Bank to implement a human resources development program in sustainable agriculture in Latin America in 1995; a renewal of joint work in Central America and Mexico with the IUCN; several alliances with universities and research institutions in Mexico, Belize, and PROCITROPICOS (Network of Research Institutions in Agriculture, and Natural Resources in the Amazon basin). With our partners CATIE is initiating the publication of a new technical journal — *Agroforestería en las Américas*— in association with ICRAF, generously funded by Denmark (mainly), and the U.S.

CATIE is fortunate to enjoy the support of many organizations. These include: the international development institutions in Canada (IDRC and CIDA), Denmark (DANIDA), the European Union, Finland (FINNIDA), France (Ministry of Foreign Affairs), Germany (BMZ/GTZ, DAAD), Japan (Ministry of Foreign Affairs, JICA) The Netherlands (Ministry of Foreign Affairs), Norway (NORAD), Sweden (SIDA, and SAREC), Switzerland (SDC), the United Kingdom (ODA), and the United States of America (USAID/G-CAP, and USDA). This support is critical to us and much appreciated.

Our strategic allies also play a key role in our work. These include: CARDI, CIAT, CIFOR, Colorado State University, CORECA (Regional Council of Ministers of Agriculture), CIMMYT, CIRAD, ICRAF, IFPRI, IICA, INIBAP, IPGRI/IBPGR, ISNAR, NATURA (European Network of Agricultural Universities), NRI, OAS, ORSTOM, Pennsylvania State University, PROMECAFE (Coffee Network for Mesoamerica), REDCA (Regional Network of Education, Research, and Technology Transfer Institutions), Agriculture University-Wageningen, Université Laval, IUCN, WWF, and most of the state, private, and non-governmental organizations in the member countries, numbering over 200 organizations.

In 1994, an additional country, Belize, joined our institution as the tenth regular member. With its incorporation, CATIE's mandate region completes the isthmus and the northen part of the American Tropics. Efforts are continuing to encourage other South American countries to join with us in efforts to serve the people of our region, and protect our environment for the well-being of our future generations.



Ruben Guevara-Moncada
Director General

RESUMEN EJECUTIVO

En la presentación del Informe, el Director General del CATIE, Dr. Rubén Guevara Moncada, destaca que es la primera ocasión en que este importante documento se presenta en el idioma inglés. La razón más importante para adoptar esta decisión es el deseo del CATIE de establecer una mejor comunicación con sus contribuyentes y la comunidad internacional, pues con más de 400 publicaciones anuales, técnicas y de otra índole el Centro ya mantiene una permanente comunicación con la comunidad de habla hispana.

Este Informe Anual 1994 contiene, además de los resultados administrativos y financieros de la Institucion, sus avances más importantes en el orden del quehacer científico-académico del Centro. Se destaca el énfasis puesto en el fortalecimiento de la Escuela de Posgrado y su ligamen con los programas de investigación, validación y transferencia de tecnología.

Asi mismo, se pone de manifiesto la contribución de la cooperación internacional en el financiamiento de los proyectos de investigación y también el esfuerzo realizado por la administración para incrementar el presupuesto básico del Centro. En tal sentido, se destaca el incremento y significado de los ingresos de las fincas comerciales que el CATIE explota en Turrialba y de los dividendos recibidos de FUNDATROPICOS.

Los ingresos totales del Centro durante 1994 fueron US$16.784.015, de los cuales US$5.613.496 corresponden al presupuesto básico y US$11.170.519 a proyectos específicos. Los gastos totales de 1994 alcanzaron US$15.986.490, con lo que se obtuvo un súperavit de US$797.525. El ingreso bruto de las actividades productivas pasó de US$485.600 en 1993 a US$813.700 en 1994 principalmente debido al incremento de los precios del café a finales de 1994 y a una buena cosecha, y al incremento en la actividad de caña de azúcar, al pasar de 17.5 ha plantadas en 1992 a 188.5 ha en 1994. Los rendimientos de la producción de caña fueron los mejores obtenidos en la zona de Turrialba (117 ton/ha) y los de mayor contenido de azúcar (262 libras/ton).

Es importante destacar que las contribuciones de las alianzas estratégicas con diferentes gobiernos e instituciones agruparon contrapartidas no efectivas por un monto de US$3.080.000, principalmente en salarios de personal profesional asociado con lo que el monto total de gastos del centro alcanzó en 1994 la suma de US$19.066.490.

En las actividades de investigación que desarrollan los Programas de Agricultura Tropical Sostenible (PATS) y de Manejo Integrado de Recursos Naturales (MIREN) se presentan

avances muy significativos que permiten vislumbrar, en el corto plazo, el mejoramiento tecnológico en la producción de cultivos y el perfeccionamiento en la protección del medio ambiente.

A. PROGRAMA DE AGRICULTURA TROPICAL SOSTENIBLE

1. Area de Cultivos Tropicales

En la Unidad de Biotecnología, con apoyo del Ministerio de Relaciones Exteriores de Francia, del CIRAD (del mismo país) y de INIBAP, se instaló una pistola de ADN que permite realizar el intercambio de materiales genéticos para el mejoramiento de especies de importancia económica para la región. Esta tecnología complementa los trabajos que la Unidad de Biotecnología del Centro desarrolla en los últimos años. Los trabajos en la producción de plantas haploides, la caracterización de germoplasma de café, cacao y plátano mediante las técnicas de extracción de ADN y el mapeo genético, con utilzación de la técnica de RAPD, han llegado a estadíos promisorios. El mejoramiento de las características productivas y de resistencia a las enfermedades más importantes de los cultivos mencionados, se vislumbra como una realidad posible a mediano plazo. En la misma Unidad se han dado los primeros pasos importantes para el mejoramiento y reproducción masiva de especies forestales en extinción o de alto valor comercial, como es el caso de la caoba (*Swietenia macrophylla*).

En la Unidad de Conservación de Recursos Fitogenéticos han continuado los trabajo de introducción de nuevo germplasma, su caracterización y evaluación, así como también importantes actividades de rejuvenecimiento de las colecciones.

2. Area de Fitoprotección

En el campo de la Fitoprotección, con apoyo de importantes contribuciones de la AID y de países europeos como Noruega, el Reino Unido, Suecia y Francia, continúa el desarrollo de actividades de manejo integrado de plagas en la región. Esas acciones comprenden tanto el uso racional de pesticidas como la investigación de métodos de control biológico. En este último aspecto debe destacarse el aislamiento y utilización exitosa en el campo de bacterias productoras de chitnasa (*Serratia marcens* y *S. entomophila*), capaces de controlar adecuadamente el hongo que produce la Sigatoka negra en el plátano y banano (*Mychosphaerella fijiensis*).

3. Area de Sistemas Agroforestales

En Agroforestería, los esfuerzos estuvieron se concentraron sobre todo en la validación de alternativas y en su transferencia hacia los agricultores, por medio de instituciones nacionales. Sin embargo, la investigación ha fortalecido el uso de más especies de árboles fijadores de nitrógeno. Debe recordarse que la mayoría de los esfuerzos en este campo se han realizado con dos o tres especies ya tradicionales, tales como la *Erythrina*, la *Gliricidia* y la *Leucaena*. La investigación con otras especies ha mostrado evidencias de que su potencial puede superarse. Arboles y arbustos como la Morera (*Morus sp.*), la amapola (*Malvaviscus arboreus*), el jocote (*Spondias purpurea*) y el chicasquil (*Snidoscolcus chayamausa*) han mostrado comportamientos similares o incluso superiores para jugar un buen papel en sistemas agroforestales y silvopastoriles.

B. PROGRAMA MANEJO INTEGRADO DE RECURSOS NATURALRALES

1. Area de Manejo y Silvicultura de Bosques Tropicales

En el Programa de Manejo Integrado de Recursos Naturales se destaca, en el área de Manejo y Silvicultura de Bosques Tropicales, el incremento exponencial del número de pequeños agricultores que bajo el Proyecto Madeleña plantan árboles como una actividad económica en sus fincas. De 40.000 pequeños agricultores que utilizaron esa práctica en los inicios del Proyecto, actualmente su número se ha elevado a 100.000. Se estima que en este proceso participan actualmente alrededor de 700 extensionistas de instituciones nacionales que han sido capacitados por el Proyecto.

En el aprovechamiento y manejo de los bosques naturales, las metodologías desarrolladas por el CATIE son aplicadas en el manejo y aprovechamiento de unos 20 grandes proyectos en la región que comprenden más de 23.000 ha. Hasta finales de 1994 había 6 proyectos más aprobados, en un área de 14.000 ha. Las actividades de formación de recursos humanos ha sido una prioridad permanente para asegurar el éxito de esos proyectos. Más de 680 personas ha participado en actividades de capacitación.

El mejoramiento genético de los recursos forestales no ha quedado relegado. Por una parte, la investigación ha definido nuevas técnicas de selección y reproducción de individuos de elite (silvicultura clonal) y, por otro, el CATIE, con apoyo de DANIDA, ha incrementado sus actividades en el Banco Latinoamericano de Semillas Forestales y se multiplican los esfuerzos para identificar y certificar rodales semilleros en el área centroamericana.

2. Area de Manejo y Conservación de la Biodiversidad

El CATIE continuó durante 1994 sus esfuerzos en el área de Manejo y Conservación de la Biodiversidad; las principales actividades han sido acciones de transferencia de tecnologías apropiadas a grupos específicos de campesinos e indígenas que obtienen su sustento, en forma primaria, de la producción de los bosques u otros ecosistemas frágiles tales como los humedales en áreas costeras. El apoyo de los gobiernos de los países nórdicos (Suecia, Noruega y Dinamarca) ha sido decisivo en este campo.

En cuanto a las actividades de Educación, el CATIE continúa trabajando en las dos modalidades tradicionales: cursos formales conducentes al grado de Maestría y cursos o eventos de capacitación no formales (que no llevan a un grado académico).

Durante 1994 se hicieron esfuerzos para actualizar y adaptar a nuevas circunstancias el *pensum* de la Escuela de Posgrado, al tiempo que las especialidades o énfasis de las maestrías se adaptó a la estructura y quehacer del Centro. En 1994 ingresaron al Posgrado 50 nuevos estudiantes, que se unieron a los 42 del período anterior, para un total de 92 estudiantes, a los que se impartieron 62 cursos formales. Se graduaron 38 estudiantes en el período.

Los cursos o eventos de capacitación no solo se incrementaron con respecto a 1993, sino que aumentaron en cuanto a días/estudiante por evento. En 165 eventos participaron 4736 estudiantes, lo cual significó 153,346 días/estudiante. También es importante destacar que se realizans esfuerzos por descentralizar y realizarlos fuera de Turrialba, e incrementar así las actividades en los países.

El Area de Comunicación e Informática muestra avances significativos, sobre todo en el campo de la informática, en donde se destaca el esfuerzo institucional por cambiar el computador central por un moderno minicomputador de mayor versatilidad y capacidad. Debe mencionarse, así mismo, la introducción del Sistema Oracle como manejador de bases de datos, así como también la instalación de la interconexión de la red de correo electrónico interno y la disponibilidad de acceso a Internet.

En el campo de la comunicación debe mencionarse, además, la contratación de una periodista que cubre, simultáneamente, las funciones de relaciones públicas de la Institución.

Finalmente, el Informe incluye la información más relevante sobre cooperación externa y la estructura de los órganos superiores de la administración, la nómina del personal profesional del Centro y el listado completo de publicaciones, las cuales se encuentran disponibles en la Biblioteca Conmemorativa Orton.

WHAT IS CATIE?

CATIE is an international, non-profit civil association, whose purpose is research and education in agricultural sciences, natural resources and related subjects in the American tropics, with emphasis on Central America and the Caribbean.

It is independent, apolitical, and has power of attorney. It is based in Costa Rica.

HISTORICAL BACKGROUND

CATIE's origin dates from the foundation of the Interamerican Institute for Agricultural Sciences (IICA) on October 7, 1942.

From its beginnings, the Institute's mandate has been research and education in agricultural sciences within the American tropics. In 1960, its General Directorate moved from Turrialba to San Jose. Teaching, training and research in agriculture, livestock production and forestry were kept on in Turrialba.

The Turrialba base was transformed into the Center for Education and Research (CEI). Between 1960 and 1969, the training of Latin American personnel in the Center was strengthened, making this decade the most important stage of IICA's Postgraduate Studies Program. The CEI subsequently became the Tropical Center for Education and Research (CTEI) in 1970. It was still dependent on IICA until 1973 when it became an autonomous entity, and continued its emphasis on education at postgraduate level with research as a support activity for advancing agricultural production technology.

IICA by then had transformed into the Interamerican Institute for Cooperation on Agriculture, with emphasis on technical cooperation, policy, trade, and integration. On September 1991, the governing body was modified to an independent, self-perpetuating Board of Directors and a Council of Ministers, that would oversee the interests of the countries in the Center's strategic plans and activities.

CATIE's MANDATE AND MISSION

CATIE's mandate was established in Chapter 1, Clause 1 of the Constitutional Contract approved by the Inter-American Board of Agriculture (IABA).

Within the framework of this mandate, CATIE's mission is:

> *Stimulate and promote research and higher education in agricultural and related sciences for development, conservation and sustainable use of natural resources in the American tropics to improve the well-being of mankind.*

OBJECTIVES

The Center's general objective is to:

> *Establish and generate research, education and technical cooperation programs with contribute to the solution of socioeconomic and agroecological problems in the American tropics regarding the sustainable development of agricultural and forestry production, natural resource management, conservation and development for the benefit of the community.*

Specific objectives:

a. To generate and validate technological practices for agricultural production and natural resource management which are economically feasible, socially and culturally acceptable and environmentally sustainable.

b. Prepare professionals at postgraduate level to contribute to the development of knowledge and execution of programs conducive to the solution of the socioeconomic and agroecological problems in tropical America.

c. Promote proficiency in technological practices developed through institutional collaboration and diffusion to end users.

d. Disseminate the information generated and stimulate the adoption of new technological practices.

MEMBERS

CATIE membership may be full or associate. Current full members are the Governments of Belize, Brazil, Costa Rica, Guatemala, El Salvador, Honduras, Mexico, Nicaragua, Panama, Venezuela, The Dominican Republic and the Interamerican Institute for Agricultural Cooperation (IICA).

The following may be associate members of CATIE: Governments of countries that are not IICA members, international governmental and non-governmental organizations, international centers and private organizations whose objectives are compatible with those of the Center and with the prior approval of the Board of Directors.

Currently, there are no associate members of CATIE, although a plan is being formulated to instigate a search amongst countries outside the American continent, businesses, non-governmental organizations and international organizations for associate members.

ORGANIZATION

The governing bodies of CATIE are:
a) the Interamerican Board of Agriculture (IABA), which acts as the Center's General Assembly, comprising all the Ministers of Agriculture of the American continent; b) the Council of Ministers, made up of the Ministers of Agriculture and/or Natural Resources/Environment from the member countries, acting to safeguard the interests of the countries; c) the Board of Directors, which acts as the instrument of higher management, is autonomous and self-perpetuating, which includes the Executive and Finance, and Academic and Scientific Committees; d) the Directors' Generals Office.

Costa Rica presides over the Council of Ministers and the Director General of CATIE acts as ex-officio Secretary.

The Board of Directors is made up of four eminent scientists or academics from the international community, four distinguished scientists or successful businessmen from the member countries, one eminent person appointed by IICA and one eminent scientist elected by the IABA, both acting in their personal capacity. Board members hold office for three years with the possibility of re-election for a further term. The Director General acts as ex-officio Secretary.

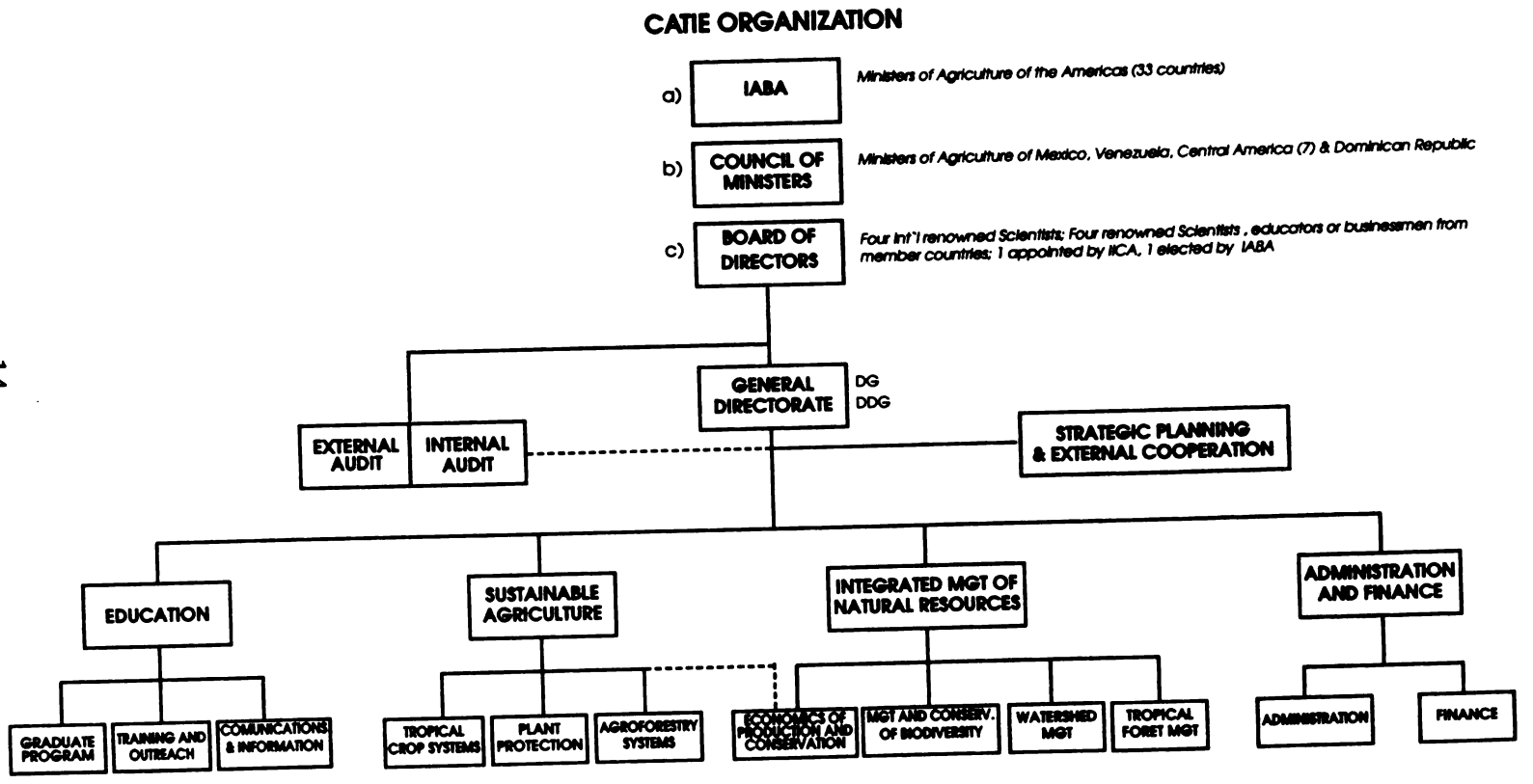
CATIE is directed by the Director General, who acts as its Chief Executive Officer, is elected by the Board of Directors and ratified by the Council of Ministers. The post has a term of up to five years, and the Director General may be re-elected once.

The Director's Office includes the Deputy Director General, appointed by the Director General.

To carry out its objectives, the Center currently has one Education Program and two Research Programs (Sustainable Tropical Agriculture and Integrated Management of Natural Resources), the Strategic Planning and External Cooperation Office, and the Directorate of Administration and Finance.

The following organization chart gives a more detailed view of the Center's organization.

Figure 1. CATIE`s Administrative Organization.



I.

RESEARCH, VALIDATION AND TRANSFER ACTIVITIES

"Resolving global problems through local solutions with regional impacts, and ample institutional and communal participation"

SUSTAINABLE TROPICAL AGRICULTURE PROGRAM (PATS)

Introduction and objective:

Sustainable Agriculture provides much hope to millions of small and medium size producers who must face the challenge of increasing productivity in CATIE's mandate region. The program continued to play a role in the development of technological options to reduce the use of pesticides and fertilizers, reduced the rate of deforestation and improve the efficient use of phytogenetic resources. This is being brought about through research, training and technological transfer.

Research in Agriculture at the Center continues to progress as it prepares to develop strategies for the new food systems of the 21st century. The coming decade will be critical in terms of agricultural production and management of natural resources. It is for this reason that PATS has tailored its activities to comply with the Center's strategic plan and to deal with the strategic issues confronting agricultural productivity in the region.

Sustainable development of agriculture and conservation of natural resources in fragile ecosystems and particularly the development of interventions for the production systems of the small and medium size farmers of the American Tropics continues to be a major target of the program.

Building capacity through training at all levels remained among the highest priorities for the past year. Improving the absorptive capacity of the national partners and building viable linkages in a continuing community of scholars for the development of sustainable agricultural systems is the culture the program is trying to emulate.

The program's objective is:

> *To generate, validate and promote technological options, which will improve productivity of the cropping systems in a manner that will sustain the natural resource base and a reduction in social and market pressures on ecosystems in the American Tropics.*

Program areas and lines of research

The program recognizes the need for an integrated approach to address the problems facing agriculture and food security in the region. For this reason PATS actively encourages a multisectorial, interdisciplinary approach in addressing its research problems through the aggregate comparative advantage of its 3 major areas:

* Agroforestry Systems
* Plant Protection Systems
* Tropical Crops Systems

Funding

The Sustainable Agriculture Program (PATS) was able to make modest progress based on the level of funding available. Core budget provided a large portion of the budget in Tropical Crops area. However, of the $4.4 million program budget, the other 2 areas Plant Protection and Agroforestry expended more than 84%, which came primarily from project funds. The program budget is shown in Table 1.

Table 1. Expenditure For Sustainable Tropical Agriculture Program 1994 (US $)

Area	Total Expenditure 1994 (US$ millions)	Core Budget US$ millions	(%)	Projects US$ millions	(%)
Plant Protection	2,33	0,04	(1.6)	2,29	(98.3)
Agroforestry Systems	1,53	0,10	(6.3)	1,43	(93.6)
Tropical Crops	0.59	0,49	(83.6)	0,10	(16.3)
Total	**4, 45**	**0,63**	**(14)**	**3,82**	**(86)**

Source: Financial Report 31 of December 1994

Program Achievements:

The advances and improvements that have been achieved in the past year has brought us closer to answering some of the challenges of sustainable progress. Some of the advances worthy of mention include:

Integrated control measures:

- Host-plant resistance to nematodes in coffee will lead the way to reduce the application of nematocides in coffee. This source of resistance is also a useful, genetic source for coffee improvement programs in the region.

- Microbial control of Black sigatoka, banana weevil and nematodes will provides great savings in the control of pests and diseases of economic importance.

- Cultural practices to reduce the incidence of virus infection in tomatoes, weed population in rice and coffee will have important implications of improving the productivity of these crops.

Seed production technology:

- The application of bio-technology techniques has greatly assisted in enhancing the multiplication capacity of vegetatively propagated crops such as bananas, plantain and root and tubers. This will enable national programs to more easily receive improved material and hasten the dissemination of technology to farmers. Simple techniques that could easily be applied in the field have also been tested and have shown much promise for yams.

Understanding home garden biodiversity and its role in food security:

- The completion of home garden case studies has shed more light on areas for substantial improvements in income, and food generations/savings by rural families.

Desirable Genes from germplasm collection:

- Genetic source for improvement of cacao pod index, earlines and high yield was identified and will be available soon to national program breeders.

Information dissemination:

- Information dissemination was given an important role in 1994 by putting several new publications, videos and articles into public/media. The series "Agroforestry" was launched. Several other forms of bulletin and guides on integrated pest management were also released. Besides article releases other information networks ware also formed with other groups of common interest. This broad based approach to information exchange allows CATIE to serve the information needs at all levels of interest in formal, technical, in-service and extension training.

During 1994, the program's progress was based on directions laid out by the Strategic Plan: Agenda to a Critical Decade, developed for 1993-2002. The three-area multi-sectorial approach gathered momentum on addressing issues that may affect agricultural sustainability in the coming years.

TROPICAL CROP SYSTEMS AREA

INTRODUCTION

The Tropical Crops Systems Area continued to play a vital role during 1994 in seeking and validating technological alternatives to improve productivity in a manner that will ensure sustainability and optimally use the natural resource base. Within this framework, all three units of the area interacted to make contributions towards achieving the overall goal. During most of the year, attention was focused on research in bio-technology, phytogenetic resources characterization and utilization as well as on resource crop management.

The participation of students in the research activities was a major contribution to the achievements of 1994. The role of the students was a major asset for furthering research in the area. Furthermore, the successful completion of these students will remain as a lasting impact of CATIE's contribution to the member countries. This was further supplemented by specific in-service training in biotechnology and phytogenetic resource management.

The area's strategy of strengthening outreach activities and regional and international linkages came in the form of staff participation in seminars, workshops, exchange visits and meetings. Similarly, the area offered relevant expertise in the form of buy-ins and execution of cooperative projects undertaken jointly between CATIE and National Program Partners.

As the area prepares for the coming decade, with the recognition of the need to reduce dependence on pesticides and other costly and environmentally unfriendly inputs, it has seized the opportunity to develop the following major thrust: Germplasm conservation, utilization and improvement, generation and transfer of production technologies, biotechnology , outreach activities and training.

Area Objectives:

The objective of the area is to improve the well being farmers through:

1. Selection of crops with high potential and resistance to pests and diseases for sustainable production systems that provide higher income to small farmers.

2. Continue the conservation, utilization and improvement of the germplasm resource and improve on its documentation to facilitate its utilization by small and medium producers.

3. With the aid of biotechnology, develop techniques for rapid propagation in-vitro and other precision methods for crop improvement, as well as to facilitate the distribution of improved germplasm to national institutions in member countries.

4. Develop improved resource crop management techniques for the member countries.

The economic competitive ability of the traditional crops in which CATIE has played a leading role such as coffee and cocoa is well established. However, the potential of tropical fruits and vegetables is increasing. For this reason, the area continued to give priority to these main perennial and annual crops.

In collaboration with various institutions, these objectives have been achieved using the following strategy. (1) Generation of technologies which are viable and adaptable by target clientele. (2) Strengthening national capacity. (3) Training and outreach.

Area achievements

The area's progress during 1994 was of relevance to further improvement of crop productivity in the region. Some of these achievements were:

- Increased efficiency in seed production in forest trees, Musa species and yams.
- Improvement of data base in genetic information of tree crops, coffee, cacao and plantain.
- Identification of genetic sources for yield improvement and disease resistance in cocoa, coffee and tropical crops.
- Further progress towards improving capacity for anther culture in coffee.

The potential benefit to national programs will be a reduction in the time taker to arrive at transferable technological packages and additional state of the art information for student training.

The Area operates within three Units: Phytogenetic Resources Conservation, Resource Crop Management and Biotechnology.

Biotechnology Unit

This Unit has concentrated on basic research to develop methodologies for the propagation, preservation and genetic improvement of high economic value species. Table 2. shows the main research topics and their applications.

Table 2. Main research topics and their applications developed by the Biotechnology Unit in 1994.

RESEARCH TOPICS	APPLICATION
Micro propagation by apex culture	Coffee, Banana, Peach Palm
Micro cutting	Forest trees, Fruit trees
Zygotic embryos	
Somatic embryo genesis	Coffee, Banana and Plantain
Cell suspensions	Forest trees
Haplomethods	
Androgenesis	Coffee
Gynogenesis	Banana
Cryopreservation	Coffee, Banana
Apex, embryos, callus	
Preservation (germplasm)	Banana and Plantain
	Roots and Tubers
	Coffee
	Orchids and Vanilla
Molecular Biology	
Genetic Mapping	Cocoa
Evaluation of Genetic diversity	Coffee

The Biotechnology Unit is financed by CATIE's core budget and by some specific projects funded by different donors (Table 3).

Table 3. Biotechnology Unit's budget for 1994

PROJECT	AMOUNT (thousands US$)	
DONORS		
Personnel and Operative Budget	170.46	Core Budget
Development of Molecular Markers for evaluation of coffee germplasm in Latin America	36.15	European Union
Genetic improvement of *Musa* spp.	52.39	European Union
Theobroma cacao; molecular markers for culture improvement	35.0	Penn State University/ACRI
TOTAL	294.00	

Selected research achievements during 1994.

Micro propagation of mahogany (*Swietenia macrophylla*) through tissue culture.

One of the main problems faced in reforestation areas is the lack of good quality seeds. As a consequence, it is common to find plantations with a high degree of phenotypic variation. Taking into account that trees have long vegetative cycles, the consequences of selecting inadequate seeds can only be observed when the trees have reached maturity. Most forest species have sexual reproduction through open pollination, resulting in a continuous genetic variation. Tissue culture techniques can offer a great potential to maintain desirable characteristics by vegetative or clonal propagation of elite trees. *In Vitro* micro propagation through micro cutting can contribute to the production of larger numbers of superior individuals.

Materials And Methods

Mahogany (*Swietenia macrophylla*) seeds from CATIE's Seed Bank were washed with detergent and water. Seeds were then immersed for 20 minutes in a commercial sodium hypo chlorite solution at 50% and washed three times in sterile distilled water.

The seeds were germinated in the dark in agar and water medium. Once they germinated, their epicotyls were cut into three parts, two including a young leaflet and one being the terminal apex. These were cultured in a medium containing WPM (Woody Plant Medium) inorganic salts, MS (Murashige and Skoog) vitamins, sucrose, BA (benzylaminopurine) and solidified with agar. The pH was adjusted to 5.8 prior to autoclaving. The three sections of each seedling were cultivated in the same container (GERBER) and placed at 27°C under a 12h-photo period.

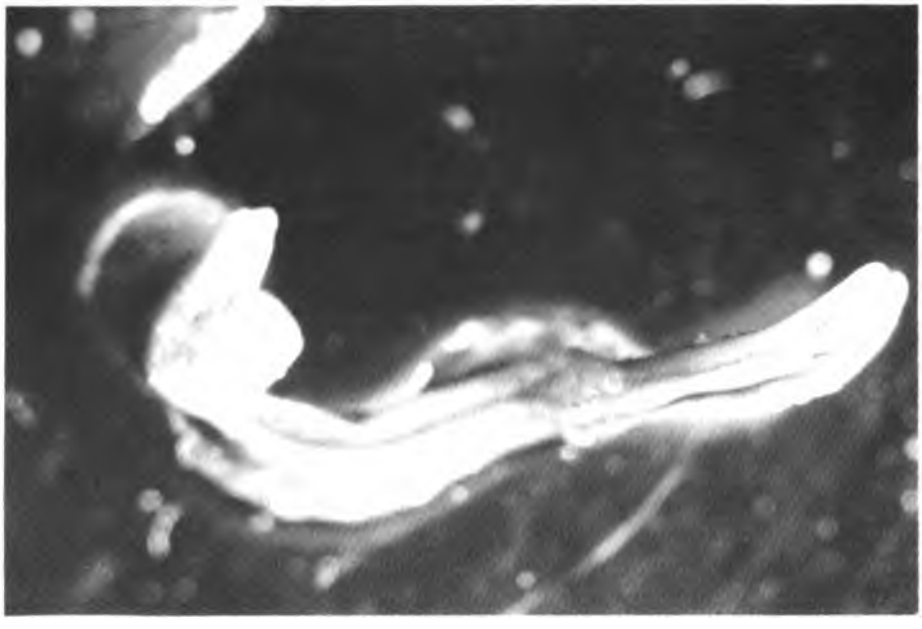
Micro propagation was done through the successive micro cutting of the young plantlets obtained. Complete development of plants with roots and leaves was done transferring the young buds to the same medium as described above but without BA and supplemented with 5g charcoal. Plantlets were hardened off by transferring them to sterilized soil in the greenhouse.

Results And Discussion

30 to 40% seed germination was obtained after 30 days.

After 40 to 60 days, shoots were obtained from each section of epicotyls. Shoots resulted from the development of the axillary buds located at the leaflet's "armpit" and from the terminal buds. Micro propagation can be achieved by micro-cutting each shoot in three parts, containing one or two axillary buds or the terminal bud. Several multiplication cycles can be done each 40-60 days. A multiplication rate of 3 could result in an average of 30 plants after 6 months of culture. In several cases (10%) it was possible to obtain 2,3 or 4 plants from one axillary bud at the same time. In this case, the plants certainly proceeded from the development of adventitious buds resulting from the exogenous BA, or from, supernumerary axillary buds which, so far, has not been documented in mahogany.

Complete plants with roots, stem and leaves were obtained after 60 days in the hormone-free medium with charcoal (Figure 8). These plants can be transferred to the greenhouse for further growth. The percentage of acclimatized plants obtained was 100%.



Although these results are preliminary, they are very promising for obtaining several plants from superior individuals. Recent research has enabled the development of axillary buds from young trees in the field. The use of liquid medium through a temporary immersion system could provide an improvement in these methods, reducing the time between two micro propagation cycles.

PLANT GENETIC ENGINEERING IN CATIE

The most sophisticated agricultural biotechnology techniques consist of adding genes to crops and switching them in a useful manner, at an appropriate time. The use of gene transfer technology to produce transgenic plants promises both qualitative and quantitative improvements in crop production.

There is no doubt that this kind of technique will soon help protect tropical crops from a wide range of pests and diseases. What were seen as promising technologies a few years ago have already produced new varieties. Great progress in the transformation of a wide range of plants has been achieved over the last few years. In mid-December 1994, the US Department of Agriculture (USDA) approved the commercialization of the first transgenic crop engineered for virus resistance.

Due to their high cost, genetic engineering techniques have been considered for many years, as methods reserved for developed countries. However, biotechnology tools are increasingly found in developing countries and the number of graduate students in this field is increasing very fast.

Gene Transfer Techniques

It is obvious that the application of such methods requires further qualified professionals, and both molecular biology and tissue culture laboratories.

Agrobacterium tumefaciens represent the best available method for gene transformation to transfer and integrate the T-DNA region of its Ti plasmid into the recipient genome. However, the use of *Agrobacterium tumefaciens*, is more specific to dicotyledonous plants, and presents serious limitations for monocotyledonous plants. To overcome such limitations, physical methods for gene transfer have been developed. Such methods include DNA uptake by protoplast through electroporation or chemical techniques or the mechanical introduction of DNA into the cell using micro injection or high velocity micro projectiles (DNA Biolistic delivery).

Another very important point for the application of these techniques is the mastering of a performant tissue culture system which allows a complete plant to be obtained from a single cell: protoplast, somatic embryo genesis and cell suspension.

CATIE's Biotechnology

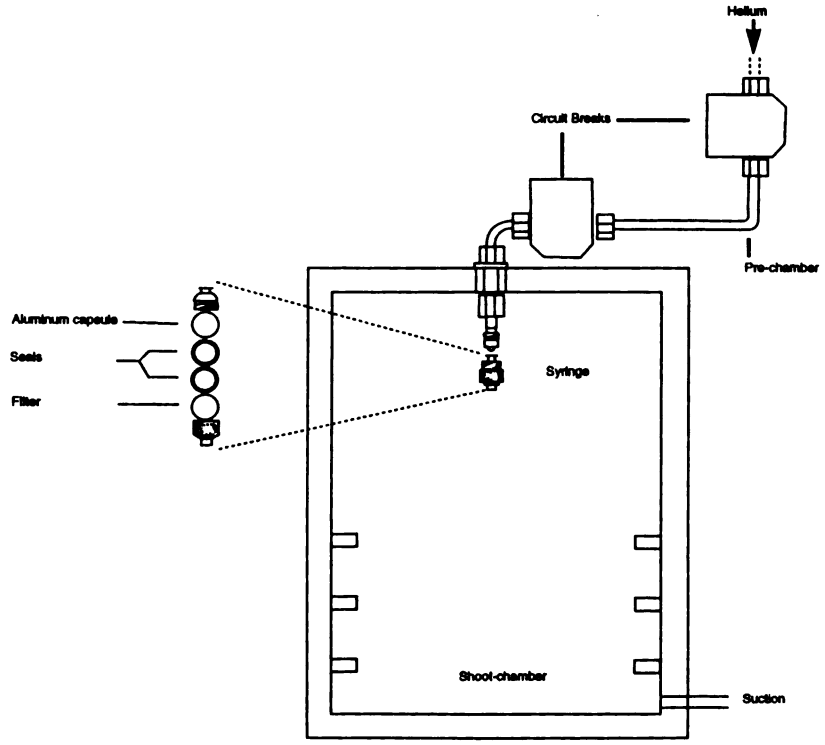
CATIE's regional actions cover many areas of which genetic improvement of forest trees and tropical crops and pest management are very important activities. Moreover, CATIE's Postgraduate School and training program are involved in training future scientists for Latin America and the Caribbean, and need to maintain, as much as possible, updated laboratory facilities.

CATIE's Biotechnology Unit began with the creation of a Tissue Culture Laboratory in May of 1983 (funded by AID-ROCAP and CATIE). This acquired more and more importance with the collaboration of international institutions, donors and core budget. During the last few years CATIE's Biotechnology Unit has strengthened its tissue culture laboratory with new and sophisticated techniques for mass propagation such as cell suspensions, somatic embryo genesis and a temporary immersion system applied to important tropical crops such as coffee, cocoa, bananas and plantain and forest trees. Four years ago, CATIE began the first work on DNA extraction and genetic mapping using RAPD techniques, followed by the use of RAPDs to define molecular markers for the characterization of coffee germplasm. CATIE is currently trying to develop a method for cow's DNA extraction. In 1994, CATIE, with the collaboration of CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement), INIBAP (International Network for Improvement of Banana and Plantain) and MAE (French Department of Foreign Affairs), was able to install all the methodology for genetic engineering with direct DNA (biolistic) delivery.

Genetic Engineering using Biolistic Delivery

The Biolistic method of genetic engineering uses a gene gun or particle gun (Figure 4).

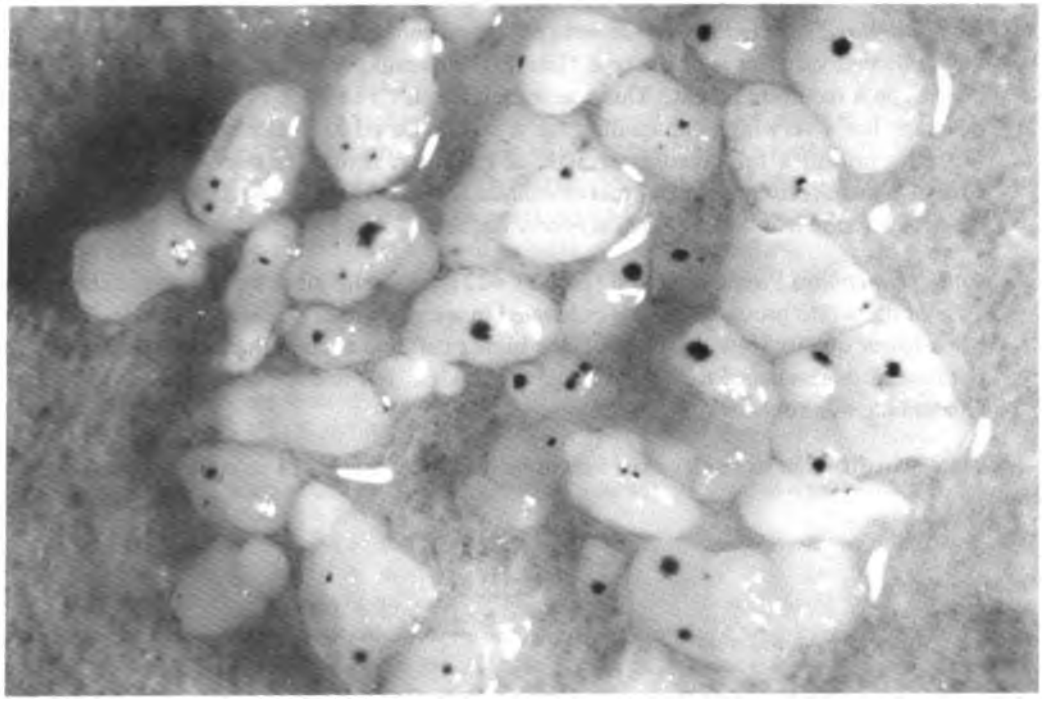
Figure 4.



The DNA package comprises the gene in question together with a promoter, an enhancer and a terminator enclosed in one plasmid. The micro particles are dropped into the ruptured membrane. Then, they are accelerated by the use of Helium pressure under a slight vacuum. When the DNA-coated micro particles are accelerated towards the target tissue (cell suspensions or ruptured somatic embryos), the membrane is stopped by a retaining pored-plate which allows the further forward movement of the micro particles. The micro particles penetrate the cell walls and the DNA coating may be unloaded as the particles pass through nuclei for further incorporation in the plant genome.

The first experiments done in CATIE, using somatic embryos of the banana cultivation "Grande Naine", as a target, allowed the transitory expression of the GUS gene (a reporter gene) to be observed (Figure 5).

Figure 5.



Conclusion

The success in transferring this method to CATIE opens new possibilities for national, regional and international programs.

It is now very important to achieve the permanent expression of transferred genes and apply this to solve real problems in the creation of new varieties resistant to pests and diseases.

Within the framework of international collaboration, CATIE is seeking to develop new plantain and banana varieties that are resistant to pests such as nematodes and bovers and fungal diseases using new strategies. These new strategies use protein inhibitor genes and involve chitinase genes for increasing the resistance to pest and fungal diseases respectively.

Anther culture in *Coffea arabica* l. for the obtainment of Haploids.

Cultivated coffee plants belong to two different species :

- *Coffea arabica* L., a tetraploïd (2n = 4x = 44) and autogamous species. The genetic structure of the cultivated varieties is of the type "line", which results from genealogical selection or back-crosses on a recurrent parent. This species represents 85 to 90 % of the world's production. Its beverage has a very high cup quality; the plant is adapted to an altitude between 800 and 1200 m. The priorities for breeding include adaptability, nematode tolerance (*Meloidogyne* and *Pratylenchus*), resistance to leaf rust (*Hemileia vastatrix*) and, in some countries such as Brazil, resistance to the leaf miner (*Perileucoptera coffeella*).

- *Coffea canephora* Pierre, a diploïd (2n = 2x =22), self-compatible species, accounting for about 10% of the world production. It is cultivated in warmer areas, at a lower altitude. The beverage has a lower quality (bitterness) and has a higher caffeine content than arabica. It is of interest because of its resistance to leaf rust and nematodes. For this reason it is used, for example in Guatemala, as a rootstock for arabica.

Thus, two different strategies exist for coffee breeding : one based on autogamy and the other on allogamy.

Aim of the research

The Study considered only *C. arabica.*

Cultivated varieties have a narrow genetic basis. In Central America, they all are susceptible to the main diseases.

The seed-to-seed cycle of coffee trees can take three years since descendence is usually evaluated over a minimum of three harvests (three years) and six back-cross cycles are necessary in order to achieve an acceptable homozygocity, it takes about 30 years before a new variety can be diffused.

A breeding program aimed to broaden this genetic basis, and increase the variability has been started at CATIE. It is partly based on classical breeding but also calls for the new tools of biotechnology, molecular biology (RFLP markers to describe the variability) and *in vitro* culture.

The search for haploid plants represent part of this program. After doubling the chromosome set of a haploid individual, the resultant homozygous coffee plants would produce a homogeneous F1 population after crossing. Moreover, in a genealogical selection program, the creation of lines would speedup. Finally, genetic studies would be easier, for example the identification of a recessive gene. The amphidiploid characteristic of arabica coffee guarantees that the plants obtained through haplomethods would behave as true haploids, being in fact di-haploids.

After some preliminary studies we chose the technique of androgenesis through isolated micro spores and anther culture.

Materials And Methods

Preliminary study

This study was carried out on three genotypes : Caturra (T-2308), Garnica (T-12855) and Catimor (T-8927).

Four different phases were studied: 1) Determination of the floral buds stage corresponding to the uninucleate stage of the micro spores. 2) Evaluation of four different disinfection methods. 3) Investigation of some pre treatments: thermal (5 °C and 28 C), physical (centrifugation for 20, 40 and 60 min.) and osmotic (20% or 40% sucrose). 4) study of different hormonal combinations (2,4-D, IBA and kinetin) and two media (Pierson and Yasuda) on callus formation.

General study

Five genotypes were studied: Catuai (T-16781), Caturra (T-15859), Garnica (T-12855), Catimor (T- 15869) and Sarchimor F3 (T-16786).

The floral buds were all taken between 7 and 9 mm, when they had a pale-green color.

The disinfection consisted of 7% Sodium hypo chlorite followed by three rinses, the third one being a 50 mg/l cysteine solution.

5 °C pre treatments were studied for 0, 2, 3, 5 and 7 days and five media were used for callogenesis, based on ANA, BAP and 2i-P combinations. For regeneration purposes, three media were used, also with different hormonal combinations.

For each treatment, a minimum of 125 anthers were cultured at 26 °C in the dark for callogenesis and at 25 °C in the light for regeneration.

Results

Preliminary study

The size of the floral bud in relation to the uninucleate stage of the micro spore varied according to the three genotypes studied. It was 7 mm for Caturra, 8 mm for Garnica and 8 or 9 mm for Catimor.

With respect to disinfection, in general the use of 8% Calcium hypo chlorite for 15 min. was the method that gave least oxidation and contamination, maintained a good viability of the micro spores and allowed the formation of a high number of calli.

The effect of the pre treatments on callus number was similar to that of the control in most of the cases. No embryogenic calli were obtained. An interaction has been observed between the length of the pre treatment and the culture medium : calli development was better when the anthers had been submitted to 5 °C for two days and cultured on a simple B5 medium.

The osmotic treatment consisting of 20% sucrose for one hour gave, in Garnica, a high nuclear activity which usually precedes a cellular division.

The use of a MS based medium did not give any result on callus induction. Conversely, B5 medium supplemented with 2 mg/l IBA and 0.5 or 1 mg/L kinetin gave a higher number of calli for Caturra and Garnica.

General study

The most efficient pre treatment was that of two days at 5 °C (Tables 4 to 7). The only periods for which all the genotypes under study responded, were with the three day pre treatment. Two media (Ascanio and C) gave best results, as well as the genotype Catuai.

The highest number of calli were obtained on medium C. Together with medium B those were the only two media where all the genotypes responded. Medium A gave the worst results. It can be seen that Catuai and Catimor seem to respond to a shorter pre treatment (2 days cold), Caturra needs a longer period, but Garnica seems to respond to all periods of time between 0 and 5 days.

It is obvious that Caturra is much more responsive than the other genotypes, Catimor being the least responsive.

So far 400 different calli have been obtained and some of them have been analyzed through histology. They do not show any typical embryogenic cells and so far no embryo has been regenerated.

Table 4 . Percentage of callogenous anthers after 3 months on Ascanio medium. Effect of the length of the 5 °C pre treatment.

Genotype	accession	0 days	2 days	3 days	5 days	7 days
Catuai	T-16781	0	34	0	0	0
Caturra	T-15859	5.2	19.3	7.2	0	0
Catimor	T-15869	0	0	0	0	0
Garnica	T-12850	0	13.5	0	0	0
Sarchim^r	T-16786	3	0	0	5.1	0

Table 5 . Percentage of callogenous anthers after three months on medium A. Effect of the length of the 5 °C pre treatment.

Genotype	accession	0 days	2 days	3 days	5 days	7 days
Catuai	T-16781	0	0	0	0	0
Caturra	T-15859	3.2	0	0	13	13
Catimor	T-15869	0	0	0	0	0
Garnica	T-12850	0	0	9.8	0	0
Sarchim^r	T-16786	0	4.6	4.2	0	0

Table 6 . Percentage of callogenous anthers after three months on medium B, according to the length of the cold pre treatment.

Genotype	accession	0 days	2 days	3 days	5 days	7 days
Catuai	T-16781	0	8.1	0	2	0
Caturra	T-15859	0	0	20	3	3
Catimor	T-15869	0	6.3	0	0	0
Garnica	T-12850	6	6.1	7.2	0	0
Sarchim^r	T-16786	0	0	3.3	0	0

Table 7 . Percentage of callogenous anthers after 3 months on medium C. Effect of length of 5 °C pre treatment.

Genotype	accession	0 days	2 days	3 days	5 days	7 days
Catuai	T-16781	0	35	20	7	0
Caturra	T-15859	5	17.1	17.3	20	38
Catimor	T-15869	0	5.2	3.1	0	0
Garnica	T-12850	11.1	12	15.2	14.9	0
Sarchim^r	T-16786	3	0	8.3	11.3	0

Identification of quantitative trait loci (QTL) related to *Phytophthora palmivora* resistance in cacao.

Black pod, caused by *Phytophthora palmivora* and other related species, is the most widespread and destructive disease of cacao, making the identification of resistant clones an integral part of breeding programs.

With cacao, as with other perennial crops, a long time is needed for the plant to reach maturity when the most important traits can be determined. This fact is the main limitation to rapid genetic improvement in cacao. In this sense, the use of molecular markers opens new possibilities for the selection of resistant genotypes, and given that molecular markers are not subject to environmental influences, the opportunity for characterizing the genotypes more precisely.

Yield and resistance to *Phytophthora* among others, are examples in cacao of quantitative traits. Their phenotypic variation is continuous and determined by the segregation of multiple loci or polygenes. The term quantitative trait loci (QTL) was coined to describe a region of a chromosome (usually defined by linkage to a marker gene) that has a significant effect on a quantitative trait.

QTL will be useful in plant breeding because they can serve as markers for selection at the early stages of plant development, and because now, it will be possible not only to find the loci, but also to identify the gene associated with the locus. Knowledge of specific genes associated with agronomic traits implies understanding at the biochemical level of processes responsible for yield, disease resistance or any number of traits defining a plant.

Materials And Methods

Two sets of information were collected (DNA marker and phenotypic data) from 137 cocoa trees belonging to the "Catongo (Catongo x Pound-12)" backcross planted at CATIE in 1991.

The DNA marker data were generated over two years using the RAPD and RFLP technologies. Over 1,000 primers were tested, of which about 14% were polymorphic and 81 segregated in a way suitable for linkage map construction.

The phenotypic data (*Phytophthora* reaction), were obtained using the paper inoculation methodology on a total of 422 pods growing on 84 trees. The inoculation method consists of impregnating a small paper disc with a $15x10^4$ zoospore suspension and placing them on five-month-old pods. Lesion size was measured after five and ten days, and the area under the curve was obtained by plotting lesion size versus time. This was the parameter used to estimate resistance.

After the DNA marker data were assembled into a linkage map, comparisons were made using analysis of variance and unpaired T-Test, between inheritance patterns of markers with the *Phytophthora* resistance data.

Results And Discussion

Area under the curve ranged from 20.8 (tree #180) to more than 75.0 (tree #93), which means that there is an important segregation in this population for *Phytophthora* resistance.

Comparisons between inheritance patterns of DNA markers with the *Phytophthora* resistance data allowed detection of chromosomal areas related to the quantitative trait, in other words to map quantitative trait loci (QTL), which are shown in Figure 6. It was possible to identify five loci for *Phytophthora* resistance on four different chromosomes.

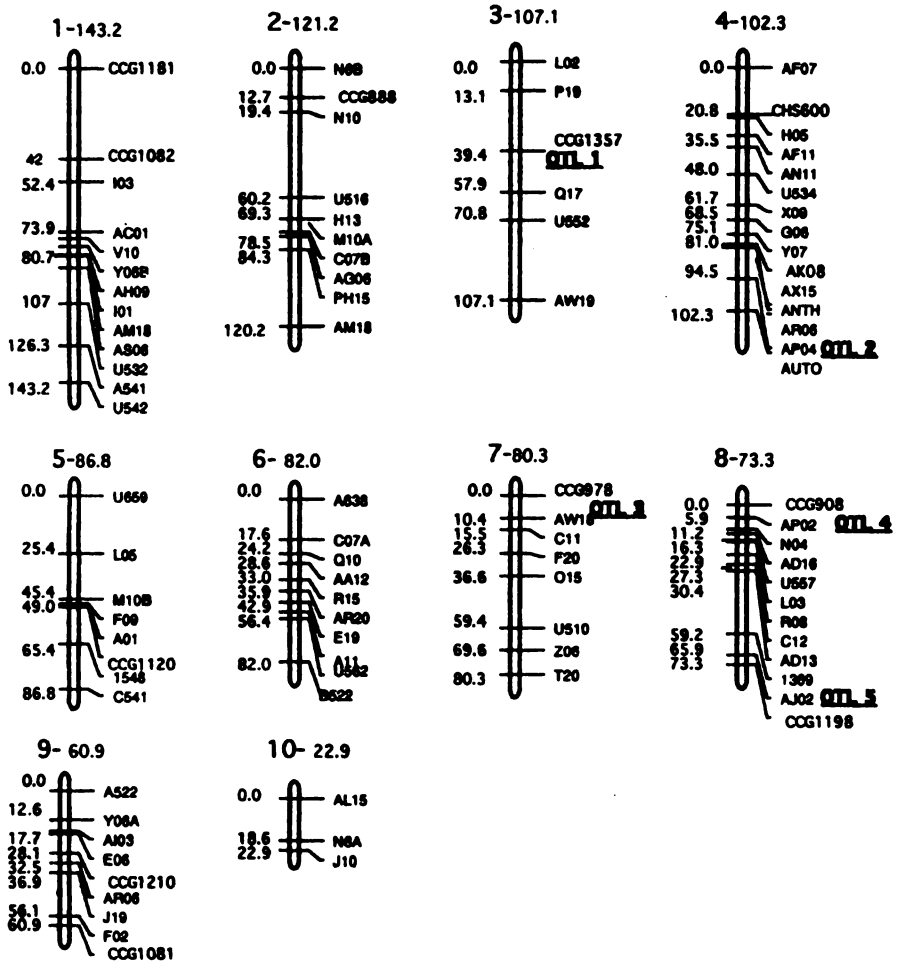


Figure 6. Genetic Linkage Map for *Theobroma cacao* Showing five quantitative trait for resistance to *Phytophtora palmivora*..

Table 8. gives QTL data for *P.palmivora* resistance. The percent of phenotypic variance represents the contribution of a particular locus to the total resistant trait. For example, markers AJ02 and CCG1198, linked within 4.4 centimorgans on chromosome 8, represent a locus accounting for close to 20% of the total trait. The total phenotypic variance accounted for by the five QTL in Table 30 is about 62.7%. Note that the resistant trait is favored by four homozygous loci and by one heterozygous locus.

These results are the first confirmations at the molecular level of the cacao horizontal/polygenic resistance to *P.palmivora*, which has been suggested by different authors. The results also seem to confirm the existence of at least 5 genes involved in resistance. As pointed out by Tan and Tan, these genes apparently have an additive action and not dominant as suggested by Spence and Bartley.

In summary, 5 QTL for *Phytophthora* resistance have been identify in a cacao backcross population at CATIE, demonstrating the usefulness of DNA markers as powerful tools in plant breeding programs.

Now, more data are being collected from new *Phytophthora* evaluations in order to increase confidence in the information. New experiments using *Moniliophthora roreri* are being considered

Table 8. QTL for *Phytophthora palmivora* Resistance in Catongo X (Catongo X Pound 12) Backcross Population

Marker	Homo zygote	Heterozygote	Difference	P-value	Percent phenotypic variance	Total number of plants	Trait favor homo or heterozygote	Chromosome number
CCG1357	50.1(45)	57.8(37)	7.6	0.0346	5.5	82	HOMO	3
autocomp	53.0(33)	65.6(10)	12.5	0.0082	15.8	43	HOMO	4
CCG978	47.9(37)	58.3(45)	10.4	0.0038	10.0	82	HOMO	7-#
AW18	47.4(37)	58.8(45)	11.4	0.0014	12.1	82	HOMO	7-#
C11	49.0(39)	57.8(43)	8.8	0.0143	7.3	82	HOMO	7-#
AJ02	60.7(44)	45.5(38)	15.2	<0.0001	21.6	82	HETE	8-@
CCG1198	59.8(43)	46.8(39)	13.0	0.0002	16.0	82	HETE	8-@
CCG906	48.3(35)	57.5(47)	9.1	0.0114	7.7	82	HOMO	8

Total phenotypic variance 62.7% # and @ represent only one QTL each.

Phytogenetic Resources Conservation Unit

The main objectives of this Unit are to:

1. Preserve the phytogenetic resources of economic importance and introduce valuable genotypes of value to regional agriculture.

2. Systematically characterize the germplasm collection, to obtain data for future breeding research stressing yield and disease resistance.

3. Provide national programs with selected genotypes of promising crops with short reproductive cycles, for distribution to farmers.

4. Train researchers, extension workers, technicians and farmers in the latest technology and management practices in the production of promising tropical crops.

Degree training, research and outreach activities function interactively with the Phytogenetic Resources Unit. CATIE has combined research and educational activities, thus providing a solid foundation and decisive projection for agricultural development in the region. Table 9 shows a summary of the general, long-term work lines of CATIE's Phytogenetic Resources Unit.

Table 9. Phytogenetic Resources Unit Work Lines

Training and Work Lines technology transfer	Applied Research	Validation	Technical Assistance	
Germplasm introduction (native and exotic)	—	X	X	—
Germplasm management and preservation:				
- field collection		X	X	X
- seed collection		X	X	X
Germplasm rejuvenation, characterization and evaluation	X	X	X	X
Germplasm documentation and utilization		X	X	X
Teaching and training support	X	X	X	X

As can be seen in Table 10. below, during 1994 the Unit had a very small budget coming from external cooperation:

Table 10. Budget of the Phytogenetic Resources Conservation Unit during 1994.

PROJECT	AMOUNT Thousand US$	SOURCE OF FUNDING
Yam Bean	24.0	European Union
Basic	128.2	CATIE's Core Budget
Total	152.2	

Unit achievements during 1994:

Rejuvenation, multiplication and description

During this phase of the work, seeds and planting material are established to rejuvenate the crop. Cultural practices, harvesting methods and crop yield are evaluated. It is important to note that at this stage a high genetic diversity is maintained to enable selection of the most desirable materials for yield in clonal gardens.

During 1994 efforts have been concentrated on rejuvenation of 500 accessions and selection of elite genotypes of collections of cocoa, peach palm, fruit trees and tuber roots.

Characterization, documentation, mailing and collections

Since 1942, CATIE has distributed germplasm (Table 11) from its collections in an unrestricted manner. This activity has run parallel to the exploration and collection of germplasm throughout Latin America.

Documentation is done electronically and there are data bases available for cocoa and coffee. Passport data on other characters of agronomic interest exist for the other collections. The elaboration of catalogs with field collection information facilitates the use of germplasm. CATIE has promoted this documentation system since it permits a better understanding of genetic variability under conservation.

Table 11. List of countries that received germplasm samples. Phytogenetic resources unit. CATIE, 1994.

Country	Number of accessions	Material Type: Seeds	Leaves	Roots	Bud woods	Shoots	Plants
Argentina	5	200					
Brazil	7	176		10			
Chile	4	1000					
Colombia	5	500					
Costa Rica	148	22151	0	20	100	12	444
Denmark	5	30					
Dominican Rep	1		3				
Ecuador	15	1050			9		
El Salvador	32	1240					
France	347	7590	5260		20		
Guatemala	41	13800					
Honduras	22	5000			10		
Nicaragua	2	300					
Panama	11	2200					
Peru		6	100				
Saint Lucia	3	700					
Surinam	10	1000					
United States	80	10433	225				
Venezuela	5	500					
Vietnam	2	600					
TOTAL	**751**	**68470**	**5588**	**30**	**139**	12	144

Cacao Research

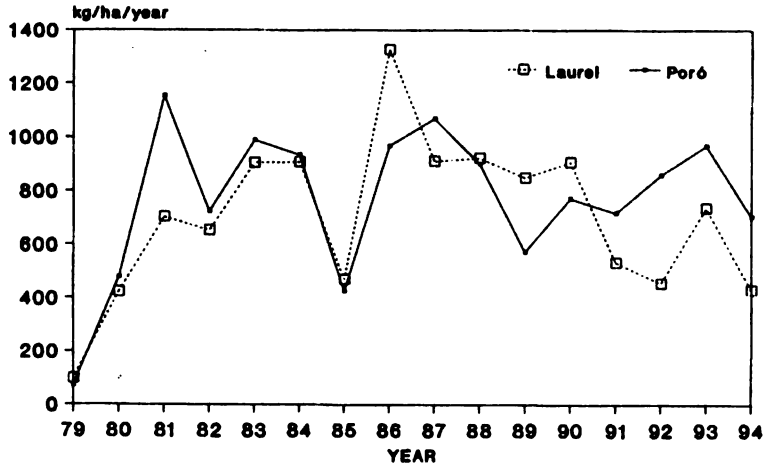
Most of the main cacao research stations in the world have breeding programs aiming at the improvement of production, disease and pest resistance and quality. Two main methods have been used for breeding: a) individual tree selection to obtain clones for vegetative production and b) selection of sexual families. Yield is a very variable character, made up of several components of a quantitative nature and highly influenced by environment. During 1994 four different trials were carried out in order to obtain additional information on the effectiveness of hybrid/clone selection for production.

a) Comparison of cacao hybrids population under two shade systems at CATIE

The cacao crop in Central America and the Caribbean Islands has traditionally been managed by farmers in different ways, using various sustainable ecological systems. Two shade systems, "poró"

(*Erythrina poeppigiana*) and "laurel" (*Cordia alliodora*) were compared to measure yield and other characteristics of a cacao hybrid population. After 16 years of collecting data on each shade systems, one hybrid population of cacao was evaluated for yield trait. There were significant differences between treatments for the 16 year average. Although no significant differences between the studied shade systems were observed, in 1994 the "poró" system presented an increase of 250 kg ha^{-1} on cacao yield when compared with the "laurel" system (Figure 4). These and other previously presented results suggest that the cacao-"poró" shade system is moderately more effective for increasing yield in cacao than the cacao-"laurel" system.

Figure 7.

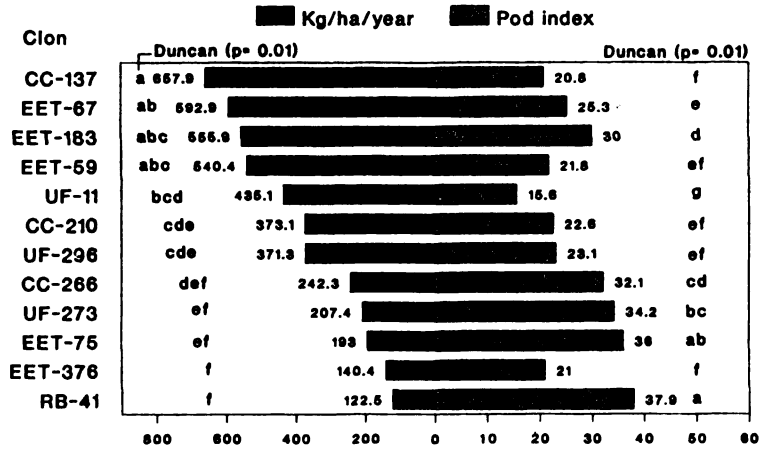


b) Comparison of 12 cocoa clones under the Turrialba environment (1987- 1993)

Twelve clones of cacao (*Theobroma cacao* L.) were compared to obtain additional information on the effectiveness of clone selection for production. Dry weight and pod index were the main selection criteria (Figure 8). After six years of evaluation for yield with each of the 12 clones, four clones were selected (CC-137, EET-59, EET-67, EET 183). Significant differences were observed among clones. The pod index showed a variation between 15,6 and 37,9 for UF-11 and RB-41 respectively.

These results suggest that the CC 137, EET 59, EET 67, EET 183, UF 11 are effective clones for improving yield as well as specific pod index. It is recommended that such clones should be included in cocoa breeding work and in the production of improved clonal gardens material for farmers.

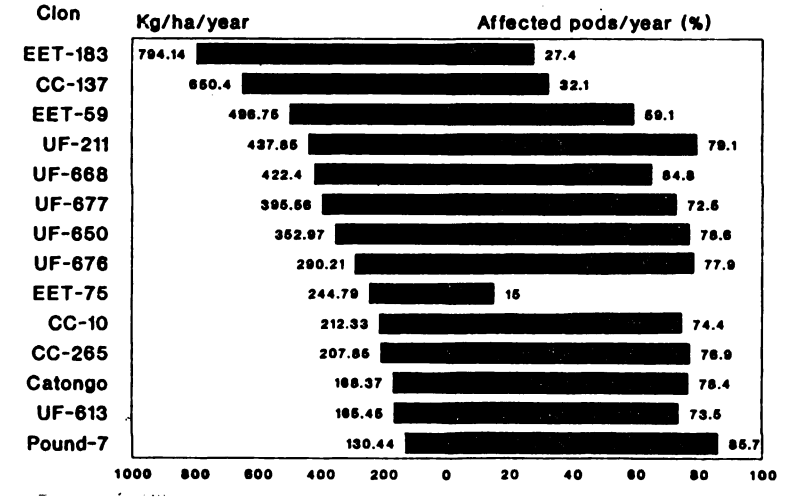
Figure 8.



c) Comparison of 14 clones under "La Lola", Costa Rica environment (1991-1994)

Examination of clone behavior and its effect on yield variation at the different locations involved should help indicate the changes that would occur in "La Lola", and should be useful for predicting yield progress under higher inoculum pressure. There were significant differences among clones (Figure 9). Two clones showed yield increases higher than 1000 kg/ha over the last two years. The EET 75 clone was the most resistant to diseases. These results indicate that good progress could be achieved by the use of clones as a breeding method of developing superior progenitors.

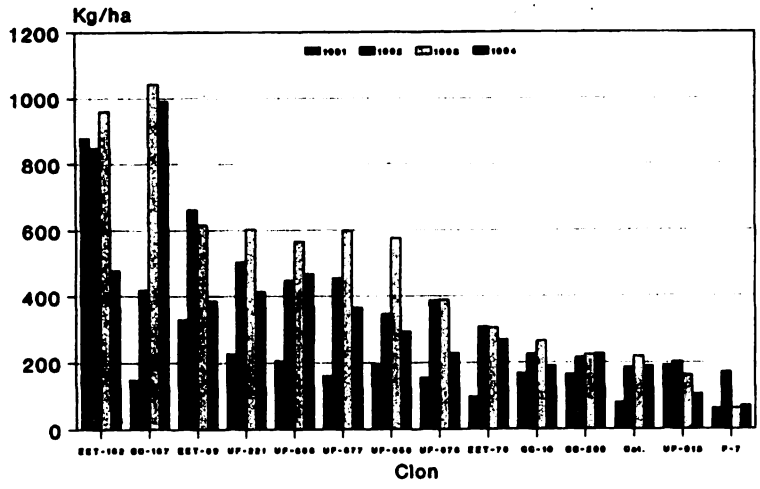
Figure 9.



d) **Observation of cacao hybrid plots at the "La Lola" environment. (1992-1993).**

Fifty-three crosses of cacao (*Theobroma cacao*) were evaluated at the "La Lola" location to obtain additional information on the effectiveness of hybrid selection for production. The number of healthy pods and pods affected by diseases were the main selection criteria. Selection by precocity and disease resistance is of great relevance in perennial crops because it enables a faster recovery of invested capital by the farmer. Moderate differences among hybrids were noted after two years of evaluation. This first report indicates that it is possible to find remarkable precocity in some clones and the single crosses are potentially good methods for improving yield and incorporating genetic resistance to diseases and pests (Figure 10).

Figure 10



Rice research

Through the Genetic Resources Unit, CATIE has a collaborative agreement with the International Tropical Agriculture Center (CIAT) and a student from Panama University has been working with rice in collaboration with both organizations.

Evaluation of the white center in rice segregating population (*Oriza sativa*)

Grain quality encompasses white center presence and endosperm opacity. Obtaining varieties with little or no white center to satisfy consumer, producers and grinders demand, is a problem due to the instability of rice lines in response to selection.

The objective of this work was to study the grains white center character, utilizing the selection technique in rice segregating population (F_3 and F_4).

The study was carried out in Colombia at the International Tropical Agriculture Center (CIAT). Six rice crosses were used: Colombia 1 x IR5, IR5 x IRAT 8, IRAT 8 X Colombia 1, IRAT 8 X IR 5. The experimental unit used consisted of a 5 m long furrow by family with a maximum of 17 plants and a planting distance of 30 x 30 cm between plants.

The Colombia 1 progenitors showed a greater number of grains without white center; IR5 showed fewer grains without white centers than Colombia 1; while IRAT 8 had the least number of white centered grains of the three populations.

In general, progenitors as well as crosses showed a tendency to increase grain numbers with white centers from one seeding to another and from one generation to the next.

Resource Crop Management Unit

Over the past several years CATIE has conducted major evaluation of crop germplasm such as yams, peppers, jicama, pumpkins. These crops have wide adaptability for the humid and subhumid areas of the center's mandated regions. This evaluation has resulted in the selection of disease resistant and high yielding lines but almost exclusively as sole cropping systems.

At the unit level, there is enough understanding to take this technology to the next step, which is to fit it into the farmers cropping system. However, some of the questions asked by the Area in terms of requirement for the next step were: What seed material is available and from where? What cost effective seed production systems exist that are affordable and have high adoption potential? What species diversity components are compatible within a spatial and temporal arrangement framework?

Based on these questions the Unit set out to address the constraints, which national programs have voiced as priority. One of these areas is the clean seed production for vegetatively propagated materials. A model technique for seed production was tested for yams. Another activity investigated the compatibility of species for increase yield.

Impact Of Set Size On Seed Production In Yams (*Dioscorea trifida*)

Yams (*Dioscorea* sp.) is one of the minor crops with high potential for efficient production of quality food energy, year-round availability and good storage ability because of dormancy. Traditionally, yams are produced in small quantities and at relatively high cost because of limited availability and high cost of planting material (seeds). Traditional seed production systems have low multiplication ratios (1:1) and high labor input .

Improvement of the seed production system with minimal inputs would greatly reduce the cost of planting material and increase productivity and competitive ability for the export market. Presently, the system of seed production in yam is primarily the traditional system, which has a low multiplication ratio. Furthermore, most growers do not have the necessary technical expertise nor the time to produce and

maintain high quality seed stock. The objective of this trial is to establish the best set size necessary for the consistent production of quality seed material.

The results (Table 12) indicate that the best sett size for seed production could be in the range between 21-50 grams and 51-100 grams. However, based on the distribution of tuber size, the 21-50 gram sett size seemed more desirable. A small size sett could be used for increase seed production. The large size set produced the highest number of medium size tubers 50-100 gms. Tubers of this size could be used for ware or market yam. Based on this preliminary result the ideal size sett for dual purpose is the 21-50 gm range.

Table 12 . Total No. of tubers, weight and category produced by different sett size of Yampi.

	Production									
Sett size range (gm)	<20 gm		21-50		51-100		>100		Total	
	No. tub.	Wt	No. tub.	Wt	No. tub.	Wt	No. tub.	Wt	No. tub	Wt
<20	197	2225	105	4300	50	4500	10	2150	362	11243
21-20	343	3600	156	6175	61	5725	13	2600	573	14793
51-100	435	3675	133	6000	57	5400	9	2200	634	13893
>100	418	4600	123	5200	77	6675	10	2375	628	14543

INIBAP's Regional Network For Latin America And The Caribbean[1]

The development of the Network Program in the region has been particularly challenging during the past three years.

INIBAP-LAC evolved from a network devoted to the exchange and enhancement of germplasm, information and training, to a scientific cooperation and collaborative research organization.

One of the Network developments has been the role played by CATIE in three strategic areas:

- Mechanisms developed by CATIE to combine the Regional Network priorities with the comparative advantages derived from collaborative research efforts with the world's most advanced *Musa* research centers, especially regarding biotechnology. In collaboration with CIRAD-

1 *The INIBAP-LAC Regional Base is located at CATIE, since 1987*

FLHOR the Center is at the cutting edge of *Musa* research in somatic embryo genesis and cell suspension.

- As a general policy, INIBAP has been promoting interaction between countries and institutions of the whole region, at the same time, strengthening the North-South interaction. Special efforts have been made by CATIE in biotechnology to raise the weakest *Musa* research programs, with those which have comparative advantages in Central America and the Caribbean. Additionally, CATIE's Biotechnology Unit has developed scientific links with research institutions of the European Union, United States and international organizations such as FAO and IPGRI.

- CATIE's recognized capabilities and comparative advantages for training in *Musa* biotechnology and other areas.

For bananas and plantain, CATIE has developed an outstanding capacity to train personnel from the whole region on tissue culture techniques, through short courses or at postgraduate level. During the past three years, more than 40 persons from 15 countries were trained in the basic principles of tissue culture techniques, mainly to micro propagate bananas and plantain. Additionally, 8 postgraduate students conducted their studies in topics related to biotechnology applied to *Musa* .

Also worthy of mention are the outstanding research studies conducted by the Integrated Pest Management Program, in topics related to nematode attacks on bananas and plantain and biological control of *Mycosphaerella fijiensis.*

Although the main achievements of INIBAP-LAC are usually published by the Network itself, the following are the most important highlights CATIE-INIBAP collaboration during 1994.

* ***Musa* Germplasm Conservation Network**

The Center maintains more than 100 *Musa in vitro* accessions and a modest *in vivo* collection for research and training purposes.

In 1994, CATIE's Biotechnology Unit made an official request to INIBAP, to be one of the three world centers to duplicate INIBAP's Transit Center (ITC) *in vitro* collection, based at the Catholic University of Leuven, Belgium. This duplication is underway.

* ***Musa* Germplasm Exchange System**

CATIE decided to enlarge the number of plantain accessions. A list of plantain from West Africa was requested from the ITC, and these which will be sent to CATIE early 1995, after respective indexation.

* **International *Musa* Testing Program**

CATIE is depository of the previously selected hybrids from Fundación Hondureña de Investigación Agrícola (FHIA), named FHIA 01, 02, and 03, which are resistant to black Sigatoka.

The Center is also depository of several hybrids of EMBRAPA's (Brazil) Banana Breeding Program, which were screened against black Sigatoka at La Lola Experiment Station in 1991.

One of those hybrids was released by EMBRAPA to the farmers in Brazil, under the name of Pionera (Pioneer).

EMBRAPA's hybrids have been used at the Biotechnology Unit to conduct somatic embryo genesis studies during 1993 and 1994.

* **Strategic Research**

Through a joint effort between the French Minister of Foreign Affairs, CATIE and INIBAP, an expert in genetic transformation from CIRAD installed a particle inflow gun at CATIE's Biotechnology Unit, to be used for research and training purposes.

* **Regional Initiatives**

CATIE and INIBAP-LAC have catalyzed several activities aimed at promoting the use of tissue culture as well as other biotechnology tools in the region. Following recommendations of the workshop on "Biotechnology Applications for the Improvement of Banana and Plantain" organized by INIBAP and CATIE in Costa Rica, 1992, both institutions are promoting the organization of a Regional Biotechnology Network on *Musa*. In 1994, the following institutions became members of this endeavor: CORBANA (Costa Rica), IBT (Cuba), FHIA (Honduras), La Duquesa-SEA (Dominican Republic) and CINVESTAV (Mexico). It is planned that several institutions from South America will be invited to be part of this initiative.

PLANT PROTECTION AREA

The Plant Protection Area in CATIE is dedicated to the development of integrated pest management (IPM) through research, training, higher education, technical assistance, and provision of advice and information. It is the only truly region-wide service of its kind with such broad coverage. The Plant Protection Area works in collaboration with national agricultural research organizations, extension programs, universities, NGO's and grower organizations to develop, validate and implement IPM in predominantly food crops of local and export importance.

It is now generally accepted that IPM must be the foundation of plant protection because it balances the need to maintain, and even increase, productivity with minimizing the negative impacts of pest control measures on the environment and human health, often by bringing about reductions in pesticide use. In the shift to sustainable agriculture systems the IPM approach confers practical advantages because of its focus on optimizing the performance of the entire system rather than maximizing just a few components of it.

The Plant Protection Area aims to accelerate the process of change from production based mainly on external inputs. This is achieved through two main thrusts. First, the refinement and implementation of known IPM principles and technologies to resolve the problems due to major pests of regional importance, or of the pest complex of particular cropping systems. Second, the development of new pest management tools, with emphasis on non-chemical methods such as microbial controls, to improve the management of recalcitrant pest problems.

Work Lines

For convenience, the diverse research and outreach work lines in the Plant Protection Area are grouped according to target pest, target crop or thematic area such as microbial control (Table 13.). These categories reflect the diverse needs of crop protection in the Region, and there is some overlap between categories. Technical assistance and training (through short courses, in-service training attachments, or formal postgraduate courses) is offered across the full range of capabilities of the personnel and services in the Area.

Table 13. Lines of work in research and outreach on Plant Protection.

Research	Validation	Training and Technology	Transfer
TARGET PESTS			
Bemisia and *Trialeurodes*	X	X	X
Heliothis and *Spodoptera*	X	X	X
Liriomyza spp.	X	X	X
Hypothenemus hampei	X	X	X
Plutella xylostella	X	X	X
Cosmopolites sordidus			
Pseudomonas spp.		X	X
Phytophthora and *Alternaria*	X	X	X
Rottboellia cochinchinensis	X		
Cyperus rotundus	X		
Echinochloa colona	X		
Meloidogyne and Radophilus	X	X	X
Phyllophaga spp.	X		
THEMATIC AREAS			
Cover Crops	X	X	X
Soil Amendments	X	X	X
Microbial Control	X		
Pesticide Management	X	X	X
Decision Criteria for IPM	X	X	X
IPM Socioeconomic	X	X	X
Gender Issues in IPM	X	X	X
Farmer Participation in IPM	X	X	X
Crop Management	X	X	X
Information Management and Services			X
TARGET CROPS			
Non-traditional export crops (e.g. broccoli, snow peas, macadamia nuts)	X	X	X
Vegetables (e.g. tomato, potatoes, cabbage bell peppers)	X	X	X
Basic grains (maize, rice)			X
Perennial crops (e.g. coffee, cocoa, plantain, bananas)	X	X	X

Funding

The Plant Protection Area was heavily dependent on external sources of funding in 1994 (Table 14).

Table 14. Plant Protection Area project and core budget funding during 1994

Project	Budget (US$ million)	Source
IPM-RENARM Project	1.33	USAID/G-CAP (USA)
CATIE/INTA Nicaragua IPM Project	0.66	NORAD/SIDA (Norway & Sweden)
NRI Projects	0.37	NRI/ODA (UK)
Coffee IPM	0.17	CIRAD (France)
Core Budget	0.07	CATIE
TOTAL	2.60	

Impacts Of The Plant Protection Area

The highlights for 1994 are presented under the later sections on the individual projects that make up the Area, and in the sections on Outreach and Education. However, the Area is more than the sum of its projects; there is considerable synergy between the different projects and, especially in terms of the Area's regional image and outreach activities, there is frequently little distinction made by beneficiaries and collaborators between the individual projects.

Impacts on Collaborating Institutions and Organizations:

The Plant Protection Area maintains a wide range of links throughout the public and private sector in Central America. However, major partners and collaborating institutions in CATIE's member countries include twelve institutions in Guatemala, two in Belize, seven in El Salvador, ten in Honduras, eleven in Nicaragua, twenty in Costa Rica, and six in Panama.

Impacts on Direct and Indirect Beneficiaries:

The majority of beneficiaries of the Area's activities are reached indirectly as a result of contributions to the Region's store of published scientific knowledge, and as a result of training and extension-oriented technical assistance leading to improved knowledge and capability in IPM in partner organizations. Through these mechanisms, it is estimated that the end beneficiaries, mostly small and medium sized farmers, conservatively number several hundred thousand.

Direct beneficiaries during 1994 included over 2,000 university professors, students, researchers, extensionists and other categories of technical and paratechnical personnel that were reached through MSc

degree and non-degree training programs and IPM information dissemination, communication and technical assistance programs.

Close to 10,000 end users directly benefited from cooperative pilot extension programs covering 6 different crops in 15 important agricultural areas throughout Central America. These included: the tomato producing areas of Zacapa and the non-traditional export crop producers in the Altiplano in Guatemala; several zones in El Salvador; the coffee-producing departments of Jinotega, Matagalpa and Carazo in Nicaragua; the vegetable crop producing areas of Grecia, Sarchí and Tierra Blanca in Costa Rica.

RENARM Project
Sustainable Agriculture And Forestry Component
Plant Protection Activity

The Plant Protection Activity is implemented by CATIE under Component 3, Sustainable Agriculture and Forestry, of the USAID funded RENARM Project (596-0150). Research, training and outreach are directed to alleviate problems associated with incorrect and irrational pesticide use, agricultural productivity and profitability, environmental issues and socioeconomic aspects of pest management in the region. As stated above the project budget for 1994 was US$1,369.309.

General objective

The general objective of the Project is to improve the economic well-being and health of the men, women and children in the Central American Region by: helping farmers increase crop productivity and economic returns; contributing to the production of residue free produce for national consumers and for export; and reducing human and environmental exposure to harmful pesticides through the development of environmentally sound pest management practices.

Highlights

Research

During 1994, research and field validation activities resulted in the project being involved in: 85 validation plots of IPM practices and programs involving five different crops, in six pilot areas, in three countries; six socioeconomic, phytosanitary or diagnostic surveys; 96 experiments of regional relevance. In the process, seven new biological control agents were identified.

Research was conducted through a range of mechanisms including student theses, collaborations with buy-ins to the project (the IPM/ICTA/CATIE/ARF Project in Guatemala and the IPM/CONCAFE/CATIE Project in Nicaragua), joint ventures with national, public and private institutions, and involvement of project personnel in research funded by other projects in the Plant Protection Area (see separate reports on NRI Projects on *Echinochloa* and tomato blight pathogens). Following are selected examples of some of the research highlights of 1994:

Use of cover crops for biological weed suppression and nematode suppression in coffee.

Cover crops, particularly cover legume, are considered highly promising for biological weed suppression. The project has an active research program in evaluating candidate species' adaptation to specific crop and climactic conditions, and also into their effects on other, non-weed, pests.

A study on the establishment of cover crops in newly planted coffee plantations indicated that the legume, *Arachis pintoi*, despite its slow rate of establishment, and *Drymaria cordata*, usually perceived as a weed in this crop, both substantially suppress weed growth between rows. *Desmodium ovalifolium* was difficult to establish, and *Centrosema macrocarpum*, *C. pubescens* and *Crotolaria spectabilis*, although they initially suppressed weed growth, had decreased to levels that were insufficient to control weeds by the end of one year. All of the cover crops increased the yields of the first coffee harvest in relation to the unweeded check, but yields in experimental plots were less than those obtained in nearby commercial areas, which indicates the possibility of competition between the cover crops and the coffee plants.

The first evaluation of three coffee plots sown with nematode antagonistic cover legume in Juan Viñas, Costa Rica, showed nematode numbers were marginally less on coffee plants growing with *Arachis pintoi*; bigger differences were found in the 3 comparison plots conducted in Nicaragua.

Coffee disease management

A five year experiment in Juan Viñas, Costa Rica, comparing alternatives for the control of *corchosis* disease was concluded. None of the cultural or chemical management tactics tested gave long term control, although disease development was delayed for the first 3 years using plastic covers plus application of chicken manure or "broza" soil amendments (11 tons/ha). The farmer plot was totally destroyed during the first year of the experiment. The development of resistant varieties (rootstock) appears to be the only viable choice left at this point.

Other studies showed that coffee susceptibility to *Fusarium* spp. increased when exposed to a combination of high light conditions, diuron residues in the potting soil and low fertilizer rates. The incidence of *Phoma costarricensis* was significantly increased by exposing the plants to 75 or 100% luminosity and the presence of diuron residues. The highest levels (76%) were recorded when *Fusarium* attack and diuron residues occurred together.

Soil Amendments

The incidence of late blight (*Phytophthora infestans*) in tomatoes was not decreased with the soil application of 15-15-15 fertilizer or the fast fermented compost *Bokashi*. However, these treatments plus calcium carbonate significantly decreased the severity of this disease. Bean chlorosis, a problem in tropical acid soils, was greatly decreased and bean yields were increased by soil application of calcium + *Bokashi*, calcium + 10-30-10 or calcium + *Bokashi* + 10-30-10. The application of calcium, 10-30-10 or *Bokashi* alone had no effects on bean chlorosis incidence.

Microbial Control-Insect Pests

Banana weevil (*Cosmopolites sordidus*) control in the field with the *Beauveria bassiana* fungus was evaluated. There was a significant reduction in the number of live insects found when the fungus was applied in rice on pseudo stem traps, when compared with the check. Fungus application also caused a significant reduction in the frequency and severity of damage caused by the weevil. Bigger effects would be expected for longer evaluation periods.

Diamondback moth, *Plutella xylostella*, control was evaluated in cabbage with a different strain of *Beauveria bassiana*. Significant differences were observed in control, degree of damage and yield with respect to the check, and the fungus effectiveness was very similar to that of the treatments with chemical insecticides or *Bacillus thuringiensis*.

In Mexico, 5 experiments conducted as part of an M.Sc. student thesis demonstrated the potential of 3 three entomopathogenic nematode strains against the coffee berry borer, *Hypothenemus hampei* in the laboratory.

Biological Control-Insect Pests

The population distribution and natural enemies of *Antiteuchus tripterus* in macadamia, were evaluated. The pests population peaks coincided with the periods of highest production of immature fruit, which are the most susceptible to attack. *Trissolcus radix* was identified as an egg parasitoid with good potential as a biological control agent, with 70% average parasitism.

Microbial Control-Nematodes

In Costa Rica, experiments demonstrated that the bacteria *Pasteuria penetrans* infects both nematode species *Meloidogyne incognita* and *M. arabicida*.

Biochemical and genetical characterization studies of *Bacillus thuringiensis* strains pathogenetic to root-knot and lesion-causing nematodes were successfully concluded in collaboration with the University of Massachusetts, Amherst, USA.

Microbial Control-Plant Pathogens

The search for antagonists of the fungus responsible for Black Sigatoka disease (*Mycosphaerella fijiensis*) in bananas focused on bacterial strains capable of producing chitinases *in vitro*. In the laboratory, 15 organisms were evaluated for their ability to attack the fungus on leaf discs; four were selected, two *Bacillus* spp., *Serratia marcens* and *S. entomophila*. The selected strains proved to be compatible with the most commonly used fungicides used in bananas. In greenhouse and field studies, the antagonism expressed under laboratory conditions was confirmed. This is the first biological control practice for Black Sigatoka disease that has been successfully evaluated under field conditions.

A parallel study determined that populations of *Bacillus* spp., Actinomycetes and *Serratia marcescens*, are greatly reduced during the dry season; however, the populations are quickly restored at the beginning of the rainy season.

In another experiment, seven isolates of *Bacillus* were selected for their ability to produce chitinase. The addition of chitin to the medium did not increase chitinase production for any of the isolates. *In vitro* tests showed that chitin application did not increase the efficiency of the seven isolates in the inhibition of *Alternaria solani* either.

Nematode management

In Panama, soil amendments with chitin at 250-350 kg/ha gave better control of *Meloidogyne salasi* in rice compared to other tactics, including the application of carbofuran (Furadan). Longer term studies are needed to determine advantages and disadvantages of this management alternative.

In Costa Rica, it was shown that *Aglaoenema* ornamental foliage plants are affected by a root-rot disease complex in which *Pratylenchus coffeae* and *Fusarium solani* play an important role. None of the cultural practices known to be effective against *Meloidogyne incognita*, such as solarization and soil amendments, showed any potential for the management of this problem. Additional studies are needed to develop alternative control methods.

Tomato disease management

Natural fungicides did not affect the development of the early blight of tomatoes, *Alternaria solani*. The fast fermented compost, *bokashi*, controlled populations of the nematode, *Meloidogyne* spp., but not the incidence of bacterial wilt, *Pseudomonas solanacearum*. *Bokashi* stimulated plant development resulting in an earlier flowering than the check treatment.

Whitefly management

Research on the whitefly (*Bemisia tabaci*) problem showed that tomato seedlings grown in nurseries covered with nets for at least the first 30 days suffer less virus disease in the field. Further benefits can be obtained by reducing post-transplant stress; growing seedlings in plastic trays, or in the cheaper option of cups made out of newspaper, allows faster development of transplants and less exposure time to whitefly. The former method is being validated in commercial plots, and has already spread widely among farmers in several tomato-producing areas of Central America.

Outreach

Outreach efforts during 1994 were directed to six major complementary elements: a) Non-degree Training b) Information and Documentation Products and Services c) Regional Plant Protection Network and Pest Diagnosis Laboratory d) Technical Assistance e) Regional and Country Level IPM Project/Program Design , and f) Country-level Training and Extension.

CATIE/INTA-NICARAGUA IPM PROJECT

At the end of 1994, the CATIE/INTA-IPM Project in Nicaragua, financed by Norway (NORAD) and Sweden (SIDA), completed five and a half years of work, reporting many activities and achievements which strengthened Nicaragua's capacity for better, more rational, more efficient, sustainable and environmentally sound pest management.

National institutions have been fortified through technical cooperation to achieve improved technical and methodological status of their professional personnel. In collaboration with hundreds of specialists, technicians and local farmers, IPM technologies have been developed, based on better bioecological knowledge geared to reducing pesticide use and crop losses.

On a regional level the project has contributed with initiatives for IPM coffee and vegetables, strategies for the integrated management of pests such as white flies, and in methods for integrating farmer participation into the IPM technology generation process.

At the end of this first phase, the project team has developed and perfected a technical and methodological approach for the sustainable mass implementation of integrated pest management, that is relevant to regional plant protection institutions and programs and for national-level IPM efforts.

A work proposal was prepared for phase II of the project (1995-98) which aims at improving the national capacity for massive IPM implementation in Nicaragua. In the interim, NORAD approved a bridge funding period of six months, until December 31st of 1994.

Lines Of Work

The following are the main lines of work of the CATIE/INTA IPM Project in training, research, technical cooperation and end-user extension:

1. Strengthening of Nicaragua's human resources and the development of cooperative, more effective work procedures

2. The development of improved IPM technologies and practices based on enhanced bioecological knowledge and understanding of pest problems

3. The implementation of formal training and technical assistance programs.

Overview Of Project Achievements

During 1994 the IPM Project in Nicaragua showed a systematic and ordered advance on its five years of work in the search for mechanisms to strengthen Nicaragua's national ability to implement integrated pest management with small and medium sized farmers.

One-day theoretical-practical workshops were developed for and offered to technicians and extensionists; in tomatoes, cabbage, musaceas IPM, and ecological IPM concepts. National specialists devel-

oped similar workshops for corn and beans IPM. These workshops included simple pamphlets, visual material appropriate for lectures and exercises and observations to be conducted in the field after the workshops to reinforce what was learned. Personnel from national institutions were trained in these workshops so that they could offer the same to others. The one-day coffee-IPM workshop was offered to approximately 300 technicians and farmers. Another three-day-long coffee-IPM workshop, which will include a field practice and a study notebook (rough draft), has been planned, to be conducted at a national level.

The project team encouraged IPM implementation in coffee, tomatoes and plantain through field plots with the participation of groups of farmers and technicians. In coffee, there were four groups with 17 plots; in tomatoes, four groups with over 30 plots; and in plantain, there were two groups with five plots; in which producers compared the improved IPM options with their former practices. Training events and materials, farmers participation in the prioritization of plant health problems, identification of options to test, data collection and the evaluation of advances among technicians and producers were of key importance in this process.

On a national level, specialists from universities, research centers and development projects met in 11 inter-institutional working groups. Each group, with an average of 8-10 participants, met four to six times during the year to exchange advances, review research methodologies and plan new work. These meetings facilitated the technical evaluations and promoted better IPM technology development strategies in areas as diverse as microbial control, ground management in perennial crops, IPM in tomatoes, plant pathology and entomology in coffee.

1994 brought about important results in various areas of collaborative research. The fungus *Beauveria bassiana* was tested in farmers' fields; in 20 hectares of coffee against the coffee berry borer, in five hectares of cotton against the boll weevil; and in four plantain plots against the banana weevil with promising results. Options for the non-chemical control of plant health problems in coffee; especially the borer, summer pests, disease complexes, nematodes and weeds were studied. The role of weeds during the advance of the rainy season and on irrigated vegetable fields in the summer, on the whitefly population increases, was confirmed.

Technical Highlights

Coffee Disease Management

In order to establish epidemiological guidelines for the management of coffee rust, field observations were made during two consecutive seasons. It was observed that amount of initial inoculum is a determining factor on the level of disease development. The time course of the epidemic depends on moderate rainfall. Epidemics result in heavy defoliation, but there is no apparent relation between disease incidence and the current harvest. Marked variations were observed in the disease development parameters from season to season, which obliges us to carry out disease sampling every year for its management. For this purpose, an easy sampling method is already available for the coffee farmers.

In another study it was shown that disease development in coffee varies under different technological management. Under traditional management, rust is the most abundant disease while, with the

removal of shade and wide row spacing, brown leaf spot becomes a major problem. Anthracnosis remains a problem independent of the management regime.

With all these criteria in mind, different options like use of organic amendments, pruning of sick branches and management of shade were incorporated in a plan to manage the disease complex of coffee. First year data has shown significant reduction of Anthracnosis and overall better plant health. It is expected that, next season, higher and better quality yields will be obtained in these plots.

Coffee nematode management

Sampling of nematode populations in the soil and roots of an established coffee plantation revealed that a composite sample from 10 plants in an area of 1 hectare, taking root samples at a depth of 15-30 cm from three different sites around the plant, provides an estimate of 80% confidence in a field of unknown nematode population density. However, if population is already high (> 5000/100 g roots), it is only necessary to sample two sites per plant.

Bioassay carried out in the laboratory confirmed lethal effects of aqueous suspension of neem cake (4% and 10% w/v) on juveniles of *Meloidogyne incognita*. However, applications of up to 4 g of Neem cake formulation (NIM-25) per plant in the nursery did not suppress nodule formation caused by artificial inoculation of the same nematode. Long term studies of the effect of organic amendments like coffee pulp and chicken manure confirmed yield increases of up to 360-380% over the check. Although no noticeable effect was found on the nematode population and *Cercospora* leaf spot, it is presumed these amendments provide the coffee plants with a balanced nutrition and favorable growth conditions.

Ecological studies on key insect pests

White flies

During a two year study on the host plants, migration and population levels of white flies in the Sebaco Valley, eight important non-cultivated and three cultivated host plants were identified as playing important roles in the population dynamics of this insect. Population fluctuation seems to be related to the life cycles of these host plants, mediated in turn by availability of water either through rain or irrigation. Availability of suitable host plants all year round is a key factor contributing to enormous population build up of this important virus vector. These results provide a good base for dialogue with the farmers on long term strategies for management of white flies and the viral diseases transmitted by them.

Coffee berry borer

Systematic observations on the fluctuations of coffee berry borer at many different sites reveal that availability of suitable fruits determine the population dynamics of this insect. Survival and multiplication takes place in fallen berries, principally under the plant circle, independent of the coverage of the inter-row spaces. Different rates for the increase of the insect damage can be obtained at different sites in one season or in different seasons in the same site, depending on the surviving population, flowering pattern, rainfall and occurrence of natural enemies like *Beauveria bassiana*.

Banana weevil

It was shown that infested planting material is the main source of inoculum responsible for early buildup of banana black weevil population in newly planted plantain. Good numbers of adults can be collected in pseudo stem traps; although the spatial distribution of the captured adults in a commercial field tends to be aggregated, placement of five pseudo stem traps in a field of 3 ha is enough to obtain a reliable estimate of the population. This information has contributed to the design of management options based on use of clean planting materials, monitoring of adult population and use of natural enemies like *Beauveria bassiana*. First year results of the trials show the feasibility of implementing these options for reduction of black weevil damage in plantain.

Use of entomopathogenic fungi for pest management

The first phase of activities regarding the use of entomopathogenic fungi for pest management in Nicaragua was completed, and a national collection of pathogenic strains of *Beauveria bassiana* and *Metarhizium anisopliae* has been established. The fungus strains have been characterized and preserved for long term storage. A method has been developed for producing conidia powder. Different fungus formulations have been tested on farmers' fields, demonstrating good potential for the management of coffee berry borer, cotton weevil, banana weevil and diamondback moth. Studies are underway designed to understand the ecological interactions between pests, the environment and these pathogens. Current results help us to understand better the ways these entomopathogenic fungi can be used for pest management.

Management of purple nutsedge

A preliminary model was proposed for purple nutsedge (*Cyperus rotundus*) management in wet-dry regions of Nicaragua based on scouting, crop choice and soil tillage during the dry season. Planting of a tolerant crop like soybean that permits using herbicide for nutsedge control, and the use of dry soil tillage reduce nutsedge infestations. On the contrary, a crop such as sesame that has no herbicide available for nutsedge control, grown without dry tillage, suffers yield reduction and leads to nutsedge increase.

Low input management of pests and diseases

Through group discussions between farmers, extensionists and IPM specialists, key pest problems were identified and practical, low-input, pest management options were selected for a range of crops. Subsequently, volunteer farmers evaluated these options in their fields with the participation of the group. At the end of the season, evaluations were carried out based on the information of pest incidence and damage, crop management practices and costs. In the example of tomatoes, it was shown that using trap crops of beans, yellow sticky traps in the seedbed, using barrier crops of sorghum, and timely scouting to determine control measures to be taken in the field, farmers were able to reduce whitefly/virus incidence and fruit worm damage, and increase their profits by lowering pest management costs. Similar low input management options were also designed and evaluated in coffee and plantain with early promising results.

Sustainable implementation of IPM

Drawing on the experience of the past five years, both from formal surveys and the subjective perceptions of the project participants, a re analysis of the process of technological change was undertaken. As a result, the CATIE/INTA IPM Project changed its focus from transferring IPM technologies to a new focus of IPM implementation with farmers. In the traditional transfer model it is necessary to convince farmers to adopt new ways to manage pests, while the implementation focus concentrates on creating conditions that will lead to better pest management decisions. The process is intended to enable key changes to occur that are considered essential for achieving better IPM practice. The hoped for changes are: improved farmer capacity to evaluate, modify and adapt new pest management options; improved capacity of extensionists to work with the farmers for IPM implementation focused on farmers' problems and conditions; improved capacity of IPM specialists to generate valid new options for pest management in a participative way; better IPM education in schools and colleges; policies that foment IPM within the context of sustainable agriculture; regional and international networks offering opportunities for sharing experiences and resources.

NRI Projects On Development Of Environmentally Friendly Management Technologies For Key Crop Pests

Introduction

The development of new technologies as management tools for intractable pest problems of regional importance is a major component of CATIE's crop protection program. The development of biological (especially microbial) control technologies is a long-term objective in its own right because of the importance of biological control in fostering sustainable agricultural practices. The group of applied research projects, collectively known as the NRI Projects, seeks to develop environmentally sound management technologies and integrate them into enhanced IPM systems for selected key pests of annual food crops. The projects emphasize microbial controls but they also incorporate, cultural control techniques and strategic usage of selected pesticides when appropriate.

Work Lines

The NRI projects are responsible for the major part of the technology generation output of the Plant Protection Area. The emphasis of the projects is on the development of promising new technologies, such as microbial controls, for some of the key pests affecting major cropping systems in Latin America and, in some cases, beyond.

Technical Highlights

NRI-*Phyllophaga*: microbial control of *Phyllophaga* spp.

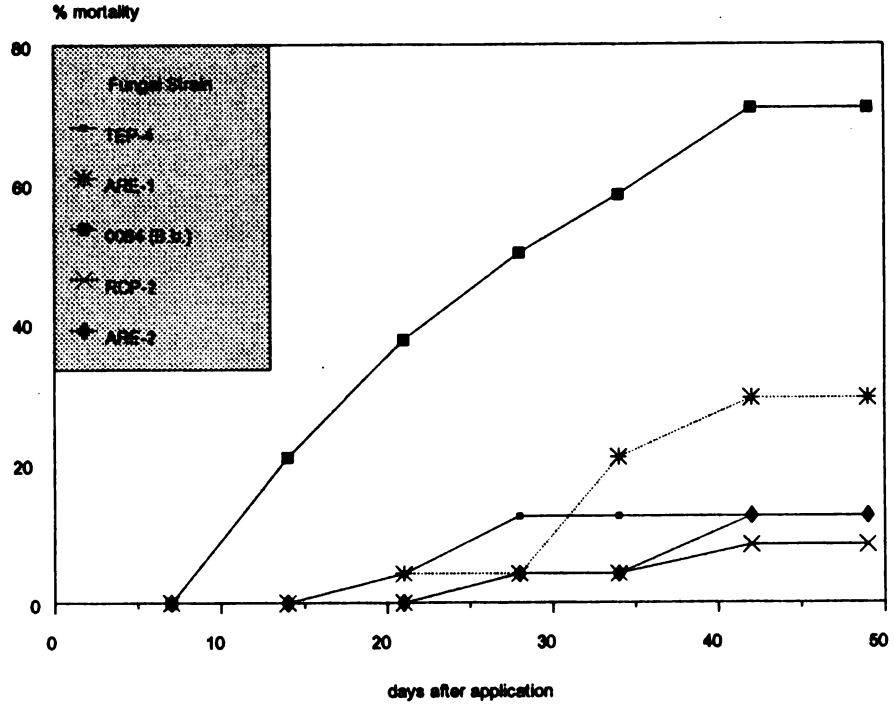
Larvae in the genus *Phyllophaga* (Col: Scarabaeidae) are whitegrubs that cause serious losses to a wide range of crops in most parts of the Americas. Damage is caused by third instar larvae feeding on the roots, weakening and frequently killing the plants. The one or two-year life cycle, the unpredictable, patchy and seasonal nature of outbreaks, and the soil dwelling habit of the larvae, contribute to farmers' frequently not attempting to control or to their delaying measures until they are no longer effective or economically justifiable. Where control is attempted, currently recommended methods rely heavily on preventive insecticide use, many of which have undesirable human toxicity and environmental characteristics, and even these methods are not effective in some crop situations.

Selection of entomopathogenic fungal strains with biocontrol potential.

Selection of promising entomopathogenic fungal strains continued during 1994. Representative *Beauveria* strains from the Entomopathogen Biodiversity Collection were screened for virulence using a redesigned maximum challenge bioassay that allows the rapid evaluation of large numbers of strains. Mixtures of equal parts by weight of 10 strains (*P. menetriesi* L2) or 5 strains (*P. menetriesi* L3) were applied on parboiled, sterilized, rice as a carrier. The strains comprising the groups that gave the highest levels of mortality were subsequently evaluated individually, using the same maximum challenge bioassay, to permit identification of the strains responsible for the virulence of the group. This methodology enabled two previously unevaluated strains of *Beauveria* (strains 0084 and 0059) to be identified as being highly virulent against *P. menetriesi* L2s and L3s from a total of 50 strains. Similar trials of 40 *Beauveria* strains against the L3s of *P. vicina* and *P. obsoleta* using groups of five strains were also completed but no high-virulence strains were identified.

Metarhizium anisopliae strains that had shown some promise against at least one *Phyllophaga* species during 1993, plus the two *Beauveria* strains selected early in 1994, were reevaluated against a range of *Phyllophaga* species by immersion in an aqueous suspension of 1×10^8 conidia ml^{-1}, and using modified bioassay methods aimed at reducing control mortality. Species against which the strains were tested were *P. menetriesi* (L3), *P. obsoleta* (L3) and *P. vicina* (L2 and L3). As no tests had been conducted in previous years against *P. elenans* (L2 and L3), a wider range of strains that had shown some promise against other *Phyllophaga* species was tested against this species. Early analysis tend to confirm previous results; most of the strains identified as highly virulent in 1993 gave the highest levels of mortality in 1994 but ,in the case of *P. menetriesi*, the new *Beauveria* strain 0084 gave a faster rate of kill than previously selected *Metarhizium* strains (see Figure 11)

Figure 11. **Mortality caused by selected *Metarhizium anisopliae* and *Beauveria bassiana* (B.b) strains applied at 1 x 10^8 conidia ml^{-2} to third instar *Phyllophaga menetriesi* larvae.**



The search for new *Phyllophaga*-active entomopathogenic fungus strains

The rarity of *Phyllophaga*-active strains in the survey of entomopathogenic fungi carried out during 1993, and doubts as to whether the *M. anisopliae* strains identified so far were sufficiently virulent, led to alternative strategies being adopted during 1994 for obtaining new, and hopefully better, strains of fungi. Twenty sites throughout Costa Rica were selected on the basis of harboring high densities of *Phyllophaga*, either currently or in the past, and soil samples collected from them. For each sample, about 25 laboratory reared *P. menetriesi* larvae were reared to death or maturity in plastic cups containing sub samples of this soil. Four of the sites (Zarcero, El Rodeo, Puntarenas and Tierra Blanca) yielded new *M. anisopliae* isolates from dead larvae. A selective micro biological medium (Milner & Lutton, 1976) was used to isolate *M. anisopliae* directly from the same soil samples, contributing about 15 new isolates for testing in 1995. The number of strains obtained was much reduced using these methods compared to the soil baiting with *Galleria melonella* or *Metamasius hemipterus* employed during the previous survey. It is however hoped that there will be more *Phyllophaga*-active strains.

Collaborations with DIECA (the Costa Rican sugarcane growers' organization) enabled mechanized sampling of *Phyllophaga* infestations in sugarcane during October and November, 1994. Twelve

infested sugarcane areas in Perez Zeledón (dominant species *P. menetriesi*), Filadelfia (*P. elenans*) and Puntarenas (*P. vicina*) were sampled by plowing and harrowing, and manually sorting exposed larvae. No *Metarhizium* or *Beauveria* infected larvae were found at any site, underlining the rarity of these diseases in *Phyllophaga* in nature. Larvae with symptoms of other diseases were collected and diagnosed in the laboratory. Diseases found were *Bacillus popilliae* (in *Anomala* sp. (Col: Scarabaeidae) and *P. menetriesi* from Perez Zeledón) and a *Mattesia*-like protozoan (in *Anomala* sp. from Perez Zeledón), both of which gave rise to *M. anisopliae* infections in larvae that died in the laboratory. Several healthy *P. vicina* larvae collected in Puntarenas also developed *M. anisopliae* infections in the laboratory. Manual collection of *P. obsoleta* larvae from a site in Tierra Blanca yielded many larvae with naturally occurring *M. anisopliae* infections. Based on field observations it is estimated that the epizootic caused approximately 30% mortality. All strains have been preserved in the Entomopathogen Biodiversity Collection pending their evaluation next year.

Evaluation of entomogenous nematode strains

A series of screening trials of new *Steinernema* and *Heterorhabditis* strains, mainly collected from lowland Caribbean environments, plus some promising strains selected from the previous year's screen, were evaluated at 600 IJs larva^{-1} against four *Phyllophaga* species. *P. menetriesi* L2 larvae were consistently more susceptible than the L3 larvae, the highest mortality 10 days after application being caused in both instars by *S. glaseri* (USA strain). Mortality levels in tests on L3 larvae of other species were low: no mortality occurred in *P. vicina*, only *S. glaseri* (USA strain) caused any mortality in *P. elenans*, and local strains PC2 (*Steinernema* sp.) and LIM1 (*Heterorhabditis* sp.) caused from 25-33% mortality in *P. obsoleta*. The poor performance of *S. glaseri* (USA strain) against *P. vicina* and *P. obsoleta* compared to the previous year, suggests there may have been some loss of virulence in this strain. Prior passing of the nematodes through the host and increasing application rates to 1000 IJs larva^{-1} had little effect on mortality in the few treatments in which this was tested. It is concluded that future work should concentrate on *S. glaseri* (USA strain) and a few of the most promising local strains, especially the lowland Caribbean strains that have proven easiest to maintain in culture.

NRI-*Rottbellia*: integrated management of itch grass (*Rottboellia cochinchinensis*)-dominated weed complexes.

Itch grass (*Rottboellia cochinchinensis* (Lour.) W.D. Clayton) is a serious and persistent weed problem in many tropical agricultural areas and conservation areas throughout the world. In Central America and Panama it causes serious crop losses and is considered one of the most noxious and serious weeds in crops such as upland rice, sorghum, sugar cane, common beans and maize. Crop losses and the costs of itch grass control limit the areas planted by small and medium-size farmers.

Previous research at CATIE demonstrated that effective in-crop control was essential for maintaining low levels of the weed, but that planting in zero tillage and prevention of seed set during the fallow period were also important. It was also shown that little viable seed remained after 12 months in the soil, underlining the importance of prevention of seed set in the weed's management. Encouraging results had been obtained from the use of inter sown legume cover crops as an alternative to herbicide as itch

grass suppressors in maize. This project builds on these previous results by providing more information on the long-term effects of management practices and developing the legume cover crop work to the point where concrete recommendations for implementation can be made, both in the original, seasonally arid, environment and in lowland humid Atlantic Zone environments. Additionally, socio-economic information has been collected on farmers in the areas likely to be targeted in eventual technology transfer activities.

Management strategies for itch grass suppression

The long term trial on the effects of integration of control tactics on itch grass populations in the seasonally arid zone of NW Costa Rica was continued into its fourth year, being the third maize sowing in the maize-beans-fallow rotation under study. There continued to be significant effects of management practices on itch grass populations. There was a higher itch grass population in plots without fallow management (21 plants m^{-2}) compared to manual weeding (15 plants m^{-2}). Although lower itch grass populations were observed in plots with zero tillage compared with conventional tillage, the effects were not significant ($p>0.05$). In-crop control by herbicide had the largest effect on itch grass populations during the crop cycle and this was greater than the effect of either tillage or fallow management. The lowest itch grass population (1.8 plants m^{-2}) was observed in plots with the higher rate of pendimethalin (1.5 Kg AI/ha). There were no significant interactions between the management components, so the combination of the best available methods of fallow management and effective in-crop control measures continues to be the best integrated program for itch grass control. Zero tillage may make an additional, smaller contribution on itch grass populations, but at this site produced lower maize yields (zero tillage and conventional tillage produced 2125 and 3000 kg ha^{-2}, respectively). Maize yields in plots weeded manually as a fallow management yielded 2933 kg ha^{-2} compared to 2033 kg ha^{-2} with no fallow management. There was also a significant effect on maize yield of using in-crop herbicide controls as compared with the check plots.

Socio-economic characterization of target farmers

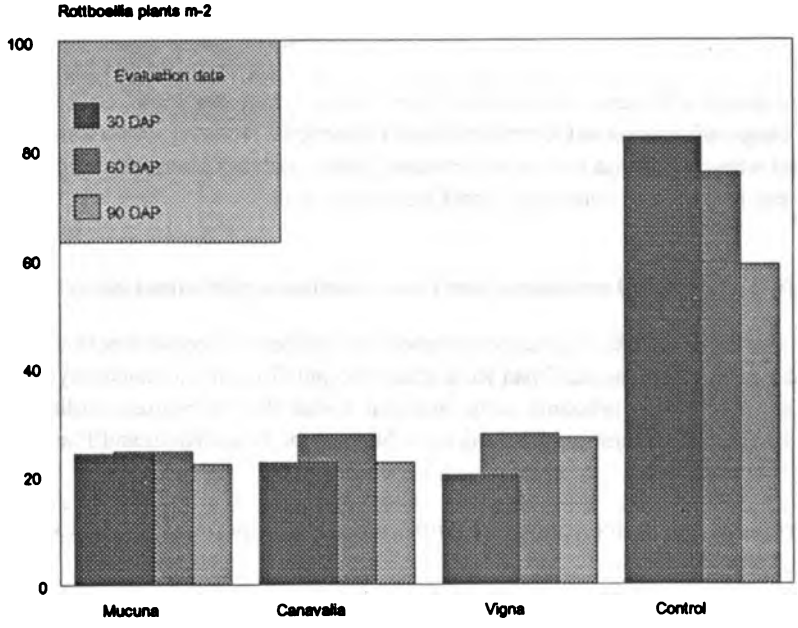
Farmer resource levels and costs of current itch grass control practices in two districts of Santa Cruz, Guanacaste were surveyed through field-based appraisals. Farmers surveyed have an average of 5.6 ha under maize-maize or maize-beans production systems. Rapid growth and establishment, and germination of seed throughout the rainy season were the most common perceptions of itch grass mentioned by farmers. They spend 34% of their resources for itch grass control. Some farmers expressed interest in becoming involved in validation of the proposed technologies for itch grass management.

Cover legume for itch grass suppression

Mucuna sp and *Canavalia ensiformis* legume covers gave the greatest suppression of itch grass (22 plants m^{-2}) compared to the check (59 plants m^{-2}) 90 days after planting (DAP) the maize crop in the seasonally arid zone. Significantly ($p<0.05$) lower itch grass populations were observed when legume cover crops were planted at 0 and 7 DAP maize than planting them 14 DAP. *Mucuna* sp. and *C. ensi-*

formis attained the highest ground cover (90 DAP) compared to *V. unguiculata* (62%, 67% and 28% respectively). The highest yields (3950 kg ha^{-2}) were obtained from maize inter sown with *C. ensiformis* planted at the same time as the crop, although there was no statistically significant difference from the other legume cover treatments (see Figure 12). Other trials however showed a competitive effect of cover legume with the maize crop.

Figure 12. Mean densities of the weed, *Rottboellia cochinchinensis*, in maize plots inter sown with cover legume species. Santa Cruz, Costa Rica, 1994.



Four legume cover crops (*Canavalia ensiformis*, *Vigna unguiculata*, *Pueraria phaseoloides* and *Mucuna* sp.) were planted in July as ground covers for suppression of itch grass in the maize/cassava cropping system. The trial is in the high rainfall Atlantic Zone which in recent years has become seriously affected by itch grass, previously assumed to be a weed mainly of seasonally dry environments. Three months after legume cover crops were planted, *C. ensiformis* had given the best ground cover (31% cover) and the lowest itch grass population, at 17 plants m^{-2} compared to 37 plants m^{-2} in the control plots. This trial continues.

Characterization of itch grass biotypes

An isoenzyme characterization for eleven itch grass populations was carried out at the Cellular and Molecular Biology Research Center, University of Costa Rica, to assist in determining how many biotypes exist in Costa Rica and to allow representative populations to be selected for pathogenicity testing of potential microbial control agents. Of several isoenzymes tested, only ß galactosidase (ß GAL) showed variation between populations. The same pattern was observed in populations from Bagatzí,

Coopesilencio, Cañas, Esparza, Colorado and Margarita, with a single ß galactosidase band named as ß GAL 3. In addition to ß GAL 3, an individual from Quepos also exhibited a band of ß GAL 1. ß GAL 1 was also observed as a single band in the population from Barranca, half of the individuals from Roxana and some individuals from La Cuesta (together with ß GAL 3). The rest of the individuals from Roxana exhibited a single, unique, band identified as ß GAL 5. The population from Jiménez showed a different ß galactosidase band (ß GAL 4), except for one individual that also had the ß GAL 3 band. These results suggest a high degree of isozymic homogeneity among itch grass populations.

NRI-*Echinochloa*: integrated control of *Echinochloa colona* (management of propanil resistant *E. colona*)

Propanil resistance in *Echinochloa colona*, the most important weed in rice worldwide, has been reported in upland rice growing areas in Central and South America. This project was initiated in October 1993 to assess the occurrence and distribution of resistant populations in Central America and to evaluate integrated management practices to control propanil-resistant populations.

Survey and evaluation of propanil-resistance and cross-resistance of Central American populations

Seed from more than 50 *E. colona* populations with differing propanil-herbicide use histories was collected in El Salvador, Nicaragua, Costa Rica, Panama, and Guatemala. Bioassay to determine the response of these populations to propanil were initiated under screen house conditions at CATIE. Resistance was documented in several populations from Nicaragua, Costa Rica, and Panama (Table 15).

Table 15. Propanil resistance status of *Echinochloa colona* populations in Central America, 1994.

COUNTRY OF ORIGIN	No. of Resistant Populations	No. of Susceptible Populations	Total Sampled
Costa Rica	8	8	16
El Salvador	0	1	1
Guatemala	0	6	6
Nicaragua	6	1	7
Panama	10	1	11
Total	24	17	41

Resistance to fenoxaprop-ethyl was confirmed in one population of *E. colona* already resistant to propanil. Further bioassay are being conducted as a project for a graduate research assistant. Two allegedly fenoxaprop-resistant populations from Panama were confirmed as susceptible as well as two populations from Nicaragua with little field exposure to this herbicide.

Management strategies for propanil-resistant populations

Two year field experiments on the effect of integrated management strategies for *E. colona* were established at two sites in Parrita, Costa Rica. Treatments consisted of incorporation or not of stubble (main plot) followed by use of glyphosate after weed emergence about three weeks later or without glyphosate application (sub-plot). Sub-sub plots consisted of conventional herbicide applications (two post-emergence applications of propanil plus one application of fenoxaprop) or a single application of a tank mixture of propanil plus pendimethalin in preemergence and one application of fenoxaprop-ethyl. Stubble incorporation did not have any effect on rice yield or *E. colona* recruitment. Glyphosate significantly decreased *E. colona* populations at both locations and resulted in substantially higher grain yield. No differences were found between conventional and modified herbicide applications either in yield or in *E. colona* infestation. No interactions were found among treatments.

Observation plots to assess the contribution of the seed bank to maintenance of *E. colona* populations indicates that only two germination flushes occurred during the growing season, regardless of tillage practices.

Studies on use of propanil synergistic

Research in support of studies being conducted at Long Ashton Research Station, UK, to assess the possibility of synergizing the activity of propanil on resistant populations was initiated at CATIE. Screen house bioassay indicate that the herbicidal activity of propanil in resistant populations can be substantially improved by adding low doses of the organophosphorous herbicide piperophos, without loss of selectivity to rice. A thesis project for an undergraduate student, partially sponsored by Rohm and Haas (Costa Rica), was initiated to systematically study the synergistic interaction between piperophos and propanil in *E. colona* and rice.

NRI-Tomato Pathogens: microbial and cultural control of early and late blight of tomato.

Fungicide resistance and environmental contamination have contributed to the pressure to develop low chemical input alternatives for vegetable disease management. *Alternaria solani* and *Phytophthora infestans* are the main fungal pathogens of tomato worldwide and they are particularly damaging in the humid tropics where fungicide applications can account for 60% of pest management costs. For example, local farmers often make over 15 mancozeb applications per season (2 per week) in an attempt to suppress these diseases. Some of the fungicides used are environmentally undesirable, and their prohibition for use in vegetables looks imminent. Thus *Alternaria solani* and *Phytophthora infestans* are priority targets for development of biological, varietal and crop management based controls.

Selection of antagonistic microorganisms against late blight, *Phytophthora infestans*

One hundred and forty microorganisms (85 bacteria and 55 fungi) isolated from the phyllosphere and endosphere of commercial and wild tomato, were evaluated for antagonism of *Phytophthora*, using detached leaf bioassay. Thirty-five (8 bacteria and 27 fungi) gave significant reductions in the size of *P.*

infestans lesions in the range of 27% to 100% (Table 16). Three bacterial strains and 12 fungi (including *Fusarium* sp., *Alternaria* sp., *Penicillium* sp. and *Trichoderma* sp.), considered representative of the range of organisms showing antagonism, were selected for further study. All the organisms were preserved on agar slips under mineral oil.

Table 16. Antagonistic effect of microorganisms selected for further study as biocontrol agents of late blight, *Phytophthora infestans*, in tomato (from a study of 140 strains).

MICROORGANISM GROUP	NO. OF STRAINS	ANTAGONISTIC EFFECT[a] 25-50%	50-75%	75-100%
Bacteria	8	4	4	-
Fusarium sp.	12	-	4	8
Trichoderma sp.	3	-	2	1
Penicillium sp.	1	-	1	-
Gliocladium sp.	2	-	2	-
Other fungi	8	-	5	3

[a] % reduction of area of foliar lesion in detached leaf bioassay

Evaluation of surfactants for improving the antagonistic ability of a *Bacillus* sp. antagonistic to early blight, *Alternaria solani*

In a screen house test designed to test five surfactants for their ability to enhance the effect of the antagonistic A30 *Bacillus* strain under simulated rainfall conditions, NP-7 was the best in terms of reduction in number (-51%) and size (-26%) of *A. solani* lesions. The effect was strongest when no artificial rainfall was applied, suggesting that the surfactant may directly affect the pathogen or the action of the antagonist. Results of a second trial were not consistent with these earlier findings.

Selection of tomato materials for resistance to early and late blight

Forty five tomato lines were received from Dr. Charles M. Rick (University of California), and eleven from Dr Richard Shattock (University of Wales). These materials, plus Hayslip (a commonly used commercial variety which is highly susceptible to both blight pathogens), were evaluated for susceptibility to *P. infestans* after spraying sporangial suspension on seedlings in the screen house. Twenty-nine materials with less than 5% necrotic leaf area after 7 days were subsequently evaluated for susceptibility to both *A. solani* and *P. infestans* on detached leaves. Twenty-two lines were selected for further evaluation in the experiment station to evaluate their field susceptibility.

Soil and foliar amendments for early and late blight control

A field trial completed in collaboration with students of the CATIE Postgraduate Program showed that use of mineral fertilizer, organic fertilization with "bokashi" (fast fermented rice-based compost) and soil applied calcium carbonate or calcium nitrate were all needed to give the maximum reduction in *P. infestans* incidence. Effects of these nutritional factors were much less in the case of *A. solani.*

Characterization of Central American *Phytophthora infestans* isolates

Characterization of Central American *P. infestans* isolated continued during 1994. Twenty-two new *P. infestans* samples were collected from different locations in Costa Rica. Only five grew well enough *in vitro* to be characterized. As has been the case with all other isolates tested previously, all were A1 mating type. Only one was sensitive to metalaxyl fungicide and four had intermediate sensitivity.

Nematode biocontrol

Field testing of *Pasteuria penetrans* and *Verticillium chlamydosporium* for the biocontrol of *Meloidogyne incognita* in tomato.

Three consecutive plantings of tomato have now been completed, comparing *Pasteuria penetrans* and *Verticillium chlamydosporium* applications with control, nematicide and chicken manure treatments. *P. penetrans* is now present in all treatments, including the controls, where high levels now obscure any effects that applying the organism might have on the nematode population. It is not yet known whether this is due to increases in a native strain caused by continuous cropping with tomato or due to rain dispersing the introduced strain to neighboring plots. *V. chlamydosporium* could not be reisolated from the soil or tomato roots.

Microbial Control Unit

The Microbial Control Unit, finished during 1993 under ODA (United Kingdom) funding, completed its first full year of operation in 1994. The Unit was primarily designed for research on microbial controls of insect pests, but during 1994, it has evolved into a support unit that also assists other research areas, e.g. a project on the microbial control of root knot nematodes. The mission of the Unit is to develop microbial control technologies in response to the demand for more effective and environmentally sound management tools for incorporation in IPM programs. Student thesis research, and contributions to in-service training programs and short courses are already beginning to add a training dimension to the activities of the Unit.

The Unit offers facilities for insect rearing, insect pathology, production and bioassay of insect pathogens and long term storage of entomopathogenic fungal and bacterial strains as part of the Plant Protection Area. Operational budget is mainly dependent on project support, and in 1994 this was most-

ly provided by the NRI-*Phyllophaga* and the ODA-supported Nematode biocontrol projects (see separate report on NRI Projects and Table 17.). Other activities in the Unit during 1994 were research on entomopathogenic nematodes for banana weevil control (RENARM-IPM Project), entomopathogenic fungi for whitefly control (EDECO Postgraduate thesis), survey for viruses of *Hypsipyla grandella* (University of Oxford collaborative project), and part of the in-service training program of two crop protection professionals from Belize.

Table 17. Current work lines and estimated commencement dates[a] of major work phases of the projects currently funded by NRI and ODA.

PROJECT AND STRATEGIC AREAS ADDRESSED	PHASES OF TECHNOLOGY DEVELOPMENT		
	Research	Validation	Transfer
NRI-Phyllophaga	Current	1996	1998
NRI-Rottboellia	Current	1995	1995
NRI-Echinochloa	Current	1996	1996
NRI-Tomato Pathogens	Current	1997	1999
Nematode Biocontrol	Current	1997	1999

[a] assuming continued funding

Other collaborative research and development links are actively being sought, with the objectives of broadening the range of expertise available in the Unit and diversifying funding sources.

AGROFORESTRY SYSTEMS AREA

This Area implements research, teaching and outreach activities involving agrisilvicultural, silvipastoral and agrisilvipastoral systems in the tropics, particularly on small farms in Central America. Major topics include the introduction of timber trees in small-medium farms, studies of forage trees and the use of nitrogen fixing trees in combination with tropical crops, in order to conserve and/or improve agricultural soils as well as to reduce the use of chemical fertilizers. The objective is to find cropping combinations which generate greater incomes for small farmers.

Activities in the Agroforestry Systems Area represent one of the main ways CATIE contributes to the sustainability of natural resources in tropical America.

The projects that operated in this Area during 1994 are shown in Table 18.

Table 18. Agroforestry projects operating during 1994 at CATIE and their respective financing and donors.

PROJECT	AMOUNT (Thousand US$)	SOURCE OF FUNDING
Coordinating Unit	238	DANIDA (Denmark)
NFT/Leucaena -Calliandra	196	SAREC (Sweden)
Small Ruminants	10	CATIE's core budget
Small Ruminants	85	GTZ (Germany)
Small Ruminants	8	OLAFO Project (Sweden)
Home Gardens Project	93	IDRC (Canada)
Agroforestry Systems	54	GTZ (Germany)
Silvipastoral Systems	85	IDRC (Canada)
Agrisilvipastoral Systems	234	CIDA (Canada)
Atlantic Zone Program	360	Wageningen (Holland)
Various Studios	59	
TOTAL	1,903	

Agroforestry Coordination Unit

DANIDA (Danish International Development Assistance) has been supporting coordination of CATIE's Agroforestry Area since 1992

During 1994, the following long and mid-term objectives were set for the Area, according to the agreement between CATIE-DANIDA: 1)Prepare a strategy for agroforestry in CATIE; 2) Strengthen cooperation among CATIE projects and other existing agroforestry projects in the region; 3) Disseminate updated agroforestry information to regional projects; and 4) Ensure that CATIE maintains high quality standards for agroforestry research and education.

Activities and Results

An Action Plan for the Agroforestry Systems Area was prepared, setting institutional priorities that will be a framework for future development.

A data base on agroforestry projects in Central America and the Dominican Republic has been established. This information helps determine project needs and constraints, and will facilitate improved planning of joint activities, which will improve and adapt agroforestry according to CATIE's Agroforestry strategic plan.

Several CATIE staff participated in workshops and meetings on Training Materials for Agroforestry that will serve as a basis for joint activities with other organizations such as ICRAF.

Agroforestry technical support and training for projects in the lowlands of the Bolivian Amazona and to the "Mi Cuenca" Project (CARE, by request of the Guatemalan government).

A Meeting of the working group on Acid Soils Management for Latin America was held in CATIE.

In coordination with the Nitrogen Fixing Trees Association (NFTA), organization of the International Expert Workshop on Nitrogen Fixing Trees for Acid Soils. Thirty papers were presented by the experts representing America, Europe, Asia and Africa.

16 papers were presented by CATIE's students and scientists at the International Workshop on Silvipastoral Systems, held in Cuba.

Technical support was provided to the IDA/FAO/HOLLAND Forestry Project, in Liberia, Guanacaste, Costa Rica, to prepare the basis for a training course on agroforestry for technical staff within the project working area.

To disseminate updated information on agroforestry to Latin American projects, two Issues of *Agroforestería en las Américas* were published in 1994.

The Proceedings of the International Meeting *Erythrina in the New and Old Worlds*, and *Erythrina Production and Use: A Field Manual* (Spanish version) were jointly edited and published by CATIE and NFTA staff.

An annotated bibliography of CATIE's Agroforestry publications is being compiled. This work is expected to be accomplished by the first quarter of 1995.

Two videos on CATIE's research, training and transfer activities in agroforestry were supported by DANIDA in cooperation with the AFN/SAREC and CIDA projects.

The agroforestry curriculum of CATIE's Graduate School was redefined and updated. Three courses at the graduate level were given: Management of Tropical soils; Agroforestry; and Research Methodologies in Agroforestry Systems.

The IX International Intensive Course on the Development of Agroforestry Systems under JICA funding was also implemented. The course lasted three months. It was attended by 21 participants from 15 Latin American countries.

A 6-week intensive course on Agroforestry was given to technical staff of the Ministry of Agriculture of Ecuador.

Continuous support was given to the maintenance of long-term experiments, especially to alley cropping (La Montaña) and Soils Conservation (San Juan Sur). Support was also given to the Soils Laboratory in terms of technical staff.

Small Ruminants and Agroforestry Project

Introduction

The project has two main objectives:

To appraise the nutritional characteristics as forage of available woody species that are traditionally under-utilized in different ecological conditions.

To validate silvipastoral alternatives which provide increases in productivity and farm income without deteriorating the natural resource base.

Activities And Results

The use of Clavelón (*Hibiscus rosa-sinensis*) as a supplement for goat milk production.

When goats, fed on a basal diet of King Grass (*P. purpureum* x *P. typhoides*), were additionally offered Clavelón (from 1.0 to 3.0% LW) significant increases in the intake of total dry matter (from 3.3% to 4.8% of live weight) and milk production (from 1.4 to 1.8 kg/animal/day) were observed. There were no effects on milk quality.

The effect of substituting concentrate with Morera (*Morus* sp.) forage on cow milk production in Turrialba.

Preliminary results indicate that milk production of grazing cows, whose additional feed was the foliage of Morera, was statistically the same (12.0 kg/animal/day) as that obtained with a concentrate supplement (12.4 kg/animal/day) and in both cases, significantly higher than production without supplements (10.1 kg/animal/day).

Effect on grazing calf weight gain substituting concentrates with Morera (*Morus* sp.)

Preliminary data indicate that the complete substitution of concentrate with Morera foliage does not significantly affect the animals' weight gain (650 and 600 g/animal/day, respectively). A greater weight gain (750 g/animal/day) was observed when 50% of the concentrate was replaced with Morera, compared to 430 g/animal/day for the control (average CATIE farm diet with 50% of the quantity of concentrate used in the experiment).

Effect of drying and adding molasses on the chemical and physical characteristics of micro-silos of 8 woody tree forage species.

The foliage of Morera (*Morus* sp.), Chicasquil (*Cnidoscolus aconitifolius*), Amapola (*Malvaviscus arboreus*), Jocote (*Spondias purpurea*), Tora blanca (*Verbesina turbacensis*),

Nacedero (*Trychantera gigantea*), Sauco Amarillo (*Sambucus candensis*) and Guácimo (*Guazuma ulmifolia*) was silaged. On average, adding 5% molasses to the silage increased the *in vitro* dry matter digestibility (IVDMD) (from 59.2 to 64.2%) and the formation of lactic acid (LA) (from 2.1 to 7.5%); crude protein (CP) content was only slightly affected (from 17.7 to 17.2%) while the production of ammonia (from 2.9 to 2.1%), pH (from 4.9 to 4.2), acetic acid (AA) (from 4.6 to 3.1%) and butyric acid (BA) (from 0.3 to 0.1%) were reduced. Drying decreased the IVDMD (from 64.1 to 59.2%) and CP (from 18.5 to 16.3%); increased pH (from 4.4 to 4.7), LA (from 3.2 to 6.5%) and decreased ammonia production (from 3.5 to 1.5%), AA (from 5.3 to 2.5%) and BA (from 0.39 to 0.01%). Morera and Chicasquil showed the better characteristics for silage under either treatment. Both maintain elevated digestibility and good physical characteristics.

Evaluation of the consumption and milk production of goats fed with Morera, Amapola and Jocote silage.

A higher consumption of dry material was observed with the Morera silage (4.9% of LW), followed by the Amapola (4.4) and the Jocote (3.2). Milk production was 1.9, 1.8 and 1.3 kg/animal/day for each forage, respectively. The production with Morera is equivalent to 0.119 $g/kg^{0.75}$ that, for a cow which weighs 350 kg, is equivalent to 9.6 kg/animal/day.

Effect of soil mulching with Poró *(Erythrina poeppigiana)* foliage on the biomass production of associated Morera.

The total DM production of Morera was 18.5, 16.5, 17.6 and 18.2 tm/ha/year for the treatment without trees and for the levels 0, 50 and 100%, respectively of Poró foliage returned to the soil. These differences were not statistically significant. The production was less than that reported in CATIE with animal manure at a level equivalent to 350 kg N/ha/year. The principal limitation was that the N supplied by the Poró foliage did not exceed 90 kg/ha/year. It is necessary to increase the plantation density of Poró in the first years.

Observations on the consumption of shrub and tree forage silage as the unique diet for young goats.

Silage of Chicasquil fino (*Cnidoscolus aconitifolius*), Chicasquil (*Cnidoscolus chayamansa*), Morera (*Morus* sp.), Amapola (*Malvaviscus arboreus*) and Jocote (*Spondias purpurea*) provided IVDMD values of 75.9, 72.3, 62.9, 42.5 and 51% for each forage, respectively. Consumption was 2.4, 2.0, 1.7, 0.8 and 1.2% LW for each forage species.

Home Gardens Project

Introduction

The CATIE Project "Socioeconomic and Biodiversity of Home Gardens in the Rural Regions of Central America" is financed by IDRC, Canada. The first phase has a duration of one and a half years (October 1993-March 1995).

The Project is principally research with a multidisciplinary approach (social, agroecological/botanical, economical) and entailed a series of investigations in different fields and a follow-up of the families and their gardens during more than ten months. Various methodologies were used to conduct field work and analyze the data both in the agroecological and the socioeconomic areas of research.

In the first year of the project, traditional home garden systems and the families that manage them, were closely studied in three Central American countries. In Honduras and Nicaragua the sample was 20 families and their gardens; in Costa Rica 12 families and their gardens. Additionally, a three month-Case Study was completed in Santa Rosa de Copán, Honduras, with a sample of 10 families and their gardens.

The general objective of the project in its first phase is to "analyze and evaluate the socioeconomic importance and biological characteristics of home gardens in the seasonally dry-wet environments of Central America, namely in Costa Rica, Honduras and Nicaragua, and to assist rural families to develop and strengthen strategies to optimize these production systems."

In the case of this project, the term home garden designates:

> *"The space adjacent to the house with a variety of plant and tree species, where domestic animals are kept. It is characterized by the reduced scale of each of its components; as well as by an extensive use of labor favoring the role that women can play in its maintenance and development."*

Home gardens provide the rural family with a package of benefits that improve rural well-being. The functions of the home garden are both complementary and essential :

- complementary because they provide the family with a variety of products throughout the year that are different from those obtained through agriculture or those that are purchased.
- essential because the majority of the rural families are not able to substitute this source of well-being with another. Without the home garden many families would find themselves in an even more precarious position.

The main benefits provided by the home garden are:

- food;
- products for sale;
- goods and services that include pleasure, recreation, an extension of the house;
- medicinal products.

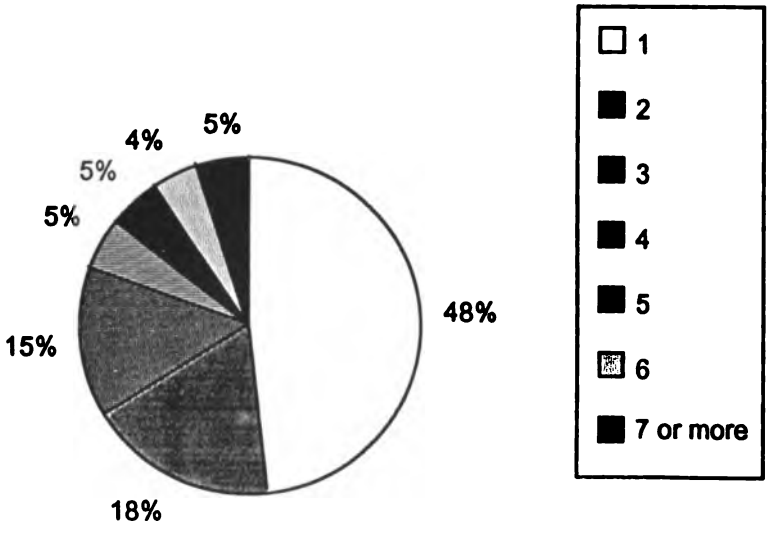
Activities And Results

1. The botanical and agroecological research in combination with the participative workshops with men and women at a local level have revealed the following:

a. There is a great variety of species in most of the research areas, but the frequency of most of the species in the gardens is very low (1 or 2 gardens out of the sample). At the same time there is a great need at the local level to increase the number of species and acquire knowledge on the use and management of new component species.

As an example of the low frequency of species in the gardens, the data from the Case Study in Camalote, Copán, Honduras are shown in Figure 13.

Figure 13. Percentage of frequency of species in the 10 gardens under study in Camalote, Copán, Honduras.



This chart shows that 48% of the 250 species that were found, occur only in one garden, and only 5% of the species are found in 7 or more gardens. This data leads to the conclusion that there is insufficient diffusion of genetic material and knowledge of that material within communities. Home garden extension policies should focus on the diffusion of genetic material already available in a given community.

b. In most of the cases there is little variety of animals in the home gardens (usually only chickens) and management is poor. There is little interest in the introduction of new species of animals except for bees in Masaya, Nicaragua. However, most families are interested in improving the management of the animals they already keep.

2. The gender research done in the first phase shows that in the different regions under study women participate to different degrees in the maintenance of species in the home gardens. Their participation is strongly related to the access and control they have over the resources and benefits of the home gardens.

3. The research on health and nutrition indicates in general terms that most of the population under study has a deficient diet and that the home gardens play an important role in supplementing the daily requirements of the families.

4. Within the project framework a considerable amount of economic data (income of the families, production of the gardens etc.) has been collected. This data is in the process of being analyzed.

5. In addition to the research, workshops at regional and national levels have been organized. There is a lack of understanding of what a home garden is and what it provides for a family. Although most extensionists have the best of intentions and all agree on the fact that a home garden should have a variety of different species, there is a *total lack* of understanding that optimization of production (as is the case of many agricultural practices) is *not* as important as guaranteeing variety of products with minimal labor and capital inputs, throughout the whole year. Thus management practices related to home gardens are different from those used in agriculture or purely commercial agroforestry plantings.

   Furthermore, through the workshops it has become clear that the Home Gardens Project has the potential to develop a leading role in the region in multidisciplinary research in agroforestry systems and in extension planning that will benefit women.

CATIE/GTZ Agroforestry in the Humid Tropics Project

Introduction

The overall objective of the project is to assess existing and to develop new or improved agroforestry systems in order to strengthen and promote the development of ecologically and economically sustainable land-use systems.

During the current fifth phase (08/92 through 07/95) the project is designed to achieve the following results:

Analysis and publication of all research results (1988-1994) from Talamanca (Costa Rica) and Bocas del Toro (Panama);

Dissemination of research results to selected staff and farmers from local agricultural and forestry organizations;

Development of the foundations for an eventual expansion of the Project to other Central American countries (in addition to Costa Rica and Panama); and

Support to CATIE's agroforestry graduate school.

In 1994, the project focused on the following areas:

- Research: both on-farm and on-station: agroforestry systems based on cocoa, plantain, coffee, goats, small scale reforestation and boundary line tree planting.

- Teaching and Training: includes both contributions to the academic teaching programs at CATIE (M.Sc. program and short courses), as well as direct transfer of knowledge to scientists, extensionists, and farmers in Talamanca, Costa Rica and Bocas del Toro, Panama.

- Transfer: some of the results of the biological and economic studies of agroforestry systems were published in eight volumes of the series "Generación y Transferencia de Tecnología" of the project. Further results were presented at various national and international meetings.

The Project works in cooperation with national and non-governmental organizations with the ultimate goal of promoting a continuous cycle of generation and dissemination of appropriate agroforestry technologies. Funds are provided by the Agency for Technical Cooperation of the Federal Republic of Germany (GTZ), the Instituto de Recursos Naturales Renovables of Panama (INRENARE), the Dirección General Forestal of Costa Rica (DGF), and the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE).

Activities And Results

Timber production from boundary line plantings

Timber production of laurel (*Cordia alliodora*), teca (*Tectona grandis*) and mangium (*Acacia mangium*) from line plantings on farm boundaries was assessed at age four on four sites of the coastal plains of Talamanca. *C. alliodora* performed poorly in sites with a high water table; *T. grandis* performed well in all sites.

Timber production of deglupta (*Eucalyptus deglupta*), terminalia (*Terminalia ivorensis*) and *C.*

alliodora from line plantings on rich alluvial soils of the Sixaola river valley, Talamanca, Costa Rica, was assessed at age six on four sites. Total stem volumes were 160, 131, and 75 m^3/km, respectively. High mortality rates were recorded for *T. ivorensis* on all sites and this species is not recommended for introduction to farms in this area. *E. deglupta* performed outstandingly on all sites.

Timber production of *T. ivorensis, A. mangium* and *T. grandis* from line plantings on alluvial soils of the Sixaola and Changuinola (Panama) river valleys was assessed at age five on three sites. Total stem volumes were 105, 79 and 62 m^3/km, respectively. All species performed well. In this area there were no mortality problems with *T. ivorensis*.

Reforestation with pure tree blocks vs. permanent association with crops (agrisilviculture)

Combining trees with annual and perennial crops (agrisilviculture) was shown to be a better reforestation alternative than pure forestry. Fruit production from arazá (*Eugenia stipitata*), a shrub from the Amazon, planted under *C. alliodora* or *A. mangium*, was 15 and 19 t/ha/year, respectively. *C. alliodora* total stem volumes were higher when in association with *E. stipitata* (90 m^3/ha at age five) than for pure *C. alliodora* stands (60 m^3/ha).

Comparison of six different combinations of plantain and cocoa under *Cordia alliodora*

Diversified agroforestry systems combining cocoa (*Theobroma cacao*), plantain (*Musa* AAB) and *C. alliodora* planted at 12x12 m (69 trees/ha) provided continuous agricultural production over a four year period, extremely high growth rates for *C. alliodora*, and attractive production levels of plantain. Six different combinations of cocoa and plantain were tested. Land equivalent ratios for these production alternatives favor these diverse systems over the corresponding monocultures.

Table 19. Land equivalent ratios (total and per crop) for different cocoa, plantain, and *C. alliodora* associations.

	Land Equivalent Ratios			
Treatment*	Cocoa	Plantain	*C.alliodora*	Total
3C:1P	0.131	0.405	0.466	1.002
2C:1P	0.116	0.425	0.466	1.007
1C:1P	0.154	0.399	0.466	1.019
2P:1C	0.043	0.454	0.466	0.963
3P:1C	0.051	0.529	0.466	1.046
IP+IC	0.127	0.510	0.466	1.103

* Proportions of cocoa (C) and plantain (P) in a total population of 1,111 plants/ha (3x3m) except 1P+1C (2,222 plants/ha).

Comparison of six shade trees for cocoa

Leguminous and timber tree species were tested as shade over cocoa in three large experiments in Talamanca and Bocas del Toro. Leguminous species included: madero negro (*Gliricidia sepium*), poró (*Erythrina poeppigiana*) and guaba (*Inga edulis*); timber species included *C. alliodora, T. ivorensis* and roble de sabana (*Tabebuia rosea*). Results for the first 6-7 years favor the use of timber trees as shade for cocoa. Cocoa production varied between 400-1000 kg/ha/year of dry beans. Timber production at the best site reached 70 m^3/ha for *C. alliodora* and 73 m^3/ha for *T. ivorensis* at age 4.3 years. On a poorer site corresponding figures are 40 m^3/ha for *C. alliodora* and 36 m^3/ha for *T. ivorensis* at age 5.0 years. *T. rosea* on the poorer site produced 20 m^3/ha.

AFN/SAREC Project

Nitrogen Fixing Trees: *Leucaena-Calliandra*, Project.

Introduction

The Leucaena-Calliandra Project had as its main objective: the study of the potential of Leucaena and Calliandra species in agroforestry systems that provide more sustainable production than crop monocultures. This Project, which began in 1989 and finished in 1994, had the financial support of the Swedish Agency for Research Cooperation with Developing Countries (SAREC).

The study of the biological, chemical and physical dynamics of the soils under agroforestry and agrisilvicultural systems became a priority within the Project's goals. A second priority was the training of the professional personnel of CATIE's member countries, especially Nicaragua, on agrisilvicultural and silvipastoral aspects.

The Leucaena-Calliandra Project produced important information on the use of agroforestry alternatives that will stimulate food production while conserving the environment and biodiversity. The results should now be validated, transferred and disseminated.

Activities and Results

Ñampi (*Colocasia esculenta* var. antiquorum) and Maize (*Zea mays* L.) Production In Alley Cropping with *Erythrina fusca* and *Calliandra calothyrsus*.

This study was established in Guápiles, Costa Rica, to evaluate the performance of ñampí in crop associations with trees of *Calliandra calothyrsus* and *Erythrina fusca* spaced at 6x0.5, 6x1 and 6x2 m. The combined analysis of three harvests of ñampí showed significant differences ($p<0.05$) between production of corms and commercial cormelos in association with trees (15.5 t/ha), and that of the control without trees (13.6 t/ha). Production was higher in the association with *E. fusca* than with *C. calothyrsus* (16.7 and 14.3 t/ha), respectively, and both were higher than the control.

Maize grain production, combining the three harvests, was higher in association with trees (4.8 t/ha) than in the monoculture (3.4 t/ha; $p< 0.01$).

In the third harvest, significant differences were found ($p<0.05$) between the monoculture (2142 kg/ha) and the average for the treatments with trees (3874 kg/ha). A significant difference ($p<0.05$) between maize yield with *C. calothyrsus* (3296 kg/ha) and *E. fusca* (4454 kg/ha) was also found.

The average biomass production from five prunings, of the trees was highest in the treatment of *C. calothyrsus* spaced at 6x0.5m (7845 kg/ha; $p<0.05$). Production of *E. fusca*, planted at 6x0.5 m, was lowest (1632 kg/ha).

Comparison of Four Tree Legume for the Maize-Maize (*Zea Mays*) Alley Cropping System.

A complete randomized block design, with three repetitions, was used to evaluate the productive response of the maize-maize crop system planted in alleys of *E. berteroana, E. fusca, C. calothyrsus* or *G. sepium*. Treatments were the tree species (planted at 6x1m) and a maize monoculture without fertilizer.

The combined analysis of six maize harvests, did not show significant differences between treatments ($p<0.05$) for the average grain yield, but for biomass production the difference was highly significant ($p<0.01$). The control plots produced 25% more grain than the plots of maize associated with *C. calothyrsus*. For stubble production, the monoculture significantly surpassed ($p<0.05$) maize associated with trees, except for the treatment with *E. fusca*. Superiority of the monoculture for both variables fluctuated between 20 and 30%.

The yield of maize planted in January was superior to maize planted in May; 2416 and 4044 kg/ha for grain, respectively, and 2886 and 4832 kg/ha for stubble, respectively.

Leaf biomass production of *E. fusca* and *C. calothyrsus* was higher than *G. sepium* and *E. berteroana*; within these two groups there was no significant differences ($p>0.05$). Biomass production of the December-January pruning was higher than the May-June pruning (4242 and 2288 kg/ha), respectively.

Biomass produced by the association of maize with *E. fusca* and *C. calothyrsus* contributed 8.0 and 7.6 t/ha, respectively. With the other associations, total incorporation was 6 t/ha. The greatest amount of biomass was produced by *E. fusca* and the biomass of this species decomposed more quickly.

It is concluded that grain production of maize in alley cropping was not statistically different to that of a monoculture ($p>0.05$) but the latter produced a significantly larger quantity of stubble.

Productivity Of Star Grass (*Cynodon nlemfuensis*) Associated With *Gliricidia sepium* and *Leucaena leucocephala* When Grazed In The Dry Tropics.

This experiment was established with the purpose of evaluating productivity of pasture lands associated with *Gliricidia sepium* and *Leucaena leucocephala*. The trial was established in November 1991 by planting trees at 6x5m. A one-year establishment period for the trees was allowed, during which the pasture was used to produce hay and seed.

The trees were pruned twice a year, at the beginning and at the end of the rainy season. Biomass was left on the land to be incorporated into the soil. Plots were grazed every 28 days, with 30 animals, for three days. Pasture production before and after grazing was determined.

The combined analysis of 10 grazing cycles that occurred during the year indicated that there was no significant differences ($p>0.05$) in pasture biomass before grazing (dry base), with values of 6021, 5943 and 5556 kg/ha for *L. leucocephala*, *G. sepium* and control treatments, respectively. However, there was a higher pasture production and higher utilization in the treatments with trees than in the control.

No difference was found in the broad-leaf weed population or in the occurrence of *Aeneolamia* spp.

The above data indicates that the presence of 320 trees per hectare did not affect star grass production. Nevertheless, it may be expected that on a long-term basis, the incorporation of biomass (litter and faeces) and N fixation, may significantly increase production and pasture consumption. To the above advantages we must also add the contribution of the trees in capturing CO_2. This work ended in June 1994, due to the lack of funds, but it is recommended that this type of study should be carried out for at least 5 years.

Evaluation Of The Agroeconomical And Financial Sustainability Of An Alley Cropping System By Associating Maize (*Zea mays* L.) With Poro (*Erythrina poeppigiana*) Planted At Different Densities.

The agroeconomical profitability of a maize-poro agroforestry system, using four spacings between trees, was evaluated from 1985 - 1994 at San Lucas, CATIE.

A randomized design with three blocks and a temporal arrangement was used. Treatments consisted of four spacings between poro trees (6x1m, 6x2m, 6x3m, 6x4m), one unfertilized monoculture of maize and a chemically fertilized monoculture. During the first thirteen cycles of maize cropping, a P_2O_5 basal application of 50 kg/ha/cycle was provided to all plots. Additionally, the control with fertilizer was given 50 kg/ha/cycle of 10-30-10. In the last five cycles no P_2O_5 was applied to treatments with trees, but 100 kg/ha/cycle of N and 60 kg of P_2O_5 was applied to the fertilized control.

Macro nutrients (N, P, K, Ca, Mg) recycled by the trees, maize yield, and the financial profitability of the different systems were evaluated over 18 complete cycles. During cycles one to seventeen, macro nutrients, soil organic matter and soil pH were evaluated. Impacts of the trees on macro nutrient reserves in the soil were also assessed. The effect on weed incidence was estimated for cycles seventeen and eighteen.

The introduction of greater numbers of trees per hectare resulted in higher amounts of recycled nutrients. However, when spacing between trees was increased from 6x1m to 6x4m, maize yield increased. In comparison with the unfertilized maize monoculture, average yield (2150 kg/ha/cycle) for a 6x4 spacing increased by 48%. However in comparison to the fertilized monoculture, yield for the 6x4 spacing treatment decreased by 14% ($p>0.05$).

In the plots with trees, macro nutrient content of the soil changed very little during the nine year experimental period. However, K content increased by 14%. Ca contents decreased for all treatments; Mg content remained stable while P content increased by 25%. There were no significant differences between treatments for these elements.

Weed biomass in the presence of poro diminished by 53% before planting maize and by 39%, 45 days after planting.

Variable costs were higher for the fertilized monoculture ($347/ha/cycle) and lowest ($218/ha/cycle) for the unfertilized monoculture. In the plots with trees, costs increased when spacing between trees was reduced.

The maize-poro system, with a density of 417 trees per hectare, and the fertilized monoculture showed the highest gross margins ($122/ha/cycle, $120/ha/cycle, respectively) and highest net income ($46/ha/cycle). Return to capital invested was higher (0.78) for the 6x4m spacing than for the fertilized monoculture (0.40). Net income analysis indicated that the systems with trees with spacings of 6x1m and the unfertilized monoculture are not profitable.

Assessment of the impact of trees (6x4 spacing) on the soil nutrient reserves showed a net profit of $1.4/ha when compared with the fertilized monoculture.

When replacing a maize monoculture with a maize-poro association, $18/ha/cycle can be saved, 88% coming from the money saved from avoiding N fertilizer applications.

Evaluation Of Loss Of Soil Nutrients By Surface Erosion, Run-Off And Leaching On Hillside Farm Lands. San Juan, Turrialba.

On the hillside/acid soils of CATIE's experimental station in Turrialba, run-off plots were established with different treatments: alleys with single rows of trees spaced at 4 m and 12 m, mulch of *Inga edulis* or *Erythrina fusca* and a control treatment.

Loss of nutrients by leaching was higher than that due to erosion and run-off. The highest values of leached elements were: 108, 6, 65, 362 and 29 kg/ha/year of N, P, K, Ca and Mg, respectively. The values for nutrient loss in the control treatment were higher than those found in the treatments with alley cropping or mulch. The annual balance of the nutrients showed a tendency for reserves to decrease year after year, P and Ca being the most critical.

The average yields of beans over three years were higher in the treatments with mulch of *E. fusca* (2007 kg/ha) and *I. edulis* (1963 kg/ha; $p<0.05$). The control produced 1337 and the alleys around 1000 kg/ha. A similar result was obtained for corn production.

Analysis Of The Initial Effect Of A Liberation Treatment On Existing Tree Regeneration In A Previously Exploited Humid Tropical Forest, Rio San Juan, Nicaragua.

The trial was installed in 1991 in an area of 15 ha. In 1992, a silvicultural treatment, whose purpose was to liberate commercially desirable trees, was applied. The effect of the liberation treatment was measured by comparing the diameter growth and changes in basal area of trees of the same species, grouped by diameter class and ecological classification, that were either liberated or untreated. Changes in populations of seedlings (dbh<5cm and height >1.5m) and saplings (5.0-9.9 dbh) were also compared *via* the use of periodic inventories based on smaller plots.

Pentaclethra macroloba (Mimosaceae), a partially shade tolerant species, and Carapa guianensis (Meliaceae), a commercially important species, dominated the adult tree population as well as the smaller regeneration.

Canopy illumination increased after the application of the liberation treatment, but had no significant effect upon the diameter growth of the commercial species. Changes in tree growth, one year after treatment application, were imperceptible.

Average diameter growth of commercial species in the control treatment during three years ranged from 0.20 to 0.85 cm y^{-1}; Tetragastris panamensis had the highest growth rate (0.67 cm y^{-1}), followed by Virola koschnyi, both partially shade tolerant species. In the liberation treatment, trees in the 30 to 39.9 cm dbh diameter class grew quickest (0.60 cm y^{-1}).

In the liberation treatment, saplings of the most abundant species, Carapa guianensis and Virola koschnyi, accounted for 68% (44 individuals ha^{-1}) of the total population of saplings of commercial species. In 1992, before liberation, there were 947 seedlings ha^{-1}; in 1993, there were 1273 seedlings ha^{-1}, an increase of 36%. In the control treatment, the same species accounted for 52% (25 individuals ha^{-1}) of the total sapling population; they also dominated the seedling population.

Changes in illumination of the seedling population in the liberation treatment occurred. Forty-two percent of the seedlings in the liberation treatment were well illuminated compared to 26% of the seedlings in the control. This effect was not observed in the sapling size class.

Agrisilvipastoral Project

Introduction

The Agrisilvipastoral project is funded by the International Development Research Center (IDRC). The Center has supported CATIE in agroforestry and silvipastoral research in the Atlantic zone of Costa Rica since 1985 and the project is currently undergoing its third and final phase. This final phase will end in July 1995. Relevant results have been obtained in the identification of species of nitrogen-fixing trees, grasses and legume that can be used by small producers to promote higher farm productivity while contributing to the environment.

Agroforestry techniques have proven to be promising alternatives for the appropriate use of natural resources in the humid zones of Costa Rica. The objective of this phase is to validate at the farm level agroforestry alternatives generated by the project's previous phases that will increase, in a sustainable manner, the productivity and income of small and medium-size farms, while contributing to the maintenance of the natural resource base. The working ecozone is the area of Guápiles and Río Frío in the province of Limón in the Atlantic zone of Costa Rica.

The main activities of the project are:

- To validate increases in milk production and weight gains from the establishment and feeding of legume protein banks in Guápiles and Río Frío
- To validate the dynamics of improved grasses and legume established in farms in Río Frío
- Analysis of milk production costs and incomes in farms in Río Frío
- Building a simulation model using linear programming for agricultural farms in the Atlantic zone of Costa Rica
- Analysis of alternatives (animal production, agricultural crops, forestry) for small and medium-size farms in the Atlantic zone of Costa Rica

Activities And Results

Milk production costs and incomes from small farms in the humid tropics of Costa Rica.

The objective of this study was to monitor dairy activity during 1994. To execute this study, a detailed follow-up of three dairy producers was carried out in the Río Frío area. Average farm size was 12 ha, of which 37% was planted with improved pastures. Average herd size was 26 cows of which 17.8 cows were always in milking. Daily total milk production was 107 kg which gives an average of 6.02 kg milk/day per milking cow, suggesting that these production systems are based on pastures with very little use of concentrates.

The cost per kg of milk (including family labor) was US$ 0.287/kg, which is very high and is above the international milk price, currently at about US$ 0.20/kg. The average milk price received during 1994 was US$ 0.293/kg. Thus, the net margin these producers received was a mere 1.8% (0.293/0.287), which is extremely low if we consider that depreciation costs of equipment and infrastructure were not included. The net income was about US$ 100/month, excluding family labor costs. Thus, average gross income per family was about US$594/month. This income is on average about 20.3% greater than what the average family could make working in nearby banana plantations.

Thus, for producers to be at an equilibrium point between continuing dairying or abandoning this activity, milk price would have to be reduced to US$ 0.262/kg, or labor cost increased. The first option is unlikely to happen in the next few years because Costa Rica negotiated a 111% tariff protection with GATT. However, labor costs have been increasing 4% per year in real terms during the last 23 years. Under the scenario that labor cost continues to increase 4% a year in the future, and assuming milk price

stays constant at US$ 0.29/kg, these producers would continue dairying for only about 6 additional years before abandoning this activity. This situation has already occurred in Río Frío. In 1992 the project collaborated with five milk producers. Since then, three producers have dropped dairy activities and are currently working in banana plantations. Farms have remained under their ownership, rented out or maintaining beef herds, which require less labor.

Validation of grass and legume mixtures on small dairy farms in Río Frío, Costa Rica.

Results from this validation show that the species *Brachiaria brizantha* has not persisted after 2.5 years of evaluation. Lack of persistency was associated with infestation from *Fusarium* fungus, which resulted in high plant mortality. However, the legume *Arachis pintoi* persisted even under high stocking rates of 3 AU/ha. A continued search should be made for another grass species which is tolerant to soils with drainage problems.

Use of *Erythrina berteroana* (poró) as a protein supplement for milking cows under grazing in the Rio Frio region of Costa Rica.

Dairy cows grazing degraded *Brachiaria* pastures produced an average of 7.7 kg/cow/day when animals were supplemented with *Erythrina* foliage; similar to the level of production obtained by supplementation with concentrate (8.3 kg/cow/day). A study to determine the economic benefits of feeding legume foliage is recommended since labor cost in the region is very high.

Establishment of improved pasture species in association with corn in the Atlantic zone of Costa Rica.

Results show that income generated from the sale of associated corn are equivalent to about 40% of the total establishment cost of the improved pastures (*B. brizantha x A. pintoi*). This management practice represents a viable alternative for the establishment of new pasture species because it significantly reduces the cost, thus facilitating the adoption of technology on small and medium farms where capital is severely limited.

Selection of forage species tolerant to shade in the Atlantic zone of Costa Rica.

First-year results from five species show that *Panicum maximum*, *B. brizantha* and *A. pintoi* were tolerant to shade (50%). Production of dry matter (DM) of these three species under 50% shade ranged from 1,000 to 3,000 kg/ha, which represents between 50% and 75% of DM production under no-shade conditions. The species *Axonopus compressus* and *Cynodon nlemfuensis* were not shade-tolerant. Based on these results, it is recommended that *P. maximum*, *B. brizantha* and *A. pintoi* can be successfully integrated in silvipastoral systems.

The effect of *E. berteroana* protein bank and/or banana supplementation on live weight (LW) gains of animals under grazing.

Results obtained from a 2.5 year grazing trial showed that mean daily live weight gains were 0.48 kg with only pasture, 0.634 kg with pasture+banana, 0.54 kg for pasture+*E. berteroana*, and 0.58 kg for the pasture+banana+*E.berteroana* treatment. The depression in LW gains with the addition of *E. berteroana* in the banana treatment is not clear and it needs to be investigated especially with respect to the possible effect of secondary *E. berteroana* compounds on animal performance. However, it is important to note that LW gains on pasture alone were improved with the addition of *E. berteroana* foliage which can be produced economically in almost all cattle farms in this zone.

The Atlantic Zone Program (CATIE/AUW/MAG)

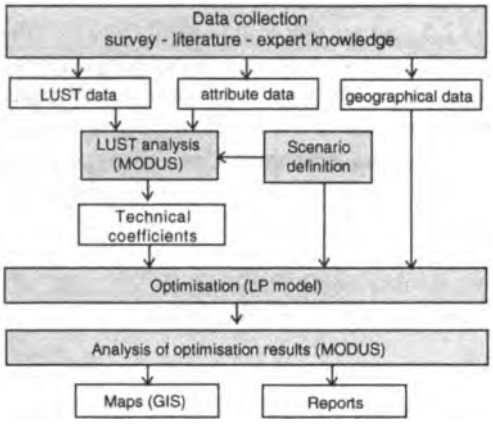
Agricultural policies and economic incentives, designed to influence land use decisions of individual producers, are important tools to achieve a more sustainable use of natural resources. However, appropriate tools for *ex-ante* assessment of effects of policies on agricultural land use are lacking in many developing countries, including those of Central America. Policy makers need to be able to evaluate alternative land use policy options from various perspectives, requiring analytical methods which take simultaneous account of socio-economic, edaphic and agronomic factors.

The Atlantic Zone Program (AZP), which is a cooperation between CATIE, Wageningen Agricultural University (WAU, The Netherlands), and the Costa Rican Ministry of Agriculture and Livestock (MAG), has long been aware of the need for a multidisciplinary methodology which can assist policy makers in evaluating alternative land use options while allowing for improved analysis of the aggregate effects of alternative policies at the (sub) regional or national level. Policy makers need information about the trade-off between income and sustainability-related goals. Consequently, the AZP is spending major efforts on the continuous development and refinement of such a methodology.

The AZP has signed memoranda of understanding with numerous other organizations in Costa Rica, including CORBANA (National Banana Corporation), DGEC (General Directorate for Statistics and Census), FAO (Food and Agricultural Organization of the United Nations), IGN (National Geographic Institute), and MIRENEM (Ministry of Natural Resources), among others. AZP maintains active working relationships with both the UCR (University of Costa Rica) and the UNA (National University).

The methodology for land use evaluation developed by the AZP, denominated *USTED* (*Uso Sostenible de Tierras En el Desarrollo*; Sustainable Land Use in Development), is based on a modular approach to the integration of different models and data bases. While integrating various techniques (Figure 14.), *USTED* is centered around a linear programming (LP) model which maximizes farm income subject to various resource and sustainability related constraints. The latter are flexible allowing the methodology to be used for assessing trade-off between income and sustainability objectives. The methodology also includes a Geographical Information System (GIS) which is used to store geo-referenced data and to visualize land use options through the generation of maps.

Figure 14. Structure of the USTED methodology.



By grouping individual farms into a number of farm types which are separately dealt with in the LP model, it is explicitly recognized that ultimate decisions regarding land use are made at the farm level. Farm types are obtained on the basis of size and soil distribution. Different options for land use are defined as combinations of soil groups and land use types with fixed input-output technologies.

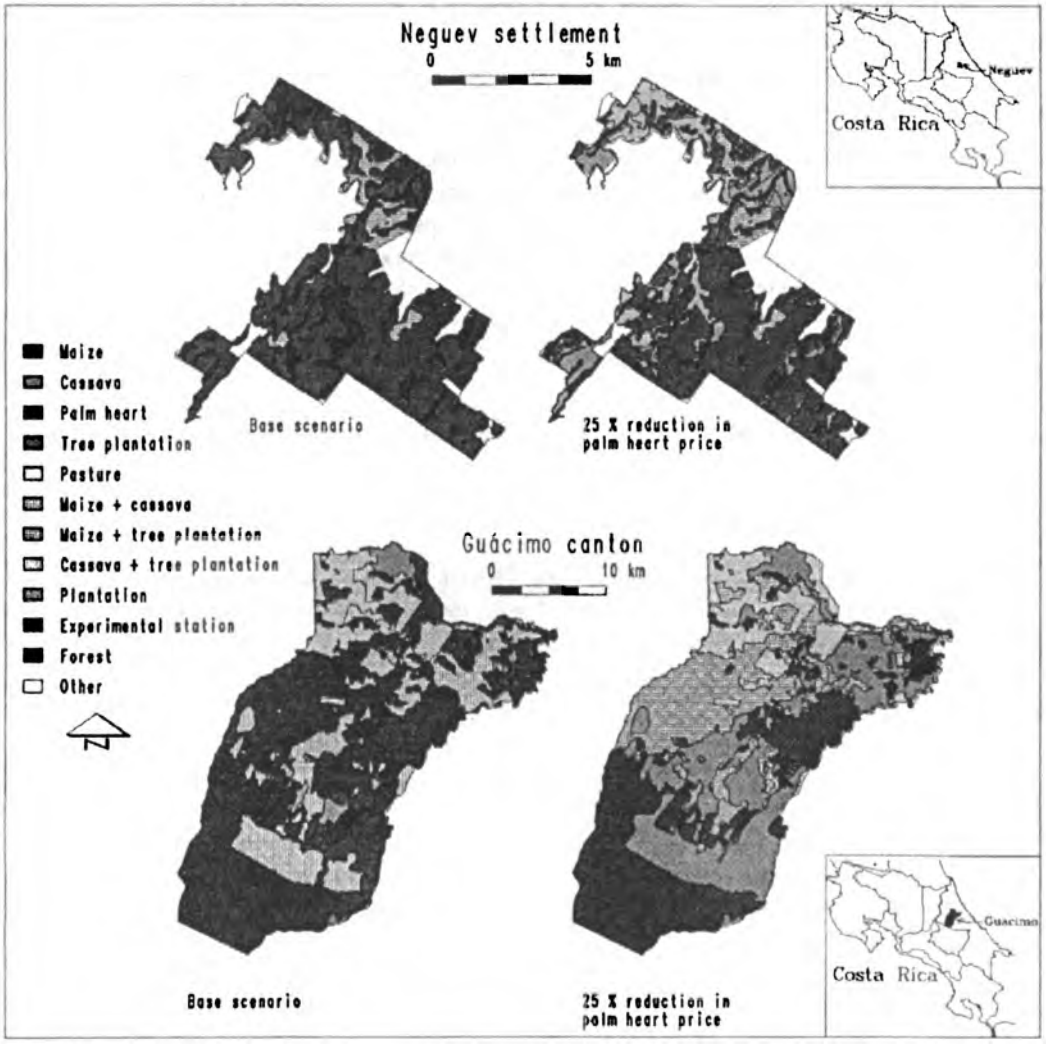
The concept of sustainability forms an integral part of the methodology and is measured through a limited number of indicators, including depletion of the soil nutrient stock and a biocide environmental impact index. Policy interventions are translated into changes in the socio-economic environment and/or resource endowments, or adjustments in sustainability requirements.

Work during 1994 has focused on the operationalization of the *USTED* methodology. After several years of data collection and organization, the methodology was made operational for *asentamiento Neguev*, a settlement of the IDA (Agricultural Development Institute) of about 5,500 ha in the Atlantic Zone of Costa Rica. Further research efforts were spent on up scaling the model towards higher levels of aggregation (canton level). Figure 15 illustrates how GIS is used to visualize some of the model outcomes for the *Neguev* settlement and *Guácimo* canton in the Atlantic Zone of Costa Rica.

Current work also focuses on the up scaling of the methodology towards the regional level and on a low-input data validation for Guanacaste, a much drier region of Costa Rica. Moreover, continuous efforts are being spent on improving the sustainability-related factors in the model, through incorporation of the effects over time of decreasing soil fertility on yields as well as the real costs associated with the use of biocides in terms of environmental degradation and human health damage.

Numerous demonstrations were conducted to familiarize various interested organizations in Costa Rica with the methodology. A number of papers were presented in both national and international conferences.

Figure 15. **Alternative land use scenarios for the Neguev settlement and Guácimo canton**



Project On Sustainable Silvipastoral Systems For Small Producers In The Central American Dry Tropics

Introduction

The Project "Sustainable Silvipastoral Systems for Small Producers in the Central American Dry Tropics," funded by the Canadian Agency for International Development (ACDI), began activities in September 1989 and ended in June 1994. The Project's main objective was to improve production and income of Central American small producers on sloping lands, in areas where a marked dry season occurs.

Work was conducted with farmers who manage cattle as one component of their production systems. Hence, agrisilvicultural systems were emphasized. The main goal was technology validation with an integral approach, which can be considered as an activity between research and extension, in several subsystems that were present on the farms: e.g. livestock, crops, agroforestry and the household. Another Project goal was to transfer the methodologies used, and the systems approach, to institutions and counterpart staff in the Project member countries.

Activities and Results

a. Definition and review of working methodologies suitable for each activity.

The integral approach: an integral approach was established taking into consideration the existence and interaction of the different subsystems on the farms.

The technology validation approach: the Project produced several documents defining and detailing technology validation models. These models have been adopted and are now being implemented in Central America.

b. Technology validation.

Activities were carried out in the following subsystems:

- Household: firewood-saving stove, home gardens and the use of composts, food preservation, management and health care of farmyard species, water sources and purification for human consumption, and community nurseries.
- Crops: soil/water conservation using contour planting and living/dead barriers, varieties adapted to the region and local seed production.
- Livestock: Herd management (management of calves, pasture management, animal reproduction and health care) and feeding during the dry season (silage, drying ovens, stubble management, improved pastures and fodder from multipurpose trees).
- Agroforestry: living fences and windbreaks, protein banks, multiple-purpose tree stand management, fruit trees in home gardens, taungya and silvipastoral systems.

c. Establishment of demonstration farms for professional personnel, researchers and producers to evaluate *a posteriori* adoption and impact of these technologies on production systems.

d. Technology transfer: in Guatemala, DIGEBESA (Dirección General de Servicios Agrícolas) included as part of its operation plan for 1994 the establishment of firewood-saving stoves, home gardens, food preservation, and nurseries; DIGESEPE (Dirección General de Servicios Pecuarios) included improved pastures, drying ovens (for fodder), stubble management, crop improvement and minor species. Institutions from El Salvador, Honduras and Nicaragua, involved in technology transfer, have also included improved technologies generated by the Project.

e. Dissemination of results and methodologies: 161 events for 5752 participants were carried out. During 1994, the Project efforts were devoted to document its experience and the results it obtained. Printing of 1000-2000 copies of each principal publication (a total of 11) will allow a widespread dissemination.

f. Training: 334 training events were carried out (9696 days/training).

g. Education: Five graduate thesis were supervised by the Project (four of them were carried out in CATIE) and nine students from Guatemala, Honduras and El Salvador obtained their first degree working with the Project. A series of field training events, especially in Guatemala were held in collaboration with the Universidad de San Carlos.

h. Studies: A series of studies were conducted as part of the technology transfer model in order to characterize the producers and to evaluate technology impact. The main studies included: characterization of the regions and the producers; human nutrition; studies of the role of women; cattle; and climactic conditions and crops.

INTEGRATED MANAGEMENT OF NATURAL RESOURCES PROGRAM (MIREN)

The Integrated Management of Natural Resources (MIREN) Program is faced with the challenge of finding ways to protect the environment while, at the same time, finding ways to provide food and resources for the ever growing human population of Central America.

The general objective of MIREN is:

> To generate, validate and promote appropriate technologies for natural resource management, conservation and sustainable use, with the social sectors that are involved.

In 1994 MIREN implemented program plans and activities in CATIE member countries in the areas of: tropical forestry (both tree planting and management of natural forests) watershed management, and biodiversity management and conservation
This included technical assistance, demonstrative projects, institutional strengthening, workshops and conferences, scholarships and teaching of graduate students and USAID mission buy-ins.

Program Areas and Work Lines

The multi-disciplinary nature of natural resource issues is accounted for by the structure of the MIREN. The program comprises the following four areas:

- Watershed Management
- Tropical Forest Management and Silviculture
- Biodiversity Management and Conservation
- Economics of Production and Conservation

Each of these program areas are discussed in greater detail below.

Watershed Management Area

In 1994 the Watershed Management Area continued to work with both appropriate technologies and socio-cultural issues in order to rehabilitate and/or conserve degraded hillsides throughout Central America that are occupied primarily by small farmers. This involved demonstrative projects, research, and training programs including:

- Implementation of demonstrative watershed rehabilitation projects in several member countries with special emphasis on hillside agriculture.
- Use of the Geographic Information System (GIS) laboratory for applied projects, research, and teaching.

- Technical assistance related to GIS technologies, extension activities, land use planning, soil conservation programs, economic evaluations, and hydrological modeling.

- Training in the form of graduate courses and thesis research, short courses and workshops (both on and off site), and through participation in regional conferences.

Biodiversity Management and Conservation

In 1994 this area continued to work to improve the protection and management of biodiversity in the region. Due to the complex interactions associated with biodiversity issues, a wide range of activities were undertaken including: the management of protected areas, buffer zone planning, socioeconomic studies, and environmental education. More specifically, this included:

- Research and the establishment of demonstrative projects to increase the understanding of interactions between local communities and protected areas.

- Policy analysis of ways to increase local community involvement in the management of protected areas.

- Identification, management, and economic analysis of non-traditional forest species

- Training and public outreach programs designed to improve the availability of information on biodiversity management. This included graduate teaching and thesis research, short courses, seminars and the publication of technical bulletins.

Economics of Production and Conservation

In 1994 the Area of Economics and Production was established. Relevant research lines were identified and justified, and a graduate program (curriculum) for the area was designed and approved by the CATIE Graduate School.

Funding

A large proportion of the MIREN budget is for project area funding. Of the $6.76 million program budget 4.8% is from direct core budget. The program budget is shown in table 20.

Table 20. Expenditure For Integrated Natural Resources Management Program 1994 (US $)

Area	Total Expenditure (US$ millions)	Core Budget (US$ millions)	(%)	Projects (US$ millions)	(%)
Program Direction	0.15	0.15	(100)	...	...
Production and Conservation Economics	0.04	0,04	(100)	...	...
Biodiversity Management and Conservation	2.09	0.03	(2)	2,06	(98)
Watershed Management	0.92	...	...	0.92	(100)
Tropical Forest Management and Silviculture	3.56	0,08	(2)	3.47	(98)
Total	6.76	0.31	(4.8)	6.45	(95.2)

Source: Financial Report December 31, 1994

Program achievements

In 1994, MIREN made significant achievements related to each Program's objectives, including:

- Establishment of a new orientation towards sustainable natural resource management strategies.
- Integrating local communities in the process of the sustainable management of natural resources.
- Training and outreach programs to meet regional demands.
- Applied research activities tailored to the needs and problems of member countries, and their populations.
- Implementation of demonstrative natural resource management projects throughout the region.

In compliance with the strategic plan of the center, the program anticipates the continuation of its role in the promotion and application of environmentally friendly technologies. In so doing it will overcome the adverse environmental impact of many current land use practices in agricultural and forested areas as well as contribute to the preservation of the resource base.

TROPICAL FOREST MANAGEMENT AND SILVICULTURE AREA

In 1994 this area continued to meet the growing demand in the region for technical expertise related to the sustainable management of tropical forests through the following activities:

- Establishment of demonstration sites in primary and secondary natural forests at strategic locations for training and technology transfer.

- Interaction with national programs in the areas of forestry management, policy, and planning.
- Monitoring and evaluation of regional forestry trials to facilitate selection of high performance genotypes and determine their best silvicultural techniques.
- Creation of technical guides for the management of 20 outstanding forestry species.
- Training and outreach activities in the form of information exchanges, graduate courses and thesis research, short courses and workshops and through participation in regional conferences.

Natural Forest Management

The four CATIE projects which deal with management of natural forests have expanded their area of activity substantially in 1994. Collectively these projects assist 25 different land ownership groups (communities, companies or private) in the management of 20,000 ha of secondary and primary natural forests.

The main emphasis in these projects is to demonstrate that it is possible, in many natural forests, to extract economically attractive amounts of commercially important timber species while at the same time causing a minimal impact to the residual stand. By skillfully manipulating secondary forests and the residual vegetation using very low-cost liberation techniques, it has been found, through experimentation, that the more commercially viable species can be induced to grow at 2 to 3 times the rate that they grow at when such silvicultural practices are not used.

By providing natural forest owners with this viable alternative, it is expected that many owners of natural forest will become convinced to manage their forests in a way which permits sustainable economic returns while at the same time conserving most of the biomass and essentially all of the biodiversity in each forest. There is a very intensive training component linked with these projects, the expectation being that, with time, land owners will become progressively more self-reliant in managing their forests.

Linked with these objectives, the natural forest management projects have also been involved with getting some forest policies adopted at the national level which will make the management of natural forests, as described above, easier to embark on both legally and financially. A special effort has been placed on simplifying the management plans which must later be approved by governmental forest services. Another effort, which has recently paid off in Guatemala, has focused on getting leases on natural forest lands authorized for communities which live in or adjacent to such forest. These leases state that communities can use these lands as long as they do so in a sustainable way; production activities, such as the low impact sustainable forest management, described above, are permissible, but other land uses (shifting agriculture etc.) are not. This practice of responsible stewardship is enabling effective buffer zones to be set up around protected areas.

Plantation Silviculture

The Madeleña Project completed its 14th consecutive year. The big highlight of this project has been the impact of the extension network which has helped enable the number of small farmers planting trees in Central America to expand from 40,000 to 100,000 over the past year. The extension network is coordinated by the Madeleña Project and involves the training and participation of over 700 extensionists which are financially supported by the national forest services, national projects and non-governmental organizations. These extensionists are trained (largely by the extension network) in aspects of forestry and extension which will be useful in guiding small farmers to take up tree growing on underutilized portions of their farms. They then transmit this information to farmers.

The research component, which has been active since the initial years of the Madeleña project (1980), provides a good source of technical backstopping.

Another CATIE project which contributes to the success of tree planting in Central America is the Tree Improvement Project which is, through a series of more than 100 on-farm trials, improving the genetic quality of 15 of the 25 species most commonly planted in Central America. Genetically improved seed is now available of , *Alnus acuminata, Cordia alliodora, Cupressus lusitanica and Eucalyptus deglupta.*

Another, allied project is the Tree Seed Project which focuses on getting small farmers to convert some of their better stands to seed production. The demand for seed is great in Central America (over 80 tons of seed, from a gamut of species, were used in 1994) and by promoting and coordinating seed production, the Tree Seed project is helping to meet this demand in a way which will ensure an adequate supply of seed, of adequate genetic and phytosanitary quality, on time and in a sustainable manner.

Principal staff from each of the 6 above-mentioned forestry projects contribute to the teaching and supervision of thesis research of students in CATIE's, graduate school.

Finally, the journal "Revista Forestal Centroamericana", provides an attractive forum for sharing newsworthy forestry articles on both the technical and policy fronts. Four thousand copies are published trimonthly; during 1994 subscriptions expanded from 443 to 956.

During 1994 the Area operated exclusively with funds coming mainly from external cooperation. USAID through RENARM/PBN Project and COSUDE (Suisse Development Cooperation) contributed to the Natural Forest Unit; ODA (U.K.) in the genetic improvement; DANIDA (Denmark) on the tree seed management and again USAID through RENARM/Madeleña; and FINNIDA (Finland) to the management of plantations. CATIE financed the coordinator position for this area.

Table 21 . shows the list of active projects during 1994 in the Area.

Table 21. Active projects during 1994 in the Area of Tropical Forest Management and Silviculture

PROJECT	US$(THOUSANDS)	SOURCE OF FUNDING
Dissemination of Multiple Use Trees	1,047.9	USAID/RENARM (U.S.A)
Forestry and Agroforestry Res. and Train.	235.2	FINNIDA/PROCAFOR Y (Finland)
Natural Forest Management	963.1	USAID/RENARM (U.S.A.)
Natural Forest Management	530.0	COSUDE (Switzerland)
PROSEFOR (Forestry Seeds)	748.0	DANIDA (Denmark)
Tree Improvement	100.3	ODA (United Kingdom)
TOTAL	3,624.5	

Dissemination Of Multiple Use Trees (RENARM/USAID-G-CAP), Forestry And Agroforestry Research And Training (FINNIDA), Madeleña-3.

Extension

The Madeleña-3 Forestry Extension Network for Central America worked smoothly in 1994. The network now involves 31 organizations including the forest services (or their equivalents) in all six countries and 25 non government organizations. As compared with 1993, the number of extensionists promoting tree planting more than doubled (now at 650). In 1994, the Madeleña Project gave more than 5000 man/women days of training to bring these extensionists up to speed on the best silvicultural techniques and extension methods. The number of farmers directly attended by these extensionists, and recorded in the projects' data base, tripled in 1994 (now at 20,000) and, given a conservative estimate that 5 neighboring farmers are also planting trees (the Jones factor), it is estimated that there are now about 100,000 farmers planting trees in Central America (up 60,000 since 1993).

Although 1994 has been an extremely productive year for the extension network, it should be underlined that service cannot keep up with the demand. For example, there are 81 additional institutions which have expressed a strong interest in becoming members of the network. Unfortunately it has been impossible to respond to this larger demand in much more than a superficial way due to the limited amount of funds (total of 1,8 million dollars per year) available to the project for extension and research.

At this juncture, it is essential to recognize the tremendous role that the 31 participating network organizations play. It is their staff, and especially their extensionists, who are actually stimulating and guiding farmers in their tree planting activities. Madeleña is merely a major catalyst, trainer-technical backstopper in the process. A more complete summary of extension activities of the Madeleña-3 Project is given in the report of Training Area of EDECO Program of this annual report.

Research

Extension has, in fact, become about 80% of the activities which are performed in the Madeleña Project. However, this has not always been the case. Until recently, Madeleña was mainly focused on setting up trials and permanent sample plots to try to determine which were the best silvicultural options over the deforested areas of the isthmus. Today very few new experiments are being laid out by the project, but 80 of the earlier experiments and several thousand of the permanent sample plots, are still being measured, assessed and analyzed. The results of these, and other experiments, are a major source of information for the huge role that the Madeleña Project provides in terms of technical backstopping for silviculture and agroforestry in the region.

Towards ensuring that the results of these experiments, and other pertinent silvicultural experiences, are placed at the disposition of extensionists, a major effort of the Madeleña Project is directed towards the writing of easily digestible guides for the extensionists (these are often used as training materials in the aforementioned training courses).

A summary of the most salient of these is given on the following pages.

- **Responding to new demands for tree cropping advice and inducing political change: the Madeleña-3 experience in Central America.**

The history of the Madeleña-3 Project is traced from its beginning in 1980. Special emphasis is given to an explanation and evaluation of the forestry extension network (as summarized in the text of this annual report). The general conclusion was that the extension effort is having a tremendous impact on training and supporting a good cadre of extensionists in appropriate technical and forest extension methods and that these extensionists in turn were getting a very large number of small farmers to plant trees successfully.

- **Dieback of *Terminalia ivorensis* in San Carlos.**

Terminalia ivorensis is native to West Africa but is one of the fastest growing timber species for much of the eastern lowlands of Central America. Unfortunately, it has recently developed a reputation for dying back when it gets up to six years of age and beyond. A sampling of soil pits and topographic positions of areas where, *T. ivorensis* was and was not dying back in the rainy area of San Carlos (4000 mm per annum) suggested that where trees were growing on sites with poor internal soil drainage, the lower part of the root system became necrotic from anaerobic soil conditions and this caused the trees to develop the debark condition. No parasitic fungi or insects were found at the time of this survey.

- ***Eucalyptus grandis*: a multiple use species in Central America.**

Throughout the tropics, where rainfall varies from 1000 to 2000 mm per annum, *Eucalyptus grandis* has often proved to be one of the fastest growing (and often the very fastest) tree species available. In Central America it has been widely tested by Madeleña in over 30 experiments. Records of its growth have also been collected from several hundred permanent sample plots.

In this silvicultural guide all relevant information known to date pertaining to how to best grow this species (seed source selection, nursery production, site selection, site preparation, fertilization, weed control, site indexing growth and yield information, management, harvesting and uses) has been highly distilled and presented in a format which can be easily understood by extensionists.

- **Laurel, *Cordia alliodora* , a multiple use species in Central America.**

Cordia alliodora is a species native to many parts of Central and South America. Is has moderately fast growth on many sites in moister parts of Central America in areas from sea level to over 1000 meters. It produces copious amounts of seed of which many germinate and survive making it one of Central America's most common naturally-regenerated species. It also produces an attractive brown and yellow wood which has excellent wood working qualities making it a favorite of carpenters. Because of its growth characteristics, and good market for the lumber, farmers commonly leave naturally regenerated laurel in their fields. The species can also be propagated from seed.

In this silvicultural guide, all relevant information known to date pertaining to how best to grow and manage both planted and naturally-regenerated *Cordia alliodora* has been highly distilled and presented in a format that can be easily understood by extensionists.

- ***Eucalyptus deglupta*, a multiple use species for Central America.**

Eucalyptus deglupta is a truly tropical eucalyptus being native to a series of islands stretching from Papua New Guinea in the south to Mindanao (The Philippines) in the north. It is a very fast growing species and has been tested by the Madeleña project on a large number of sites in Central America where it has shown excellent growth rates and form in those areas between 300 to 900 masl and having more than 2000 mm of well distributed annual rainfall. The species produces a pinkish moderate density wood which behaves well during milling and drying (especially for a eucalyptus).

Although this has been a most popular tree for planting in many parts of Central America, it also has some problems (susceptible to in areas with long summer dry season, poor growth when there is heavy grass competition, susceptibility to leaf cutter ants and mites (which cause leaf defoliation) and butt rot).

In this silvicultural guide, all relevant information known to date pertaining to how to best grow *Eucalyptus deglupta*, and avoid the aforementioned problems, has been highly distilled and presented in a format that can be easily understood by extensionists.

- **An improved users guide for MIRASE. Internal Report.**

MIRASE is a date base that the Madeleña Project employs to help determine how profitable tree planting is for those small farmers who plant trees. Basically it is a computerized accounting system which keeps track of tree planting costs and returns from harvests for a sample of about 700 farmers.

This paper, reviews the way in which MIRASE was being used. Some attempts were made to analyze subsets of existing data. On the basis of this exercise, recommendations were made for how to improve data collection in the field and how to record these data in the computer so that more insightful results could be obtained. A new users guide was written incorporating these changes.

- **Live fences from *Gliricidia sepium*: a promising agroforestry technique for the dry Pacific zone of Nicaragua.**

Over the past years the Madeleña Project has found that the use of *Gliricidia sepium*, as live fence posts, is a particularly popular tree-planting practice in Nicaragua. To date, several hundred kilometers of live fences have been established. In principle, the practice is not too complicated; two-meter long sprouts are cut off of existing trees or stumps and are planted in a line of holes which correspond to where the farmer would like to have new fence posts.

However, there is also a considerable amount of art required in getting these new fence posts to survive and there are better techniques for managing these "posts" once they get established. This book, written for extensionists, covers these aspects in detail.

- **Establishment and management of shade trees over cacao.**

Some amount of shade is useful in cacao plantations. If the amount of shade is right, the cacao trees in the understory of these trees will bear good levels of cocoa pods, will have a minimum of flower and pod diseases, and at the same time, will be protected from excessive insulation which could shorten their productive longevity. Since these shade trees can, if the right species are used, also provide large amounts of valuable timber, there can also be some substantial long term (20-25 year) economic benefits of using shade trees. This book draws on many years of experience to show what the best options are for getting the best returns from this agroforestry system. This publication contains an exceptionally large number of color plates and line drawings which help illustrate optimal techniques for every stage in the establishment and management of the cacao-shade tree agroforestry system.

- **Yield and site quality for *Gmelina arborea, Tectona grandis, Bombacopsis quinata* and *Pinus caribaea* in Guanacaste, Costa Rica.**

Guanacaste receives a fairly high annual rainfall (2000 + mm), but it is also characterized by a long dry season (5-7 months) and, in places by superficial soils. The first three, of the four species mentioned in the title, are those which are most commonly planted in the region. In some locations growth of these species is outstanding but on many others sites it is not. This study had the objective of determining how 20 environmental factors influenced the growth of these species. Multiple regression techniques were used. Species response varied, but generally topographic position, exposure to wind, shallow soils and low available Ca and Mg contents of soils were always among the factors which augured poorly for the growth of these species.

Tree Seed Project (PROSEFOR)

The Tree Seed Project began work in October, 1992 as part of the support given during the last years by CATIE to the Central American countries and the Dominican Republic in the field of silviculture. An adequate supply of genetic quality seed is a necessary basis for forestry development in the member countries.

These countries have shown a clear interest in reforestation and have already identified the species that can be planted in a wide range of site conditions, to satisfy some of the needs for forest products of the increasing population. One of the main problems facing reforestation is the scarcity of seed which has a high genetic and physiological quality.

PROSEFOR is funded by the Danish Ministry of Foreign Affairs through its International Assistance (DANIDA). The budget for 1994 was $748000.00 of which $627002 (84%) has already been spent.

Work Lines

* Strengthen CATIE Tree Seed Bank to provide better support for training on seed management and contribute to forest progress through seed research.

* Strengthen activities in the member countries in terms of:

- Identification, selection and technical management of seed sources to meet the demand, using genetically improved material and developing a national register of seed sources.

- Training seed bank technical personnel and seed producers in production, collection and management of forest seeds.

- Strengthen national seed banks to improve seed collection, management, storage and distribution.

- Disseminate technical information on seed production and management for local forest staff and seed producers.

PROSEFOR Highlights

The BLSF (Banco Latinoamericano de Semillas Forestales) Building was completed. It now has the infrastructure and necessary equipment to provide training and research support on seed collection, management, storage and distribution. Bank personnel have been properly trained. Training of graduate students has already been started.

300 technicians were trained trough PROSEFOR's training activities; this allowed the selection of 189 seed sources in the seven member countries, 59 of them are already under management and genet-

ically improved tree seed is being supplied. With PROSEFOR support, a Seed Sources Certification System was established in Costa Rica where 10 sources of *Gmelina arborea* have already been registered by the National Seed Office (ONS).

Table 22. Seed stands identified and selected per country.

Country	Identified	Selected	Managed	Species
Guatemala	98	41	1	23
Honduras	16	—	11	27
El Salvador	36	2	7	16
Nicaragua	295	—	—	73
Costa Rica	—	52	30	17
Panama	—	6	6	5
Dominican Republic	9	6	4	3
Total	454	189	59	—

PROSEFOR started the evaluation of seed banks in the member countries and training of personnel to improve their register and operative systems. Preparation and distribution of seed catalogues by the seed banks was also accomplished. Seed banks in the Dominican Republic and El Salvador were also given support in terms of infrastructure.

Two issues of the "Genetic Improvement and Tree Seeds" bulletin were published and are being distributed to 2,000 subscribers.

The Proceedings of one regional and seven local courses on "Selection and Management of Seed Sources" and other documents were also published.

During 1994 the BLSF harvested 213.31 kg. of tree seeds from 15 different species in Costa Rica. Also the BLSF sold 181.2 kg. of seeds from 41 different species. Seeds were sold in reply to 137 requests from 17 different countries.

Tree Improvement Project

The Tree Improvement Project (TIP), funded by the British Overseas Development Administration (ODA), is part of CATIE's Forest Genetic Resources Unit, one of the constituent technical units of the Tropical Forests Management and Silviculture Area. The activities of the Project fall into three main categories: development of clonal silviculture appropriate for small and medium farmers; identification and development of improved forest germplasm; dissemination, demonstration and education in the techniques and germplasm developed and in forest genetics in general. During 1994 the project made important advances in all of these areas.

Technical achievements

The advent of clonal silviculture has been one of the most important developments in forestry in recent decades. Since 1990, the TIP has been working to make benefits of this technology, to date utilized principally by large companies, available to small holder farmers. During 1994, the TIP began the process of applying the pioneering methods of appropriate technology vegetative propagation developed in previous years (see annual reports for 1993 and 1994) to small holder tree improvement. A network of 11 on-farm clonal trials of *Cordia alliodora* and *Gmelina arborea* was established. These experiments, which are located in a wide range of sites in the Atlantic, northern and dry Pacific zones of Costa Rica, are the first clonal trials to be planted in small holder production systems in Central America; the clonal trials of *Cordia alliodora* appear to be the first ever anywhere for this important species. On the basis of these trials, the best clones will be selected for further testing and operational planting.

In spite of the great advantages of clonal silviculture, no tree improvement program is complete without a parallel program of development and production of improved seed. During 1994, the TIP has made important advances in this field. In addition to the improved seed of *Eucalyptus deglupta* first made available in 1993, the Project now also has available improved seed of *Alnus acuminata*, *Cordia alliodora* and *Cupressus lusitanica*. This germplasm, derived from genetically-tested mother trees, is already being distributed to Central American small holders. This is the first time that seed of this grade of selection has been made available in Central America.

Since 1990, the Project, together with collaborators from the Institute of Terrestrial Ecology, Scotland, has been engaged in research directed at resolving the long-standing problem of the mahogany shoot-borer, which prevents large-scale plantations of this potentially highly-profitable species. A pioneering interdisciplinary approach, looking at both genetic resistance and pest characteristics, is beginning to yield highly promising results. In both mahogany and Spanish cedar, genetic variation in resistance to the insect has been detected through field trials. In addition, well-defined spatial (related to soil characteristics) and temporal (related to tree phenology) attack peaks have been observed. In conjunction with other control options, there now appears to be good possibilities of applying this information in the design of realistic pest management strategies.

Parallel to the production of seed from elite trees, during 1994 the project has been actively managing the breeding populations developed over the last decade. During the last year, the project executed an intensive program of rouging (genetic thinning), through which progeny tests of *Alnus acuminata*, *Gmelina arborea* y *Vochysia guatemalensis* are being converted to seedling seed orchards.

As a further result of the intensive analysis of data undertaken in support of the roguing program, the project has generated a continuous flow of forest genetic information. This has been transmitted to client groups through publications, field days and training events. In collaboration with CATIE's Forest Seed Project (PROSEFOR), the eighth and ninth numbers of the bulletin 'Tree Improvement and Forest Seed' were published. This medium of information dissemination and exchange has been published continually by the TIP since 1987. In the bulletin, project articles on genetic variation in three forest species were published, including the first ever report on genetic variation in *Vochysia guatemalensis*.

Production From Natural Forests Project (USAID/RENARM)

The "Production from Natural Forests" (PBN) Project is one of four activities which CATIE is executing under the framework of the AID-funded Regional Natural Resources Management Project (RENARM). Although the official start-up date was April, 1991, most field activities did not begin in earnest until the second quarter of 1992, when activities outside of Costa Rica were initiated.

The PBN activity continues to generate, validate and promote some of the conditions and technologies necessary for attracting the private sector, government institutions, non-government organizations, communities and individual forest-owners to adopt and apply the results of research and field demonstrations related to the practical management, conservation and sustainable use of the natural forests of Central America.

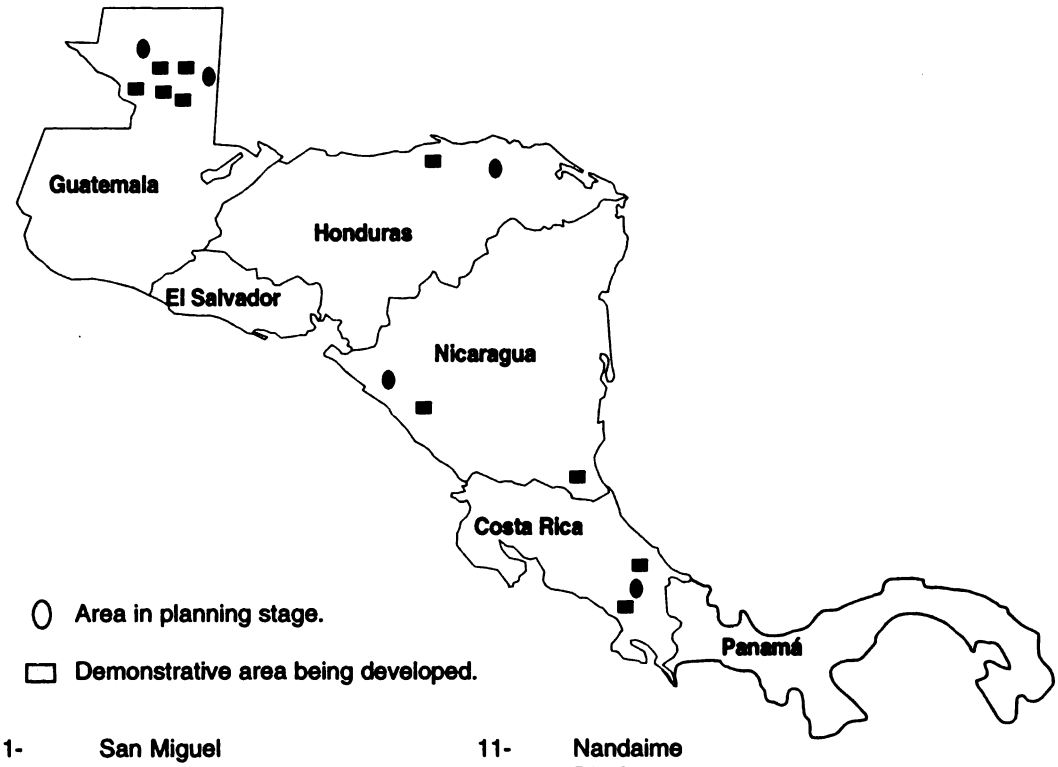
PBN's specific objectives are to:

- demonstrate that the management and silviculture of the lowland tropical forests (primary, intervened and secondary) is technically feasible, financially profitable, ecologically sustainable and socially acceptable;
- improve the technical capacity of counterpart organizations to sustainable manage the natural forest;
- generate, validate and disseminate appropriate technologies for the management and silviculture of tropical natural forests;
- contribute to the improvement of a policy framework which favors and supports the management of the natural forests in Central America.

The project is actively working in Costa Rica, Guatemala, Nicaragua and Honduras, and at the end of 1994 received the go-ahead and financial support to begin activities in Belize (Figure 16).

Project Technical Personnel includes 15 staff members (11 working out of Costa Rica, 2 assigned full-time to Guatemala and 2 assigned full-time to Nicaragua), an administrative support staff of 8, and an additional full-time crew of 10 forest worker/laborers.

Figure 16. **Production From Natural Forest Project (USAID/RENARM) location of work areas in Central America, 1994**



1- San Miguel
2- Tikal
3- San Jose
4- Arcas
5- San Francisco
6- El Porvenir
7- Arroyo Colorado
8- La Ceiba
9- El Carbon, Olancho
10- Chinandega
- El Quebrachal
- El Cacao
- Los Tablones

11- Nandaime
12- Rio San Juan
- Los Fijos
- La Lupe
13- Guapiles
- Los Laureles de Corinto
- Finca Garita
14- Florencia Sur
15- Pilar del Cajon

Work Lines

Building on CATIE's past experiences in natural forest management and silviculture, PBN has employed a strategy which incorporates three main lines of work or fields of activity, in order to achieve its objectives. These lines of work are:

A) Demonstration of Sustainable Management

B) Technology Transfer

C) Generation, Compilation and Analysis of Information Related to the Silviculture and Management of Natural Forest

Main Technical Achievements To Date:

The following is a summary of PBN's main technical achievements to date.

* The project has ongoing activities in 16 sites located among five of the countries within the region, where demonstration and applied research in activities related to forest management and silviculture are carried out with a variety of counterpart organizations. The work continues to focus on Costa Rica, Guatemala and Nicaragua.

* The project has participated in the design and supervision of more than 20 forest inventories for the purposes of reconnaissance, preparation of forest management plans and the preparation of harvesting plans. More than 23,000 ha of natural forest have been sampled for these purposes.

* Six forest management plans have been approved and are being implemented, with over 14,000 ha under management.

* A total of 93 permanent sample plots at different sites in four of the countries continue to be monitored on a regular basis. These provide valuable and scarce information on growth rates, mortality and regeneration of natural forest. In a large portion of these plots, the project has applied silvicultural treatments appropriate to the management objectives and aimed to ensure regeneration and increase the productivity of selected species without significantly altering forest biodiversity.

* Over the years, the project has developed an efficient computer program for storing, processing and analyzing the vast quantities of data being generated by the permanent sample plots. This program continues to be updated and refined and serves as a valuable tool for monitoring changes in forest composition and dynamics resulting from management and silvicultural interventions; thus helping to guide future management activities.

* During 1994, PBN organized more than 40 training and dissemination events (including 11 courses and workshops). In total, more than 680 people were involved in these events.

  An example of one of these training events was an innovative three-day course organized by

CATIE's "Natural Forest Management Unit" (of which PBN forms an integral part) directed specifically at Costa Rican journalists who cover environmental issues and who need to be aware of the role which productive activities play as part of a successful strategy for managing and conserving the country's natural resources.

* The Project has interacted and established contacts with over 60 organizations throughout the region, with the aim of promoting the project's activities, defining and implementing joint efforts, and exchanging relevant information. These organizations are varied and range from government institutions to community groups.

* PBN technical staff continued to assist CATIE's Graduate School by giving Masters-level courses in silviculture and natural forest management; advise and guide graduate students in the development and implementation of research topics; and provide financial support to four additional students who entered the Management and Silviculture of Tropical Forests Masters Program in 1994.

* The Project continues publishing several technical documents related to its activities in the region and makes occasional contributions to the "Revista Forestal Centroamericana".

One important document prepared by PBN in 1994 was "A Model for Simplifying Management Plans for the Natural Broadleaf Tropical Forests of the Region" (Printed in Spanish: Modelo de Simplificación de Planes de Manejo Para Bosques Naturales Latifoliados en la Region Centroamericana). This document considered the input from a wide range of interested parties throughout the region and was formally presented by the Tropical Forestry Action Plan's Regional Director, to the Central American Forest Council (Consejo Centroamericano de Bosques). The council members unanimously endorsed it and agreed to support follow-up activities which include the development of individual country guidelines, using the Model as a starting point, and establishing pilot management areas to validate the approach. In the case of Costa Rica, the Model was adopted immediately, with only slight modifications.

The following is a sample of some of PBN's activities and their impacts on natural forest management in the region:

Costa Rica (San Isidro de El General)

The information generated by PBN investigations since 1988 on its Research and Demonstration site near San Isidro de El General, is coming to be recognized as one of the most significant and far-reaching forestry data banks in the region. There, CATIE, under the terms of an agreement with Coopemadereros, DGF, IDA and USAID, is working in a secondary forest approximately 40 years of age.

Despite the study's short time span it is evident that the case near San Isidro de El General provides promising and positive results for sustained natural forest management. In this site, the chosen management approach has been shown to be not only technically viable, but also economically profitable, ecologically stable and socially acceptable. The benefits of integrating forestry activities within a profitable farm economy have become clear.

The forest totals 180 ha in area. In annual cutting blocks (arranged for a cutting cycle of 10-15 years) the forest is being selectively harvested for sawlogs, after which it is given a timber-stand improvement, accompanied by a "liberation" of individual trees selected for future harvest.

The "liberation" focuses on freeing promising selected trees from competition with nearby trees. The removal of competing trees from around each selected tree improves crown illumination, thus optimizing site productivity (in terms of volume). This result suggests that natural forest management can yield economic benefits over a shorter period than commonly believed. The rate of increment in basal area measured at d.b.h. increased by a factor of two, compared to the growth rate of "selectionable" trees which were not liberated.

While the data accumulated is not sufficient to permit comparisons between individual tree species of the forest, it has been noted that some of these native species demonstrate rates of diameter growth within the same order of magnitude as those of exotic species commonly used in the region's programs of reforestation.

Because the silvicultural activities are not directed against any particular species, they provoke no significant change in vegetative diversity. As shown in table 23, the presence of botanical families has not been affected by silvicultural treatment to any major extent.

Table 23. Changes in the relative stocking of botanical families as a result of silvicultural treatment, 1990-1991 (mean number of trees per hectare, 10-49 cm d.b.h.)

FAMILY	% CHANGE
Annonaceae	-3
Leguminosae	-1
Melastomaceae	-1
Myristicaceae	+2
Rosaceae	-1
Sapotaceae	+2
Vochysiaceae	-1

Income derived from the sale of sawlogs and fuelwood produced by the harvest and the liberation provided adequate funds to cover the costs involved. In short, productivity is optimized, without incurring heavy costs that require long amortization periods.

In order to conserve and protect the wildlife in the forest (with its important implications for seed dissemination and thus resource sustainability) an area has been set aside free from human intervention, thus serving as an effective refuge for animals and birds.

Guatemala (Petén)

In Guatemala, PBN has had a major impact in protecting Petén forests from destruction, by providing timely technical assistance for sustainable community forestry projects in the Maya Biosphere Reserve (MBR). Of equal importance, PBN is the vital focal point which supports a network of organizations, communities, government agencies and researchers involved in natural forest management.

PBN's impact in these two key roles have been the following:

1. Community Forestry

Due in large part to financial, technical and field support from PBN, natural forest management is now being applied as a viable land-use in the MBR. In March 1994, Guatemala approved regulations (developed with PBN support) for allocating community forest concessions on state lands within the MBR. After a long struggle, local communities have finally been granted long-term forest access rights, which include clearly defined responsibilities and rules to ensure sustainability. San Miguel la Palotada was the first community to receive a government concession, and was assisted by PBN in:

* writing of the Forest Management Plan approved by CONAP;
* purchase of oxen and training for community members on low-impact timber extraction;
* application of silvicultural treatments to increase forest productivity and economic returns; and
* establishment of permanent sample-plots for the long-term monitoring of forest dynamics in response to changes provoked by silvicultural treatments and resulting from logging operations.

As a result of San Miguel's initial success, other communities are following suit with PBN technical assistance:

* La Pasadita has finished an 18,800 ha forest inventory and is completing a management plan (PBN assisted in inventory design, fieldwork, data analysis, concession delimitation and writing of the plan).
* In April 1994, CONAP approved regulations (developed with PBN support) governing private forest management. The first contract was signed with the community of Bethel, which harvested 100 hectares of their 2,870 ha forest (PBN assisted with the harvesting plan, the application of low-impact harvesting techniques and an economic analysis of the operation).
* The La Tecnica cooperative has completed an inventory and management plan for its 3,000 ha forest and sustainable logging is scheduled for 1995 (PBN provided the methodology for the analysis of inventory).
* The 3,600 ha Bio-Itzá Forest Reserve was established in 1991 by indigenous inhabitants of San José (PBN executed a forest inventory, prepared a management plan, established permanent study plots, and implemented a low-impact logging and silvicultural operation of wood residues and standing trees with the community).
* Uaxactun is developing a large (100,000 ha) concession to include non-timber and timber resources (Uaxactun and CONAP have requested PBN technical assistance for this task).

2. Focal Point for Natural Forest Management

In 1994, PBN offered various guidelines for the Petén in the fields of forest inventory, silvicultural strategies, data analysis, environmental impact assessment and management planning.

The staff of PBN gave courses ranging from low-impact timber-extraction with oxen, to the use of Global Positioning Systems. Its willingness to provide practical alternatives and assist in their adoption has fostered greater collaboration among projects and communities and has created a more or less unified front for dealing with natural forest management in the Peten.

PBN is the only project in the entire Peten which has established long-term forestry research related to:

* Silvicultural treatments to promote seeding and improved growth of tree species utilized for timber, fauna and tourism (ARCAS, San Miguel la Palotada and the Bio-Itza Reserve);
* Comparison of the impacts of traditional logging techniques with low-impact harvesting (CUDEP experimental forest); and
* Forest dynamics and growth-rates on harvested and unharvested sites.

Some of the research results related to the above are still pending, while others have been utilized by virtually every NGO working on forestry in the northern Peten and have been crucial for establishing legitimate forest management (versus traditional extraction).

PBN's relationship with Guatemala's University of San Carlos, Peten branch (CUDEP) and La Istancia, the university's 676 ha experimental forest, has been crucial for developing a hub of applied forestry research. In 1994, PBN initiated and carried out research with students and faculty related to silviculture, low-impact harvesting, forest dynamics and economic analysis. Support has included construction of a forestry research station, and assistance to several Petén students.

A keystone course entitled "Inventarios Forestales para el Bosque Peteneco" was offered to a wide range of NGO and Government technicians to foment a greater standardization of field methods and data analysis for forest management efforts.

In an effort to further disseminate successful forest management strategies developed over the past several years, PBN carried out a "Seminario Movil para el Manejo Forestal Comunitario de la Selva Maya" involving rural dwellers from communities in Petén, Belize and Mexico. Seminar participants evaluated various forest management strategies (wildlife, ecotourism, agroforestry, timber, and non-timber products) in the three countries, with the purpose of fostering greater participation by locals in the design of community forestry concessions.

The widespread acceptance of community-based natural forest management (based on ecological sustainability, social acceptance and financial profitability) and a strong collaborative research effort have allowed PBN to yield tremendous conservation benefits by:

* maintaining a varied portfolio of natural resources, thus providing economic incentives for forest protection;

* reducing the invasion of currently unmanaged, common forest lands by individuals with non-forest based economic interests;
* minimizing over-harvesting of economically attractive products and preventing the creation of unsustainable industries;
* fostering active local participation in all aspects of design, planning and implementation of management strategies for community forests; and
* maintaining the natural biodiversity and structure of the forest ecosystem relatively intact, and extending the range of habitat around core areas for wildlife populations.

Nicaragua

Of the many activities carried out by PBN in Nicaragua during 1994, two are of timely importance:

* Until recently, the small holders of the Rio San Juan region used to sell the trees from their farms to timber contractors who paid them prices far below the true value, thereby disincentivating any possibility for management. The involvement and active participation of á local community (Las Maravillas) during the demonstration of low-impact harvesting and the application of a silvicultural treatment in PBN's Research and Demonstration Area known as "La Lupe", motivated the population to organize itself into the "Association of the Friends of the Forest". The members realized that the well-managed forest can be a continual and complementary source of income which can contribute to the economic welfare of the family, with immediate possibilities.

* The course entitled "Formulation of Management Plans for the Broadleaf Forests of Nicaragua" was particularly notable and of singular importance for the participation it gave to many of the Regional Directors and Department Heads of the National Forest Service of Nicaragua, Project Leaders and Non-government Organizations involved in the management of the humid tropical broadleaf forests of the country.

  In addition to covering the technical, economic and social bases for forest management, the course introduced the participants to a recent PBN working-paper outlining guidelines for management plan simplification (Modelo de Simplificación de Planes de Manejo Para Bosques Naturales Latifoliados en la Region Centroamericana).

  As a result of this event, the National Forest Service and participating projects created a Forestry Technical Commission for forest management activities within the buffer zone of the Indio Maíz Biosphere Reserve of the Río San Juan region. This Commission has prepared a proposal entitled "A Strategy for the Special Consideration of a Modified Forest Management Code for the Buffer Zone" (Estrategia para un régimen especial del manejo forestal de la Zona de Amortiguamiento), which contains guiding principles, norms and procedures for the management of the forests of the region. This document is in the final stages of revision prior to being submitted to the corresponding authorities.

  Another concrete result of PBN's interaction through its training events is to have convinced decision makers and professionals within the forest service of the need to directly involve rural

communities in forest management, and of the enormous potential which this activity has to improve the socio-economic conditions of this sector.

Figure 17. **PBN technical staff carrying out one of the annual measurements in the permanent sample plots in the secondary forest at Pilar de Cajon, near San Isidro, Costa Rica.**

Silviculture In Natural Forests Project. CATIE/COSUDE/DGF/ODA

1994 was a year of change for the Silviculture of Natural Forests Project (SBN). The previous internal division of 'mountain forest' and 'lowland forest' working groups was abandoned. It was felt that this was neither the best way to maximize results, nor to develop personal opportunities and relationships of the people involved. The original project organigram effectively limited communication between researchers, making the collective evaluation of research proposals, the discussion of their methodologies and the sharing of results extremely difficult.

The organigram proposed establishes 'Working Groups' for the seven 'Fields of Action' or working lines identified within the Project. The 'Working Groups' concept is similar to that of 'Circles of

Total Quality' as developed in the management philosophy of 'Total Quality' which seeks to obtain the maximum motivation and participation of those involved. Those working groups are: Applied/Basic Research, Adaptive Research, Information Management, Technology Transfer, Teaching and Training, Technical Dissemination and Administrative and Management.

Total Budget for 1994 was US$530 000 (on SFr 743 000) funded by the Swiss Government.

Technical Achievements by Fields of Action

+ Applied/Basic Research

- A protocol for the study of natural regeneration was finalized.
- Growth data for the primary forest of La Tirimbina were analyzed.
- Growth measurements continued to be taken in the primary forests of Villa Mills, La Tirimbina and Changuinola and in the secondary forests of Villa Mills, La Tirimbina and San Carlos.
- The permanent sample plots of Villa Mills, La Tirimbina, Changuinola and San Carlos were maintained.
- The permanent regeneration plots in Villa Mills and La Tirimbina continued to be monitored.
- Support was given to the studies of floral diversity in La Tirimbina and Corinto (Guápiles).
- Databases for dynamic processes and biodiversity in natural forests were kept up to date.
- A research proposal on site indices was formulated for San Carlos.
- A research proposal on phenology and seed dispersal was formulated for San Carlos.

+ Adaptive Research

- Protocols for taking field data were established.
- The four demonstration sites listed as follows continued to be maintained and developed.
  Villa Mills: primary and secondary mountain forest,
  La Tirimbina: primary and secondary lowland forest,
  San Carlos: secondary lowland forest,
  Changuinola: primary lowland swamp forest.
- Management databases were kept up to date.
- The operational focuses of the management of primary lowland and mountain forest were defined.
- A financial analysis of the management model of La Tirimbina was carried out as were preliminary analysis for Villa Mills and for the thinning in San Carlos.

Activities and Results

Analysis of composition and growth data from the intervened lowland primary rain forest of La Tirimbina.

The study was carried out in an intervened primary rain forest, part of 'Finca La Tirimbina' in La Virgen de Sarapiquí, Heredia Province in the Huetar Norte region of Costa Rica (latitude 10°25'N, longitude 84°47'W).

According to the Holdridge system of classification, the area pertains to very wet tropical forest (bmh-T) and very wet premontane, transition to basal forest (bmh-P). The annual mean temperature is 24.5°C with mean maximum and minimum of 26.2°C and 25.4°C respectively. The mean annual precipitation is estimated to be 3 864.8 mm with no dry months.

Methodology

There are approximately 80 ha of primary forest on Finca La Tirimbina. The study is being carried out on an area of 29.2 ha. The area is divided into nine blocks of 180 x 180 m with a central measurement area, or permanent sample plot, of 100 x 100 m (1 ha) and a buffer strip of 40 m. Between 1989 and 1990 the forest was harvested, the technical details can be found in Quirós & Finnegan (1994) and the financial analysis in Quirós & Reiche (in press).

For the growth study a randomized block design was used with three treatments and three repetitions of each: Control, Liberation-Refinement and Shelterwood. The control plots received no silvicultural treatment after harvesting. Refinement-Liberation was carried out in 1991 and consisted of elimination of non-commercial species with DBH of 40 cm or greater, by poison girdling, except for some individuals that were conserved to safeguard the floristic diversity of the stand (refinement). Also eliminated were all trees of 10 cm DBH or greater competing or suppressing with trees selected for future harvest within a 10 m radius of the latter (liberation). The Shelterwood treatment was applied in 1992 and involved the elimination of all mid and lower story individuals whose crowns overlapped or were competing with trees considered to be of future harvest.

Results

In 1990 246 species of trees and palms with DBH greater than 10 cm were recorded. A count in 1994 recorded 229 species of which 7 are palms and 54 are trees of current commercial value.

The control plots contain the greatest number of species due to a greater number of smaller diameter individuals. In comparison with the 1990 results, by 1994 the number of individuals in the control plots had decreased by 0.4% whilst in the Refinement-Liberation and Shelterwood plots the corresponding reductions were 18% and 21%, respectively. Basal area reduction for these two treatments was 35% and 7%, respectively, the latter figure being much smaller as the Shelterwood treatment mainly removed individuals of smaller DBH growing below the protective crown.

An average of 20 recruits ha^{-1} yr^{-1} were recorded in the control plots, and between 16 and 14 recruits ha^{-1} yr^{-1} in the treated plots. These include 110 species (of which 54 are commercial) the most frequent being *Ferdinandusa panamensis, Pentaclethra macroloba, Laetia procera, Miconia elata, Casearia arborea* and *Pouruma aspera,* the proportions varying between treatments.

Table 24. Stand data for intervened primary lowland rain forest on Finca La Tirimbina. (Values correspond to means of three plots of 1 ha for each treatment.)

Variable	Control		Ref-Lib		Shelterwood	
	1990	1994	1990	1994	1990	1994
Total N° species	179	185	172	163	174	160
Species ha^{-1}.	103	107	100	94	109	100
Trees ha^{-1}	502	515	483	393	495	391
Basal area (m^2 ha^{-1})	21.9	22.7	25.1	17.7	22.2	20.1
Mortality (1990-94)*	10%		28%		29%	
Recruitment (1990-94)	11%		11%		10%	

* includes trees removed as part of treatments

In all the treatments the most common and dominant species is *Pentaclethra macroloba* occupying 31% of basal area and representing 15% of individuals. Also abundant, but varying in importance between treatments are *Ferdinandusa panamensis,* the palms *Welfia georgii, Socratea durissima, Iriartea gigantea* and the tree species *Macrolobium costaricensis, Minquartia guianensis, Laetia procera, Casearia arborea, Vochysia ferruginea, Qualea paraense* and *Dendropanax arboreus.*

Based on the 1994 measurements, it is estimated that 14% of crowns can be categorized as emergent or with full vertical illumination, 49% receive direct lateral light and 37% little or no direct light. Crown forms are categorized as 23% good or perfect, 68% tolerable, 9% poor or worse. Most trees are free of significant climber infestation, only 17% are infested to a degree thought likely to affect growth.

Diameter growth.

The study of diameter increments includes all individuals, except palms, measured for at least two consecutive years. Analysis of growth between 1990 and 1994 demonstrates that the effects of the treatments have been positive on the remaining stand.

At the beginning of the study the control plots showed greater increments than the Refinement-Liberation treatment. Towards the end of the period, median growth of treated plots was significantly higher, a response demonstrated by species classified as shade intolerant as well as by those classified as shade tolerant (Table 25).

Significant differences were also found between the Shelterwood treatment and the Control, the shade intolerant species of the former showing significantly higher median growth rates during the latter half of the period whilst the shade tolerant species demonstrated a positive response from the beginning of the period (Table 25).

When all species were considered as one and grouped by diameter class, there were no significant differences between the control and the Refinement-Liberation treatment at the beginning of the peri-

od. However during the final period, the differences were highly significant for all diameter classes, the treatment having a positive effect.

The Shelterwood treatment showed significantly higher diameter increments for all diameter classes during the entire period in comparison with the Control. However median growth rates during the final year were significantly lower than those of the first year following application of the treatment.

Individual increments were also related to the following four variables: canopy position of the species at maturity; crown illumination, crown form and climber infestation. The data displayed in Table 43. suggest that the highest increments are obtained by: a) species of the canopy and sub-canopy; b) trees with excellent or good illumination; c) trees with perfectly or nearly perfectly circular crowns; d) trees completely or nearly completely free of climbers.

Correlation analysis by treatment and by ecological group verified that in the treated plots, crown form demonstrates the best linear relationship with median diameter increment, followed by climber infestation, and crown illumination. Despite initial diameter having a great influence on growth, it did not show a significant linear correlation, it being curvilinear. The results of the analysis do, however, show a strong linear correlation between initial diameter and other variables such as crown illumination and stem form.

Table 25. Median diameter increment (mm yr^{-1}) of all species for the measurement periods 1990-91 and 1993-1994, for four independent variables.

STRATA	CONTROL		REF-LIB		SHELTERWOOD	
	90-91	93-94	90-91	93-94	90-91	93-94
Understory	1.5	1.0	1.0	2.0	1.0	2.0
Intermediate	2.0	2.0	1.0	4.0	2.0	2.0
Subcanopy	5.0	5.0	3.0	6.0	5.0	4.0
Canopy	4.0	4.0	4.0	7.0	5.0	6.0

CROWN ILLUMINATION	CONTROL		REF-LIB		SHELTERWOOD	
	90-91	93-94	90-91	93-94	90-91	93-94
Emergent	6.0	4.0	5.0	11.0	8.0	7.0
Vertical Light	5.0	6.0	5.0	7.0	8.0	6.0
Lateral Light	3.5	4.0	3.6	6.5	4.0	5.0
Moderate Light	2.0	2.0	1.0	3.0	2.0	2.0
No Direct Light	2.0	2.0	1.0	2.0	0.5	2.0

CROWN FORM	CONTROL		REF-LIB		SHELTERWOOD	
	90-91	93-94	90-91	93-94	90-91	93-94
Perfect	9.0	13.0	13.0	10.0	15.0	18.0
Good	5.0	4.0	5.0	9.0	8.0	8.0
Tolerable	3.0	3.0	2.0	5.0	3.0	4.0
Poor	1.0	1.0	1.0	2.0	2.0	2.0
Very Poor	0.0	1.0	0.0	1.5	0.0	0.0

CLIMBER	CONTROL		REF-LIB		SHELTERWOOD	
INFESTATION	90-91	93-94	90-91	93-94	90-91	93-94
None	3.0	3.0	3.0	6.0	5.0	5.0
Stem Only	3.0	4.0	2.0	4.0	2.0	3.0
Crown only	3.0	3.0	2.0	3.0	2.0	2.0
Crown & Stem (low)	1.0	2.0	1.0	2.0	2.0	1.0
Crown & Stem (high)	2.0	1.0	0.0	0.0	1.0	1.0

Technology Transfer: Silviculture of Intervened Primary Forests

Since 1993 the Silviculture of Natural Forests Project and CODEFORSA (The San Carlos Commission for Forestry Development) have entered into a mutually beneficial cooperation agreement. CODEFORSA is a well established and respected NGO involved in the management of natural forests in the Huetar Norte region of Costa Rica and recognizes the need for the transference and implementation of technologies appropriate to sustainable forest management.

This cooperation involves the application of post-harvest silvicultural treatments in management units (farms) under the administration of the 'Promotion of Reforestation and Natural Forest Management in Huetar Norte' Project managed by CODEFORSA. Technical assistance and training is given by CATIE for the work which is carried out by the professional staff of CODEFORSA.

Materials and Methods

Work is being carried out at the following seven sites (units), each with an average effective working area of 50 hectares:

unit 02 Doña Alba
unit 03 La Montura
unit 04 Samen
unit 07 Octubre 78
unit 08 La Legua
unit 09 Elky Maria
unit 12 El Jardin

The design and application of each treatment is based on forestry data collected prior to the harvest and complemented by the development of a post harvest silvicultural plan based on diagnostic, remnant and silvicultural sampling.

Achievements

i) In the forests in which work has been carried out, post-harvest silviculture represents an effective and practical tool in the management process, as it aims to improve the productivity of the immature stand and hence its final yield.

ii) Cooperation between the two institutions has been important for both. For CATIE it has represented an effective means of putting into practice on a wider scale the technological advances made at its experimental sites. For CODEFORSA it has meant an opportunity for training of professional and technical staff which has been of direct effect for owners of forests and the 300 associates of the organization.

iii) From January 1995 these methodologies are being applied at a national level and they have been incorporated in the new national guide for management plans.

WATERSHED MANAGEMENT AREA

The Watershed Management Area consists of two technical units, both of which have a multidisciplinary focus in the planning and management of natural resources and biodiversity within watersheds. The activities of the Area involve the evaluation of biophysical and socioeconomic variables at the farm and watershed levels of analysis, while accounting for related effects at the watershed level. The goal of the Area is to create the conditions where public and private institutions in CATIE member countries can generate, transfer and apply appropriate technologies that promote the sustainable use of natural resources.

The Area is promoting social and cultural harmony, appropriate technologies, rehabilitation of degraded lands and immediate solutions that have both direct and indirect benefits to small hillside farmers. Its principal objective is to:

> Identify, develop, and disseminate effective techniques for the rehabilitation and management of watersheds. The principal strategy to accomplish this involves working at the farm level through participatory and extension activities involving both relevant institutions and local farmers.

The two technical units of the Watershed Management Area are Watershed Rehabilitation and Geographic Information System Analysis.

* *Watershed Rehabilitation.* With emphasis on the rehabilitation of small hillside farms and production systems, this Area has generated appropriate mechanisms for institutions responsible for watershed planning and the improvement of deteriorated areas. This has involved investigating, validating, evaluating, and diffusing technological practices that promote the appropriate use of natural resources in compliance with identified requirements such as sustainable agriculture and ecosystem stability.

* *Geographic Information Systems (GIS).* This unit includes a center for the collection of digitally stored GIS and remote sensing data. This GIS center provides data processing and other GIS services to users on demand, and is involved with the teaching of GIS technology as a support tool for the planning , management and monitoring of natural resources and agricultural activities in the member countries.

The Watershed Management Area is mainly supported by the RENARM/WATERSHED project, which began in 1990 and is scheduled to finish in December, 1995.

The main operating budget for 1994 was $861,000. The donor was USAID through the regional RENARM project. The area also received $90,000 in 1994 from an agreement between CATIE and ORSTOM (France). This project titled: "Soil Conservation in Tropical Ecosystems" financed an international expert and research costs.

Institutional achievements of the Area during 1994 can be summarized as follows:

- Establishment of a GIS laboratory and center (international experts and state of the art equipment and technology) for research, training and applied natural resource management projects. This has included numerous international training events in the GIS laboratory at CATIE , as well as many visits to member countries where on-demand GIS training and/or assistance was provided.
- Contributions have been made to the CATIE MSc. program in the form of courses taught by staff in the Watershed Management Area and by assistance provided to Watershed Management graduate students conducting thesis research in CATIE member countries.
- The completion of watershed management activities and implementation projects at the field level in CATIE member countries with particular emphasis on GIS applications in hillside agricultural areas.
- More than 700 beneficiaries of projects' activities in Central America, Dominican Republic and Bolivia.
- Thirty-two collaborative institutions from Central American countries working with watershed management projects.

The RENARM/USAID/G-CAP Watershed Management Project

The Watershed Management Project is a component of the USAID/RENARM Project #3: "Sustainable Agriculture & Forestry". With the goal of sustainable agricultural and natural resource development, the Watershed Management Area of the CATIE/RENARM project has addressed inappropriate land uses in sensitive watershed areas in order to maximize agricultural production, increase standards of living among small farmers, improve water quality, increase hydroelectricity production, improve irrigation practices, control flooding, and improve recreation and tourism opportunities.

The RENARM/Watershed Management Area Project is divided in two work units: 1) The rehabilitation of watersheds, and 2) Geographic Information Systems. The first work unit attempts to develop, use, and diffuse appropriate technologies for the rehabilitation and management of two watersheds in each country (Central America and Panama). The GIS unit is responsible for diffusing this technology, by providing support through technical assistance and training, and the installation of GIS units in several Central America and Panama institutions.

Table 26. summarizes the most important work lines of this project.

Table 26. Principal components of the watershed management working units

1) REHABILITATION OF WATERSHED COMPONENTS	ACTIONS
Methods for determining appropriate land uses	V
Hydrological modeling	R - V - T
Land use management and planning	V - T
Soil conservation	R - V - T
The use of fertilizer substitutes	R
Evaluation of erosion and flooding	R
Demonstrative areas within watersheds	V - T
Planning of rehabilitation projects	V
Analysis of social and cultural factors in watersheds	R
Economic analysis of rehabilitation programs	R - V
2) GEOGRAPHIC INFORMATION SYSTEM COMPONENTS	
Classification and evaluation of optical satellite images	R - V
Evaluation of potential use of radar images in tropical regions	R
Erosion estimation methodologies	R - V
Land use classification systems	V
Technical assistance to member countries	V - T

R= Research V= Validation T= Technology Transfer

The RENARM/Watershed Management Project, financed by USAID had a 1994 budget of $861,000. These fund were used to finance scholarships for Watershed Management students in the CATIE graduate program, as well as technical assistance to 6 member countries in Central America and Panama. With direct and indirect matching funds (salaries, equipment, offices, and logistics) generated by institutions in these 6 member countries, the total Project budget was $1,300,000.

Technical Accomplishments Of The Project

The principal accomplishments of the RENARM/Watershed Management Project during 1994 include member country watershed rehabilitation and planning projects, graduate training, and geographic information system activities.

The Project maintained a leadership role in the region through the continuation and follow-up of numerous watershed rehabilitation programs and activities in the region. This included technical assistance, training, post-graduate education, and the strengthening of counterpart national institutions with both financial and human resources in order to continue watershed management activities at the field level. More specifically, implementation and follow-up work was continued on 10 watershed management plans, 4 new watershed management plans were introduced, and GIS systems were introduced in 5 nation-

al institutions.

Specific watershed plans and projects impacted by the Project in 1994 included:

- Rehabilitation of Las Cañas River Watershed, El Salvador
- Rehabilitation of Nueve Pozas and Cerro Colopeca Rivers Watershed, Honduras
- Rehabilitation of Humuya and Yure Rivers Watershed, Honduras
- Hydrologic Modeling of Cangrejal River, Honduras
- Hydrologic Modeling of Caldera River, Panama
- Reforestation Project of the Coastal area of Managua Lake, Nicaragua
- Rehabilitation of Río Virilla Upper Watershed, Costa Rica
- Hydrologic and Hydraulic Modeling of Tuis River, Costa Rica
- Training of Extension Agents, MICUENCA Project, Guatemala
- Operation Modeling, El Cajón Reservoir, Honduras

The RENARM/Watershed Management Project in 1994 conducted 20 training events for over 300 professionals and technicians working in the member country projects listed above. The emphasis of these training events was to train extension agents and other national professionals to be able to administer demonstrative areas and to work directly with small scale hillside farmers within targeted watersheds.

Achievements of the above watershed plans and projects have been described in publications, conference presentations, masters thesis and internal CATIE documents.

Geographic Information Systems

The Geographic Information Systems (GIS) Unit of the RENARM/Watershed Management Project completed many achievements in 1994 which are expected to improve watershed management activities in the CATIE member countries. In addition to participating in graduate teaching and research activities, the Unit provided technical assistance and/or GIS data to various projects within CATIE (MADELEÑA, OLAFO, BOSQUES NATURALES), as well as to 6 new institutions in CATIE member countries (MICUENCA y SEGEPLAN in Guatemala, ECOT-PAF/MARENA in Nicaragua, SISVAH, CNFL and ASCONA in Costa Rica, CEL in El Salvador, FUNDECOR in Costa Rica, CONAL in Nicaragua, and FAUSAC in Guatemala). The GIS unit also participated in providing short courses in Bolivia and the Dominican Republic. A collaborative research project involving RADAR technology is continuing with University of Sherbrooke. To promote the financial independence of the GIS Lab several activities such as training, technical assistance have begun to be charged for. Finally, several project proposals have been written with the intent of generating additional external research and training funds.

Finally, an abstract of the two Masters Thesis research completed during 1994 is presented.

LEON PEREZ, C. 1994. Land Evaluation in the Upper Section of the Reventazon River Watershed, Costa Rica: Application of an automated system - ALES- and a Geographic Information System -IDRISI-.

- Evaluation models were developed with data from a GIS system (IDRISI) and the use of an expert system ALES (Automated Land Evaluation System). Six land utilization types in the

Reventazon Watershed were analyzed: technified coffee monocrop with shade, sugar cane (humid lowland), sugar cane (humid highland), technified Irazu Potatoes, Kikuyo Grass, and Tropical Humid Forest. Both physical suitability (based on FAO methodologies) and Economic Suitability analysis were conducted. Tropical Humid Forest land uses were found to have the highest level of both physical and economic suitability. In fact, 94% of the watershed was found to be physically suitable for Tropical Humid Forests which had a gross margin of ¢1,383,200/Ha/Yr. Highland sugar cane production was found to be suitable in less than 0.5% of the watershed in spite of the high economic suitability (Internal Rate of Return of 25.5% and Cost Benefit Ratio of 1.36). Lowland sugar cane production was found suitable in 20% of the watershed, yet had slightly lesser economic values than highland sugarcane. Irazu Potatoes and Kikuyo grass production both had similar physical suitability levels (25% and 21% of the watershed respectively), and both were economically profitable. Coffee production was physically suitable in 36% of the watershed, but had very low economic suitability measures (IRR< -0.64 and Cost Benefit Ratio < 0.9).

VALENZUELA, O. 1994. Evaluation of traditional and agroforestry based soil conservation practices in Santa Cruz, Nicoya y Hojancha, Guanacaste, Costa Rica. MSc. Thesis.

- Two experiments were conducted to study traditional and agroforestry practices for soil conservation and determine their biophysical and economical impacts. In the first, "frijol tapado", zero tillage with mulch and zero tillage without mulch were evaluated. These were repeated in three sites: La Florida, Matambú and San Isidro. Three other treatments: (1) *Gliricidia sepium* live barriers and with base knitted with *Dracaena mesengiana* (2) only *Gliricidia* live barriers and (3) without barriers were evaluated in the second experiment. These were repeated in three sites: Juan Díaz, Matambú and San Isidro. Sites corresponded to Hojancha, Nicoya and Santa Cruz, counties in the province of Guanacaste.

  A completely random design was used. Variables evaluated were erosion, crop yield (maize, beans), fertility, feasibility, net family income and cash requirement. Erosion was measured with stakes.

  Results obtained indicate that double barriers, "frijol tapado" and zero tillage with mulch showed the least soil loss. Corn as well as bean yields were statistically the same in both experiments and in all sites, except in Juan Díaz where the double barrier treatment achieved the best yield. As far as sites are concerned, San Isidro showed the best bean yield, while Matambú reached the highest corn yields even though it also had the highest number of plants.

  The best economic feasibility as well as highest net family income and lowest cash requirement corresponded to "frijol tapado". The best feasibility in the second experiment varied from site to site, in Juan Díaz for double barriers, while treatments without barriers showed this in Matambú and San Isidro. The same behavior was seen in each site as far as net family income was concerned. The highest cash requirement was for double barriers.

BIODIVERSITY MANAGEMENT AND CONSERVATION AREA

The main fields included in this Area are wetlands management, non-timber forest products, diversified management of natural forests, ethnobotany and protected areas and buffer zone management. It seeks natural resource management alternatives to benefit local rural communities that live in areas rich in natural ecosystems.

During 1994, activities carried out by the Area of Biodiversity Management and Conservation were significant. Some of the achievements were:

- The initiation of a new option in Biodiversity Management and Conservation in CATIE's Graduate Program in Management of Natural Resources. This specific program was started in 1994, and during this year all courses planned were successfully conducted. Five students made up the first graduating class in this specialization, and all of them are already developing their thesis work.

- First International Course on Biodiversity Management. This was a new three-week strategic course of CATIE. Twelve professionals from different Latin American countries participated.

- Implementation of the annual International Course on Protected Areas. 5 weeks. 27 professionals from Latin American countries attended this Course in 1994. The course was jointly funded by WWF and Unesco.

- Renewal of the Area main Projects.

  Submission and approval by DANIDA of the proposal for the second phase of the Project Wise Use of Mangrove Resources, for a two-year period and a total budget of US$1.275,000. The Agreement was signed in October, 1994.

  Implementation of the External evaluation of the Olafo Project, which was very positive and included a recommendation for Project extension through an additional phase from 1996 on. A proposal profile was prepared and submitted to the donors, for a three-year period (1996-1998) and total budget of US$3.720,000.

- Negotiations of new projects were initiated. During 1994 a significant effort was devoted to negotiations for future projects in Peten, Guatemala. Negotiations with AHT (Germany) also progressed for the implementation of the Project for Conservation of Peten Forests (PROSELVA) and for participation in the Projects on Management of Natural Resources of the Peten Integrated Development Plan, to be funded by IDB. Materialization of both efforts might result in projects for twenty-five millions dollars to be implemented in the next seven years, in which other CATIE Areas will also participate.

- Organization of five workshops to identify training needs on protected areas around the region. These workshops were held in Costa Rica, Nicaragua, Honduras, El Salvador and Guatemala.

Conservation For Sustainable Development In Central America (OLAFO) (NORAD - - DANIDA Contribution)

The Project Conservation for Sustainable Development in Central America is a regional project based at CATIE, Turrialba with five Demonstrative Areas in five Central American countries (Guatemala, Honduras, Nicaragua, Costa Rica and Panama).

The Project aims to test in the field the feasibility of a concept of rural sustainable development based upon the appropriate use of natural resources by local communities for their own benefit. The Project focus its attention in natural ecosystems, basically rain tropical lowland forests and mangrove.

The specific project objective for Phase 2 (1993-1995) is: "Group of peasants in demonstration areas have validated models of production systems based upon the sustainable us of forests and other traditional farm components, with the support of national institutions that have acquired the ability to diffuse the models."

Strategy

To achieve its objectives, the Project established the following strategies:

* To attach value to biological diversity resources of the natural tropical ecosystems through their productive use by local communities. These resources include timber from traditional and non traditional species and non timber forest products.

* To generate new income for rural communities from new productive alternatives or from improved traditional activities. As a consequence of this strategy the Project went into financial and marketing studies, as well as the establishment of rotational funds and on-farm basic processing of harvested/collected materials

* Users' participation in all Project phases and activities, including decision making.

* Simultaneous and coordinated work with local organized groups and with active national institutions in the Demonstrative Areas.

* Multidisciplinary technical work.

* Simultaneous work at different complexity levels (species/ecosystem/landscape; crop/production system/region; family/producer group/community).

* Implementation of research, development, validation, transfer and training activities within the same framework.

* Working at a demonstrative level. Due to the large complexity of the issues addressed by the Project, it was decided to concentrate activities in small rural villages in agricultural frontier areas. Presently Olafo is active in twelve of these villages (30 to 50 families each) in the above mentioned countries.

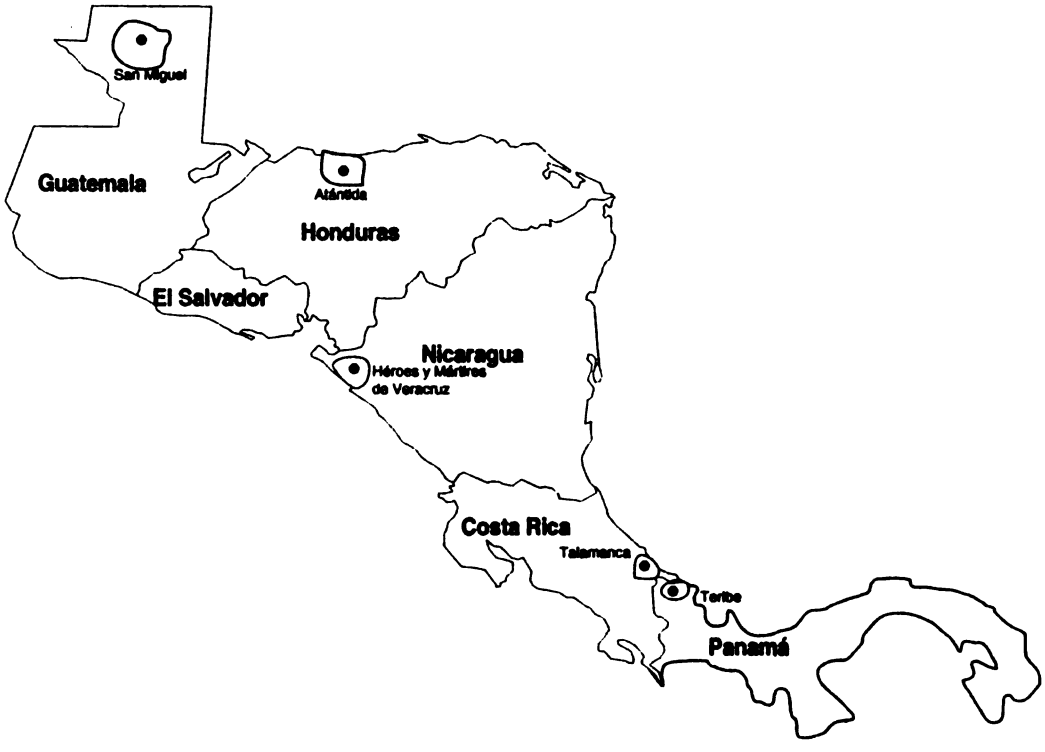
Funding

The Donor Agencies are SIDA (Sweden), DANIDA (Denmark), NORAD (Norway). Total Budget for 1994 was US$1.675,246.00.

Activities

Main Project activities at each Demonstrative Area (Figure 18.) are described briefly as follows:

Figure 18. Localization of demonstrative areas. OLAFO Project.



Peten, Guatemala

Olafo activities in Peten are located in the Multiple Use Area of the Maya Biosphere Reserve in northern Peten, and they are focused on two communities: San Miguel and La Pasadita. Both are agricultural frontier areas, their inhabitants are recent migrants from Orient (eastern Guatemala), and all of them practice shifting agriculture with corn as the main crop. They do not own their land and carry out several forest extractive activities (xate, all spice and chicle) in order to enlarge their meager income. Average cash income in the area is in the order of US$ 600.-/year. Project activities since 1989 were focused on community organization, solution of highly pressing needs as water and health facilities, and the introduction of bee-keeping as a new income source and the use of green cover crops (*Mucuna pruriens*) to extend the cropping period in the same plot, avoiding the clearing of additional forests.

In 1994 an effort started in 1993 crystallized with the agreement between CONAP (Protected Areas Council) and APROSAM (the San Miguel Producers Association) establishing a forest concession of 7.000 has. in the Multiple Use Area to be managed by APROSAM by 25 years with time-extension rights included. The agreement accepted a forest management plan prepared previously by APROSAM and Olafo, and forest logging activities started in April 1994 in a first plot of 40 has. Logging was carried out carefully, using techniques as vine-cutting previous to logging, oriented tee-felling practices, on-site sawing of logs to reduce them to manageable pieces, forest extraction by hand or oxen, etc. Total timber harvested was 161 cubic meters, roughly equivalent to 2 trees/ha. In late 1994 post harvesting silvicultural treatments were made, aiming to liberate natural regeneration and provide adequate conditions for a better harvest after the next 20 years.

APROSAM members, that include all 35 families from San Miguel and neighboring areas, were benefited with 656 days of well paid labor (4.50 US$/day), and it also got a net income of US$ 820.- that was used to buy a small sawmill aiming to process their timber to board in 1995 rather than selling it as logs as they did in 1994.

Along with timber production, Olafo continued validation activities in forage trees for goats feeding, honey production and green cover crops. Due to the good results obtained, the preparation of extension materials for these activities was planned for 1995.

Atlantida, Honduras

1994 was the first year of activities in this Area. A new small local team (coordinator, one professional and administrative support) was set in place and a basic diagnostic of the area was completed. COATLAHL, a local cooperative of hand-sawing groups, will work jointly with Olafo, that also will provide technical support to the National Forestry School (through the Lancetilla Botanical Garden) and the Project of Production in Broadleaf Forests (COHDEFOR/Canada). Training needs of local professionals from national institutions and NGO's were identified and a training course in well coordinated modules was designed. The first module of the this course was taught in late 1994.

Leon-Corinto Mangrove, Nicaragua

The mangrove of the northern Pacific coast of Nicaragua has been used by local communities for many years. In the last two decades its use was intensified due to the migration of people to these areas, looking for alternative sources of income under the pressure of social conflicts (land concentration in large cotton plantations in the 70s, followed by the war in the 80s and the economic crisis in the 90s). Project activities are focused in three small communities (Salinas Grandes, Peñitas and Alemania Federal), the first two in the buffer zone of the Juan Venado Island Reserve.

Project activities in the first years were focused on assessing the ecological and social situation and to strengthen local organization. The appropriate use of mangrove forest resources was identified as the top priority for Olafo in this area. Two attempts to carry out a mangrove forest inventory failed, and a completely new technique was devised in 1993 and applied in 1994 with good results, being the first inventory with productive purposes carried out in Central America. The methodology included the generation of specific volume tables for the different mangrove species, as well as original techniques to measure the trees and to assess the situation of the plant communities at the different areas. Simultaneously with these studies, where all fuelwood-cutters were involved, Olafo promoted the organization of ASOLEP (Fuelwood-cutters Association of Peñitas). Olafo and ASOLEP opened negotiations with MARENA (Natural Resources Ministry) to obtain a long-term forest concession on the mangrove forests to be used by ASOLEP under a forest management plan. At the end of 1994 everything was ready to start with pilot logging in four 5 ha. plots. Pilot logging was required to complete tables to convert tree measures in volume of fuelwood, bark, roundwood, charcoal and other products obtained from mangrove trees.

Other productive activities introduced by Olafo were continued, as honey production, charcoal production, shell handicrafts and green iguana farming. All activities are being monitors by Olafo staff aiming to complete the validation process in order to start transfer activities in the third phase of the Project.

Talamanca, Costa Rica

In Talamanca, Costa Rica, Olafo activities are concentrated in the lowlands close to the Caribbean Sea, and focused on two sites: Kekoldi Indian Reserve (inhabited by bri-bri Indians) and San Rafael de Bordon (a community of migrants from the northwestern part of the country).

While most Olafo activities in Talamanca in the first years were concentrated on research on non-timber forest products, in 1994 a shift of efforts was completed aiming to an approach centered on production. In Kekoldi the work to improve traditional crops (cocoa, ginger) was increased and the production was marketed through APPTA (Small Producers Association of Talamanca) into the market of organic products in the industrialized countries. Simultaneously Olafo increased its activities to strengthen handicrafts production in order to benefit from the growing tourist activities in the area. Local handicrafters received training from more experienced crafters from other countries (Honduras) for the use of *Carludovica palmata*, a palm promoted by Olafo to replace materials traditionally obtained from *Heteropsis oblongifolia* and *Philodendron rigidifolium* whose natural populations are already exhausted.

Olafo also helped the local Kekoldi Reserve Association to get a grant from UNDP to build a craft shop close to the main touristic road to improve marketing conditions. These handicrafts activities were not constrained to Kekoldi, but opened to all bri-bri communities in the area, resulting in a significant participation of crafters from other two communities: Uatsi and Yorkin.

In 1994 there was also a very significant effort to complete a product-development cycle with *Quassia amara*, a medicinal and insecticide plant. This effort included a total inventory of plants in Kekoldi, a national survey of *Quassia* wild populations in Costa Rica, as well as the completion of marketing studies and chemical studies. All these efforts, carried out jointly by Olafo and other participant institutions (see the Olafo working network later), were presented in a Regional Meeting on *Quassia amara* held in CATIE in November.

In San Rafael activities were focused in the monitoring of timber extraction in individual family farms, and the establishment of the community nursery for ornamental species (*Zamia skinneri* and *Reinhardtia gracilis*). Propagation problems with both species continued and Olafo resorted back to seed propagation, including the identification of seed plants in the forests, a long and tedious task. There were also relevant efforts in the marketing aspects, that showed the need to carry out pilot market tests with these species, task to be completed in 1995.

Teribe Valley, Panama

This Area is located in the northwestern part of the country in the Caribbean province of Bocas del Toro. The Teribe Valley is an area inhabited by the teribe Indians, and Olafo is focusing its activities here in four communities: Siey Kin, Siey Yic, Solon and Bonyic. As Teribes made a sustainable use of their environment, the objective of Olafo in this area is the strengthening of this group and its activities in order to increase their opportunities to survive as an entity.

Activities in 1994 were focused in supporting teribe leaders in their effort to get legal rights on their traditional lands through the legal declaration of a "Comarca" (autonomous Indian territory). Besides that, Olafo is working with groups of farmers in the mentioned communities aiming to improve the production of their traditional crops (cocoa, oranges, *Cordia alliodora* trees) as well as some other crops introduced recently as pineapples.

From the social perspective Olafo is strengthening existing organizations and promoting the recuperation of cultural values through activities as ethnobotanic studies, oral transmission of knowledge from the elder to youth, and other.

The strengthening of handicrafters organizations was also pursued, including training, the establishment of a rotational fund to buy tools for woodwork and contacts with MICI (Commerce and Industry Ministry) to market teribe handicrafts throughout the country through specific MICI programs.

The OLAFO network

The Olafo Project does not work in isolation, by the contrary, it devotes significant effort to joint projects and activities with other institutions and organizations throughout Central America aiming to strengthen or develop local capacities to continue with the activities promoted by the Project. More than twenty institutions participate in these efforts. Some of these institutions are governmental like counterpart institutions in Guatemala: MAGA (Agriculture Ministry), CONAP (Protected Areas Council), Nicaragua: MARENA (Natural Resources Ministry), and Panama: INRENARE (Natural Resources Ministry), MICI (Commerce and Industry Ministry). All these counterparts contribute permanent staff and funds for the development of joint activities in the Demonstrative Areas. Other institutions are linked through research efforts, as the group participating in the development of Quassia amara, integrated by CIPRONA (Center for Natural Products Research, University of Costa Rica), Fabio Baudrit Agricultural Experiment Station (University of Costa Rica), Agricultural School (National University, Costa Rica), Phytopathology Laboratory (Univ. of Costa Rica), Pharmacy School (San Carlos University, Guatemala), Biological Assays Laboratory (University of Costa Rica), Natural Sciences School (National University, Nicaragua), CECOTROPIC (a Nicaraguan NGO) and UNAH (National University, Honduras). These are just two examples of the Olafo efforts to integrate and to catalyze research to improve the sustained use of neotropical natural resources in Central America.

NON TIMBER FOREST PRODUCTS UNDER RESEARCH BY OLAFO

SCIENTIFIC NAME	USES
Carludovica palmata (Cyclanthaceae)	Fiber crafts (baskets, bags, etc.)
Zamia skinneri (Zamiaceae)	Ornamental plant
Reinhardtia gracilis (Arecaceae)	Ornamental plant
Quassia amara (Simaroubaceae)	Medicinal, insecticide
Chamaedorea elegans (Arecaceae)	Ornamental leaves
Desmoncus spp. (Arecaceae)	Fiber crafts (furniture, bags, hats)
Smilax spp (Smilacaceae)	Medicinal plant

Achievements

Achievements during 1994 are ordered based on expected results stated in the Plan of operation.

Strengthening of local groups

* A forest concession for 25 years was obtained for management and utilization of 7000 ha of forest in San Miguel community, Peten, Guatemala. Inventory and logging activities were carried out in the first 40 ha.

* All necessary activities to initiate mangrove timber utilization under a management plan (Heroes y Mártires) were completed in Nicaragua.

* Over twelve training events were carried out for farmers in the Demonstrative Areas in the fol-

lowing topics: fiber utilization for crafts, timber treatment, storage and drying, tools handling, administration of rotative funds, administrative aspects and community organizations.

* Follow-up has been provided to the installation of transfer plots of maize and green cover crops, and goat modules in Peten, Guatemala.

* Support was provided to the communities to obtain access to national institutions for the approval of producer groups, forest concessions and institutional support on productive and organizational aspects.

* The establishment of a crafts store was completed in Kekoldi Indigenous Reserve, Talamanca, Costa Rica, serving also other bri-bri communities as Uatsi and Yorkin.

Validation and incorporation of sustainable management practices

* In cooperation with MARENA Wood Analysis Laboratory from Nicaragua, a study on timber properties of mangrove species was completed and published. These studies will improve the scope of uses of these species.

* Economical analysis and marketing studies were carried out for non-traditional products such as ornamental, medicine plants, timber products, fruit trees production, goat modules, production of green iguanas and farm components (base grains, home garden, etc.)

* Rapid appraisal of production systems in two areas of Talamanca, Costa Rica and one in Teribe, Panama. Characterization of the traditional system shifting cultivation Peten, Guatemala and of coal producers in Cabeza de Indio community (Honduras).

* Evaluation of the impact of the forest utilization in the natural population of *Chamaedorea* spp. in Peten. A characterization and management study of *Desmoncus* sp. was already carried out, and the characterization of the ecological community of *Calophyllum brasiliensis* is being carried out.

* Support was provided for building a nursery in Talamanca (Costa Rica), where ornamental seeds and plants collected after forest exploration will be saved.

* Mangrove firewood extraction was evaluated, and growth plots for this species were established.

* A methodology was prepared for forest inventories and forest management plans in the mangrove forests.

* Validation was carried out in goat production modules with six producers in Peten (Guatemala).

Wise Use Of Mangrove Resources Project (DANIDA)

Wise Use of Mangrove Resources initiated activities in 1992. The project was planned for a four-year period, implemented in two phases. The first phase finished in December 1993, and the second phase has been implemented since July 1994 and will finish on June 30 1996. A necessary "bridge phase" was established between January and June 1994. Project activities are carried out in two field areas (Figure 19): Estero Real (Nicaragua) and Terraba-Sierpe (Costa Rica).

Figure 19. Localization of demonstrative areas. Mangrove Project.

The Project main objectives are aimed to the sustainable use of mangrove ecosystem resources to the benefit of the local population, as well as to increase awareness on a regional level about the importance of preserving and managing mangrove areas as income sources, natural flora and fauna conservation and coastal protection values.

These objectives will be achieved through a joint positive interaction and work between government and local population for the implementation of management plans for the sustainable use of mangrove areas. It is also expected to increase income levels from alternative production systems aimed to reduce pressure on mangrove resources.

Project Strategy

To achieve the above mentioned results, the Project adopted the following strategies:

* community-based actions, meaning the involvement of local communities in all aspects related with the joint work between project and communities as selection of alternatives, organization of groups, identification of training needs, establishment of rotational funds, etc.

* use of existing knowledge. The project is not attempting to carry our research, but mostly validation and extension of techniques already known. Some adaptive research will be carried out when highly necessary.

* integrated approach, meaning that the Project will not consider just the activities carried out in the mangrove, but all activities belonging to the production systems. This is important because most of the mangrove resource-users also carry out relevant activities out of the mangrove forests as agriculture, fishing, shrimp farming, small scale ranching, etc. Giving consideration to these activities will make easier to alleviate pressure on mangrove resources.

* appropriate planning, meaning the need to recognize the existence of different levels of planning depending on the user of the plan. Resource-use plans will be developed for local groups aiming to use these resources, as mangrove forest management plans for forest concessions, or management plans for natural fishing ponds. An overall regional plan (or strategy) will be developed with the Natural Resources National Institutions to help them in the administration of the whole area, considering its multiple objectives (production, conservation, tourism, human settlements, etc.).

Funding

The project is supported by DANIDA (Denmark), total budget for 1994 was US$473,713. US$148,158 for Nicaragua's project, US$200,957 for project located in Costa Rica, and US$124,598 for CATIE's core budget.

Activities

Main Project activities at each Demonstrative Area are described briefly as follows:

Estero Real, Nicaragua

Estero Real is the largest mangrove area in Nicaragua, located in the southern part of the Gulf of Fonseca, shared by Nicaragua, Honduras and El Salvador. After a rapid diagnostics period, the Project focused its activities in two communities: Puerto Morazán and Tonalá. At both areas activities of community strengthening and organization, as well as environmental education were carried out. In Puerto Morazán the work is centered in two shrimp-farming Cooperatives: Lucrecia Lindo and Herrera Membreño, that existed before the arrival of the Project. Both Cooperatives were strengthened in their

administrative abilities (accounting, internal organization, use of credits, etc.) as well as in the technical ones (improvement of shrimp farming techniques). As a result of these activities both cooperatives were able to repay its credits and were freed of heavy debts with local Banks; moreover, both started to move in 1994 from artisanal farming to semi-intensive methods, incorporating water-pumping equipment and other improvements. Mangrove Project is also active with URCOCAM (Regional Union of Shrimp farming Cooperatives) aiming to transfer these experiences to more than 20 other cooperatives affiliated to URCOCAM.

In Tonala the Project work was oriented to fuelwood-cutters that were not organized when the Project started. Presently there are four different Cooperatives organized and the first of them is in the preparation of a management plan for a mangrove forest concession to be requested to MARENA with Mangrove Project support. Considering the experience gained in this issue by Olafo, it is expected that this concession will under way in 1995. Several other productive alternatives introduced by the Project are under validation in Tonalá as charcoal production, green iguana farming, bee keeping and home orchards.

Terraba-Sierpe, Costa Rica

In Terraba-Sierpe the activities of the Project were focused on completing the strengthening of Coopemangle (the Project target group) and starting the preparation of the Management Plan of the Terraba-Sierpe National Wetland, to be implemented by MIRENEM (Natural Resources Ministry of Costa Rica). The work with Coopemangle was completed successfully after a detailed charcoal market study that generated a direct agreement between Coopemangle and a retail chain-store in the capital. This agreement allowed Coopemangle to sell its product in small 3-kg paper bags under their own brand name, and to jump over the whole middle-men chain, improving their income significantly and establishing a robust cash flow. Simultaneously, Coopemangle with Project support established strong links with several national institutions and NGO's that will ensure that Coopemangle will receive permanent attention, training and assistance in the future, specially after the phasing-out of the Project planned for December 1995.

Regarding the Management Plan, the Project made and agreement with the IUCN Regional Wetlands Program to get technical support to complete this task. A joint team was established, a work plan agreed and the first meetings with local organizations, national institutions, scientists, the private sector, etc., started in late 1994. These meetings opened a space for participation and negotiation that did not exist before. The outcome was very positive, with agreements about area use-zoning approved by all parts. Based on these results a draft plan will be completed in early 1995, to open a final round of consultations aiming to a final version to be implemented by MIRENEM since mid-1995.

Mangrove - OLAFO joint operation

It is important to remark the joint operation of the Mangrove and Olafo Projects as a model of optimization of human resources. The Mangrove Project was planned based upon the experience of Olafo in the mangrove of Nicaragua. Instead of developing a different Project it was decided to establish new

field teams in Estero Real and Terraba-Sierpe, but using Olafo Headquarters team as the source of technical support and advice for these teams. The Mangrove Project contributes to this team with an expert in mangrove. In 1994 the joint operation was increased when the Coordination of both Projects were unified. The experience has been very interesting and positive. All Area Coordinators from both Projects met regularly to present and analyze their experiences, professionals of the same fields from both Projects met regularly with CATIE Headquarters experts, training activities are implemented with participation of staff from both Projects, staff exchanges to strengthen weak aspects of some Areas were implemented. Obviously, the management of a larger body brought some unexpected problems that are being solved.

Achievements

Achievements during 1994 are ordered based on the results expected and established in the Plan of Operation.

Estero Real, Nicaragua

Forest management plans

* A forest inventory of the Cantagallo, Cantagallito and Canal Principal areas was carried out to prepare management plans.

* A utilization plan was design for Cantagallo Estero to be implemented in the first half of 1995.

* Support was provided to two woodcutters groups to obtain legal forest concession for the mangrove management.

Management strategy

* Involvement of eleven national institutions and local organizations to discuss the scope and participation in the global strategy for the Estero Real management.

Strengthening of local groups

* Technical assistance to woodcutters' group to reforest with red mangrove, and also to other groups in activities for iguanas, shrimps, honey, vegetables and coal production.

* Establishment of rotation funds for the implementation and improvement of green iguanas, vegetables and apiculture production.

Alternative income sources

* Studies on natural shrimp populations at post-larvae stage in Gulf of Fonseca. Activities are jointly carried out with the Chinese Mission.

* Economical monitoring for validation of honey production and firewood extraction alternatives.

* Financial analysis for honey, firewood, coal and iguanas production. Market rapid appraisal for honey production.

* Research on natural and artificial mangrove propagation.

* Support to the Universidad Centroamericana (UCA) on the study of phenology and natural regeneration of the mangrove species.

Terraba-Sierpe, Costa Rica

Management plan for the Terraba-Sierpe National Wetland

* A document containing bibliographic information of studies carried out in the Terraba-Sierpe area was completed.

* A first draft of the management plan for Terraba-Sierpe was jointly prepared with IUCN.

Strengthening of local groups

* Support to Coopemangle for institutional and financial support from organizations such as Instituto de Fomento Cooperativo (INFOCOOP) and the Consejo Permanente de Cooperativas (CPCA).

* Support to a women group working on local sale of bakery products.

* Ten training events oriented to target groups were carried out on productive aspects (bakery, wetlands management, charcoal production and sale), administrative and community organization.

WWF/CATIE Coordination Project

The Central America Regional Office of the World Wildlife Fund (WWF) has been operating from CATIE since 1986 to coordinate WWF's conservation work in the region. In 1994, WWF strengthened the regional office by bringing on two new staff members: a senior program official to focus on natural forest management in the region and an administrative official.

WWF has continued providing direct financial support and technical assistance to several priority conservation projects. These include: ecodevelopment in the Sierra de las Minas Biosphere Reserve and the Conservation Trust Fund in Guatemala; the Natural Resource Management and Protection Project (NARMAP) in Belize; integrated conservation and development work in the Rio Platano Biosphere Reserve and Gulf of Fonseca wetlands in Honduras; conservation planning in the Cayos Miskitos Reserve of Nicaragua; and the Arenal project, Association of Producers of Pejibaye, Jimenez, Association of Paraforesters on the Osa Peninsula, and Monteverde Reserve in Costa Rica.

Direct support to various region wide training initiatives in collaboration with CATIE has also been a continuing hallmark of WWF's program in Central America. The XVI International Course on Protected Areas Management was held at CATIE in April 1994, with 28 participants representing 17 Latin American countries and 23 government and non-government organizations. At CATIE, WWF was responsible for the third trimester master's level course on protected areas management and collaborated on the thesis committees of four post-graduate students. WWF also provided instructors in the International Course on Rehabilitation of Watersheds, in the Masters Course on Natural Forest Management, and in the Central American Meeting on Domestication of Medicinal Plants. Finally, WWF provided direct financial support to the region wide initiative, Simplification of Forest Management Plans in Tropical Broadleaf Forests, jointly held at CATIE by CATIE/PBN and the Central America Tropical Forest Action Plan.

From its small project grants fund, the WWF Regional Office provided partial financial support to several publications including: "Wildlife Management and Regulatory Requirements", an analysis of the situation in Central America by Patricia Madrigal and Vivienne Solis; "Biological Diversity and Sustainable Development", published by the AMBIO Foundation; the magazine "VIDA y Ambiente" published by the VIDA Association; and "Maravillas de la Fauna Guatemalteca", by Lorena Calvo. The small grants fund also sponsored three participants to the Annual Conference for Environmental Educators in Mexico. In Costa Rica, the small grants fund provided partial support to a number of events including the third meeting of the Ecological Youth Clubs, the first workshop for professors of technical schools in the Atlantic zone, and the second seminar on environmental education in Costa Rica.

AREA OF ECONOMICS OF PRODUCTION AND CONSERVATION

The work in the areas of economics, sociology and extension date back to the Center's foundation. The organization of the new area started in 1993 with an institutional consultation of all the social scientist at CATIE. The consultation led to the approval of the new discipline by the Technical and Academic Committee of the Graduate School in August 1994.

The decision was a major landmark in the field, since it ensured that the graduate activities could proceed with the total acceptance of the Center's academic and technical community.

This decision strengthened the relevant guidelines in CATIE's Strategic Plan, "Agenda for a Critical Decade".

A further meeting was covered in 1994 to agree upon the following main objectives:

Objectives Of The Area

- To consider and analyze the socioeconomic and gender issues that influence and determine sustainable development in tropical agriculture and sustainable natural resource management.
- To promote a holistic approach in the strategies aimed at sustainable development of tropical agriculture and natural resources management, so that CATIE's technological contributions fully consider socioeconomic, management and gender factors.
- To establish strategic alliances and specific projects with institutions and organizations whose interests complement CATIE's activities.

Graduate Profile

The graduate profile was established in 1994 and is summarized below:

- To understand the political and philosophical basis of environmental issues from all relevant angles,
- To evaluate, quantify and analyze environmental problems and issues and develop workable solutions within the existing "holistic" context.
- To understand the management processes of environmental problems in the private and public sectors.
- To undertake all of the above in a participatory way including all members of the public, regardless of sex, ethnic background, religion or any other factor.
- To be able to develop initiatives promoting the transition from unsustainable to sustainable forms of production and consumption.

Based on CATIE's comparative advantage and research tradition the following areas are being emphasized:

- Ecological economic analysis of tropical agriculture production activities,
- Ecological economic analysis of life support systems of tropical ecosystems.
- Accounting, valuation and management of natural capital, and other goods and services.
- Social Organization and Indigenous Systems in tropical ecosystems management,
- Gender issues and their impact on sustainable agricultural and management of natural resources.

ACHIEVEMENTS

+ Activities in support of education.

Five graduate school courses were taught during 1994:

- introduction to agricultural economics analysis.
- forest economics.
- administration and management of agricultural research.
- identification,formulation and evaluation of forestry and agroforestry projects.
- introduction to environmental sociology.

Graduate student supervision:

- Principal Advisors to 6 M.Sc. students.
- Thesis committee for 4 M.Sc. students.

Short term training activities.

- Organization and execution of the first international course in identification, preparation and evaluation of forestry and agroforestry projects, with a total of 12 participants.

- Lectures given for courses in other CATIE areas:
  - International agroforestry course. 2 days.
  - International agroforestry course for Ecuadorian professionals. 3 days.
  - Management of biodiversity. 2 hours.
  - Forest management and silviculture. 2 hours.
  - International courses in management of protected areas. 4 hours.
  - Regional course in agricultural research for sustainable development. (IICA/CATIE). 2 hours.

Technical Accomplishments

The following three theses were completed during 1994:

LOPEZ, F. S. 1994. Determining economic and comparative profitability of natural forest management activity with regards to livestock. Cordillera Volcanica Central, Costa Rica. Mag. Sc. Thesis. Turrialba, Costa Rica. CATIE. 115 p.

- The study determines and compares the financial profitability of the initial operations in the forest management for the sustainable production of timber in relation with the live stock activity of the double purpose.

  The work was developed in 12 farms located inside the Conservation Area of the Central Volcanic Cordillera (FUNDECOR). Seven of the farms combined their activities, live stock with forestry, while the other five are exclusively forestry lands.

The average intensity of timber exploitation in natural forests was 39%, in an average effective management area of 50.4 ha and with an average extracted volume of 564.5 cubic meters. The average total cost of the initial operation of forest management was 1.871 colones (US$32,15) per cubic meter of roundwood extracted. The gross margin resulting from the operation amounts to 3.853 colones (US$24,9) per cubic meter.

It was also estimated the best level for the extraction of roundwood of 525,8 m^3 for all effective management area with a minimum cost of 1.160 colones (US$7,5) per cubic meter.

The average profitability on the variable cost was 19.4% for all the investments of the farms assigned to the management activity. While the profitability on the variable cost of the live stock activity as estimated in 4.0% for all investments.

The return (repayment) for each unit of investment in variable cost was estimated to be 8.6 colones for the forest management activity, and 1.5 colones for livestock, and in each case it is larger than 1, but the return of the investment in variable costs of management activity is higher than the live stock in the period of the considerate study (1993/1994).

SARAVIA, A. A. 1994. Economical impact analysis: how will the construction of the Angostura Hydrological Project will affect ecotourism activities in Turrialba, Costa Rica.

- This study evaluated the effect of constructing the Angostura Hydroelectric Project (AHP) on ecotourism activities, especially on rafting. The river (9.5 km) between Tucurrique and the Angostura bridge has the ideal characteristics for this sport for inexperienced rafters, and with this project it would be eliminated.

  The area was visited and the principal impacts that the AHP would have were identified through a literature review and surveys. These were classified according to tangible and intangible costs, and a methodology was designed to evaluate each one.

  To determine impacts related with rafting, those sectors involved with this activity were determined. These were identified as tourists, rafting companies, population, restaurants and hotels; different surveys were elaborated to compile information from each of these groups. Results obtained were analyzed with the help of the Quattro Pro software.

  Results showed that incomes lost from this activity per group would be the following: hotels US$1,688,755.20, restaurants US$68,812.80, and the rafting companies US$10,313,895.00.

  If the rafting activity disappears on the Reventazon river, total losses would be US$43,729,150.50, which amount to 7.6% of Costa Rica's total income from tourist.

SOIHET E. C. 1994. Knowledge, acceptance and consequences of the possible application of a certified system on sustainable management of Costa Rican forests.

- This work consisted of an exploratory study to determine the existing degree of knowledge in Costa Rica concerning wood certification, whether this being currently applied, and whether consumers are willing to adopt the practice of consuming certified wood with the implications that this involves.

  Five groups which could be involved in wood certification were determined, namely: consumers, sawmills, forest owners, public servants and environmental NGO's; a different survey was elaborated for each of these.

  The study conducted in the cities of Alajuela and Limon, since 77.6% of Costa Rica's wood is produced there. San Jose was chosen for consumer surveys, since it is the greater consumer center in the country.

  Among the main results, we find that 100% of the population, 81% of sawmill owners, 11% of NGO's and 15% of state workers do not know about the certification system. However, when they are told on what this consists, and the degree of acceptance measured, it was determined that the population accepts and is willing to pay 17% more for certified wood, and 65% of the sawmills and forest owners are willing to adopt it.

Participation in world congress.

III World Congress of Ecological Economics. International Society for Ecological Economics. San Jose, Costa Rica. Paper Presented. Economics vs. Timber Pricing and its Probable Impact in National Accounts: The Costa Rican Case. 1980-1991. Page 140 of the Abstract of the Congress.

Participation in special commissions.

Working group of the Trent/Chapingo natural resources network. Prepared for the Government of Canada under the First Round of Proposal. Representing CATIE as a potential collaborative institutions.

Costa Rican national commission for the adjustment of national income accounts. Working group of experts from various Costa Rican institutions and international institutions under CR/World Bank/UNDP financing and auspices. This will continue through 1995.

Forest, Trees and People Project. FAO/Regional Project. Representing CATIE in the Advisory Council.

Support for CATIE project formulation

The area collaborated in the preparation of three project proposals with the Strategic Planning and External Relations Office:

- Water Development Project: Chixoy River Basin Guatemala.
- Watershed Development Project: Bayano, Panama.
- Agricultural Research Development Project: Northern Chapare Regional Institute. Bolivia.

Creation of the Agroforestry Regional Center for Small Farmers, Indigenous Producers and Women for Central America: La Lola Center (first draft).

II.

EDUCATION ACTIVITIES

"Empoverment of people through knowledge; strengthening of organizations through human resource development and technical cooperation".

EDUCATION FOR DEVELOPMENT AND CONSERVATION PROGRAM (EDECO)

The Development and promotion of technological options and practices appropriate for tropical ecosystems faces the problem of a lack of human resources with the necessary abilities and knowledge to conduct research, education and strategic management for sustainable development and conservation of fragile ecosystems. The Program works closely with the research programs. Its objective is:

> *To develop, specialize and train human resources with the necessary attitudes, abilities and knowledge to promote and implement sustainable natural resources management, conservation and use in the American tropics, with the participation of the community.*

The Program has three fundamental lines of work: formal post-graduate education, training and communication and information systems.

This report comprises the activities undertaken by the different Areas and Units of the Program of Education for Conservation and Development. The Areas of Graduate Studies, Training and Outreach as well as the Information and Communication System will individually report activities performed in 1994 after the general information of the program that follows:

At The Program Level

The main activities of the program during 1994 were:

- Internal consolidation of activities according to CATIE's Strategic Plan
- Funding efforts.
- Strategic Alliances and Networking for Educational Activities
- CATIE's Ph. D. Program

Internal Consolidation

Significant efforts were made to streamline the program in order to comply with its mission. These efforts included:

- Complete review and refocusing of the graduate courses. This was done in collaboration with the technical areas of the institution and was completed in the first quarter of the year.

- Improved organization of library facilities and integration of services with those of INFORAT (Latin American Forestry Information).

- Functional contacts were made with the technical areas of research programs to better coordinate CATIE's training and outreach activities.

- Integration of an information systems and communications advisory committee and Computer Center's advisory committee to better guide respective activities in relation to the institution's mission.

- Computerization of the graduate school's administration system was completed in 1994.

- Communication with alumni was improved through PASE (Program for Advising and Follow-up of Alumni).

- Several promotional materials featuring the training, graduate studies and other educational services that CATIE offers were produced and distributed world-wide. These materials included videos and bulletins.

- The development and finalization of the Program's Plan of Action for 1995-1997.

Funding

The program's major efforts went into the preparation of several proposals and in certain cases the negotiation for funding. These included:

- Interamerican plan for higher education (PIESA). This project proposal was rolled over from 1993. Despite intense review and revision its fate for funding is still pending. The plan calls for scholarship funds for graduate students and costs to cover training and the preparation of educational materials.

- Encounter with Turrialba. This proposal's main objective is to create an avenue through which former graduate students (alumni) can come back to CATIE a certain number of years after their graduation. Funding was secured for the 1995 Encounter.

- A regional technology transfer proposal for US$1,0 million has been submitted to the Kellogg Foundation. According to the latest reports Kellogg is revising this proposal.
- Strengthening of higher education proposal submitted to DANIDA for US$2.500,000.

- Training and Graduate Studies in Research for Development for Sustainable use of Agriculture in the American Tropics. CIAT/CATIE for US$550,000 approved for financing by IDB (Interamerican Development Bank).

- A proposal requesting professors or international staff in Agroforestry and a Biometrician/Information Specialist has also been submitted to U.N. Committee for Intergovernmental Migration (CIM)/GTZ in Germany through their office in San Jose. This request is being evaluated by the respective organization.

- A proposal, along with Université Laval, and the University of Alberta (in Canada) was submitted to the consideration of the Canadian international Development Agency (CIDA) for US$375,000, for a joint Master's degree in Agroforestry.

Strategic alliances and networking:

* Networking: Major work in this area has been to further consolidate the Regional Network for Cooperation in Higher Education and Agricultural and Natural Resources (REDCA) as one of the main outreach mechanism that the institution has available. To this effect two main activities took place.

- National Committees of REDCA in Mexico and Venezuela were formally established and began work. Thus National Committees have been established in all the countries of CATIE's mandate except Belize. Efforts are being made to establish this country's national committee in 1995.

- Coordination of the executive committee meeting and general assembly meeting of REDCA 1994, both held in Guatemala City. Representatives from all the national committees participated (over 100 delegates from 12 countries).

- REDCA's collaboration has been very important in taking several of our training courses to the countries using funds from the Dutch External Cooperation earmarked for strengthening REDCA's institutions.

- Special emphasis was also placed on strengthening other traditional alliances with OUI (Inter-American Organization of Universities), NATURA (European Network of Agricultural Universities), among others.

* Strategic Alliances: The program has dedicated itself to establishing strategic alliances in line with CATIE's Strategic Plan and EDECO's main Plan of Action. These include:

- The establishment of strategic alliances with Colorado State University and the University of Florida to begin a Ph. D. Program at CATIE in Tropical Forestry and Agroforestry. Development of this strategy has been very encouraging and there are significant advances along these lines as can be seen from the section on Ph. D Programs later in this report.

- Strategic alliances with IICA (Inter-American Institute for Cooperation on Agriculture) following the directives given by the Director Generals of both IICA and CATIE. These involved four levels of activities concerning educational services.

- IICA's support to fund graduate students from the Interamerican Member Countries. Three graduate students started their studies in January 1995 funded by IICA as the first step in a greater collaborative plan for the future.

CATIE's Ph. D. Program

This initiative has been under discussion and documented, but it was not until the last six months of 1994 that EDECO established functional contacts with several institutions in the United States. Of these, the Colorado State University (CSU) and the University of Florida responded positively. By the end of 1994, CATIE/CSU Joint Ph. D. Program Document was successfully drawn up. Discussions for a program involving the University of Florida are currently in progress. The CSU/CATIE Ph. D. program has the following main features:

- Tropical Forestry within the context of Natural Resources.
- Degree Granting Institution. CATIE with the recognition of CSU.
- Students will be admitted to this program upon successful completion of admission requirements of CSU and acceptance by CATIE.
- Students will be enrolled in CATIE but will take some of their graduate courses (according to their individual programs) at CSU as non degree students of CSU. Credits for the courses will be transferred to CATIE.
- Upon the successful completion of qualifying exam established by CATIE-CSU students will take their research residence in CATIE.
- Students can have their major professor at CSU or at CATIE depending on the individual's interest. In either case there will be a co-advisor at the corresponding institution.
- At least one of the student's committee members will be from either CATIE or CSU.
- CATIE's faculty in Tropical Forestry will have an affiliate professor status at CSU and similarly, CSU's faculty member in tropical forestry or natural resources will have affiliate professor status at CATIE.

The joint Ph. D. program on Agroforestry with the University of Florida is being planned and developed using the same structure and characteristics as the one with CSU.

The proposed date for starting the CATIE/Ph. D. program with CSU is the fall of 1995, following approval by CATIE's Board of Directors.

Budgetary Notes

The program's 1994 Annual Budget and its applications are shown in the following table.

Table 27. EDECO Program Budget for 1994, including all sources of funding.

AREA/UNIT	BUDGET US$		SOURCE OF FUNDING
Program Directorate	70,168		CATIE's core budget
Graduate Studies Area	535,606		
		227,221	CATIE's core budget
		308,385	The Netherlands project
Training Area	225,960		
		104,080	CATIE's core budget
		24,495	The Netherlands project
		97,385	JICA Agroforestry course
Communication and Information Area	1,109,719		
Computer Center and Biometric Unit		280,839	CATIE's core budget
Library and Documentation		343,057	CATIE's core budget US$112,465 IICA's contribution US$123,482 The Netherlands project US$107,110
Design and Printing Unit		61,509	CATIE's core budget
Public Relations		50,000	CATIE's core budget
Agroforestry in the Americas Journal		40,993	DANIDA
Central America Forestry Journal		220,571	FINNIDA
IPM Journal		112,750	RENARM/G-CAP
TOTALS	**1,941,453**		

This total does not include the salaries and benefits of the 35 professors, and their operating costs, which is included as contributions to the research budget.

GRADUATE STUDIES AREA

The general objective of the graduate studies area is:

> *To direct and administer the oldest graduate school in Latin America in the field of agriculture and natural resources, emphasizing sustainable development with a vision of the future,maintaining its leadership and relevance in the formation of human resources at the MS and Ph.D. level.*

The major characteristics of CATIE graduates are:

- multidisciplinary and holistic training.
- emphasis on sustainable agriculture and integrated management of natural resources.
- appropriate technology and community participation and
- administrative and communication capabilities.

CATIE master's program has the following options:

Sustainable Tropical Agriculture with specialization in:

- Tropical Crops.
- Plant Protection.
- Agroforestry Systems.

Integrated Management of Natural Resources with specialization in:

- Watershed Management.
- Management and Conservation of Biodiversity.
- Management and Silviculture of Tropical Forests

The planning and approval process for the of Environmental Economics and Sociology specialization within Natural Resources was completed and the new options will begin in January of 1996.

Major Activities Of The Area In 1994

Graduate Enrollment

1994 saw the consolidation of efforts begun in 1993. A total of 264 students requested admission to the Master's program in 1994. Of these, 102 were admitted and 50 have begun studies. A major change made during 1994 was the decision to have two enrollment periods: one in late March and another in late August.

This change was made to enable admitted candidates to secure outside funding sources. Under the previous system this was not possible.

Of the 264 candidates that applied for admission in 1994,a total of 160 (or 43.9%) came from CATIE member countries. This indicates that the institution has substantial prestige and credibility throughout the region.

Major Sources Of Financing

The average cost of a two year CATIE course of studies is US$32,000 or roughly US$16,000 a year. Table 28 shows that in 1994, 12 more assistantship were available compared to 1993.

In 1994 the major source of funding for assistantships were the Regional Natural Resources Management Program of the U.S. AID (RENARM/G-CAP) financed assistantship with a total of 17 followed by the Dutch government with 9. Other important donors were Germany's Academic Exchange Program (DAAD) and the Overseas Development Administration of the United Kingdom (ODA) with 5 assistantship each.

The total received in 1994 for financing graduate assistantship for the two year period 1994/1995 was nearly US$1.6 million.

Table 28. **Source and amount of funds of scholarships during 1994 at CATIE's graduate studies program.**

SOURCE	CLASS 93-94 No.	CLASS 93-94 US$	CLASS 94-95 No.	CLASS 94-95 US$	TOTAL
I. Bilateral Agreement/countries					
USAID/BRAZIL	0	0	0	16.190	16.190
IPM-NORAD Project (Nicaragua)	2	31.680	0	0	31.680
II. National Institution funds					
CONACYT-MEXICO	1	15.840	0	0	15.840
INIFAP-MEXICO	0	0	1	16.190	16.190
CORDEP-BOLIVIA	0	0	1	16.190	16.190
EMBRAPA-BRAZIL	1	15.840	3	48.570	64.410
PROINPA-BOLIVIA	1	15.840	0	0	15.840
SEFORVEN-VENEZUELA	0	0	1	16.190	16.190
III.Scholarships given by CATIE grant projects					
RENARM PROJECT	9	142.560	17	275.230	417.790
NATURAL FOREST	(4)	(63.360)	(5)	(80.950)	(144.310)
WATERSHED MANAGEMENT	(3)	(47.520)	(8)	(129.520)	(177.040)
IPM	(2)	(31.680)	(4)	(64.760)	(96.440)
OLAFO PROJECT	2	31.680	2	32.380	64.060
GTZ PROJECT	1	15.840	0	0	15.840
IV.Scholarships sponsored by cooperating countries and administrated by CATIE					
NETHERLANDS	13	205.920	9	145.710	351.630
DAAD-GERMANY	5	62.750	5	75.250	138.000
ODA-UNITED KINGDOM	1	15.840	5	80.950	96.790
V. Others					
FAO	0	0	2	32.380	32.380
KELLOGG	0	0	1	16.190	16.190
MUTIS-SPAIN/IICA	0	0	2	32.380	32.380
OAS	2	31.680	0	0	31.680
TOTALS	**38**	**585.470**	**50**	**809.500**	**1.394.970**

Note: 50% of these totals are returned to the students, so that they can cover their housing, board and personal expenses.

Students of the 1994/95 Class by source of Funding, Nationality and Field Of Interest.

Tables 29 and 30 show a summary of the major characteristics of the 1994/95 class. It indicates that agroforestry and watershed management were the two major areas of interest for the students in this class.

Table 29. Students of the 1994/1995 Class by source of funding, nationality and field of interest.

NAME	COUNTRY	SOURCE OF FUNDING
SUSTAINABLE TROPICAL AGRICULTURE		
PLANT PROTECTION SYSTEMS		
Chavez Fallas Lilliana	Costa Rica	RENARM/IPM
Herrera Jacquelin Francois	Guatemala	DAAD (Germany)
Miranda Corrales Jorge Eduardo	Costa Rica	RENARM/IPM
Padilla Raudales Mario Roberto	Honduras	RENARM/IPM
Perez Jimenez Osvaldo Eddy	Dominican Rep.	ODA (U. K.)
Ruiz Silvera Carlos Argenis	Venezuela	Netherlands
Suazo Hernandez Pilar Enrique	Honduras	RENARM/IPM
Zamora Solorzano Martha Elizabeth	Nicaragua	DAAD (Germany)
TROPICAL CROPS		
Souza Rodriguez Vanda Gorette	Brazil	EMBRAPA (Brazil)
Wilches Morales Aida Vanessa	Colombia	Netherlands
AGROFORESTRY SYSTEMS		
Cadima Medrano Nancy De Fatima	Bolivia	FAO
Camas Gomez Robertony	Mexico	INIFAP (Mexico)
Chaimsohn Francisco Paulo	Brazil	MUTIS (Spain)
Duarte Ribeiro George	Brazil	EMBRAPA (Brazil)
Hazel Filho Aderaldo	Brazil	EMBRAPA (Brazil)
Hernandez Guerra Oscar	El Salvador	MUTIS (Spain)
Lopez Ortiz Silvia	Mexico	KELLOG (U.S.A.)
Mora Mora Luis Idelso	Venezuela	ODA (U. K.)
Paz Quevedo Napoleon Edgardo	El Salvador	DAAD (Germany)
Quintanilla Quintanilla Juan Rosa	El Salvador	DAAD (Germany)
Samaniego Peña Juan A.	Panama	Netherlands
Shiguemi Tawara Carlos	Brazil	ODA (U. K.)
Tavares Da Costa Fernanda Carla	Brazil	AID (U.S.A.)
Urgiles Contreras Jose Francisco	Ecuador	ODA (U. K.)
Yañez Kernke Marcia Adriana	Mexico	ODA (U. K.)
Zelada Sanchez Efrain	Bolivia	CORDEP (Bolivia)

INTEGRATED MANAGEMENT OF NATURAL RESOURCES

TROPICAL FOREST MANAGEMENT AND SILVICULTURE

Colan Colan Violeta Bertha	Peru	Netherlands
Diaz Peña Yajaira Violeta	Venezuela	Seforven (Venezuela)
Granador Lorca Jose Nicolas	Guatemala	RENARM/Nat. Forest
Herrera Fernandez Bernal	Costa Rica	RENARM/Nat. Forest
Lacayo Ortiz Blanca Isabel	Nicaragua	RENARM/Nat. Forest
Rodriguez Alfaro Juan Jose	Costa Rica	RENARM/Nat. Forest
Sanchez Sanchez Mario	Bolivia	FAO
Saravia Cruz Henry Antonio	Nicaragua	RENARM/Nat. Forest
Vasquez Mejia Jorge Obispo	Guatemala	DAAD (Germany)

WATERSHED MANAGEMENT

Baides Portillo Jose Rafael	El Salvador	RENARM/Watershed
Castañeda Romero Luis Fernando	El Salvador	RENARM/Watershed
De La Piedra Constantino Ruben.	Mexico	Netherlands
Goitia Antezana Jorge Milton	Bolivia	Netherlands.
Medina Banegas Juan Manual	Honduras	RENARM/Watershed
Melgar Douglas Armando	El Salvador	RENARM/Watershed
Mendoza Garcia Roger Baltazar	Honduras	RENARM/Watershed
Saenz Segura Fernando	Costa Rica	RENARM/Watershed
Suazo Cervantes Mauro Silvio	Honduras	RENARM/Watershed
Turcios Carrasco Willmer Reynaldo	Honduras	RENARM/Watershed

BIODIVERSITY MANAGEMENT AND CONSERVATION

Galvez Ruano Jose Juventio	Guatemala	OLAFO (Sweden)
Mou Sue Luis Lin	Panama	Netherlands
Pinazzo Salinas Jorge Amado	Paraguay	Netherlands
Reyes Rodas Reginaldo	Guatemala	OLAFO (Sweden)
Sencion Irazabal Gustavo	Uruguay	Netherlands

Table 30. Total of graduate students at CATIE during 1994, by specialization.

SPECIALIZATION	NUMBER OF STUDENTS/CLASS		TOTAL
	93-94	94-95	
Tropical Crops	3	2	5
Plant Protection	9	8	17
Agroforestry Systems	7	16	23
Tropical Forest Management and Silviculture	9	9	18
Watershed Management	7	10	17
Biodiversity Management and Conservation	1	5	6
TOTAL	42	50	92

The major changes between the two classes are the following:

- a reduction in interest in tropical crops,
- a total lack of interest in livestock production, and
- increased importance of the specialization management and conservation of biodiversity.

In general the institution appears to be experiencing a slow but systematic move away from agricultural related areas, with the exception of plant protection, towards natural resources management, perhaps as a reflection of priorities and concerns for the environmental and conservation problems affecting the countries of the region.

Courses

Table 31. shows a list of courses taught at the Graduate School during the academic year of 1994, their professors and the number of students.

Table 31. Courses Taught at the Graduate School during the Academic Year of 1994.

First Quarter	Professor	Students	Credits
Statistics	Pedro Ferreira	52	4
Introduction to Agricultural Economics	Juan Aguirre	50	3
Ecological Basis for Sustainable Production	Bryan Finnegan	50	3
English	Xinia Chacon	52	0
Utilization and Management of Scientific Literature	Laura Coto	50	0
General Dasonomy	Daniel Marmillod	50	2
Genetics	Assefaw Tewolde	7	2
Introduction to Integrated Pest Management	Octavio Ramirez	7	3
Second Quarter			
Experimental Design	Pedro Ferreira	43	3
Administration and Management of Agricultural Research	Juan Aguirre	19	3
Natural Resource Economics	Steven Shultz	23	3
Agrometeorology	Francisco Jimenez	6	3
Plant Physiology	Ana Abdelnour	7	3
Introduction to Biotechnology	Jean V. Escalant	7	3
Plant Improvement	Jorge Morera	3	3
Insect Management	Luko Hilje	8	3
Diagnostics in IPM I	Elkin Bustamante	9	3
Ecological Basis of Silviculture and Agroforestry	Bryan Finnegan	25	3
Foodstuffs Utilization and Evaluation	Maria Kass	5	3
Dendrology	Luis Poveda	6	2

Hydrology and Hydraulics	Hernan Solis	10	3
Planning of Natural Spaces	Jose Luis Villa	10	3
Community Participation and Organization	Alejandro Martinez	11	2
Third Quarter			
Rural Development	Fernando Ferran	15	3
Sampling Techniques	Pedro Ferreira	11	2
Plant Anatomy	Nelly Velasquez	3	3
Introduction to the Dynamics of Agroforestry Systems	Jose Arze	4	3
Plant Genetics Resources	Jorge Morera	4	3
Population Genetics	Assefaw Tewolde	3	3
Crop Systems	Marikis Alvarez	3	3
Diagnostics in IPM II	Daniel Coto	8	3
Nematode Management	Nahum Marban	8	3
Agroforestry Systems	Donald Kass	18	3
Animal Production Systems	Federico Hollman	4	3
Global Tendencies in Agroforestry Systems Seminar	Gerardo Budowsky	25	1
Soil and Water Conservation	Jorge Faustino	15	3
Management of Geographic Information Systems	Sergio Velasquez	22	3
Management of Wildlife	Dagmar Werner	5	3
Ecology and Management of Coastline Ecosystems	Alejandro Imbach	5	3
Management of Protected Areas	Miguel Cifuentes	10	3
Management of Forestry Seeds	Rodolfo Salazar	3	2
Forest Plantation Silviculture	Luis Ugalde	16	3
Forest Economics	Juan Aguirre	10	3
Fourth Quarter			
Sustainable Management of Tropical Soils	Donald Kass	7	3
Tissue Culture	Jean V Escalant	1	3
Advanced Genetics	Assefaw Tewolde	2	3
Plant Disease Management	Elkin Bustamante	8	3
Weed Management	Bernal Valverde	8	3
Economics of Plant Protection	Octavio Ramirez	8	3
Research Methodology in Agroforestry Systems	Luis Camero	14	3
Pasture and Forage Production and Utilization	Muhammad Ibrahim	6	3
Animal Evaluation	Assefaw Tewolde	2	3
Land Use Planning	Jorge Faustino	10	3
Watershed Management	Carlos Rivas P	11	4
Forestry and Agroforestry Project Identification, Formulation and Evaluation	Juan Aguirre	29	3
Environmental Sociology	Jan Karremans	9	3
Extension and Communication	B Ramakrishna	8	3
Biodiversity Policy and Legislation	Alejandro Imbach	8	3
Natural Forest Silviculture	Ian Hutchinson	13	3
Genetic Improvement of Forest Species	Jonathan Cornelius	4	3
Forest Management	Juan Flores/JJ Campos	10	3

Other Activities

In 1994 the Graduated Studies Areas began a series of administrative changes that provided closer relations for students and professors with the area.

The changes introduced were:

- Direct technical revision and screening of all applications on an individual basis in close coordination with each technical area.
- Increased selection pressure: the minimum admission grade was raised from 70% to 75% and in 1995 it is expected to rise to 80%,
- Earlier announcement of admitted candidates to facilitate the search for other sources of financing,
- Monthly meetings between the head of the area and the student body to discuss technical and administrative problems, affecting the students.
- Closer coordination and joint activities were possible, with the heads of the technical areas.

These activities support all the normal technical and administrative activities and enhance the area's service capabilities.

Major Achievements Of The Graduate Studies Area For 1994

- Revised the Graduate Studies Area options to update its quality and contents.
- Approved a new option in Environmental Economics and Sociology.
- Released the admission decisions earlier which, in 1995, allowed at least 10 of our students to secure other sources of funding.
- Improved and increased promotional campaign to further advance CATIE's status as an alternative Graduate Studies Center in the region with the support of IICA, local offices and REDCA local chapters.
- Established the ground work for Ph. D. Studies in 1996.
- Established strategic alliances with Colorado State University, University of Florida, Université de Laval, University of Alberta, and NATURA in Europe.

TRAINING AREA

Training is a teaching and learning process whose general objective is:

> *To promote the acquisition of knowledge and abilities of Latin American and Caribbean professionals, and modify attitudes referring to a specific occupational field, through the development of short-term activities.*

These activities are implemented in the context of CATIE's strategies and actions relative to the REDCA, taking advantage of the opportunities for collaboration that this has to offer.

Given that CATIE's Educational mandate is extended to the American Continent, its focus is centered on the realistic demands of countries in the Americas. This is done with the active participation of CATIE's two technical programs, at the Center's headquarters as well as in member countries. During 1994, CATIE followed the following basic strategies:

- Different training methods according to the audience and the objectives sought.
- Decentralization of training events developed in Turrialba.
- Promotion of educational materials production.
- Strategic alliances.
- Strengthening of the institution's strategic courses.

During 1994, 1000 information booklets, 5000 brochures, and 1500 information sheets were distributed to different institutions in Latin America for training events.

An information system was developed to register training activities in a data base, to support decision adoption at different levels. The system stores data on students, courses (events) and professors to produce precise, up-to-date information which can be used at any time.

In 1994, 222 training events for 5659 people were held both in Turrialba and outside, mainly in the member countries. Of these, 137 were courses with 2254 participants, and workshops with 2466. CATIE supported national institutions in member countries in direct activities such as field days with producers, in which 8056 people participated.

The number of students, days and events per type carried out in 1994 in CATIE, is shown in Table 32. The majority of activities are related to strategic and special courses. Although the number of special courses was greater (36) than strategic courses (15), the time spent on strategic courses expressed in hours/student is greater (4477) than for special courses (4193).

Table 32. Training Activities In Turrialba. 1994

Number of activities, days, and events by type

	Students	Days	*Events*
Strategic courses	187	4,477	*15*
Special courses	547	4,193	*36*
Meetings	47	265	*2*
Workshops	142	586	*4*
TOTAL	923	9,521	*57*

Table 33. shows the number of strategic courses offered during 1994, number of students, length in days and number of countries which sent students to each of the courses.

Table 33. Strategic Courses 1994

(days, students, and countries of origin)

COURSES	DAYS	STUDENTS	COUNTRIES
Special Course For Agricultural Librarians and Docum.	12	2	*1*
Data Base Formation Using Micro Cds-Isis (Module Ii)	12	14	*6*
Agricultural Simulation and Expert Systems	26	9	*6*
Specialization In Agroforestry Systems Development	81	21	*13*
International Course for Genetic Resources and Their Use	12	11	*7*
Technical-Practical Course of Tissue Cultures	12	12	*10*
XVI Protected Areas Course	29	28	*16*
Geographic Information Systems	12	18	*7*
Watershed Rehabilitation	12	20	*7*
Biodiversity Management	19	11	*6*
Forestry Genetic Breeding	26	11	*4*
Identification, Selection and Management of Seed Stands	12	24	*10*
Librarian Specialization (Module I)	12	6	*4*
TOTAL	277	187	

Table 34. shows in detail the number of students and time spent in days/student, per participant's country for all of the training events carried out in Turrialba.

Table 34. Training Activities by Country. Turrialba, 1994

COUNTRIES	STUDENTS	DAYS
ARGENTINA	6	43
AUSTRALIA	2	10
BARBADOS	1	3
BELIZE	1	81
BOLIVIA	22	410
BRAZIL	26	483
CANADA	1	3
COLOMBIA	26	277
COSTA RICA	172	1,408
CUBA	3	35
CHILE	9	90
ECUADOR	13	346
EL SALVADOR	132	1,193
SPAIN	1	7
UNITED STATES	19	85
FRANCE	2	8
GERMANY	5	19
GUATEMALA	145	1,223
GUYANA	1	3
HOLLAND	9	39
HONDURAS	38	614
ITALY	1	3
JAMAICA	1	3
JAPAN	1	32
MEXICO	23	338
NICARAGUA	96	844
PANAMA	84	704
PARAGUAY	4	37
PERU	11	172
DOMINICAN REPUBLIC	22	465
SWITZERLAND	1	5
SURINAME	2	14
TRINIDAD	3	9
URUGUAY	8	112
VENEZUELA	15	308
VIETNAM	2	16
OTHERS	15	79
TOTAL	923	9,521

Training activities conducted outside Turrialba, principally in CATIE's member countries through specific projects, have offered training for 4736 participants, in 165 training events involving a time commitment of 151,342 days/student. Tables 35, 36 and 37 show the number of events, students and time involved in days/student in member countries where projects conducted training activities in 1994.

Table 35. Training Events in Member Countries
Events by country and project

PROJECT	CR	ES	GU	HO	MEX	NI	PA	RD	TOTAL
Protected Areas	1					1			2
Library Science	4								4
Biotechnology	2								2
Mangrove						12			12
Forestry Genetic Improvement	2								2
NRI-Biotechnology Control	1					2			3
OLAFO/Biodiversity	10		1			8	2		21
PROSEFOR/Forestry Seeds	5	6	2	1			1	2	17
Plant Genetic Resources	4								4
RENARM Projects	46	9	12	6		16	2	1	92
Central America Forestry Journal	1	2				1			4
REDCA		1			1				2
TOTAL	75	17	17	7	1	39	6	3	*165*

CR=Costa Rica ES=El Salvador GU=Guatemala HO=Honduras
Mex=Mexico NI=Nicaragua PA=Panama RD=Rep.Dom.

Table 36. Training Events in Member Countries.
Students By Country And Project

PROJECT	CR	ES	GU	HO	MEX	NI	PA	RD	TOTAL
Protected Areas	29					16			45
Library Science	15								15
Biotechnology	11								11
Mangrove						183			183
Forestry Genetic Improvement	12								12
NRI-Biotechnology Control	50					80			130
OLAFO/Biodiversity	166		25			137	16		344
PROSEFOR/Forestry Seeds	102	126	53	25			23	60	389
Plant Genetic Resources	24								24
RENARM Projects	1,213	184	1,042	155		814	46	11	3,465
Central America Forestry Journal	13	22				21			56
REDCA		42			20				
TOTAL	1,622	365	1,142	180	20	1,230	106	71	*4,736*

CR=Costa Rica ES=El Salvador GU=Guatemala HO=Honduras
Mex=Mexico NI=Nicaragua PA=Panama RD=Rep.Dom.

Table 37. Training Events in Member Countries. Students-Days By Country And Project

PROJECT	CR	ES	GU	HO	MEX	NI	PA	RD	TOTAL
Protected Areas	841					16			*857*
Library Science	182								*182*
Biotechnology	132								*132*
Mangrove						590			*590*
Forestry Genetic Improvement	330								*330*
NRI-Biotechnology Control	250					80			*330*
OLAFO/Biodiversity	1,594		75			208	32		*1,909*
PROSEFOR/Forestry Seeds	475	229	157	100			92	162	*1,215*
Plant Genetic Resources	207								*207*
RENARM Projects	13,964	729	122,125	682		7,144	349	66	*145,059*
Central America Forestry Journal		65	123				21		*209*
REDCA		126			200				
TOTAL	17,975	1,149	122,480	782	200	8,038	228	228	*151,346*

CR=Costa Rica ES=El Salvador GU=Guatemala HO=Honduras
Mex=Mexico NI=Nicaragua PA=Panama RD=Rep.Dom.

Tables 38, 39 and 40 present in detail the number of events, students and effort level days/student per type of training event conducted by CATIE's projects outside Turrialba.

Table 38. Training Events in Member Countries. Events by type of events and project

	IT	CU	TM	SE	W	*TOTAL*
Protected Areas		1	1			2
Library Science	2	2				*4*
Biotechnology	1	1				2
Mangrove		8			4	*12*
Forestry Genetic Improvement	1	1				2
NRI-Biotechnology Control			1	2		*3*
OLAFO/Biodiversity	1	14			6	*21*
PROSEFOR/Forestry Seeds		10		2	5	*17*
Plant Genetic Resources	2	2				*4*
RENARM Projects	10	43	1	24	14	92
Central America Forestry Journal		3			1	*4*
REDCA		1			1	2
TOTAL	17	86	3	28	31	*165*

IT= In-service Training CU=Course TM=Technical Meeting SE=Seminar W=Workshop

Table 39. Training Events in Member Countries. Students by type of events and project

	IT	CU	TM	SE	W	*TOTAL*
Protected Areas		29	16			*45*
Library Science	2	13				*15*
Biotechnology	1	10				*11*
Mangrove		108			75	*183*
Forestry Genetic Improvement	1	11				*12*
NRI-Biotechnology Control			35	95		*130*
OLAFO/Biodiversity	1	240			103	*344*
PROSEFOR/Forestry Seeds		236		37	116	*389*
Plant Genetic Resources	2	22				*24*
RENARM Projects Central America Forestry Journal	21	796 35	25	2,292	331 21	*3,465* *56*
REDCA		20			42	*62*
TOTAL	28	1,520	76	2,424	688	*4,736*

IT= In-service Training CU=Course TM=Technical Meeting SE=Seminar W=Workshop

Table 40. Training Events in Member Countries. Students-days by type of events and project

	IT	CU	TM	SE	W	*TOTAL*
Protected Areas		841	16			*857*
Library Science	26	156				*182*
Biotechnology	12	120				*132*
Mangrove		277			313	*590*
Forestry Genetic Improvement	22	308				*330*
NRI-Biotechnology Control			35	295		*330*
OLAFO/Biodiversity	5	1,684			220	*1,909*
PROSEFOR/Forestry Seeds		1,051		48	116	*1,215*
Plant Genetic Resources	20	187				*207*
RENARM Projects Central America Forestry Journal	106	3,463 188	25	140,639	826 21	*145,059* *209*
REDCA		200			126	*426*
TOTAL	*191*	8,475	76	140,982	1,622	***151,346***

IT= In-service Training CU=Course TM=Technical Meeting SE=Seminar W=Workshop

Main Achievements in Training

- Increased the number of training events from 120 in 1993 to 222 in 1994.
- Increased the total of professionals trained from 1300 in 1993, to 5659 in 1994.
- Integrated the total number of countries represented in training to 36.
- Integrated the work of the main projects in CATIE to offer training as a unit rather than like separate entities thus increasing the area of coverage more effectively.

Project Training Activities

Some important training activities promoted by different projects are presented in the following paragraphs:

INIBAP

Besides other activities sponsored by INIBAP-LAC in different member country, training at CATIE has been focused on tissue culture. During 1994, CATIE organized a hands-on tissue culture course (May 16-27, 1994), which was attended by participants from 10 countries. INIBAP-LAC, sponsored the attendance of two participants from Bolivia and Dominican Republic.

Additionally, the Regional Coordinator provided information and advice to postgraduate students, who conducted research studies in *Musa* topics. He was also member of the Counselor Committee of two MS candidates.

IPM/RENARM Project

Five plant protection professionals received in-service training. More than 20 seminars and workshops were conducted, including the *III Central American & Caribbean Workshop on Whiteflies* in Antigua, Guatemala (over 100 participants) and the *Central American Seminar-Workshop on the Biology and Control of Phyllophaga*, at CATIE (60 participants), the latter funded by PRIAG and organized in conjunction with the NRI *Phyllophaga* project. The total number involved in these events exceeded 1000 people. In addition, twelve one week short courses (150 participants) and over 100 one day informal training sessions were provided (over 600 participants) were offered.

GTZ Agroforestry Project

In the area of technical training the main thrust was on monthly training events for local teams of professionals (Equipos Técnicos Locales ETL), consisting of 35 extensionists and professionals from producer organizations in Talamanca and Bocas del Toro. During 1994, 14 training events were held, emphasizing the presentation of concepts in seminars and management techniques during field days which included practical.

Madeleña-3 Project

Madeleña3 carries out its activities in each country in conjunction with the Forest Extension Network, composed of 6 counterpart institutions and 25 network members. The main objective is to disseminate forestry and agroforestry information on tree nurseries, establishment and management of forest plantations, and the economical and utilization-related aspects of MUT. Information on monitoring of extension and training activities is stored and processed under the MIRA-EXT component.

The courses plantations silviculture and information management systems were taught for CATIE's Graduate Program. Support was also provided to the course on natural resources economics.

In addition, three graduate theses were supported in CATIE, and sixteen in the member countries, at the undergraduate level.

A regional seminar on forest extension, six seminar/workshops on forest extension and five seminar/workshops on forest and agroforestry research, 16 short formal courses, 74 short events including talks, field trips, and in service training, were implemented.

Support to other CATIE Projects, such as PROSEFOR, Genetic Improvement, Watershed Management, Agroforestry, PROCAFOR 4, seven bilateral projects, CEMAPIF, *Revista Forestal Centroamericana*, as well as some Latin American universities was also provided.

More than 2000 people (20% women) including technical staff, Network extensionists and farmers, were trained on nurseries, establishment and management of Multiple Use Trees, information management, bibliographical documentation, and extensionist exchange between countries.

PROSEFOR

During 1994, PROSEFOR significantly contributed to training technical personnel in the member countries in the field of seed source identification, selection and management.

More than 300 technicians were trained, actively participation in the practical exercises, identification, selection and technical management of seed sources (Table 41.)

Table 41. Technical personnel trained by PROSEFOR in the member countries.

Country Orientation	Regional Seminars	Course Total	National	Courses
Guatemala	3	38	—	41
Honduras	3	25	—	28
El Salvador	3	55	—	58
Nicaragua	3	—	—	3
Costa Rica	4	67	—	71
Panama	3	23	17	26
Dominican Republic	3	34	26	37
Total	22	242	43	307

COSUDE Natural Forest Management Project

- Active participation in the courses 'Natural Forest Silviculture' and 'Forest Ecology' which form part of the syllabuses of the forestry degree courses of The National University (UNA) and The Costa Rican Technological Institute (ITCR).
- The Project actively participated in the following courses:
  - Interdependence: Economic Development and Environmental Concerns in Tropical Countries.
  - Management of Natural Forests (WWF and Fundación Neotropica).
  - International Course on the Management of Biodiversity.
- Training was given on aspects of directional felling, chainsaw maintenance, and the operation of frame mounted chainsaws to project workers in San Carlos, and of the projects RENARM and OLAFO in Petén Guatemala, San Juan Nicaragua and Baja Talamanca Costa Rica.
- In conjunction with the projects RENARM and OLAFO, a field day 'Sustainable Management of Natural Tropical Forests' was carried out for the benefit of journalists.
- 27 field days were held in the various Project sites.
- For the CATIE Master's degree, three courses were taught and a fourth was aided by Project staff. Dr Bryan Finnegan was named best teacher by the students.
- The special course on tropical forests was coordinated by the Project.
- Supervision (as chief supervisor) was given to seven CATIE Master's students and ten were advised (as member of the advisory committee).

- A doctoral student, two students from The National University (UNA) and one from The Costa Rican Technological Institute (ITCR) received advice.

RENARM/USAID-G-CAP Watershed Management Project

Graduate student training is an activity considered essential to the long term development of watershed rehabilitation and planning in CATIE member countries. In 1994 the RENARM/Watershed Management Project awarded scholarships to 10 students, supervised thesis research for 5 students, and taught 6 courses through the CATIE graduate program (Hydrology, Natural Resource Economics, Soil and Water Conservation, GIS Systems, Watershed Management, and Rural Extension). As well, Watershed Management staff participated in thesis committees for students in other CATIE specialty areas.

Conservation for Sustainable Development in Central America: OLAFO Project

- Graduate Program courses: Dasometry, Management of Coastal ecosystems, Community Organization and Politics and Legislation of Biodiversity given by Project staff.
- Six graduate students (M.Sc.) from CATIE and ten undergraduate students from different Universities in Central America are advised by Project staff.
- Four graduate students funded by the Project.
- Twenty training events (13 short courses, 6 workshops and two community courses) were given at the regional level on technical and administrative aspects.
- Two in-service training courses were given on: traditional techniques in natural resources management, medicinal plants and forest management.
- International Course on Biodiversity Management (strategic course), held at CATIE on September 12-30, 1994.

Wise Use of Mangrove Resources Project

- A methodological guide was prepared for the development of a program on Environmental Education to be implemented in the primary schools of the area. This program is in coordination with the Ministry of Education of Nicaragua.
- Technical assistance to national teams responsible for planing Golfo de Fonseca Project activities. The National Coordinator of the Mangrove Project is a member of the Technical Committee of the Golfo de Fonseca Project.
- Twelve training events (8 short courses, 4 workshops and 4 field days) to local groups on: forest

inventories, charcoal, iguana, shrimp and honey production, cooperative administration, community organization and forest utilization.

- Implementation of the Environmental Education Program. This program included:

  - Coordination and approval by the Costa Rican Ministry of Education.
  - Organization of teacher groups
  - Training of 22 school teachers in the area
  - Preparation of teaching materials

Area of Economics of Production and Conservation

Short term training activities.

- Organization and execution of the first international course in identification, preparation and evaluation of forestry and agroforestry projects, with a total of 12 participants.

- Lectures given for courses in other CATIE areas:
  - International agroforestry course. 2 days.
  - International agroforestry course for Ecuadorian professionals. 3 days.
  - Management of biodiversity. 2 hours.
  - Forest management and silviculture. 2 hours.
  - International courses in management of protected areas. 4 hours.
  - Regional course in agricultural research for sustainable development. (IICA/CATIE). 2 hours.

COMMUNICATION AND INFORMATION SYSTEMS AREA

Within the framework of this Area, the Program aims to disclose research results and link research with the teaching process.

To achieve this aim the Area operates two different Units: The Computing and Statistical Services Unit and the Communication Unit.

During 1994 efforts were made to implement a strategy to incorporate a wide range of activities spread through different areas or projects of the Institution into the Communication Unit. This centralization process will improve communication and dissemination of results when it is in place.

For this reason during 1994, while the centralization process took place and a Coordinator was nominated, the Area did not operate as two separate units.

Information Management System And Statistical Services Unit

The Information Management System And Statistical Services Unit provides support to the Research and Education Programs and to the Administration of data management and electronic communication. In addition, it is actively involved in the academic and research activities of the Center.

Electronic information systems are a crucial tool for the fulfillment of the strategic goals of a regional center like CATIE. The Unit develops and maintains the electronic administrative systems and provides central technical support to CATIE's projects in the development and maintenance of scientific databases.

CATIE's central computer network, now links several local area networks belonging to different Projects and Units. This network includes more than 120 terminals, providing access to central computing services, including access to Internet. Being a regional institute, CATIE puts a high priority on the areas of outreach and communications. Particular priority is given to electronic communication as a crucial tool for scientific exchange, remote education and outreach.

Graduate education in tropical agriculture and natural resources at CATIE has a significant quantitative component and produces a professional with a high computer literacy level. This is achieved through systematic training and exposure to modern software, and databases, as well as statistical and geographic information systems methodology. Our modern computer laboratories are used intensively through different stages of graduate education, as a requirement of regular courses and also as optional short term training in specific topics.

We also offer short term training in statistical and computer applications for agriculture and natural resources to professionals of the region and elsewhere.

Consulting services are provided for researchers and graduate students, mainly in the area of statistics but also for computing tasks.. Planning of experiments and sample surveys, multivariate analysis of data, and database construction and maintenance, are topics that are usually dealt with as part of the consulting activities of the Unit.

Work Lines

The Information Management System And Statistical Services Unit provides the following five types or lines of activities:

1. Electronic communications and networking.

   Internal electronic mail and remote access to databases, and worldwide e-mail and access to the services of Internet.

2. Systems development and maintenance.

Support is provided to the research and education programs, and to the administration, for systems development and maintenance.

3. Data processing, hardware and software support.

The Unit supports data processing by offering a series of options that can be reached through the terminals, microcomputers and LANs linked to the fiber optics central computer network of the institution.

4. Graduate and short term training.

The Unit actively collaborates with the Graduate School by teaching statistical courses. In addition short term training courses on statistics and the use of technical software are offered.

5. Statistical and computing consulting services.

Graduate students and researchers consult on issues such as experimental design, sample survey analysis, database development and maintenance.

Budget execution

CATIE's core budget assigned US$280,839 for 1994. This is the only financial source of the Unit.

Achievements

1. Electronic Communications and Networking.

The fiber optics backbone of the central computer network, linking the buildings that spread over CATIE's Campus, was installed during the first quarter of the year. During the second and third quarter, the network grew within the buildings, where a net of coaxial cables and UTP (i.e. telephone) cables gradually extended linking minicomputers and Local Area Networks to the main backbone. More than 120 microcomputers were connected and now have full access to the services. The total cost of the network, including the minicomputer SUN Sparcstation SS-10, was approximately $65,000.

During the third quarter of the year, connection to Internet was achieved. CATIE's internal network is linked to the national network CRNet through a 64 Kbps dedicated line. Through CRNet, CATIE has access to the Internet through a satellite link to the NSF-Sprint-Panamsat gateway in Homestead, Florida.

2. Systems development and maintenance

The most significant achievement of the year in terms of software development was the completion of the conversion of the financial software SIIF, originally running under SQL CROSS on an IBM 9375 computer, to ORACLE, running under Solaris 2.3.

After several months of parallel processing on both machines, the new ORACLE system replaced the old financial system SIIF in September 1994. Users of both systems declare that the new SIIF is four to five times faster than the old one. The smooth transition to a new modern financial software was due to the constant, efficient and responsible work of the program developers, and the constant support of the staff of the Financial Department.

A second crucial software item that was converted to ORACLE, was the Sponsored Projects Administration System (SAP), originally developed under FOX. The SAP system was converted and its financial modules were integrated with SIIF.

Several changes and improvements were introduced into the Payroll system, which at present runs under SAS-UNIX. This system was running previously under Cobol-SAS in the IBM 9375 computer. Conversion of the payroll to ORACLE is a goal for 1995.

The three systems (SIIF, Payroll and SAP) are now fully integrated and running on the central SUN minicomputer. They can be accessed, by authorized persons, from any point of CATIE's network, and from any point of the globe through Internet.

A number of other administrative applications were developed and improved during 1994. This was the case with the Graduate School, the Surveyor's Office and the Travel Agency system.

As a joint venture between IICA/PRIAG and CATIE, efforts to develop a database of agricultural technology for Central America were initiated. The structure for a database was established, and comprises a network of national databases, running under FOX, and combined into a regional database, to be located at CATIE, running under ORACLE. The FOX and ORACLE software is ready, and a training and testing period is now starting. Collection of data is expected to start in 1995.

3. Data processing, hardware and software support.

Access to central data-bases, running under ORACLE, and to central statistical software (SAS), running under Solaris 2.3/UNIX in a SUN SS-10-512 minicomputer, was offered in the last quarter of 1994. Previously databases, and SAS CMS were running in the IBM 9375 computer and in microcomputers elsewhere.

4. Graduate and Short Term Training.

Three graduate courses, namely Statistics, Sampling Techniques and Multivariate Analysis, were given by the staff of the CSSU. Teaching assistance was also provided to the graduate course of Experimental Design.

Fifteen short training courses, on issues such as 'Introduction to SAS Software: Applications to Agriculture', 'Preparing Presentations with Harvard Graphics', etc., were delivered. The total number of participants was 200, 60% women.

5. Statistical and computing consulting services.

An unknown number (>1000) of consulting meetings with students, scientists, and administrative staff, were attended. Design and analysis of experiments, multivariate analysis of data, estimation of sample sizes, database construction, etc., were frequent topics.

Communication Unit

This unit is responsible for the coordination of the Orton Memorial Library, the publishing of periodicals and extension materials produced in CATIE, the bibliographic data bases and public relations at institutional level. All these activities are dispersed in different programs, areas and projects and during 1994 efforts were made to centralize some of them when this process was evaluated as profitable.

Orton Memorial Library

The Orton Memorial Library (BCO) operates with contributions from IICA, the Dutch Government and some of CATIE's Projects such as PROMECAFE (Coffee Network in Central America, Mexico and the Dominican Republic), OLAFO (Conservation for Development Project), RENARM/AID, GTZ, IDRC and DANIDA. CATIE's core budget financed the acquisition of periodical collections in 1994, as it is shown in Table 42.

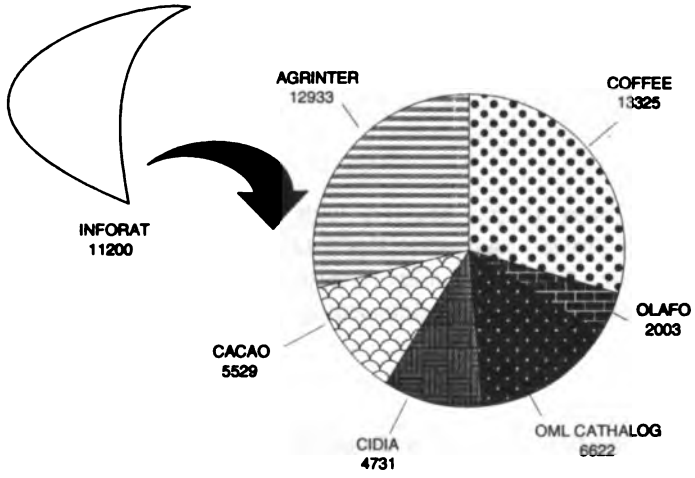
Table 42. Financial contribution received by Orton Memorial Library during 1994.

SOURCE OF FUNDING	US$ (thousands)
IICA	123,5
Dutch Government	
- Library	50,8
- Inforat	56,3
CATIE's Projects	13,5
CATIE's core budget	112,5
TOTAL	**356,6**

During 1994 the Library initiated a program to computerize services and information management. This was possible thanks to Dutch funds that contributed upgrading computer hardware at the Library. The same funds contributed to INFORAT (Latin America Forestry Information Service), which is now part of the Library, offering a more efficient service for technical staff through a redistribution of personnel. A long term objective consists of the computerization of all references kept at the Library.

One of the library's major undertakings was to incorporate different bibliographic data bases existing in other CATIE areas or projects. At the end of 1994 most of this work was done. Only a data base from the Plant Protection Area is still to be incorporated in the new system. This task was complicated by the use of different software and methodologies from that used in the Library's system. The new data base also had to be matched to avoid duplication of information. Figure 20. shows the local data bases available at the Library and total accessions.

Figure 20. Local Bibliographic Data Bases at the Orton Memorial Library



Other activities of the BCO included the acquisition of 4.279 new books and 8.287 periodicals, 16,000 visitors were attended, 5870 telephone requests, 1427 international requests were answered and more than 20.000 copies of material were mailed.

BCO is the coordination institution for REDCAFE (Regional Network for Coffee Bibliography), RIBRENAC (Regional Network for Natural Resources Bibliography) and also a regional center for AGRINET, AGRIS (FAO), UPEB and IUCN information systems.

Central American Forestry Journal

The Central American Forestry Journal (RFCA), which is part of the Central American Forestry Program (PROCAFOR) financed by the Government of Finland (FINNIDA), has made considerable advances during 1994. Its importance was recognized by the Central American Forestry Council and the number of subscribers has increased continuously.

The Central American Forestry Journal is a quarterly technical and practical publication, dealing with natural resources, rural development and environmental issues. It targets people working in conservation, management and utilization of natural resources in different sectors. It provides a means of integrating the regional forestry sector and exchanging technical information on renewable natural resources. The RFCA also acts as a forum for discussions on regional forestry, environmental and rural development issues and gives particular reference to the integration of the forestry sector in the local economy on a sustainable social, economic and ecological basis.

The RFCA is composed of three sub components:

- publication of the Central American Forestry Journal;
- organization of courses in technical writing;
- activities insuring the sustainability of the journal in a long run.

Financial situation

The total budget of the Project for 1994 was FIM 2 108 773 (FIM 5 = approximately US$ 1), but part of it is channeled through the Helsinki University Knowledge Services, a Finnish company which FINNIDA has contracted to implement PROCAFOR. The CATIE budget totaled US$ 220 571.

Other revenues, including sales of subscriptions and individual issues, and advertisement earnings, totaled almost US$ 15 000.

During 1994, the RFCA printed 4.000 copies of each of the four issues published. Each number included a poster of a different native tree species. The main themes of the journal were as follows:

RFCA 3 (7):	Reforestation and incentives (68 p, including a poster)
RFCA 3 (8):	Extension (68 p, including a poster)
RFCA 3 (9):	Mangrove forests (64 p, including a poster)
RFCA 3 (10):	Forestry management plans (68 p, including a poster)

During 1994, the number of subscribers increased to 906 (Table 43.). Moreover the magazine was sent regularly without charge to 111 libraries and information centers, to 126 institutions on an exchange basis and to all people who have cooperated in the journal's preparation. The main office located in Turrialba, Costa Rica, as well as members of the National Commissions in the different Central American countries, private sellers and different libraries sold more than 3 000 single issues during 1994. Additional issues were sent without charge to different organizations in order to publicize the journal.

The National Commissions play an important role in insuring regional participation in the journal. They are composed of representatives from different sectors, including education, administration, professional organizations, private enterprises and NGO's.

Three one-week courses on technical writing, were organized in Chimaltenango and Petén in Guatemala and in El Salvador. 35 professionals participated in these courses.

Table 43. Subscriptions received compared to expired subscriptions up to December 1994

COUNTRY	SUBSCRIPTIONS RECEIVED	SUBSCRIPTIONS EXPIRED	TOTAL STANDING	%
Argentina	3	1	2	
Belgium	1	1	0	
Belize	6	3	3	0,33
Bolivia	15	2	13	
Brazil	13	3	10	
Canada	3	2	1	
Chile	1	0	1	
Colombia	9	1	8	
Costa Rica	356	45	311	34,33
Denmark	1	0	1	
Dominican Republic	14	2	12	
Ecuador	9	2	7	
El Salvador	45	2	43	4,75
Finland	14	1	13	
France	2	0	2	
Germany	8	0	8	
Guatemala	148	41	107	11,81
Holland	3	0	3	
Honduras	92	14	78	8,61
Japan	1	0	1	
Madagascar	1	0	1	
Mexico	18	5	13	
Mozambique	1	0	1	
Nicaragua	142	39	103	11,37
Norway	1	0	1	
Panama	162	42	120	13,24
Paraguay	1	0	1	
Peru	9	1	8	
Puerto Rico	1	0	1	
Scotland	1	0	1	
Senegal	1	0	1	
Spain	2	1	1	
Switzerland	7	2	5	
United Kingdom	1	0	1	
Uruguay	2	0	2	
USA	29	9	20	
Venezuela	4	3	1	
TOTAL	1128	222	906	
	Total expired 19,7%		Total standing 80,3%	

Agroforestry In The Americas Journal

In 1953, the thesis work of Cesar Augusto Pérez Figueroa presented a new approach for agricultural production in CATIE. This work was the beginning of what would be later known as agroforestry not only in CATIE but in the rest of the world.

Now, forty-two years later, CATIE has become a worldwide leading center in agroforestry.

In 1994 the first issue of the scientific journal "Agroforestería en las Américas", were published, thanks to the economic support of the Danish Government, through its International Development Assistance (DANIDA).

During 1994 ICRAF found additional economical support from the USDA for printing additional issues, distribution, and some technical support.

The main reasons for publishing a journal devoted to agroforestry, are:

- The need to promote the scientific work developed by CATIE during its 42 years of research in the field of agroforestry.
- An agroforestry bulletin, published in previous years, had a limited distribution, irregular publication, and few pages.
- Institutional authorities had an interest in more aggressively agroforestry research and education in the member countries and the region.
- The absence of a specialized journal on agroforestry in the region containing the most relevant research work in agroforestry in Latin American countries.
- The urgent need for a journal in Spanish.

The journal is divided into eight sections as follows: Editorial, New advances in Research, How to do it?, Agroforestry News, Book Reviews, Agroforestry Events and Agroforestry Publications.

In 1995, new sections will be included to organize information received by the journal and present it in a summarized way.

As its name indicates, the journal is distributed in America and to several countries in Europe, Africa and Asia.

To determine potential readers, the mailing list of the Agroforestry Bulletin of INFORAT was reviewed as a starting point. After selecting and adding addresses, a final list was obtained, with a total of 2150 references, including research, teaching, government and private institutions, as well as NGO's.

In the first issue of the journal, a subscription form was included to identify readers interested in receiving the publication, as well as new readers.

The second issue of the journal was distributed to 2630 readers and for the third issue, 2934 addresses are registered. It is important to note that besides distribution to these addresses, two copies per issue are sent, INFORAT receives 200 copies for distribution, as well as 40 for CATIE's library and 200 copies for ICRAF.

Presently, we are working with the agroforestry networks of Bolivia and Ecuador, to assess whether they could assume the distribution of the journal in those countries. We are planning to contact the other networks of the Region for the same purpose.

Total budget sponsored by DANIDA for the Journal during 1994 was US$40,993.

Achievements:

Starting in August of 1994, the first three issues of Agroforestería en las América were published, at two-month intervals.

A Data Base of readers or subscribers was completed.

A bank of graphic materials was started.

One brochure and one poster advertising the journal were prepared and published.

Two meetings with the Editorial Committee were held at CATIE.

Distribution of the journal in Ecuador and Bolivia was organized through its agroforestry networks.

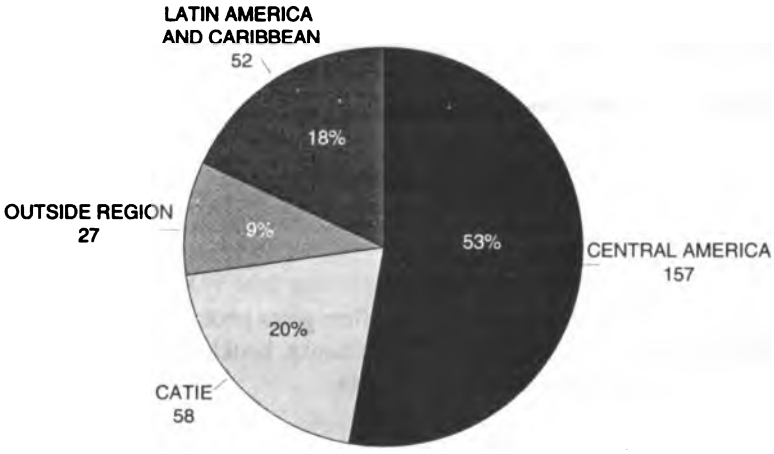
The Integrated Pest Management Journal

The IPM Journal is published and distributed by the Plant Protection Information and Communication Center as part of the IPM/RENARM Project.

The IPM Journal is published quarterly and during 1994 numbers 30, 31, 32 and 33 were published indicating its continued demand for over eight years.

During this time the Journal has published 266 scientific papers from 294 authors from CATIE, Central America, Latin America and outside the region. Figure 21. shows a pie distribution of articles according to the author's country of origin.

Figure 21. **Distribution of articles published in the IPM Journal since publication began according to the author's country of origin.**



The IPM Journal prints 1.100 copies per issue that consistently reach an average of 950 plant protection specialists. To date the IPM Journal is supported by the IPM/RENARM Project and is free of charge. As these RENARM projects are ending, provisions will be made to ensure continuity, along the same lines that the Central America Forestry Journal is planning.

In addition to the IPM Journal the Plant Protection Information and Documentation Center produced 4 issues of the IPM newsletter and IPM Current Contents, consistently reaching an average of 950 plant protection specialists. It also replied to 3128 customer requests for a variety of printed information and bibliographic searches, and to 9087 requests for information contained in data-bases. The regional distribution of the Pesticide Bulletin reached a total of 2700 units distributed to 156 subscribers during the fourth quarter of 1994, and continues growing steadily.

Special publications during 1994 included:

- "Phytophagous Mites of Central America, an Illustrated Guide" (English version).
- "Crop Protection for Extensionists" this is a series of publications begun last year to meet the information needs of extensionists. The first two issues titled "Control Biológico de Insectos" and "Lecturas sobre Manejo Integrado de Plagas" were published and distributed.
- "Tapado, Siembra de Cobertura" (Slash/Mulch Conference Proceedings). Both Spanish and English versions were published under an agreement with the University of Cornell.

- "Boletín Mosca Blanca al Día" three issues were revised, published and distributed.

- "Hoja Técnica IPM" four issues were published.

- Revista "Manejo Integrado de Plagas" Indice de Materias, No.1-30 (IPM Quarterly Journal). Subject Index, No. 1-30 (1986-1993) was prepared.

The IPM Information Center had during 1994 a total budget of US$112,750 apported by RENARM/G-CAP.

Printing Shop

CATIE operates a printing department which offers gives photo and art design services. During 1994 this department printed more than 300.000 units of books, booklets, brochures, forms, thesis, journals, etc. for more than US$152,200, as shown in Table 44.

Table 44. Publications printed at CATIE

DESCRIPTION	NUMBER OF UNITS	COST US$ (Thousands)
Books and Journals	51.240	97,4
Thesis	300	7,5
Forms	159.760	7,9
Pamphlets	33.460	8,7
Cards	25.845	3,2
Posters	7.200	5,7
Photos	2.165	3,6
Slides	6.240	15,6
Other services and materials	-	2,6
TOTAL	US$ 152,2	

Public Relations Office

In July 1994, a journalist was hired to design and implement a public relations policy in CATIE.

Since then, professional and permanent information issues are produced to keep the public inside and outside the Institution informed has been on CATIE's educational, research and outreach activities. In the first period the action focused on Costa Rica and news items have been prepared for 12 newspapers, 7 informative journals, 123 radio stations, 5 TV channels and 6 international news agencies.

The office produces a quarterly bulletin in Spanish called "Noticias de Turrialba" (Turrialba News), bimonthly the sheet "CATIE en Acción" (CATIE in Action), and CATIE's activities bulletin (Table 44).

The office also receives visitors and tourists that come to the campus.

Table 45. Publications of the Public Relations Office

ITEM	No. OF ISSUES
Noticias de Turrialba (Turrialba News)	2
CATIE en Action (CATIE in Action)	10
News Releases	25
CATIE's Activities	9

III. FINANCING

Summary of Accounting Activities and Policies

CATIE is a legal, international, non-profit institution. CATIE was founded in 1973 and in 1983 a new contract was signed for an additional twenty year period.

CATIE's resources originate from regular incomes, agreements and productive activities. It's financial management information has been classified into five funds, according to their purpose and source (independent or consolidated financial statements): Basic Activities Fund, Trust Fund, Retirement Fund for Principal Professional Staff, Plant Fund and Agricultural Activities Fund. The accounting records and financial statements are expressed in US dollars (US$).

As shown in Table 46. below, total revenues during 1994 were US$16,784,015 and total expenses US$15,986,490. This let a positive balance of US$795,525 as an excess of revenues over expenses. Table 46 shows the combined statements of assets, liabilities and fund balances until December 1994. The most important fact in CATIE's financial situation is that since 1992 the Board of Directors has continuously been congratulating the Administration, due to its clear and expert management, and that the liability of the Institution with the Retirement Fund for Principal Professional Staff is almost sold. From US$1,147,092 in January 1992, it became to US$127,800 in December 1994

Table 46. Income and Expense Balance up to December 31, 1994. (US$)

INCOME	
Membership	1.797,400
Technical Support Service	153,691
Teaching Activities	477,601
Productive Activities	1.658,160
Logistical and Administrative Support	1.208,930
Exchange Difference	69,047
Other Incomes	248,667
Subtotal	5.613,496
Trust Funds Income	11.170,519
Total Income	**16.784,015**
EXPENSES	
Directors Office and Senior Management	628,831
Administration and Services	917,969
Technical Programs	1.820,703
Productive Activities	1.249,259
Depreciation	199,209
Subtotal	4.815,971
Expenses in Trust Funds	11.170,519
Total Expenses	**15.986,490**
Income - Expenses Surplus	**797,525**

Table 47. Asset, liability and balance combined statement of funds to December 31, 1994 (US$)

ASSETS	
Current Assets:	
Cash	3.009,886.40
Negotiable assets	688,600.00
Document and account receivable	
CATIE's members	487,901.35
Other entries	373,098.36
Total account receivable	**860,999.71**
Inventories	339,564.62
Expenses paid in advance	14,532.89
Total current assets	**4.913,583.62**
Building, machinery and equipment	2.948,052.48
Member long term account receivable	791,365.00
Other assets	3,040.79
Funds of account receivable	2.895,847.36
TOTAL ASSETS	**11.551,889.25**
FUND LIABILITIES AND BALANCES	
Current liabilities:	
Document and account payable:	
Credit Institutions	13,291.41
Account payable	668,352.29
In Trust Funds	1.462,196.60
Accrued expenses	266,152.56
Supplies	108,116.43
Total current liabilities	**3.125,961.55**
Long term liabilities:	
Account payable funds	2.895,847.36
Social benefits	254,006.52
Total long term liabilities	**3.149,853.88**
TOTAL LIABILITIES	**5.667,963.17**
Fund statement	5.883,926.08
TOTAL LIABILITIES AND WORK FUNDS	**11.551,889.25**

Differences with Generally Accepted Accounting Principles

As CATIE is a non profit institution, its financial statements have been prepared according with practices formulated by the Board of Directors, oriented to fulfill budgetary needs. This is why they differ, in some aspects, with generally accepted accounting principles.

CATIE's Contractual Position

The most important terms of CATIE's current contract are:

a) The Inter-American Board of Agriculture (IABA) will be CATIE's highest governing body.

b) CATIE's members may be regular or adherent. The annual contribution of regular members must not be lower than US$50,000.

c) IICA will contribute with CATIE's Core Budget a contribution of IABA member countries, up to a maximum of 5% of budget quotas.

d) The new contract has a 20 year term, which may by renewed for equal successive terms.

e) CATIE's capital is constituted by its usufruct, by contract terms, farms, buildings, equipment and other properties and assets donated by IICA, as well as the assets acquired by CATIE.

f) At termination of the contract, all the assets given in usufruct will be returned to the IICA. The remaining assets will be distributed among CATIE's active members, based on their contribution.

g) CATIE may freely make use of foreign currency for transactions in or from Costa Rica.

IV. ADMINISTRATION

The main objective of the Administration Area has been to raise efficiency, by streamlining and updating the procedures and strategies established by CATIE's Direction General.

To achieve this General Objective, the following specific objectives were drawn up:

1. Reduction and updating of unnecessary procedures.
2. Increase income and decrease expenditures.
3. Efficient use of human, physical and financial resources.
4. Increase quality and quantity of the services offered by the Area.

The following Table shows a comparison of current (1994) and 1993 incomes for the productive activities under the Areas' responsibility. Table 48. shows that in 1994 income was higher than that from 1993, and the expenses were less for all of the activities.

Table 48. Income and Expenditures Comparison (Actual). 1994 vs. 1993.

Productive	1993		1994		Difference %	
Activity	Income	Expenditures	Income	Expenditures	Income	Expenditures
Vehicle Rent	151,486	161,725	174,106	124,642	14.93%	-22.93%
Lodging	396,614	155,494	447,624	138,887	12.86%	-10.68%
Photocopies	46,916	59,138	75,488	24,311	60.90%	-58.89%
International Club	69,454	68,169	93,098	69,715	34.04%	2.27%

Quantitatively, this demonstrates a more efficient operative development of the Administration Area.

In addition, the Physical Plant Unit increased the time spent fulfilling work orders from 55% in February and 70% in March to 90% in April and May.

FUNDATROPICOS (CATIE FOUNDATION)

The 1994 budget of the support fund sponsored by "FUNDATROPICOS" was the equivalent of US$419.155 to execute the institutional physical plant maintenance program, according to the purposes of the Foundation, shown in Table 48.

This fund allowed the Physical Unit to make significant repairs, starting a process of change from a corrective maintenance system to one of preventative maintenance. This would reduce operation costs and increase the quality of service.

Table 49. Expenditure of FUNDATROPICOS Budget (Maintenance) 1994. (Amounts in US$)

ACTIVITY	EXPENDITURE	
PERMANENT ACTIVITIES		
BASIC SERVICES		
Basic Services	18,026.68	
RESIDENCE MAINTENANCE		
Basic Maintenance of Residences	64,420.92	
BUILDING MAINTENANCE		
Basic Maintenance of Buildings	29,274.41	
PARK AREA MAINTENANCE		
Park Area Maintenance	7,725.37	
EQUIPMENT MAINTENANCE		
Maintenance of Park Area Equipment	9,071.16	
Maintenance of Carpenter work shop machines		
		128,518.54
SPECIAL ACTIVITIES		
Renovation Main Building (H.A.Wallace)	1,372.38	
Renovation P.A.T.S. Building	8.319.15	
Renovation Student Apartments	4,621.39	
Renovation Diary Farm	352.99	
Renovation Parking lots	4,924.06	
6-102 House	3,104.23	
Club roof	4,240.02	
Connections	9,635.92	
Abaca Residences	24,129.51	
Computer Center Roof	3,900.31	
Garage and filling station	0.00	
Improvement of tanks and livestock areas	0.00	
Repair and paint of Biotechnology Building	0.00	
Workshop transfer-Warehouse conditioning	0.00	
		64,599.96
OPERATIVE SUBTOTAL		193,118.50
PERSONNEL COSTS		213,401.65
TOTAL BUDGET		**$406,520.15**

FARM ACTIVITIES

Coffee

During the 1994-1995 crop period, the coffee production was 2.221 fanegas, with an average of 49.3 fanegas/ha. This contrasts with the production of the previous 1993-1994 period in which the production was 1.478 fanegas with an average of 38.8 fanegas/ha.

Also, during 1994 the 1993-1994 export crop was sold at US$91.35 qq (1qq = 100 pounds) If the local marketing is added, total gross income from coffee activities at CATIE reach the amount of US$361,800 as shown in Table 49.

Sugar Cane

The sugar cane farm increased plantings of soca cane from 17.5 ha to 188.5 ha. In 1992 the sugar cane harvest was 1,101 tons; during 1993, 3,126 tons and in 1994, 6,647 tons.

During 1994 CATIE's sugar cane production won first prize as best producer in the sugar mill, in both sugar cane yield per hectare (117 ton/ha) and sugar content (262 pounds/ton).

CATIE is expanding its sugar activities increasing the area up to 200 has. and expects to harvest 12,000 tons in 1995.

Livestock Farm

The livestock activity fulfilled the commitment made by the Administration to generate at least US$28.500, on livestock sales. Total sales amounted to US$45,500 (Table 49), exceeding the proposed goal.

The dairy and creamery achieved a production of 389.000 kilos of packed milk sold to ASE-CATIE and 99,000 boxes of cream. 61% is from farm production and the rest is bought two producers in the area.

To reinforce this activity, and make the plant self-sufficient in milk, 25 Jersey x Holstein heifers were bought from the lowland zone of San Carlos, Costa Rica. These are near production.

According to the 1994 inventory (closed December 31st.) both activities from the livestock farm (meat and milk), have 603 head of cattle.

Forestry Farm

Part of the forestry activity included plantation thinning. Since some forestry permits are still lacking, the process has not yet finished.

20 hectares of hillside areas were reforested with the assistance of some of the CATIE projects. These areas lie adjacent to the "Noche Buena Barrio", near the Centro Agrícola Cantonal plant of Diversificación Agrícola.

In Table 49. the gross income produced by CATIE's commercial farms over the last four years (1991-1994) are shown.

Table 50. Gross income generated by CATIE's commercial farms during the years 1991 - 1994. Amount in thousand of US$.

ACTIVITY	1991	1992	1993	1994
Sugar Cane	57.9	26.2	68.2	185.2
Coffee	153.1	107.9	99.0	361.8
Forest Products	21.8	29.2	53.4	35.4
Meat livestock	56.4	103.1	42.4	45.5
Milk livestock	109.3	226.8	222.6	185.8
Total	**398.5**	**493.2**	**485.6**	**813.7**

V. EXTERNAL COOPERATION

In order to carry out main educational and research activities, during 1994 CATIE received funds from different countries. We wish to thank all the governments and people involved that contributed to the development and conservation of the American tropics. Table 51 shows contributions by country.

Table 51. Contributions to CATIE's research and education activities by country.

COUNTRY	CONTRIBUTION Amount US$
Canada (IDRC, CIDA)	429,184
Denmark (DANIDA)	2,042,383
Finland (FINNIDA)	559,457
France (Ministry of Foreign Affairs and CIRAD)	19,512
Germany (GTZ, BMZ)	591,355
Japan (JICA)	94,454
Netherlands (Ministry of Foreign Affairs)	676,509
Norway (NORAD)	885,269
Sweden (SAREC, SIDA)	905,099
Switzerland (COSUDE)	292,261
United Kingdom (ODA, NRI)	418,899
United States of America (AID)	4,406,201
Other Institutions (WWF, IBPGR and European Community)	164,723
TOTAL	**11,485,305**

Other non cash contributions made by different governments or institutions is the assignment of technical personnel to Institutional research and education activities, as shown in Table 52.

Table 52. **CATIE's Associated Principal Staff (APS) assigned by different countries and institutions.**

COUNTRY	No. of APS
Denmark	1
Finland	2
France	6.5*
Germany	3
Netherlands	2.6**
Sweden	1
Switzerland	2
United Kingdom	4
United States of America	1
World Wildlife Fund	3
INIBAP	1
I U C N	1**

* One of the technicians is 50% paid by CATIE's Core budget.
** Three technicians have 20% of time assigned to CATIE.

Taable 53. shows an estimate of the contributions received through the strategic alliances with donor institutions and which include the staff of Table 52.

Table 53. **CATIE's Counterpart Contributions in Alliance with Strategic partners. (US thousands).**

INSTITUTION	1994
CIRAD - France	850
IPGRI / INIBAP	150
ICRAF	25
ISNAR	20
CIFOR	30
Penn State Univ. / ACRI	125
NRI - United Kingdom	250
COSUDE - Switzerland	495
GTZ - Germany	400
ODA - United Kingdom	200
UA - Wageningen - Netherlands	70
DGIZ - Netherlands	150
MAE - France	90
W W F	200
I U C N	25
TOTAL	3,080

The following Table shows the budget of current projects, during 1994.

Table 54. Budget of current projects during 1994.

PROJECT	DONOR	BUDGET
EDUCATION FOR CONSERVATION AND DEVELOPMENT PROJECT		
Strengthening Institutional Capacities	TheNetherlands	578,277
Agroforestry International Course	JICA, Japan	94,454
SUSTAINABLE TROPICAL AGRICULTURE PROGRAM		
Tropical Crops Area		
Seed Management Unit	IBPGR	4,939
Banana Genetic Improvement - MUSA	E. U.	52,395
RLFP Technique - Coffee Germplasm	E. U.	36,157
Yam Bean Jicama (Germplasm)	E. U.	38,322
Plant Protection Area		
IPM and pests in Central America	NRI - U.K.	66,898
Integrated Control of *Echinochloa Colonum*	NRI - U.K.	77,404
Weeds (Integrated Management of Itch Grass)	NRI - U.K.	74,880
Pathology (Microbial and cultural control)	NRI - U.K.	29,905
Entomology (Microbial control of Phyllophaga)	NRI - U.K.	26,220
Laboratories (ODA)	NRI - U.K.	34,270
IPM in Nicaragua	NORAD	449,375
RENARM/Plant Protection (includes Buy-ins)	AID/G-CAP	1,345,580
Nematodes	CIRAD	19,512
Agroforestry Systems Area		
Agroforestry Coordination Unit	DANIDA	238,479
Nitrogen Fixing Trees - Costa Rica	SAREC	178,609
Agroforestry Coordination - Phase V	GTZ	494,991
Goat Agroforestry	GTZ	96,364
Forestry - Agroforestry Technical Assistance FORESTA	P.W./AID	79,068

Research and Training in the Atlantic Zone	U.Wageningen	98,232
Home Gardens	IDRC	100,000
Agrisilvipastoral Systems	IDRC	95,042
Agrisilvipastoral Systems	ACDI	234,142
Animal Productions Symposium	AID/G-CAP	15,210

INTEGRATED MANAGEMENT OF NATURAL RESOURCES PROGRAM

Tropical Forest Management and Silviculture Area

Forestry and Agroforestry Research and Training (P1)	FINNIDA	338,886
Central American Forestry Journal (P3)	FINNIDA	220,571
RENARM/Natural Forest Management	AID/G-CAP	969,553
RENARM/Dissemination of Multiple Use Trees	AID/G-CAP	1,135,329
ODA and Oxford University	O.D.A.	9,000
Forest Research and Training - Phase VI	S.D.C. (COSUDE)	292,261
Forestry Seeds in Central America (PROSEFOR)	DANIDA	718,400
ODA Tree Improvement	O.D.A.	100,322

Watershed Management Area

RENARM/Watershed Management	AID/G-CAP	861,461

Biodiversity Management and Conservation Area

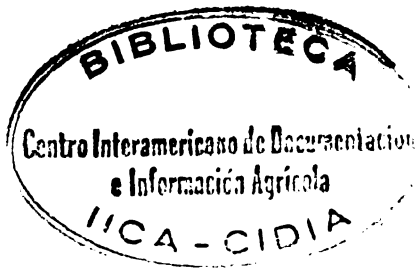
Wise Use of Mangrove in Costa Rica and Nicaragua	DANIDA	473,713
WWF Project Coordination	WWF	32,910
Conservation for Sustainable Development in Central America (OLAFO II)	SIDA	726,490
Conservation for Sustainable Development in Central America (OLAFO II)	NORAD	435,894
Conservation for Sustainable Development in Central America (OLAFO II)	DANIDA	611,791
TOTAL		**11,485,305**

Table 55 shows the new institutional agreements signed by CATIE during 1994.

Table 55. Signed Institutional Agreements With CATIE In 1994.

AGREEMENT	OBJECTIVE	TIME FRAME
3rd Amendment CIDA/CATIE	Sustainable agrisilvipastoral systems for small farmers in the dry tropics of Central America.	April 1, 1994 June 31, 1994
IICA/CATIE	Strengthening of the cooperative program for technology development and modernization of coffee technologies in Central America, Mexico, and the Dominican Republic (PROMECAFE).	February 1, 1994 February 1, 1997
EARTH/CATIE	Cooperative recruitment of students in Central America.	April 1, 1994 March 31, 1995
IPGRI/CATIE	Classification, distribution, and exchange of seeds to collectors in Nambia	June 15, 1994 September. 15, 1994
PRODERE/CATIE	Addition to the cooperative technical agreement for the payment of salaries	January 1, 1994 March 31, 1994
IICA/CATIE	Joint declaration to reinforce the start of an integrated cooperation between IICA and CATIE.	March 20, 1994
CCSS/CATIE	Application of family medical and maternity insurance with protection in conforming existing regulations.	March 1, 1994 February 18, 1995
STANDARD FRUIT COMPANY DE COSTA RICA/CATIE	Conduct research on 1) "Efecto de microorganismos quitinolíticos en el desarrollo de Sigatoka Negra (*Mycosphaerella fijiensis* var difformis) en musáceas" and 2) The dynamics of micro-flora in temperate and hot areas of Sigatoka (3 month study)	February 4, 1994 February 4, 1995
UNA/CATIE	Strengthen collaborations in the areas of natural resources and sustainable development through teaching, research, training, and extension activities.	April 13, 1994 April 13, 1999
UAW/CATIE	Update and modify the agreement of cooperation signed May 22, 1986.	April 20, 1994 April 20, 1995

UJCV/CATIE	Strengthen formal joint collaborations in the areas of human and sustainable development through teaching, research, training and extension activities.	April 13, 1994
MAGA/CATIE	Agreements # 21-94 for the administration of financial resources (400,000 quetzales)	From December 31, 1994
CATIE	Promote the development of electricity energy supplies throughout the country	April 29, 1994 April 29, 1997
NORAD/CATIE	Support to the Integrated Pest Management Project (IPM) for Nicaragua,(An extension to Phase I, 1994)	July, 1994 December, 1994
FONDO REDES/CATIE	Provide CATIE technical assistance to various development projects located throughout southern Mexico	April 6, 1994
CIRAD-FLHOR/CATIE	Collaborate with the development of agricultural practices applied to plantain and banana crops for domestic consumption in CATIE member countries and other areas of Latin America and the Caribbean	September 1, 1994 September 1, 1996
IDRC/CATIE	Research on "Socioeconomic and biodiversity factors associated with home gardening in the semi-dry areas of Central America	September, 1993 March, 1995 2nd Phase starting April 1, 1995
DANIDA-NORAD- SIDA/CATIE	Contribute to the economic and cultural development of the rural communities of the Central America tropics, compatible with conservation of natural ecosystems and conservation and use of tropical biodiversity.	August 4, 1994 December, 31, 1996
SEGEPLAN/CATIE	Collaborate with the implementation of the Program for the protection of the Peten Tropical Forest (PDI, PROSELVA and other related projects)	November 2, 1994
DANIDA/CATIE	Second phase of "Wise Use of Mangrove Resources in Estero Real, Nicaragua and Térraba-Sierpe, Costa Rica" Project.	July 1994 June 1996
OIRSA/CATIE	Institutional strengthening to help institutions in Central America, Mexico, and Panama with plant protection problems	October, 1994 October, 1998
WWF/CATIE	Support of protected areas programs(training, equipment, scholarships)	December 1, 1994 June 31, 1995



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Area: Tropical Forest Management and Silviculture Area

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Area: Watershed Management Area

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XIV. GLOSSARY OF INSTITUTIONAL ABBREVIATIONS

ACRI	American Cocoa Research Institute
AFN	Nitrogen Fixing Tree Project, CATIE
AHP	Angostura Hydroelectric Project, Costa Rica
APPTA	Small Producers Association of Talamanca, Costa Rica
APROSAM	San Miguel Producers Association, Guatemala
ASCONA	Costa Rican Association for Nature Conservation
ASOLEP	Fuelwood-cutters Association of Peñitas
AUW	Agricultural University of Wageningen, the Netherlands
AZP	Atlantic Zone Program, CATIE
BCO	Orton Memorial Library, CATIE
BLSF	Latinamerican Forestry Seed Bank, CATIE
BMZ	Ministry of Cooperation of the Federal Republic of Germany
CATIE	Tropical Agricultural Research and Higher Education Center
CCSS	Costa Rica Social Security Institute
CEL	Electric Commission of Rio Lempa, El Salvador
CEMAPIF	Small Industry Forestry, Management and Utilization Center, Nicaragua
CIAT	International Center for Tropical Agriculture
CIDA	Canadian International Development Agency
CIFOR	Center for International Forestry Research
CIM	Intergovernmental Migration Committee
CIPRONA	Center for Natural Products Research, University of Costa Rica
CIRAD	International Agricultural Research and Development Center of France
CNFL	National Light and Power Company, Costa Rica
CODEFORSA	San Carlos Commission for Forestry Development, Costa Rica
COHDEFOR	Honduran Corporation for Forestry Development
CONACYT	National Science and Technology Commission, Mexico
CONCAFE	National Coffee Council, Nicaragua
CORBANA	Banana Development Coorporation, Costa Rica
CSU	Colorado State University
DAAD	German Academic Exchange Service
DANIDA	Danish International Development Agency
DGEC	General Directorate for Statistics and Census, Costa Rica
DGF	Forestry Directorate General, Costa Rica
DIECA	Costa Rican Sugarcane Growers' Organization
DIGEBESA	General Direction of Agricultural Services, Guatemala
DIGESEPE	General Direction of Livestock Services, Guatemala
EDECO	Education For Development and Conservation Program, CATIE
EMBRAPA	Brazilian Agriculture Coorporation

EU	European Union
FAO	U. N. Food and Agriculture Organization
FHIA	Honduran Agricultural Research Foundation
FINNIDA	Finnish International Development Agency
FUNDATROPICOS	CATIE's Foundation
GIS	Geographic Information System, CATIE
GTZ	German Agency for Technical Cooperation
IABA	Inter-american Board of Agriculture
IBPGR	International Board for Plant Genetic Resources
ICRAF	International Center for Research in Agroforestry
ICTA	Agricultural Science and Technology Institute, Guatemala
IDA	Agricultural Development Institute, Costa Rica
IDB	Interamerican Development Bank
IDRC	International Development Research Center of Canada
IGN	National Geographic Institute, Costa Rica
IICA	Inter-American Institute for Cooperation on Agriculture
INFOCOOP	Institute for Cooperative Promotion, Costa Rica
INFORAT	Tropical American Forestry Information and Documentation Service, CATIE
INIBAP	International Network for Improvement of Banana and Plantain
INIFAP	Forestry and Agroforestry National Research Institute, Mexico
INRENARE	Institute of Renewable Natural Resources, Panama
INTA	National Institute for Agricultural Technology, Nicaragua
IPGRI	International Plant Genetic Resource Institute
IPM	Integrated Pest Management Project, CATIE
ISNAR	International System for National Agricultural Research
ITC	Inibap's Transit Center
ITCR	Technological Institute of Costa Rica
IUCN	International Union for the Conservation of Nature
JICA	Japanese International Cooperation Agency
MAE	French Department of Foreign Affairs
MAG	Ministry of Agriculture and Livestock, Costa Rica
MAGA	Agriculture Livestock, and Food Ministry of Guatemala
MARENA	Natural Resources and Environment Ministry, Nicaragua
MBR	Maya Biosphere Reserve, Guatemala
MICI	Commerce and Industry Ministry, Panama
MIREN	Integrated Management of Natural Resources Program, CATIE
MIRENEM	Natural Resources Ministry of Costa Rica
MUT	Multiple Use Trees Project, CATIE
NARMAP	Natural Resource Management and Protection Project, Belize
NATURA	European Network of Agricultural Universities
NFTA	Nitrogen Fixing Tree Association
NGO's	Non-governmental Organizations
NORAD	Norwegian International Development Authority
NRI	National Research Institute, United Kingdom

ODA	Overseas Development Administration of the United Kingdom
OIRSA	Regional Organization for Animal and Plant Sanitary Protection
OLAFO	Conservation for Development Project, CATIE
ONS	National Seed Office, Costa Rica
ORSTOM	French Institute of Scientific Research for Development Cooperation
OUI	Inter-American Organization of Universities
PASE	Program for Advising and Follow-up of Alumni, CATIE
PATS	Sustainable Tropical Agriculture Program, CATIE
PBN	Production from Natural Forests Project, CATIE
PRIAG	Regional Research in Basic Grains Project
PROCAFOR	Central American Forestry Program
PRODERE	United Nations Program for Displaced Persons, Repatriates and War Refugees
PROMECAFE	Coffee Network in Central America, Mexico and the Dominican Republic
PROSEFOR	Forestry Seed Project, CATIE
PROSELVA	Project for Conservation of Peten Forests
REDCA	Regional Network for Cooperation in Higher Education and Agricultural and Natural Resources
REDCAFE	Regional Network for Coffee Bibliography
RENARM	Regional Environmental and Natural Resource Management Project
RFCA	Central American Forestry Journal, CATIE
RIBRENAC	Regional Network for Natural Resources Bibliography, CATIE
ROCAP	Regional Office for Central American Programs, USAID
SAREC	Swedish Agency for Research Cooperation with Developing Countries
SBN	Silviculture of Natural Forests Project, CATIE
SDC (COSUDE)	Swiss Cooperation for Development
SIDA	Swedish International Development Authority
U N	United Nations
UCA	Universidad Centroamericana
UCR	University of Costa Rica
UJCV	Universidad Jose Cecilio del Valle, Honduras
UNA	National University of Costa Rica
UNAH	National University, Honduras
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPEB	Union of Banana Exporting Countries
URCOCAM	Regional Union of Shrimp farming Cooperatives
USAID	United States Agency for International Development
USDA	US Department of Agriculture
WWF	World Wildlife Fund

XV. SCIENTIFIC NAMES INDEX

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