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RESEARCH PROJECT TO IMPROVE AND DEVELOP AGROFORESTRY SYSTEMS FOR THE SEASONALLY DRY UPLANDS OF WESTERN COSTA RICA

FORMULATION

PREPARED BY

THE INTERNATIONAL COUNCIL FOR RESEARCH IN AGROFORESTRY (ICRAF)

IN COOPERATION WITH

CENTRO AGRICOLA REGIONAL - PURISCAL (CAR)

CENTRO AGONOMICO TROPICAL DE INVESTIGACION Y ENSENANZA (CATIE) AND

THE GERMAN AGENCY FOR TECHNICAL COOPERATION (GTZ AT CATIE)

RESEARCH PROJECT ON DEVELOPMENT AND IMPROVEMENT OF AGROFORESTRY SYSTEMS FOR THE SEASONALLY DRY UPLANDS OF COSTA RICA

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PART I PROJECT FORMULATION

1. BACKGROUND & OBJECTIVES

ICRAF has identified the sub-humid highlands of Central and South America as one of the ecological zones within the American Tropics where cooperative activities should be developed in the context of its Collaborative and Special Projects Program. Within the framework of its agroforestry and farming systems programs the Centro Agronomico Tropical de Investigacion Y Ensenanza (C.A.T.I.E.) is expanding its rapid appraisal and on-farm research activities in agroforestry systems for hillslope farms.

Given a common interest in agroforestry systems for the mid-elevation highlands of Costa Rica, ICRAF and CATIE sought collaborating national institutions with similar focus. Two departments of the Costa Rican Ministry of Agriculture (MAG) are currently involved in farming systems and resource management research and extension programs. The National Forestry Office (DNF) and the Regional Agricultural Centres (CAR) have several projects in progress that require methodologies and technologies for the improvement or development of agroforestry systems.

Based on an established CATIE/MAG/GTZ agroforestry/farming systems project in the West Central zone of Costa Rica, ICRAF was invited by CATIE, together with MAG and DNF, to participate in a rapid appraisal workshop and project formulation mission in Acosta-Puriscal in March of 1983.

The primary objectives of the mission were to design agroforestry alternatives to overcome production and/or sustainability constraints in the existing land use systems of the Acosta-puriscal region, and to outline the research needed to generate and refine the required technology. Implicit in this is the development of a research - extension methodology and general prototypes of agroforestry technologies to be modified and tested in similar hillslope environments throughout Central America. Other objectives included the strengthening of institutional collaboration for agroforestry research and the testing and refinement of the ICRAF diagnostic and design methodology for agroforestry systems.

2. METHODOLOGY

The mission proceeded according to the general approach developed by ICRAF for diagnosis of existing land management practices and design of agroforestry alternatives (Raintree 1981). The usual procedural sequence is as follows:-

i. Review of baseline information prepared by National and Regional Institutions, to select land use systems of interest and to identify representative sample farms in consultation with qualified informants.

ii Regional reconnaissance and diagnostic evaluation of ecosystem condition, constraints and potentials followed by identificatio[n] of land use sustainability problems evident at the ecosystem le[vel]

iii. Diagnostic interviews with sample farmers to identify:

a) First, the perceived problems with respect to household nee[ds]

b) Then, land management problems and constraints which are implicated in the generation of present (productivity) and future (sustainability) problems.

c) The strategies which the farmers are presently following to mitigate these problems.

iv. Diagnostic analysis to evaluate the land use problems clarifying relationships among contributing factors and assigning priorities to them.

v. Derivation of functional and general design specifications for problem-solving interventions.

vi. Analysis of a wide range of technology options (of both an agroforestry and a non-agroforestry nature) for addressing the identified design specifications.

vii. Analysis of alternative systems plus technologies and comparison with technological improvements in existing systems.

viii. Evaluation of design alternatives and choice of a limited set of best bet options.

ix. Identification of research needs to generate the required technology, if not already available.

x. Analysis of the existing institutional infrastructure responsible for developing and disseminating the proposed technological alternatives.

xi. Formulation of project outline.

The mission was organised and coordinated by Dr. J. Heuveldop, Forester, (CATIE/GTZ) who supervised the compilation and analysis of information on the region of interest, the choice of study sites, and the organization of the mission itself*. The first meeting was held at CAR Headquarters at Santiago de Puriscal (in the study area), hosted jointly by CAR and CATIE, as a workshop for participating research and extension personnel from five national and regional institutions plus the ICRAF

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* the participants and the detailed itinerary for the mission are listed in tabular form on the attached sheets, Appendix A.

team consisting of Dr. F. Torres (Livestock scientist) and Dr. D. Rocheleau (Geographer).

The initial workshop (1½ days) served a double purpose. The ICRAF team presented the diagnostic and design methodology to the group and discussed its application to the Acosta-Puriscal region. This served as a training and orientation for the Diagnostic and Design phase of the mission. The second half of the workshop was devoted to discussion and analysis of pre-diagnostic information and new data presented by the qualified informants. During this session the group revised and elaborated the rapid appraisal itinerary, the farming system sample group and the information checklist for interviews and observations.

The following week March 2-6 was devoted to field reconnaissance and on-farm interviews conducted by three interdisciplinary teams. Meetings at the team and group level served as forums for methodological discussion and also as workshop for summary, analysis and comparison of results.

Following the diagnostic and design survey the group reconvened at CATIE to formulate design specifications for the problem-solving technologies, to elaborate farming system and ecosystem data bases, and to evaluate tentative design proposals with senior CATIE specialists in forestry, cropping systems and animal production. Preliminary conclusions and tentative project proposals were discussed with representatives of CATIE, CAR and DGF and the workshop participants. The following project proposal is the result of the workshops, field work and subsequent deliberations.

PART II PROJECT PROPOSAL

1. The Problem in regional context

Costa Rica, like Central America as a whole, is characterized by a marked diversity of ecological zones, ranging from large expanses of tropical rainforest and tropical dry forest to islands of montane forests and grasslands (Holdridge, 1970). Half of the entire population of Central America lives in the tropical moist forest life zone, in topography ranging from undulating hills to very steep inclines (von Platen et al, 1982; Posner et al 1981).
Marginal hillslope lands in many parts of Central America have been settled by smallholders displaced from higher potential valley and hillslope lands by urban expansion and large scale commercial production. In many cases the settlers have deforested, grazed and cultivated the rugged hillslopes using technologies developed in less fragile, more productive environments. This has accelerated erosion and mass wasting processes and has resulted in a net degradation of the local and regional resource base.

Declining soil fertility and soil volume have depressed yields and production efficiency in relation to labor investment in many small hillslope farms. This has motivated farmers to clear yet more land and to invest more family labor to maintain subsistence or low-level commercial production. After occupying available nearby land of similar quality, farmers have opened up new plots in distant and often far less productive areas in yet more fragile ecosystems. Once farmers have exhausted these peripheral lands, or have reached a point of dimisishing returns for travel or labor investments in distant holdings, the next alternatives are: intensification of labor on current holdings, off-farm employment, or migration to cities and frontier areas. This process has resulted in a depopulation of some of the montane agricultural regions degraded by soil erosion and soil nutrient depletion. In other cases the farm households maintain small farm plots but come to depend heavily on off-farm employment to meet basic needs. The subsequent regional shift to extensive grazing operations in many cases has further degraded the soil and water resource base while yielding less food production than previous land use systems.

This overall process can be seen in various stages of development throughout the highlands of Central America. The situation demands alternative technologies for improvement and/or eventual replacement of existing hillslope farming systems. The technologies proposed must provide sustainable production at economically reasonable levels for the inhabitants of the seasonally dry, lower to mid-elevation highlands. This case study assess the potential of an agroforestry systems approach to land use, combining soil conservation, agronomy, animal husbandry and reforestation technologies, to promote sustainable production systems for small holders in the Acosta-Puriscal region of Costa Rica. The methodology and resulting technologies are intended for further testing and application within the larger regional context of the marginal hillslope lands of Central America.

2. The Study Area

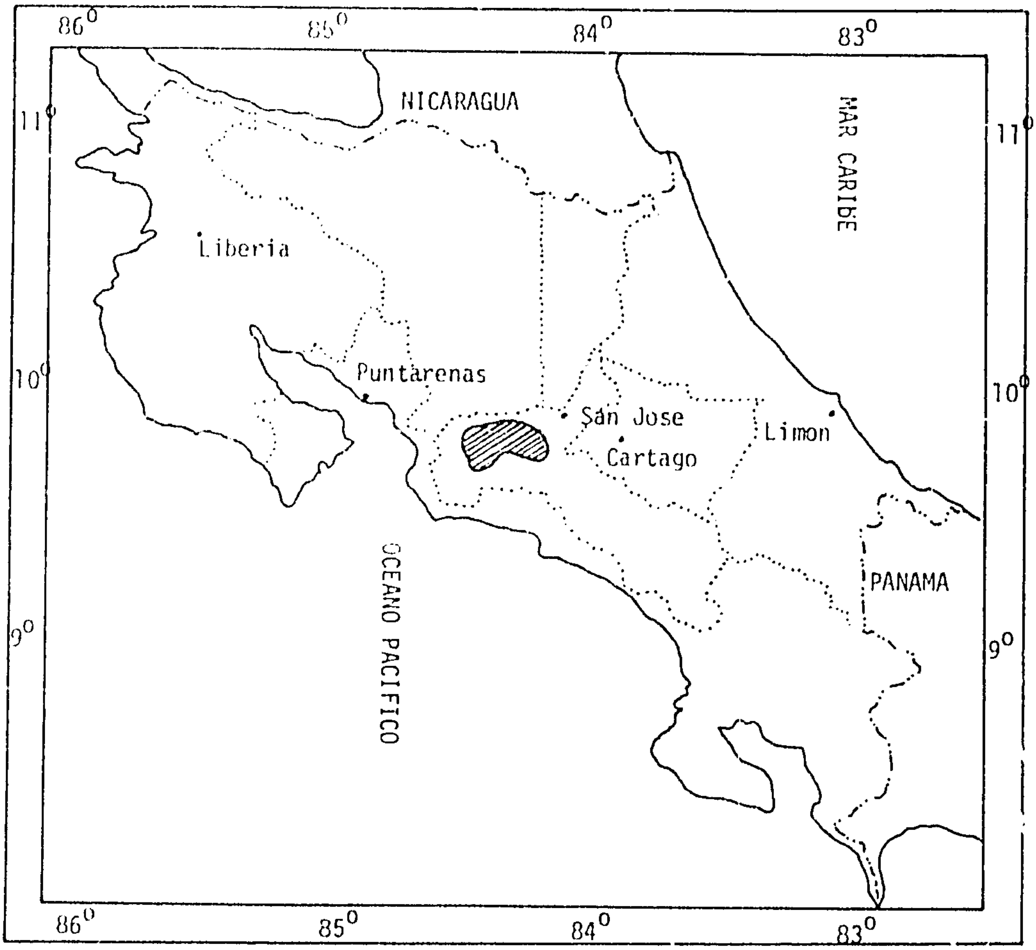
2.1. Location

The Acosta-Puriscal region is in the Central highlands of Costa Rica at 800-1200m elevation. It is situated on the Southeastern slope of the mountains at the southern extreme of the Central Valley, and lies approximately 60 km SW of San Jose (Fig.1). Two target areas, Acosta and Puriscal, were differentiated within the region on the basis or topography and land use (Fig. 2). These sub-regions were defined by a previous CATIE-MAG-GTZ research project and were adopted both for the convenience of data base continuity and for the intrinsic merits of the regional sub-divisions. Most of the baseline information for the study area and farming systems descriptions have been extracted from studies conducted by von Platen, Rodriguez and Lagemann (1982).

2.2. Settlement and History

Prior to contact with the Spanish the indigenous people in the region cultivated maize, tubers and pejibaye palm. Colonists began to settle the mountains of Acosta in the 1850's and Puriscal was settled 25 years later. The extension of coffee cultivation, coupled with population pressure, pushed the colonists out of the Central Valley and up into the Acosta Puriscal region. They initially raised maize and beans for subsistence. Eventually the Puriscal colonists specialized in maize, beans and sugar cane production for the commercial markets of San Jose (von Platen et al 1982, Barlett, 1977). During the 1930's tobacco and coffee cultivation were initiated in Puriscal and livestock-raising was further developed. Small farmers without much capital adcpted tobacco as a cash crop, while larger farms with some capital established coffee plantations for herds of cattle (von Melle 1983; jimenez, 1983).

Figure 1 : General Map of Costa Rica and the study area



(Source von Platen et al 1982 page 12)

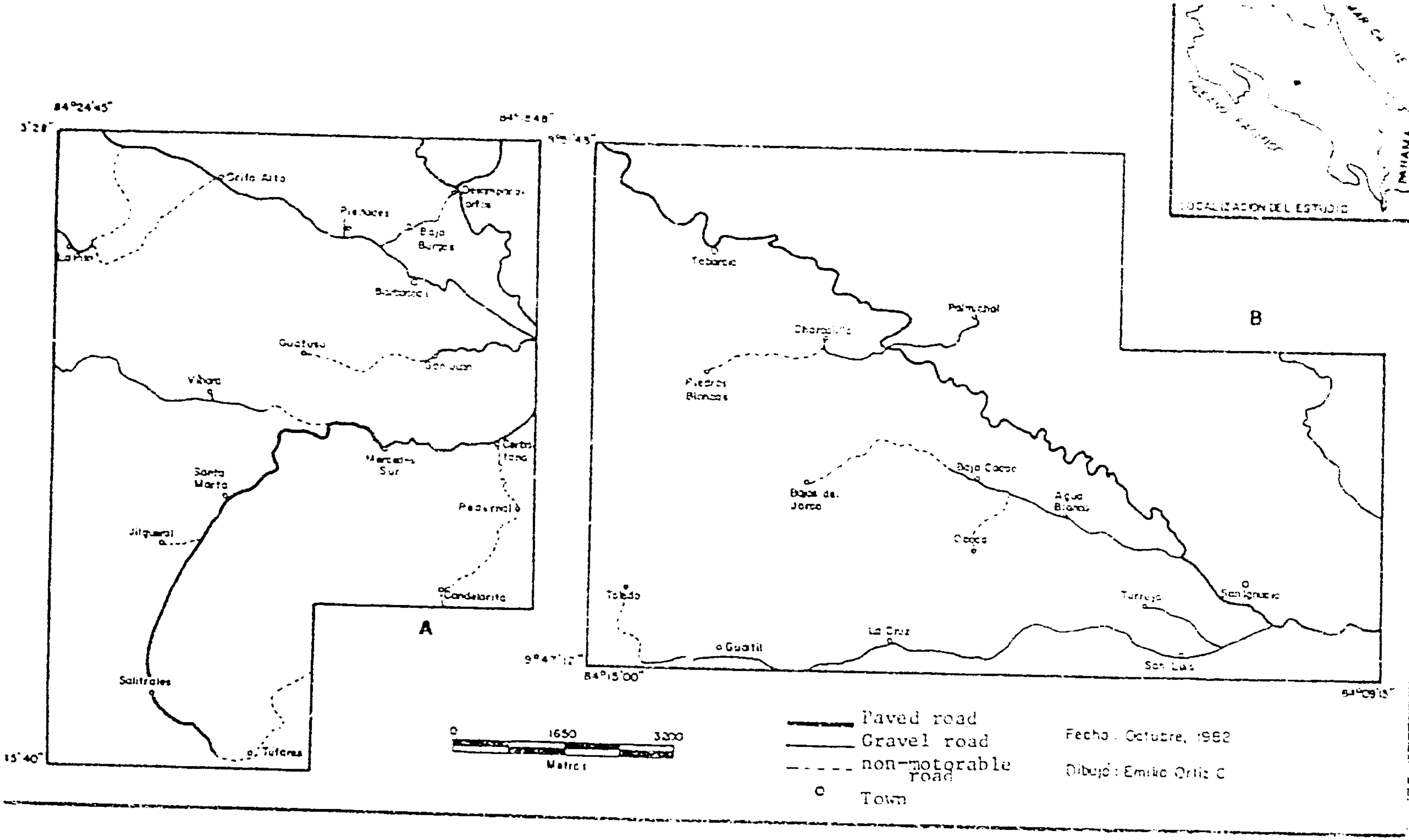


Fig. 2 Location of Study Area A = Puriscal - Salitrales ; B = Tabarcia - San Ignacio de Acosta

Source Topographic map sheets 3345 (I, II, III, IV)

In Acosta subsistence production remains important to the present. Coffee has been the major source of cash income and the most widespread cash crop. Topographic constraints limited the introduction of cattle into most parts of Acosta.

The population in both areas has been in a constant state of flux. Net immigration and establishment of new settlement gave way to transient communities spawned by internal migration.

As the forests of the Santiago de Puriscal area were depleted, and population continued to expand many residents of the original settlements moved to the southern part of the region. Most of their former lands were aggregated into larger holdings and converted to pasture (Bonilla, 1983).

The recent trend has been one of net out-migration to the cities or to the frontier areas in Guapiles, Qnepos, San Isidrode El General, San Carlos, and Sarapigui, (Borilla, 1983). The current population density is 100 persons per km^2 in Acosta (= 8,200 total) and 77 person per km^2 in Puriscal (= 11,500 total). Approximately 15% of the population lives in the townships of San Ignacio de Acosta (1,000 pop) and Santiago de Puriscal (2,500 pop) (Thrupp, 1980, Barlett, 1977).

2.3. Climate and Natural Vegetation

The region falls within the tropical seasonally dry climatic zone (AM) according to the Koppen classification.

The temperature is relatively constant throughout the region with very little fluctuation around the mean annual temperature of 21°C. The rainfall is more variable than temperature, both seasonally and in terms of geographical distribution. Annual rainfall ranges from 1300 mm to 3400 mm in Acosta, with an average of 2300 mm. In Puriscal the range is from 1600 mm to 3500 mm and the mean is 2100 mm.

The calculated water balance, based on the bimodal rainfall distribution, exhibits a pronounced water deficit for crop growth from December through April. The discrepancy between crop water requirements and available moisture is illustrated in the climatic diagrams and water balance tables for Acosta and Puriscal, respectively (Fig. 3&4; Tables 1&2, Appendix B). Another climatic limitation for agriculture is the high erosion potential resulting from the high total rainfall and its markedly seasonal distribution.

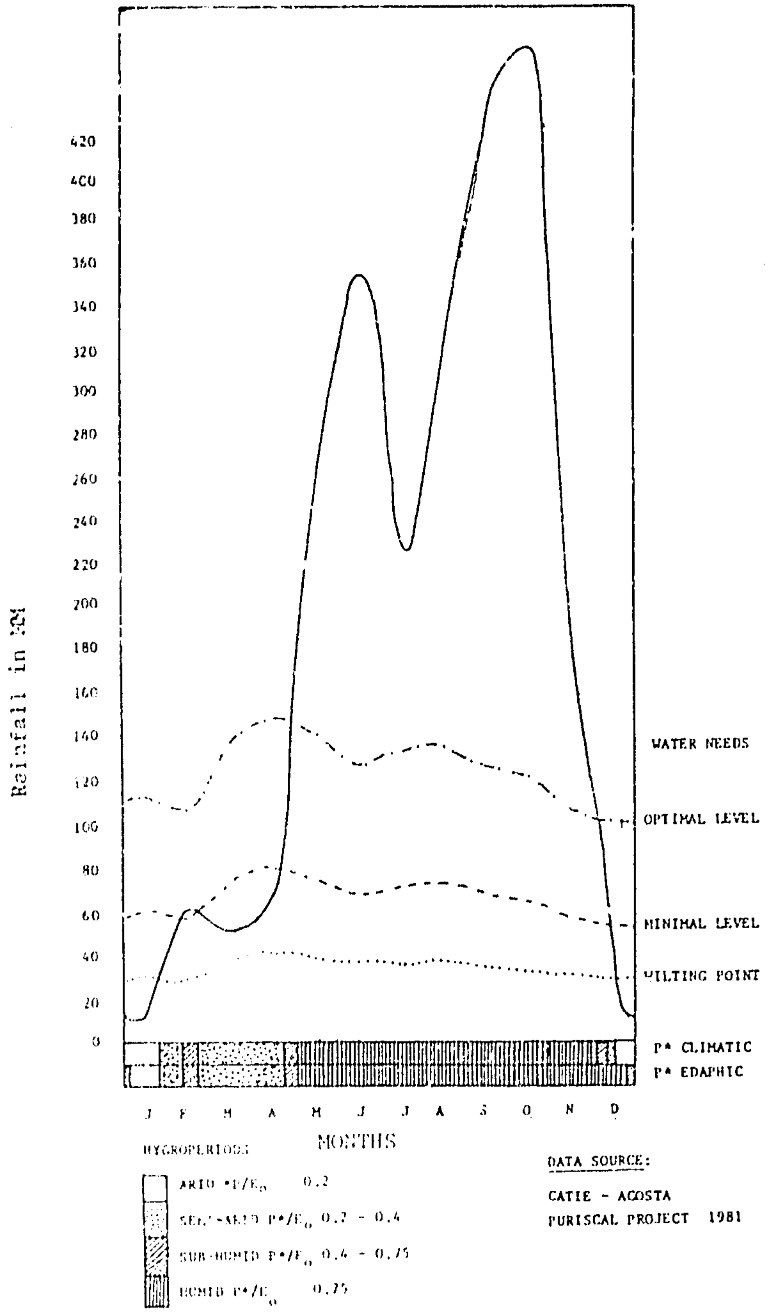
The study area includes a total of ten life zones, as defined by the Holdridge bio-climatic classification. The three life zones most representative of the conditions in Acosta-Puriscal are the Tropical Moist Forest (bh-T), the Premontane Moist Forest (bh-P) and Premontane Wet Forest (bp-P). The natural vegetation is a dense forest of diverse species composition dominated by broadleaf evergreen trees. Within the remnant natural forests of Puriscal the most important species (by frequency) are *Cordia bicolor, Clethra lanate, Luehea speciosa* and *Ficus velutina.* In Acosta the most common species are *Spondias mombin, Ficus velutina, Styraz argenteus,* and *Dpysa robinoides* (Heuveldop and Espinoza, 1983).

Many of the natural forest species, including some of the above, have been integrated into the cropping and grazing systems of the region.

2.4. Topography and Soils

The elevation in Acosta-Puriscal ranges from 500 to 1600 m above mean sea level. In general the area is characterized by rough topography with steep slopes, interspersed with intermontane valleys and zones of moderate relief and undulating topography. In the Acosta sub-region the topography is more consistently rough (average slope 30-60%), while in Puriscal there is more variation, ranging from moderate slopes (20-30%) to very steep slopes (100%). More than 75% of the surface in Acosta exceeds 40% while in Puriscal less than 40% of the area has a slope ≃ 40% (Alvarado et al 1982).

Fig 1 Climatic Diagram for Acosta
Loc. ACOSTA
Altitude 1096m Mean annual evapotranspiration (pot) 1546E_o



DATA SOURCE:

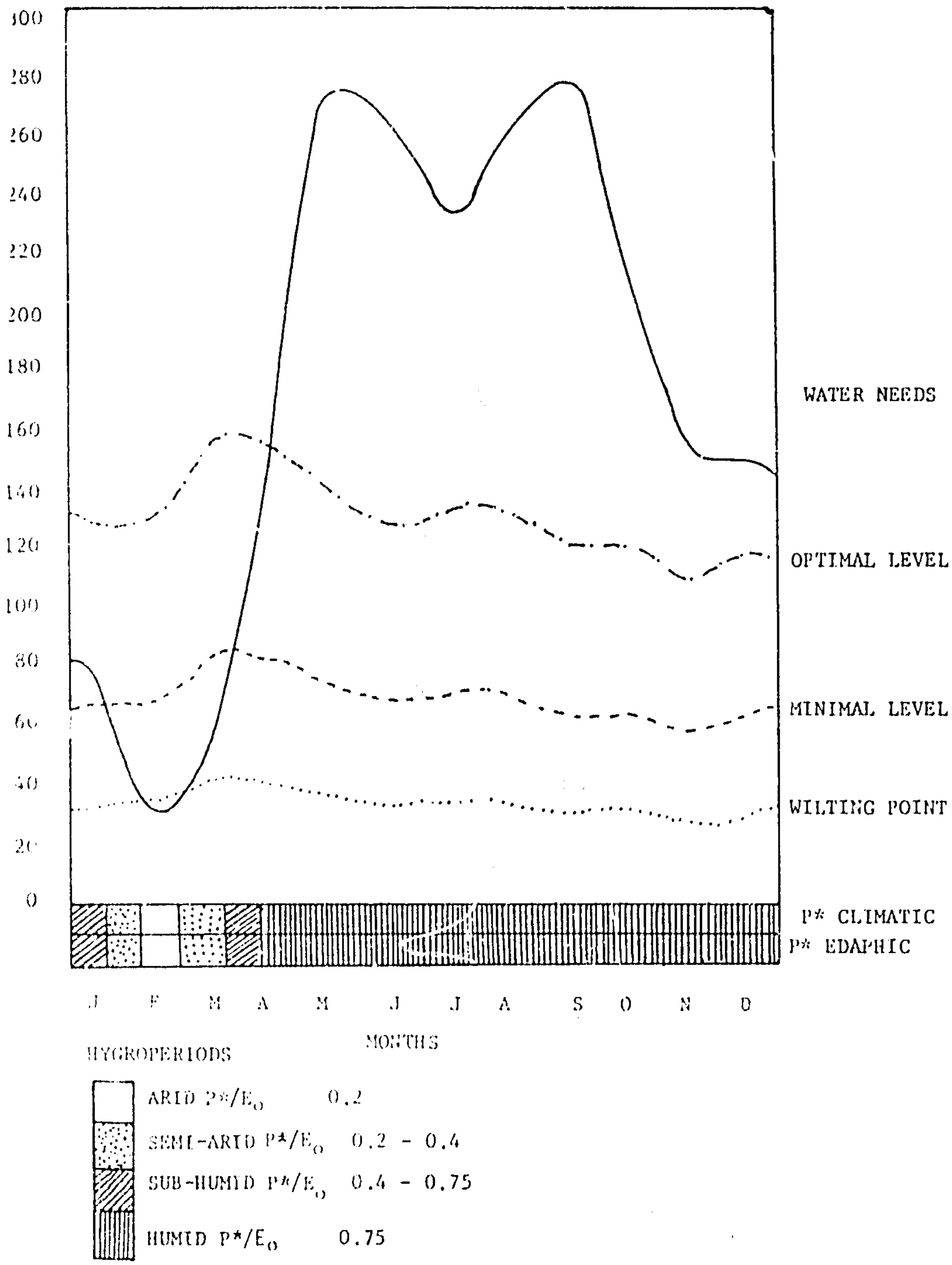
CATIE - ACOSTA
PURISCAL PROJECT 1981

P* CLIMATIC - RAINFALL
P* EDAPHIC - RAINFALL + 100 mm SOIL WATER CAPACITY

Fig 4 Climatic Diagram for Puriscal

Loc. PURISCAL

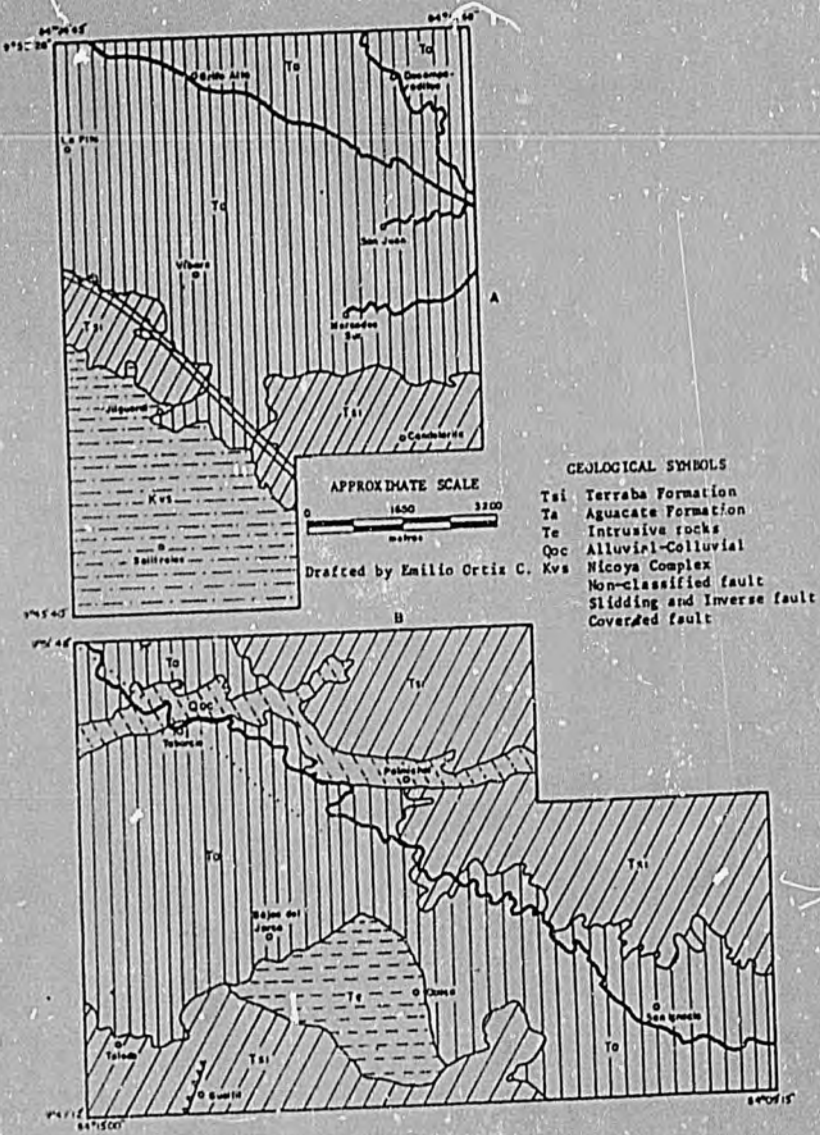
Altitude 1102m Mean annual evapotranspiration (pot) 1567E_o



The geologically complex area is divided into 5 structural groups (see Fig. 5) whose origins include volcanic, tectonic and erosion/deposition processes. Parent materials for soils in the area include basalt, volcanic ash, limestone, diorite, granite and recent colluvial and alluvial deposits. The weathering and soil formation rates of soils derived from these materials vary substantially. The combined results of rough topography and the diverse parent material is a wide variation in soil type, fertility and susceptibility to erosion. The majority of the soils in the area are classified as Inceptisols or Ultisols within the Soil Taxonomy. The specific soil groups found in the region have been described and classified at the Great Group level by a CATIE/GTZ soil survey. Most of the soils are characterized by physical and/or chemical limitations for agricultural production. The distribution of soil groups in Acosta and Puriscal indicates the extent of shallow and/or infertile soils in the study area (see Table 3: Figures 6 and 7 in Appendix C) (Alvarado et al 1982).

Table 3

Soil Order	Group	% Area Covered	
		Puriscal	Acosta
Entisol	1. Lithic Ustortheut	6%	9%
Inceptisol	2. Typic a). Lithic b). Fluventic and c). Ustropepts	11%	51%
	3. Ustic humitropep	-	10%
	4. Typic dystrandept	1%	-
	5. Udic haplustalf	9%	-
Alfisol	6. Aquic a). and Ustic b). Tropohumults	54%	30%
	7. Rhodustult	19%	—



SOURCE Ministry of Industry and Commerce.
Director of Geology, Mines and Petroleum.
National Geographical Institute.

Fig 5 Geological map of the Project area

Source A. Alvarado et al 1982 (CATIE)

All of the soils, except the Alfisols, have in common a low base sturation, and low fertility. Other limitations for agriculture include shallow depth in some Ultisols and Alfisols (5, 6b, and 7) and inadequate drainage in aquic soils (6a). In the case of Andepts (4) the presence of amorphous (allophane) clays leads to phosphorus deficiencies.

Erosion potential is also high for most of these soils owing to a combination of topography, rainfall and inherent soil characteristics. Land slips, landslides, and terracettes occur frequently on the steeper slopes (40%) and a moderate level of gulley erosion is apparent in areas of deeper soils and gentler slopes. Soil compaction from overgrazing, and evidence of prior sheet erosion (e.g. exposed B horizons of soil profiles) are also widespread, especially in the degraded pastureland of Puriscal. In Acosta, rill and sheet erosion occur frequently in coffee stands and in small plots in annual food crops.

2.5 Land Use Capability

The pronounced discrepacy between potential and actual land use was a major criterion for the initiation of the existing national and regional projects in Acosta-Puriscal.

More than 60% of the land in Puriscal and almost 90% of the land in Acosta is classified as having serious limitations for agriculture (classes VI, VII or VIII of the US Soil Conversation Survey (see Figs. 8 and 9 in Appendix D). Any form of cultivation is usually excluded from the list of recommended uses for land in class VI or higher. The usual recommended uses for these more limited lands are: forest, grazing and tree crops (Class VI); commercial or semi-commercial forestry (Class VII); and non-commercial forest reserves (Class VIII). The lands with higher agricultural potential (Classes II, III and IV) are confined primarily to the immediate vicinity of the town of Santiago de Puriscal and to the Tabarcia River Valley (Alvarado et al 1982).

The major limitations on land use in Classes VI, VII and VIII are the high clay content of some of the soils, low native soil fertility and steep slopes. The effects of inappropriate land uses in these areas include: soil compaction, land slips, soil moisture deficits, soil nutrient depletion and high erosion losses.

The Class VIII lands are limited by extreme steepness of slope and shallow or rocky soil profiles; the consequences of inappropriate use include all of the above-mentioned effects often more serious in magnitude. The introduction of appropriate agoforestry technologies may considerably broaden the range of sustainable land use systems applicable in these Class VI-VIII lands. One of the objectives of the proposed research is to develop sustainable production systems adapted to the limitations of these environments and the needs of the inhabitants.

2.6. Land Cover, Land Use Systems and Land Tenure

The dominant land cover by area is pasture land (72% Puriscal, 41% Acosta), used primarily for extensive grazing operations, usually in undulating to steep lands. This is more pronounced in Puriscal but applies to Acosta as well; (see land cover maps in Appendix E). The remainder of the land is in nearly equal proportions of forest, perennial crops (mostly coffee) and annual crops, with annuals (including tobacco) occupying relatively more land area than perennials in Puriscal.

Croplands (particularly cash crops) tend to be concentrated along roads throughout the region (See Figs. 10 and 11) (appendix E). The farming systems within the region are all based to some extent on a mixture of cash crop and subsistence production. The emphasis varies with farm size, sub-region and site accessibility. Farms in Acosta tend to be much smaller and less commercialized than the Puriscal farms (von Melle, 1983).

Small and medium sized farms (10 ha) occupy most of the land in Acosta, while in Puriscal farms of 10 ha cover 85% of the land area. In Acosta 65% of the farms are less than 5 ha, accounting for 29% of total land area, 25% are between 5 and 10 ha (these constitute 43% of the land area) and 10% of the farms are greater than 10 ha (29% of the land area). Land distribution in Puriscal is much more skewed. The farms of less than 5 ha are 46% of the total number of farms but occupy 9% of the land area, 11% of the farms are in the 5-10 ha size range (5.6% of land area) and the 43% of the farms that are 10 ha cover 85 % of the land area (See Table 4). In Acosta small farms devote most of the land to coffee and other perennials, followed by grains for subsistence. The larger farms in the same sub-region allocate the largest proportion of land to pasture for commercial operations with coffee occupying the next largest land area. Small farms in Puriscal allocate most of the land to annual crops (grains for food and cash and tobacco as a cash crop). Larger farms in Puriscal allot over 70% of the land to pasture and other non-crop uses which may be complimented by annual subsistence and cash crops. (See Table 5).

Table 4: Distribution of managed land by class*

	ACOSTA			PURISCAL		
	Percentage of		Average ha	Percentage of		Average ha
Class	Farms	Land	of class	farms	Land	of class
0-2.99 ha	50.0	15.4	1.4	28.6	3.0	1.3
3-4.99 ha	15.0	13.3	4.0	17.9	6.0	4.0
5-6.99 ha	5.0	7.0	6.3	7.1	3.3	5.5
7-9.99 ha	20.0	35.8	8.0	3.6	2.3	7.7[a]
10 ha	10.0	28.5	12.8	42.8	85.4	23.4
TOTAL:	100.0	100.0	4.5	100.0	100.0	11.7

* Taken from Platen, H. von, et al 1982

Table 5: On-farm land use in Acosta and Puriscal % Land Occupied by Dominant Crop (or Land Cover*)

	Acosta	Puriscal
Pasture	41%	72%
Coffee	29%	8%
Tobacco	-	7%
Annual Food Crops	18%	9%
Other	12%	4%

* Taken from Platen, H. von. et al 1982

2.7 Household and Labour Characteristics

The farm households in the area have an average of 7.5 persons each. The major difference between Acosta and Puriscal is in the proportions of adult men and children (See Table 6).

Table 6: Number of Family Members

Age	Acosta	Puriscal
40 years	1.3	1.0
10-14 years	1.5	1.3
60 years	0.2	0.2
Women 15-60 years	2.2	2.2
Men 15-60 years	2.2	3.0
Total	7.4	7.7

(From von Platen et al 1982)

Approximately 68% of the farmers (and their families) work off farm in Acosta (average 92 days/year) and 32% of the farmers in Puriscal work outside the farm (27 days/year average).

Table 7 shows the labor invested in farms in Acosta and Puriscal and figures 12 and 13 , from von Platen et al, 1982, illustrate the distribution of labor use by activity and by month . Labor from outside the region is hired only during the coffee harvest (October, November), which is the period of peak labor demand. Both Acosta and Puriscal experience seasonal labour shortages and seasonal slumps in employment and/or on-farm use of labor.

2.8 Community Infrastructure

The area is served by 2 urban centres. Santiago de Puriscal is a high-level functional centre which provides social, cultural and economic services, including an adult night school and an agricultural school. San Ignacio de Acosta is a middle-level centre that offers basic health, banking and marketing services plus an agricutural high school.

The physical infrastructure in Puriscal includes a dense network of roads and paths with all-weather roads to urban markets in the capital (see Fig.2). San Ignacio de Acosta is also linked to San Jose by an all weather road, but the road connecting the two towns of San Ignacio and Santiago is plagued by landslide hazards and presents an obstacle to ordinary vehicular traffic during the rainy seasons (von Platen et al 1982)

Marketing infrastructure includes municipal markets in the two main towns, several public markets in the capital, government supported coffee and grain cooperatives in Santiago de Puriscal and a private coffee processing plant that purchases parts of the harvest in Acosta.

Table 7: Labour Investment in Acosta

CONCEPT	ACOSTA	PURISCAL
TOTAL Workdays	333	541
Farmer	130	167
Family	142	294
Hired Labor	61	80

Fig. 12 Labor use during the year (Average man-days per month)

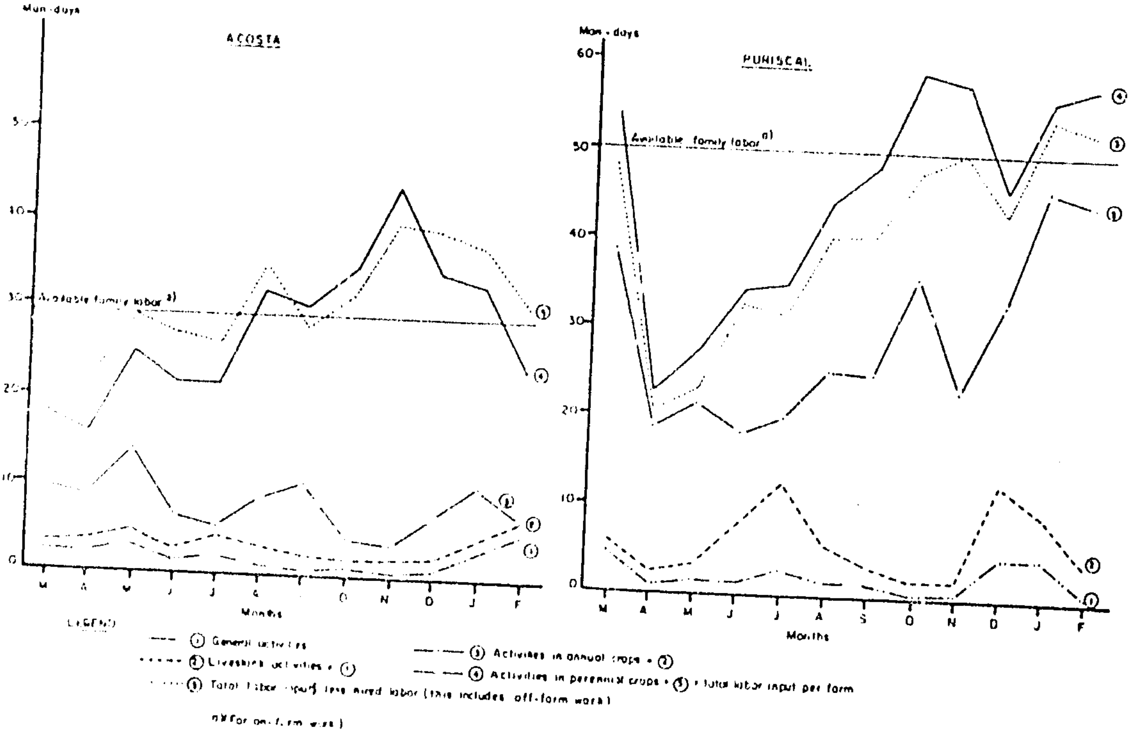
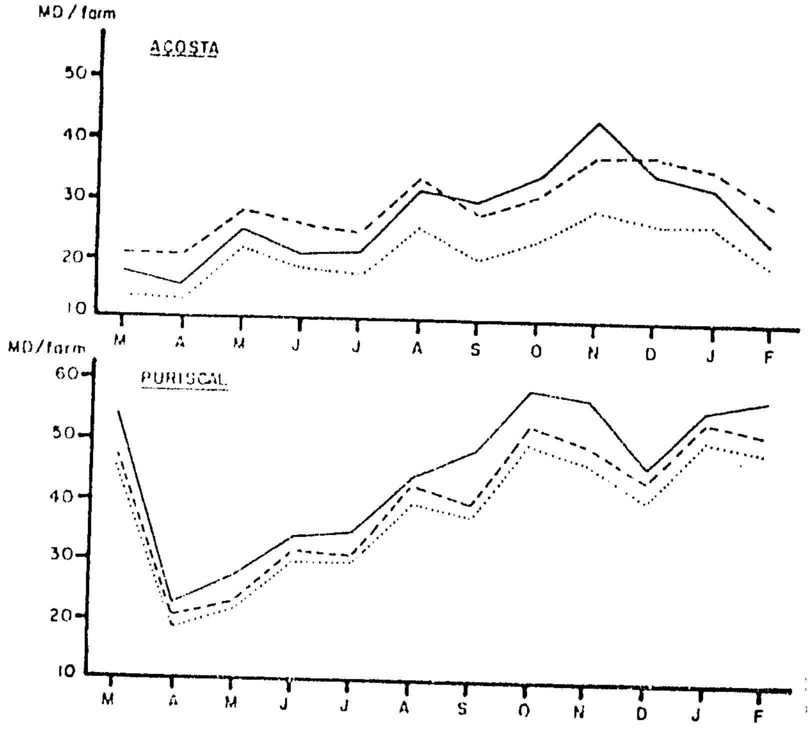


Fig. 13 Comparison between total farm labor input, family labor input and off-farm activities. Average MD/farm



LEGEND.

——— Total farm labor

-·--- Family labor input plus off-farm activities

········ Family labor input (farm)

These mechanisms are supplemented by sale of tobacco directly to the tobacco companies under contractual agreement, and sale of products at the farm gate to retailers and wholesalers who act as middle men for municipal and national markets.

The area is also served by a regional office of the Ministry of Agriculture, based in Santiago de Puriscal. The extension service includes agronomists, tree crop horticulturalists, livestock specialists, and foresters assigned to farm production of fuelwood and timber. Acosta-Puriscal also includes the target area of project 032, a bilateral (Costa Rica/US) project for natural resource planning and management in the upland watersheds.

3. DIAGNOSIS OF PROBLEMS AND POTENTIALS AT THE REGIONAL LEVEL

A visual comparison of land use capability maps with actual land use shows extremes of both under - utilization and over - utilization of land resources relative to biophysical potential for sustained production. Field reconnaissance confirmed this and revealed serious problems of productivity and sustainability within the region.

3.1 Production Problems and Potentials

Discrepancies between existing productivity and apparent production demand (at farm and regional levels) constitutes a major problem. Current land use fails to meet basic needs of farm families in some cases. In other instances off-farm demands for farm products cannot be satisfied because of low-productivity. Inter-regional demands on agricultural and forest lands relate to both rates and types of production. Small farm households and landless households require staple foods, milk, eggs, meat, building materials, raw materials for cottage industry as well as sources of employment. The absence of such local products or employment represent regional opportunity costs of existing land use systems. The magnitude of opportunity cost is related to the amount of land used and to the difference in the actual and potential productivity of the land and the available labor.

The qualitative aspect of opportunity cost is more critical in the case of extensive grazing lands since local demand for the product of pasture (beef) is very low relative to the need for cropland and forest products (food, cash, timber, raw materials).

3.2 Sustainability Problems

Visible evidence of soil and water management problems can be found throughout the region. The frequency and severity of erosion features, soil compaction, and impoverished stands of natural vegetation and crops indicate a degradation of the resource base and a downward spiral in future productivity. Large tracts of overgrazed pasture land have been damaged by land slips, gullies and terracettes. Many of the fields planted to annual crops are located on the steeper slopes and show signs of rill and sheet erosion. The interruption and uncontrolled channelling of drainage by roads, footpaths, and cattle trails have also caused numerous landslips and gullies. Roads and overgrazing of pastures on steep slopes and/or heavy clay soils appear to be the most signficant causes of erosion features in the region (in terms of both frequency and severity). The effects of rill and laminar erosion in croplands are reflected more in the poor condition of crops, due to decreased soil depth, nutrient depletion and exaggeration of soil moisture deficit. These effects are manifested most directly at the farm level and are felt at the regional level as indirect results of decreased production.

The causes of these problems are of two types. First there are management practices and technologies within existing land use systems that could be changed or improved to reduce soil erosion. For example,reduction of stocking rates, rotational grazing and introduction of improved herbaceous and tree species in pastures could reduce the damage within this system.

However, spatial distribution of land use types and proportional allocation of total land area to various uses also constitute causes of land degradation. The relative location of coffee, annual crops and pastures often results in placement of high value perennial crops (such as coffee) close to the home and/or on the best lands. Annual food crops are often relegated to the least productive and most fragile lands. High potential areas in undulating topography and in valley floors are often devoted to grazing, while more intensive uses occupy steep hillslope lands. The net result is an increase in the amount of erosion and runoff produced per unit of production in the region.

The proportion of total land area allocated to each use also affects the sustainability of each land use system and of the regional system as a whole. The over-allocation of land for grazing reduces the available area for food and cash crop production and requires the further intensification of these activities in order to meet production demand (on-farm and regional) on available land. Also, the relative amount of land in pasture versus woodland or perennial crops disrupts the hydrologic cycle in the area and reduces available soil moisture for plant production on-site. Many farmers have migrated from Acosta-Puriscal to the Guapiles frontier area due to decreased production of degraded pasture and cropland (Thrupp, 1980). This demonstrates the effects and magnitude of sustainability problems in the region.

3.3. Specifications for Potential AF Technologies and Land Use Systems for Solution of Problems Within the Study Area

The improvement of existing systems by agroforestry technologies can best be implemented at the farm level and will be discussed within the context of farming system diagnosis and design of agroforestry technologies adoptable by land managers.

Changes in the relative areal extent and geographic distribution of land use systems require a larger than-farm analysis and plan, but may be implemented later at the farm level. As such, all suggested solutions to regional scale problems must be reconciled with farm manager needs and constraints. The major changes indicated for each system are as follows:-

Medium to Large Farms, Puriscal

Pasture Lands

- intensify and diversify production in high potential pasture land.

- diversify and shift land use toward silvopastoral and perennial cropping systems in poor quality and/or fragile pasture lands.

Coffee Stands

- diversify production in unshaded coffee plots (which requires agroforestry technologies that increase and maintain soil fertility, soil stability, and soil moisture storage) to increase cash income, to protect the soil, and to provide other products for home and regional use (food, timber, raw materials).

- establish employment and marketing opportunities based on processing and sale of products from existing and proposed agroforestry systems that produce fruit and wood.

Small Farms, Acosta

Annual Croplands

- intensify production of food crop plots on medium and high potential land.

- stabilize and diversify production on low potential land to increase available food and to assure continued production on fragile land.

- implement soil conservation measures (with vegetative components) in annual croplands on moderate slopes.

- introduce food-producing agroforestry systems adapted to steep slopes and thin soils, to replace annual croplands in extreme topographic conditions.

Coffee Stands

- intensify overall production in multipurpose coffee plots to increase cash income from coffee and fruits.

- establish employment and marketing opportunities based on processing and sale of products from existing and improved agroforestry systems (e.g. more commercialized fruit production).

Animal Production

- reduce land degradation caused by overstocking of small pastures.

- increase food and cash yields from animal production enterprises.

- establish employment and marketing opportunities based on animal production.

4. SELECTED FARMING SYSTEMS

As indicated in the distribution of land use and farm size in the study area, farms are stratified by region in terms of both size and enterprise. The farming systems selected for further study typify the distinct farm management and land use problems in Acosta and Puriscal, respectively.

The major systems of interest in each area were chosen on the basis of the following criteria: (1) high potential for meeting regional needs and improving the situation of local farmers, (2) existing conflicts between actual production and on-farm and local needs; (3) presence of sustainability problems (erosion, landslips, excessive runoff) at the farm or watershed level. Two systems were identified: the medium to large-sized, more commercial farms of Puriscal and the small farms of Acosta (10 ha).

The large and medium-sized farms of Puriscal producing coffee, cattle and tobacco, with supplemental food crop production, represent systems with high potential for improvement by agroforestry technology, both in terms of farm family welfare and regional economic production. The extensive but overgrazed hillslope pasture lands within this system warrant further research both in terms of sustainability problems at the farm and watershed level, and in terms of economic productivity per unit area (from a regional or national viewpoint).

The choice of small mixed subsistence - commercial farms (in Acosta) also reflects both production and sustainability criteria. There is an apparent need for greater productivity at the farm and regional level and sustainability problems (soil erosion, soil nutrient depletion and excessive runoff) are manifested at the farm level. Both coffee and food crop plots in this system can benefit from improvement or introduction of agroforestry technology.

4.1 Small Farms, Acosta

The small farms of Acosta, like the larger farms in Puriscal are extremely diverse. In this case, however, the diversity is expressed more in ecological terms, while the commercial enterprises are more limited. Most of the farms combine commercial and subsistence production based on coffee and grain crops, respectively.

The small farm households are heavily dependent on the coffee crop for cash income. Other than coffee, labor is the commodity most commonly commercialized. Off-farm employment is the major alternative source of income. Many households depend heavily on seasonal employment in the coffee harvest on nearby holdings, while other families rely on wages earned by one or more members employed full-time on other farms, in the towns, or in the capital (Esipinoza, 1983).

Beside cash earnings, farmer objectives include risks spreading and production of a wide variety of goods needed by the farm household (staple foods, fuel, and diverse supplementary foods). Maize and beans are usually produced and consumed on farm with little or no surplus for sale. Rice is purchased at local markets (Tabarcia, San Ignacio) and animal protein is limited mostly to eggs, milk and/or meat produced on-farm with occasional purchased supplements, depending on family income.

Both commercial and subsistence production are based on low capital inputs and a flexible schedule of labor input. The latter is structured to accommodate seasonal demands for off-farm labor, as well as seasonal labor peaks in coffee stands on-farm. Agrochemical and other material inputs are minimal, especially in grain crops. Coffee stands often receive greater priority for available labor and materials, but input levels are still, well below those of parallel enterprises in Puriscal.

4.1.1 Coffee

The coffee stands in Acosta's small farms are, in most cases (84% of the area in coffee), structurally and functionally, diverse agroforestry systems based on some degree of intercropping with bananas, plantains, fuelwood and/or fruit trees. Most of these stands are well established and the coffee plants themselves are often over 30 years old (in need of renovation) while the shade trees may be even older. On farms of ≃ 10ha, these multipurpose, multi-tiered stands usually cover between 0.5 and 3 ha. Coffee stands thus account for a large proportion of the land area and are also major sources of cash for meeting household expenses (including food purchases).

In addition to cash income, the small intercropped coffee plots provide both staples (plantains, bananas) and other fruits *(Citrus* spp., *Mangifera indica, Persea americana and spondia purpurea)*, most of which are consumed by the family or are wasted due to marketing difficulties. Such plots also produce enough fuelwood to meet on-farm demands. The prunings from 3 ha of coffee alone produce sufficient fuelwood for a farm family for one year. If shade trees are also lopped, then fuelwood needs may be met by plots ≃ 2ha (Lemckert and Campos 1981; Esipinoza, 1983).

Production on the traditional small farms averages 730kg/ha of dried coffee with an annual production value of ₡29,000/ha and a gross margin of ₡25,000/ha. As such it is by far the most profitable activity in Acosta, per unit land as well as in return to labor. It also compares well with tobacco and traditional coffee enterprises in Puriscal, though it yields 50% of the high input coffee systems in Puriscal. The productivity of the Acosta enterprise, however, is further enhanced by the subsistence value of the other products from the mixed stands (von Platen et al 1982).

4.1.2 Grain crops

In general the small farms of Acosta produce grains for subsistence. Maize (alone) and "covered beans" (e.g. red beans sown into cut-over fallow) are the major products of small plots planted to annual crops.

Only a single crop of maize is usually grown, during the first cropping cycle from May to August (See Fig. 15). Beans are not intercropped with maize due to the high risk of loss from excessive rains in May and June. In most cases the maize is planted into hillslope plots (10-50% slope) which have been neither terraced nor plowed. The sites are cleared of vegetation by hand.

Total annual labor input is 89 man-days/ha. Fertilizer is applied in about half of the maize plots in Acosta (21 kg/ha N, 45 kg/ha P_2O_5 ; 15kg/ha K_2O). Other agrochemicals are rarely if ever used on maize.

The average yield is 1,700 kg/ha with a value of ₡7,641kg/ha and a gross margin of ₡6,732/ha. Compared to other products maize gives a low return to both land and labor. However it plays an important role in the system as feed for chickens and as a staple food (von Platen et al 1982).

Beans in Acosta are grown almost exclusively as "covered beans" during the second cropping cycle. This reflects climatic and topographic constraints in Acosta as well as the high opportunity cost of labor during the second cropping cycle, which coincides with the coffee harvest. Excessive rains preclude raising beans during the first cropping cycle, and the steep slopes favor a no-till system. The high seasonal labor demand for coffee supports the continuation of this practice.

Labor input is very low, at 38 man-days/ha. No fertilizers or other agrochemical are used. Covered beans yield ≈ 528kg/ha in Acosta, with a value of ₡9,502/ha and a gross margin of ₡8,555/ha. This is better than both maize and animal production, though less than coffee, in terms of returns per unit land. The returns per unit labor, however, exceed those of all other enterprises in Acosta (Lagemann and Heuveldop, 1982).

4.1.3 Animal production

Animal production on small farms in Acosta is limited mainly to small animal and milk production for on-farm consumption. Milk cows and sometimes calves are kept if there is grazing land available after meeting requirements for grain and coffee plots. Milk cows are often native or mixed breeds and give 2 liters a day throughout most of the year. Some farmers also have dual purpose cattle to provide meat for home consumption or as a source of cash income. The smaller farms, however, are usually too limited by land to engage in this enterprise.

Chickens are almost always kept for egg production and some meat, even in households with very limited resources (85% of all Acosta farms have chickens with an average of 25 chickens each). Chickens run loose and are fed on maize (10kg/animal/year) plus kitchen and garden scraps. Some farmers recently attempted to develop commercial egg production enterprises, but the high cost of concentrated feed and fluctuating egg prices caused them to abandon the effort.

Almost 40% of the small farms in Acosta keep pigs, mainly for home consumption. Expansion of the enterprises is limited in part by the availability of feed, but even more by lack of water for keeping pens clean. There is strong social pressure from neighbours against letting pigs roam freely due to crop damage. Estimates of the economic returns from animal production enterprises in Acosta are given in Table 8.

Table 8 : Economic Returns from Animal Production in Acosta

Type	Annual Production value* ₡ per farm
Cattle	6400
Pigs	680
Chickens	2400

* Average land area = 6 ha.
From von Platen et al 1982

4.2 Medium to Large Farms, Puriscal

The dominant farming system in this area, in terms of areal coverage, is based on a mixture of commercial enterprises. These farming systems are characterized by economic (as oppossed to ecological) diversity. Three or more cash enterprises are often combined, with a mixture of extensive low-input enterprises such as grazing and more intensive high-input operations such as coffee and tobacco production. Extensive cattle grazing accounts for 70% of the land on these farms (avg. 16 ha), while coffee usually occupies 3 ha, grain crops (maize and beans) cover 2 ha and tobacco plots normally cover 1 ha.

The farm usually produces enough maize and beans for home consumption with the surplus (30 to 50% of the harvest) sold as cash crop. Rice is purchased, often at a cost equal or lower than the value of surplus grain sales. Sufficient meat and dairy products for the household are produced on-farm, with a large proportion of surplus for sale and/or trade. The other main sources of cash income are tobacco and coffee production. Cash earnings from these enterprises are used to purchase personal and household goods, supplementary and/or processed foodstuffs, construction materials, transportation, and the capital and labor inputs for agricultural enterprises. Some farmers also have other sources of cash income and savings investment that provide constant returns, such as:-

1. small stores that buy and sell local produce as well as domestic goods and food from other regions; and

2. vehicles that transport produce to market from the owner's farm as well as from nearby farms (as cargo or as farm-gate purchases).

The specific characteristics of the major enterprises and their roles in the farming system as a whole are described in greater detail below.

4.2.1 Animal Production

Beef and dual purpose cattle predominate on the medium and large farms of Puriscal. Beef cattle are native and native/Cebu crosses. Multi-purpose and milk cows may be Holsteins, Jeseys or crosses. On the average there are 16 animal units/farm, at a stocking rate of 0.8 animal units per hectare, which usually increases substantially at the beginning of the rainy season. A large number of steers are later sold when pasture production decreases during the dry season. Depending upon the management and composition of the herd, and the disposition of family labor, cheese may be produced for home consumption and/or for sale.

Farms based on extensive grazing of beef and multipurpose cattle are covered primarily by unimproved or poorly maintained pastures. Large tracts of overgrazed pasture land have been damaged by land slips, gullies and terracettes. A few improved pastures have been planted to Cyrodon plectostachyus and Brachiaria ruziziensis, the latter being more successful on poor hillslope soils. Living fence posts are used in most pastures, whether improved or unimproved, but are currently under-utilised as sources of fodder.

Cattle management depends on family, and some hired labor. The permanent hired labor force usually consists of one or two persons who take responsibility for daily vigilance and management of the herd and for regular maintenance of farm infrastructure. Overall the system is one which minimizes labor inputs.

Capital inputs for maintenance are also minimal (₡40/animal/year). Production rates are low as are profits per unit land. The average net income is ₡1,000/ha/year. The returns per unit labor, however, are fairly high. Moreover the cattle operation is more than a source of regular income, the herd itself, as well as land, serve as banks for saving and investment (von Platen el al 1982).

4.2.2 Coffee

Coffee constitutes a much smaller proportion of total land cover. It may, however, be the major source of income followed closely by grazing and/or annual cropping activities. In some cases coffee is a secondary cash crop in Puriscal. The tendency is toward the gradual establishment or expansion of coffee and grain crops at the expense of existing tobacco and pasture land (on large holdings).

Coffee holdings on large farms tend to be fairly homogeneous, to use little shade and are usually planted to the improved caturra variety. The recently established stands in Puriscal are almost exclusively caturra variety and most are closely spaced (4000 plants/ha) without shade. Both material and labor inputs are high compared to grain and cattle production. Agrochemicals used include fertilizers (509kg of NPK* per hectare per year and 439kg of 33% N per hectare per year) as well as insecticides and fungicides. Weeding may be done manually or with the aid of herbicides (Gramoxone/Paraquot).

Labor input is 200 man-days/ha/year and is allocated primarily to harvesting (100 man-days/ha/year); pruning, fertilization and weeding (80 man-days/ha/year); and planting (20 man-day/ha/year) (von Platen et al 1982).

Off-farm labor is hired to establish, harvest and maintain the stands. Seasonal labor shortage is the major limit to expansion of coffee production in Puriscal, in part because of competing labor demands for tobacco in the autumn season. (See Figure 14).

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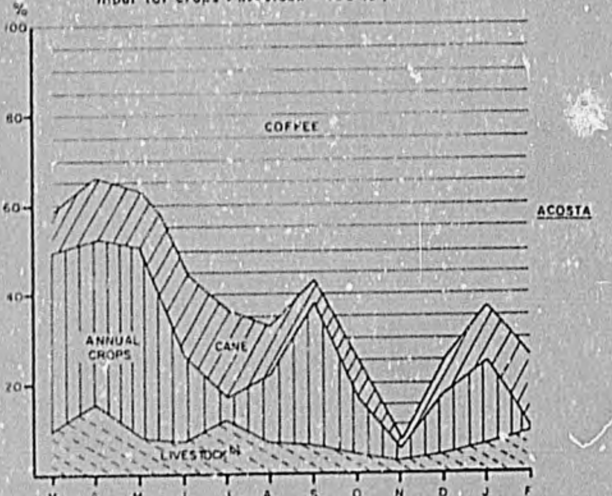
* Fertilizer mix is 18-20% N., 5-10% P_2O_5, and 10-15% K_2O

Fig. 14 Labor use per farm enterprise during the year
(Percentages of mean man days per month, labor input for crops + livestock = 100 %)



a) Without tobacco b) Including pasture cleaning

From von Platen et al. 1982

Annual production varies from 920kg/ha of dried coffee (other varieties) to 1,760 kg/ha of dried coffee (caturra var.) The value of the harvest ranges from ₡36,000/ha to ₡62,000/ha, with gross margins of ₡31,000 and ₡55,000/ha respectively.

4.2.3 Tobacco and Grain Crops

Annual crop production in the medium to large mixed enterprise farms of Puriscal is characterized by a fairly high degree of commercialization of maize and bean crops and a strong emphasis on tobacco. Maize and tobacco are usually grown in seasonal rotation on the tobacco terraces (See Fig. 15). Maize and beans are also intercropped in some plots, and beans may also be sown into cut-over fallow ("covered beans").

Tobacco is grown from October to January, usually under contract to a specific company, with area limited by an allotment system. It requires high labor inputs in October, January and February (207 man-days/ha/year). High agrochemical inputs are also required (by contract). Fertilizer is applied at planting (N-P-K-Mg 12-12-17-12) followed by 351 kg/ha of NPK (total weight of pure nutrients, equal proportions). About half of the farmers use some combinations of fungicide, insecticide and herbicide. Yields range from 300-1800 kg dry leaves/ha with an average of 1144kg/ha (just above the national average). The corresponding value of the average annual harvest is ₡36,000/ha and the gross margin/ha is ₡29,000.

Maize planted in rotation with tobacco benefits from the agrochemical and labor inputs to the terraces. In both maize and maize-bean plots NPK (10-13-10) and N (33% ammonium sulphate) fertilizers are applied, though at lower rates than in tobacco. Fungicides and pesticides are not widely used for grain crops; about 12% of the farmers use them. Herbicides, however, are used in 33% of the maize fields and 40% of the bean fields, prior to planting. Yields vary widely, with an average of 2,061kg/ha for maize alone at a value ₡9,277/ha and a gross margin of ₡7,613/ha. Maize and beans planted together yield an average of 1,629kg/ha of maize and 350kg/ha of beans with a value of ₡10,000 and a gross margin of ₡9,000ha.

The "covered beans" receive little or no fertilizer input and are sown into a cut-over fallow (of 6 months to 2 years). Yields average 463kg/ha, with a production value of ₵8,300 and a gross margin of ₵7,700 (von Platen et al 1982).

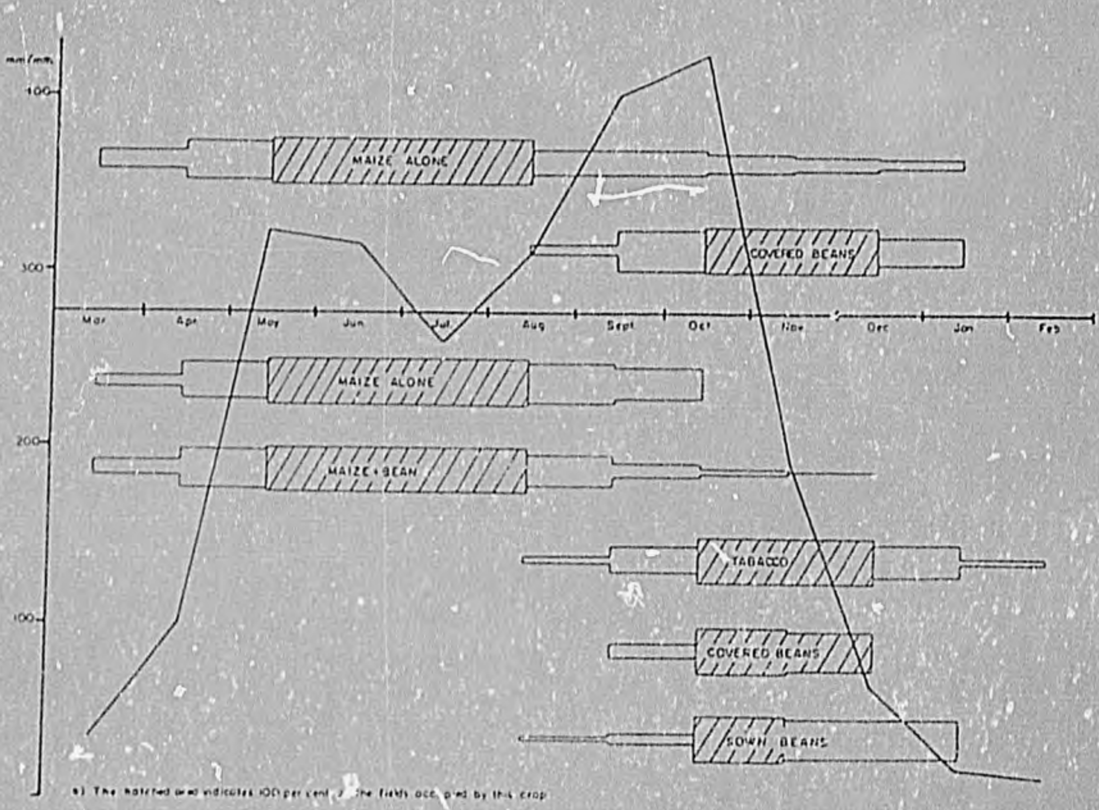


Fig 15 Land occupation during the year for the most important annual crops and rainfall distribution per month (From von Platen et al 1982)

5. DIAGNOSIS OF PROBLEMS AND POTENTIALS OF THE TARGET FARMING SYSTEMS

The problems and potentials in both farming systems were diagnosed in terms of the basic needs of the farm household: food, water, fuel, shelter, cash, raw materials for handicrafts, and savings/investment. The problems may be related to present production for fulfillment of these needs (usually perceived by the farmer) or they may be based on sustainability of production for meeting these needs in the future (often perceived more by the D&D team).

The problems and potentials listed in the summary table (Table 9 and 10) reflect the combined concerns of the farm families and the D + D team). An indication of farmer vs. D + D team perception of problems is listed for each statement. This is to assure subsequent coupling of solutions to farmer-perceived problems with solutions to problems of less immediate concern to farm households. Thus every technology should address the stated priorities of the farmer, at least in part, to guarantee its utility and adoptability at the farm level.

The symptoms and their apparent causes are grouped by the basic household needs affected. The symptoms may refer to constraints or to unrealized potentials within the farming system. A more detailed diagnosis follows, with the design specifications for technological solutions for each case.

5.1 Small Farms Acosta

5.1.1 Diagnosis

Acosta farm families most often mentioned food and cash as basic needs not being adequately filled. Existing cash enterprises in need of improvement are coffee production and off-farm employement. Potential enterprises in need of development are varied, but the most promising are citrus and/or pejibaye production. The former was mentioned repeatedly by farmers in the area. Food production problems include both quantity and quality of grain yields and inadequate protein in the family diet.

Cash production is limited in large part by low yields of coffee stands. The low yields are caused by three main factors: manager's objectives, low-soil fertility, and inadequate management. The first cause must be well understood to properly deal with the second and third. Most small coffee stands represent a multipurpose land use to produce coffee, fuel, fruits and even staple foods.

TABLE: 9 DIAGNOSIS-SMALL FARMS, ACOSTA

* = perceived by farmer, + = observed by team

Basic needs affected	Symptoms	Apparent causes
Food and water	Lack of milk for home consumption *+	Shortage of grazing land, fodder
	Low productivity of corn fields +	Low soil fertility, soil moisture deficit.
	Damage of corn crops *	Exposure of crops to heavy winds
	Inadequate water for small animal production or veg. gardens. *+	Dependence on seasonal rainfall or limited public water supply
	High cost of small animal production *+	Competition with farm family for same food or cash for feed
	Erosion in corn fields +	Inadequate ground cover and erosion control measures
		Placement of annual crops on steep slopes
Cash	Low productivity of coffee stands *+	Inadequate mgt. of shade Low soil fertility - high cost fertilizers
	Lack of employment opportunities *+	Lack of processing facilities for existing and potential local food products.
		Lack of raw materials for wood products mfg.
	Difficulty in marketing fruit crops. *+	Inadequate marketing and processing infrastructure for local fruit production
	Erosion in coffee stands +	Lack of groundcover and erosion control structures.
		Location of plots on excessively steep slopes.
Shelter + related infrastructure	Shortage of wood and fuel supply over medium and long term +	Forest clearing and cutting of forest re-growth.
	Erosion along roads and paths +	Inadequate drainage Inappropriate location of routes.

TABLE 10: DIAGNOSIS MEDIUM TO LARGE FARMS, PURISCAL

* = perceived by farmer, + = observed by team

Basic needs affected	Symptoms	Apparent causes
Food and water	Lack of water for domestic needs in summer *+	Climate and topographic effects aggravated by deforestation and soil degradation
	Damage to corn crop*+	Tillage practice, lack of ground cover, excessive slope
Cash	Lack of pasture, fodder in summer *+	Low productivity of native species, soil compaction
	Erosion in pasture +	Slope, soil type and stocking rate
	Low productivity and and development of coffee stands *+	Low productive capacity of hillslope soils
		Pests and diseases
		High cost and poor utilization of agrochemicals
	Low quantity and quality of tobacco production *+	Exposure to winds in summer
	Erosion in tobacco plots *+	Tillage methods, ground cover excessive slope.
Shelter + related infrastructure	Shortage of timber supply over medium and long term +	Forest clearing and cutting of forest re-growth
	Erosion along roads and paths +	Inadequate drainage
		In appropriate location of routes.

Farmers also seek to avoid risk through diversification. Given these objectives there is still an excessive decrease in coffee yields due to soil nutrient depletion and the high cost of inorganic fertilizer. Added to this is the competition between coffee management and wage labor, the timing of the latter usually coinciding with peak labor demand for the small coffee stands.

Related to the problems associated with coffee are the low cash income, insecurity, and seasonality of off-farm employment in the area. The manufacturing and service sectors of the economy are not adequately developed to provide alternative employment that complements coffee production.

Lack of suitable off-farm employment for women is particularly acute. Women do not engage in casual labor off-farm except in the coffee harvest. Many other tasks are considered to be exclusively male occupations. Several women indicated an interest in off-farm employment or in more profitable off-season enterprises on-farm.

Marketing of citrus and/or pejibaye fruits is an obstacle to development of a promising enterprise already of interest to farmers. Increased fruit production, as well as local processing and marketing of produce represent unrealized potential for cash earnings by small and large farmers alike. Such an intergrated industry could also provide a convenient source of employment for small farmers and their near-land less heirs including young women. Some farmers have already investigated the requirements for setting up a small processor for existing citrus production.

Food production on small farms is often not adequate to meet family needs. Women mentioned the imbalance of the farm family diet and the difficulty of producing adequate meat, milk and/or eggs for family consumption. Purchase of these items on a regular basis is difficult if not impossible because of the high cost relative to small farm income.

Low on-farm yields of meat and milk are caused by shortage of fodder for cattle. This stems from inadequate land resources, poor fodder species and overstocking, which have led to degradation of pasture land. Erosion, compaction and soil nutrient depletion are common in the grazing lands. Egg production is limited by the high cost of purchased feed and the low quantity and quality of grain (maize) produced on the farm.

The production of beans and maize cannot meet family needs year round. Most small farm households experience seasonal shortages of maize and/or beans and must purchase some of these grains as well as rice, which is purchased year round.

The low productivity of grain crops results from soil degradation and inadequate management. Soil erosion and the high cost of inorganic fertilizers contribute to low soil fertility. Farmers have not yet encountered appropriate low-input technologies for sustainable production of maize and beans at acceptable levels. The soil-conserving covered bean technology does, however, offer a good opportunity for increasing current yields with improvements of existing practice.

Two approaches are viable for improving the farming system according to the design specifications. Productivity of coffee and grain crops can be increased in small increments by stepped changes. Sustainability of cattle production can also be improved by gradual relatively minor changes. However, there is also an opportunity for transformation of the cattle enterprise to another (mixed) form of land use which would increase returns and ecosystem sustainability. Both options are addressed under alternative technologies, bases on existing systems and research in progress within the region (Apolo 1979, Beer, 1979; Budowski, 1981; Gonzale, 1979; Rosero, 1979; Rosero and Gewald, 1979; Russo, 1983).

5.1.2: Design Specification for Technology Development

Points of intervention and corresponding constraints to designed technologies are derived from the causal relationships outlined above. These performance criteria for potential technologies are outlined in Table 11.

Table 11: Acosta - Small Farms

Basic needs affected	Points of intervention	Requirements
Cash	Soil fertility (coffee)	- maintain diversified multi-purpose enterprise - low capital input - avoid competition with existing labour peaks (Oct-Dec) - increase ground cover, prevent erosion
	Community level fruit marketing and processing	- develop outlets for other products of coffee-based enterprise - provide off-farm employment outside of peak labour period (Oct-Dec).
	Soil degradation in staple food plots	- maintain some grain production on steep slopes - low capital input - reduce labour requirements during peak season (Oct-Dec) - improve ground-cover or otherwise prevent erosion
	Animal protein production	- use existing limited land resources (rugged topography, small plots) - low capital input - minimize labour use (Oct-Dec) - reduce risk
	Community level-marketing and processing of animal products	- facilitates marketing/processing of eventual surpluses of milk, cheese, meat and/or animals - provide profitable on-farm or coop. employment for women (in off-season or year round)

5.2 Medium to Large Farms, Puriscal:

5.2.1 Diagnosis

Since these farms emphasize commercial production, most of the problems and potentials relate to cash-producing activities. Various aspects of cattle, annual cash crop and coffee production were all cited by farmers as needing improvement or change. In both tobacco and coffee production the shrinking profit margin was repeatedly cited as a problem. This results from a combination of rising input prices, heavy dependence on agrochemicals and underutilization of potential site productivity.

Tobacco production is also characterized by problems of sustainability, particularly on steep slopes which are clean-cultivated. Terracing reduces but does not prevent erosion, and maintenance of the terraces requires substantial labor input.

Maize and bean crops, which are combined cash and food crop enterprises in Puriscal, suffer from both low present yields and sustainability problems. The production of covered beans is characterized mainly by low yields, but is not so much affected by sustainability problems. Incentives to incorporate existing technology into grain crop production have been lacking. However, the recent development of better marketing channels through the Puriscal office of the national grain cooperative provides a major incentive for intensification. Adoption of soil conservation technology is blocked mainly by labor constraints and by the low investment priority of grain crop plots relative to plots in tobacco and coffee.

Cattle grazing operations in Puriscal have a low productivity per unit land in both economic and biological terms. Net income is approx. ₡1,000/ha, the lowest return/ha of all the major farm enterprises. In part this reflects manager objectives, e.g. production of some profit and constant cash income from a secure investment, with minimum labor input.

The low stocking rate and poor economic returns also result from the degraded condition of soil and vegetation in most pastureland, particularly on moderate to steep slopes. This degradation is due to lack of rotation and/or pasture improvement and to the overutilization of fragile hillslope sites.

5.2.2 Design Specification

Design specifications are identified by points of intervention, that is, by the part of the system to be modified. The technology requirements define the constraints or needs that pertain to each point. The specifications for each diagnosed problem/potential are summarized in tabular form below.

Puriscal - Medium to Large Farms

Basic needs affected	Points of intervention	Requirements
Cash	Cost of inputs	- reduce competition for labour with other enterprises
	Land productivity	- increase cash crop production - minimize competiti[on] for labour
	Soil erosion tobacco pasture	- should be compatible with tobacco technology - low labour input (year round)
	fodder availability	- low capital investment - low labour input (year round)

Given that existing cash resources are inadequate to purchase costly external inputs and given the need for a transition period between existing and new systems, a gradual incremental change in technology is proposed. The intended results are gradual improvements in productivity and sustainability, with more pronounced and immediate improvement in the quality of diet and returns to labour (on and off farm). The most realistic strategy is one that maintains the current low input pattern.

6. ALTERNATIVE TECHNOLOGIES

6.1 Small Farms, Acosta

6.1.1 Non-agroforestry alternatives

- For cash needs

The current improved technology consists of new (Caturra) coffee without shade using heavy fertilizer inputs. This could increase net income (von Platen and Lagemann, 1982), but is incompatible with farmer's objectives and constraints. When partially applied (e.g., by erradicating shade trees) this has led to failure (Espinoza, 1983).

Rising herbaceous components (legume species) have been used in other systems (e.g. cacao + maize), providing soil nutrients as well as weed control. They could also supply a moderate amount of high quality fodder. Potential advantages over the woody component would come from a better ground cover and the possibility of increasing density of cash producing plants (coffee and/or fruit trees). The main disadvantages stems from water competition between the legume creeper and the perennial cash crops, particularly during the dry season. *Desmodium ovalifolium* would appear as one species adapted to the particular environment, but others should be tried as well.

- For food needs

C Cost of inputs for improved varieties plus fertilizer is again incompatible with both ground cover and labour constraints. Attempts to improve the covered bean practice on the basis of improved varieties + fertilizer are also constrained because of risky outputs (great variation, 42%) and a small increase in net income (12%). See paper by von Platen and Rodriguez 1982.

6.1.2 Agroforestry Alternatives

- For cash needs
- Farm level

+ The intervention point (soil fertility) is approached through the introduction of an N-fixing component which can decrease the need for inorganic fertilizer and improve both soil structure (increasing OM content) and ground cover. Two types of components can be used, woody and herbaceous. The woody component is already present, providing shade, OM, fuel and N, amounts depending on the species (see Roskoski, 1982). Shade trees also decrease the density of cash producing components in the system.

  The existing system provides a good opportunity for improvement of woody component species and management.

  System diversity is maintained by maintaining or introducing fruit tree components. The most obvious are citrus, already abundant in the area, as long as a stable market outlet can be established. Another alternative could be Pejibaye *(Guilielma gasipaes)* which can produce 10 kg of edible dry matter per tree, producing a light shade. Besides the marketing question mark, Pejibaye would have the disadvantage of its spiny stem, a very uncomfortable feature for those working on the steep slopes of Acosta. However spineless varieties exist and could be selected.

- Community level

A local processing plant for either citrus or pejibaye could tackle both marketing and unemployment problems. In this respect, the harvesting season for citrus would complement coffee, avoiding labour competition.

- For food needs

- Farm level

+ Soil degradation (erosion and fertility) could be mitigated through the service role of N-fixing woody perennials, but the spatial arrangement will change according to the commodity enterprise (maize or beans). For maize, hedge intercropping along contour lines can provide N to increase yield (Torres, 1983) and mulch to reduce weeding, while enhancing erosion control through natural terracing. To avoid competing for labour with coffee harvesting, maize production should be confined to the first growing season. The rest of the year hedges could be used as a source of fodder. For covered beans, an enriched fallow system would improve both yields and soil protection. It should be based on an easy to establish N-fixing woody perennial. For both systems *Calliandra calothyrsus* appears to be a potential component.

+ Small ruminants are the most suitable animals on which to base the animal protein enterprise. Goats have the advantage of a high milk producing capability coupled with sturdiness and ability to thrive under a wide variety of feeds. There are also more animal units per unit feed, thus spreading risk and increasing sales opportunities relative to milk cow enterprises.

However, the high instinct for survival makes goats also a potential hazard, if left unmanaged. For this reason they will have to be fed through a cut-and-carry or a tethered system, or a combination of both.

Forage production on grazing areas can be improved through the combination of shrubby legume *(e.g. Desmodium gyroides)* on trees *(Gliricidia sepium, Erythrina poepeggiana)*, in combination with grasses, which may overcome the management-induced dominance of either family, so common when only herbaceous components are used in the mixture. Should that balance be achieved, it would enhance the probability of an adequate N supply of grasses, and protein supply to animals the latter could also be provided from either the live mulch cover of the coffee system or legume hedges in the maize enterprise. The main problem of the goat enterprise could arise from acceptability by land managers (goat milk is now bought as a speciality food or medicine) and labour demand. This may prove to be a bottleneck for some families, particularly under a cut-and-carry system.

6.2 Medium to Large Farms, Puriscal

6.2.1 Non-agroforestry alternatives

For cash needs

This more commercial system with a higher degree of specialization within enterprises (like coffee based systems) is prepared to adopt "modern" technology linked to heavier inputs. However, the increased cost of inputs and lack of credit is leading to a decrease in the applied rates vis-a-vis the recommended ones in the coffee-based system. In the coffee plots the effects of an increase in the cost of inputs can be mitigated by live mulch from herbaceous components. Additional labour required could be compensated by a decrease in weeding. Species such as Desmodium ovalifolium could be promising improvements to this system.

In the livestock system the approach of maximizing returns to labour inputs and the "saving bank" role attached to it dictate an extensive grazing technology. Although profitable, alternatives based on cultivated pastures and grazing management are not being adopted. This may actually be a blessing in disguise. An increase in pasture productivity would obviously lead to increase in stocking rate, which could very well end up again in overstocking at a higher level, particularly if the "savings" purpose predominates (which is usually better served by greater number than by animal condition). This condition coupled with bad management could lead to a degradation chain worse than the current one, i.e., with a faster rate of deterioration.

The specific requirements of tobacco technology would indicate that conventional soil conservation practices are the right ones to use in annual cash crops, which will indirectly benefit also the basic grains enterprise. Strict company supervision of contract farmers insures implementation of soil conservation technologies as well as application of agrochemical inputs.

6.2.2. Agroforestry alternatives

For cash needs

- Farm

+ Input costs to the coffee systems can be cut by improvement or addition of N-fixing woody components, depending on labor availability.

+ Land productivity in the same system could be increased by incorporating timber tree components. Careful selection should be made to introduce self pruning species (which do not increase labour requirement) and species that provide light shade (to avoid effect on coffee yield).

+ In the grazing land there could be an improving and a transforming agroforestry approach. The former will be aimed essentially at arresting the soil degradation process, by avoiding cattle trampling on soil slips or areas prone to them. Since erosion is way down in the manager's problem priority list, controlling techniques will have to be linked to the solution of perceived problems.

One such problem is a lack of fodder in the dry period. A fodder producing tree like *Gliricidia sepium* could be used as a true living fence (no wire) with trees planted close in a "barrier" of long stakes around the affected area. This barrier will produce fodder which can be lopped during the dry period. It has been estimated that each tree can produce 6kg DM yr-1). This would be almost enough to feed 1 cow for 1 day (1 cow consumes approx.6kg of DM/day). A closely planted fence could yield 375-500kg/yr per 100 m of "barrier" (75-200 stakes) depending on use of wire. The enclosed area could then be restored by planting pasture/shrubs/trees.

The tranforming approach would aim at establishing a silvopastoral system, as a way of offering a more sustainable alternative to the erosion-fostering cattle operation. It consists in combining cultivated pastures with timber producing trees planted in strips along the contour between living fences of fodder trees. As tree bands are planted stocking rate may be decreased, but fodder from living fences should more than compensate for area lost, depending on spacing and silvicultural management*. Provided there is a market for timber, this practice has been shown to be more profitable than either beef or timber production alone (see annex Appendix F). Although managers can still overstock the pasture component, it is expected that the tree strips will protect and improve the soil. Such a system is not fully compatible with all of the manager's objectives under the present circumstances. It may, however, prove to be ecologically sound and economically viable and its dissemination could be supported by policy incentives, (which is how most existing pasturelands were established).

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*Each strip will consist of two rows of living fence fodder trees between which will be three timber tree rows at 2.5m apart. Fodder trees spacing will be 2.5m from timber trees and 1.5m within row. Strips will be 50m apart.

7. RESEARCH REQUIRED

7.1. Small Scale Farms - Acosta

7.1.1. Enriched fallow (for covered beans)

Research objective: to assess the effect of increasing the proportion of fast growing-nitrogen fixing shrubs on the soil restoration capability of the vegetation cover.

Information required:

- Suitability of different species (e.g., *Calliandra calothyrsus*, *Desmodium spp.*, *Leucaena leucocephala*, etc.)

- Establishment practice (time, seeding rate, sowing technique).

Parameters to be monitored:

- Survival and growth
- Soil improvement
- Labour required to cover beans
- Weed growth
- Bean yield

7.1.2. Hedge Intercropping of Maize

Research objective: to evaluate the effect of intercropping maize with hedges of nitrogen-fixing shrubs on grain yield and erosion control.

Information required:

- Suitability of hedgerow species for:
+ ability to coppice at low heights
+ appropriate growth rate (sufficient to provide mulch for one or two crops per year without adversely affecting adjacent crops).

+ yield of large, broad, slowly decomposing leaves (for organic matter contribution, weed control, and moisture conservation), (e.g., *Calliandra calothyrsus*, *Leucaena leucocephala*, *Cassia* spp., *Acacia auriculiformis*).

- Spacing within and between hedges
- Cutting height and frequency
- Cropping frequency
- Other inputs required for sustained production
- Labour and capital productivity of the system relative to alternatives.

Parameters to be monitored:

- Soil fertility and moisture conservation
- Soil physical characteristics
- Weed control
- Erosion control
- Crop yields
- Minimum inputs required for system sustainability (e.g. fertilizer, herbicides, etc.)

7.1.3 Shaded Coffee

Research objective: to identify species and cultivars of nitrogen-fixing multipurpose trees that increase yield of coffee plants growing in the vicinity.

Information required:

- Suitability of species for:

  + intercropping with coffee
  + fixing nitrogen
  + satisfying other needs (e.g., food, fuel).

Parameters to be monitored:

- Coffee yield and soil characteristics in relation to distance from nursing tree
- Propagation techniques
- Silvicultural management
- Yield of by-products
- Labour and other inputs

7.1.4. Livestock Production

Research objective: to develop goat production systems based on the utilization of fodder from leguminous shrubs used in covered beans and hedge intercropping, along with other on-farm produced feedstuff that cannot be used for human consumption.

Information required:

To be completed by the Animal Production Programme of CATIE.

7.1.5 Intercropping of Fruit Trees with Coffee and/or Food Crops in the Uplands

Tropical fruit marketing study

Research objective: identify the potential to expand tropical fruit production in Acosta-Puriscal beyond the present local market level.

Information required:

Present status of the tropical fruit sector

- production by type of fruit, season and location
- prices along the marketing chain
- marketing systems
- consumption, uses
- processing technologies and c pacities

Scope for expanding production

- national and export market potential
- required infrastructure for processing and marketing

Pre-feasibility study for an agro-industrial tropical fruit project.

7.2 Medium Scale Farms - Puriscal

7.2.1 Intercropping of timber trees with pastures

7.2.1.1 Timber and wood products marketing study

Research objective: identify the marketing potential of timber from plantation forest.

Information required:

- Present status of the timber and wood products sector

+ production by type of timber and species
+ current inputs to production
+ prices along the marketing chain(s)
+ marketing system(s)
+ consumption, uses
+ processing technologies and capabilities

- Scope for expanding production

+ local, regional, national and export market potential
+ required infrastructure for processing and marketing
+ potential role of cooperatives and credit incentives in promoting a viable timber industry
+ potential for generating employment (amount, type, wage, group).

7.2.1.2 Developing timber and fodder strips

In discussing this research line it is assumed that information available on timber species and silvicultural management, as well as practices for planting *Erythrina or Gliricidia* living posts, are sufficient to establish timber-cum-fodder strips along contour lines.

Research objective: to evaluate the impact of contour strips of trees producing timber and fodder upon cattle production and soil erosion.

Information required:

- Effect of width and frequency of contour tree-strips upon:

+ production and distribution of fodder per unit of intercropped land
+ cattle management, including both the time when strips are being planted and when they are already established.
+ soil erosion and runoff
+ labour and material inputs

Parameters to be monitored:

- quantitative and qualitative production of fodder from living posts, as affected by lopping intensity and frequency
- utilizing of tree fodder by cattle
- cattle behaviour, as related to browsing lopped branches, rotating among paddocks and getting to watering points
- soil erosion*and water run-off, as influenced by vegetative cover and cattle movement
- labour requirements and timing to lop fodder trees, establish and attend plantation strips and herd cattle.

* includes monitoring of landslips, changes in microtopography

7.3 Integration of Technologies in Existing Systems - Acosta and Puriscal

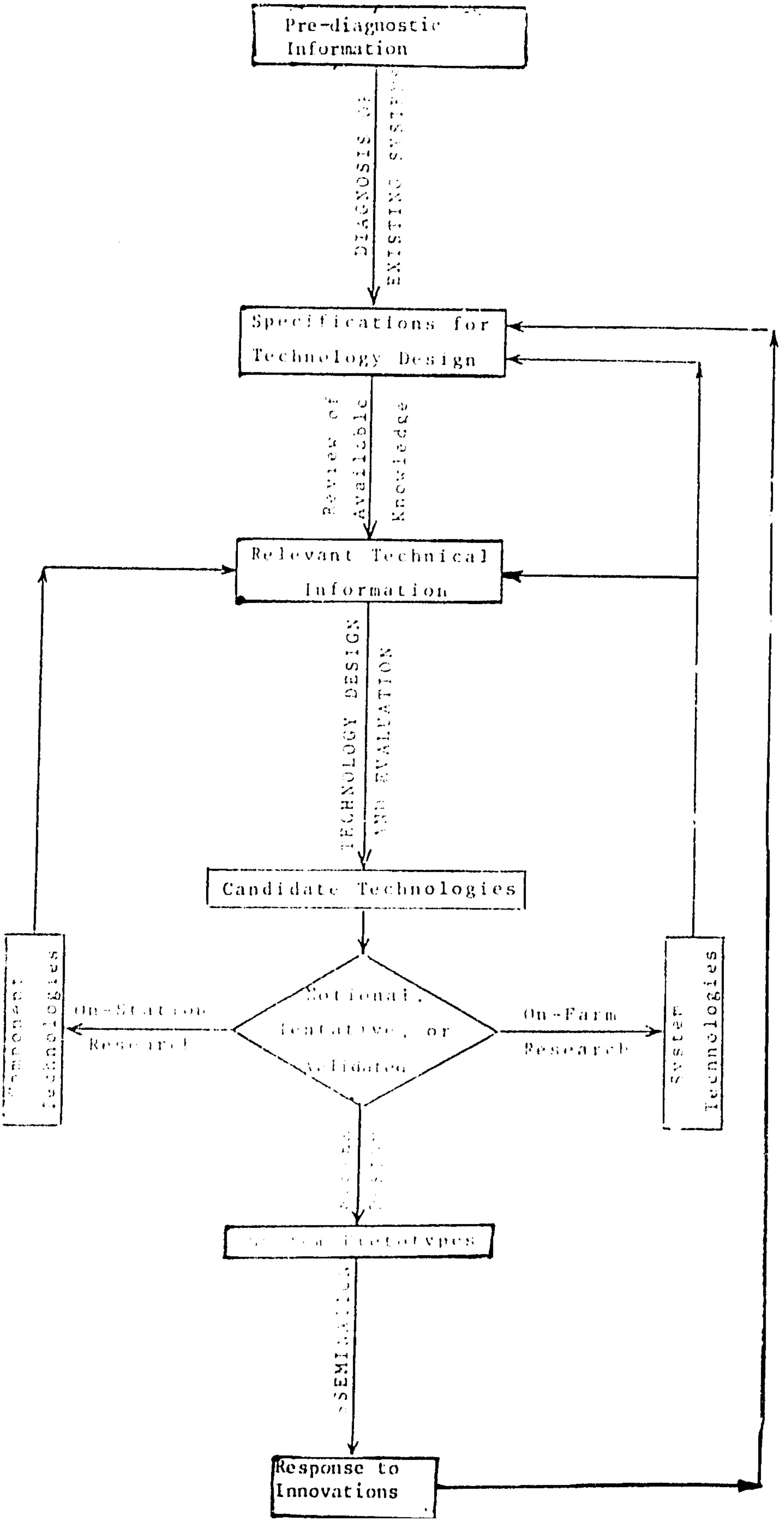
The approach followed in formulating this Project emphasizes a comprehensive analysis of the farm as a whole; research priorities reflect what were interpreted to be the most relevant proplems, as perceived by farmers or experts. The hypothesis underlying such an approach is that technologies designed to overcome problems perceived by farmers would be more easily adoptable. In the case of problems identified by experts as existing or potential constraints (e.g. soil conservation), which farmers either have not perceived yet or place in a low priority, technologies designed to overcome them are introduced as part of a multipurpose practice responding to some of the farmers' perceived problems.

But technologies have been designed on the basis of a preliminary diagnosis carried out at the formulating stage of project development. Such diagnosis, of a static type, is useful to indicate what the outstanding features of the proposed technology should be. A more refined design would require, however, an analysis of the system dynamics, as well as of the farmers' reactions to introduced innovations . It is assumed that a better understanding of both system dynamics and farmers' reactions may lead to modifications in the preliminary design, which would enhance the adoptability of practices by generating more appropriate technologies (those that meet a felt need, can be easily understood, and use resources readily accessible to farmers).

In this context research on integration of technologies has to do essentially with monitoring of both dynamics of existing systems and systems' response (including farmers' perceptions) to introduced innovations. The latter is accomplished through on-farm experimentation, which plays a critical role in technology development, as depicted in Fig. 16.

The role of on-farm experimentation appears as particularly relevant for Acosta-Puriscal, with no experimental station serving that specific ecozone. Under these cir ances on -farm research may not be restricted to testing tentative validated technologies, but will also deal with those of a notional type. Given the natural risk aversion of farmers and the effect failures may have upon the scientists-farmers credibility gap, there is a need to operate under a flexible scheme. This should follow the principle that the degree of farmer's involvement in the research process is inversely related to the reliability of the proposed technology. In other words, there would be on-farm experiments which are carried out under the control of the researcher, while others will be controlled by farmers.

Fig. 16 DIAGNOSIS AND DESIGN TO GENERATE APPROPRIATE AGROFORESTRY TECHNOLOGIES



Given that many of the technologies proposed in section 6 are still at the tentative, if not notional stage, two phases are envisaged for research on integration of technologies in this Project. The first phase will focus on:

i) improving the preliminary diagrosis by monitoring existing systems; and

ii) carry out research managed trials on farms, mainly geared at evaluating the technical performance of proposed technologies (while learning about farming perceptions of such innovations).

The second phase will concentrate on farmer managed trials to evaluate:

i) the technical and economic performance at the enterprise level (coffee, maize, livestock, etc.) of practices developed in phase one; and

ii) the fit of such practices into the whole system.

Research objective: to monitor the bio-physical and socio-economic dynamics of prevailing systems and experimental alternatives for:

- improving the preliminary diagnosis; and
- providing feed-back on the design of both proposed technologies and on-farm/on-station experimentation.

Information required:

- Improved description and monitoring of relevant aspects of the system's structure and function.
- Monitoring relevant aspects of experimental interventions, including the experimental parameters identified under the various component technologies (refer to section
- Monitoring of farmers' perceptions, evaluations and responses to introduced technologies.

- Monitoring of interactions between the improved farming systems and the surrounding environment (physical, economic and social aspects).
- Evaluation of system performance to assess the effects of the experimental technologies through time. Criteria for evaluation will combine farmers' judgements with measured or observed effects on farm management constraints, use of resources, and fulfillment of household objectives.

Parameters to be monitored:

- inputs to and outputs from the system (biophysical and socio-economic)
- performance indicators for technologies
- perceptions and decisions at farm level
- measurements to document effects on farm management constraints and supply problems
- indices of family and household well-being
- impacts on surrounding environment (run-off/erosion; production and marketing of subsistence and commercial crops; labour supply; cash flow).

8. ORGANIZATION AND MANAGEMENT

The research proposal outlined in section 7 clearly indicates the need for inputs from several disciplines, working together in an interdisciplinary fashion. Fortunately, in the institutional structure of Costa Rica most of the relevant technical disciplines operate within the Ministry of Agriculture, although under different sections (General Directorates of Extension, Forestry, Livestock and Research). At the regional level all these sections operate administratively from a Regional Agricultural Centre (CAR) based at Santiago de Puriscal, with seven extension agencies distributed throughout the Central Region.

Given the need for all Directorates to be actively involved in the implementation of the Project, the most sensible approach would be to assemble an interdisciplinary team with scientists coming from Research, Forestry, Livestock and Extension, specifically assigned to the task of carrying out the Agroforestry Project. The team would be operating from and administratively linked to the CAR headquarters at Puriscal.

8.1 The Project Team

The team working full-time on the research activities outlined in section 7 should be constituted as follows:

No.	Field	Level	Backstopping Institution
1	Agroforestry Systems	Senior	CATIE/ICRAF
1	Agronomist - Soil Specialist	Junior	MAG-Research
1	Pasture Agronomist	"	MAG-Livestock
1	Forester	"	MAG-Forestry
1	Social Scientist	"	MAG-Extension
1	Soil Erosion or Watershed Specialist	"	CATIE

Each of the scientists should be assisted by one technician in the corresponding field:

8.2 Organizational Structure

The Project will be managed by the Senior Agroforester and governed by a Management Committee constituted by the Directors of Forestry, Extension, Research and Livestock, the CAR Director, a CATIE representative, the Project Manager (ex-officio)and a donor representative. This Management Committee will have mainly a normative responsibility, dealing with the annual work plan, budget and report.

It will meet once a year but may be convened upon the request of any of its members, whenever an urgent matter arises. The Management Committee will be assisted by a Technical Committee, chaired by the Director of the CAR and composed of scientists from the MAG Directorates, CATIE, ICRAF and the Project Manager. This Committee will be meeting at least once a year at the Station to:

i) review research progress
ii) evaluate the detailed plan of work for the coming year; and
iii) propose institutional commitments to support the work plan.

8.3 Programme of Work

Two phases are visualized once the Project has been approved and funds made available: a "preparatory" and an "implementing" one.

8.3.1 Preparatory phase

Three main objectives will be pursued during this phase:

a. Assessing the marketing potential of fruits and timber trees
b. Recruiting staff and exposing the team to the agroforestry approach to land management.
c. Formulating a detailed research plan.

As mentioned in section 7 the marketing study should provide information to validate, or not, the proposal of increasing cash income via intercropping fruit trees-coffee and timber trees-pastures. It would be desirable that such studies precedes any field experimentation.

Senior and junior scientists recruited for the Project would most probably have a conventional disciplinary background, with different-degrees of exposure to land management problems. It is visualized, therefore, that once the team is assembled CATIE, in cooperation with ICRAF, should organize a short "in situ" training to introduce team members to land management appraisal, with emphasis on agroforestry. The training exercise will also be used to discuss findings of the preliminary diagnosis, as well as the derived research proposal.

It is expected that the short introductory training exercise will enable the team to fully participate in the subsequent discussions with the Technical Committee to consolidate the research proposal and draw up a detailed experimental plan (including design, lay out, research,protocol etc.) Discussions will be guided by the research proposal contained in this document (see sections 5 and 6) and should result in a concrete plan of activities to be implemented by the Project Team in the next Phase of the Programme of Work.

8.3.2 Implementation Phase

As indicated in section 6, and given the nature of the main technological components (trees), the Project is scheduled for a period of six years. Although the plan of work is the expected output of the previous phase, a tentative one is proposed in Table * , assuming that funds would be available at the beginning of 1984.

8.3.4 BUDGET (to be drafted by MAC and CATIE)

* This will be worked out in cooperation with the local participating Institutions.

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Appendix A : List of Participants and Itinerary for Agroforestry System D&D, Workshop/ Survey

University of Costa Rica Ciudad Universitaria Rodrigo Facio San Pedro, SAN JOSE	Dr. Alfredo Alvarado**
CATIE, D.R.N.R. Department of Renewable Natural Resources	Dr. Gerardo Budowski * Ing. Luis Ugalde A * Ing. Jeffrey Jone * Ing. Jorge Hernandez * Ing. John Beer Dr. Jochen Heuveldop Dr. Carlos Quesada Ing. Carlos Reiche Ing. Gustavo Bronstein Ing. Ricardo Russo Ing. Leo Espinoza *
CATIE, D.P.V. Department of Plant Production	German Escobor * Jose Arze * Tomas Schlichter
CATIE, D.P.A. Department of Animal Production	Dr. Rolain Borel * Marco Esnaola * Roberto Cerdas
MAG/DGF, San Jose (Ministry of Agriculture) (Forestry Administration)	Ing. Ramiro Jimenez Sherry Munoz German Rodriguez Edgar Sandi Richard Garriguez
CAR, Puriscal Apartado 85 (Regional Centre, Ministry of Agriculture)	Gilbert Charpentier Danilo Boza Tobias Hidalgo
Project 032, Puriscal (Watershed management Project AID/DGF/MAG)	Guillermo Arias **
ASCONA, SAN JOSE (National Conservation Assoc.)	Gideon van Melle
C/o D.R.N.R. (Consultants, Dept. of Renewable Natural Resources)	Nancy Glover Norman Price
ICRAF	Dr. Filemon Torres Dr. Dianne Rocheleau

* First Workshop only

** Second Workshop only; all others participated in field <u>and</u> worksshop activities.

Itinerary for Agroforestry Systems D & D Workshop / Survey

Cooperative Project ICRAF-CATIE, MAG, CAR, DGF, ASCONA

Feb 28th to March 11th, 1983

Monday 2/28		Santiago de Puriscal (CAR offices)
	am	Introduction, presentation and discussion
	pm	of itinerary and methodology for D&D exercise.
Tuesday 3/1	am	CAR Offices, Evaluation of pre-diagnostic information, discussion with qualified informants, formation and briefing of 3 field teams
	pm	Puriscal region: Field reconnaissance and first farm visits (1 farm interview per group)
Wednesday 3/2	am	Puriscal region: Field reconnaissance and second farm visits (1 farm interview per group).
	pm	CAR offices: Summary and evaluation of information by work groups
Thursday 3/3	am	CAR offices: Information exchange between groups
	pm	CAR offices: Summary and analysis of results by all groups.
Friday 3/4	am	Acosta region: third and fourth farm visits (2 farm interviews per group)
	pm	Final regional reconnaissance CAR Offices: Summary of information by groups
Saturday 3/5	am	CATIE, Turrialba: Evaluation of Information by team representatives (2 per group).
Monday 3/7	am	CATIE: ICRAF-CATIE work session on format for information evaluation.
	pm	Full group, presentation and discussion of results from Friday (Acosta) surveys;
	evening	ICRAF-CATIE work groups, Classification of farm types, summary of farm characteristics and problems; Preparation of specifications for technology designs.

Tuesday 3/8	am	CATIE: ICRAF-CATIE work group (A) - formulation of common criteria for design specifications and discussion of tentative designs.
		CATIE/MAG/DGF/ASCONA work group (B) - elaboration of information by farm and by farm type
	pm	Group (B) - Elaboration of pre-diagnostic regional information with newly compiled data plus results of D & D Field work.
		CATIE/ICRAF/CAR (Group A) discussion of candidate technologies.
Wednesday 3/9		
	am	CATIE: Full group, presentation and discussion of D & D conclusions and candidate technologies.
	pm	Group B, workshop continued, elaboration of regional and farming systems data.
		Group A, discussion of candidate technologies with CATIE Forestry and Agroforestry specialists.
Thursday 3/9	am	CATIE: Group B - Workshops, on regional firewood use and production, land use and land capability, and farm household/farm enterprise budgets;
		Group A - discussion of candidate technologies with CATIE Agricultural Economists and Agronomists.
	pm	Group B, workshops continued.
		Group A, Discussion of candidate technologies with CATIE Animal Production specialists.
	evening	All participants, Farewell dinner.
Friday 3/11	am	CATIE: Presentation of results by groups A & B Discussion of farm level vs. regional land use conflicts, Elaboration and modification of candidate technologies previously screened and revised by CATIE/ICRAF teams.
	pm	Discusssion of project proposal by CATIE, CAR, ICRAF DGF representatives.
		ICRAF visit to CATIE agroforestry experimental sites with Dr. G. Budowski.

Appendix B Water Budget for Acosta and Puriscal

TABLE I WATER BUDGET ACOSTA (COSTA RICA)

The following table gives the water budget for Acosta which is diagramatically demonstrated in Fig I

WATER BUDGET

LOCATION: Acosta, Costa Rica Alt. 1094m

Mean Annual Potential Evapotranspiration 1504E_o

Period	P	ET (0.75E_o	P-ET	WD	WS	S	DS	EA
Jan	11	113	-102	102		0	0	011
Feb	61	107	-46	46		0	0	061
Mar	50	139	-89	89		0	0	050
Apr	65	150	-85	85		0	0	065
May	261	142	119	-	19	100	100	142
Jun	354	127	227	-	227	100	0	127
Jul	224	134	90	-	90	100	0	134
Aug	244	136	106	-	108	100	0	136
Sep	436	127	309	-	309	100	0	127
Oct	460	122	338	-	338	100	0	122
Nov	173	106	67	-	67	100	0	106
Dec	17	101	-84	-	16	16	-84	101
Totals	2356	1504		322	1158			1182

Adapted from Thornthwate (1948)

Key

P - Precipition in mm
E_o - Potential Evaporation
ET - Potential Evapotranspiration
WD - Water deficit
WS - Water Surplus
S - Soil water (Rainfall + 100mm Soil Water Capacity
S - Change in S

TABLE II WATER BUDGET PURISCAL (COSTA RICA)

Note: Precipitation and evapotranspiration data was drawn from PLATEN VON H. 1981 Page 9. The rest of the data was computed from these basic data. The method of computation was adapted from Thornthwaite (1948). The water budget is diagramatically represented in Fig II.

WATER BUDGET

Location PURISCAL COSTA RICA Alt. 1102m

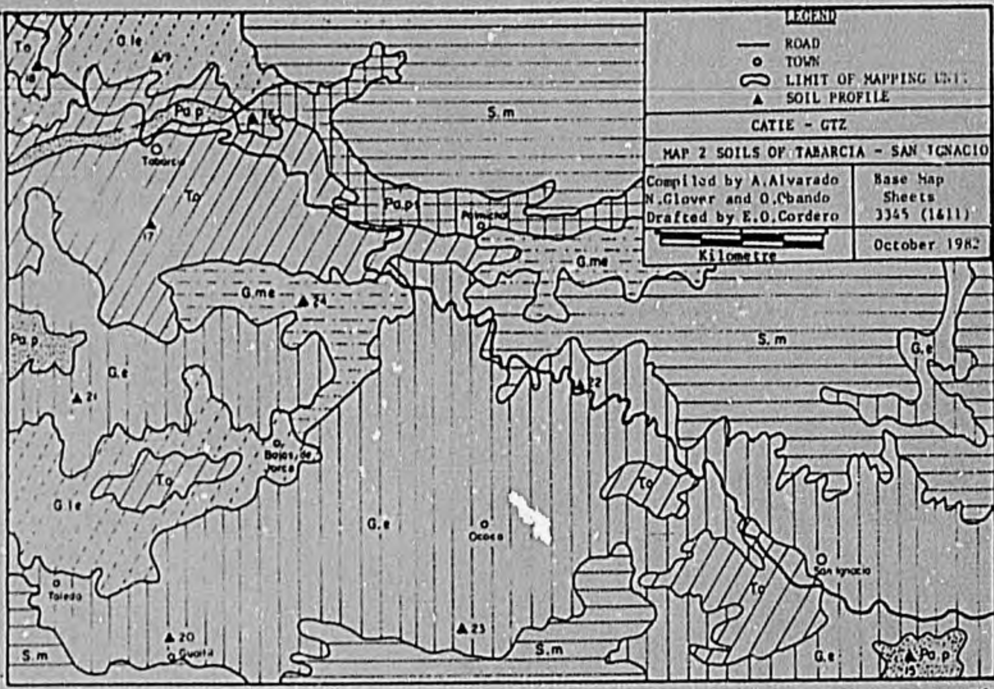
Mean annual rainfall 2145mm
Mean annual Potential evapotranspiration 1567E_o

Period	P	ET ($0.75 E_o$)	P-ET	WD	WS	S	S	EA
Jan	75	127	-52	52	-	48	0	75
Feb	29	130	-101	101	-	0	0	29
Mar	57	159	-102	102	-	0	0	57
Apr	157	155	4	-	4	4	4	155
May	277	139	138	-	138	100	96	139
Jun	258	127	131	-	131	100	0	127
Jul	231	132	99	-	99	100	0	132
Aug	262	132	130	-	130	100	0	132
Sep	279	120	159	-	159	100	0	120
Oct	214	120	94	-	94	100	0	120
Nov	154	108	46	-	46	100	0	108
Dec	150	118	32	-	32	100	0	118
Total	2145	1567		255	833			1312

Note EA + D = EP 1312 + 255 = 1567

EA + S = P 1312 + 833 = 2145

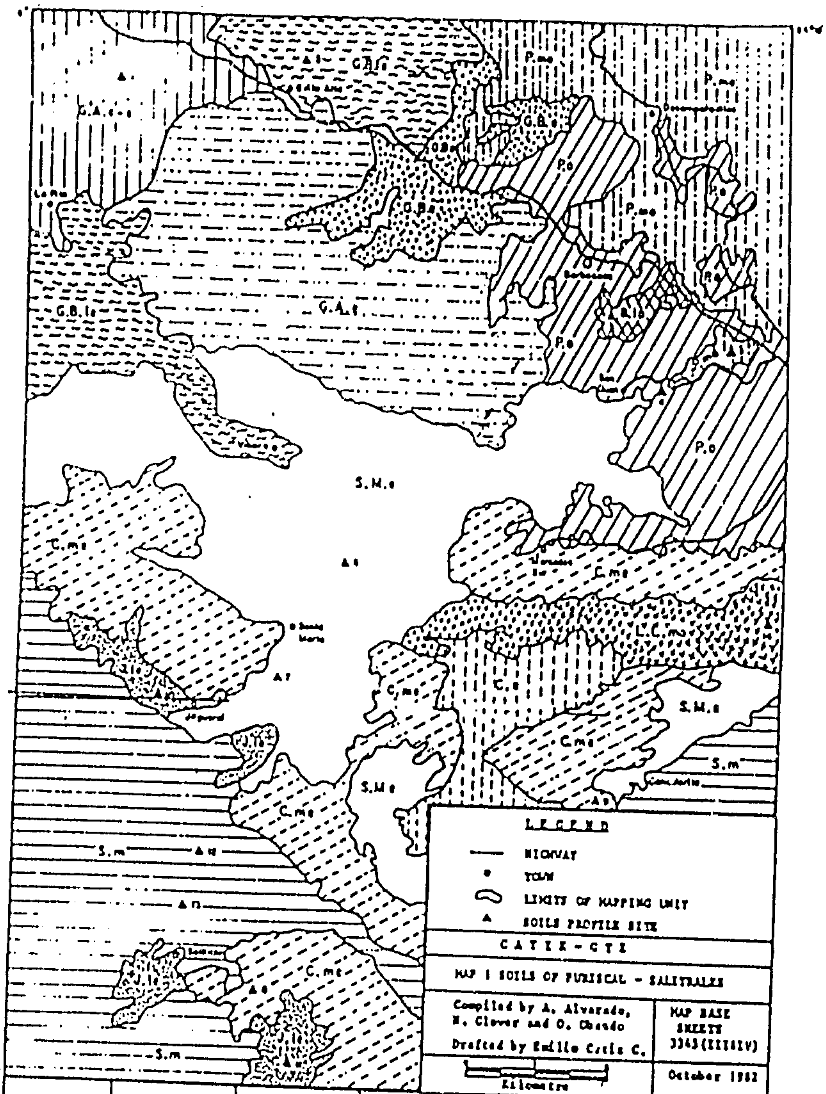
Appendix C Soils maps for Tarbarcia (Acosta), and Puriscal.



Geologic Structure	Mapping Unit	Taxonomic Unit	(Topography)	Symbol	Area ha	%	Slope %
Alluvial and Colluvial Quaternary (Holocene)	Palmichal Association	Fluventic Ustropept Lithic Ustropept	Flat, stony, Flat, not rocky	Pa.p-s Pa.p	250 128	3.0 1.5	1-3
Formation (Tertiary)	Complex	Ustic Humitropept	Undulating to strongly undulating	T.o	855	10.2	6-25
	Association	Ustic Tropohumult Typic Ustropept	Slightly sloping	G.le	682	8.1	25-40
			moderately sloping	G.e	3912	46.[illegible]	40-60
			Steep slopes	G.me	248	2.9	60-75
Formation (Tertiary)	Association	Lithic Ustorthent Lithic Ustropept Ustic Tropohumult	Mountainous	S.m	3345	27.5	> 75

Fig. 6 Soils of Acosta

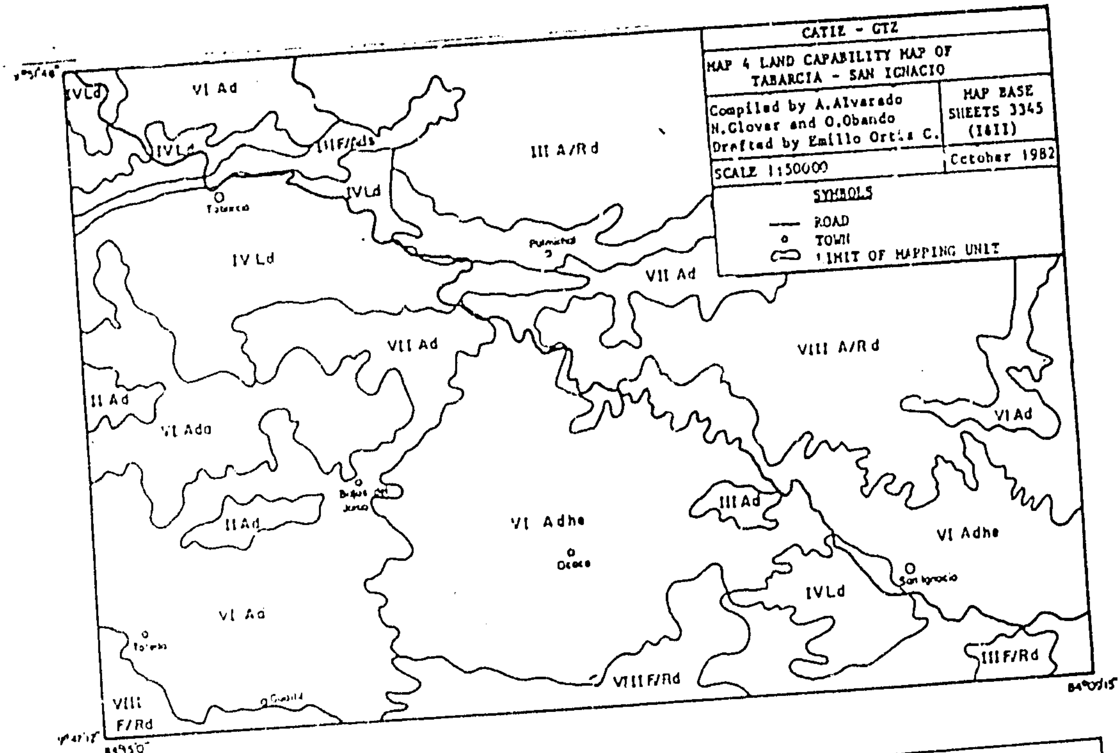
Source Heuveldop J and L Espinoza (ed.) 1983 (page 112)



GEOLOGIC STRUCTURE	MAPPING UNIT	TAXONOMIC UNIT	TOPOGRAPHY	SYMBOL	AREA Ha	AREA %	SLOPE %
Aguacate Formation (Tertiary)	Grife Alto (Complex)	Typic Rhodustult	Slightly sloping rocks	C.A.e-s	928	6.4	25-40
			Slightly sloping to sloping	C.A.s	1738	12.1	25-60
	Grife Bajo (Complex)	Aquic Tropohumult	Slightly sloping	CB.le	970	6.6	25-40
			Moderate slopes	C.B.e	370	2.5	40-60
	Barbacoas (Complex)	Typic Dystrandept	Slightly undulating to undulating	B.lo	65	0.4	3-12
	Puriscal (Complex)	Ustic Tropohumult	Undulating	P.o	1298	8.9	6-12
			Slightly undulating	P.me	1187	8.1	12-25
Terraba Aguacate Formation (Tertiary)	La Legua (Complex	Fluventic Ustropept	Undulating to strongly undula.	L.L so	360	2.5	6-25
	Santa Marta (Association)	Ustic Tropohumult, Udic Haplustalf	Moderately to slightly sloping	S.M.e	2428	16.7	25-60
	Candelarita (Complex	Ustic Tropohumult	Moderately sloping	C.e	382	2.6	40-60
			Steep slopes	C.me	2137	14.7	60-75
Complex and Formation (Cretaceous)	Jilgueral (Complex)	Fluventic Ustropept	Strongly undulating to slightly sloping	J.lo	315	2.2	12-40
	Salitrales Association	Ustic Tropohumult Lithic Ustropept Lithic Ustorthent	Mountainous	S.m	2372	16.3	75

Fig 7 soils of Puriscal
Source Heuveldop J and L Espinoza (ed) 1983 page 109)

Appendix D Land use capability - Maps for Acosta and Puriscal

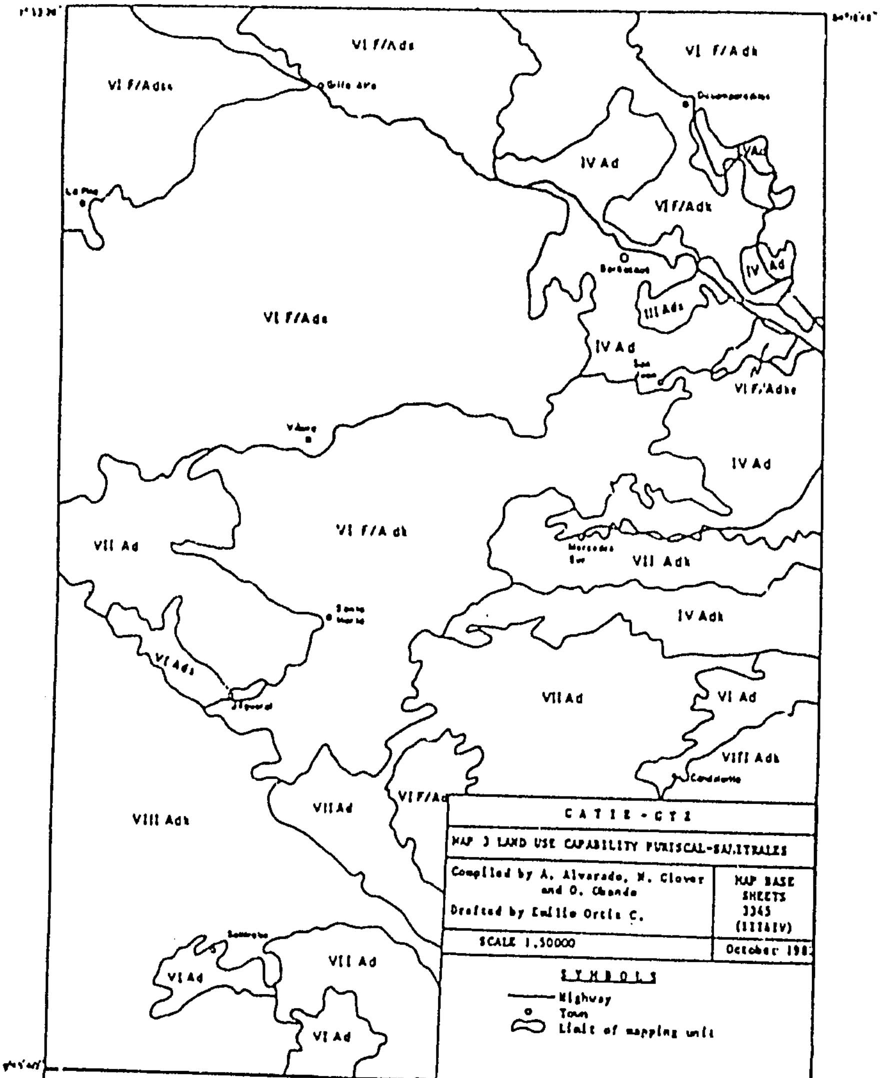


L E G E N D

LAND CAPABILITY - ACOSTA			Area	
Capability Class	Sub-Class	Capability Unit	Ha	%
II	II A Clay	II Ad Clay, Ustic	102	1.2
III	III A Clay	III Ad Clay, Ustic	54	0.6
	III F/A Cle.c 735Z	III F/Ads Clay-loam Ustic, Stony,	938	11.2
	III F/P Sardy loam	III F/Rd Sandy-loam, Ustic	348	4.1
IV	IV L Silt	IV Ld Silt, Ustic	1122	13.4
VI	VI A Clay	VI Ad Clay, Ustic	1352	16.1
		VI Adhe and Ade Clay, Ustic, acidic, low C.E.C & clayey U.b.	2665	31.7
VII	VII A Clay	VII Ad Clay,Ustic.	372	4.4
VIII	VII A/R Sandy-clay	Sandy-clay Ustic	[illegible]05	12.7
	VIII F/R Sandy loam Ustic	VIII F/Rd Sandy-loam Ustic	382	4.5

A = Clayey; F = Ustic; s = Stony; hye = Acidic; e = Low C.E.C.

Fig. 8



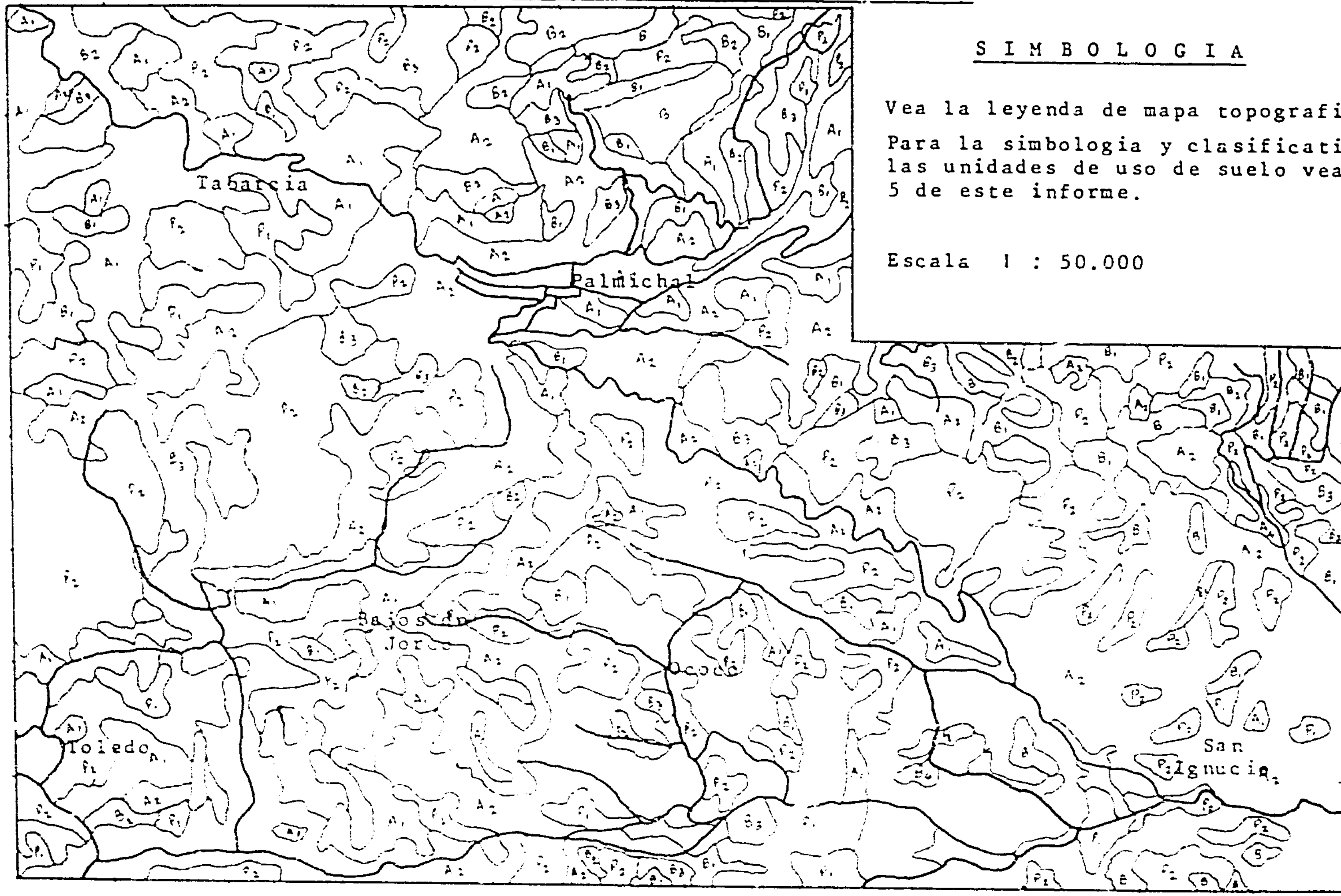
LEGEND

Capability Class	Sub-Class	Capability Unit	AREA Ha	AREA %
III	III A Clay	III Adx Ustic, Clay, Amorphous Clays	65	0.4
IV	IV A Clay	IV Ad Ustic, Clay	1278	8.7
		IV Adk Ustic, Clay, K-deficient	340	2.4
VI	VI A Clay	VI Ad Ustic, Clay	345	2.4
		VI Ads Ustic, Clay, Stony	105	0.7
	VI F/A Clay-Loam	VI F/A dk Clay-Loam, ustic, K-deficient	2020	13.8
		VI F/A dx Clay-Loam, Ustic, Amorphous Clays	3595	24.5
		VI F/A dsx Clay-Loam, Ustic, stony, amorphous clays	1245	8.5
		VI F/A dke Clay-Loam, Ustic, low cat. exchange capacity K-deficient	700	4.8
VII	VII A Clay	VII Ad Ustic, Clay	2200	15.0
		VII Adk Ustic, Clay, K-efficient	430	2.9
VIII	VIII A Clay	VIII Adk Ustic, Clay K-deficient	2312	15.8

A=Clay F=Loam d=Ustic s=Rocky or Stony k=K-deficient x=Amorphous Clays (P-fixation) e=low cat. exchange capac'.y

Fig. 9 Land use capability Puriscal

MAPA DEL USO ACTUAL DE SUELO DEL AREA TABARCIA - SAN IGNACIO DE ACOSTA.



SIMBOLOGIA

Vea la leyenda de mapa topografico IGN.

Para la simbologia y clasification de las unidades de uso de suelo vea pagina 5 de este informe.

Escala 1 : 50.000

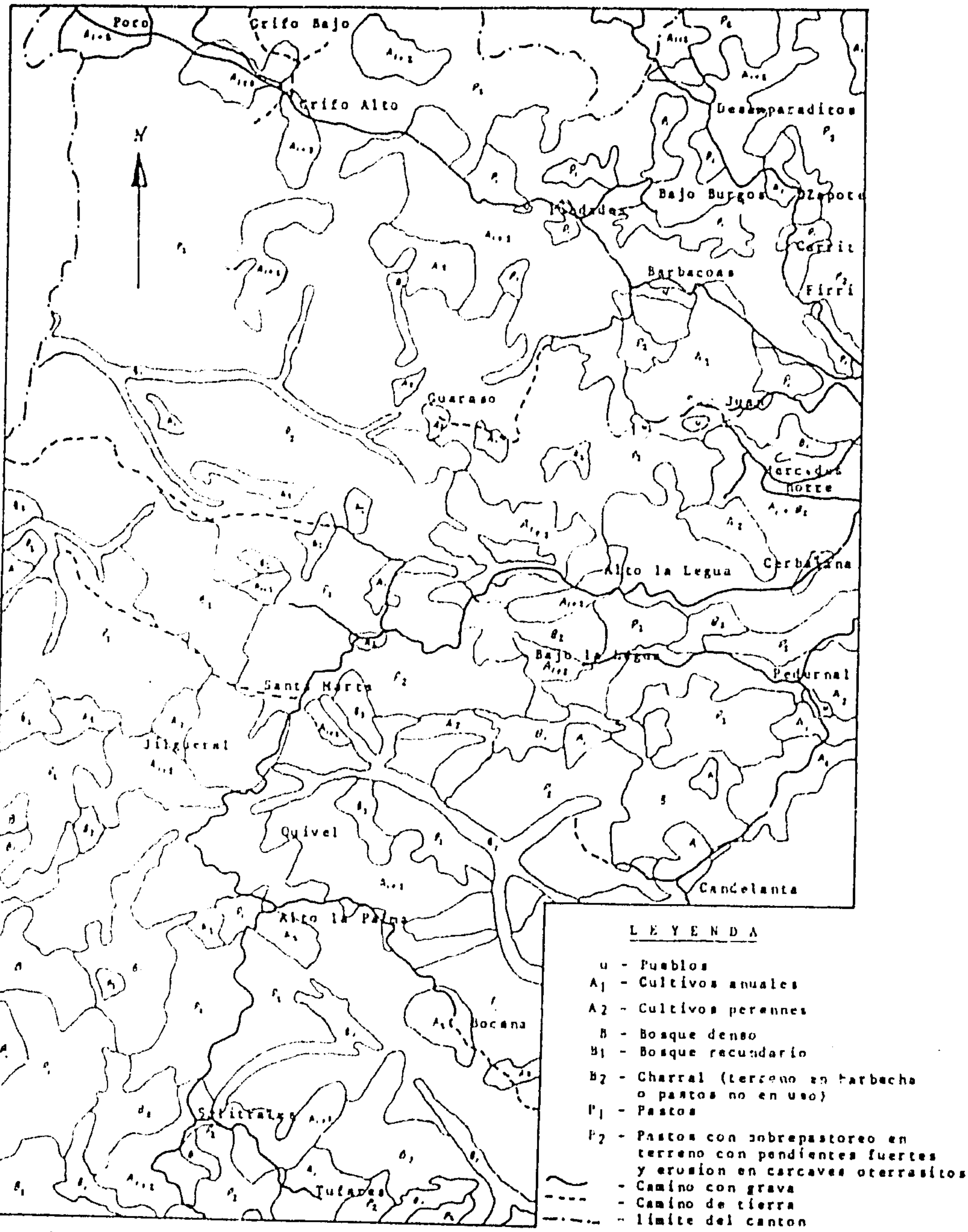
Mapa de fotointerpretacion.

12/1982 G. van Melle/ASCONA

Appendix E Landcover maps showing cropland concentration along roads for Tabarcia Acosta and Puriscal

Fig 10

MAPA DE USO DE LA TIERRA ACTUAL DE LA CUENCA PURISCAL



Mapa dibujado por G.v.Melle. 1983

Escala 1:50,000

EX-ANTE ECONOMIC ANALYSIS SILVO PASTORAL SYSTEMS PURISCAL

D.A. HOEKSTRA - AGRICULTURAL ECONOMIST, ICRAF.

Introduction

An economic analysis, from the farmer's point of view, at a discount rate of 12 % shows that a change from the present grazing system to a silvo pastoral system will increase the total farm income, even if all additional labour has to be hired.

A "with" and "without" approach was followed to estimate the 'economics' of the proposed technologies (models). All computations were made on a micro computer using MULBUD.

"Without" situation

Data on the present livestock operation were based on von Platen et al and on assumptions made by qualified informants (2).

Present net income from grazing (cow-calf operation) is ₡ 1,000 per hectare assuming a stocking rate of about 1.13 A.U at peak periods (just before sellings) and about 0.8 A.U. after selling. Assuming a price of about ₡ 10,000 per A.U, the livestock investment cost in this system is about ₡ 8,000 per hectare.

Based on discussions held, it was understood and therefore assumed that livestock income from the system would in fact gradually decline because of overgrazing and soil erosion.

The following assumptions were made with regard to this decline in productivity.

Year 1 to 5 - same net income per hectare i.e. ₡ 1,000
Year 6 to 10 - lowering of stocking rate to 0.7 A.U. and a drop in net income to ₡ 875/hectare.
Year 11 to 14 - lowering of stocking rate to 0.6 A.U. and a drop in net income to ₡ 750/hectare.
Year 15 to 18 - lowering of stocking rate to 0.5 A.U. and a drop in net income to ₡ 625/hectare.
Year 19 to 20 - lowering of stocking rate to 0.4 A.U. and a drop in net income to ₡ 500/hectare.

Table 1 summarises this system. Note that the invested capital in cattle is included in the first year cost, (materials) however since the farmer already has these cattle on his farm, it is <u>not</u> a cash expenditure during the first year.

Also note that the livestock income gradually declines over time on the basis of the aforementioned assumptions. Additional income is obtained in years 6, 11, 15, 19 when some of the cattle have to be sold over and above the ordinary sales, to arrive at the lower stocking rates.

Finally, in year 20, the remaining stock value is brought in as a benefit, however since the farmer is not selling the animals, it should <u>not</u> be interpreted as a cash receipt during that year.

Using a discount rate of 12% this system gives a net present value to the land of ₵ 682 over a 20 year period (since the livestock income data provided, did not indicate that they were net of labour cost (family or hired), the above may in fact be overestimated).

Table 1 Summary results (without situation)

* YEAR	SEASON	TOTAL LABOUR	* V A R I A B L E C O S T S * LABOUR COSTS (c)	MATERIAL COSTS (c)	TOTAL COSTS (c)	GROSS REV-ENUE (c)	NET REVENUE (c)
1	1		0.00	7999.20	7999.20	1000.00	-6999.20
2	1		0.00	0.00	0.00	1000.00	1000.00
3	1		0.00	0.00	0.00	1000.00	1000.00
4	1		0.00	0.00	0.00	1000.00	1000.00
5	1		0.00	0.00	0.00	1000.00	1000.00
6	1		0.00	0.00	0.00	1876.00	1876.00
7	1		0.00	0.00	0.00	875.00	875.00
8	1		0.00	0.00	0.00	875.00	875.00
9	1		0.00	0.00	0.00	875.00	875.00
10	1		0.00	0.00	0.00	875.00	875.00
11	1		0.00	0.00	0.00	1752.00	1752.00
12	1		0.00	0.00	0.00	750.00	[illegible].00
13	1		0.00	0.00	0.00	750.00	[illegible].00
14	1		0.00	0.00	0.00	750.00	750.00
15	1		0.00	0.00	0.00	1625.00	1625.00
16	1		0.00	0.00	0.00	625.00	625.00
17	1		0.00	0.00	0.00	625.00	625.00
18	1		0.00	0.00	0.00	625.00	625.00
19	1		0.00	0.00	0.00	1500.00	1500.00
20	1		0.00	0.00	0.00	1500.00	1500.00

"With" situation

Several models were analysed and are briefly discussed.

- Fenced off (improved) pasture with scattered trees (varying number). The main drawback of this system is the decline in livestock income during the first three years as compared to the "without" situation. Generally speaking, the more trees the better the results (same fencing cost), also, because livestock operations don't seem to be very profitable in any case. Although this system may improve the net return per hectare, it is doubtful that the sustainability of the pasture component would be improved as compared with the without situation.

- Individually protected scattered trees in (improved) pasture. Although no hard data were available, qualified informants reported prohibitively high cost for protecting individual trees. Improving the pasture component would again mean a temporary loss (though for a shorter period) of livestock income. Sustainability would probably not be improved with this system.

- Tree strips along the contours in pastures. A major advantage of this system is the reduction in erosion in the pastures and hence sustainability can be assumed to be improved. Since the trees are grown in strips the remaining pasture area can be grased without interuption. The stocking rates could in fact be increased as compared with the "without" situation since the Glyricidia used as a living fence will increase overall fodder availability by 20% (net of the losses incurred because of the tree strips). Also, because of the paddlocking with these treestrips, per animal production is assumed to be increased by 15% from ₡1,250 to 1,440 per animal unit.

Tables 2 and 3 (a, b and c) show the total income flow derived from this system (not just the incremental one) broken down into the individual components i.e. 20% of the land in trees and 80% of the land in pasture.

able 2. Summary results "with" situation*

	YEAR	SEASON	TOTAL LABOUR	VARIABLE COSTS: LABOUR COSTS	VARIABLE COSTS: MATERIAL COSTS	VARIABLE COSTS: TOTAL COSTS	GROSS REV-ENUE	NET REVENUE
			Mandays	(co)	(co)	(co)	(co)	(co)
) Tree component (20% of the land)	1	1	28.00	3920.00	4505.00	8425.00	0.00	-8425.00
	2	1	12.00	1680.00	345.00	2025.00	0.00	-2025.00
	3	1	5.00	700.00	0.00	700.00	0.00	-700.00
	4	1	0.00	0.00	0.00	0.00	0.00	0.00
	5	1	0.00	0.00	0.00	0.00	0.00	0.00
	6	1	0.00	0.00	0.00	0.00	0.00	0.00
	7	1	0.00	0.00	0.00	0.00	0.00	0.00
	8	1	0.00	0.00	0.00	0.00	0.00	0.00
	9	1	0.00	0.00	0.00	0.00	0.00	0.00
	10	1	0.00	0.00	0.00	0.00	0.00	0.00
	11	1	0.00	0.00	0.00	0.00	0.00	0.00
	12	1	0.00	0.00	0.00	0.00	0.00	0.00
	13	1	0.00	0.00	0.00	0.00	0.00	0.00
	14	1	0.00	0.00	0.00	0.00	0.00	0.00
	15	1	0.00	0.00	0.00	0.00	6000.00	6000.00
	16	1	0.00	0.00	0.00	0.00	0.00	0.00
	17	1	0.00	0.00	0.00	0.00	0.00	0.00
	18	1	0.00	0.00	0.00	0.00	0.00	0.00
	19	1	0.00	0.00	0.00	0.00	0.00	0.00
	20	1	0.00	0.00	0.00	0.00	120000*0	120000*0
) Pasture/livestock component, (80% of the land)	1	1	3.00	420.00	9600.00	10020.00	1382.40	-8637.60
	2	1	3.00	420.00	0.00	420.00	1382.40	962.40
	3	1	3.00	420.00	0.00	420.00	1382.40	962.40
	4	1	3.00	420.00	0.00	420.00	1382.40	962.40
	5	1	3.00	420.00	0.00	420.00	1382.40	962.40
	6	1	3.00	420.00	0.00	420.00	1382.40	962.40
	7	1	3.00	420.00	0.00	420.00	1382.40	962.40
	8	1	3.00	420.00	0.00	420.00	1382.40	962.40
	9	1	3.00	420.00	0.00	420.00	1382.40	962.40
	10	1	3.00	420.00	0.00	420.00	1382.40	962.40
	11	1	3.00	420.00	0.00	420.00	1382.40	962.40
	12	1	3.00	420.00	0.00	420.00	1382.40	962.40
	13	1	3.00	420.00	0.00	420.00	1382.40	962.40
	14	1	3.00	420.00	0.00	420.00	1382.40	962.40
	15	1	3.00	420.00	0.00	420.00	1382.40	962.40
	16	1	3.00	420.00	0.00	420.00	1382.40	962.40
	17	1	3.00	420.00	0.00	420.00	1382.40	962.40
	18	1	3.00	420.00	0.00	420.00	1382.40	962.40
	19	1	3.00	420.00	0.00	420.00	1382.40	962.40
	20	1	3.00	420.00	0.00	420.00	10982.40	10562.40
:) Silvi pastoral model	1	1	31.00	4340.00	14105.00	18445.00	1382.40	17062*60
	2	1	15.00	2100.00	345.00	2445.00	1382.40	-1062.60
	3	1	8.00	1120.00	0.00	1120.00	1382.40	262.40
	4	1	3.00	420.00	0.00	420.00	1382.40	962.40
	5	1	3.00	420.00	0.00	420.00	1382.40	962.40
	6	1	3.00	420.00	0.00	420.00	1382.40	962.40
	7	1	3.00	420.00	0.00	420.00	1382.40	962.40
	8	1	3.00	420.00	0.00	420.00	1382.40	962.40
	9	1	3.00	420.00	0.00	420.00	1382.40	962.40
	10	1	3.00	420.00	0.00	420.00	1382.40	962.40
	11	1	3.00	420.00	0.00	420.00	1382.40	962.40
	12	1	3.00	420.00	0.00	420.00	1382.40	962.40
	13	1	3.00	420.00	0.00	420.00	1382.40	962.40
	14	1	3.00	420.00	0.00	420.00	1382.40	962.40
	15	1	3.00	420.00	0.00	420.00	7382.40	6962.40
	16	1	3.00	420.00	0.00	420.00	1382.40	962.40
	17	1	3.00	420.00	0.00	420.00	1382.40	962.40
	18	1	3.00	420.00	0.00	420.00	1382.40	962.40
	19	1	3.00	420.00	0.00	420.00	1382.40	962.40
	20	1	3.00	420.00	0.00	420.00	130982*4	130562*44

*Labour costed at ¢140/ manday

Table 3. Summary results "With" situation*

	YEAR	SEASON	TOTAL LABOUR	LABOUR COSTS	MATERIAL COSTS	TOTAL COSTS	GROSS REVENUE	NET REVENUE
			Mandays	(co)	(co)	(co)	(co)	(co)
a) Tree component (20% of the land)	1	1	28.00	0.00	4505.00	4505.00	0.00	-4505.00
	2	1	12.00	0.00	345.00	345.00	0.00	-345.00
	3	1	5.00	0.00	0.00	0.00	0.00	0.00
	4	1	0.00	0.00	0.00	0.00	0.00	0.00
	5	1	0.00	0.00	0.00	0.00	0.00	0.00
	6	1	0.00	0.00	0.00	0.00	0.00	0.00
	7	1	0.00	0.00	0.00	0.00	0.00	0.00
	8	1	0.00	0.00	0.00	0.00	0.00	0.00
	9	1	0.00	0.00	0.00	0.00	0.00	0.00
	10	1	0.00	0.00	0.00	0.00	0.00	0.00
	11	1	0.00	0.00	0.00	0.00	0.00	0.00
	12	1	0.00	0.00	0.00	0.00	0.00	0.00
	13	1	0.00	0.00	0.00	0.00	0.00	0.00
	14	1	0.00	0.00	0.00	0.00	0.00	0.00
	15	1	0.00	0.00	0.00	0.00	6000.00	6000.00
	16	1	0.00	0.00	0.00	0.00	0.00	0.00
	17	1	0.00	0.00	0.00	0.00	0.00	0.00
	18	1	0.00	0.00	0.00	0.00	0.00	0.00
	19	1	0.00	0.00	0.00	0.00	0.00	0.00
	20	1	0.00	0.00	0.00	0.00	120000*0	120000*0
b) Pasture/livestock component. (80% of the land)	1	1	3.00	0.00	9600.00	9600.00	1382.40	-8217.60
	2	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	3	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	4	1	3.00	0.00	0.00	0.00	1332.40	1382.40
	5	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	6	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	7	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	8	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	9	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	10	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	11	1	3.00	0.00	0.00	0.00	1362.40	1382.40
	12	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	13	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	14	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	15	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	16	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	17	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	18	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	19	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	20	1	3.00	0.00	0.00	0.00	10982.40	10982.40
c) Silvi-pastoral model	1	1	31.00	0.00	14105.00	14105.00	1382.40	12722*60
	2	1	15.00	0.00	345.00	345.00	1382.40	1037.40
	3	1	8.00	0.00	0.00	0.00	1382.40	1382.40
	4	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	5	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	6	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	7	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	8	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	9	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	10	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	11	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	12	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	13	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	14	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	15	1	3.00	0.00	0.00	0.00	7382.40	7382.40
	16	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	17	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	18	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	19	1	3.00	0.00	0.00	0.00	1382.40	1382.40
	20	1	3.00	0.00	0.00	0.00	130982*4	130982*44

*Labour costed at ₵ 0/ manday

In tables 2 a, b and c, it is assumed that all labour is hired at ₵ 140/manday or withdrawn from other farm activities (opportunity cost of this labour assumed to be equal to market price labour i.e. ₵ 140/manday). In tables 3 a, b and c, on the other hand, it is assumed that all labour is provided by the household at zero opportunity cost (no alternative labour opportunities at the time).

The tree component of the model shows a considerable labour and materials input for establishing the living fence and the trees (see also Annex 1 and 2). Most of these costs dissapear however after 3 to 4 years. First harvesting is assumed to take place after 14 years and final harvesting at year 20. It has been assumed that there is no farmer (paid) labour required for harvesting. The per unit price received for the wood is therefore net of labour cost. Production was aasumed to be 1 m^3/tree.

The livestock pasture component shows again the total invested amount in cattle in the first year. The additional investment of ₵ 1,600 (1.6 A.U) will in fact be a cash cost since the farmer will either have to purchase or refrain from selling animals normally sold, so as to arrive at the 20% increased stocking rate. The endvalue of the livestock is shown as a benefit in year 20, however it should not be interpreted as a cash receipt.

The increase in gross revenue from livestock is partly obtained from the fodder lopped from the fence and lopping labour estimated at 3 mandays per year has therefore been allocated to the pasture component.

The sums of the net present value, broken down into individual components, are summarised in Table 4.

Table 4. Sum Net Present Values 'With' Situation (at 12%)
(in ₵)

	Labour cost ₵140/manday	Sero labour cost
Trees	3,902	9,239
Pasture/livestock	-388	2,749
Silvi pastoral	3,514	11,988

Analysis and Discussion of the Results

At a 12% discount rate, the net returns per hectare of pasture can be improved considerably i.e. from ₵ 682 to ₵ 3,514 (labour paid for) or ₵ 11,988 (labour valued at zero), by changing from the present land use to a silvi pastoral system.

Table 4 shows however that if labour has to be costed, either because the farmer has to withdraw it's own labour from other activities, on or off-farm, or because he hires the additional labour, the pasture component of the system does infact have a lower return than in the existing situation i.e. - ₵ 388 as compared to ₵ 682. A breakeven analysis showed that a 27% increase in per livestock unit production (rather than the 15% assumed so far) over and above the 20% increase in carrying capacity would provide the same net present value for the pasture component of the system in the "with" and "without" situation. Alternatively, assuming the same 15% increase in per livestock unit production, an increase in stocking rate of 67% (instead of 20%) is required for the pasture in the "with" situation to break even with the pasture component of the "without" situation.

A comparison of the cash flows of the "with" and "without" situation shows that if labour is not valued, only the first year shows a negative balance over the regular flow of net income derived from the "without" situation. On a per hectare basis the net investment during the first year would be the ₵ 6,105, including the additional investment in livestock (see Annex 2).

Such an investment may be too much for many farmers. However the advantage of this system is, that in principal, it is scale neutral, meaning that it may be introduced at a level a farmer can afford in terms of investment costs. This is also important from a labour cost point of view, because the likelyhood of approaching a zero opportunity cost for labour is much higher if the system is introduced at a rather modest scale as compared to been introduced on a larger scale. Alternatively, a farmer may seek loan funds to finance this investment.

Finally, the sensitivity of the results were tested against changes in the assumed discount rate. The internal rates of return of the additional investment (N.P.V 'without' situation equals N.P.V 'with' situation) was about 13.5% if labour is costed and about 21% if labour cost are assumed to be zero. Whether or not such a rate is attractive enough for the farmers in Puriscal depends on the loan facilities they can obtain and on what they consider a reasonable time value of money. Usually the larger the farms, the lower the acceptable discount rate. An indication of the possible acceptability can be obtained from the rate which farmers presently obtain from their livestock operation i.e. 13.8%.

References

1. Platen von H., Rodriquez P. and J. Lagemann.
Farming Systems in Acosta-Puriscal Costa Rica,(1982).

2. ICRAF (1983) Agroforestry Research Project Proposed.
Acosta Puriscal (draft).

Annex 1

CROP: SILVI PASTORAL MODEL

YEAR	SEASON	PRP	PLT	WED	FRT	PST	PRN	OTH	HRV	PRS	SEL	TOTAL LABOUR
		: LABOUR				REQUIREMENTS !						
		** * * *			LABOUR			HOURS * *				* * * *
1	1	12	10	5	1	0	3	0	0	0	0	31.00
2	1	4	2	5	1	0	3	0	0	0	0	15.00
3	1	0	0	5	0	0	3	0	0	0	0	8.00
4	1	0	0	0	0	0	3	0	0	0	0	3.00
5	1	0	0	0	0	0	3	0	0	0	0	3.00
6	1	0	0	0	0	0	3	0	0	0	0	3.00
7	1	0	0	0	0	0	3	0	0	0	0	3.00
8	1	0	0	0	0	0	3	0	0	0	0	3.00
9	1	0	0	0	0	0	3	0	0	0	0	3.00
10	1	0	0	0	0	0	3	0	0	0	0	3.00
11	1	0	0	0	0	0	3	0	0	0	0	3.00
12	1	0	0	0	0	0	3	0	0	0	0	3.00
13	1	0	0	0	0	0	3	0	0	0	0	3.00
14	1	0	0	0	0	0	3	0	0	0	0	3.00
15	1	0	0	0	0	0	3	0	0	0	0	3.00
16	1	0	0	0	0	0	3	0	0	0	0	3.00
17	1	0	0	0	0	0	3	0	0	0	0	3.00
18	1	0	0	0	0	0	3	0	0	0	0	3.00
19	1	0	0	0	0	0	3	0	0	0	0	3.00
20	1	0	0	0	0	0	3	0	0	0	0	3.00

Explanatory notes : PRP is labour for establishing the fence.

Annex 2

CROP: SILVI PASTORAL MODEL

AREA UNIT: Hectare

!MATERIAL REQUIREMENTS!

* * YEAR	SEASON	PLANTING		WEEDING		FERTILIZERS n.p.k.				CHEMICALS				OTHER		TOTAL MATERIAL VARIABLE COSTS
		lo	co	lo	co	lo	co	lo	co	lo	co	lo	co	lo	co	co
1	1	240	2400	0	0	7	105	0	0	0	0	0	0	2	2000	4505.00
2	1	24	240	0	0	7	105	0	0	0	0	0	0	0	0	345.00
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
13	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
16	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
17	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
18	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
19	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
20	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00

(By MULBUD)

Note : Additional investment in livestock (₵ 1,600) in first year not included in the print out.

Column others contains cost of barbed wire and nails for 400 meters (2 wires).