SITE SELECTION IN PARA

COMPARISONS OF MARABA, PARAGOMINAS,

AND SANTAREM

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ABBREVIATIONS

APRUBAN	Rural Workers Association for Santarém
BASA	Bank of Amazonia
BB	Bank of Brazil
CAT	Agro-Environmental Center for Tocantins
CATIE	Tropical Agricultural Research and Training Center
CEBA	Low Amazon Experimental Station
CEMEX	Timber Commerce and Export
CEPASP	Center for Syndicates and Popular Education, Research and Assistance
CEPLAC	Cacau Growing Plan Executive Comission
CIAT	International Center for Tropical Agriculture
CNS	National Council for Rubber Tappers
CPAA	Agroforestry Research Center for Western Amazon
CPAF/AC	Agroforestry Research Center for Acre State
CPAF/RO	Agroforestry Research Center for Rondonia State
CPATU	Agroforestry Research Center for Eastern Amazon
COSIPAR	Para State Metallurgical Company
CTM	Center for Wood Technology
CVRD	Vale do Rio Doce Company
FASE	Federation for the Social Assistance and Educational Organizations
FATA	Agrarian Foundation of Tocantins-Araguaia
GTZ	German Agency for Technical Cooperation
EMATER	Organization for Technical Assistance and Rural Extension
EMBRAPA	Brazilian Organization for Agricultural Research
IBAMA	Brazilian Institute for Natural Resources and Environment
ICRAF	International Center for Agroforestry Research
IDESP	Para State Development Institut
IICA	Inter-American Institute for Agricultural Cooperation, Organization of American States
IMAZON	Institut for Amazon Man and Environment
INCRA	National Institute for Colonization and Agrarian Reform
ITTO	International Tropical Timber Organization
LASAT	Socio-economic Laboratory for Tocantins
ODA	Overseas Development Assistance
PROCITROPICOS	Cooperative Program on Research and Technology Transfer for South American Tropics
REBRAF	Agroforestry Brazilian Network
SAGRI	Secretary for Agriculture of Para State
SINDSERPA	Sawmill Sindicate of Para State
STRI	Rural Workers Syndicate of Itupiranga
STRJ	Rural Workers Syndicate of Jacunda
STRM	Rural Workers Syndicate of Marabá
STRP	Rural Workers Syndicate of Paragominas
STRS	Rural Workers Syndicate of Santarém
STRSJA	Rural Workers Syndicate of S. Jao do Araguaia
SUDAM	Superintendence for Development of Amazon
UFPA	Federal University of Para
WHRC	Woods Hole Research Center
WWF	World Wildlife Foundation

I. INTRODUCTION

In an effort to establish an integrated planning process in the development of strategic research priorities and institutional strengthening activities in the Brazilian Amazon, PROCITROPICOS is currently supporting a Consortium involving EMBRAPA, ICRAF, CIAT and IICA. As tropical forest exploitation is a critical land use in the region, CATIE was also invited to participate because of its strong scientific expertise in the management of tropical forests.

The purpose of this joint research effort is to mitigate deforestation, land use depletion and rural poverty through the generation or adaptation of technologies, land use strategies and policies allowing the improvement of land use systems.

To achieve this purpose, the Consortium will apply a participatory approach to rural development, implementing research in close collaboration with rural household communities, governmental and non-governmental development organizations, and national and regional policy-makers. A comparative research framework over continua such as time since colonization, size of land holding, or involvement in cash economies will allow meaningful interpretations of existing land use patterns and of future trends. Also, the research agenda will be interdisciplinary in nature.

At a meeting of international institutions in February 1992, in Porto Velho, it was decided that this Consortium would focus on two areas, one in the States of Acre and Rondonia (connected to the activities of the Slash and Burn Project), and the other in the State of Pará. In June 1992, at CIAT headquarters in Cali, a methodology for site selection was discussed and adapted by scientists from the member institutions of the Consortium.

In August/September 1992, groups of scientists from EMBRAPA/CPATU and CIAT started collecting secondary information and visited the candidate areas of Marabá, Tome-Açu, Paragominas and Santarém. The objective of the visit was to collect pre-diagnostic information in preparation for a research mission scheduled for November 1992. At a subsequent workshop held in Manaus in October 1992, to plan site selection methodology in Para State, it was decided to exclude the region of Tome-Açu from the list of candidate sites.

In November 1992 a multidisciplinary team of 14 scientists from CIAT (3), ICRAF (2), EMBRAPA/CPATU (6), EMBRAPA/CPAA (1), EMBRAPA/CPAF-RO (1) and EMBRAPA/CPAF-AC (1) (see Research Team list) implemented a rapid rural appraisal (RRA) in the three candidate areas, followed by a comparative analysis of the three sites, respecting to biophysical, socioeconomical and political aspects.

II. OBJECTIVES AND METHODOLOGY

The ultimate objective of the joint exercise is to select sites which would fulfill the *following conditions:*

- Exhibit strategic problems and potentials for future development, which are representative of land use systems of Amazon Region.

- Serve as suitable areas for implementation of projects of national and international institutions collaborating with this Research Consortium.

- Possess agroecological and socioeconomic conditions which would provide a solid base for comparison, contrast and extrapolation of research results to other areas of the Brazilian Amazon, and the humid lowlands of South and Central America.

- Permit collaboration with international and national public and private institutions of research, development and policy formulation.

Additionally, the exercise will permit the fine-tuning of methodologies for detecting constraints, suggesting research priorities and selecting suitable sites as well as to evaluate the "joint venture" approach for interinstitutional collaboration with national partners, under an interdisciplinary and holistic strategy, toward land use systems development.

The methodology adopted consisted of two steps:

a. General biophysical and socioeconomic characterization of the sites based on secondary information collected mainly from publications, institution archives and local staff.

b. Implementation of the RRA by a multidisciplinary team, including scientists from the research partners (see Research Team List) and local staff (from EMATER, STRP and CAT).

The complete Research Group went to Marabá (10 to 15 November). There, three multidisciplinary teams were formed for reconnaissance and interviews. In addition, several group members visited sawmills, silvicultural experiments and a forest reserve. Due to limitation of time and funds, the team was divided in two after Marabá. One team of 8 members went to Santarém (15 to 20 November) while the other team of 6 members went to Paragominas (16 to 20 November). For effective interaction and communication and for logistic reasons, two teams were again formed in each site and, again, when necessary, another team was formed for specific visits, mainly to the forestry sector.

Table 1 presents the agriculture/livestock areas visited in the three candidate regions, followed by the number of interviewers as well as the number of farms visited which, including the three sites, amounted 63. Figure 1 presents the location of the four preliminary candidate areas in Pará State. Figures 2 to 4 present maps indicating all visiting areas, respectively for Marabá, Santarém and Paragominas.

Table 1. Number of farms visited and number of interviewing team members per area visited.

Region	Municipality/Area/Community	Interview Team	Farms Visited
	Itupiranga:		
	Lastancia	6	4
	S. João Batista	6	2
	Jacunda:		
	Vila Bagaço	5	3
MARABA	Santa Maria	5	3
	S. João do Araquaia:		
	Araras	6	3
	Maraba:		
	PA-70	5	3
	Brasispanha	6	3
	Murumuru	6	4
	Rod. Santarem/Curua-Una:		
	Perema	5	1
	Curupira	5	1
	Ipaupixuna	5	1
	Boa Esperanca	5	1
	Ramal da Moca	5	3
	Igarapé da Lama	5	1
	Santa Rosa	5	1
	Ubinzal do Una	5	1
SANTAREM	**Rod. Santarém/Cuiaba**		
	Km. 56	5	1
	Boa Esperança	5	1
	Nova Esperança	5	1
	Ramal Santa Julia	5	1
	Mujui dos Pereira	5	1
	Jaboti	5	1
	Sao Benedito	5	1
	Cipoal	5	1
	Varzea:		
	Urucurituba	11	1
	Piracaoera	11	2
	Pinduri	11	1
	Rio Capim:		
	S. Sebastião	4	3
	Nazaré	4	2
PARAGOMINAS	**Gleba 22**	5	3
	Del Rey	5	4
	Br-010	4	4

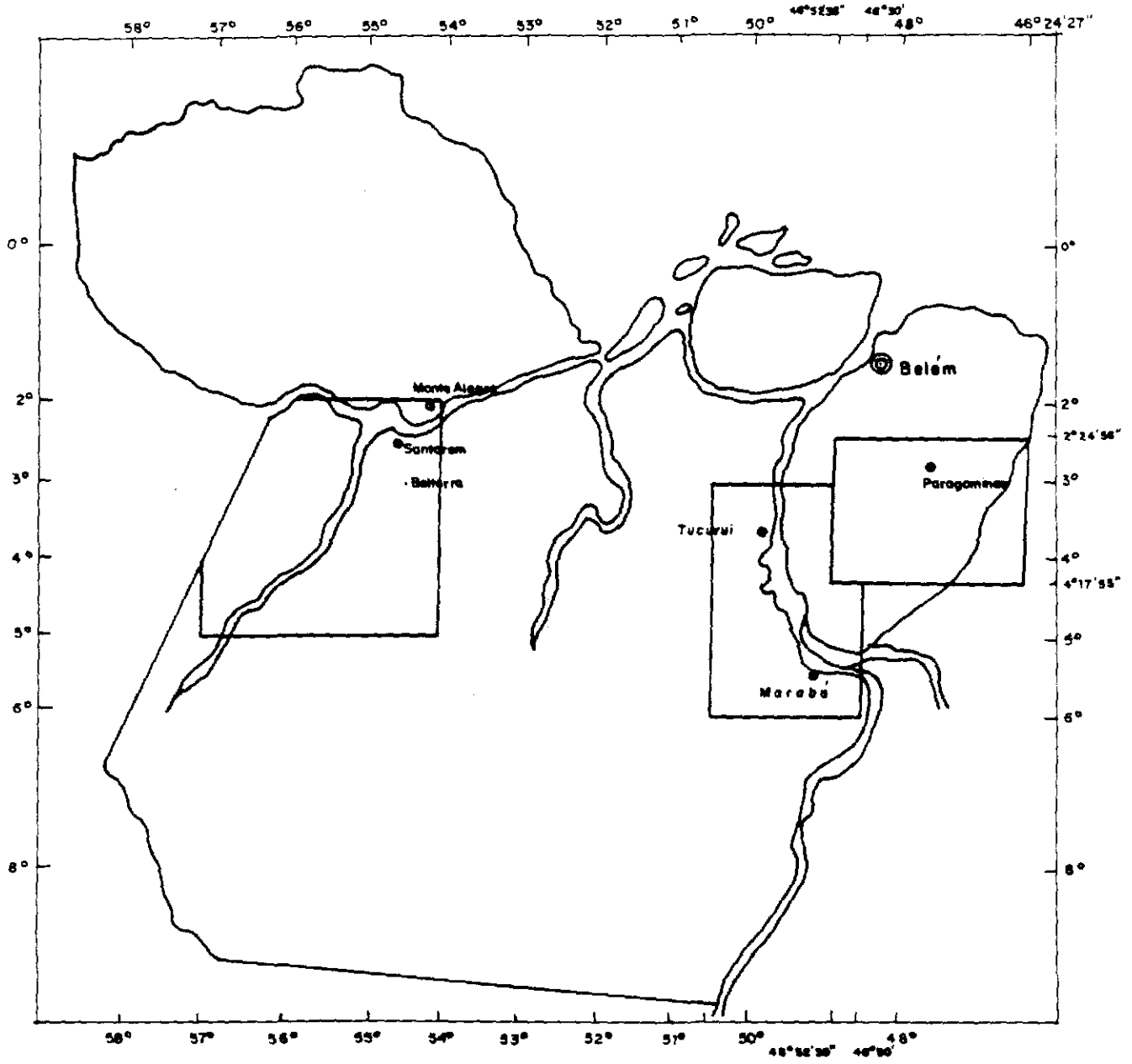


Fig. 1. Location of the three candidate areas in Pará State.

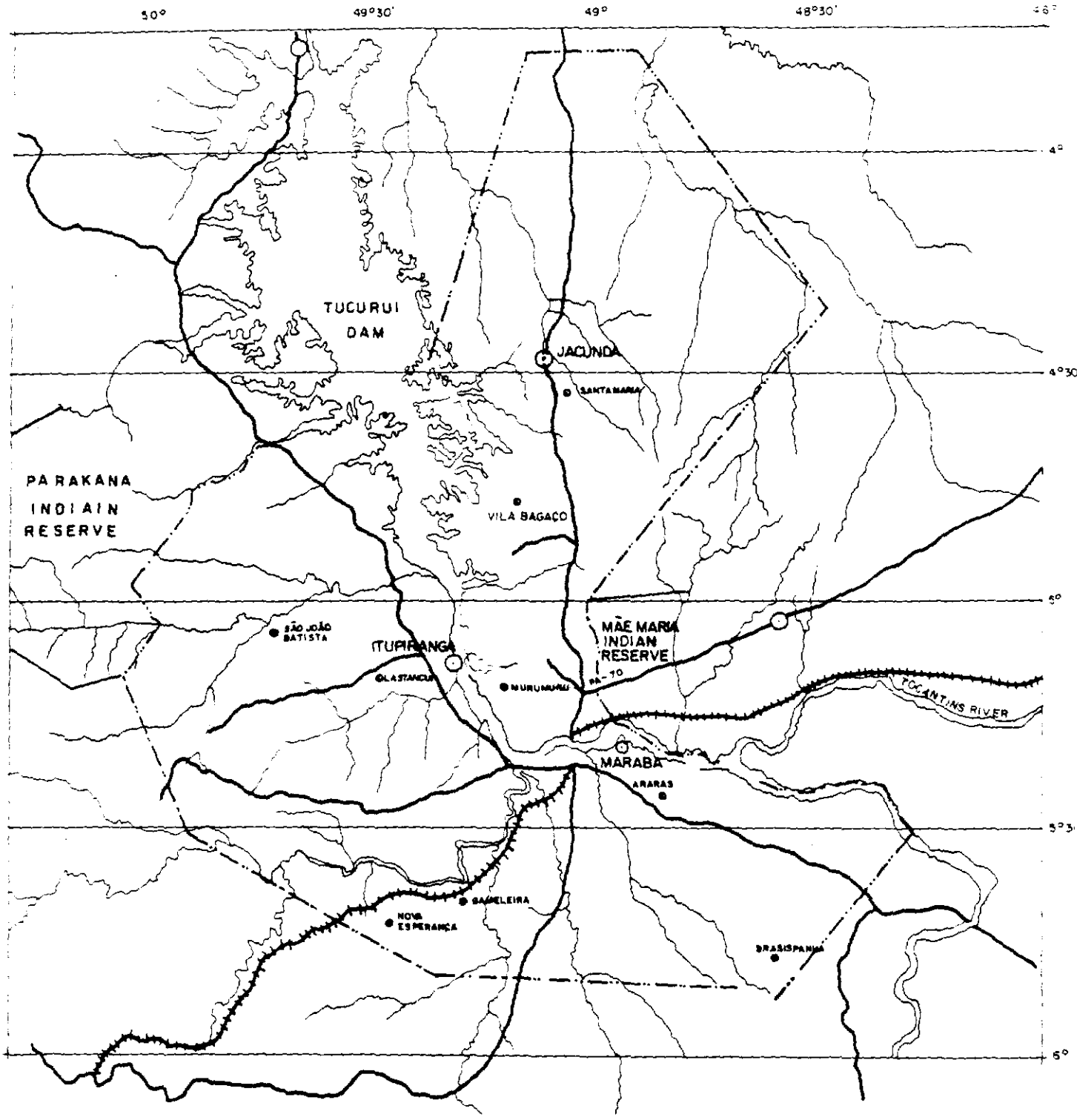


Fig. 2. Location of sites visited in Maraba area

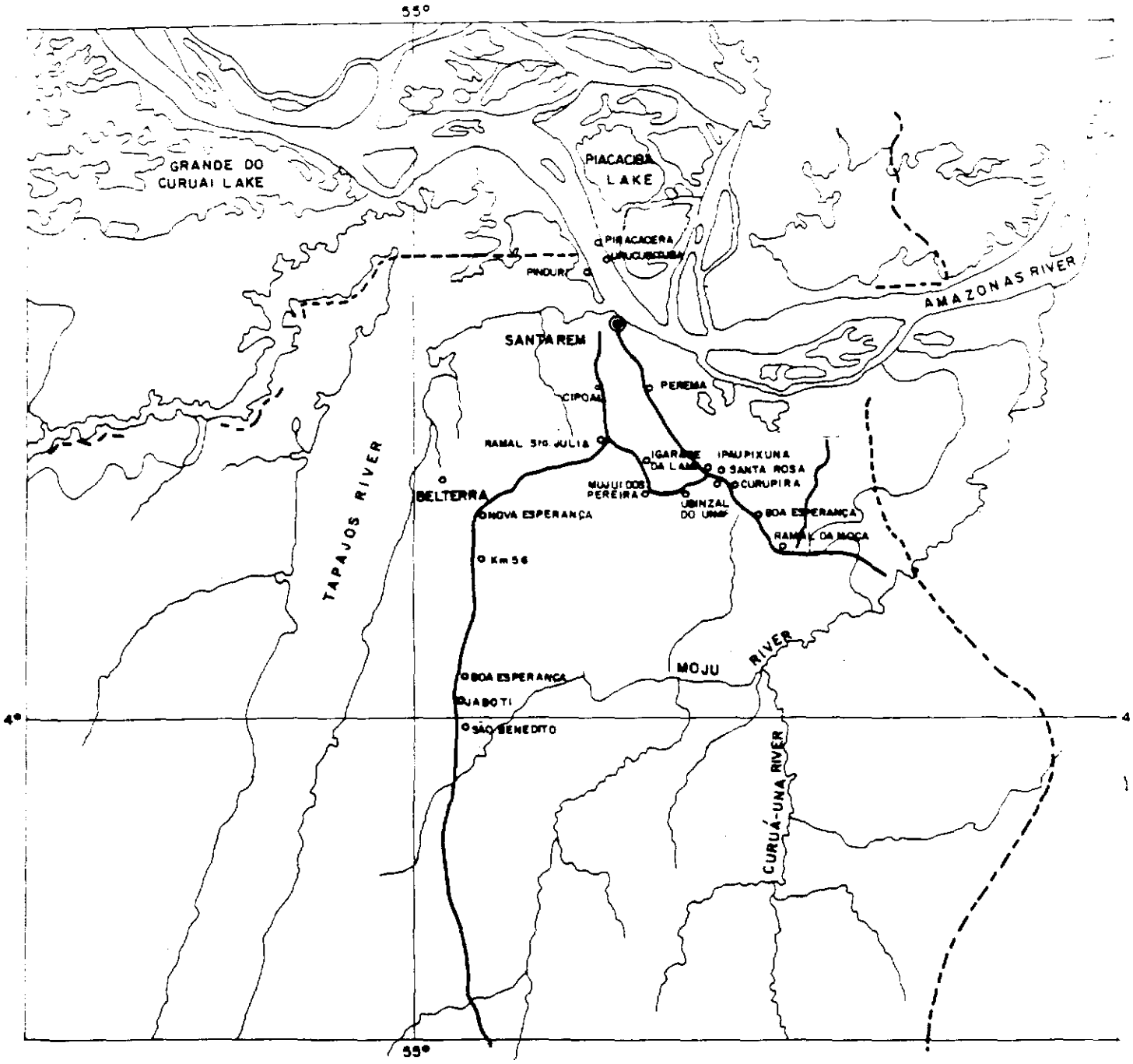


Fig. 3 - Location of sites visited in Santarem area.

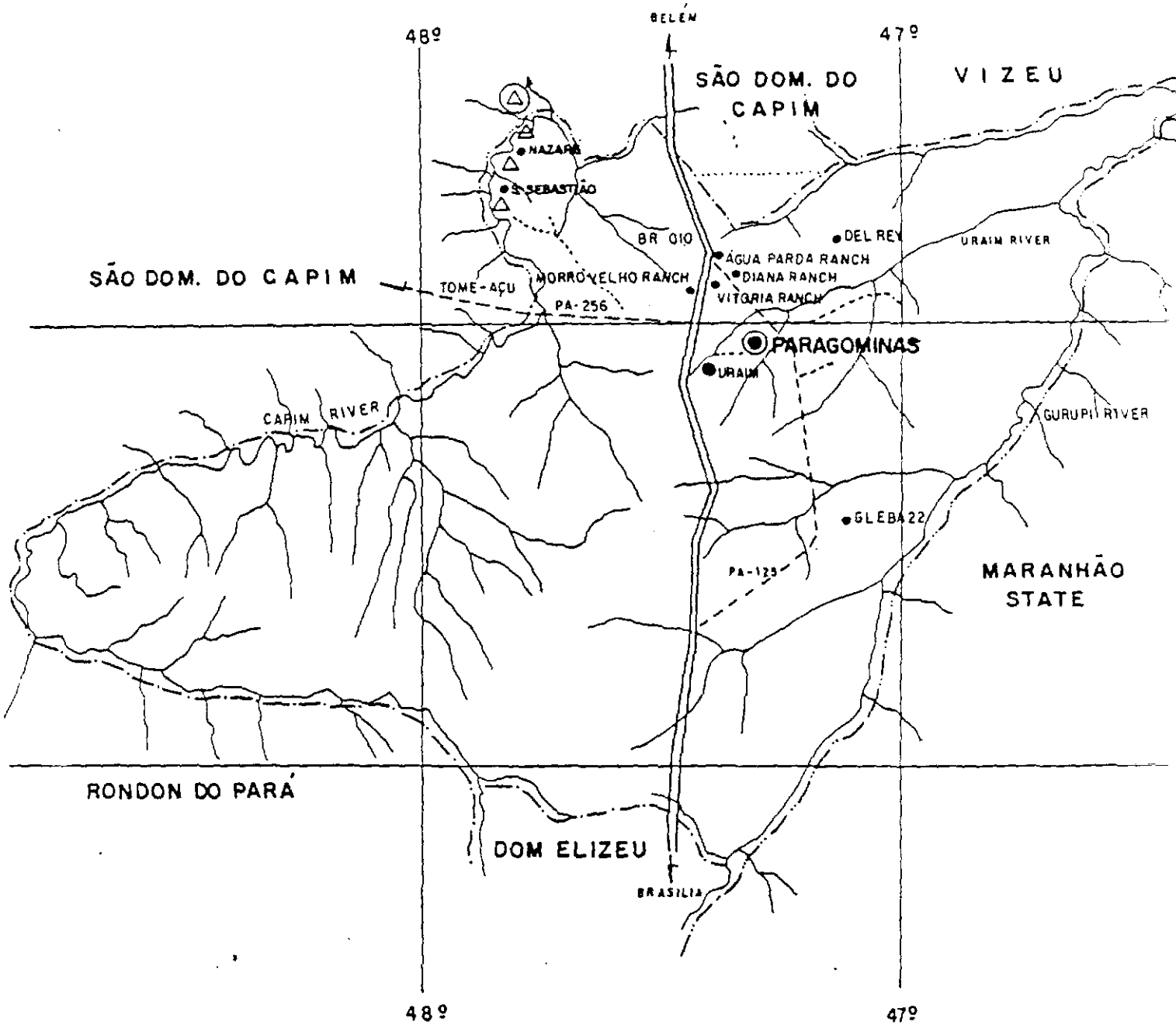


Fig. 4 - Location of sites visited in Paragominas area

III. BACKGROUND

1. AREA DESCRIPTION

The area in Marabá region is located within latitudes 04° 30' and 06° 00'S and longitudes 48° 30' and 50° 00', covering parts of the municipalities of Marabá, Itupiranga, Jacunda and S. João do Araguaia. The Santarém and Paragominas regions correspond to the limits of the respective municipalities.

2. MACRO BIOPHYSICAL CHARACTERIZATION

The basic soil, climatic, vegetation and hydrology information for the candidate areas in Para State is presented in Table 2. In the Marabá area, terrain varies from relatively flat to steep slopes (up to 45% especially near Itupiranga). The relief pattern is a result of the diversity of the geological substrate. However, there are not very significant differences between the dominant soils found in the three areas. The rainfall distribution is different among the sites. Marabá area is characterized by a relatively long dry season extending mainly from May to October and by frequent dry spells during the wet season (mainly in January), although within the area there is increasing rainfall to the north. The water table is relatively shallow. In both Santarém and Paragominas the stream network is less dense and in extensive areas the water table is deep, even exceeding 100 m. Rainfall in Santarém averages between 1900 and 2200 mm per year with a 2-3 month dry season. In Paragominas the dry season is also relatively long compared to Santarém.

Table 2. Biophysical characteristics in candidate areas of Pará State.

Criteria	Marabá	Santarém	Paragominas
Soils			
Plateau:			
Ultisols	Frequent	Frequent	Frequent
Oxisols	Dominant	Dominant	Dominant
Alfisols	Small area	-	-
Acid soils	Dominant	Dominant	Dominant
Aluminum saturation	Medium/high	Medium/high	Medium/high
Phosphorus level	Low	Low	Low
Slope	Plane/steep	Plane/medium	Plane/steep
Climate			
Annual rainfall (mm)	1500 to 2000	1900 to 2200	1800
Months with <60 mm	2 to 6	2 to 3	4 to 6
Max. Annual Temp.	32.0 to 33.0	31.0	32.0 to 33.0
Min. Annual Temp.	21.0	22.0	21.0
Vegetation			
Plateau:			
Open forest	Dominant	-	Dominant
Dense forest	-	Dominant	-
Babassu	Frequent	Frequent	-
Hidrology			
Springs and streams	Available	Limited	Limited
Water table (m deep)	2 to 20	12 to 105	15 to 100

Sources: SUDAM, EMBRAPA/CPATU, EMBRAPA/SNLCS.

3. SOCIOECONOMIC/POLITICAL CHARACTERIZATION

a. Demography

Among the three sites, Marabá has experienced the highest populational increase during the last decade, 326% compared to 172% for Paragominas and 5% for Santarém. This situation in Marabá is due mainly to mining activities (gold in Serra Pelada and iron in Carajás) a hydrolectric dam at Tucurui and road construction. Tables 3a and 3b present, respectively, data on population distribution and evolution for the three candidate areas.

b. Education and Health

Table 3c summarizes the information on education and health infrastructure in the candidate areas.

4. FARMERS' ORGANIZATIONS

Marabá. The base unit of organization is the Rural Workers Union (STR), organized by municipality. Some of these unions (STRI, STRJ, STRM and STRSJA) in turn are affiliated with the FATA, a part of CAT. The foundation serves both as a mechanism for obtaining external funding and as a conduit for these funds to CAT's activities. The research laboratory (LASAT) serves a research and development function of CAT by providing farmers with direct access to results of field research and the agencies conducting this research. Reflecting the insecure land tenure situation in that area, much effort from workers organizations is toward guaranteeing land for their members, although STRM additionally is attempting some technical advice. Besides of the Syndicates, many community level rural workers organizations are being formed with the ultimate purpose of alleviating the isolation of small farmers. These organizations are not yet able to mitigate technical and infrastructure constraints of those areas.

Table 3a. Population distribution in the municipal regions of Marabá, Santarém and Paragominas.

Municipality	Area (Km^2)	Urban Pop.	Rural Pop.	Total Pop.	Pop. Density (Km^{-2})
Itupiranga	15.890	5.171	14.824	41.100	2.6
Sao João do Araguaia	2.640	11.029	25.167	36.002	13.7
Maraba	15.288	49.545	105.508	155.053	10.1
Jacuanda	6.059	172	81.890	82.062	13.5
Santarem	33.874	190.826	73.382	263.208	7.7
Paragominas	24.778	79.374	40.769	120.143	4.8

Source: IDESP (1990)

Table 3b. Population evolution in the candidate sites.

Variable	Marabá*		Paragominas		Santarém	
	1980	1989	1980	1989	1980	1989
Total	126.258	314.449	27.168	120.143	192.203	263.208
Density (p/km^2)	1.85	7.88	1.78	4.85	7.38	7.77
Urban (%)		20		66		72

Source: IDESP (1981 and 1990)
***Marabá, Itupiranga, Jacunda and S. João do Araguaia**

Table 3c. Education and health units in the municipalities included in the candidate areas.

Municipality	Education		Health (# of Units)
	University	School* Urban + Rural	
Marabá	1	147	19
S.J. Araguaia	-	121	6
Itupiranga	-	70	5
Jacunda	-	75	6
Paragominas	-	76	4
Santarém	3	492	17

Source: IDESP (1990)
*** Elementary and High School.**

Santarém. APRUSAN and STRS are the main farmers organizations from this area. APRUSAN recently has prepared a diagnostic document, after a survey and discussion with approximately 6.000 farmers from about 105 communities. The main actions purposed in this document are: improvement of roads and commercialization; exemption of commercialization fees; mechanization units; irrigation ("varzea" and plateau); water collection and storage; producers market; technical assistance; rural electrification; fruit agro-industry and infrastructure for raising fish.

Paragominas. The STRP has affiliates from 7 out of the 19 rural communities existing in this area and is carrying out activities aiming to improve the sustainability of agriculture in the area. There are two agronomists contracted by this syndicate which are participating in training activities with other institutions like REBRAF and EMATER, and in community level nurseries for fruits and forest species.

5. OPERATING INSTITUTIONS

a. Governmental

Marabá. Some governmental institutions are found in the area including EMATER (regional and local offices), and SAGRI (Office). UFPA has an University Campus for Southern Pará State, offering a few undergraduate level courses. Also CAT, based near Marabá, supports rural workers organizations, commercializes products through FATA, develops socioeconomic research, and offers every year an eleven-months long familiar agriculture specialization course for agronomists and other agrarian sciences professionals every year.

Santarém. There are many governmental institutions well established at this site. Although EMATER is experiencing a critical economical situation, its extension staff seems to be cooperative and receptive to the Consortium activities. SAGRI also has an office there. BB and BASA are the institutions responsible for rural credit in the region. CEPLAC has an extension unit there, assisting cocoa growers. EMBRAPA/CPATU has an experimental station at Belterra and several

forestry and agroforestry projects in the area. In Cacaual Grande, close to Santarém, CPATU has another extensive experimental station (CEBA) mainly working with livestock. In addition to EMBRAPA, SUDAM and IBAMA are also contributing to the forestry and timber sector. The CTM/SUDAM has an impressive structure for timber research although it is experiencing shortage of staff members. UFPA has its Lower Amazon Campus headquartered in Santarém.

Paragominas. EMATER, SAGRI, and INCRA have operating offices in the site. EMBRAPA/CPATU has long-developed research projects in this area, mainly in pastures improvent and agro-silvi-pastoral systems. Rural credit is mainly offered by BB and BASA.

b. Non-governmental

Marabá. FASE is advising rural workers' unions in their organization as well as promoting training activities. CEPASP concerned with the community of Araras, supporting the workers organization as well as promoting the storage and commercialization of their products (cupuaçu pulp mainly). CNS is in the process of changing its name to National Extrativism Council and in the Marabá region is working with brazil-nut gatherers. Recently, the local CNS group prepared a working agenda, including technical purposals such as land reclamation with perennial crops, agroforestry systems, and agro-industry.

Santarém. The only NGO contacted in this area was the group "Health and Happiness", concerned with perennial species dissemination among small farmers, mainly on the "varzea". This NGO has also promoted training activities with the collaboration of REBRAF and CPATU.

Paragominas. Two NGOs have been active in the region. These are IMAZON and WHRC. IMAZON has conducted a comprehensive survey of the timber sector in the region. Presently it is focusing research on sustainable forest management practices. WHRC investigates the environmental impacts of cattle ranching activities and ways to reclaim land. Studies of the role of deep roots on

the water and nutrient cycling in primary and secondary forests have also been carried out by them there with the participation of scientists from CPATU.

c. Governmental Plans for the Area

There are three land use options among those indicated in the Ecological-Economical Zoning of Pará State (IDESP 1991) which apply to the candidate areas as follows:

1. Areas are appropriate for extractive self-sustainable forest management (fruits, leafs, flowers, resins, latex, gums, barks, fibers, etc.). Discontinuous deforestation up to 10 ha for purposes of family agriculture and/or livestock will be also allowed in these areas.

2. Areas are appropriate for agricultural and livestock activity with priority for agro-silvi-pastoral combinations, or intensive cropping techniques in restricted areas, forestry exploitation, forestation and reforestation. Deforestation should follow current laws avoiding continuity of crop areas over 100 ha.

3. Sustainable forest management should be practiced for native tropical timber species.

According to this Ecological-Economical Zoning of Pará State being carried out by IDESP, the three candidate areas should be used as follows:

Marabá. Most of the area of Marabá, Itupiranga and São João do Araguaia should be used as option 1 and most of Jacundá area should be used as option 3.

Santarém. Most of Santarém area is recommended for the adoption of option 1; some areas of Varzea and around Tucurui dam are recommended for option 3; and some areas in the Tapajos influence are recommended for option 2.

Paragominas. Most of these area should be used as option 2 and a small area as option 1.

IV. LAND USE SYSTEMS IN PARA

Land use systems in Pará can be divided somewhat artificially into five main cropping systems among which there are many interconnections and much overlap: 1. Food crop systems (relayed with fallow, pasture, or perennials); 2. Pasture systems (relayed from crops or extensive ranching); 3. Homegardens; 4. Forestry systems (including extraction or management/silviculture of timber, charcoal, and non-timber forest products); and -- of least priority to the Consortium as it is now formulated to concentrate on upland acid soils -- 5. Flood plain systems (cropping and ranching) which may interact with larger farming systems including upland areas. We will briefly review these systems and then draw some tabular comparisons among the three sites visited.

1. FOOD CROP SYSTEMS

The basic crops are similar to other parts of the Amazon including manioc (in great variety), rice, maize, and cowpeas. (See Table 4 for detailed comparisons.) The droughts of Pará favor cowpea over the common bean found elsewhere. Within the state there are some trends where rice is dominant in Marabá, cassava in Paragominas, and cassava and maize in Santarém, but all of these crops are found at all sites. Only in Paragominas, where ranching and forest extraction dominate, are food crop systems in general little exploited. The exact rotations of the major crops varies from site to site with seasonality and markets, and need to be better defined. The cropping sequence is then followed by either fallow, perennials or pastures.

Table 4. Land Use distribution

CRITERIA	MARABA				PARAGOMINAS				SANTAREM			
MAJOR AGRICULTURAL CROPS	1980		1990		1980		1990		1980		1990	
	ha	yield	ha	yield	ha	yield	ha	yield	ha	yield	ha	yield
rice	12.165	1.300	4.900	1.300	11.745	980	490	700	9.000	800	6.500	1.000
cowpea (kg/ha)	1.040	720	2.150	360	100	500	-	-	576	347	800	400
beans (kg/ha)	-	-	830	550	-	-	-	-	-	-	250	700
maize (kg/ha)	7.426	1.200	2.675	1.200	2.140	800	4.000	500	1.750	800	5.000	1.000
cassava (t/ha)	1.355	15*	5.350	15	2.309	14	40.000	10	8.065	19	9.000	12
banana (bunch/ha)	652	1.200	2.160	1.250	98	1.250	100	1.250	1.062	2.176	960	2.200
coconut (fruits/ha)	2	4.500	2	5.000	60	6.383	40	6.000	60	4.000	125	6.000
orange (fruits/ha)	19	120.000	63	75.000	20	190.000	-	-	170	150.000	350	60.000
papaya (fruits/ha)	-	-	-	-	4	52.500	-	-	-	-	19	24.000
black peper (t/ha)	-	-	28	2.250	111	3.700	1.925	2500	305	2.250	1.900	2.500
EXTRACTIVE PRODUCT		1980 yield		1988 yield		1980 yield		1988 yield		1980 yield		1988 yield
rubber (t)		-		-		-		-		450		187
cupuaçu (kg)		-		-		-		-		6		2
cabbage-palm (t)		-		-		-		-		8		229
Brazil-nut (t)		14.42		5.115		-		-		1,4		61
timber												
- charcoal (t)		117		152		450		3.100		800		622
- firewood (m^3)		78.000		89.000		86.000		336.000		200.000		338.000
- log (m^3)		109.200		230.000		300.000		2.120.000		100.000		40.024
LIVESTOCK POPULATIONS		1980		1989		1980		1989		1980		1989
sheeplike		2.435		2.480		2.500		3.000		1.292		12.200
caprine		1.417		1.700		1.210		2.000		424		4.825
pig		66.331		145.400		14.059		35.000		32.081		27.000
chicken		326.202		379.900		67.822		30.000		446.707		552.516
bovine		322.761		417.000		160.348		505.000		86.797		87.000
buffalo		250		236		400		100		6.000		11.560

Source: Annual statistics of Pará, IDESP, 1981 and 1982, FIBGE, 1986.

a. **Fallow Systems**

Traditional Amazonian swidden-fallow agriculture incorporates a managed fallow (although modern variants often use the fallow unmanaged) to reduce weed and pest loads and restore soil properties. This system is still much in evidence in Para although we gathered little information on the traditional system as such or on the ranges of variation on this system. This investigation should be given top priority in project formulation (see research priorities). Fallow management can successfully combine informal perennial cultivation (which follows).

b. Relayed Perennials

Following the annual cropping cycles, perennial crops may be planted in single stands, such as oranges, or in mixed groves. A wide array of crop combinations was noted (Table 5), most of them highly dynamic with different species coming on line and dropping out with time.

Although the array of crop combinations is impressive and shows the innovative spirit of small farmers, the area occupied by such agroforestry systems still pales compared to the area in basic staples and second growth. Agroforestry systems are not yet a major land-use system in the area visited, but they are growing in significance. When in balance with other land-use systems, agroforestry systems provide a suite of environmental services, such as increased biodiversity, soil protection, improved soil moisture retention, and protection for water courses.

The following species were deliberately left in home gardens when clearing the forest or old second growth: jangada, embileira, piquiá, babaçu and morototó. Spontaneous seedlings of wild cacao (*Theobroma cacao*), Brazil nut, babaçu, and bacabá (*Oenocarpus distichus*) are sometimes protected in home gardens.

c. Relayed Pastures

Substituting pastures for fallows is a common modern adaptation of traditional Amazonian agriculture. After the harvest of food crops or during planting, pastures like "brachiarao" (*Brachiaria brizantha*) are established. This process called "pecuarizacao" is most important among small holders of Marabá and Santarém.

Table 5. Some perennial crop combinations observed in the vicinity of Marabá and Santarém, Pará.

Crop Combinations	Location
Banana, cupuaçu, pineapple Brazil nut, mango, tangerine, açaí, piquiá, jackfruit, tutaruba	Lastancia, Mun. Itupiranga
Banana, cupuaçu, papaya, Cassava, ingá, ata, grozela, mango, coconut, pineapple, lime	Lastancia, Mun. Itupiranga
Pineapple, *Panicum maximum* Cassava, cupuaçu, sweet potato	Lastancia, Mun. São João Batista, Mun. Itupiranga
Coconut, cupuaçu	Km. 3 Itupiranga-Coco Chato
Banana, cupuaçu, pineapple, papaya	Sitio Sapecado, Vicinal Ferrovia, Km. 35 PA 150, Marabá-Xinguara
Passionfruit, orange	Comunidade Cipoal, Km 15 Santarém-Rurópolis
Cassava, Jaraná[1]	Comunidade Cipoal, Km 15 Santarém-Rurópolis
Black pepper, rubber, orange, cupuaçu, coconut, cashew	Comunidade Boa Esperaça, Km 70 Santarém-Rurópolis
Black pepper, Brazil nut, biribá, mango, azeitona, guava, coffee, pineapple	Comunidade Sao Benedito, Km 77 Santarém-Rurópolis
Cassava, banana	Km. 46 Santarém-Rurópolis
Orange, rubber	Km. 46 Santarém-Rurópolis
Passionfruit, Barbados cherry	Km. 33 Santarém-Curuá-Una
Black pepper, coconut	Km. 68 Santarém-Rurópolis

[1] *Timber species left when old second growth cleared.*

However, many small producers do not have capital to build fences or to buy cattle, so they may rent or sell the "improved" property to ranchers (opting for land improvement investments over agricultural investments). Within these food crop-pasture systems, weed invasion and the labor required to control weeds are seen as major constraints. The result is an accumulation of Amazonian land in rapidly deteriorating pasture, while the demand for new pastures fuels further deforestation. This trend is unfavorably compared with either the traditional rotation of crops with fallows returning to crops (1.a.) or with managed pastures (see Research Priorities).

2. PASTURE SYSTEMS

There are two major pasture systems in Amazonia: the food crop-pasture systems already introduced (1.c.) and large scale ranching. In exceptional cases, small farmers have slowly accumulated pasture and cattle to make the transition to ranching (seen in Santarém), but it is unusual. Most large ranchers come from outside Amazonia (or at least outside the farming sector) with capital to invest.

a. From food crops (See 1.c. above).

b. Ranching

In Pará little sustainable management of cattle pastures is evidenced, inspite of being a major land use particularly in Paragominas. Large scale cattle ranching is undertaken by large investors (we interviewed businessmen, garimpeiros, and ranchers originating from the south) at least as much for land speculation as for livestock profits. Ranching often unmanaged extraction of timber which precedes complete deforestation for pasture establishment. Large investments or subsidies are needed in obtaining the land, mechanized conversion, pasture and herd establishment, and now in pasture reclamation. The ranchers are often very closed as to the financial details of these processes and are seldom found to reinvest in local area development. Thus, as practiced, this type of ranching is an extractive land use to be compared to the timber industries with which it is often paired. However, research alternatives are available (see Research Priorities).

3. HOMEGARDENS

Home gardens are an important dimension to land-use systems because they serve as testing grounds for new crops to the area. By planting a few individuals of an unknown crop in the backyard, a farmer makes a minimal investment while observing its performance and trying its products. Home gardens also serve as launching pads for some new domesticates. Farmers sometimes leave native trees when clearing forest or old second growth for their homes if they are deemed useful. Sometimes these forest vestiges produce seedlings in home gardens, where they are tended. Another way that wild species enter the proto-domestication stage is when seedlings sprout spontaneously in house yards, either as a result of natural dispersion or from seeds discarded by family members. Home gardens are thus propitious "hunting grounds" for promising new crops in Amazonia and as sources of germplasm for agroforestry and perennial cropping systems.

Home gardens are typically much richer in valuable species than adjacent fields. A total of 57 species of plants, mostly perennials, were detected in just 14 home gardens sampled in the vicinity of Marabá and Santarém (Table 6). Besides the plants, homegardens also contain small animals: chickens, pigs, goats, etc. mostly for home consumption.

Although the sample is too small to draw any firm conclusions, home gardens seem to be richer in the Santarém area, probably because more of the farmers were born in Pará or at least have lived most of their lives in the state.

4. FOREST EXTRACTION AND MANAGEMENT

Forestry in Pará is practiced on several fronts with unmanaged and unsustainable extraction dominating over the meager efforts toward long-term forestry development. We have identified extraction of timber, wood for charcoal, and non-timber forest products -- seldom coordinated and often competing -- as well as the nacent efforts at forest management and silviculture. Timber extraction is

Table 6. Plant species found in home gardens in the vicinity of Marabá and Santarém, Pará (exclusive of ornamentas, medicinal plants, and vegetables).

	Location													
Plant	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Açai[3]									+				+	+
Almeixa						+	+							
Annatto		+	+		+			+		+	+	+	+	+
Arabica coffee		+		+	+	+	+				+	+		+
Araticum											+			
Avocado			+		+	+			+	+	+	+	+	
Azeitona										+	+			
Babaçu[1,2,3]							+					+[2]	+	
Bacaba (*O. distichus*)[3]												+[2]		+
Banana		+			+			+	+	+	+		+	+
Barbados cherry											+			+
Beans (*P. vulgaris)*								+						
Biribá							+		+	+	+	+		
Black pepper						+	+		+					
Brazil nut[3]							+	+			+	+[2]		
Breadfruit											+			
Cacao[3]			+			+	+	+	+			+	+[3]	
Calabash gourd							+		+				+	+
Capsicum pepper		+	+								+			+
Cashew	+	+	+	+	+	+					+	+		+
Cassava	+		+					+						
Coconut	+				+		+				+		+	+
Cotton			+		+							+		+
Cupuaçu[3]	+		+			+	+	+	+	+	+	+		+
Cumaru[3]											+			
Cupuí[4]											+			
Embileira[1]				+										
Guava	+	+	+	+	+	+	+		+		+	+		+
Genipapo														+
Ingá						+								+
Jackfruit	+					+				+	+	+	+	+

Jangada[1]				+										
Lima				+			+			+				
Lime					+	+			+	+				
Lemon grass											+			
Malay apple											+			
Mango	+	+	+	+		+	+	+	+	+	+	+		+
Morototó[1,3]										+				
Murici			+						+				+	
Mucaúba[3]						+							+	
Oiticica			+											
Orange	+	+	+		+	+		+	+	+	+	+	+	+
Papaya	+		+		+				+	+		+	+	+
Peach palm			+						+	+		+	+	+
Pineapple	+	+		+		+					+	+		
Piquiá[1]				+										
Pitomba												+		
Rough lemon						+			+			+		
Soursop			+				+			+			+	
Sugarcane											+		+	
Sweet potato	+													
Tamarind	+													
Tangerine	+	+				+	+		+	+	+	+		
Tobacco								+						
Tropical almond			+											
Yellow mombim				+			+					+[2]		

[1] Spared when forest or old second growth cleared
[2] Spontaneous
[3] Occurs wild in forest or old second growth
[4] *Theobroma speciosum*

1. Vicente Souza, Lastancia, Itupiranga Municipality, Pará (born in Piaui).
2. Raimundo Pereira de Souza, Lastancia, Itupiranga Municipality, Pará (born in Maranhão).
3. José Brito, Lastancia, Itupiranga Municipality, Pará (born in Itupiranga, Pará).
4. Francisco Geronimo do Nascimento, Lastancia, Itupiranga Municipality, Pará (born in Piaui).
5. Lourenço Araújo, Lastancia, Itupiranga Municipality, Pará (born in Maranhão).
6. Manoel França de Sousa, São João Batista, Itupiranga Municipality, Pará (born in Itupiranga, Pará).

7. José Ribeiro, São João Batista, Itupiranga Municipality, Pará (born in Goias).
8. Ricardo Ribeiro, Sitio Sapecado, vicinal Ferrovia, km 35 PA 150 Marabá-Xinguara, Pará (born in Minas Gerais).
9. Francisco Lira, Comunidade Cipoal, km 15 Santarém-Rurópolis, Santarém Municipality, Pará (born in Pará).
10. Juliano Pereira, Comunidade Boa Esperança, km 70 Santarém-Rurópolis, Santarém Municipality, Pará (born in Pará).
11. Raimundo Carneiro, Comunidade São Benedito, 7 km along side-road from km 77 Santarém-Rurópolis, Santarém Municipality, Pará (born Ceará).
12. Sergio Freitas, Sitio Santo Antonio, km 56 Santarém-Rurópolis, Santarém Municipality, Pará (born near Santarém, Pará).
13. Nenas Souza, km 46 Santarém-Rurópolis, Santarém Municipality, Pará (born near Santarém, Pará).
14. Miguel Pires, km 68 Santarém-Rurópolis, Santarém Municipality, Pará (born in Pará).

of most importance in Paragominas, charcoal and non-timber extraction in Marabá, while forest management and silviculture both at the state and private level is best developed in Santarém.

a. Timber Extraction

Frontier timber extraction without management still very much dominates forestry practices in Pará. While timber trees are occasionally being harvested in the vicinity of all the farming communities visited, with most accessable areas already logged the active lumbering front has now moved well away from the main roads. Some of the larger logging trucks bring timber from as far away as 200 km to sawmills in Marabá and Paragominas. The timber sector represents the main source of income in Paragominas and about 80% of timber production is for the domestic market. Greater profits are made elsewhere (e.g., Santarém) from plywood, veneer, and parquet flooring, but the equipment is very expensive and the scale of operation large. There is a tendency toward finished wood products (vertical integration) particularly for the export market. Compared to other areas in Latin America, a surprisingly large number of species, up to 100, are sometimes being harvested, but a more restricted selective harvest is still the rule. Low profitability and undervaluation of wood products discourages the adoption of sustainable management practices (see limitations and opportunities) and the migratory advance of the timber industry is taken for granted.

b. Charcoal Extraction

In Marabá, there is extremely active charcoal production for intensive iron smelting. Diverse levels of society are incorporated from the poorest, recent immigrants (working the kilns and cutting the wood) to ranchers (hiring these workers as share-producers) and industry (producing and purchasing). The forest management investigation related to charcoal is limited to a poorly defined extraction study and single species reforestation trials, neither of which have any hope of meeting the industrial demands. Roughly calculated, one smelter, for sustainable production would need approximately 35,000 ha of optimally producing eucalyptus or 100,00 ha of natural forest. At present 6-10 smelters are functioning with construction of up to 20 total, implying an unsustainable demand.

Even extraction of wood from swiddens cannot be done sustainably for several reasons. First, there is not sufficient wood generated. Secondly, productivity of the land declines with reduction of the organic inputs. Thirdly, accelerated cutting of forest encourages an accelerated advance of the unsustainable agricultural frontier.

c. Non-timber extraction

It is important to integrate the management of non-timber forest products with that of timber, an option little considered in Pará. Unfortunately, we have little information on this important component of forest use for lack of appropriate contacts. We are aware that extractors exist in Pará with a strong historical base. Additionally, the literature from the area on indigenous and caboclo management for forests is extensive and pertinent to developing sustainable forest management. Only a small sample of the non-timber plant species collected from the forest were noted (Table 7). When the range of uses of these products is considered, including medicines, fiber, construction, food, resins, and beverages, there must be hundreds of species.

Marabá was the only area where we saw active small farmer extraction, management and commercialization of non-timber forest products, especially cupuaçu, babaçu, bacaba and Brazilnuts. Farmers recognize the advantages of low labor inputs for the cash or use-value received ("subsidy of nature"). In Marabá there exists an NGO (supported by WWF) promoting the commercialization of cupuacu and other extracted products.

d. Forest Management and Silviculture

IBAMA's requirement for forest management plans to avoid taxation has triggered a booming business in production of management plans for forest industry ranches. However, there is little real evidence of extraction management and less of silvicultural management in Pará. Ultimately, the forest industry has a vested interest in the long-term productivity of the forest, so there may be a basis for initiating participatory forest management. Farmer and rancher management of woodlots is another area of potential commitment (see Research Priorities).

Table 7. Some non-timber products collected from upland forest in the vicinity of Paragominas, Marabá, and Santarém.

Product	Marabá	Paragominas	Santarém
Brazil nut	+ + +		+
Cupuaçu	+ + +	+	
Bacaba	+	+	+
Bacaçu	+ + +		+
Guarumã[1]			+
Cacauí[2]	+ +		+
Cacao [3]	Absent	+ +	+
Curua		Absent	+
Taboca [4]	+ +		
Taboquinha [4]	+ +		
Taboqui [4]	+		
Ubim palm [5]	+		
Macauba [6]	+		+
Quina	+		
Conduru [7]	+		
Copaíba [7]	+	+	+
Jatoba [7]	+	+	+
Açaí (*Euterpe oleracea*)		+	+
Açaí da terra firme[8]			+
Piquiá	+	+	+
Andiroba [7]		+	+
Cajá	+	+	
Bacuri	+	+	
Tucum palm [9]	+	+	
Inajá palm	+	+	+
Uxi		+	

[1] *Ischnosiphon obliquus* (Marantaceae); a moisture loving plant used to make tipitís for squeezing cassava dough.

[2] *Theobroma speciosum* a relative of cacao with edible fruit.

[3] Apparently wild populations in forest.

[4] Several species of bamboos are used to make baskets and for light construction.

[5] Unidentified palm used to thatch houses.

[6] *Acrocomia* palm; oily fruit eaten by people and fed to livestock.

[7] Medicinal plant.

[8] *Euterpe precatoria*; fruit eaten

[9] *Astrocaryum vulgare*; fiber used for hammocks and cord.

In Marabá and Santarém we visited sites for experimental forest management. The CVRC Florestas Rio Doce, outside Marabá, has eucalyptus plantations meant as experimental production for charcoal kilns. These are less than successful, holding little hope for sustainable charcoal production. There are also studies on physiological ecology of natural forest, but these are not directly oriented toward management or production.

The infrastructure and initiative for forest management is more obvious in Santarem than elsewhere. Organizations working on forestry in the area include: CPATU, IBAMA, ITF, ITTO, ODA, GTZ, CEMEX, SUDAM, UFPa. In Belterra forest management investigations of CPATU/EMBRAPA are concentrated on both natural forest management of primary and secondary forests and on plantations. The same forest species are studied in both plantations and secondary regeneration. The Tapajos Forest Reserve is managed by IBAMA which has three major research thrusts: forest management, private sector incorporation in forest management, and social forestry with the squatters along the Tapajos River. Finally, in Santarem, a case was seen of a timber company attempting to sustainable manage natural forest for timber production and plantation management of *Swietenia macrophilla, Cedrela odorata,* and *Tabebuia serratifolia* and other species.

5. FLOODPLAIN AGRICULTURE AND RANCHING

Although *varzea* is of least priority to the consortium as it is now formulated to concentrate on upland acid soils, these flood plain systems are extremely important within the sustainable management of the Amazon, and thus can not be altogether ignored. Additionally, floodplain cropping and ranching may both interact with larger farming systems including upland areas. Varzeas are particularly prominent in Santarem where they are farmed intensively to produce vegetables for local and Belem markets and as an important pasture rotation component. With the lack of pasture management on *terra firme*, natural pastures on varzeas are used to reduce dry season pressure on degraded pastures inland. Water buffalo production is promising.

Table 8 is perhaps the most concise way to review this brief summary of land use systems rapidly evaluated at the three sites visited in Pará. Land use in Marabá seems to be characterized by the predominance of small farm swidden-fallow agriculture or by the accumulation of low-grade pastures from swiddens relayed into grazing. The area is also notable for historical non-timber forest extraction which continues to some extent and for the present day corridor of production characterized by charcoal extraction for smelters. Land use in Paragominas is characterized by ranching with degrading pastures and extractive logging without management. In contrast to these dominant land uses, there are only 400 small farm families in Paragominas. Land use in Santarém is the most complex with medium to high frequency of all of the defined systems (except unsustainable charcoal production). Of particular interest is the presence of perennial agroforestry systems and forest management and silviculture, as well as the historically developed market connections.

Table 8. LAND USE SYSTEMS compared among three sites visited in Pará. Frequency of system within areas is ranked as high, medium or low. The frequency desired by the consortium is also rated. Varzea is not rated for the consortium because it is outside the goals as defined.

Sites	Marabá	Santarém	Paragominas	Consort *preference*
Land Use Systems:				
1. Food crop systems relayed with:				
a. fallow	High	High	Low	High
b. perennials	Low	Medium	Low	High
c. pasture	High	Medium	Low	High
2. Pasture systems				
a. from crops	High	Medium	Low	High
b. ranching	Medium	Medium	High	Low
3. Homegardens	Medium	High	Medium	Medium
4. Forestry systems: Extraction or Management				
a. timber extraction	Medium	Medium	High	Medium
b. charcoal extraction	High	Low	Low	Low
c. NTFP extraction	High	High	Low	High
d. Management and Silviculture	Low	Medium	Low	Medium
5. Varzea	Low	High	Low	-

V. CONSTRAINTS TO SUSTAINABLE PRODUCTION OF THE PREDOMINANT LAND USE SYSTEMS

1. SOCIOECONOMIC CONSTRAINTS

Sustainable land use practices require not only adequate land and resources but also farming experience and institutional support if they are to be successfully implemented. Characteristics of the land, the land users, and existing infrastructure play a role in determining sustainability of farming systems. At the level of the land user, important factors include previous occupation, farming experience, health, migration experience, marital status, and family size. Access to financial resources and technical advice are also vital for successful establishment of farmers. Higher educational attainment enables the land user not only to access appropriate information, but also to interpret and use it adequately.

Obviously, individual characteristics alone do not determine the sustainability of land use in the Amazon. Farm families usually make decisions and take actions within their social and environmental context. The social environment is defined by institutional infrastructure (physical, cultural and administrative), land tenure systems, and market and labor relations. Physical infrastructure, such as roads and market outlets, is the most readily recognized social structural constraint. The proximity of labor markets and the opportunities for off-farm work may increase opportunities for alternative family income and the hiring of farm labor.

Cultural infrastructure, although harder to identify, is often just as important to sustainability of land use. Such infrastructure commonly involves a network of relationships between individuals who share common origins, religions, ethnic or language backgrounds. The existence of such a network may determine access to information and resources, and the flow of ideas and innovations within communities.

Administrative infrastructure includes not only the laws and policies concerning land settlement and land use, but also the numerous governmental institutions that administer those policies. Other important institutions include both agricultural extension and economic development programs. Credit is also one of the primary constraints of the institutional environment upon the long term success of farmers. Access to and availability of credit are critical to farm innovation.

Comparable with our ratings of land use at each site, we rated the socioeconomic concerns of the Consortium summarized again in Table 9. Marabá is characterized by reasonable levels of infrastructure and institutional development and a high level of community organization, only offset by the political nature of these organizations. There is much polarization of the community, particularly related to development, which foments continuing social tension and violence. This is an atmosphere which makes development research highly charged and difficult. Paragominas rates low in the minimum socioeconomic infrastructure and institutions necessary to elaborate sound development research. Santarém rates very high in infrastructure, institutions, and markets. This probably reflects the longterm, sustained development of Santarém as an Amazonian market center; this characteristic would make it a particularly good site for time series studies with other newly developing sites in Acre-Rondonia. In Santarém, community organization is moderate.

2. BIOPHYSICAL CONSTRAINTS

Soil Related Factors

The acid terra firme soils of the Amazon are generally low in most of the essential nutrients for sustainable harvests of annual crop and tree products. Traditional systems have relied on the slashing and burning of forest biomass to release accumulated nutrients. The nutrient input to the soil from ash is used to produce annual and some perennial crops for a period of 2 to 3 years before the site is abandoned and a forest fallow forms. A site is usually abandoned when yields

Table 9. Socioeconomic Variables compared among three sites visited in Pará. Level of socioeconomic factors within areas is ranked as High, Medium or Low. The frequency desired by the Consortium is also rated. Varzea is not rated for the Consortium because it is outside the goals as defined.

Sites	Marabá	Santarém	Paragominas	Consort preference
Socioeconomic variables:				
Diversification	High	High	Low	High
Population	High	High	Low	High
Infrastructure	Medium	High	Low	High
Institutions				
Investigation	Medium	High	Low	
Development	Medium	High	Medium	High
Education	Yes	Yes	No	
Community Organization	High	Medium	Medium	High
Conflict	High	Low	Medium	Low
Markets	Med-High	High	Low	High

begin to decline and the labor (weeding, pest control, soil protection) required to maintain productivity exceeds that of slashing and burning a new patch of forest.

The productivity of crop, pasture and tree species on acid, infertile soils (Oxisols, Ultisols, Dystropepts, Psamments, and Spodosols) is limited mainly by chemical *constraints to root expansion.* High aluminum saturation in the subsoil, low levels of Ca and P, and a lack of weatherable minerals can severely limit plant productivity and thereby reduce nutrient capture and recycling as compared to more fertile sites. Thus, low levels of P in acid soils could severely limit nitrogen fixation by leguminous tree species. Studies of N-fixing annuals have shown that both nodulation and nodule function require adequate levels of soil P.

Two major technological strategies are available: 1) the use of adapted germplasm in crop, pasture and agroforestry systems that *promote nutrient* cycling and nutrient use efficiency, soil conservation, diversified product, and low nutrient export in harvests, and/or 2) the use of organic or inorganic inputs.

Deforestation

Both small farmers and large ranchers slash and burn the primary forest prior to cropping or pasture establishment. Deforestation for cropping occurs at a scale of 1-2 ha annually, whereas ranching usually results in a one time clearance of between 50 and 5000 ha. Both groups use the remaining primary forest for harvesting products such as fruits, nuts, game, medicinal plants, fence posts and timber. However, little is known about sustainable management of forest products. Additionally, given the low valorization and poor market structure for forest resources, there are disincentives for forest management.

The timber extraction activities of saw mill operators in Pará are best described as a "mining" of *the valuable wood resources with little or no concern* for the future timber production potential of the areas currently being exploited. There is no supervision of this timber extraction activity by trained forest managers. The reasons for this are several: lack of a coherent forest policy within an integrated land use policy and plan; lack of adequately trained and motivated forest managers; an ever expanding agricultural frontier that promotes deforestation and

discourages forest management due to insecure land tenure, availability of apparently "limitless" primary forest, and the low stumpage price paid by the timber industry. Many of these same problems plague extraction of non-timber forest products and their sustainable management.

Farming and Cropping Systems

Constraints on realistic options for sustainable and economic crop production are severe. Biodiversity is often limited to a few cultivars of a few annuals. Management of weeds, pests and diseases is by fire. Fallow management is seldom encountered. Rotations are ill defined and lack complimentarity. Tree crops are often restricted to backyards or woodlots. Cash crops are few, of low value and limited by transportation. Farmers are willing to experiment with options but are generally frustrated by the lack there of. Cattle are often viewed as the only realistic alternative.

Pastures

Weed invasion and the labor required to control weeds are seen as major limitations in all of the land use systems observed in Pará. They are especially serious in food crop and pasture sub-systems. The problem is, in many cases, secondary, resulting from other limitations or deficiencies in the system. In the particular case of pastures, the primary causes of weed invasion are:

1. Poorly adapted germplasm; lack of vigor and poor competitive ability.

2. Poor establishment resulting in low population density and abundant space for weeds.

3. Lack of legumes in the pasture leading to N deficiency and declining vigor of the grass.

4. Inappropriate grazing management for maintaining stable and persistent legume-based pastures.

Given these socioeconomic and biophysical constraints to sustainable production, the Consortium preliminarily analyzes research priorities for Pará.

VI. RESEARCH PRIORITIES

A landscape may be considered a socioeconomically and ecologically linked unit of land. In some cases this may be a watershed, but in the Amazon we must consider less a topographic unit and more a linkage unit. In our agroecological context linkages among land use systems are critical (e.g., forests, fallows and farmlands within a region). Within development research we must also incorporate socioeconomic linkages. *Initially, we loosely defined regions* of closely interconnected ecological and socioeconomic systems; thus, we have been considering "windows" (areas around Marabá, Paragominas and Santarém) in which research on representative problems in resource management in the Amazon can be carried out. Within this people-and-landscape we will be analyzing the 1. Socioeconomic Environment and the 2. Landscape, including: a. Farming and Forestry Systems and b. Management of Components within Systems. These major subjects of research are further detailed.

1. SOCIOECONOMIC ENVIRONMENT

Within the sociological environment we intend to include a cross section of the stake holders in the Amazon: indigenous people, extractors, caboclos, and established colonists (farmers), ranchers, foresters, and business people, as well as the newest wave of people within these same vocations. The economic environment must represent the range within the Amazon from the highly capitalized investments to the low-input (high-management) systems (e.g., ranches or forestry operations that are capital-intensive compared to those that are management-intensive). The area(s) in which we choose to do research must include this spectrum of people and their associated land uses.

An initial and continuing sociological focus will be on orienting the large multidisciplinary team in designing and implementing participatory analyses, investigations and technology development (e.g., sociological analysis, design and research techniques including: farmer first and forester first, farmer to farmer transfer, and interistitutional participation and transfer), as well as participatory evaluation of consortium advances. Participants will include the broadest range of people possible to allow historical and economic comparisons.

In addition, the Consortium must take on a socioeconomic evaluation of the causes of deforestation and alternatives at a range of levels from indigenous management to governmental policy. The behavior of existing systems must be characterized and monitored in coordination with agronomists and land use experts. Farmer (in the broadest sense including indigenous peoples, women, absentee ranchers, loggers, etc.) and community decision-making under trade-offs between short-term gains and long-term conservation of the resource base must be emphasized. Policy analyses on trends and conflicts among various sectors are needed. These studies will give a basis for the development of new technologies the Consortium hopes to generate for alternatives to deforestation and land degradation.

Economic and market analyses are slated for a range of concerns. Markets, processing and commercialization must be evaluated for a number of products such as farinha, fruits, forest products and underutilized crops. Labor availability, cost, and efficiency need to be determined with possible economic experimentation. Very little information is available on the forest sector and an analysis of both timber and non-timber forest products must be given high priority to appraise markets and their structures, experimental adjustments, and incentives for forest management among other aspects. Furthermore, value of fallows and forests (both primary and secondary) needs to be established in both the household and market economies.

2. LANDSCAPE ELEMENTS

Landscape elements must be analyzed at a range of levels which we simply divide into: a. land use and farming systems and b. management of systems components. Here we include the technological and management investigation the Consortium will consider undertaking within various farming and forestry systems described in the Land Use section.

a. <u>The land use systems and farming systems</u> investigations will describe and manipulate large scale interactions among crops, pastures, agroforestry, fallows and forests.

Food crop systems are relayed with fallows, perennials, or pastures. Cropping systems need to be diversified both in types of crops and in system management. Thus, we need research on multiuse trees, underutilized tropical crops, and forest products, as well as intercropping, relaying, lay farming, rotations, agro- and social forestry and fallow management. In general, fallows need to be investigated including fallow recuperation, enrichment, acceleration, and alternatives. Hand-in-hand with fallows and cropping is soils management, here we consider the general characteristics of the effect of food crop systems on soil quality, leaving the specific management options to system components below.

There is a need for either dead or live mulch covers under many annual and tree crops and there is an excellent potential for legumes well adapted to the hot, humid tropics to fill this need. Some land use systems would greatly benefit from such an association and in some cases, the cover crop could be a valuable forage source in the early development stages of silvo-pastoral systems.

In ranching, pasture systems are developed after a cropping sequence or from forest; however, tropical pastures do not have to inevitably degrade after two to three years as presently seen. It has been demonstrated that legume-based pastures can be highly productive and stable for at least 10 years when properly

managed. In addition, pastures can be very effective fallows during which time weeds are controlled, soil fertility is improved, (increased o.m. content, availability of N, P, and S), biological activity and soil physical conditions are enhanced and disease and insect cycles are broken. However, for small farmers, one of the major limitations to the use of pastures as fallows for food crops is the interfacing of the two cycles at the end of the pasture cycle. This is a potential line of research in agro-pastoral systems.

Homegardens are already present and variously diversified (see Land Use). This may be an area for "farmer-to-farmer" transfer since we did find successful examples of multiuse, multispecies homegardens. In general, systems research may emphasize their establishment, diversification and expansion as agroforestry systems, as well as their role in home economies and nutrition.

Forestry systems are found on various scales from the woodlot to the government forest estate, from the highly capitalized to low-input, and from extraction to management. It is important that the research span these continua. Our emphasis is on developing management and silvicultural techniques suitable or adaptable to these various conditions; when such is not feasible (e.g., charcoal production for iron smelters) we must carefully define and characterize these situations, eventually leaving the solutions to the policy sectors. We are inclined to view as feasible timber and non-timber forest product management in natural forest in a range of situations including woodlots, communal lands, reserves and estates. Our initial research efforts in this area will thus concentrate on natural forest management under these conditions. Forest product diversification of both timber and non-timber is greatly needed in use, management and marketing. Recuperation of degraded forest after "high-grading" (i.e., previous timbering for the most valuable woods) is another priority for maintenance and management of natural forest. Plantation forestry is not a priority because of its expense, lack of biodiversity, and prioritization in other programs.

Varzea is not a priority area for research within the Consortium, however from the landscape and systems perspective, it would be shortsighted to ignore their role in the evolution of Amazonian farming and economic systems. Initial integration

of these areas into our research agenda may be limited to the interrelationships between tierra firme and varzea farming and economic systems. Later, if deemed appropriate landscape and systems priorities might include stabilization of these lands through vegetation management. However, fine tuned management of these unique habitats would be left to other projects with which we might collaborate.

b. Management within systems will concentrate on the components of farming and forest systems and specific interactions among components. To some extend the further definition of exactly which components will be given priority depends on the systems analysis. This is particularly true in the forestry sector where we have merely presented lists of components (see Land Use); further definition awaits initial analysis. In agriculture we can better anticipate components. Soil management will include such components as residues, covers, mulches and green manures, as well as nitrogen fixation and phosphorus availability. Integrated pest management must particularly emphasize weed control since weed proliferation is so vigorous in the humid lowland tropics. Cultural controls of all pest will be crucial. Repeatedly we observed the importance of fire management and control; fire is a basic tool in tropical agriculture, but its use must be determined.

Management of biodiversity is a component of land use systems that spans all scales from diversity among ecosystems (gama diversity) to germplasm. These levels and their diversity must be characterized and management developed to maximize the useful diversity. Specific adaptations within germplasm need also be sought (e.g., tolerance of drought, heat, acid soil, fire, pests, and pathogens). Finally, biophysical interactions within and among crops will need fine-tuning--integrated crop management, weed-crop interactions, time of cropping cycles, and ecophysiological correspondence of crops and germplasm. These component considerations overlap all or many of the land use systems, so that appropriate germplasm for example must be sought regardless of the specific constraint or conditions.

3. SITE COMPARISONS FOR RESEARCH POTENTIAL

The ability to address these basic problems of Amazonian land use are somewhat different at the different sites. For example, there is little food cropping in Paragominas which would limit cropping systems investigations, while active silviculture is only found in Santarém. Again, we resort to Table 10 for site comparisons among research priorities, and again Santarém and secondarily Marabá are indicated as preferred sites for accommodating the research priorities of the Consortium for Pará.

Table 10. Potential for Addressing Amazonian Land Use Research Topics compared among three sites visited in Pará. Tractability of conducting research within areas in ranked as high, medium or low.

Sites:	Marabá	Santarém	Paragominas
Research Topics:			
1. Socioeconomic Environment			
a. Stakeholder diversity	High	High	Low
b. Economic diversity	Med-High	High	Low
2. Landscape:			
Farming and Forestry Systems			
a. Food crop systems relayed with:			
- Fallow	High	High	Low
- Perennials	Medium	Medium	Low
- Pasture	High	Medium	Low
b. Pasture systems			
- From crops	High	Medium	Low
- Ranching	Medium	Medium	High
c. Homegardens	Medium	High	Medium
d. Forestry systems with Management and Silviculture			
- Timber	Low-Med	Medium	Low
- Non-timber	High	High	Low
e. Varzea	Low	High	Low
3. Component Management			
a. Soil management	Med-High	Med-High	Low-Med
b. IPM	High	High	Low
c. Fire management	High	High	High
d. Biodiversity			
- Ecosystem	High	High	Low-Med
- Germplasm	Medium	High	Low-Med
- Biophysical	High	High	High

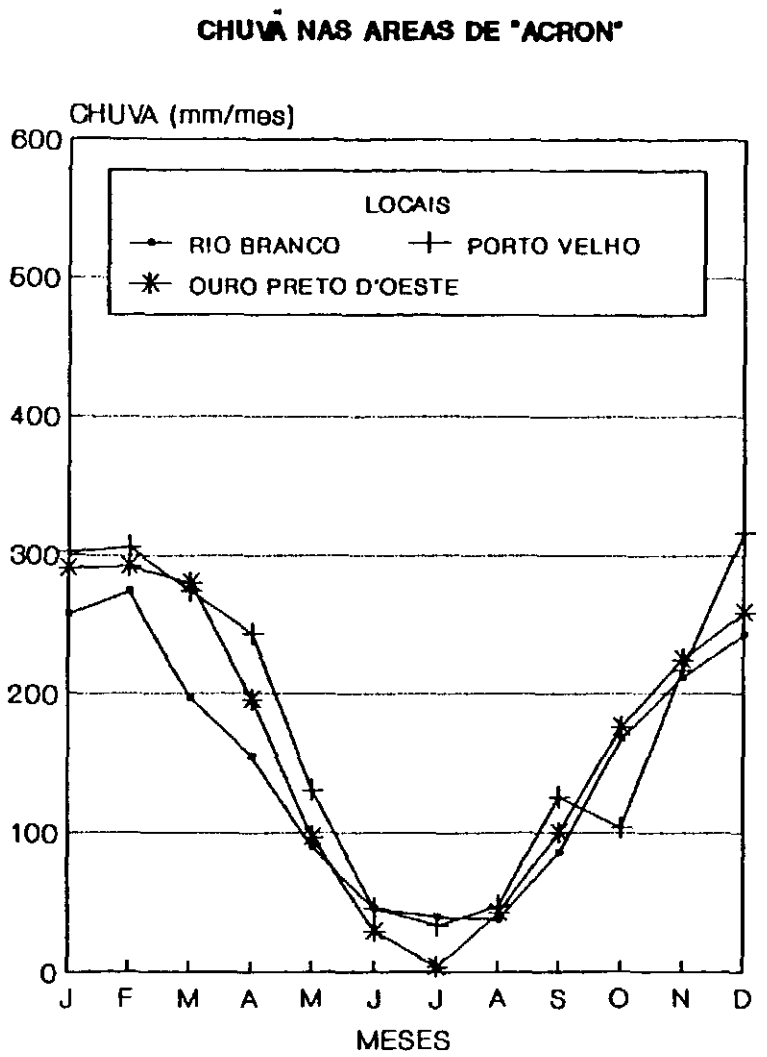
VII. CONCLUSIONS

1. SITE SELECTION

The selection of Santarém as the Pará comparative site was a result of many considerations. The climate in Santarém is most similar to the site selected in "Acron" (Figure 5). Santarém is a mid-Amazonian market/production center of antiquity. Agricultural development there responds to the modern economic situation with minimal governmental manipulation. We found the greatest range of agricultural and forestry systems from the dirt poor to grand haciendas, from woodlot management (or none) to state forest reserves and international forest industries. Members of all sectors were interested in collaborating with the Consortium. Additionally, infrastructure for research was impressive.

In contrast, the other two sites considered had distinct drawbacks. Little infrastructure was available. Marabá is characterized by active colonization and appears very similar to the selected sites in Acre and Rondonia. The Consortium RRA team was concerned about locating the Consortium's proposed activities in a region of growing conflict and confrontations over land. In such conflicts, international programs can very easily become the scapegoats of local feuding parties. Other uncontrollable externalities that could have an unpredictable impact on the Consortium's activities include the presence of a politically powerful and environmentally destructive mining sector.

Paragominas is a polarized extreme dominated by pastures and rapidly degrading forest with little agricultural development. Jim Spain was able to give a view of the site over time: Paragominas has apparently grown but barely developed with most profits, except for some pasture renovation, being exported. This is not true



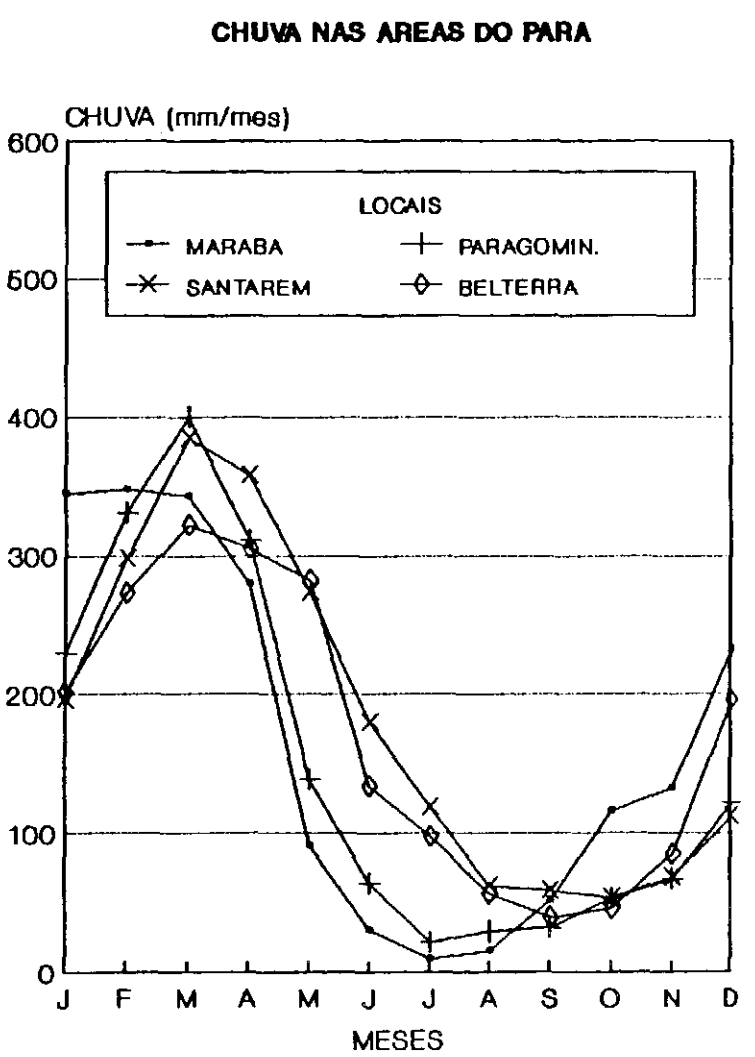


Figure 5. Climate.

of Santarém with a strong regional economy complemented by a more balanced export production.

Reasons for the choice of Santarém as a preferred site are demonstrated in the comparisons of Land Use Systems (Table 8), socioeconomic considerations (Table 9), and research potential (Table 10). Additionally, the comparison of Santarém with "Acron" is advantageous in that although many conditions are similar (e.g., climate, socioeconomic diversity, land use diversity and research potential) there is one outstanding difference. "Acron" represents a frontier colonization zone on the upper Amazon, whereas Santarém in a long established and continuously developing mid-Amazonian center with a diversified local market. This development comparison is invaluable in the consortium's investigations "on" development. We have the opportunity of compare recent, planned and sponsored colonization in the Amazon with the historical socioeconomic evolution of spontaneous trade center.

In summary, the consensus of the RRA team was that Santarém represented the best set of conditions with regard to the diversity of land use systems, land pressure infrastructure, institutional partners, socio-political stability, and medium to long-term development prospects to satisfy most of the program priorities of all members of the Consortium. Santarém and Marabá both have an impressive diversity of land use systems, whereas Paragominas is dominated by extensive pastures, little agricultural development, and degrading remnant primary forest. Three major factors in favor of Santarém over Marabá were 1) the large number of potential national collaborator institutions (public and private) and their keen interest in working with the consortium, 2) impressive infrastructure for research, and 3) the lack of conflicts over land between landless farmers and large land holders.

2. EVALUATION OF THE METHODOLOGY AND SITE SELECTION GUIDELINES

Advantages:

a. The use of local researchers to conduct the RRA was extremely valuable in that it provided many of them, a first hand glimpse of the realities that farmers face in the field. The combination of researchers from national institutions with researchers from international institutions served to reinforce the training in the diagnosis of the land use systems.

b. The site selection criteria are very useful in the setting out of a systematic framework for achieving a minimum data set that is common across sites being compared. Rapid execution is possible in collaboration with local research and development personnel and pre-diagnostic site information.

Disadvantages:

a. The success of the RRA, is very dependent on the quality of the pre-RRA data provided by the local host institution. To ensure adequate coverage of all the relevant biophysical, socio-economic, and political factors, the interested International Consortium partners may need to provide consultants to help local institutions in the collection and synthesis of the primary data.

b. Political factors affecting land use (such as land tenure issues, subsidies, indigenous versus migrant farmers) are very important in the process of site selection. This fact is not explicit in the current methodology.

c. The interpretation of the information obtained from the RRA is subject to individual and institutional bias. The bias originates from the quality of the pre-diagnostic information provided, the farmers selected for interviews, and the "agendas" of the host and/or Consortium member institutions. A more objective exercise, however, would take up considerably more time in the initial design, data collection and analysis.

d. The site selection guidelines help describe the current situation. Special attention must be devoted to identify trends over time. The RRA team needs to be flexible in conducting the field interviews with the broadest possible spectrum of local land users. Information gleaned from successful farmers/ entrepreneurs can identify important strategies for ensuring sustainability of land use systems.

1 July, 1993

Dear Consortium:

A final document on ~~Site~~ Selection in Pará: Comparisons of Marabá, Paragominas and Santarém is prepared at last by the Consortium of EMBRAPA, ICRAF, CIAT, and IICA. Please, distribute it to all collaborating individuals and organizations.

Unfortunately, we must emphasize that the Consortium no longer has the hopes it once did for developing two research sites in the Brazilian Amazon. "Acron" must take precedent because of our GEF funding commitment. I am particularly disappointed by the unlikelihood of developing research in Santarém, but must face the realities of funding and institutional commitment.

I personally would like to apologize for delays in this document which for my part occurred largely for two reasons:

1. I have been transferred to Central America to develop a similar project to that envisioned in Santarém. My new program commitments have been prioritized and are ultimately consuming.

2. Communications among Central America, CIAT, and all of you have not been rapid.

Normally, I take pride in efficient realization of duties within defined timeframes. This has not been possible. I am sorry. In the future, we should consider programing an extra 5 days for immediate completion of a joint document as done on most consultancies.

Thank you very much for your significant efforts and continuing interests in the Consortium.

Sincerely,

For, Gloria Stella Torres

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