

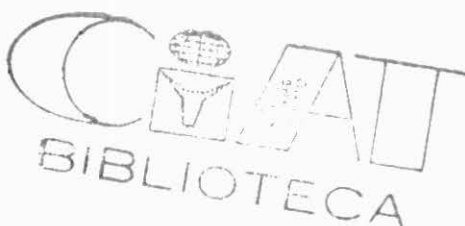
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INSTITUTE FOR THE STUDY OF SOCIETY, POPULATION AND NATURE

ISPN

AN ANALYSIS OF FOREST MARGINS AND SAVANNA AGROSYSTEMS IN BRAZIL

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Data Analysis
Maps
Database
Bibliography

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The present study resulted from a cooperative agreement between CIAT (International Center for Tropical Agriculture in Cali, Colombia) and ISPN.

Brasília, Brazil

March 15, 1992

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I. Introduction

Brazilian attempts to settle large numbers of agricultural producers in tropical forest regions during recent decades have generally produced frustrating results. By the same token, attempts to increase agricultural output, whether through large-scale, capital-intensive establishments, or through more modest enterprises, have similarly met with little success there. Fundamental obstacles, such as the distance to markets, transportation problems, inadequate soil conditions and the general hostility of the tropical forest ambience to traditional agricultural practices are at the root of this failure.

At the same time, part of the less-heralded "cerrados" or savanna region was encountering notable success in adapting modern technologies and thereby increasing agricultural productivity, particularly of export-oriented grain crops. Thus, it was inevitable that the savannas and other regions, which had been incompletely-exploited in the past, acquire greater visibility and interest among agricultural planners during the 1980s and 1990s. However, remarkably little systematic research has been carried out on such regions. The present study resulted from the interest which CIAT, the Center for Tropical Agriculture in Cali, Colombia has begun to dedicate to this area. The SPN Institute in Brasília, Brazil was commissioned by CIAT to carry out an exploratory study on savannas and forest margins with a view to analyzing their past

history, their current agricultural structure, their demographic composition and their future prospects.

The present monograph presents the first results of a broad-based attempt to describe the historical processes and the current makeup of the Brazilian savannas and forest margins regions. Given the size of the region and the breadth of settlement experiences encompassed therein, a broad-based taxonomy was devised to help organize and analyze part of the vast, yet disjointed sources of data which ISPN brought together with respect to the region.

The study begins with a broad overview of occupational processes in savannas and forest margins in the Center-West and pre-amazon regions during the last 20 years. Data from the agricultural and demographic censuses, as well as production statistics at the municipal level, are used to provide a first image of developments in the region. In this section, a review of general and macro-economic policies which have affected the settlement of the savannas and forest margins regions are also provided. Subsequently, the distinctions between savannas and marginal forests are established, as well the methodological procedures utilized to differentiate and classify sub-regions within each of them.

The next two major sections deal, respectively, with the economic, agricultural and demographic developments, in each of the

savannas and forest margins regions. Therein, issues dealing with policy-formulation, land use, economic change, land tenure evolution, agricultural production, productivity, cattle raising, rural employment and demographic growth are dealt with. Inasmuch as possible, each of these matters is dealt with in the specific context of each of the 9 sub-regions into which the 2.8 million km² of savannas and marginal forests have been divided. The last section attempts to bring together a brief summary of the principal conclusions and recommendations based thereon.

Before entering into the main body of the text, the methodological procedures utilized to differentiate savannas from forest margins and to subdivide each of these into sub-regions should be explained.

Given the time and financial resources constraints, the procedure adopted to differentiate savannas and forest margins was basically to utilize an EMBRAPA map of Brazil's vegetation (see Embrapa, 1988), and to superimpose upon it a map with the same scale, containing the country's state and microregional subdivision¹. This provided the basis for the definition of the geographical area of each of the two main groupings.

¹The political subdivision employed was that of IBGE which prevailed until 1985. For a few very large units (Rondônia, Mato Grosso's 332 microregion, and an area in the north of Pará) a further subdivision, at the municipal level, was made in order to allow meaningful comparisons.

Once this was completed, the data collection phase was undertaken. Microregional and municipal data from the 1970 to 1985 agricultural censuses were utilized, along with data from the 1970 and 1980 demographic censuses and from the preliminary results of the 1991 demographic census; in addition IBGE's Produção Agrícola Municipal (1984 and 1990) and sundry other sources were manipulated. Simultaneously, a bibliographical survey was made in order to provide background material, along with references for the policies studies.

The abundant materials thus obtained and painstakingly organized provided the main input of the study. It was developed in two sequential phases: the first consisted in focusing each of the two subregions -- the forest margins and the savannas -- as a whole. With the help of maps the disaggregated information was referred to spatial units and a detailed analysis of the evolution and of the recent situation of these subregions was performed. Based on this we were able to establish a preliminary zoning of the two regions, reflecting basically the impacts of the agricultural processes which affected each subregion. The second phase consisted in a disaggregated analysis of the two regions, emphasizing the effects of regional policies and other developments, and considering each of the zones into which the subregions were divided.

Maps 1 to 3 provide an illustration of the initial procedures

and inform us about the areas studied. Map 1 locates the forest margins and the savannas, in block, within Brazil; as can be seen, these areas encompass a very large portion of the country's total space. Map 2 reproduces elements of EMBRAPA's vegetation map covering the area of study; there we can distinguish between areas predominantly in tropical forests, clearly in savannas, and in "ecological tension" (areas of transition from one type of vegetation to another). The latter are important in the forest margins of the north of Mato Grosso, and in the south of the savannas. The two subregions, with their microregional or municipal divisions, are represented in Map 3. There the geographic units predominantly in forests, those in savannas and those in which the areas of ecological tension predominate can be observed. Maps such as this, into which we added information reflecting the main agricultural processes, were used to analyze both the spatial and temporal evolution of the two subregions' agriculture.

70°

60°

50°

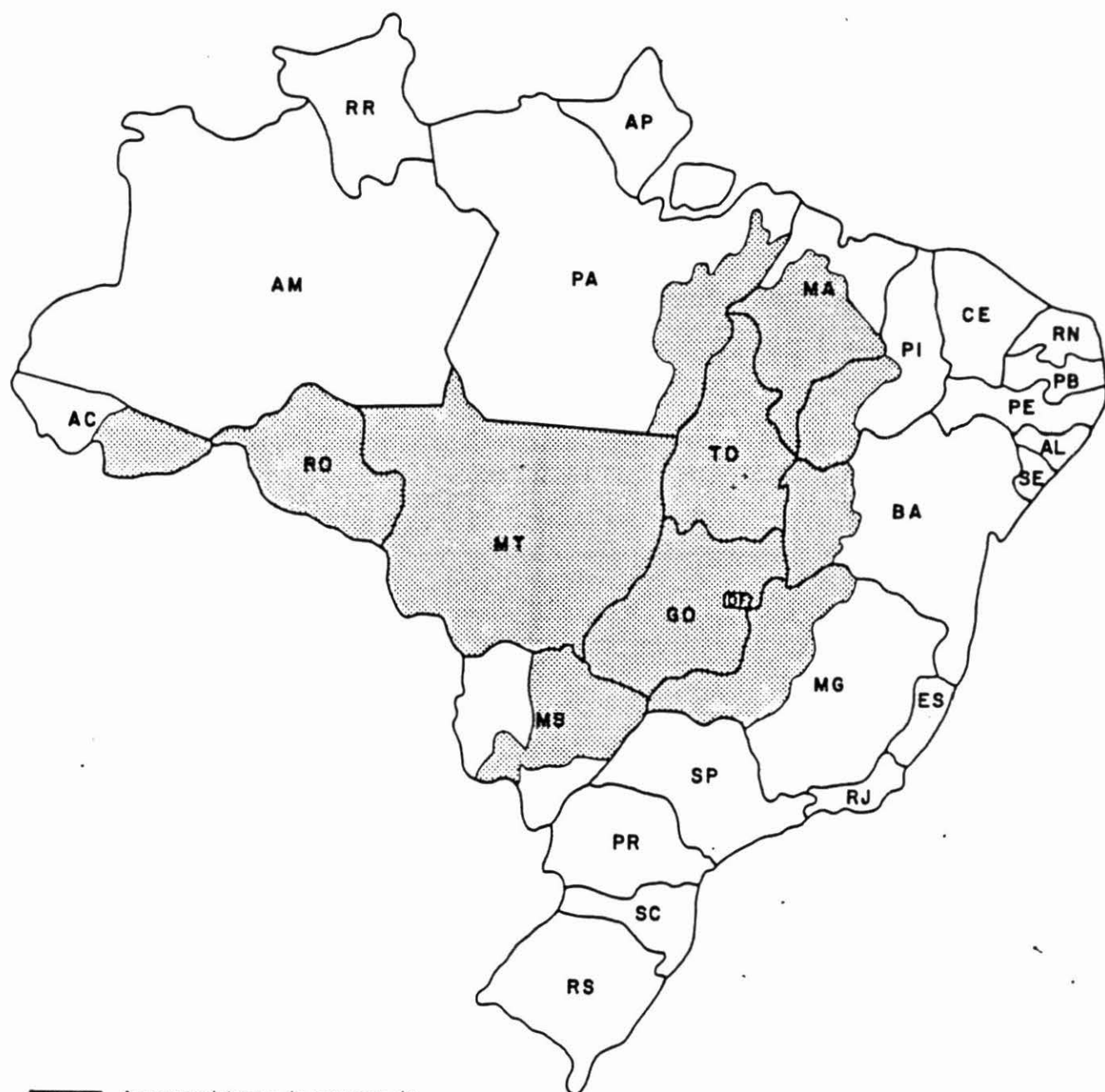
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AGROECOSSISTEMAS DE MARGENS DE
FLORESTAS E DE CERRADOS

Localização

MAP 1



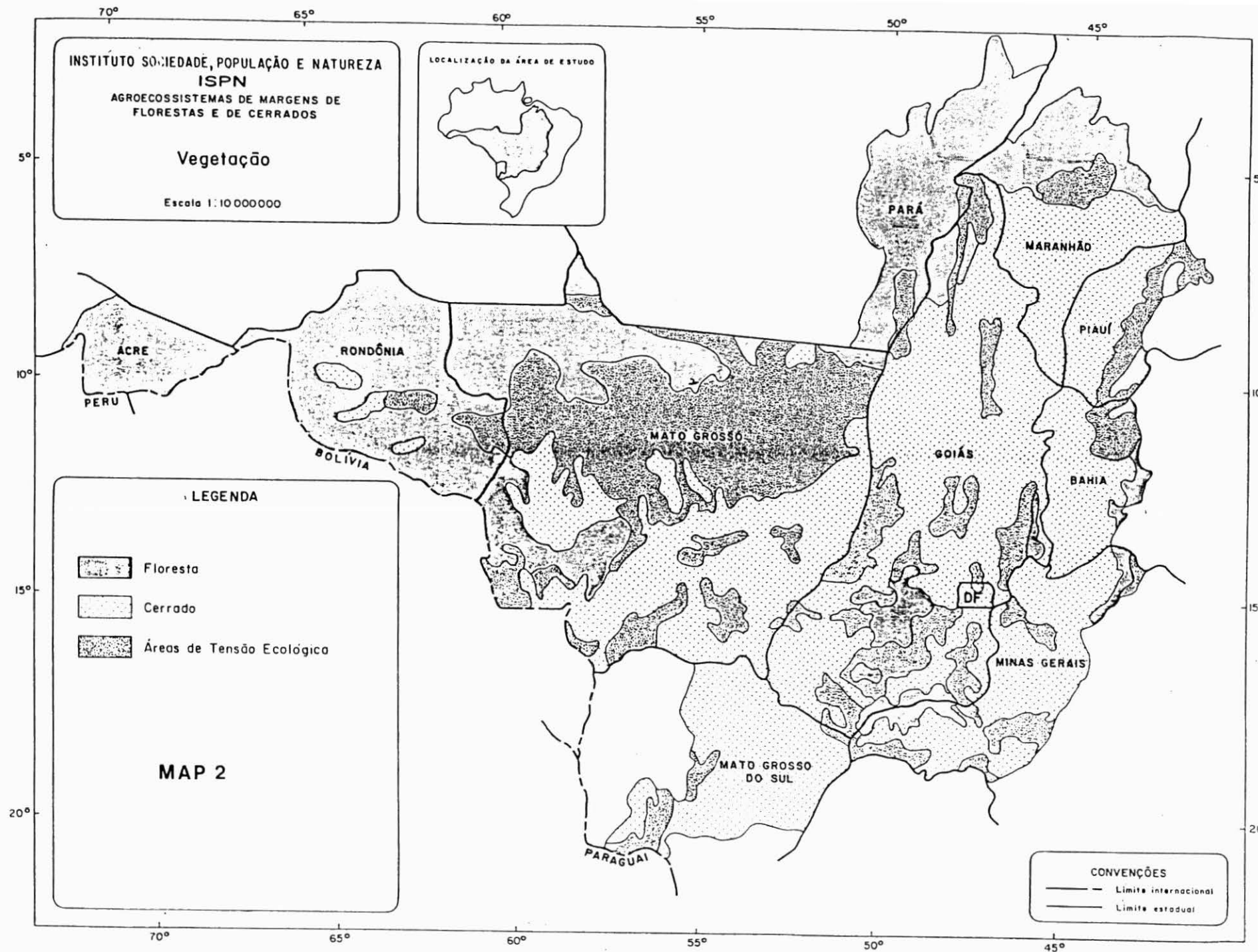
 Agroecossistemas de margens de
florestas e de cerrados

70°

60°

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INSTITUTO SOCIEDADE, POPULAÇÃO E NATUREZA
ISPN
AGROECOSSISTEMAS DE MARGENS DE
FLORESTAS E DE CERRADOS

Brazil
Forest Margin and Savanna Ecosystems

Political Division
Escale 1:10 000 000

LOCALIZAÇÃO DA ÁREA DE ESTUDO



5°

10°

15°

20°

ACRE
003

PERU

RORONIA
001

BOLÍVIA

PARÁ

MATO GROSSO

MATO GROSSO DO SUL

PARAGUAI

MARANHÃO

PIAUI

BAHIA

MINAS GERAIS

LEGEND

Forest Margins



Rainforest



Predominant Areas of Ecological Tension

Savannas



Predominantly "Cerrados"



Cerrados with substantial participation of Areas of Ecological Tension



Boundary between Forest and Savannas

MAP3

MUNICÍPIOS

Pará
1- Paragominas
2- São Domingos do Capim

Mato Grosso (MR-332)
1- Aripuanã
2- Barra do Garças
3- Chapada dos Guimarães
4- Diamantina
5- Luciara
6- Nobres
7- Porto dos Gaúchos
8- Água Boa
9- Alta Floresta
10- Canarana
11- Colíder
12- Nova Brasilândia
13- Nova Xavantina
14- Paranaíta
15- Rio Claro
16- Santa Teresinha
17- São Félix do Araguaia
18- Sinop

MUNICÍPIOS

Rorônia
1- Guajará-Mirim
2- Porto Velho
3- Ariquemes
4- Cacoal
5- Ji-Paraná
6- Pimenta Buena
7- Vilhena

CONVENÇÕES

— Limite internacional
— Limite estadual
— Limite de microrregião
160 Número da microrregião em 1980
--- Limite de município

II. Recent evolution of the two agrosystems

II.1. An overview of the penetration and occupation in the two agrosystems.

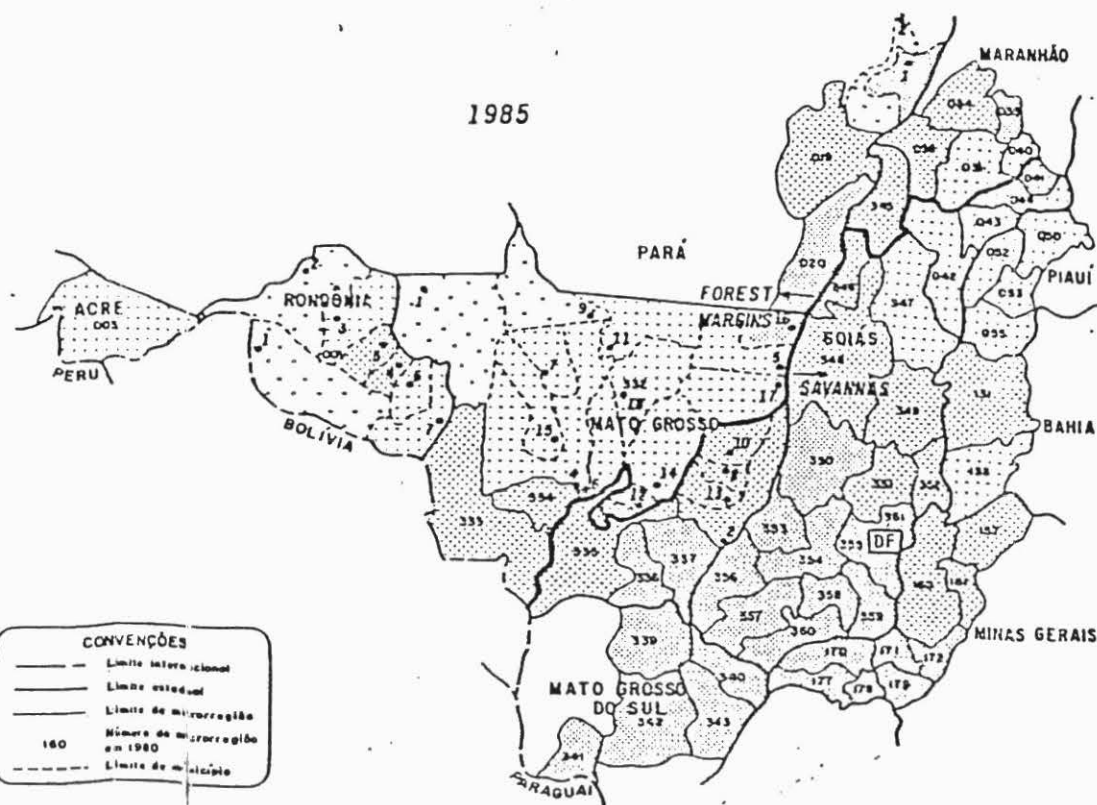
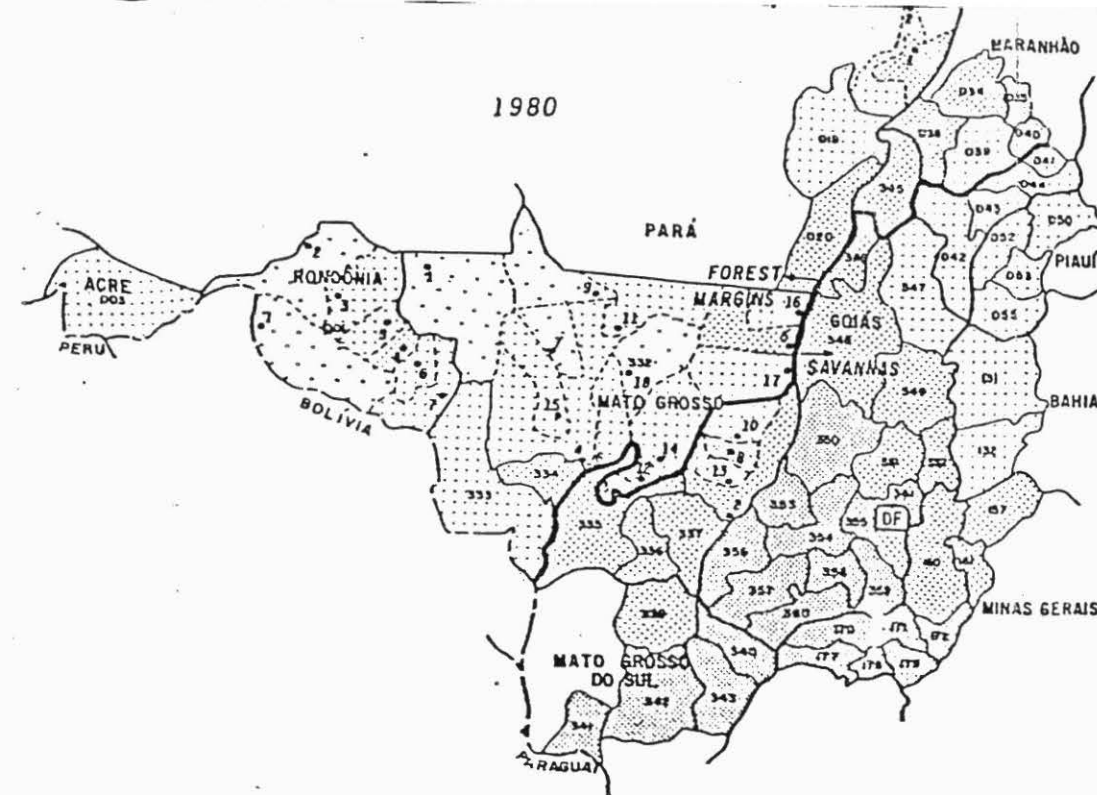
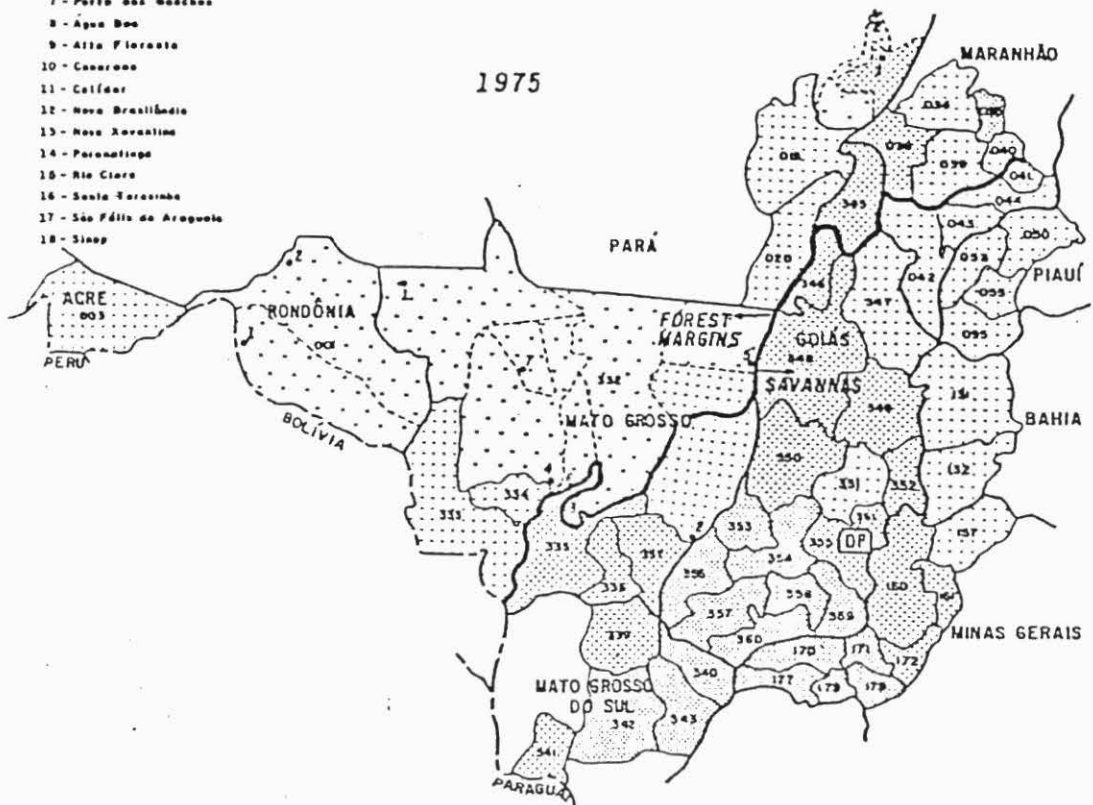
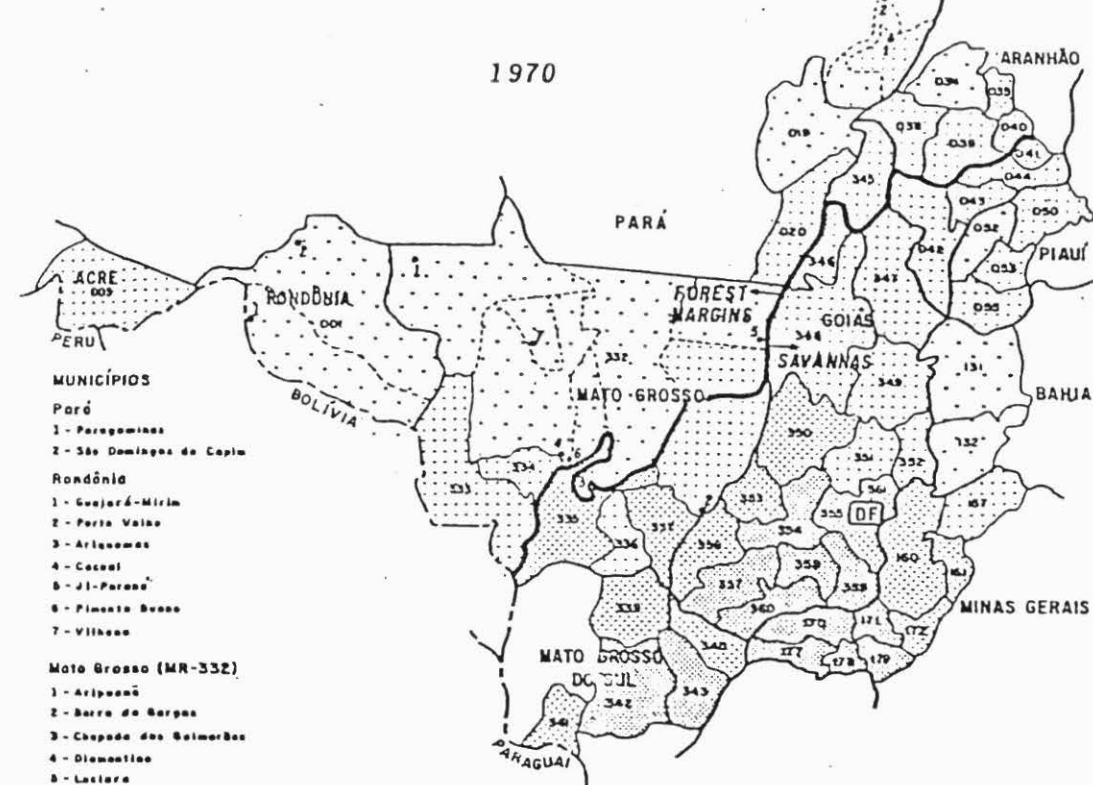
In the early 1950s, the contiguous agrosystems of the forest margins and of the savannas were virtually empty. The expansion of Brazil's agricultural frontier barely reached the southern periphery of the savanna subregion; in fact, technologies to exploit the savannas productively were not available at that time, impeding a northward movement of commercial agriculture. Moreover, the occupation of land for agricultural purposes in the Amazon was still incipient.

The construction of Brasília in the core of the savanna areas and the development of a transportation and communication system linking the new capital to the Center-South created conditions, in the late 1950s and early 1960s, for the incorporation into agriculture of the more fertile and accessible land areas in the south of the savanna subregion. Moreover, in the late 1950s, the Belém-Brasília highway was constructed, providing a land connection between the Center-South and the eastern portion of the forest margins subregion; a highway linking Cuiabá to Rondônia was also constructed, establishing an important connection to the western portion of the subregion.

The transportation network in the two regions was fundamental

for the expansion of the agricultural frontier which took place with considerably greater impetus after 1970. Highway construction in the southern portion of the savanna subregions continued to expand, opening up important areas in the states of Minas Gerais, Goiás and Mato Grosso do Sul and in the south of Mato Grosso; eventually east-west links were also established in the subregion. Furthermore, in the 1970s, the objective of integrating the Amazon with the Center-South, part of the Amazonian strategy established by the Federal Government in 1965, led to the construction of important highways connecting both subregions. This, and a series of policies -- regional development and general policies -- brought about the incorporation of substantial areas of land into farms and ranches in the two subregions. Important increases in agricultural and beef cattle production began taking place in the savanna sub-region.

In this section we analyze trends since 1970 in the incorporation of land into agriculture, in the alteration of space promoted by agricultural activities, in agricultural intensity and technical levels, and in cattle-raising activities of the forest margins and the savannas, based on information from agricultural censuses of 1970, 1975, 1980 and 1985 (the last agricultural census undertaken in Brazil). We conclude with an examination of the demographic evolution and characteristics of the two regions.



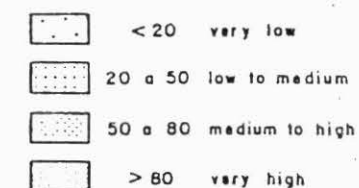
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Evolution of the Incorporation of Land



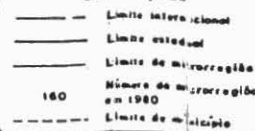
LEGEND

Percentage of the Geographical Area
in Agricultural Establishments



MAP 4

CONVENÇÕES



II.1.1. Trends in the incorporation of land into agriculture.

Map 4 provides an overview of the incorporation of land into agriculture since 1970, both in the forest margins and in the savanna regions. The indicator of land occupation utilized here is the proportion of the land area of each **microregion**² in agricultural establishments (an establishment is an operational unit), in each of the census years. Intensity of occupation is classified as follows: a. very low occupation - less than 20% of the area of the microregion in agricultural establishments; b. low to medium occupation - from 20 to 49.9%; c. medium to high occupation - from 50 to 78.9%; and very high occupation - 80% or more of the microregion in agricultural establishments.

II.1.1.1. The incorporation of land in the savannas.

Map 4 shows that, in 1970, the incorporation of land into agricultural units of the savanna region was already quite significant. Practically all of the microregions of Mato Grosso do Sul, of the "cerrado" areas of Minas Gerais, and of the southern portion of Goiás and of Mato Grosso, already had more than 50% of their land in agricultural units, and a very significant portion of these areas had proportions in the 80% or more class. These were the areas affected by highway construction in the 1950s and 1960s; thus, in 1970, parts of these areas had, for many years, been

²The microregion is the basic geographical unit employed here, composed by a group of municipalities with fairly homogeneous characteristics, as defined by IBGE.

connected, by passable roads with the more dynamic areas of Brazil's Center-South. However, these agricultural activities were still limited by the lack of technologies to exploit their "cerrado" lands. It should be noted, however, that the savanna areas more to the north -- in eastern Mato Grosso, in the recently created (1988) state of Tocantins, in the south of Maranhão and in southwest of Piauí had microregions with very low rates of occupation; and the two microregions of Bahia were virtually empty.

As we focus the other census years, there is a clear intensification in the incorporation of land. In the 1975, 1980 and 1985 censuses, the number of microregions in the two upper intervals increases, in a north-northeastern movement. There is also a marked increase in the number of microregions with very high proportions of their land areas in agricultural units in the south of the subregion. In 1985, only a few more remote microregions of Tocantins, Maranhão, Piauí and Bahia still had less than 50% of their land area in agricultural establishments.

This intensification of the incorporation of land was a consequence of the evolution of the transportation system in the region, of the inception of regional development policies, and of the rise of new agricultural production opportunities in the "cerrado" areas, particularly after 1975. However, as we will see, even in 1985 there were vast savanna areas with very low agricultural utilization.

II.1.1.2. The incorporation of land in the forest margins.

Map 4 shows that, in 1970, most of the forest margins subregion had very low proportion of land occupation. All of Rondônia, most of the north of Mato Grosso and parts of the Pará and the Maranhão areas included in the subregion had less than 20% of their geographical areas in agricultural establishments. The rest of the subregion still had proportions in the 20 to 49.9% range.

After 1975, we observe an intensification of the occupation of land mostly along the main penetration roads built in the region. Thus, in 1985, the geographical units of Mato Grosso and Rondonia along the Cuiabá-Porto Velho highway had medium to high proportions of their area in establishments, and similar trends can be observed in the private colonization areas of northern Mato Grosso, under the influence of the Cuiabá-Santarém highway, and in the north of Goiás (today Tocantins) and Pará areas, affected by the Belém-Brasília and the Transamazônica highways.

It should be noted, however, that even in 1985, a considerable portion of Rondônia and of northwest Mato Grosso still had less than 20% of their land areas in agricultural establishments. This indicates that there is gross exaggeration in the claim that the agricultural frontier in the north of Brazil is "closed"³. It is

³The frontier is closed if there is no more land to be occupied under practices common to frontier areas.

1980



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Altered Area in Relation to the Total
Area in Agricultural Establishments

LOCALIZAÇÃO DA ÁREA DE ESTUDO

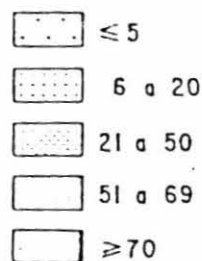


1985



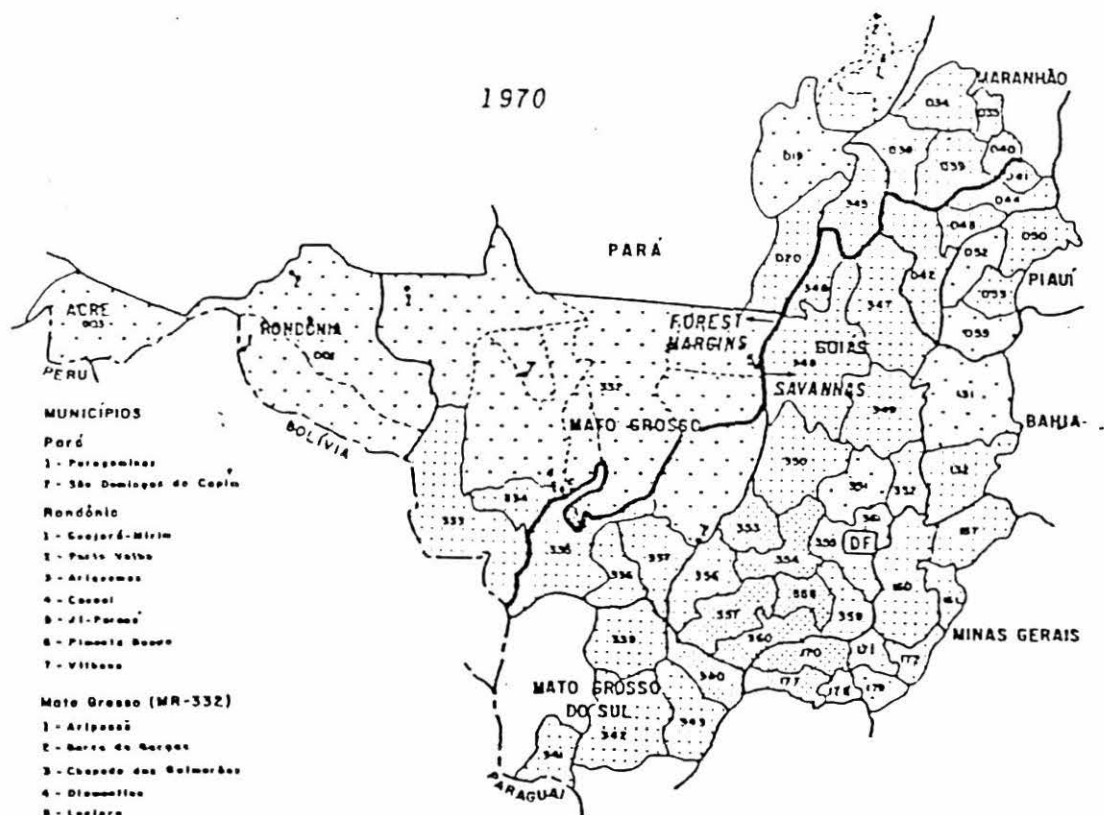
LEGEND

Percentage of the Area in Establishments
Altered by Agricultural Activities

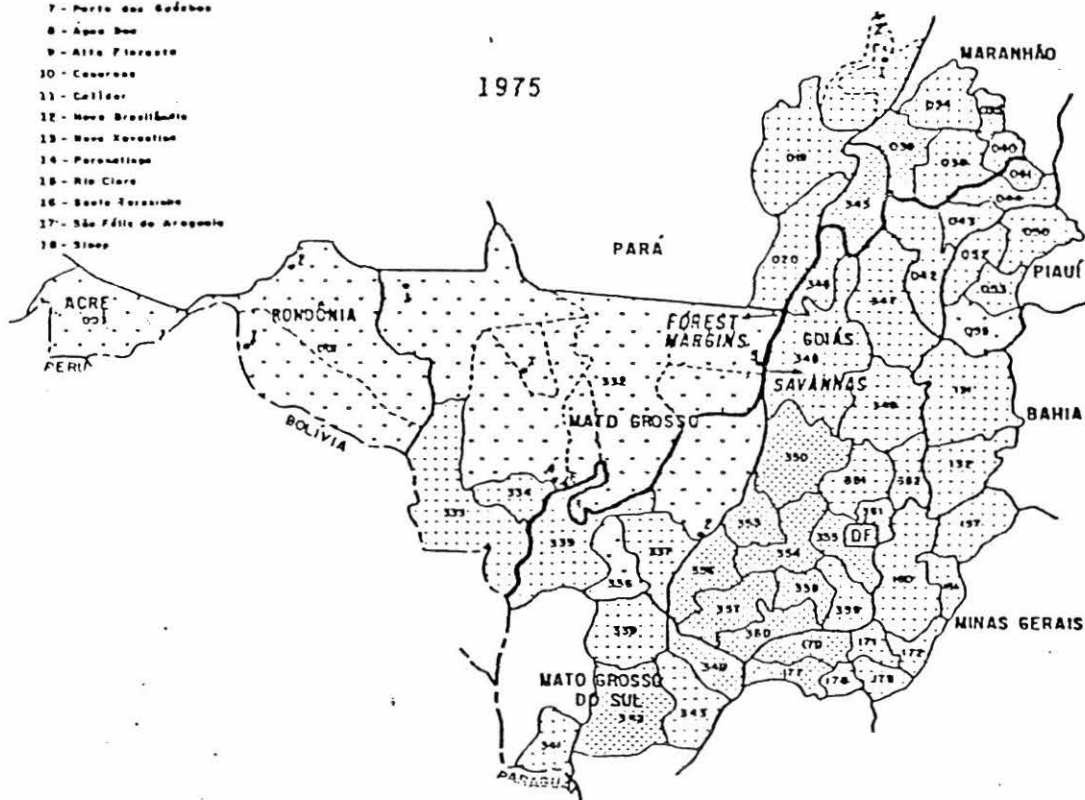


MAP 5

1970



1975



true that stagnation in road construction and improvement during the 1980s has prevented an expansion of potential frontier areas⁴ even in the forest margins subregion, and even more so in the Amazonian core to the north. This points to a reduction in the rate of land occupation in the subregion, but also to the potential danger of a resumption of the processes that affected the Amazonian region in the past, when the Brazilian economy recovers and resources for highway construction become available. The pressures capable of generating a new wave of uncontrolled settlements persist.

II.1.2. Trends in the area affected by agricultural processes.

Map 5 presents changes in land area as affected by agricultural processes in the two subregions; this is measured by the proportion of the total area in establishments in each **microregion**, which have been cleared at any time for the cultivation of crops and pastures and for reforestation, or for the construction of roads, buildings and other farm structures. This includes basically the area in farms not covered by native vegetation (such as forests and native pastures). The basic sources of information were the agricultural censuses of 1970, 1975, 1980 and 1985.

⁴For the concept of the frontier as an **area**, that is created and modified by especial conditions, with emphasis on the expansion of transportation systems, see Sawyer, 1983.

Needless to say, the process of land clearing for agricultural purposes means different things in each of the two subregions. In the forest margins it means, to a large extent, the removal of native forests; and in the savanna areas, the removal of "cerrado" vegetation. We should note, however, that important parts of the transition areas of the forest margins are "cerrados", and that the savanna subregion has important areas originally covered with forest (mostly removed today).

II.1.2.1. The areas affected in the savanna subregion.

Examining Map 5 we see that, in 1970, the areas substantially altered by agricultural processes were relatively small. Most of the savanna subregion had less than 20% of its area in agricultural establishments affected; only a group of **microregions** in the south of the region -- those more directly affected by the process of frontier expansion from the Center-South of Brazil and having important areas with more fertile land originally in forests -- had proportions of affected areas between 21 and 50%.

In the 1970s and 1980s, the proportion of agricultural establishments altered in the savanna subregion increased markedly. Examining this evolution in the 1975, 1980 and 1985 maps, we observe a movement to the north and to the east in the **microregions** with percentages of their areas in establishments affected by agricultural processes in the 21 to 50% range; there is also an increase in land alteration in the southern portion of the

subregion. In 1985, only a few of the more remote savanna **microregions** of Tocantins, southern Maranhão, southwestern Piauí and western Bahia still had areas with proportions in the low 6 to 20% range. However, the proportions of the **microregions** of the center-south of the subregion -- in the states of Minas Gerais, Goiás and Mato Grosso do Sul -- were in the high 51 to 69% range, and a few in the more than 70% range. In this portion of the savanna subregion, agricultural and cattle production has expanded considerably, especially since 1975.

II.1.2.2. The areas affected in the forest margins.

As of 1970, most of the forest margins subregion had virtually been unaffected by agricultural processes. If we remember that only a small part of the subregion had then been incorporated into agricultural establishments, the low proportion means that only a minor area had been cleared. This is true even in the few geographic units that, in 1970, already had proportions of their areas in establishments affected in the 6 to 20% range.

The situation changed rapidly, particularly after 1975. The same units pointed out in the last section as incorporating growing amounts of land in establishments also presented increasing proportions of areas cleared for agricultural purposes. In 1985, we observe large areas with proportions of alterations in the 21 to 50% range in Rondônia, in the south of Mato Grosso and of Pará, in the northern tip of Tocantins, and in the area of demographic

overflow of Maranhão. A substantial portion of the rest of the subregion had proportions in the 6 to 20% range, but there were still considerable areas -- the same with low occupation rates indicated in the previous section -- with lower than 5% proportions.

II.1.3. Evolution of agricultural technology and intensity.

This section presents an analysis of the evolution of agriculture in the two agrosystems, based on indicators of intensity of land use and of technological level, constructed with information from the last four agricultural censuses. We use simple but effective indicators composed of the following elements:

- a. The proportion of the area in agricultural establishments in plant crops (both yearly and permanent (tree) crops);
- b. The average number of tractors per 1000 hectares cultivated;

The first is an **index of intensity**. The assumption is that, as a rule, plant crops are the most intensive activity of the agricultural complex. Thus, the higher the proportion of farmland devoted to plant crops of a **microregion**, the greater the intensity of its agriculture.

The second indicator is an **index of technological level**. The

idea is that the conservative modernization model adopted by Brazil has led to the introduction of agricultural technologies which, among other things, promoted the use of tractors and mechanical implements. There are other important modern inputs, such as chemical fertilizers, selected seeds, pesticides but, as a rule, the new technological packages require the use of mechanical implements; those have been fundamental for the cultivation of the large commercial farms benefitted by conservative modernization.

These two indicators would have little meaning if employed in their absolute values. The agriculture of a region in a given year has a level of intensity and of technification relative to the agriculture of a standard area in a point in time. We have selected as the standard case the average of the two indicators for the state of São Paulo in 1980. São Paulo is one of the most advanced agricultural states in Brazil; in 1980, this state had a considerably more intensive and technical agriculture than that of any other state in the country. Moreover, the influence of São Paulo's agricultural methods on the evolution of the agriculture of significant portions of our region has been substantial.

Therefore, we took as basis the average agricultural intensity, and the average number of tractors per 1000 hectares of São Paulo, as revealed by the 1980 census. The **microregions** of our study area have, in a given census year, agricultural intensities that vary between near zero (empty units), to more than 100% (units

with a very high intensity). Similarly, their technical levels range from near zero (units with very low technical levels), to more than 100% (highly technified units).

The two indicators are employed in conjunction, to help in establishing areas of the two subregions having common characteristics and to examine the evolution of their agricultural systems. We established the following categories:

CATEGORIES	INTENSITY INDEX	TECHN. LEVEL INDEX
1. Virtually empty areas	0-10%	0-10%
2. Low to medium intensity and very low technical level	10.1-40%	0-10%
3. Low to medium intensity and low to medium technical level	0-40%	10.1-40%
4. Low to medium intensity and medium to high technical Level	0-40%	40.1 & +
5. Medium to high intensity and very low technical level	40.1 & +	0-10%
6. Medium to high intensity and low to medium technical Level	40.1 & +	10.1-40%
7. Medium to high intensity and medium to high technical level	40.1 & +	40.1 & +

Map 6 shows the spatial pattern of these categories in each of the census years, thus allowing an analysis of the evolution of agriculture in each of the subregions.

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Evolution of Agricultural Intensity
and Technical Level

1970, 1975, 1980, 1985

LOCALIZAÇÃO DA ÁREA DE ESTUDO

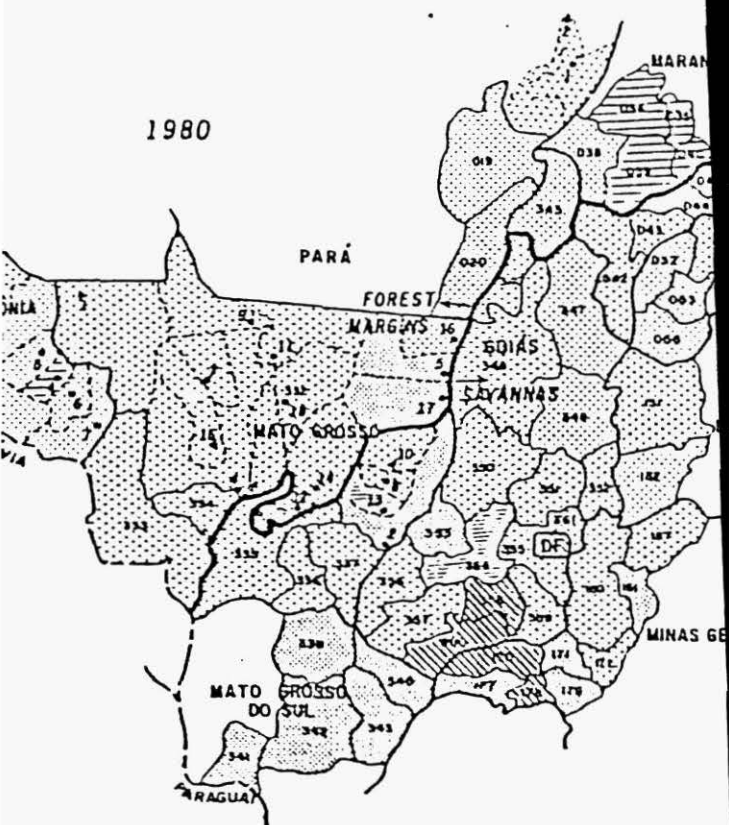


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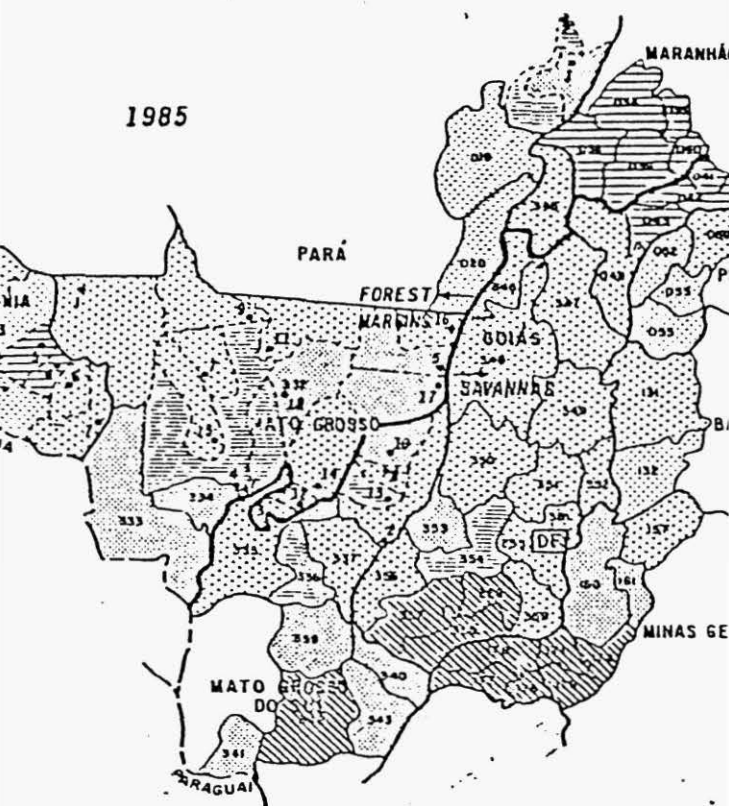
Symbol	Intensity %	Technical Level %	Characteristic	
			Intensity	Technification
	≤ 10	≤ 10	virtually empty areas	
	10,01-40	≤ 10	low to middle	almost none
	≤ 40	10,01-40	low to middle	low to middle
	≤ 40	> 40	low to middle	middle to high
	> 40	0-10	middle to high	almost none
	> 40	10-40	middle to high	low to middle
	> 40	> 40	middle to high	middle to high

MAP 6

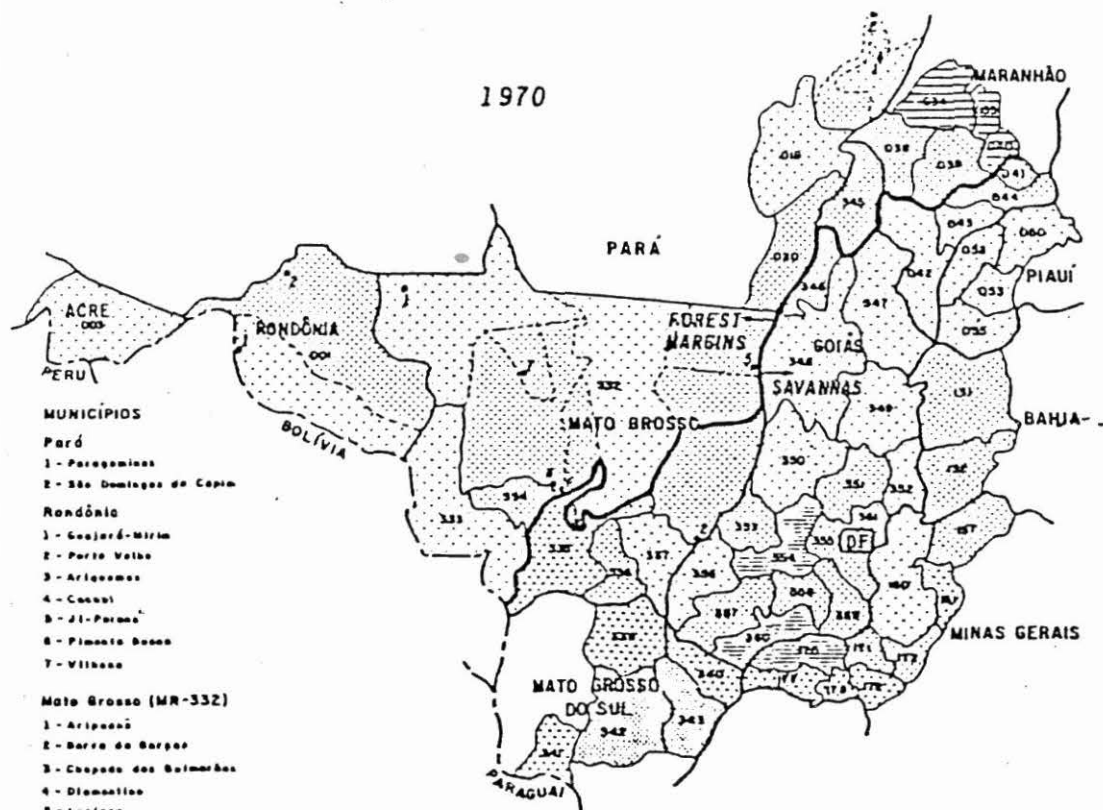
1980



1985



1970



MUNICÍPIOS

Pará

- 1 - Paragominas
- 2 - São Domingos do Capim

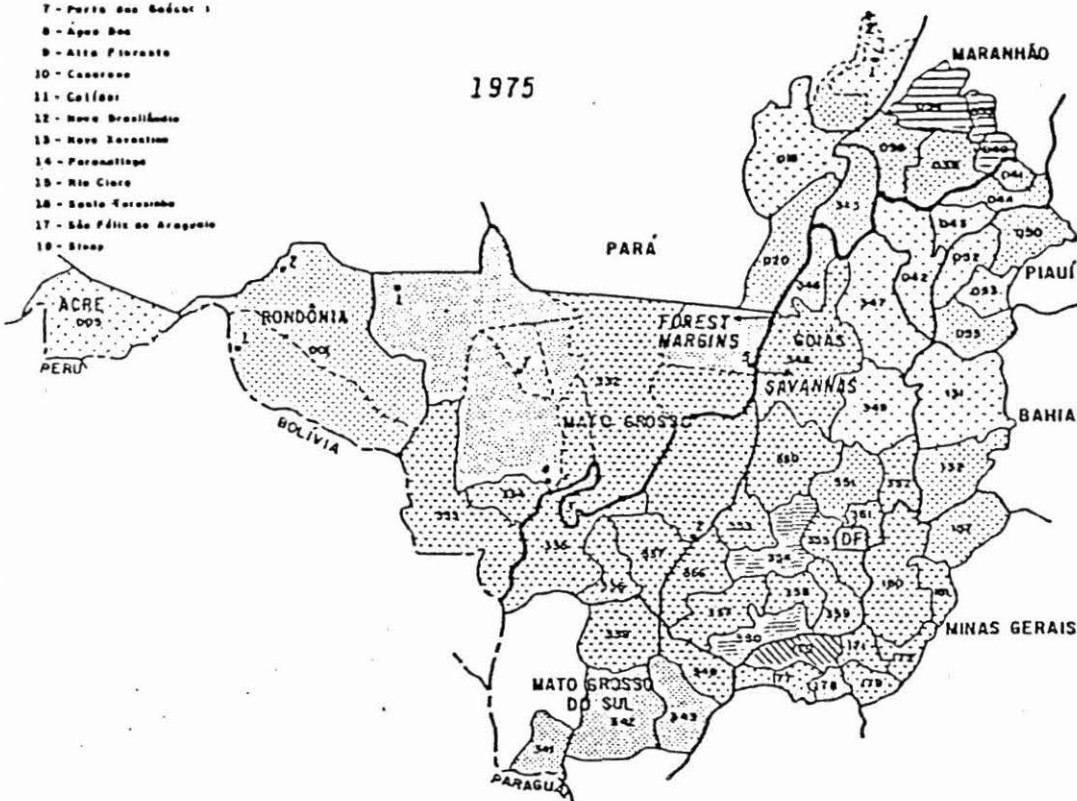
Rondônia

- 1 - Guajará-Mirim
- 2 - Porto Velho
- 3 - Ariquemes
- 4 - Caceres
- 5 - Ji-Paraná
- 6 - Pimenta Bueno
- 7 - Vilhena

Mato Grosso (MR-332)

- 1 - Aripuanã
- 2 - Barra do Garças
- 3 - Chapada dos Guimarães
- 4 - Diamantino
- 5 - Laceria
- 6 - Nobres
- 7 - Porto dos Gaúchos
- 8 - Apoiados
- 9 - Alto Piraí
- 10 - Caceres
- 11 - Caldas
- 12 - Nova Brasilândia
- 13 - Nova Xerxantina
- 14 - Paranaíba
- 15 - Rio Claro
- 16 - Santa Euzébia
- 17 - São Félix do Araguaia
- 18 - Sinop

1975



CONVENÇÕES

- Limite internacional
- Limite estadual
- Limite de microregião
- 160 Número de microregiões em 1980
- Limite de município

II.1.3.1. Evolution of intensity and technical levels in the savannas.

Focusing on the 1970 map, we see that the most expressive agricultural area of the region as a whole is in the south of the savanna areas -- the south of Mato Grosso do Sul, the Minas Gerais Triangle area and the south of Goiás. Beginning in the mid-1950s (with the construction of Brasília) the agricultural frontier overflowed the more developed region in the southeast of Brazil, into these areas. Their more fertile lands -- originally covered with forests -- were cleared and incorporated, predominantly, into an agriculture of low to medium intensity and of low technical level; we observe, in the south, a few **microregions** with higher agricultural intensities and technical levels. In 1970, however, most of the area outside this core was virtually empty or had agriculture of low intensity and very low technical levels.

Examining the maps for 1975, 1980 and 1985, we observe, on the one hand, a clear tendency towards an increase in the intensity and technical level of agriculture in the southern portion of the savanna subregion and, on the other, an expansion of agriculture in areas which were nearly empty in 1970, reaching particularly the north of Mato Grosso do Sul, the South of Mato Grosso, the center and north of today's Goiás (after the creation of Tocantins), the west of Minas Gerais and of Bahia. In 1985, the savanna subregion had no "virtually empty areas", but large extensions of its territory -- particularly in Tocantins, Maranhão, Piauí and in the southwest of Bahia -- still had agriculture with very low

intensities and technical levels.

In the 1985 map, it is possible to detect basically four agricultural systems in the savanna subregion: 1. a modern, high technology and dynamic system encompassing most of Mato Grosso do Sul, the Minas Gerais Triangle area, parts of the south and the center of Goiás and of the south of Mato Grosso. 2. a fairly new system, with still low agricultural intensity but with high technical levels, encompassing the area surrounding Brasília, in Goiás, and the west of Minas Gerais. This is an area of recent agricultural expansion, in which agriculture already arrived in a modern form. 3. an area of recent agricultural frontier expansion, encompassing mostly agriculture of low intensity, and low to medium technical levels. Most of it surrounds systems (1) and (2) but it also includes the west of Bahia. 4. the "almost empty" system composed of most of Tocantins, and the "cerrado" areas of Maranhão and Piauí. Agriculture there is still incipient and of low technical level. These are remote areas wherein conditions for the evolution of a more advanced commercial agriculture are still precarious.

II.1.3.2. Agriculture in the forest margins.

Map 6 shows that in 1970, most of the forest margins subregion had either "virtually empty areas" or areas with low intensity and very rudimentary agriculture -- the latter in Rondônia, parts of Mato Grosso, the northern section of Tocantins and the eastern

section of Pará. The only exceptions were three **microregions** in the north of Maranhão's forest margins, which had agriculture of medium to high intensity but with almost no technology. These areas were already receiving a demographic overflow from the poor and overcrowded portions of Brazil's Northeast.

The maps for 1975, 1980 and 1985 show the following trends:

1. a spread in the high-intensity, low-technology agriculture in Maranhão; in 1985 all of that state's forest margin **microregions** were in this category. 2. In the west of the subregion we observe an intensification of Rondônia's and (to a much lesser degree) Acre's agriculture; however, the technological level remains low⁵. As a matter of fact, in 1985 there are already two geographical units of this state with a high-intensity, no-technology pattern similar to that of Maranhão; this is the area of concentration of the large inflow of migrants from the Center-South of Brazil, which took place after 1975. 3. In the center-north of the state of Mato Grosso we observe an important area into which agriculture of low to medium intensity and medium to high technical levels have evolved. This is the area where most of the Amazonian private colonization projects have been implanted. 4. an area, running from the northeast of Mato Grosso through east Pará and north Tocantins, and including southern Maranhão, with low to medium intensity agriculture and predominantly low to medium technical

⁵It should be noted that intensification takes place mostly in the upper portion of Rondônia, served by the Cuiabá-Porto Velho highway; there lays the main area of destination of the large inflow of migrants from the center and south of Brazil.

levels. In 1985, the main exceptions were the two geographical units in the north of Pará, with higher technical levels. This is the area in which most of the large fiscal incentive cattle ranches are located; it has also received a growing inflow of poor migrants (peasants and farm workers from deprived areas of Brazil). Since the legal status of an important portion of its lands is uncertain, there have been frequent disputes and violence. 5. finally, there is a still largely unoccupied area between Rondônia and the private colonization area of Mato Grosso, having a very low intensity and low to medium technical levels.

II.1.4. Cattle ranching activities.

We examine here indicators of trends in cattle ranching activities. After an analysis of changes in the number of cattle and of density, we look at the spatial concentration of the herd in the two subregions in 1985.

The size of the cattle herd of the region as a whole more than doubled between 1970 and 1985, from 18 million to almost 47 million head. In the period its density (animals per km² of the region's geographical space) jumped from 6.37 to 16.50. Growth has been quite significant; however, it has been far from uniform spatially. In 1970, the forest margins' cattle herd (nearly 1.5 million animals) was only 8.1% of the total of the two regions. Its cattle density was very low: only 1.11 animals per km². In 1985, the subregion's herd totaled 8.9 million animals -- an almost six-fold

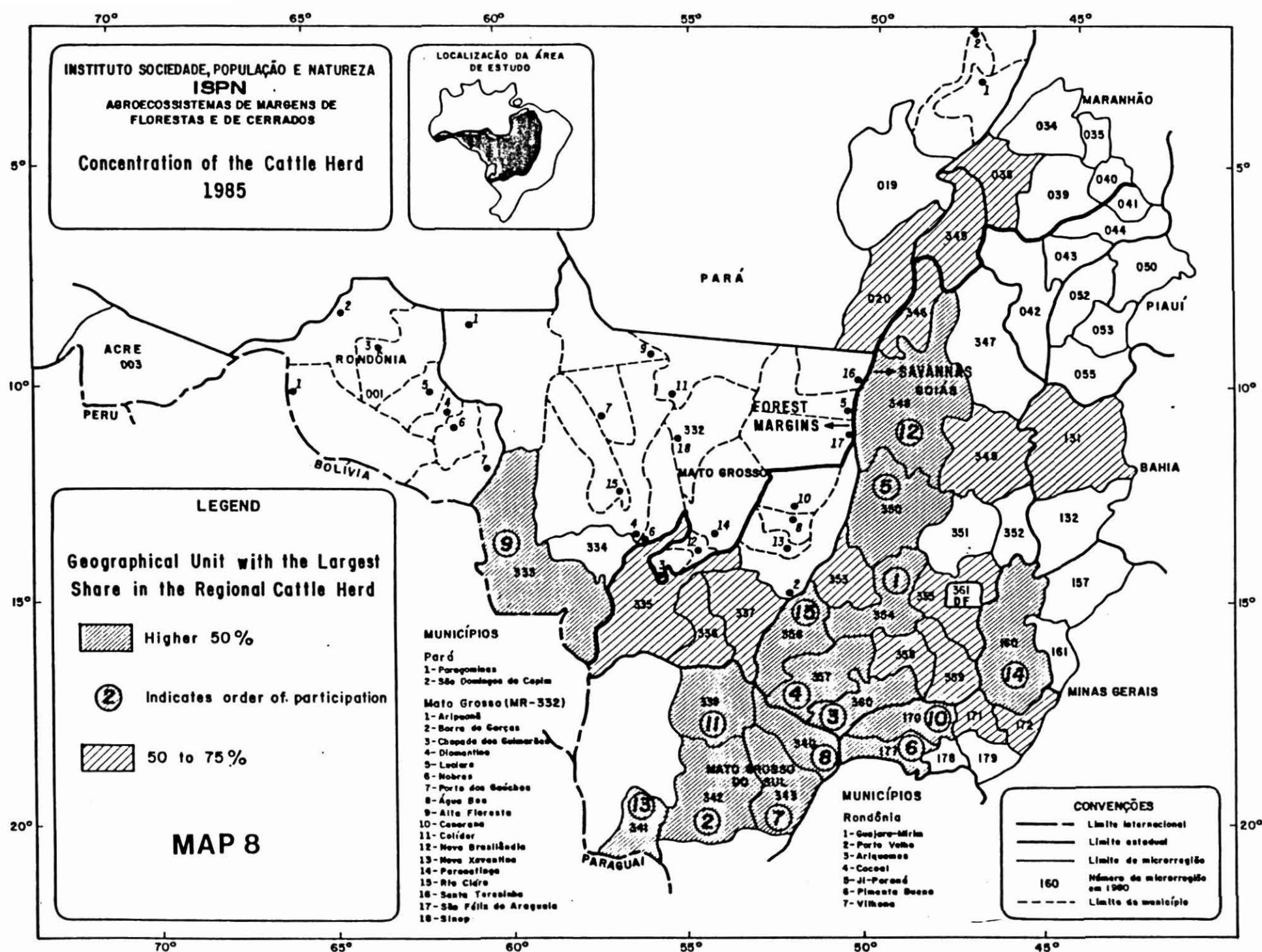
increase over the 1970 herd. The 1985 cattle density reached 6.78 animals per km², much higher than in 1970, but only a little over 40% of the average for the region as a whole. The 1985 forest margins' share of the regional total herd showed an increase over that in 1970, but it was still below 20%. In spite of the incentives and special programs for most of the subregion, it is still far behind the cattle sector of the savannas.

Between 1970 and 1985, the cattle herd of the savannas increased 2.3 times, from 16.6 million to 37.8 million animals. As a result, its cattle density increased, from 10.68 to 24.36 animals per km². In 1985 the subregion had 80.9% of the total regional herd; and most of it was also concentrated in a fairly small section of the subregion.

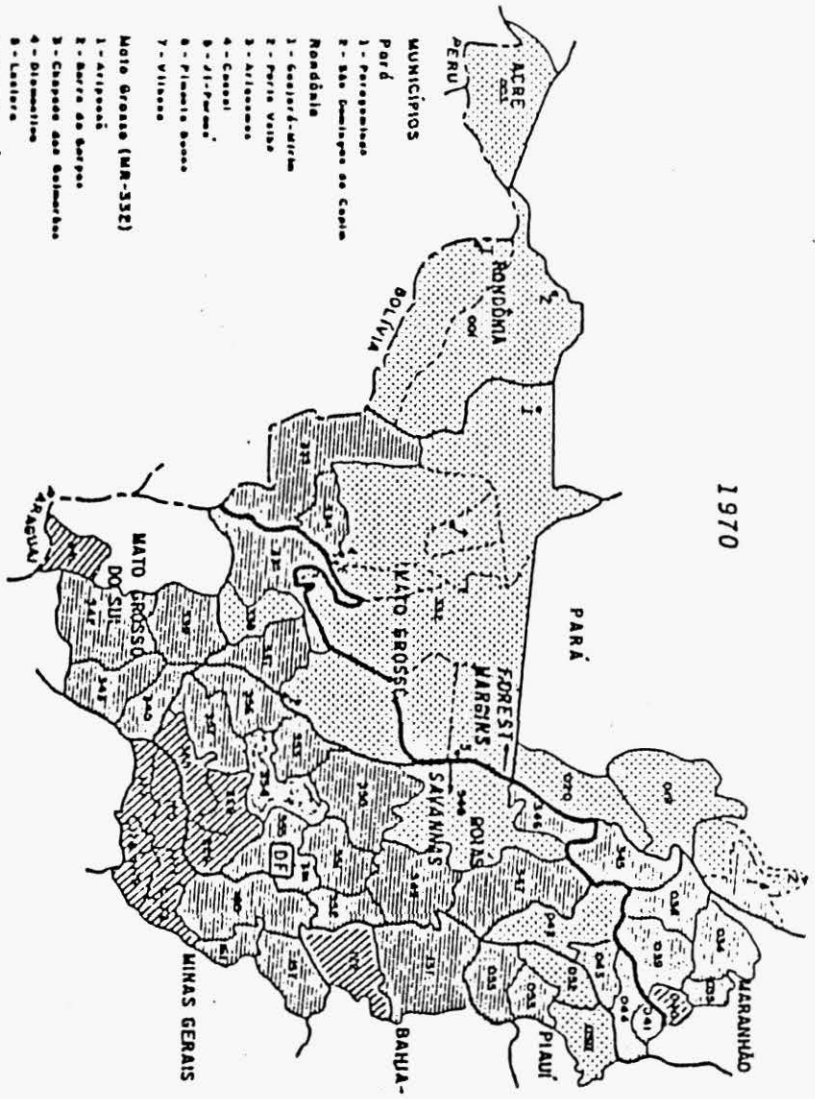
Next, we examine the evolution of cattle density in the two subregions.

II.1.4.1. Cattle density in the savannas.

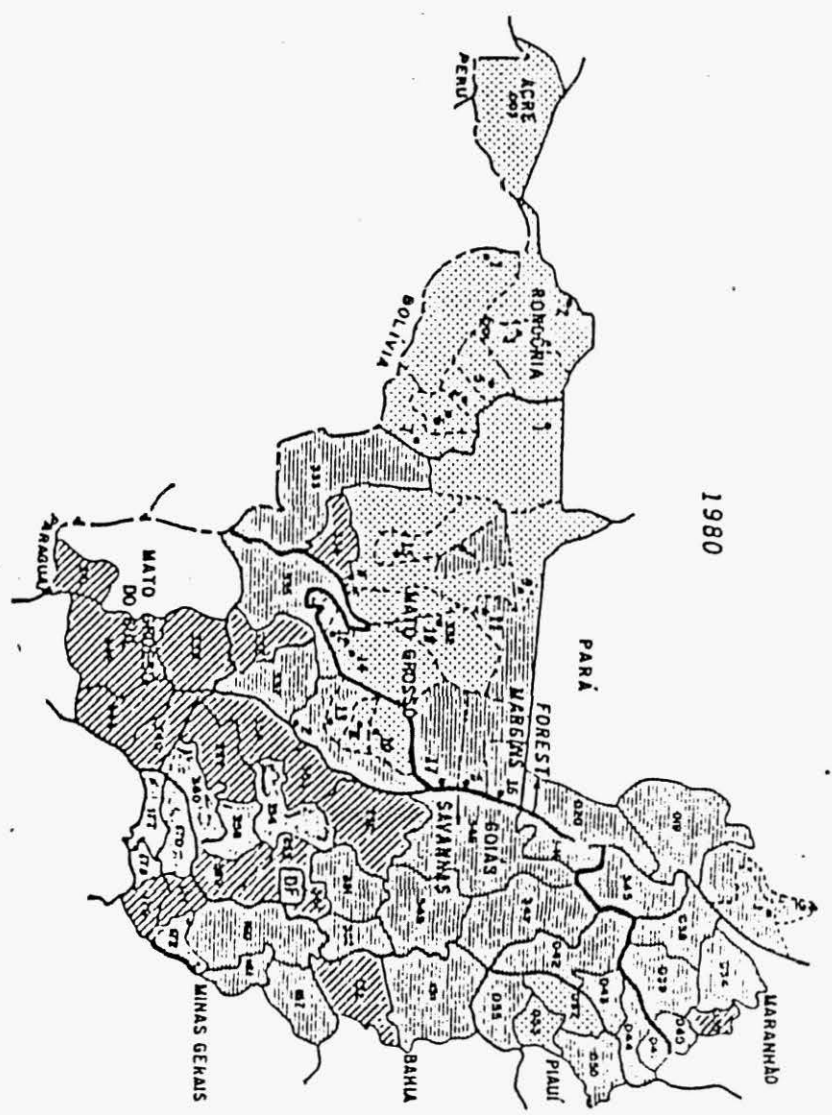
Map 7 shows the cattle density in the two subregions, for the 1970, 1975, 1980 and 1985 census years. Focusing on the 1970 map, we see that most of the savannas still had low cattle densities. The exceptions were some **microregions** in the Minas Gerais Triangle area, the south of Goiás, and Mato Grosso do Sul, with medium to high densities; and only one **microregion**, 354 (Mato Grosso de Goiás), had a cattle density in the highest class (more than 50



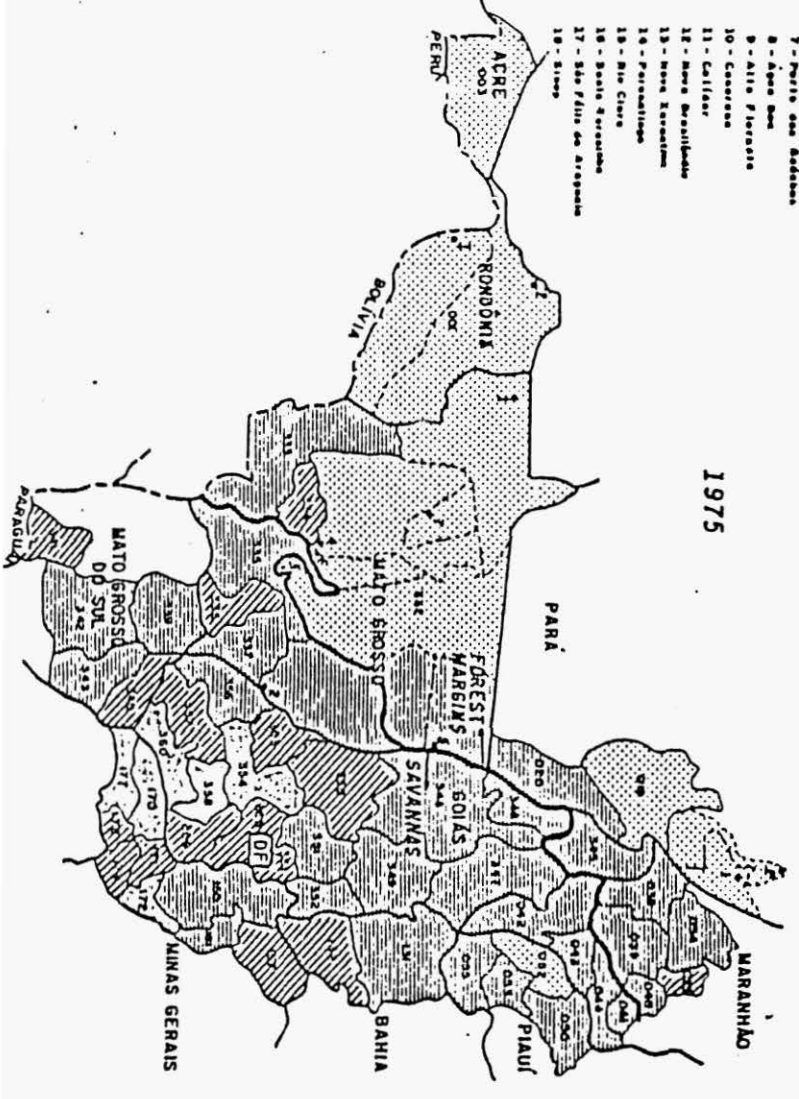
1970



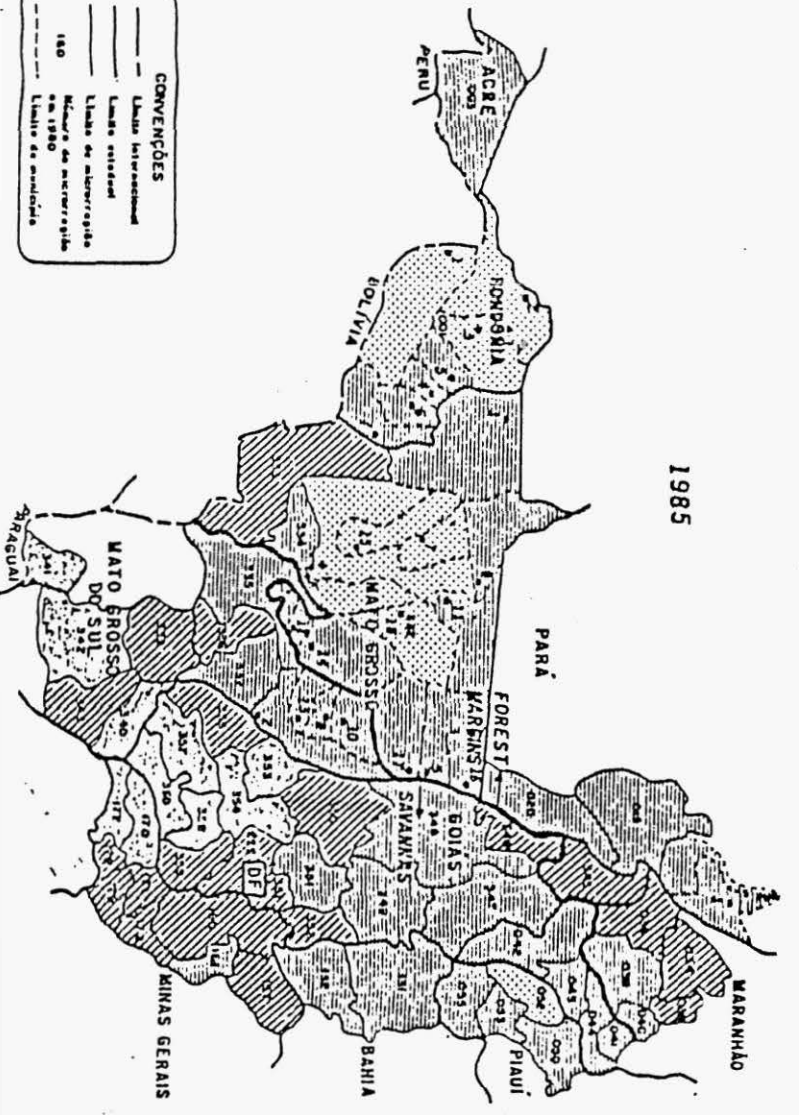
1980



1975

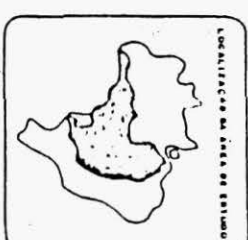


1985



INSTITUTO SOCIEDADE, POPULAÇÃO E NATUREZA
ISPIN
AGROECOSSISTEMAS DE MARGENS DE
FLORESTAS E DE CERRADOS

Density of Beef Cattle Herd



LEGENDA

Heads per 100 Hectares

≤ 9

10 a 24

25 a 49

≥ 50

MAP 7

CONVENÇÕES

— Limite Internacional

— Limite Estadual

— Limite de microrregião

— Microrregião em 1980

— Limite de município

animals per km²).

In 1975, the geographical units in the highest density class had increased markedly. This increase persisted in subsequent years so that, in 1985, a very significant portions of Mato Grosso do Sul, of the center and south of Goiás and the Minas Gerais Triangle had densities in the highest class. As seen, those are also areas of considerable agricultural expansion and modernization. The development of adequate transportation, processing and marketing systems has allowed a simultaneous expansion and modernization of both agricultural and livestock activities of this area.

As for the other geographical units, we see that the cattle density of those adjacent to the more developed area in the south of the subregion also experienced increases. However, even in 1985, the more remote parts of the subregion still had large areas of low densities.

Map 7 shows that most of the cattle herd of the two regions is concentrated in the savannas. Ranking the geographical units from that with the highest proportion of the region's cattle herd to that with the lowest participation, the map shows the location of the units with the higher proportions containing 50% of the region's total herd in 1985, and those containing between 50 and 75% of the total in that year. With one exception, all of the units in the higher 50% range were in the savannas, with a very strong

concentration in Mato Grosso do Sul, the Minas Gerais Triangle and the center and south of Goiás. And, considering the units in the 50-75% range we seen that on'y two -- in the southwest Pará and in the north of Tocantins -- are in the forest margins.

II.1.4.2. Cattle density in the forest margins.

The 1970 cattle density map shows almost all of the forest margins subregion with very low cattle densities (most of its units had less than 9 head per km²). In the subsequent census years, the cattle density increased, but even in 1985, most of the subregion's units had densities in the low 10 to 24 heads per 100 hectares class, and only a few had densities in the medium to high range (25 to 49 heads per 100 hectares). Moreover, Rondônia and the center-north of Mato Grosso still had large areas in the lowest density range. Even now, the cattle sector of the forest margins is modest, notwithstanding the special incentives it has received since 1970.

It should be noted that in 1985 the geographical units with middle to high densities were in the southwest of Mato Grosso and in the area of concentration of large fiscal incentives projects, specially in Tocantins and Maranhão. However, as shown below, the expansion of planted pastures there has been higher than that of cattle numbers, an indication of the low success of its cattle enterprises.

II.1.5. The human population.

Concluding the overall analysis, we examine elements of the demographic trends in the two subregions in the 1970-1991 period, based on information from the demographic censuses of 1970, 1980 and 1991 (preliminary results). First, we focus on the overall numbers and growth rates; next, we analyze changes in the demographic density.

II.1.5.1. Population and growth rates.

Taking the region as a whole, its population increased from 8.3 million inhabitants in 1970, to 12.5 million in 1980 and 18 million in 1991. The annual growth rates were 4.2% in the 1970-80 period and 3.8% in the 1980-91 period. These rates were considerably higher than the corresponding national averages, and the region's share of Brazil's population increased from 9.1% in 1970 to 12% in 1991. It is clear that, from 1970 to 1991, in-migration has been considerable in the region.

a. **The demographic evolution in the savannas.** This subregion's population grew from 6.5 million inhabitants in 1970 to 9.1 million in 1980 and 12.6 million in 1990. The annual growth rates were 3.4% in the 1970-80 period, and 3.3% in the 1980-91 period. These rates are lower than the averages for the region as a whole, so that the share of the savannas in the region's total population fell from 78.3% in 1970 to 70.0% in 1991. However, in 1991, its proportion of the region's total population was still substantial. Moreover, the

subregion's growth rates were considerably higher than the national averages and its share of Brazil's population increased from 7.1% in 1970 to 8.4% in 1991. This indicates that the savannas received population from the rest of the country.

We should note, however, that the increase in population of the savanna subregion was, to a large extent, related to urban processes. In 1991, the Brasília and Goiânia metropolitan areas alone concentrated nearly one-fourth of the subregion's total population, and there were other medium-sized cities -- such as Uberaba, Uberlândia, Campo Grande and Anápolis -- in which a sizeable proportion the savanna's population lived. As a matter of fact, as the analysis of section IV shows, the rapidly expanding modern agriculture of the "cerrados" has absorbed very little manpower and the rural population of most of the subregion's geographical units has declined in the period. The demographic dynamism of the savanna subregion had little to do with the vitality of its agriculture.

b. The demographic evolution of the forest margins. Population in the forest margins increased from 1.8 million inhabitants in 1970 to 3.3 million in 1980 and 5.4 million in 1991. In the last two decades, the subregion's annual rates of population growth were very high -- 6.5% for the 1970-80 period and 5.1% in the 1980-91 period -- and the region's share in Brazil's total population increased from 2.0% in 1970 to 3.6% in 1991.

The forest margins have, therefore, received population from the rest of the country (including from parts of the savanna subregion). Areas such as Rondônia, the north of Mato Grosso, the east of Pará, the north of Tocantins and the west of Maranhão attracted substantial inflows of population from 1970 to the end of the 1980s. However, the growth rates of the subregion's geographical units indicate that the microregions to the north and east of Maranhão have expelled population more recently, and that other units in Maranhão, Tocantins, Pará and east Mato Grosso are losing impetus in terms of population absorption.

In fact, there are indications that even the demographically more dynamic portions of the subregion may be experiencing a deceleration in migratory inflows (see Martine, 1990). Since a significant portion of these inflows have been related to rural processes -- the occupation of land by small farmers and landless workers from other parts of the country, the formation of cattle ranches with official incentives, the search of land for speculative purposes, public and private colonization projects (Sawyer, 1984; Mueller, 1983) -- and since the failure rates of most of those in terms of agricultural production has been high, the retention of migrants in some of the new areas has declined. The tendency of re-migration and the rapid increase in the urban population of Brazil's Northern Region indicate that the rates of increase in the subregion's rural population may be declining very significantly. However, only an analysis of the complete 1991

demographic census (as of now there are only preliminary head count results) will allow more definite conclusions regarding these trends.

II.1.5.2. Population densities.

The region as a whole has a very low demographic density. In 1970, it had an average of only 2.93 inhabitants per km²; this ratio increased to 4.40 and to 6.97 inhabitants per km² in 1980 and 1991, respectively. Even in 1991, the region's density was only 40% of Brazil's total. Densities are higher in the southeast and in the northeast of the region, but even in 1991 there were extensive areas in its center-north section with very low densities.

As the spatial pattern of demographic density of the subregions, starting with the **forest margins**, in 1970, the subregion was virtually empty. Only a few geographical units of Maranhão, Piauí and the north of Tocantins had densities in the 2.01 to 5 inhabitants per km² class, and only two in Maranhão had densities in the 15.01 to 30 inhabitants per km² interval. By 1980, the population densities of the northeastern units of the forest margins register increases, and parts of Acre, Rondônia and Pará also show signs of demographic vitality. The rest of the region, however, still had very low densities. In 1991, we see increasing density of population in the northeast, while parts of Pará and Rondônia also show higher densities. Moreover, there are areas of Mato Grosso and Acre with densities in the 2.01 to 5 inhabitants

per km² class; however, there is still a very significant portion of the subregion in the lowest density interval.

As a whole, the savannas have higher population densities but, even in 1991, they still had large areas with less than 5 inhabitants per km². In 1970, the subregion's southern section already had geographical units with fairly high demographic densities; and in the other census years, there was an increasingly larger area with densities in the higher intervals. In 1991, this area had reached several units of Mato Grosso do Sul, the south of Goiás, the Minas Gerais Triangle and the south of Mato Grosso. This is the area of modern, dynamic agriculture, where most of the cattle herd is located. We should note, however, that its geographical units with the highest demographic densities are precisely those with the largest urban centers, such as Brasília, Goiânia, Uberlândia, Uberaba, Anápolis, Campo Grande, Cuiabá and Rondonópolis. Some of those are important centers of agricultural support, but others are typical multifaceted metropolitan centers. When this was being written, the 1991 census data on rural population was not yet available, but it is possible to say that the rural population, even of the more densely populated areas of the south of the savanna subregion, has been thinning out (see Mueller, 1983). There are areas of much lower population densities in both the savannas and the forest margins, with more significant rural sectors in terms of population and use of manpower.

II.2. Main public policies affecting the occupation of the region.

This section examines the main policies which affected the occupation and incorporation of land into agriculture in the forest margin and savanna regions after 1970. Here the analysis is general; a more specific and detailed analysis is provided in the sections on the evolution of each of the regions. We examine, first, the overall policies with important impacts in the process of frontier expansion in the two subregions; then we present a brief analysis of policies specifically designed to influence the process.

II.2.1. Effects of overall policies.

II.2.1.1. General development policies.

General economic development policies had important impacts in the opening and on the incorporation of land into agriculture in the two regions. This was particularly true in the period of rapid growth between 1968 and 1980. The overall climate and the view that Brazil was destined to become a first-rate economy established an environment conducive to risk-taking. Expectations that easy speculative gains would result from pioneer ventures almost everywhere were also important in the move by private agents to incorporate large areas of land into agricultural ventures in the subregions. The period of crisis and stagnation of the 1980s changed the situation, but the opportunity to obtain gains by

manipulating the fiscal incentives scheme and other special programs (see below) maintained the motivation to occupy and clear large areas of land.

Moreover, the conservative modernization of agriculture which took place starting in the late 1960s, as part of the general development strategy, also produced important effects on the process of frontier expansion. As a consequence of conservative modernization, land concentration in Brazil's center-south was maintained high or increased, and large numbers of small farmers and rural workers were driven off the areas of more developed agriculture, generating growing flows of migrants, both to the large urban-industrial centers (the main portion), and to areas in the agricultural frontier (see Martine, 1989 and 1990).

II.2.1.2. General policies affecting land prices.

Through their effects on land prices, certain overall policies and economic problems had important impacts on the opening and occupation of the region. Of those, the more important were identified as: the almost total exemption of agricultural income from taxation (stressed by Binswanger, 1991); the subsidized credit schemes for agriculture (Brandão, 1988); and speculation with land prompted by an unstable and increasing inflation rate.

a. **The income tax exemption effect.** In discussing the effects of the income tax shelter created for agriculture, Binswanger

(1991) could be read as contending that this has affected directly the occupation of land in the Legal Amazon region (which encompasses important portions of the savanna subregion). The income tax exemption would induce private and corporate investors to undertake agricultural projects there, even if they had lower rates of return non-agricultural projects (Biswanger, 1991, p. 822). If this is meant to apply directly to the large livestock projects undertaken in the Amazon, the conclusion would not be correct since most of those have not produced incomes. As shown by Gasques and Yokomizo (1986), very few of the fiscal incentives agricultural projects in the Amazon have succeeded in generating incomes which could be taxed if there were no exemption. At the most, the direct effect of the income tax exemption would be applicable to the large soybean farmers in the savanna areas of the Legal Amazon (in Mato Grosso).

In fact, Binswanger's argument is meant to be general. By exempting agricultural activities from income taxation, they would be developed beyond the levels determined without tax exemption, they would artificially increase the demand as well as the real price of land everywhere; this, in turn, would induce the occupation of land in the frontier. In other words, in the areas of established (and profit generating) agriculture, the price of land is much higher than it would be without the tax exemption, and this leads to the incorporation of much cheaper lands on the frontier.

However, this argument is only partially true. Bisnwanger seems to ignore the fact that agricultural products have been subjected to strong explicit and implicit taxation, which tends to offset the income tax exemption. For instance, until recently the exports of manufactured goods were exempted from all forms of taxation and, at times, received tax-linked subsidies, while the exportation of agricultural commodities were subjected to a large sales tax. Moreover, agriculture has been subjected to a strong implicit taxation, resulting from ceiling prices on basic food items, and from the determination of export quotas, embargoes, overvalued foreign exchange rates, the subsidized importation of certain items, dumping from government stocks, and a variety of other interventions. The effect of those has been a downward pressure on agricultural prices (see Oliveira, 1984); there was, therefore, a countervailing downward pressures on the demand for and price of land. It is an empirical question whether the effect of all the distortions has been a net increase in land prices.

b. The subsidized agricultural credit effect. As for the effects of the agricultural credit subsidies on land prices, there is evidence that this has been the main avenue by which land prices have markedly increased in real terms after 1970 in Brazil. Between 1970 and the early 1980s, agricultural credit was provided, to farmers who qualified, at strongly negative real interest rates. For many years rural credit had a fixed nominal rate which, when the loan was due, proved to be much lower than the rate of

inflation in the loan period. In fact, Oliveira (1984) shows that through the credit schemes the more modern and influential farmers -- those which qualified for agricultural credit -- were partially compensated for the implicit taxation of agriculture discussed above. Thus, the demand for land in areas suitable for modern agriculture -- including some in the savanna subregion -- was increased, with a spill-over effect on the areas of recent frontier expansion.

A study by Brandão (1988) indicates that rural credit schemes were the main determinants in the rapid increase in agricultural land prices of the 1970s and early 1980s. What happened was that, in the presence of subsidies, the banks increased substantially the requirements of collateral. One of these requirements was that the farmer applying for credit be the legal proprietor of the land he farmed. That is, landowners had privileged access to subsidized rural credit. With the sharp expansion which took place in the 1970s, of the availability of rural credit with large interest rate subsidies, the demand for land, and its price, increased rapidly.

After 1982, due mainly to pressures exerted by the World Bank and the International Monetary Fund, the amount of credit for agriculture declined markedly and interest rate credit subsidies were drastically reduced. The agricultural credit schemes were seen as an obstacle to a responsible monetary policy, besides being considered a strong element of distortion; thus the two

international agencies pressured the Brazilian government to reduce rural credit and to curtail subsidies.

c. **The effect of unstable and increasing inflation.** Finally, the effects of unstable and increasing inflation experienced by Brazil, particularly after 1973, should be mentioned, since they exerted an upward pressure on land prices. Since the real value of land (rural and urban) usually does not depreciate with inflation, in an unstable inflationary environment, the demand for land is increased -- not as a result of a rise in its productivity or the direct return for activities undertaken in it, but as a reserve of value.

II.2.1.3. **The effects of inadequate rules of land allocation.**

Binswanger(1991) also emphasizes the detrimental effects of inadequate rules concerning the occupation of land in the Amazon -- particularly of those regarding squatting in public lands. Both small settlers and large operators were able to easily establish claims on land by squatting. Moreover, the rules encouraged deforestation since the final amount of land granted a title under official procedures was related to the area cleared and showing signs of being explored.

A similar effect stemmed from Brazil's land tax. Although the country has a progressive land tax on the size of land holdings, there are many exceptions and loopholes. And the rate charged on a

holding is reduced if it can be shown that the land is being exploited. This induces deforestation and the quick formation of pastures as a means of demonstrating that the land is "productive".

These effects were particularly important in the euphoric phases of Amazonian expansion of the 1970s and early 1980s. New rules, recently passed, make it more difficult to clear land in the rain forest areas of the Legal Amazon region. Furthermore, the will and the capacity of the Federal Government to control and to police senseless deforestation has increased somewhat, although the size of the region and the difficulties of moving within it makes this an extremely complicated task.

In conclusion, a combination of the effects of general policies, of speculative effects associated with a high and unstable inflation, of subsidized rural credit policy, together with a booming situation in the world market of some commodities in parts of the period (for instance, soybeans and orange juice) and with incentive programs to induce the cultivation of certain commodities (sugar cane for automotive alcohol; import substitution of wheat), were responsible for very significant increases in real agricultural land prices. These increases have played an important role in stimulating the incorporation of land in the region.

II.2.1.4. Regional and sectoral development programs.

Since the late 1960s a growing number of regional and sectoral

development programs have been created for significant portions of both the forest margins and the savanna subregion; most of them had important impacts on the occupation and incorporation of land into agriculture there. Here we merely list the most important of such programs; sections III and IV have details on their effects on the savanna and the forest margins subregions, respectively.

II.2.1.4.1. Regional development programs for the forest margins.

For the forest margins subregion, the main regional development programs with impact on its agriculture were:

a. A program of tax incentives for investment in the Legal Amazon region, important beneficiaries of which were large agricultural ventures (mainly cattle ranches). Section IV has a more detailed discussion of the fiscal incentive scheme; it is important to note, however, that this program was responsible for the incorporation of substantial areas of land into agriculture, not only in the forest margins, but also in parts of the savannas included in the Legal Amazon region.

b. A similar (and older) program for the Northeast of Brazil. This fiscal incentive scheme has affected the incorporation of land into agriculture, not only in Maranhão's forest margins areas, but also in the savanna subregion included in the northeastern area defined for the program (in Bahia, Piauí and in the "cerrado" areas of Maranhão).

c. Official colonization programs in the Amazon. Since 1970 several colonization programs devoted to small farmers and landless workers from other parts of the country were created. At first, they were to be "model" programs but with time they became remedial actions to accommodate a growing flow of migrants in search for land in the Amazon.

d. A sectoral public investment program for the Amazon and the Northeast (PROTERRA), intended to allow for improvements in infrastructure in parts of these regions and to induce the development of their agricultures. For the forest margins subregion, one of most important impacts of this program was that it provided stimulus and resources for the formation of private colonization programs, mainly devoted to farmers with experience and some capital from the south, interested in acquiring cheap land on the frontier to undertake commercial farming. This had an important impact on the evolution of agriculture in parts of Mato Grosso's forest margins.

e. A growth poles program for the Amazon region (POLOAMAZÔNIA), created in 1976 to concentrate public resources in areas considered of larger potential for development. Improving the infrastructure and developing some support for agriculture in the selected areas, the program had impact in the occupation and use of land in agricultural ventures.

f. The Integrated Program for the Development of Brazil's Northwestern Frontier (POLONOROESTE), established in 1981. Its main objective was to put some order into the occupation of Rondônia and of western Mato Grosso. At the core of the program was the reconstruction and paving of the Cuiabá-Porto Velho road, but it had parallel projects for land settlement, agricultural development and feeder road construction. POLONOROESTE was financed through a World Bank loan (World Bank, 1981).

g. The Grande Carajás project, created in the early 1980s, for an integrated exploitation of the vast mineral wealth of the Carajás area in eastern Amazon. This is obviously not a project centered on agriculture but it has had direct and indirect impacts on the occupation of land for agriculture in its area of influence.

h. Last, but by no means least, the highway construction program instituted in the early 1970s, which underwent changes and adaptations and additions over time. This program was created mainly with strategic, national security aims but, with the construction of new highways, the agricultural frontier of the forest margins was allowed to expand considerably.

II.2.1.4.2. Regional and sectoral programs and the savanna subregion.

The main official regional development and sectoral programs with important impacts in the savanna subregion were:

a. The program for the development of the "cerrados " (POLOCENTRO). Established in the mid-1970s under the growth poles concept, it improved the infrastructure of selected areas (all in the savanna subregion), and created extremely generous, highly subsidized credit lines for farmers willing to undertake modern farming in these areas.

b. A part of the POLOCENTRO program was the provision of financial resources for the creation and adaptation of agricultural technologies for the "cerrados". In the early 1970s, the Brazilian savannas had a very poor, low productivity agriculture. POLOCENTRO helped to finance an effort, coordinated (and, to a considerable extent, executed) by EMBRAPA, which led to the creation of forms of productively farming the savannas. This was one of the rare successful offsprings of the plethora of official regional and sectoral programs instituted since the late 1960s.

c. The Japanese-Brazilian Program for the Development of the Cerrados (PRODECER), established with financing from a loan by the Japanese government, to promote a selective occupation of specific areas of the savanna subregion. Initially these areas were all in Minas Gerais, but more recently they were extended to Bahia, Goiás and Mato Grosso.

d. Effects of development programs for other regions, on the savanna subregion. The fiscal incentive schemes for the Amazon and

the Northeast had impacts on the expansion of agriculture in the "cerrados" of Bahia, Tocantins and Mato Grosso. As we have seen, the fiscal incentives programs we've established to develop these two regions, but their official areas of influence include considerable portions of the "cerrados" of the mentioned states. Agricultural ventures there were, therefore, influenced by the incentives schemes.

In conclusion, together with the effects of general policies and of overall economic expansion, regional and sectoral policies provide strong inducements for the occupation of land and for agricultural expansion and modernization in parts of the savannas and (to a lesser degree) of the forest margins. Recently most of these programs have been phased out or remain virtually inactive; the fiscal crisis of the 1980s and the more liberal stance of the administration which took power in 1990 have reduced considerably the impetus to promote regional development with special programs such as those examined above.

II.3. A preliminary zoning of the two subregions.

The above sections' analysis provides elements for a preliminary zoning of the forest margins and the savanna subregions. The discussion of trends in the incorporation of land into agriculture, in the area affected by agricultural processes, in agricultural intensities and technical levels, in cattle

activities, as well as of demographic evolution allows the identification of a spatial pattern within the two subregions that represents a first step in a zoning process.

The preliminary character of the zoning attempted should be emphasized. A complete, accurate and detailed zoning would have to take into account important elements of the ecosystem which are still virtually ignored, such as land fertility and other physical characteristics involved in the configuration of the agricultural potential of the various areas of the two subregions, as well as details about their infrastructure, their systems of agricultural processing and marketing and about their links with the Brazilian economy. We only intended to portray the changes in space established by the main trends and tendencies of agriculture of the forest margins and the savannas, as revealed by the last four agricultural censuses, together with the demographic pattern that evolved in the two decades, and which was also strongly affected by agricultural processes.

Moreover, there is no pretense of uniformity within the areas into which the two subregions are divided. They are all quite large in size and it would be really remarkable if one of them presented fairly homogeneous basic characteristics. A more detailed and precise zoning would require a much more extended study than that which we have been able to perform in the time horizon and with the resources at our disposal.

Finally, it is not possible to affirm that all of the areas into which each subregions has been divided constitute a permanent, deep-rooted zone. In a few cases, one can be fairly sure of this; in others, however, the zone will probably experience changes and fragmentation, with parts becoming incorporated into other zones. We should remember that considerable portions of the two subregions are still agricultural frontier areas and, therefore, subject to changes that can be significant.

The next subsections describe the zoning established for the two subregions.

II.3.1. A zoning of the forest margins.

Based on last section's analysis it was possible to identify five fairly homogeneous zones in the forest margins' area:

a. **Zone M.I.** Area of older settlement, from the densely populated, poor portions of the Northeast, composed of microregions 034, 035, 038, 039 and 040, all in Maranhão. In 1991, its units already exhibited high to very high demographic densities; the inflow of migrants from the Northeast started in the 1950s so that, by 1980, its population was quite large.

In 1985 a large percentage of Zone M.I's geographical area was in agricultural establishments, and the proportion of the area in farms affected by agricultural processes was considerable. Zone I

has a high-intensity, low-technology agriculture, and its production is mostly of subsistence crops; the output of commercial crops was negligible (see section III). Its cattle herd is not important and its 1985 cattle density was low.

b. **Zone M.II.** Area of large fiscal incentives projects and of spontaneous peasant settlement. It encompasses an area, running from the northeast of Mato Grosso through east Pará and north Tocantins, and including parts of Maranhão. In 1985 this zone had a relatively high proportion of its land in agricultural establishments, and most of its units exhibited medium to high proportions of their agricultural areas affected by agricultural processes. They had a low to medium intensity agriculture and predominantly low to medium technical levels. The main exceptions, in 1985, were the two geographical units in the north of Pará, with somewhat higher technical levels.

A substantial portion of the large fiscal incentive cattle ranches is concentrated in this zone; it has also received a growing inflow of poor migrants (peasants and farm workers from deprived areas of Brazil). Since the legal status of an important portion of its lands is uncertain, there have been frequent disputes and violence there. It also experiences the impact of the Grande Carajás mineral project. This is an area of considerable turmoil, in spite of the still low to medium demographic densities of most of its units.

In terms of the forest margins production, Zone II has some significance in rice; the 1985 beef cattle densities of its units were still low, in spite of their fiscal incentives ranches.

Zone M.II is composed of the municipalities of Luciara, of São Felix do Araguaia and of Santa Teresinha in the northeast of Mato Grosso's microregion 332; **microregions** 019 and 020 and the municipalities of Paragominas and São Domingos do Capim in Pará; and **microregion** 345 of Tocantins.

c. **Zone M.III.** The area strongly marked by public colonization. In the extreme west of the subregion, Zone M.III includes the microregion 003 of Acre, and all of the state of Rondônia. Last section's analysis show that, since 1970, these areas experienced a rapid incorporation of land into agricultural establishments, a substantial alteration of land by agricultural processes, and a sharp intensification (especially in Rondônia) of their agriculture; however, technological levels remain low everywhere. The demographic density of parts of this zone has increased substantially; it should be noted, however, that the area more strongly affected has been the upper portion of Rondônia, served by the Cuiabá-Porto Velho highway. This is the main area of destination of the large inflow of migrants from the center and south of Brazil and these were the main agents for agricultural change. As a matter of fact, in 1985 two geographical units located there already showed a high-intensity, no-technology pattern

similar to that of northern Maranhão.

In 1985, the zone was mostly a producer of subsistence crops; however, due to Rondônia, it had some significance in the forest margins' rice output and of coffee. Moreover, a few of this state's units exhibited medium to high beef cattle densities.

d. **Zone M.IV.** Area of private colonization and commercial agriculture. It is located in a large area in the center-north of the state of Mato Grosso which was occupied after the mid 1970s. In 1985, it still had substantial unoccupied lands and its beef cattle density was very low, but this is the area where most of the Amazon private colonization projects were implanted. This year, it still had an agriculture of low to medium intensity, but of medium to high technical levels. The inflow of farmers with experience and some capital from the south, attracted by cheap land within this zone, has already turned it into an important commercial agriculture area. In spite of recent problems, it still generates most of the soybean production of the forest margins and it is also a fairly important producer of rice. However, in spite of its agricultural expansion, the 1991 demographic density of this zone was still very low.

Zone M.IV occupies a substantial portion of the immense Mato Grosso microregion 332 (according to the official geographical division prevailing until 1984). In order to perform a meaningful

analysis we have worked with the **microregion's** municipalities. Zone M.III includes the following "municípios" (of the 1985 division): Alta Floresta, Porto do Gaúchos, Diamantino, Nobres, Colider, Sinop, Chapada dos Guimarães, Nova Brasilândia, Paranatinga and Rio Claro.

e. **Zone M.V** A composite area, of public and private colonization, low intensity agriculture. It includes both, the huge municipality of Aripuanã in the northwest of Mato Grosso, and this state's microregions 333 and 334. Until recently this was an almost empty area, but the paving of the highway between Cuiabá to Porto Velho, which crosses the south and the center of this zone, and the recent construction of roads into Aripuanã facilitated the incorporation of land there; moreover, a few public and private colonization projects have also been implanted, inducing some agricultural expansion. However, there are still considerable unoccupied areas, and agriculture there exhibits a very low intensity and low to medium technical levels. Nevertheless, **microregion 333** is a fairly important ranching area of the forest margins, and it has some presence in rice and in maize (see section III).

II.3.2. A zoning of the savanna subregion.

Based on last section's analysis, it is possible to detect basically four agricultural systems in the savanna subregion. They are:

a. **Zone S.I** - areas of more advanced, modern, commercial agriculture. This dynamic system encompasses most of Mato Grosso do Sul (microregions 339, 340, 341, 342 and 343), Mato Grosso's microregions 336 and 337, the center-southwest of Goiás (microregions 354, 356, 357, 358 and 360) and the Minas Gerais Triangle area (microregions 170, 171, 172, 177, 178 and 179). In 1985, a high proportion of this zone's geographical area was already in agricultural establishments and the percentage of its farm areas altered by agricultural processes was quite substantial. Most of its units had agricultures of low to medium intensities but of high technical levels. Furthermore, the zone's 1985 cattle density was substantial; as a matter of fact, it concentrated most of the savanna's cattle herd. It was also responsible for most of the savanna's soybean, corn and coffee production and it was important in rice, beans and cassava.

The 1991 demographic density of Zone S.I was quite high, but this was mainly due to the fact that it contains a number of large urban centers, including the capital city of Brasília. In fact, the modernization of this area's agriculture has generated a considerable rural exodus.

Evidently, this is far from an homogeneous area. Parts of it have lands of higher fertility and are well served in terms of infrastructure, marketing and processing systems, but parts are not as well endowed and their agriculture reflects the difference.

However, only a zoning pattern which considered elements not yet available to us, would be able to identify more precisely these areas and establish with some confidence a subzoning.

b. **Zone S.II.** Area of recent, low intensity but modern agriculture. It encompasses the area surrounding Brasília in the Federal District, in Goiás (microregions 351, 352, 355, 359) and in the west of Minas Gerais (microregions 160 and 161). This is an area of fairly recent agricultural expansion (it began in the late 1970s) and in which agriculture has arrived in an already modern form. Therefore, in spite of the fact that, in 1985, the percentage of the zone's geographical area in agricultural establishments was high, the proportion of its land area affected by agricultural processes was still low. The demographic densities of most of its geographic units was in the medium to high range, but this was basically caused by the influence of the Federal District and of its area of influence.

Zone S.II is strong in soybean and, to a lesser degree, in rice. Its cattle density is in the medium to high range.

c. **Zone S.III.** A peripheral area of agricultural expansion. This is an area of recent agricultural frontier expansion, with an agriculture of low intensity and low to medium technical levels. Most of it surrounds systems (1) and (2). It includes the municipalities of Barra do Garças, Nova Xavantina Canarana and Água

Boa from the 332 microregion of Mato Grosso; **microregions** 346, 348 and 349 in Tocantins, 350, and 353 in Goiás, 157 in Minas Gerais and 131 and 132 in Bahia. This zone still has a low proportion of its geographical area in agricultural establishments and its farmland has not been strongly affected by agricultural processes. Its cattle density is reduced and its agricultural production is not yet considerable. However, some of its units have been showing some dynamism more recently. This is the case, for instance, of **microregion** 131 (Barreiras) in the west of Bahia.

In 1991, Zone S.III still had a low demographic density. With very few exceptions this is mainly a rural area of small population.

d. **Zone S.IV.** Areas of very low agricultural development. This almost empty agricultural system is composed of the "cerrado" areas of Maranhão and Piauí and of microregions 346, 347 and 348 of Tocantins, and 334 and 335 of Mato Grosso. Agriculture there is still incipient and of low technical level. These are remote, virtually residual areas, presently having small possibilities of evolving towards a more advanced commercial agriculture. Moreover, with a few exceptions, the demographic densities of their geographical units are quite reduced.

Before concluding this section, it is important to note that,

while some of the zones defined above are well established, others are still being formed and may well change in the future. This is particularly the case of Zones S.III and S.IV in the savannas subregion. Being predominantly frontier areas, events such as the development of transportation systems and the introduction of special programs may substantially change the situation of some units within each, altering their configuration. This will probably occur to **microregion** 131 in Bahia, which may be included in Zone S.II. Similarly, **microregion** 042 of Maranhão, the area of influence of the Norte-Sul railroad (under construction) together with the Carajás railroad, is said to be a potentially booming region for soybeans; if this becomes a reality, it may have to be moved from Zone S.IV to S.III (or, depending on events, to S.II). Being frontier areas these two zones are far from being formed.

III Evolution of agriculture in forest margins

III.1 Regional and sectorial policies for the forest margins

Beginning in the late 1960s, the forest margins experienced the impact of a slew of policies, purportedly aimed at developing the Amazon and at improving the agriculture of pioneer areas. This section provides a structured review of these policies, as an element for understanding the process of occupation and agricultural expansion which took place within the subregion.

To begin with, it is important to bear in mind that the recent expansion of the agricultural frontier in the forest margins reflects the style of development followed by Brazil after World War II, which is characterized by urban bias and exclusion of large segments of the population from its benefits (Mueller, 1992). This style of development acquired particularly perverse characteristics after 1968. On the one hand, it increasingly privileged large enterprises and the ruling elites; on the other, the conservative modernization of agriculture, modernization without previous distributive reforms, generated growing numbers of migrants, pushed out of from the main agricultural areas in the Center-South. A large proportion of these migrants moved to the main urban-industrial centers, but a considerable number went to the agricultural frontier which, in the late 1960s, reached the Amazon. Thus, the rural areas of the Center-South joined the poverty stricken Northeast as a source of destitute migrants. In the 1970s

the process was intensified, with sharp consequences in terms of land occupation and removal of the rain forest. From the inception of the Amazon strategy in the mid-1960s, to its recent downfall, frontier expansion in the region has proceeded in the following phases:

a. **The incipient phase, up to 1965.** Policies aimed at integrating the Amazon into the Brazilian economy were attempted before the 1960s, but their effects were not significant (Mahar, 1978). However, in the late 1950s, the first major road linking the region to the Center-South -- the Belém-Brasília highway -- was built. It established a connection between the more dynamic areas of Brazil and the southeast part of the region, later an important area of agricultural frontier expansion and deforestation.

b. **Formation of the military regime's Amazonian strategy (1965-69).** The military regime established in 1964 soon defined a specific Amazonian strategy. Contrary to what is commonly thought, it was not the concept of a resource frontier to be exploited for national development that moved the new regime; instead, the main objectives were geopolitical. The projects and actions conceived for the region did not undergo any test of economic viability test. The first major natural resources survey (the RADAM survey) began after such projects were started and, in most of the cases, large investments were implemented without cost-benefit analyses (Torres, 1990). The main objectives of the strategy were to induce rapid

occupation of parts of the huge empty spaces of Brazil's Amazon, regardless of the economic (not to say environmental) sustainability of the process, and to integrate the region into the mainstream of the country's economy. It was thought that, by establishing a demographic and an economic basis for the defense of the enormous extension of the country's international borders to the north and the west of the region, and by promoting the settlement of its huge empty spaces, claims by foreign powers over the region would be more easily prevented. A motto frequently voiced in the 1970s was "integrar para não entregar" ("use it or lose it").

In 1965 the **Operação Amazônia** was instituted, to begin implementing the new strategy. Its main instrument was a regional development program based chiefly on the concession of tax rebates and other financial incentives to private investment in the Amazon. Many of the investment projects contemplated by this scheme were agricultural, primarily extensive livestock ranches. Between 1966 and 1969, a total of 166 large livestock projects was approved, or 21.7 % of all projects approved up to 1988.

The 1960s also saw the beginning of the construction of the Cuiabá-Porto Velho highway, which later brought into Rondônia, large numbers of land-hungry settlers -- mostly rural migrants from the Center-South.

c. **Intensification of the amazon strategy (1970-75).** In 1970, the military stepped up sharply its policies to promote the occupation of the Amazon. The main instrument was the **Programa de Integração Nacional** (National Integration Program) -- PIN, combining large investments in road construction in the Amazon with short-lived attempts at promoting public "model" agricultural settlements for small farmers and peasants. It also broadened significantly the incentives and official inducements for private investments in the Amazon. Moreover, virtually all public lands then owned by the region's states were transferred to the federal government, which thus acquired substantial control over an enormous stock of land.

The road construction program, aimed at crisscrossing the Amazon with highways, was extremely ambitious. The Transamazon highway crossed the region from east to west and there was to be a road along the perimeter of most of the Brazilian Amazon's international border. Other trunk roads would be built or improved to provide the more developed Center-South access to strategic portions of the region.

However, only part of the projected roads were actually built -- especially a portion of the Transamazon highway, together with the Manaus-Porto Velho and the Cuiabá-Santarém trunk roads (see figure 1). The Cuiabá-Porto Velho highway was also concluded. Given access to areas of land previously protected by a dense rain forest

from almost all forms of human intervention, these roads were fundamental for the promotion of agricultural colonization in the forest margins.

As for small farmer settlement, reportedly moved by the situation of the overcrowded, poverty-stricken Northeast, the military regime launched, under PIN, a colonization program along the eastern parts of the Transamazon road, aimed at alleviating that region's demographic pressure. At the same time, model colonization projects were created in the then Federal Territory of Rondônia, with the objective of attracting small farmers with some experience in modern agriculture from the south. In both cases, the objective was to settle the chosen areas in an orderly fashion, in widely publicized "model" colonization projects.

The fiscal incentives program was also stepped up. Between 1966 and 1972 substantial areas of land were incorporated into agricultural projects, some of which were enormous. Most of the fiscal incentives projects are located in a large area, encompassing the northeast of Mato Grosso, the east of Pará, the north of Tocantins, and the southwest of Maranhão. The high world prices of beef in the early 1970s led the military regime to announce that the Amazon would soon become a major exporter of this commodity.

In short, the idea behind PIN was, on the one hand, to have an

orderly flow of migrants from the Northeast and the Southeast settle parts of the Amazon, produce subsistence goods and furnish manpower for other developments; and on the other, to have private initiative, stimulated by the fiscal incentives scheme, originate a growing flow of agricultural products, both for the domestic market and for exports. In this way, the region would be settled and incorporated into the national economy, and the danger of foreign intervention would be put off.

d. Loss of impetus and changes in instruments (1975-79).

Events did not materialize as expected, however. The oil crises of the decade reduced the country's growth and made it more difficult to obtain resources for the road construction program. Moreover, the increases in oil prices made evident the problem of the remoteness of the settlement areas. Consequently, there was a substantial abatement in road construction in the region.

The period witnessed a considerable change in Amazon occupation tactics. After 1974, a growth-poles conception replaced the shotgun tactic, of the past. The idea was to concentrate efforts in areas considered to have higher potential, avoiding dispersal of scarce resources. This came at a time of official disappointment, with both public colonization and with the fiscal incentives projects.

The public colonization projects turned out to be a failure.

There were severe administrative problems, agricultural technology applied by the settlers was inappropriate and they had difficulties in adapting to the region's environment. Thus, "model" colonization was phased out. However, a much larger flow of spontaneous immigration had begun, propelled by small farmers and workers displaced by the conservative modernization of agriculture in the Center-South. This forced the government to continue implementing colonization schemes, though now in a remedial fashion. In spite of these efforts, the pressure of spontaneous migration was such that the demand for plots in colonization projects by far exceeded those made available by the government; therefore, there was an increasing invasion of land by migrant families, both in parts of eastern Amazônia and in Rondonia. Large numbers of outsiders settled in public and private land wherever road access was available and repression was unable to stave off invasion. By and large, invasion of public land was condoned and even, eventually, "regularized" by the government; however, occupation of private or disputed lands frequently resulted in violence.

The enthusiasm with public colonization was replaced with strong hopes for private, government induced colonization. In the early 1970s, the government started providing access to public lands, together with subsidized credit, for the implementation by private ventures and cooperatives of private colonization projects, destined mainly for settlers with some capital and experience from the south of Brazil. Most of these projects were implemented in the

forest margins of north Mato Grosso, in areas of transition between rainforest and savanna.

Private colonization gained impetus particularly in the 1976-81 period. Between 1970 and 1986, 104 private colonization projects were created, with a total area of 2,9 million hectares; 66.8 % of the projects were established between 1975 and 1981, covering 68.1 % of the total area in these projects. The size of farms sold was mainly in the 100 to 500 hectare range. Their settlers' main objective was to cultivate commercial crops. This, high world prices and a favorable policy environment, soon turned the north of Mato Grosso into an important producer of soybeans.

As for the large-scale fiscal incentive projects, they also fell far short of original expectations, and the number of new projects was sharply reduced. In the 1973-79 period, only 56 projects were approved, or 7.6 % of the number approved between 1966 and 1988. This meant a sharp decline; in the previous 7-year period, 312 projects, or 40.7% of the 1966-88 total, had been approved. Moreover, new rules were established, prohibiting projects in the core of the Amazon rain forest and providing for stricter controls.

However, the hopes placed on large investments in the Amazon were far from over. At this time Daniel Ludwig's huge Jari project, in the eastern Amazon, began to take shape. Over 100,000 hectares

of the total 1,5 million owned by the enterprise were cleared and planted with Gmelina and Pinus caribea, to be used as raw material for a large pulp plant that had been imported from Japan; rice was cultivated on 4,000 hectares of flood plain; and minerals were discovered and exploited (Fearnside and Rankin, 1980). All of this was done with Ludwig's own resources but with backing from the government. The high official praise received by this initiative suggested that it was to be the new avenue for the development of Amazonia.

e. Large growth-poles programs and uncontrolled expansion of incentives projects (1980-88). The two main Amazon programs of the period were the POLONOROESTE program in the west and the Grande Carajás complex in eastern Amazon. The latter was a large multisectorial program based on the extraction, transformation and exportation of the mineral wealth of the Carajás region, in a clear export enclave orientation. The agricultural component of the Grande Carajás project was modest, but the migrants attracted to its agricultural area of influence can be expected to have impacts in terms of deforestation. Moreover, the project included controversial components, such as the melting of iron ore with charcoal, partly extracted from the native forest.

The Integrated Development of the Northwest Frontier program (POLONOROESTE), financed with resources from a World Bank loan, was conceived to impose some order to the chaotic occupation of Rondônia and parts of Mato Grosso state. It aimed at improving the

possibilities of success of the area's migrants, at reducing environmental degradation, and at providing protection for its Indian population (World Bank, 1981). Unfortunately, however, most of these goals were not achieved. The main objective of the government with POLONOROESTE seems to have been to obtain resources for paving the highway between Cuiabá and Porto Velho.

In this period, there was an almost uncontrolled expansion of fiscal incentive projects. Their past failure suggested that this line of action should be discontinued, but the political pressure by interest groups kept the scheme going. The transfer of wealth it promoted was such that favored groups fought fiercely against interruption. The transfer took place directly, through the incentives and subsidies schemes, and indirectly, through the rapid increase in the price of land fostered by the process and by the flight into real estate promoted by accelerating inflation (Binswanger, 1991). In the 7 years between 1980 and 1986, the fiscal incentives scheme approved 353 agricultural projects, or 46.1 % of the total for the 1966-88 period. The size of the projects tended to be smaller, and most of them were in the periphery of the rain forest. However, control by the federal agency in charge of the fiscal incentives program became lax and the mismanagement of the enterprises and the inappropriate use of incentive monies became acute (Yokomizo, 1989).

The fiscal incentive scheme was reduced in 1987, and

temporarily suspended in 1989 by a government decree. Agricultural fiscal incentive projects in the Amazon core can only be resumed after the conclusion of a space ordination study, presently being executed. However, the Constitution approved in 1988 maintained the mechanism of fiscal incentives as an instrument of regional development, and there is the danger of a resumption of agricultural projects in the future. Now they can only be undertaken in the already degraded areas -- most in the forest margins subregion -- or in the savanna areas of the Legal Amazonia region.

Finally, this period saw the failure of the Jari project. Increasing problems with the enterprise led Ludwig to transfer, in 1982, his control to a Brazilian group with government backing. The difficulties of undertaking large-scale ventures in the Amazon defeated even this American billionaire (Mueller, 1983).

In conclusion, the general policies reviewed in section II.2, together with the lost of policies which evolved since the late 1960s with the aim of incorporating the Amazon into the mainstream of Brazil's economy, had an enormous impact in the forest margins subregion -- not in terms of agricultural and livestock production, but of population movements, social transformation, occupation of land and alterations of the ecosystem. Public lands and colonization policies especially affected Rondônia and parts of the east-northeast areas of the subregion. The latter area has also

been the locus of many large livestock ranches fiscal incentives projects. The coincidence in space of the fiscal incentives agricultural projects and of a large inflow of destitute migrants, have generated conflicts and violence. Special policies and incentives also induced the expansion of a modern, medium-to-large farm agriculture in the center and north of Mato Grosso. Finally, the lack of success of the Northeastern development strategy, together with the lure of some Amazonian policies, induced a growing inflow of peasants to the northern units of Maranhão.

Therefore, policies and socioeconomic processes originating outside the forest margins deeply affected the evolution of its agriculture and determined the spacial pattern we detected for this subregion.

III.2 Evolution of incorporated areas in forest margins

Forest margins in Brazil include a total of 131.7 million hectares. As of 1970, only 4.2% (or 5.5 million hectares) of this area had been incorporated into agricultural production. From that moment on, however, incorporated areas showed a significant increase, attaining 17.8 million hectares in 1985 or, 13.5% of the total area. (Figure M1) This growth indicated an average annual increment of some 820 thousand hectares.

The evolution of this process can be analyzed by looking at

land use and at regional changes in incorporated areas.

The most important reason for incorporation of land area is for use as pasture. Of the total 12.3 million hectares of forest margins lands which were incorporated between 1970 and 1985, 9.0 million (or 73.3%) became pasture.⁶ In addition, another 1.9 million hectares consisted of crop land (15.4%) and 1.4 million hectares of land (11.3%) lay fallow or was unproductive.

When the evolution of incorporated land area is examined by each sub-region of forest margins (section II.3.1), it can be seen that the most significant increase occurred in the sub-region of Large Projects, which showed an increment of 4.8 million hectares in the period (39.0% of the total increment), followed by the sub-region of Older Colonization, which showed an increase of 2.5 million hectares, equal to 20.3% of the total. These two regions which, together, make up most of what is conventionally called "Eastern Amazonia", thus jointly aggregated an additional 10.9 million hectares of incorporated land in 1985, corresponding to 61% of the total in forest margins at that time. (Figure M2)

In addition, as could be expected, these sub-regions show the

⁶It should be noted that, to some extent, the incorporation of pasture land is not independent from the rate of incorporation of crop land. Given the poor sustainability of agriculture in the region, it is probable that part of the land cleared for crop at one moment in time will eventually be converted into pasture.

greatest proportion of incorporated areas by comparison to their respective total land area (24.4% for the Large Projects sub-region and 38.7% for the Older Colonizations sub-region).

III.2.1 Spatial distribution of the incorporated lands

Some forms of utilization of land areas are more important in some sub-regions than others. Indeed, it can be seen in Table M.1 that the most important sub-region in terms of agricultural land area is that of Private Colonization (26.1% of the total crop land), the most important in terms of seeded pasture land is the Large Projects sub-region (44.0% of the total) and the most important in terms of land lying fallow or unproductive is the Older Colonization sub-region (42,1% of the total).⁷

Table 1

Spatial Distribution of the Utilization of Incorporated Land Area by Sub-Region, Forest Margins, Brazil, 1985. (in 000s of ha.)

SUB-REGIONS	Agric. %	Past. %	Fallow %	TOTAL %
Older Col.	549 21,4	2.033 19,1	1.912 42,1	4.497 25,3
Large Proj.	466 18,2	4.671 44,0	1.299 28,6	6.443 36,3
Official Col.	582 22,7	1.107 10,4	286 6,3	1.984 11,2
Private Col.	668 26,1	1.227 11,5	642 14,1	2.552 14,3
Mixed Areas	296 11,6	1.590 15,0	402 8,9	2.295 12,9
FOREST MAR.	2.561 100	10.627 100	4.541 100	17.771 100
% alteration	(14,5)	(59,9)	(25,6)	(100,0)

SOURCE: IBGE, Censo Agropecuário, 1985.

Undoubtedly, these differentiated outcomes of occupation

⁷The evolution of this process between 1970 and 1985 can be observed in Figures M3, M4 e M5.

reflect different settlement processes as well as the variety of public policies adopted in different regions. The main processes can be described briefly as follows:

a. **The sub-region of older colonization** is the oldest in terms of its phase of occupation, which explains why almost 40% of its total land area had been incorporated into agricultural activities in some form. Basically, this is an area affected by the expansion of the peasant front which, in turn, tends to run a collision course with the expansion of ranching activities. (Musumeci, 1987) The older age of this occupational process and the various "pressures" suffered by the peasant economy would, in some sense, explain the large quantity of fallow and unproductive lands as well as the slow growth of crop lands. At the same time, the simultaneous presence of ranching concerns in the area would explain the high incidence of seeded pasture lands in the region.⁸ Perhaps the most important observation concerning the usages of incorporated land is the significant increase in seeded pasture, together with the relative stagnation of growth in the incorporation of crop land and the slow expansion of the stock of fallow or unutilized lands. (Figure M6)

b. **The sub-region of large projects** presented the greatest increase in absolute terms, mainly due to the increase in pasture

⁸Correlating information on the utilization of land with that on land tenure would permit the verification of this hypothesis. Unfortunately, that cannot be carried out within the scope of this study.

lands. Seeded pasture land in the sub-region by itself accounted for 26.4% of all incorporated lands in forest margins areas in 1985. Apparently, this process is closely tied to the fiscal incentives' policy directed to large agricultural establishments and to the land speculation associated with it. (Becker, 1982).⁹ Nevertheless, as will be demonstrated below, increases in production in the area are much less significant than increases in land area given over to pasture in the region. Other points worth mentioning are the significant land area lying fallow or in disuse (1.3 million hectares) and the relative insignificance of crop land. (Figure M7)

c. Occupation of the **official colonization sub-region** is more recent. Until 1970, the region was practically virgin in agricultural terms. From the moment the BR-364 Highway was opened up and colonization programs undertaken, settlement became intensive. This is particularly so as of the late 1970s, when POLONOROESTE, which paved the highway and reinforced official colonization activities, began to be implemented. As of 1985, INCRA (the National Institute for Agrarian Reform and Colonization), had settled some 59 thousand families on rural lots in Rondonia, through some form of colonization projects or measures. (Torres, 1990a). Later, this movement was extended to Southeast Acre, particularly in the municipalities of Plácido de Castro e Rio

⁹It is estimated that, between 1965 and 1984, 1 billion dollars in fiscal incentives were destined to large-scale agricultural projects (Torres, 1990b).

Branco. In the sub-region as a whole, agricultural land has increased importantly. In 1985, the region made up 22.7% of the total crop land of forest margins, although it contributed only 11.1% of the incorporated area. Permanent crops made up a significant part of the total (39.2%) as did seeded pasture lands, (Figure M8), even in small and medium-sized establishments. (Millikan, 1988). Another element which will be discussed later concerns the doubtful prospects for economic viability in the region, in the absence of continued government subsidies (Martine, 1991).

d. **The sub-region of private colonization**, located predominantly in a region of ecological tension (i.e. between savannas and forest) shows the largest increase in agricultural land. From low levels in 1970, it became the most important agricultural area within the forest margins (26.1% of the total). As will be seen later, it is also the region having the highest technological and production levels. This is due, in part, to the pattern of colonization employed. Settlement was carried out largely by migrants from Rio Grande do Sul who had experience in modern agriculture, were at least minimally capitalized and who benefitted (at least in the initial stages of settlement) from access to subsidized credit and to modern technology adapted to transitional savannas areas. (Mueller, 1990) In this context, the expansion of soybean plantation was particularly significant. This particular crop benefitted, in addition, from general policies,

nationally-unified minimum prices and fuel policies. The increase in seeded pasture area is also noteworthy. (Figure M9)

e. **The mixed area of colonization**, so called because it was affected both by POLONOROESTE (official colonization) and by private colonization projects, shows relatively modest growth on various indicators of land utilization, although the increase in cattle ranching is greater here than in contiguous regions. (Figure M10)

III.3 Population and employment

III.3.1 Agricultural personnel

Employment in agriculture in the forest margins region more than doubled between 1970 and 1985, going from 634 thousand to 1500 thousand persons occupied in agriculture. Nevertheless, as can be seen in Table M.2, this growth has been occurring at declining rates and shows strong internal redistribution.

Thus, it can be seen from Table 2 that agricultural personnel grew at the rate of 8,2% a year between 1970-75, at 5.6% a year between 1975-80, and at 2,2% a year between 1980-85.

At the same time, there have been significant changes in the relative participation of agricultural personnel within different sub-regions of forest margins over time. Older Colonization areas

had a slow growth in agricultural personnel between 1970 and 1980, and then practically stagnated between 1980-85. Meanwhile, other sub-regions, such as the Official Colonization sub-region, showed rapid growth; thus, the former went from 69.9% of all agricultural personnel to 40.3%, while the latter gained 17.6% percentage points in the interim.

Table M.2

Agricultural Personnel. Forest Margins, 1970-85								(thousands)	
Sub-region	1970		1975		1980		1985		
	Occ.	Per. %	Occ.	Per. %	Occ.	Per. %	Occ.	Per. %	
Older Col.	437	68,9	524	55,7	587	47,6	589	39,3	
Large Proj.	92	14,5	160	17,0	229	18,6	314	20,9	
Official Col.	59	9,3	142	15,1	238	19,3	405	27,1	
Private Col.	8	1,3	24	2,6	61	4,9	82	5,5	
Mixed Areas	38	6,0	90	9,6	117	9,6	106	7,2	
FOREST MARGINS	634	100,0	940	100,0	1233	100,0	1500	100,0	
Growth rate	(8,2% a.a.)		(5,6% a.a.)		(2,2% a.a.)				

SOURCE: IBGE, Censos Agropecuários, 1970-1985.

In absolute terms, it can be observed that 40.0% of the increase in personnel occurred in the Official Colonization sub-region and 26% in the Large Projects sub-region. In the latter case, it is highly likely that growth was related to previously-existing peasant settlements.

In addition, the absorption of rural manpower in the different regions is related to type of crop, degree of technology, and intensity of occupation in the sub-region. An indicator of these differences can be seen in Table M.3, where data on number of

hectares in agricultural land is related to agricultural personnel.

While some sub-regions showed a low and stagnated ratio of hectare per occupied person of agricultural land over time (such as in the Older Colonization sub-region), others showed relatively higher and growing coefficients (such as the Private Colonization sub-region).

Table M.3

Agricultural Land by Occupied Personnel (hectares per worker)
Forest Margins, 1970-1985.

Sub-regions	1970	1975	1980	1985
Spont. Col.	0.84	0.96	1.02	0.93
Large Proj.	1.18	1.82	1.56	1.49
Official Col.	1.18	1.54	1.79	1.43
Private Col.	1.89	2.50	6.67	8.33
Mixed Areas	2.22	1.67	2.08	2.78
FOREST MARGINS	1.02	1.30	1.64	1.69

SOURCE: IBGE, Censos Agropecuários, 1970-1985.

The causes of this differential behavior are diversified and merit closer analysis:

a. In the sub-region of **older colonization**, the expansion of peasant agriculture appears to have reached its limits in terms of area and, given the traditional level of technologies used, of employment generation. Other factors of interest in this region are the expansion of cattle ranching - which uses little manpower - and the absence of any form of agricultural modernization.

b. In the sub-region of Large Projects, employment growth occurred principally outside the large establishments benefitted by fiscal incentives. (Yokomizo, 1989) Apparently, the peasant front in Maranhão (Sawyer, 1984), despite the frequency and intensity of conflicts over land, has managed to expand into this region somewhat, a fact which helps explain the relatively low ratio of hectares per person in this sub-region.

c) The sub-region of **public colonization** was practically the only rural area in Brazil which managed to absorb, in relative terms, large numbers of agricultural workers. (Martine, 1991) This occurred mainly as the result of strong governmental incentives to the formation of a peasantry in the sub-region. In any event, the strength of this movement appears to have declined greatly in the last half of the 1980s, largely due to the fiscal crisis of the government and the significant decline in the transfer of public resources to the region. At the same time, agricultural activity in the region never did manage to achieve a competitive commercial status due to the great distance to markets, the poor quality of soils and the inherent difficulties of dealing with tropical agriculture. (Martine, 1987) These factors are reflected in the relatively low correlation of area and employment in this sub-region.

d) As observed earlier, the **private colonization** sub-region is an area which, apparently, was born a modern venture. The degree of

use of technology has increased significantly and agricultural production, based largely on the production of soybeans, has grown importantly. For this reason, agricultural employment grew much more slowly than the land area under crops. Thus, the number of hectares per person occupied in agriculture grew 4.4 times in 15 years.

e) Once more, the **mixed area of colonization** presents a pattern which is intermediary between the areas of Private and Official Colonization, showing a number of hectares per occupied individual which is close to the average for the two sub-regions. In general, however, this sub-region does not show significant absorption of manpower during the interim.

III.3.2 Evolution of demographic growth

The relative growth of population by sub-region is analogous to the patterns observed with respect to the increase in agricultural manpower in the sub-areas of forest margins. That is, population increased but at declining rates of growth between 1970 and 1991. Moreover, within the area under study, internal redistribution was prominent, with Older Colonization sub-regions decreasing and all others showing commensurate increases, in relative terms. (Table M.4)

The sub-region with the greatest increase in relative participation was the Official Colonization area, which gained 12.5

percentage points during the period, against a loss of 25.7 percentage points in the sub-region of Older Colonization.

Table M.4

Evolution of Population in Forest Margins, 1970-1991 (thousands)

Sub-regions	1970		1980		1991	
	Number	%	Number	%	Number	%
Older Col.	1.038	58,8	1.462	44,1	1.728	33,2
Large Proj.	308	17,5	687	20,7	1.166	22,4
Official Col.	243	13,8	713	21,5	1.372	26,3
Private Col.	28	1,6	137	4,1	478	9,2
Mixed Areas	148	2,6	318	9,6	464	8,9
FOREST MARG.	1.733	100,0	3.316	100,0	5208 1233	100,0

SOURCE: IBGE, Censos Demográficos, 1970-1991.

Unfortunately, data on rural and urban residence from the 1991 Census are still unavailable at this writing. Nevertheless, there are strong indications that the proportion of the population in urban areas has increased significantly, particularly in the Private Colonization sub-region which, given the more capital-intensive characteristics of its agriculture and the low level of rural employment it generates, tends to concentrate population in urban areas.

It is also relevant to point out that the forest margins region as a whole showed a significant decline in its rate of population growth during the period under analysis. Thus, it went from an average annual growth of 6.5% a year in the 1970s to one of 4.2% in the 1980s. These data, disaggregated by sub-region, can be seen in Table M.5.

Table M.5

Rate of Growth of Population in Forest Margins Areas, 1970-91.

Sub-regions	1980/70	1991/80
Older Col.	3,5	1,5
Large Projects	8,4	4,9
Official Col.	11,4	6,3
Private Col.	17,1	12,3
Mixed Areas	8,0	3,5
FOREST MARGINS	6,5	4,2

SOURCE: IBGE, Censos Demográficos, 1970-1991.

Assuming a rate of natural increase of 3.0% a year in the area as a whole, it can be deduced that the sub-region of Older Settlement is already expelling large quantities of migrants; meanwhile, the Private Colonization sub-region would, under this assumption, continue to absorb large quantities of migrants.

Overall, however, it is plausible to assume that, during the 1990s, the forest margins region as a whole will receive relatively little net migration; indeed, with the possible exception of the Private Colonization sub-region, it will be a source of out-migration during this decade. Perhaps even more important is the fact that, in the future, migratory movements will be increasingly less important in the growth patterns of the forest margins area; it can be safely predicted that natural increase - which itself will, more and more, tend to reflect urban fertility patterns - will set the future pace of population growth in the region. (Sawyer et. alii, 1990)

III.4. Land tenure

As stated earlier, agricultural activity in forest margin areas underwent a spectacular increase between 1970 and 1985. The number of agricultural establishments grew from 204 thousand in 1970 to 375 thousand in 1985. Land area incorporated into agricultural activity showed an even more striking increase, from 17 million to 52 million hectares, during the interim. Despite variations over time, concentration of land remained extremely high throughout the period. Figure M.11 dramatically highlights this disequilibrium. Therein, it is clearly demonstrated that small farms, which constitute the bulk of all agricultural establishments, control a very small segment of the total land area. At the other end of the scale, farms having more than 100 km² each, which are almost negligible in number, control a major section of the total land area.

Although concentration of land in the hands of a few establishments is the most marked characteristic of land tenure in the forest margins region throughout the period under study, this feature shows variations over time. A significant point which is worth drawing out in this connection is the high correlation between the variations in patterns of land tenure over time and the shifts in policies at the national level.

In general terms, it can be stated that the 1970-75 period was marked by an official emphasis on small-farmer colonization. A

large-scale effort was made to occupy the Amazon region with small farmers, thereby relieving social pressures in other depressed areas and, at the same time, attending to the needs of the military government's geopolitical strategy. The effects of this amazonian strategy clearly spilled over into forest margins areas and are visible in the multiplication of small farmers during this period.

By contrast, the 1975-80 period saw a sharp reversal in government approaches to the occupation of "virgin" lands. Basically, it abolished the strategy of small-farmer occupation and concentrated on attracting large-scale "modern" enterprises to the region. (Martine, 1980 and Fearnside, 1984) Moreover, it extended the perimeter of its settlement concern to include the Amazonian periphery as well as non-Amazonian lands. Government strategy during this period is best represented by the "Land Regularization", "Fiscal Incentives" and "Growth Pole" programs which were implemented or reinforced at this time.

The outcome of this strategy clearly favored the multiplication of larger farms and enterprises. But it also contributed to the intensification of conflicts with small farmers who pre-existed in the region or who had later been attracted to it by the ufanistic propaganda of the early 1970s. To some extent, Polonoroeste was an anomaly in the overall scheme of things, to the extent that it represented an effort to conciliate the overall economic strategy directed to the Amazon region with social

concerns as to the fate of small farmers.

The early 1980s were marked by the beginning of the most profound economic crisis in modern Brazilian history; this is reflected in public policies towards agriculture and towards frontier expansion, and thus in the resulting structure of land tenure. In essence, the fiscal crisis cut off the availability of funds for subsidized credit, for fiscal incentives, for minimum price policies and for other forms of government largesse. The shortage of funds was soon felt by producers throughout the country, accustomed as they were to subsidies and modernization-promotion incentives. Such measures had, as mentioned elsewhere in this paper, favored speculation in land and thus, provoked a spiralling of land prices which, ultimately, expelled small producers and generated a massive rural exodus. (Mueller, 1987, Martine, 1987)

All of these trends were arrested by the crisis period; this reversal, in turn, appeared to create a new social space wherein a greater number of small farmers gained access to land and were able to maintain themselves in rural areas during the height of the crisis. There is no question but that this was only a temporary setback of prior modernization and concentration trends, but, as seen below, it had a great influence on land tenure during the 1980-85 period.

But patterns of landholding also vary significantly according to the history and type of occupation in each of the sub-regions of the forest margins. The next paragraphs attempt to analyze trends in land tenure in these different areas of settlement and their interaction with the changing macro framework. Obviously, the size and internal heterogeneity within each of these sub-regions makes generalization difficult; nevertheless, the real differences between sub-regions in landholding - despite these difficulties - validate the classification scheme. The discussion which follows is based on Figures M.11 to M.16.

a. **The older colonization sub-region.** As can be seen from Figure M.12, the form of occupation characterized here as "Older Colonization", underwent a relatively small and irregular increase in its number of establishments during the 1970-85 period. Within the area of forest margins as a whole, this sub-region was, by far, the most important category in terms of number of farms. Nevertheless, its participation in the total number of farms in the area of forest margins decreased from 72% in 1970 to 48% in 1985. Evidently, this is due to the fact that, on the whole, the areas in this category had attracted the greatest number of settlers prior to the initial date of the period under study (i.e. 1970). Since then, this area has suffered much less drastic changes than other categories.

Nevertheless, several characteristics of the changes in land

tenure in this sub-region are worth noting. On the one hand, it can be seen that the number of establishments in it has fluctuated over time. First, a marked increase occurred between 1970-75, but then the total number of farms receded again between 1975-80. This is generally consistent with overall changes, described above, affecting the prospects of small farmers in the Amazon region at the time. But it is also interesting to observe that the number of farms in this category rose again in the 1980-85 period. This, as has been explained above, can be traced to the effects of the deep economic crisis in Brazil which, *inter alia*, had the effect of reducing subsidies for modern agricultural production, thereby curtailing speculation in land and opening up new possibilities for small-scale subsistence farming.

It is interesting to note that, although the number of farms grew slowly and irregularly, the land area classified under this category more than doubled during the 1970-85 period, going from 3.2 to 6.7 million hectares. Evidently, the general trend towards large-scale incorporation of land provoked by public policy in the pre-crisis period was responsible for this increase. As noted earlier, much of it is due to the growth of ranching activities in the region. From 1970 to 1980, the increase in land area was rapid and significant, particularly in the larger size-categories of farms. However, it is interesting to note that, between 1980 and 1985, the largest farms actually suffered a reduction in total land area, with the slack being taken up by farms in the intermediate

categories. This finding corroborates the idea that the crisis period reduced interest in land speculation and favored the possibilities of smaller farmers having access to land.

b. The large-scale projects sub-region. As shown in Figure M.13, the most prominent features of land tenure in this sub-region are the highly-skewed distribution of land and the rapid increase in land area, particularly in very large establishments. Indeed, this area, which benefitted from various types of fiscal incentives, began the period under analysis with 5.1 million hectares for 23 thousand establishments and reached 1985 with 18.7 million hectares for 55 thousand production units. Thus, the average land area which, in 1970, already attained 222 hectares per farm - despite the fact that 65% of the farmers had less than 50 hectares - increased to 338 hectares per farm in 1985. A total of 194 establishments, equivalent to 0.7% of all units, controlled 7.4 million hectares, for an average of over 38,000 hectares per farm.

Again, it is interesting to note that, during the crisis period, the number of small farms (0-50 hectares) expanded sharply - although their share of the total land area did not improve noticeably.

c. The official colonization sub-region. As could be expected, this sub-region, predominantly settled through official

colonization programs, presents a much less-skewed distribution of land than other areas in forest margins. Undoubtedly, the main feature of land tenure in this sub-region is a considerably smaller proportion of all establishments having less than 50 hectares and significantly higher proportions in the two intermediate categories i.e. 50-200 hectares and 200-1000 hectares. At the same time, the proportion of all establishments and land area in farms having 1000 or more hectares is surprisingly high; thus, for instance, it is considerably higher than that found in older spontaneous settlement areas. (Figure M.14)

The evolution of land tenure over time within this sub-region portrays interesting patterns. Thus, for instance, it can be noted that the apportionment of 100 hectare plots between 1970 and 1975 clearly affected the overall land distribution by inflating the 50-200 ha. category. Between 1975-80, "Rapid Settlement" schemes in Rondonia continued to favor the distribution of smaller plots - including those in the under 50 ha. category. Thus, the proportion of establishments in the smaller-sized categories increased. On the other hand, the "Land Regularization" program favored larger establishments and caused an abrupt shift towards concentration of larger segments of the total land area in the two largest farm-size categories.

The Polonoroeste program persisted with the small-farmer strategy and thereby favored the redistribution of land between

1980-85; the least-concentrated land distribution in the various areas under analysis within the forest margins region resulted from the sum of these various land distribution schemes aimed at small farmers. Another factor which helped to reduce land concentration was the fact that many of the settlers who gained access to a piece of land under official colonization programs either sold or rented part of their plot to other migrants. The latter thus became sharecroppers or tenant farmers on small pieces of land which resembled, in size, the plots which they had left behind in their respective regions of origin. (Martine, 1990)

e. The private colonization sub-region. The extremely skewed landholding structure in this category reflects the basic strategy adopted by farmers and entrepreneurs who had gained access to large tracts of land in one of the various land distribution, fiscal incentives or "regularization" schemes promoted by the government during the 1970s. Through such measures, the land area in this sub-region showed the greatest relative increase. From a total of 2.2 million hectares in 1970, this region increased to 10.2 billion hectares in 1985; most of this increase occurred during the 1975-80 period when the various land distribution schemes were applied. (Figure M.15)

Basically, private colonization programs grew out of the attempt to generate rapid income gains by the recently-legitimated owners of large tracts in the Amazon or pre-Amazon region. The idea

was that landowners would divide up a minor proportion of their total land area into small plots which would then be sold to colonists. The size of the plots and the amount of infrastructure provided by the developer varied from project to project, but it was calculated that the resources generated by selling these plots would permit the developer to initiate his own agricultural production; meanwhile, the labor pool accumulated in the colonization projects would be tapped by the developers for their own activities. (Hébert, 1982; Almeida, 1989)

The land tenure system which grew out of this approach correctly reflects the disequilibria involved. Before these programs were initiated, three-quarters of the establishments owned 1% of the land area while 1.5% of the establishments controlled 75% of the land. The main changes in this distribution occurred in the 1975-85 period, when the number of establishments increased greatly and the largest category (10,000 ha. and over) reduced its share from 75% of the total land area in 1975 to 59% in 1980 and 46% in 1985. Altogether, the number of establishments in this category remains small (9,945 out of a total of 255,884 in the forest margins region) and the land distribution highly skewed.

f. Mixed colonization areas. As was to be expected, the landholding patterns in this region are less clearly defined. It has the highest proportion of establishments in the smallest size class of any sub-region except the "Older Colonization" area. Yet,

it has also maintained, over time, the highest proportion of its total land area in the largest size category of establishments of any sub-region except that of private colonization. Interestingly enough, it is the only sub-region which did not show a significant increase in small farms during the 1980-85 crisis periods. Given the indefinite characteristics of the region, there appears to be little point in trying to analyze these features in any detail. (Figures M.16)

e) **Overview of land tenure in the forest margins region.** The analysis of landholding patterns in different sub-regions and periods of time provides a source of tantalizing hypotheses and observations. The size of the categories units utilized in the analysis, and the variety of historical contexts encompassed therein, obviously hinder generalization. Nevertheless, several points stand out. One is that there definitely are clear differences between different sub-regions shaped by diverse historical contexts. Another is that the impact of public policy has undoubtedly been significant in the configuration of land tenure in different sub-regions. Actually, the enormous diversity of approaches by the State in different regions, with different social groups in different periods of time, would itself constitute matter for a fascinating study.

Lastly, the prospects for future landholding patterns are largely uncertain; the most recent period for which data are

available show a recurrence of the growth of small farming units in the context of the economic crisis. Whether and to what extent land has become reconcentrated in more recent years is difficult to ascertain.

III.5 Production and productivity

In this section, the recent evolution of production and productivity in the forest margins regions is analyzed.

Table M.6 presents several indicators of production and productivity with reference to various crops in the forest margins region and compares them with indicators at the level of the country as a whole.

Table M.6

Production and Productivity of Various Products in the Forest Margins Region and in Brazil, 1990

	Regional Production (000s tons)	% of Brazil's Total (%)	Productivity M.F. Region (ton/ha)	Productivity Brazil (ton/ha)
Rice	872	11,7	1,05	1,88
Beans	131	5,9	0,51	0,48
Corn	753	3,5	1,06	1,87
Soybean	1.377	6,9	1,90	1,73
Coffee	267	9,1	1,13	1,01
Cassava	2.889	11,9	11,89	12,56

SOURCE: IBGE, Produção Agrícola Municipal, 1990.

Initially, it can be observed that the forest margins region accounts for a maximum of 12% of national production in any one crop. Only in cassava, rice and coffee is the region's production

equivalent to more than 7% of the national total.

It has been demonstrated that the modernization of Brazil's agriculture has affected only a few of the agricultural production chains (Silva e Kageyama, 1987). In this connection, it is interesting to note that only in crops which have **not** been modernized does the forest margins region attain a level of productivity similar to that of the country as a whole. The one notable exception concerns soybeans, which has a high level of productivity by national standards. In this case, however, production is restricted to parts of the "Private Colonization" subregion, located in areas of ecological tension between the Amazon forest and the savannas.

In other words, productivity in the region is, for the most part, similar to that of the national average only with respect to the least dynamic crops of Brazilian agriculture. Given the great distance to national markets, and thus, high transportation costs, these low productivity levels do not bode well for the future agricultural prospects of the region. Changes in minimum price policies - which subsidize the transport of agricultural products from more distant regions - and fuel price equalization policies, discussed in sections IV.2.3.4 and IV.2.3.5, can have a serious detrimental effect on the region's economy.

Data on destination of crops produced in the region are

unfortunately unavailable. But, to some extent, the distance problem could be attenuated to the extent that the production of rice, beans, corn and cassava in the forest margins region were channelled to local markets in cities such as Belém, Manaus, São Luís, Porto Velho and others. Conversely, the distance factor can also serve as a barrier to the importation of these standard staples from other, higher productivity regions. In this sense, urban concentration and demographic growth in proximate regions tend to guarantee a local market which would ensure the survival of low and medium productivity regional agriculture in the forest margins region.

The prospects for the production of soybeans and coffee in the region are more problematical since they are basically destined to other regions in the country and to the export market. **Ceteris paribus**, these crops would have to have considerably higher productivity levels than the national average in order to justify their continued production in the forest margins region.

In this vein, it is also pertinent to examine the evolution of productivity over time. The data in Table M.7 address this issue by examining the variation of productivity of different crops in the forest margins region and in Brazil between 1984-1990.

These data highlight the difficulty of the situation being faced by the forest margins region, which has suffered a large

decrease in productivity in rice, corn and cassava, in contrast to significant gains in productivity at the national level. The case of rice, is particularly serious, both in view of its large productivity loss and its traditionally important role in frontier regions. (Velho, 1972)

Table M.7

Changes in the Relative Productivity of the Forest Margins Region and of Brazil in Selected Crops, 1984-1990.

Products	Forest Margins	Brazil
Rice	-22,8	11,5
Beans	6,2	-3,4
Corn	-4,5	6,3
Soybeans	0,0	1,2
Coffee	13,0	-11,2
Cassava	-6,5	6,3

SOURCE: IBGE, Produção Agrícola Municipal, 1984 e 1990.

These declines in productivity are, in all probability, related to a reduction in the fertility of the soil, coupled with a decrease in the rate of incorporation of new land. Rice is typically planted soon after clearing the forest cover; consequently, a decrease in deforestation tends to be associated with a decline in the region's productivity.

The increased productivity of coffee in forest margins - in contrast with a decrease at the national level - is also worth commenting. In this case, one should look closely at the data base; indeed, the first year of this comparison, 1984, relates to a period in which coffee trees in Rondonia (which is the main coffee-

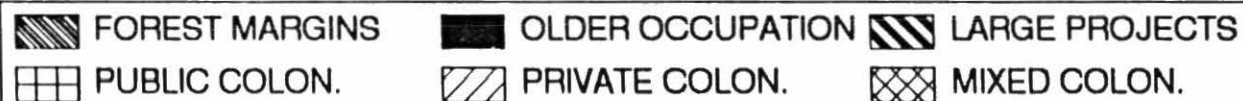
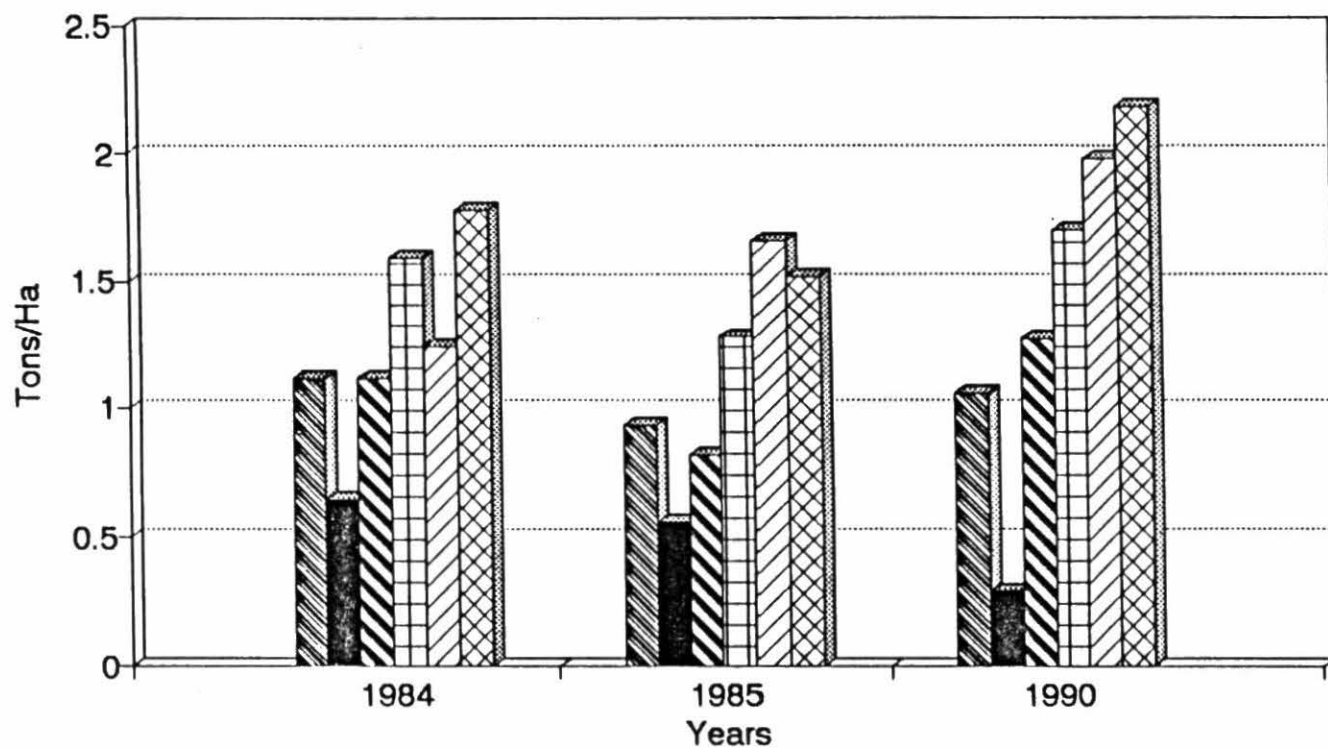
producing area within the forest margins region) had only recently begun to yield fruit. Thus, it is quite likely that the apparent increase in productivity shown here is spurious.

Overall, then, the 1984-90 period does not generally show increases in productivity capable of overcoming the initial shortcomings and disadvantages in productivity levels of the forest margins region nor in making up for the significant difficulties posed by the distance factor.

The following discussion addresses the situation of specific products in selected sub-regions.

a. Rice in the older colonization sub-region. This sub-region was responsible for 48.5% of the total production of that crop in forest margins, in 1984, with a total of 617 thousand tons. By 1990, this had decreased to 345 thousand tons and 39.6% of the region's total production. In large part, this is due to a striking loss in productivity (from 1.52 tons per hectare in 1984 to 0.79 in 1990). This result is consistent with the observations made earlier with respect to the significant increase in lands lying fallow or in disuse, to the increase in cattle ranching and to the division of small farms into even smaller units. It should be noted that a similar decline in productivity affected corn crops (Figures M.17 to M.20).

Fig M.20-YIELDS OF MAIZE
FOREST MARGINS, 1984-1990



b. Cassava in the older colonization sub-region and in that of large projects. Between 1984 and 1990, these two regions more than doubled their production of cassava; this went from 727 thousand tons to 2.101 thousand tons and made up 72,7% of cassava production in the forest margins region. Such changes, however, did not result from an increase in productivity (Figures M23 and M24). On the contrary, there are indications that the significant decline in productivity of rice in the Older Colonization sub-region and, to a lesser extent, in the Large Projects sub-region, has induced the substitution of rice crops with cassava on small farms, particularly on those which no longer had uncleared land areas. This hypothesis, however, merits further testing.

c. Soybeans and corn in the private colonization sub-region. This sub-region was responsible for 89% of the production of soybeans in the Forest Margins region, in 1990, and it had a productivity level above the national average (1.90 tons per hectare). By itself, the region produced 1,227 tons of soybeans, which corresponded to 6.1% of the country's production. Even considering the subsidies implicit in minimum prices and fuel policies, this production is certainly meaningful. Apparently, corn crops are also benefitting, in part, from this dynamism; thus, the productivity of corn grew significantly between 1984 and 1990, although at lower levels than that of soybeans. Not surprisingly, this region shows a considerable increase in the use of tractors. (Figures M19 to M22 and M25).

d) **Coffee in the official colonization sub-region.** Although productivity levels are similar to the national average in 1990 (1.2 tons per hectare) and although total production increased significantly from 52 thousand tons to 160 thousand, coffee cannot be considered a dynamic crop. First, this crop is on the decline at the national level and, secondly, the distance to ports of embarkation is too great to make exportation feasible. In any event, the region is responsible for 50% of the coffee production of Forests Margins and has played a particularly important role in efforts to establish permanent crops in the region.

III.5.1 The evolution of cattle ranching

Although we lack detailed data for the recent period, ranching would merit further discussion. In Table M.8, data on the number of cattle, on the dimensions of seeded pasture land, and on the ratio between cattle and land area for the 1970-1985 period, are presented.

Table M.8

Evolution of Cattle Ranching in the Forest Margins Region, by Selected Indicators, 1970-1985.

	Number (000s)	Rate of growth (%)	Seeded Pasture Land (000s ha)	Rate of growth (%)	No. of cattle per ha. of Pasture	Cattle per Km ² = 100 ha
1970	1.467	-	1.641	-	0,89	1,11
1975	3.043	15,7	6.629	32,2	0,46	2,31
1980	6.903	17,8	7.900	3,6	0,87	5,24
1985	8.924	5,3	10.627	6,1	0,84	6,78

SOURCE: Censos Agropecuários 1970-1985.

This table prompts several important considerations concerning the evolution of ranching activities in the forest margins region.

a. The rates of growth of both cattle and pasture area are quite high; over the period, however, pasture grew faster than the number of heads of cattle. This can be taken to indicate that speculative activities are at the root of much of the growth of pasture land. This notion is reinforced by the observation that variations in the rate of growth of pasture tend to follow the changes in fiscal incentives policy (see section III.1). Another important observation relates to the significant decline in the rate of growth of pasture over time.

b. The density of cattle per area of pasture varies little over time (except for the year 1975), which suggests that there have been few changes in ranching practices from a technical standpoint, during the period under review. At the same time, these levels, associated to relative low cattle densities, indicate area-extensive methods.

In sub-regional terms, the principal ranching zone is the sub-region of Large Projects, which accounted for 36.1% of the regional herd and 44.0% of the seeded pasture in the forest margins region; the Official Colonization and Mixed Colonization sub-regions also showed considerable increases.

In the Official Colonization sub-region, case studies have shown significant increase in the number of heads of cattle mainly due to the efforts of small and medium establishments. This would indicate the changeover from crop to pasture land. (Millikan, 1988; Hecht et alli, 1988)

Fig M.1-USE OF AGRICULTURAL AREAS
FOREST MARGINS, 1970-1985

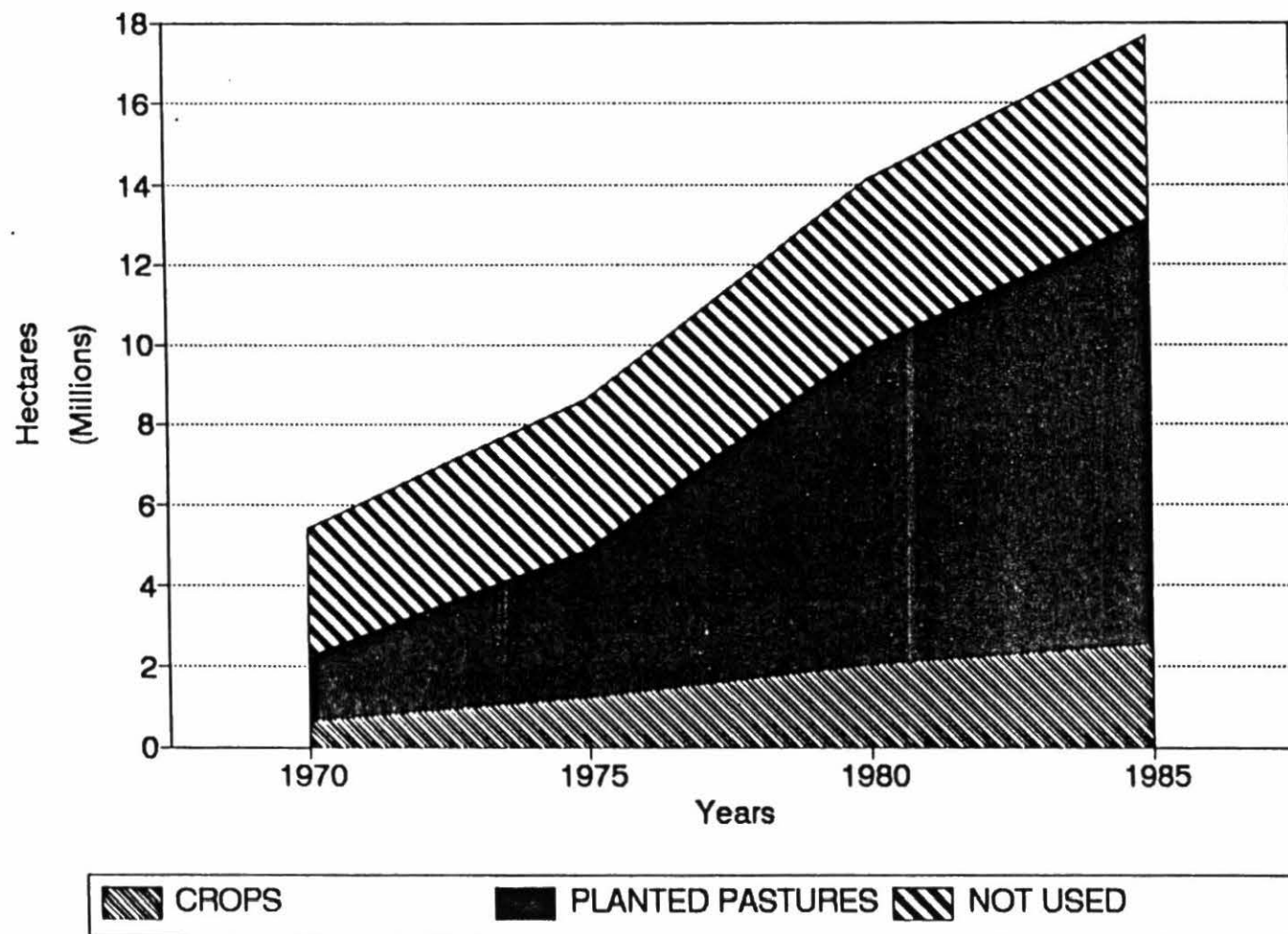


Fig M.2-THE AFFECTED AREA
FOREST MARGINS AND ZONES, 1970-1985

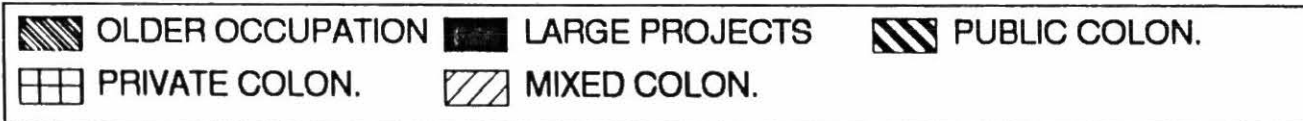
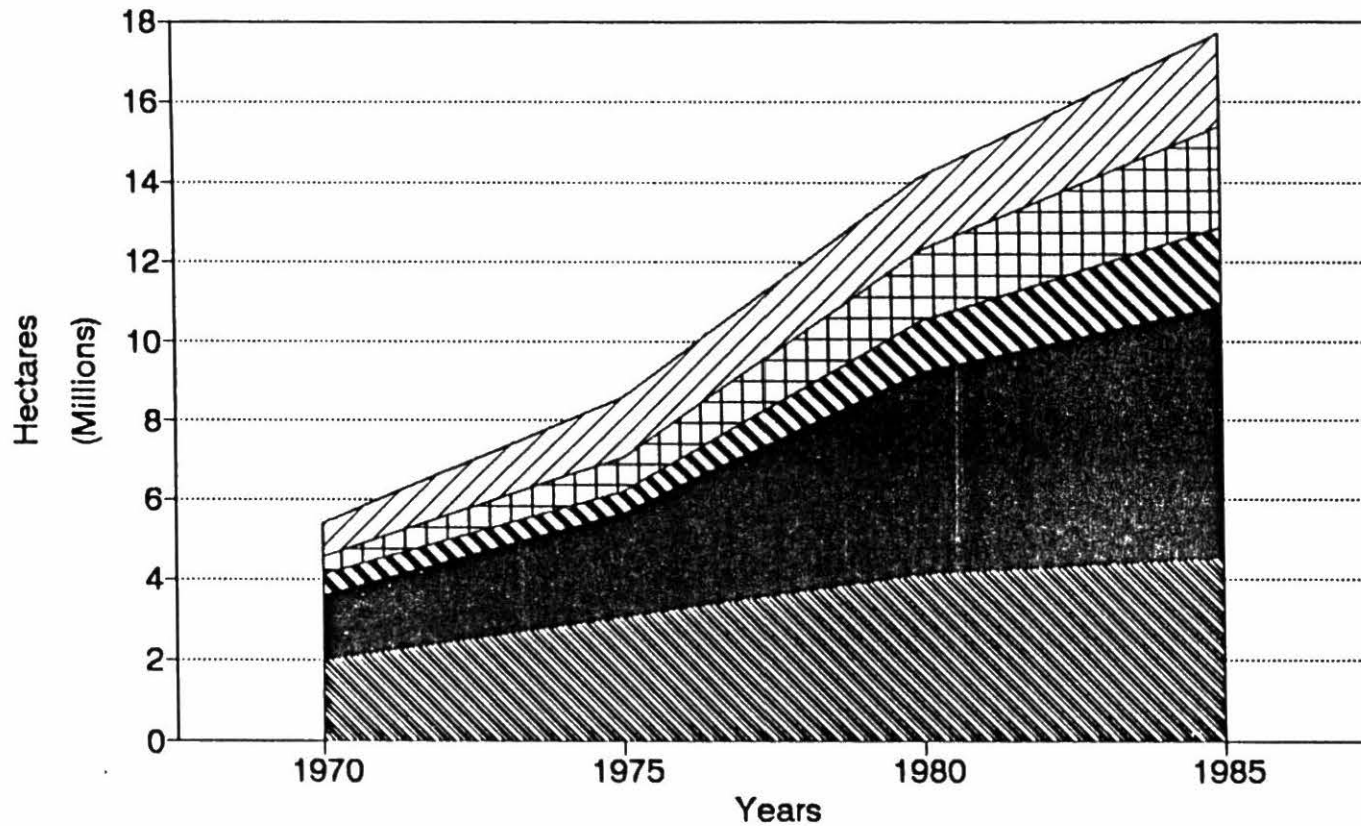


Fig M.3-AREA IN CROPS
FOREST MARGINS AND ZONES, 1970-1985

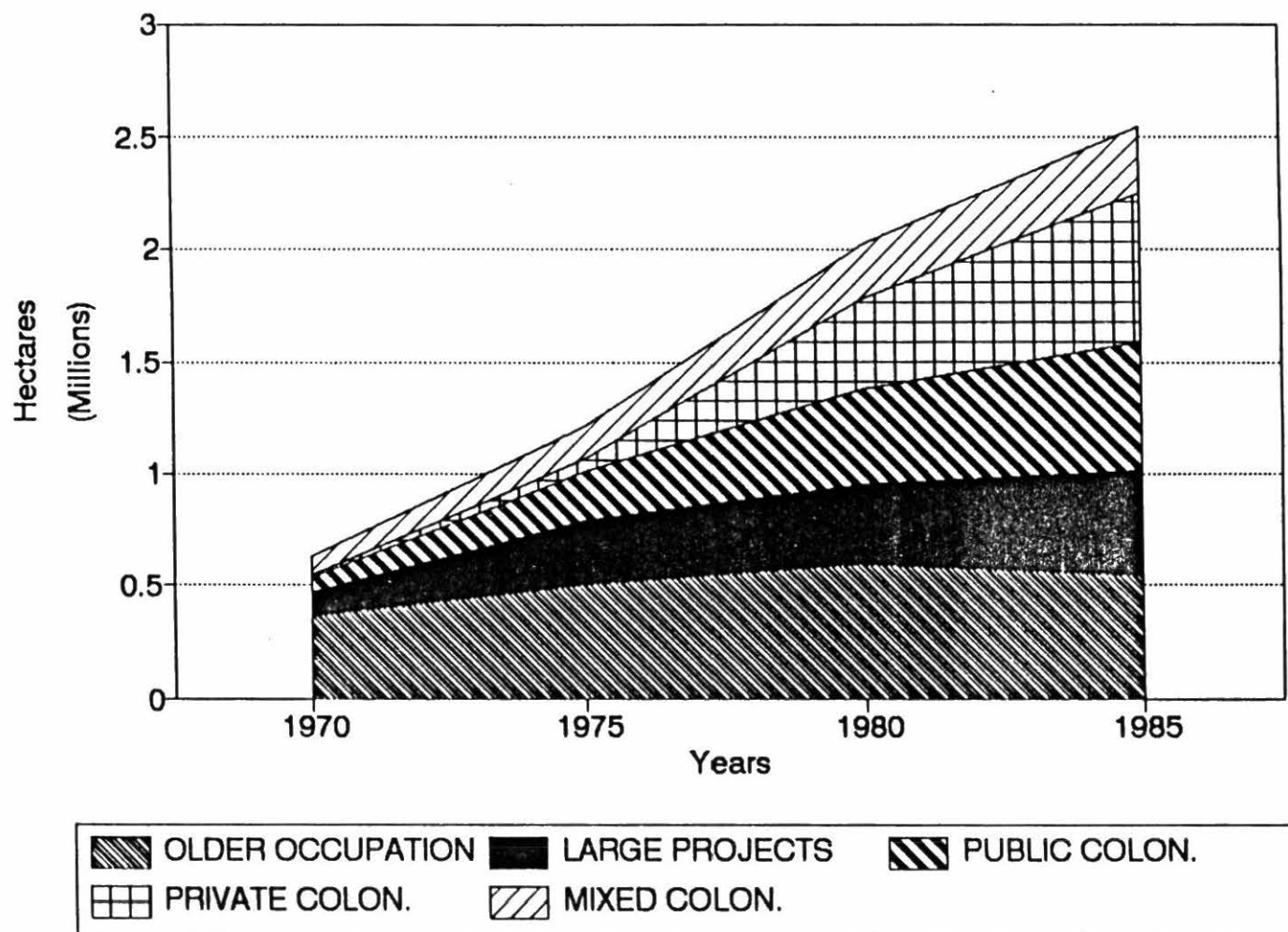


Fig M.4-AREA IN PLANTED PASTURES
FOREST MARGINS AND ZONES, 1970-1985

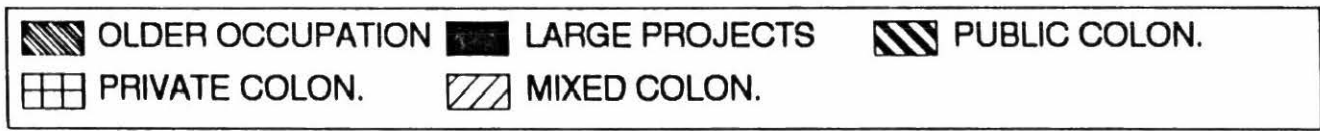
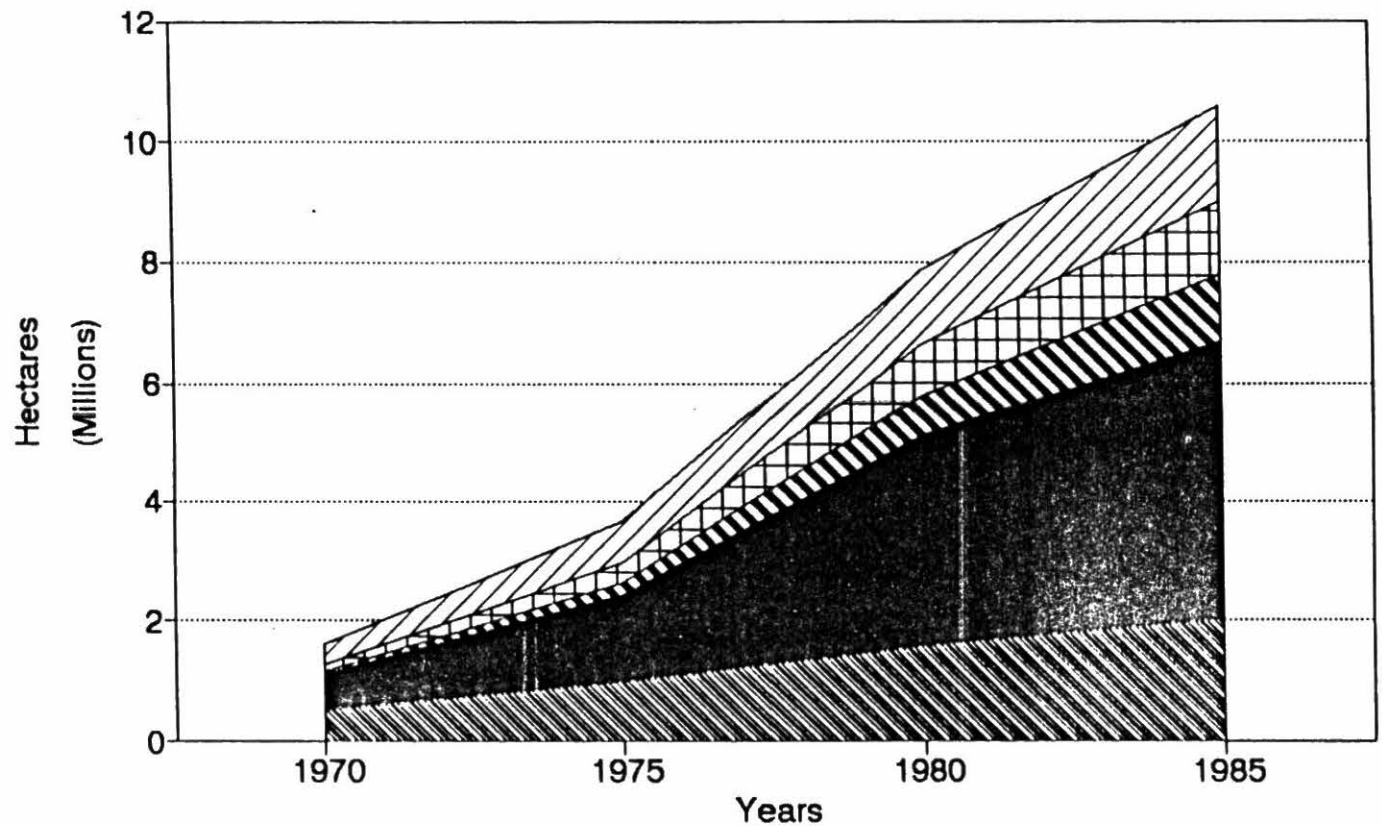


Fig M.5-AREA CLEARED BUT NOT USED
FOREST MARGINS AND ZONES, 1970-1985

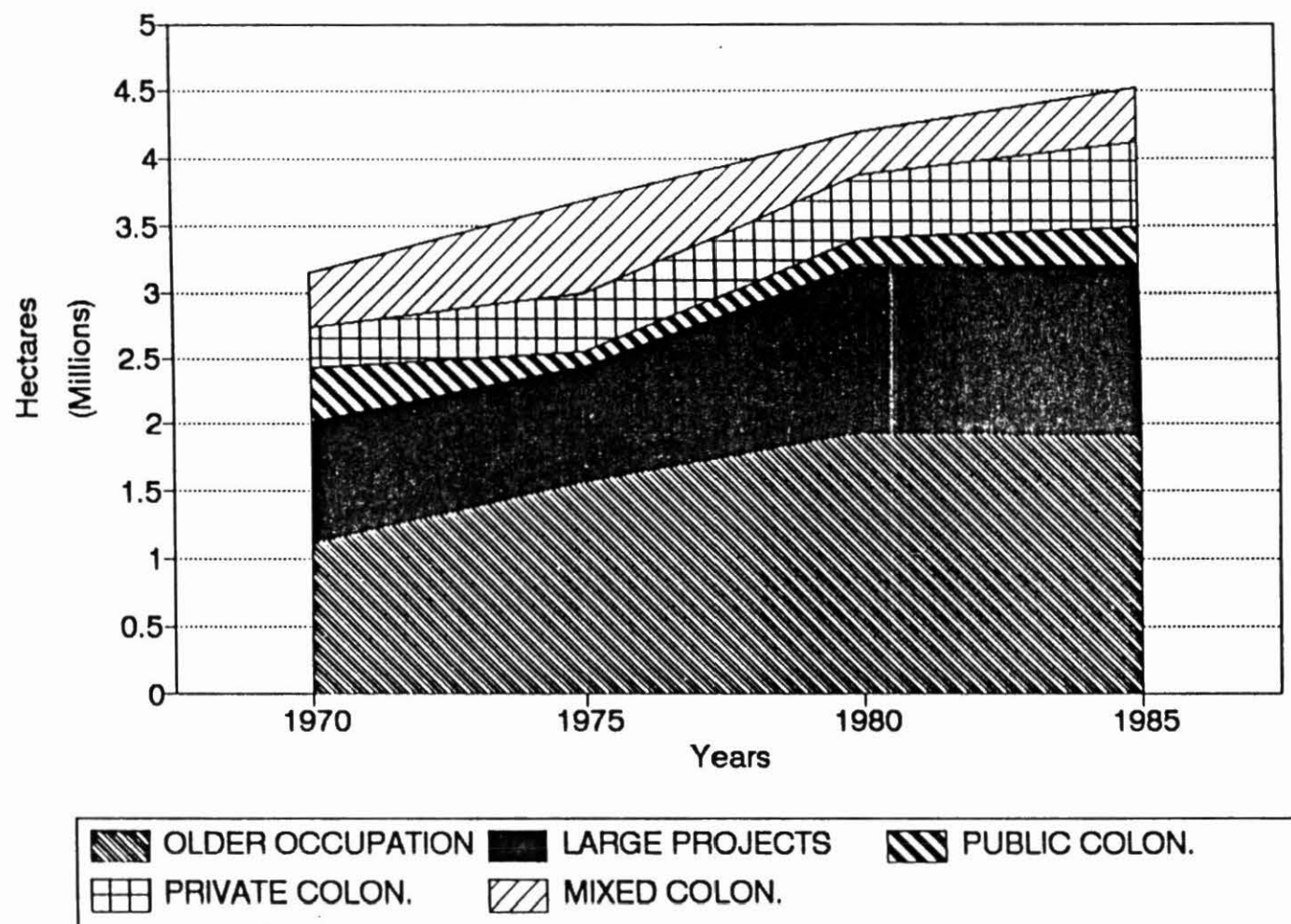
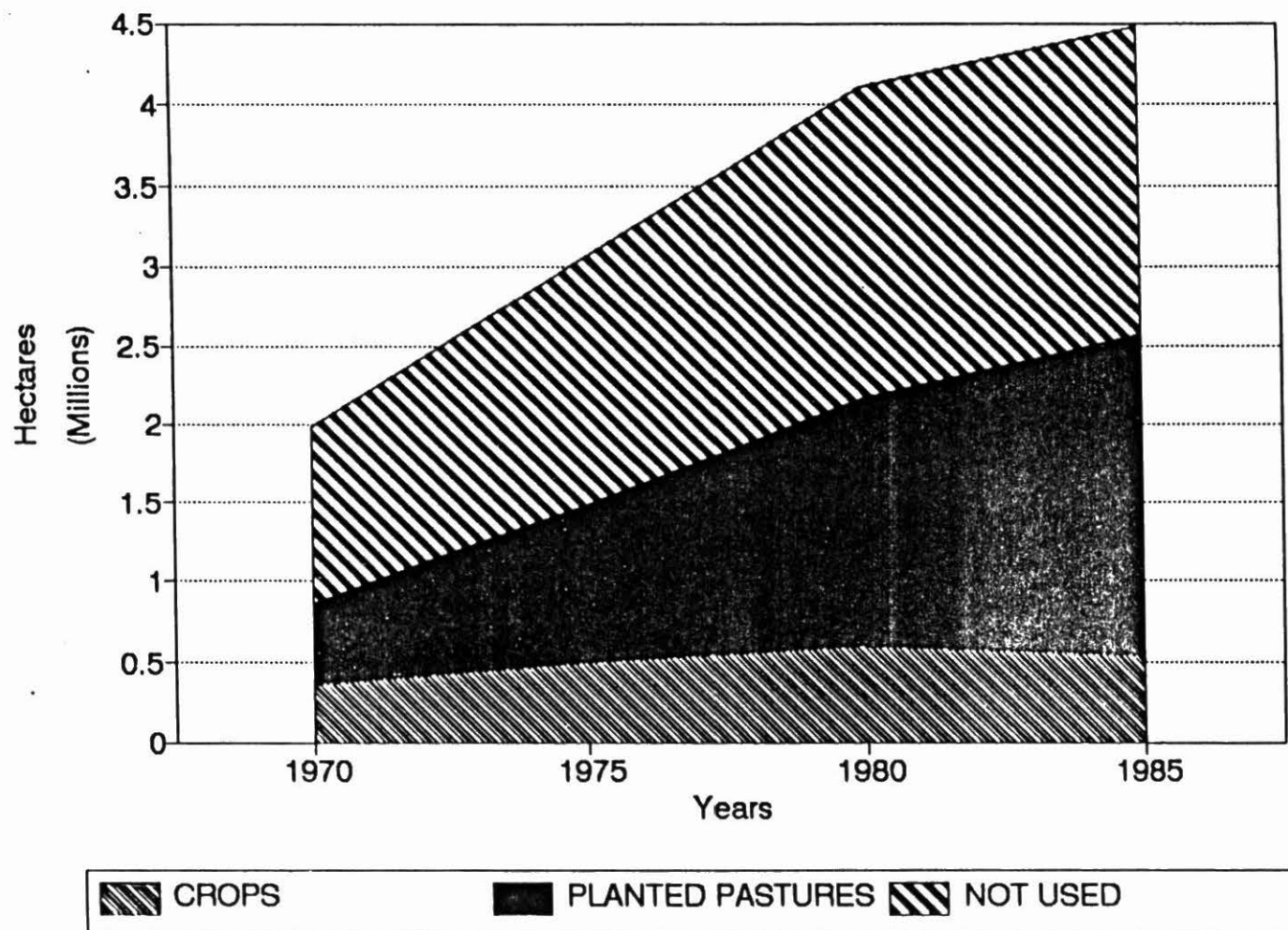


Fig M.6-AREAS AFFECTED BY AGRICULTURE
OLDER OCCUPATION



**Fig M.7-AREAS AFFECTED BY AGRICULTURE
LARGE PROJECTS**

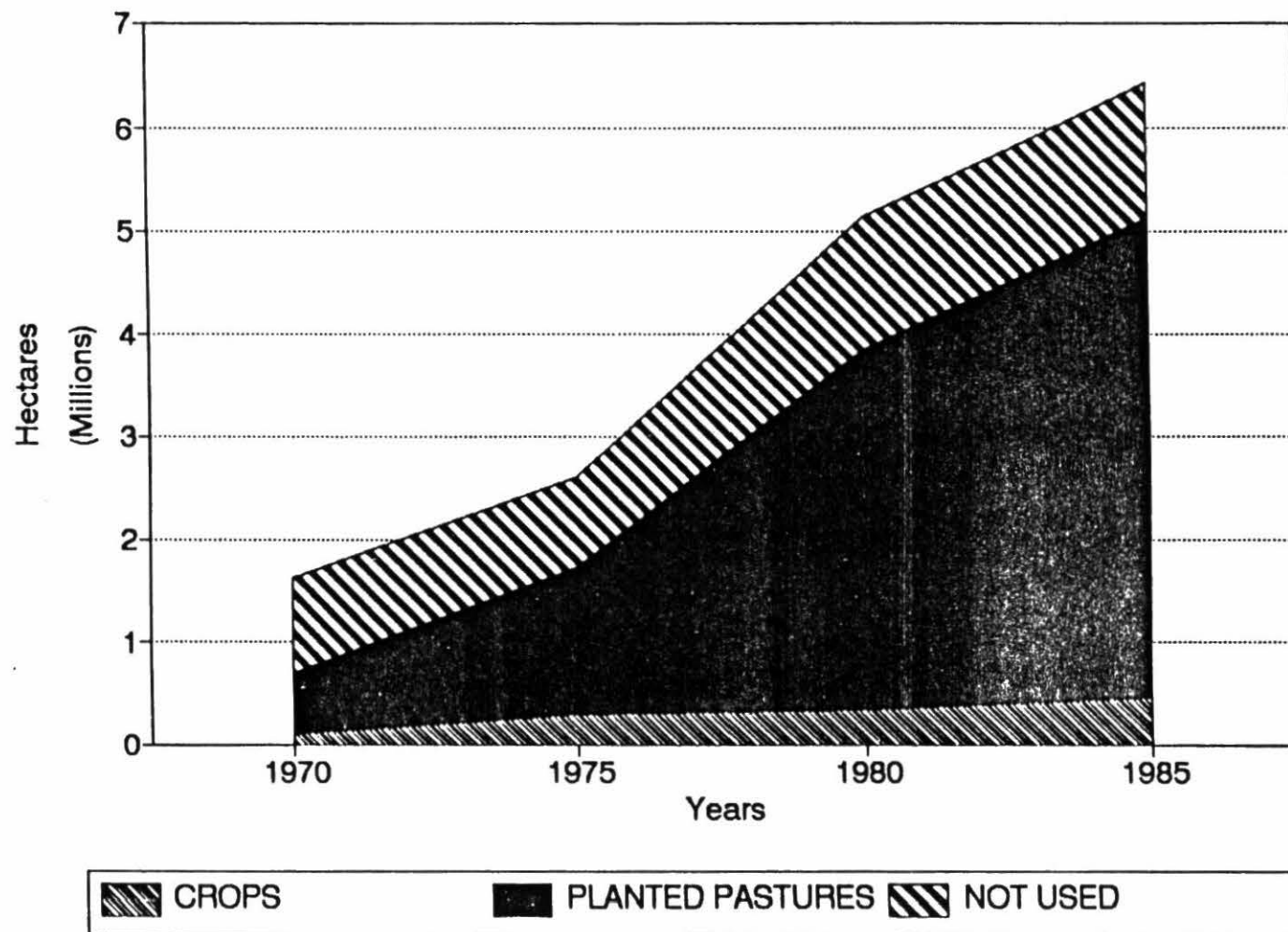


Fig M.8-AREAS AFFECTED BY AGRICULTURE
PUBLIC COLONIZATION

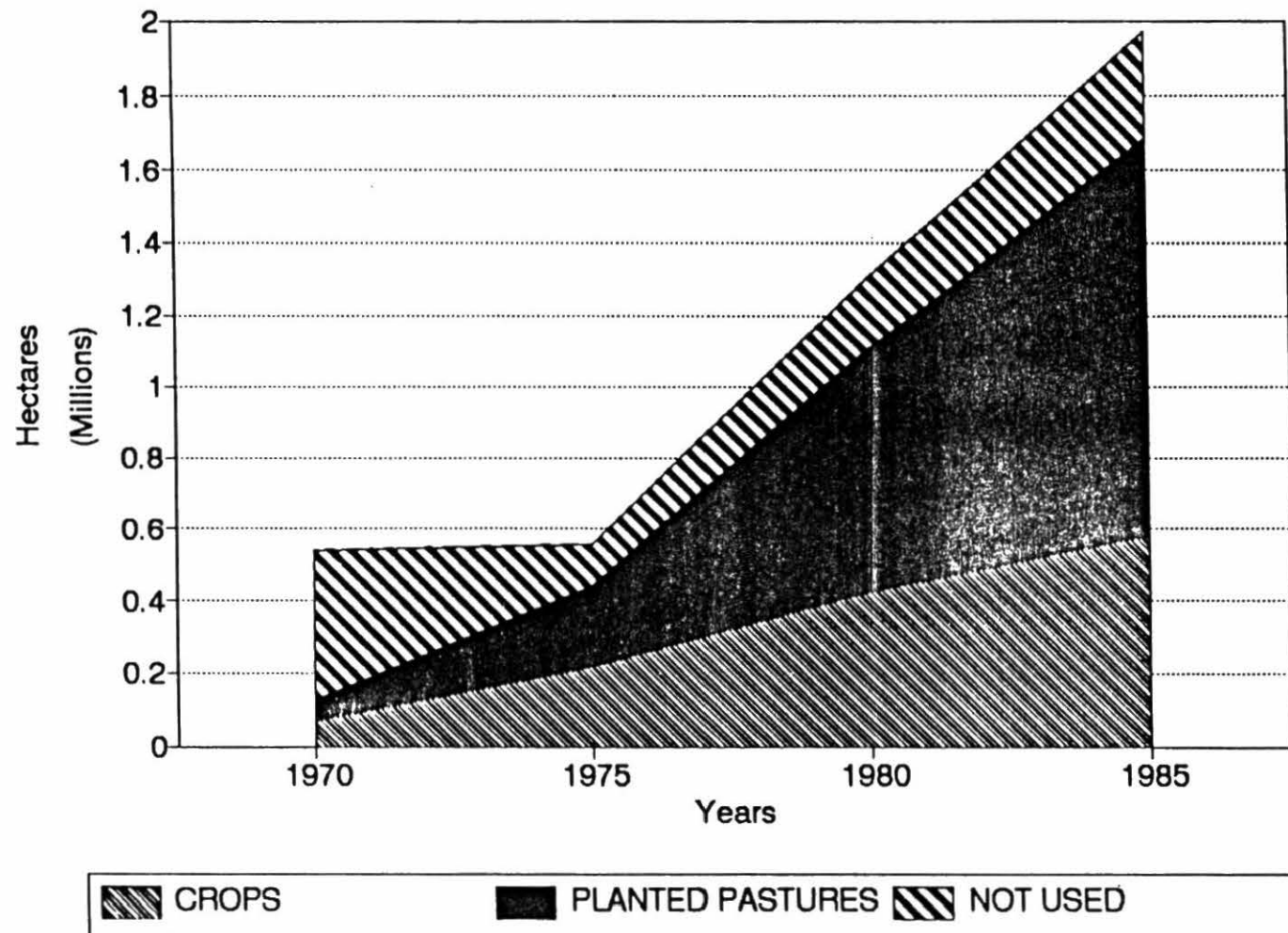


Fig M.9-AREAS AFFECTED BY AGRICULTURE
PRIVATE COLONIZATION

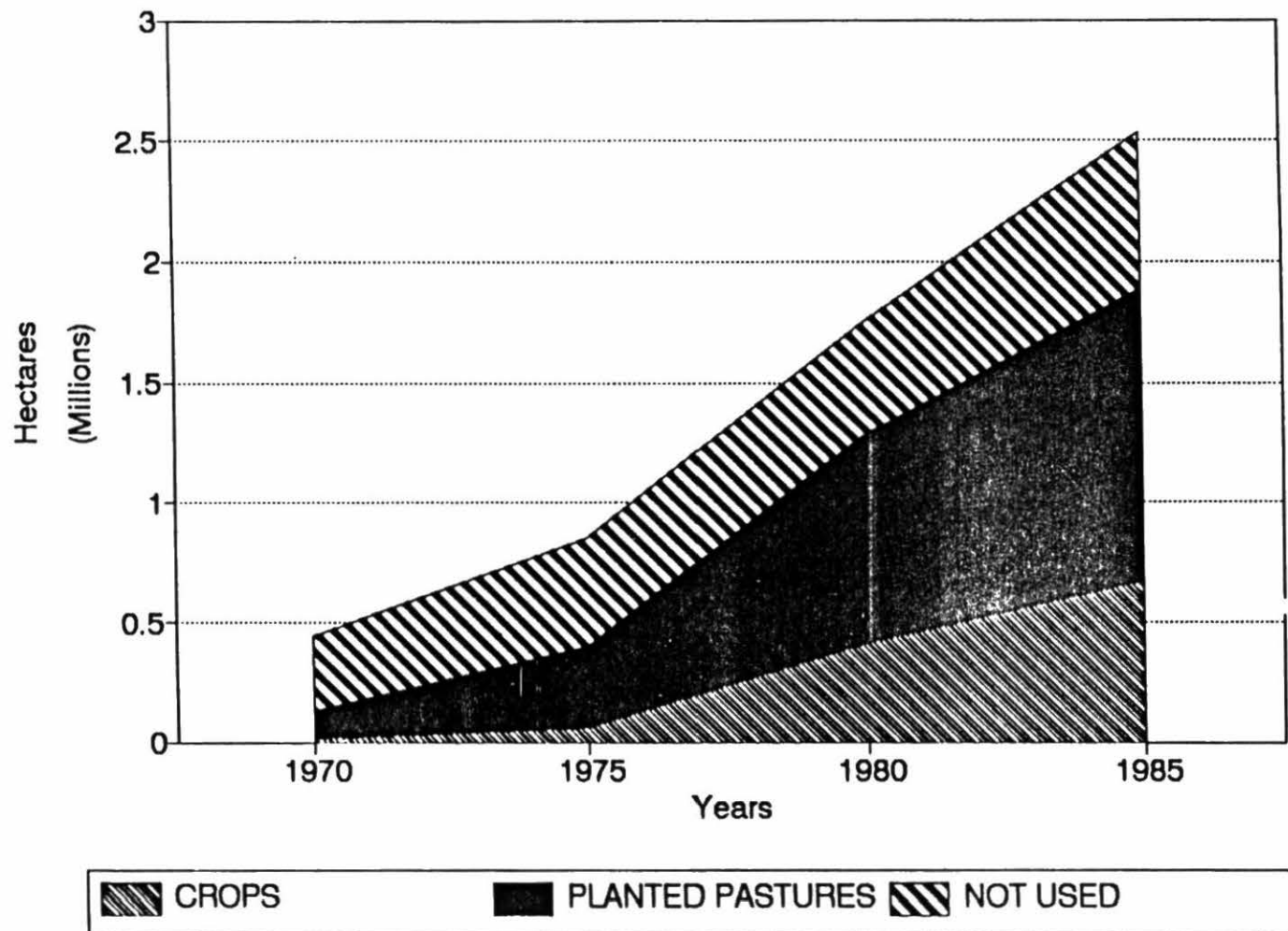


Fig M.10-AREAS AFFECTED BY AGRICULTURE
MIXED COLONIZATION

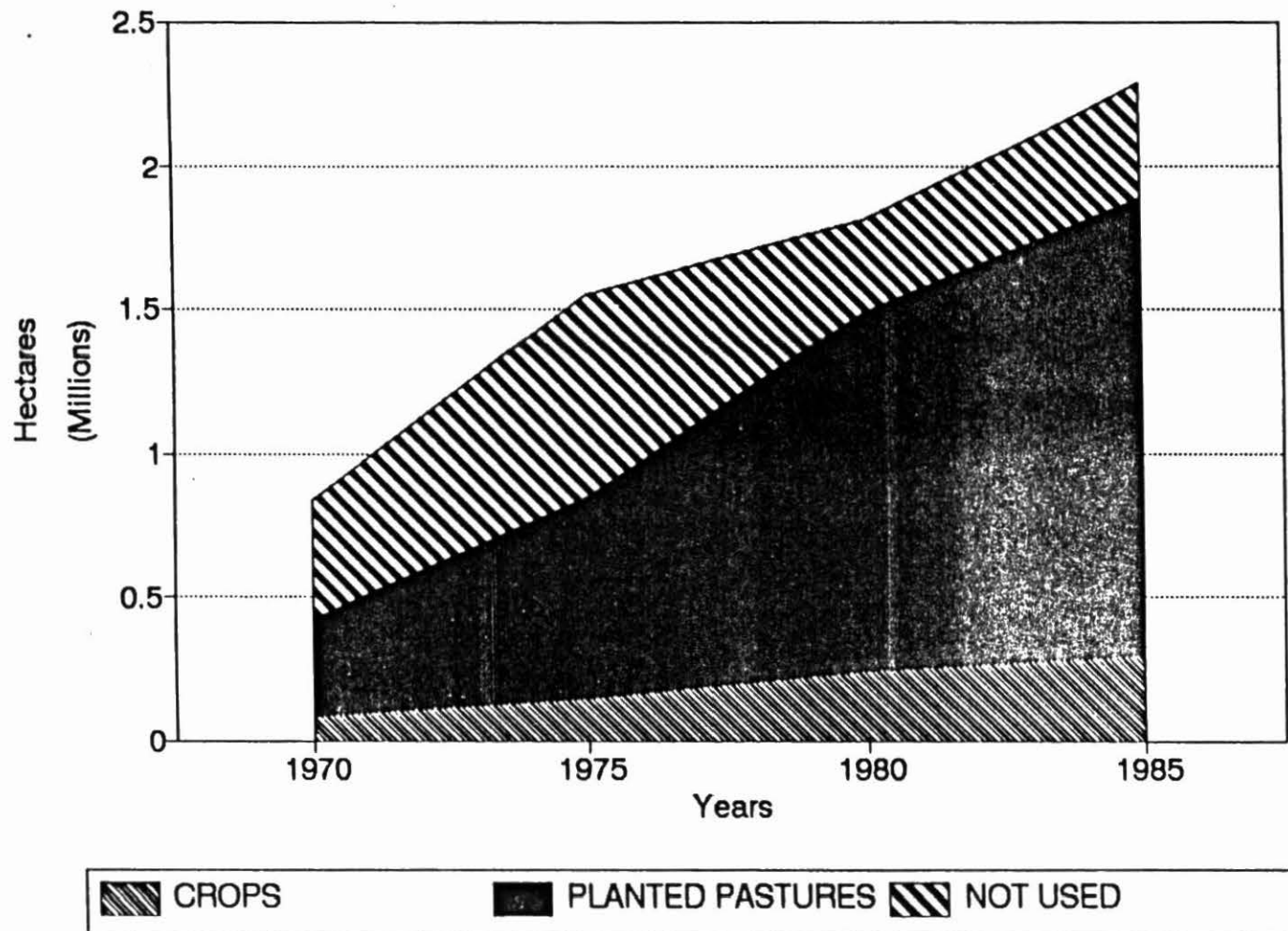


Fig M.11-FOREST MARGINS LAND TENURE

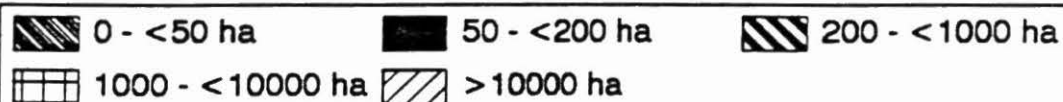
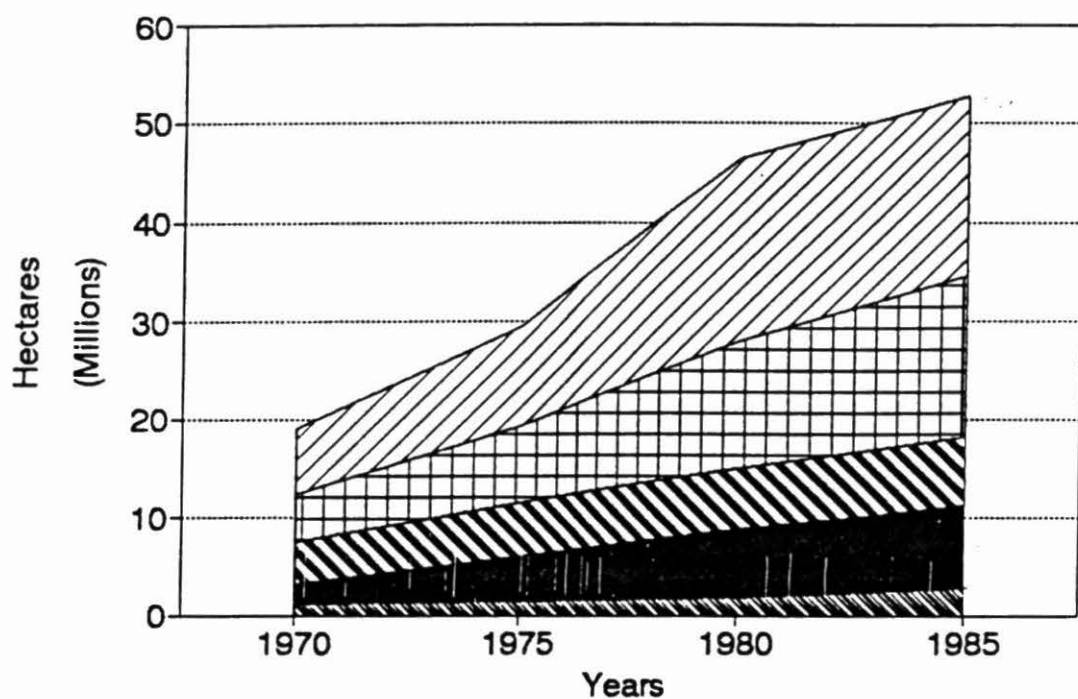
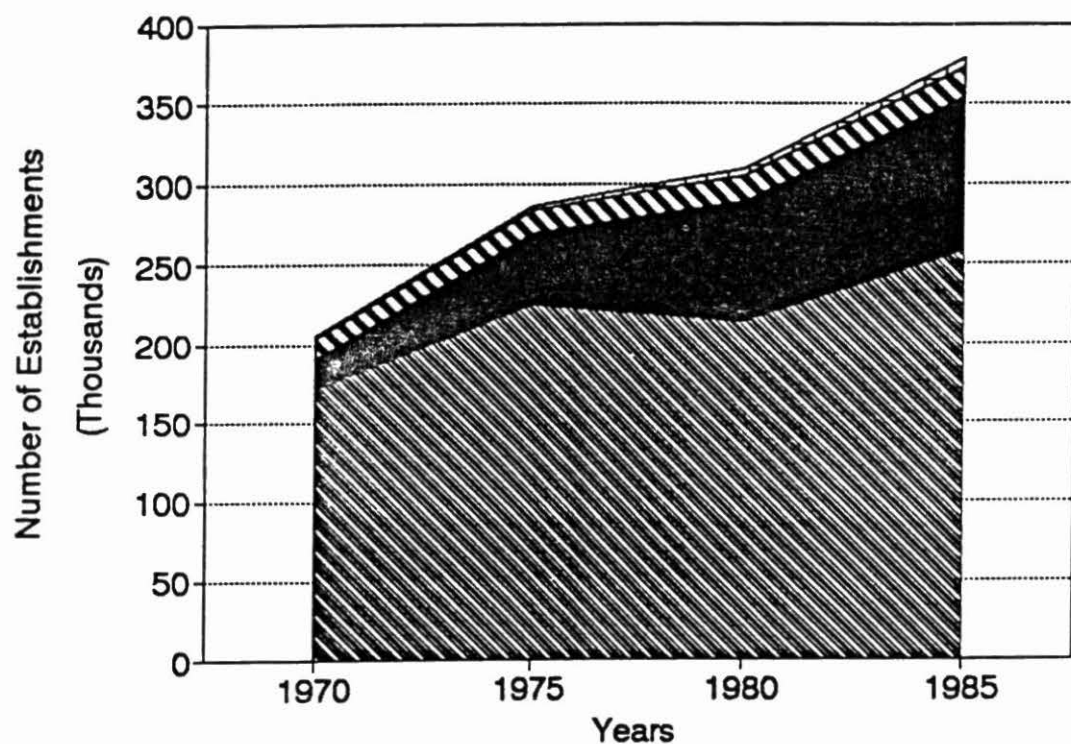


Fig M.12-OLDER OCCUPATION LAND TENURE

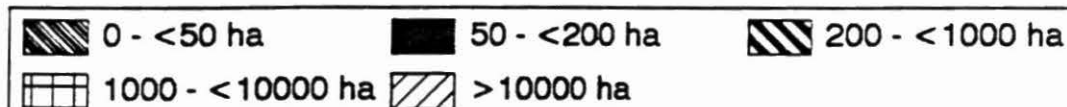
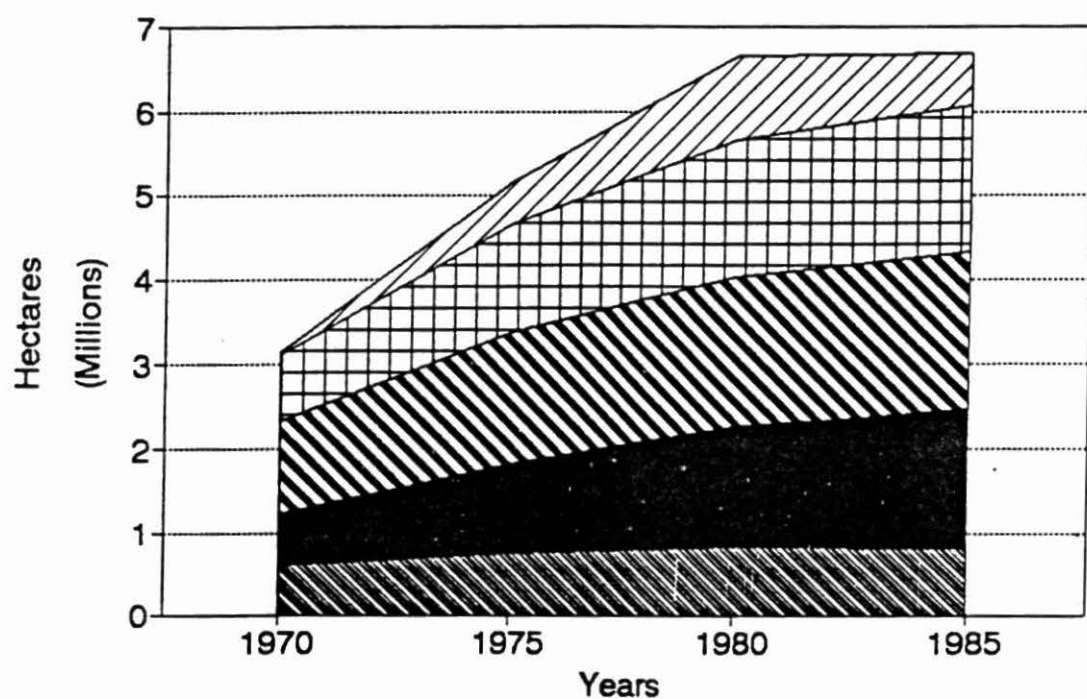
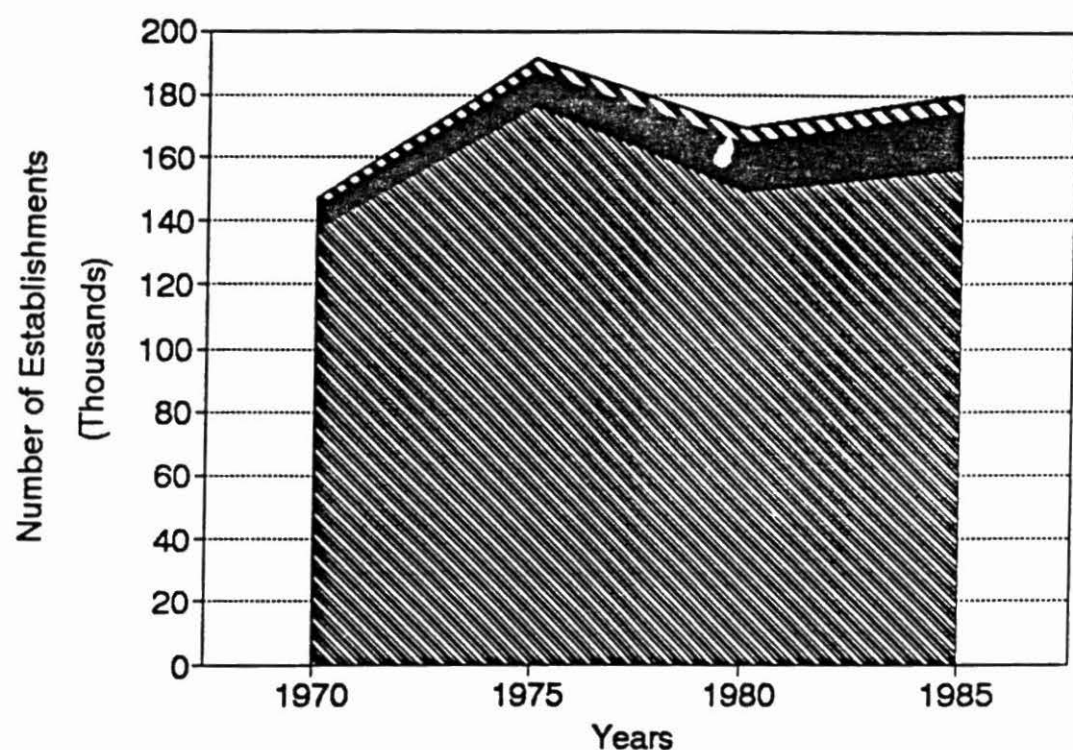


Fig M.13-LARGE PROJECTS LAND TENURE

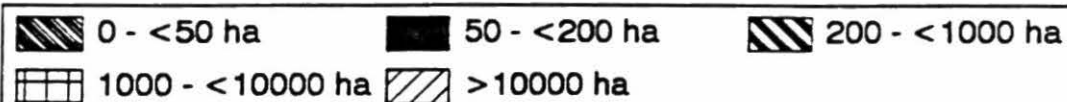
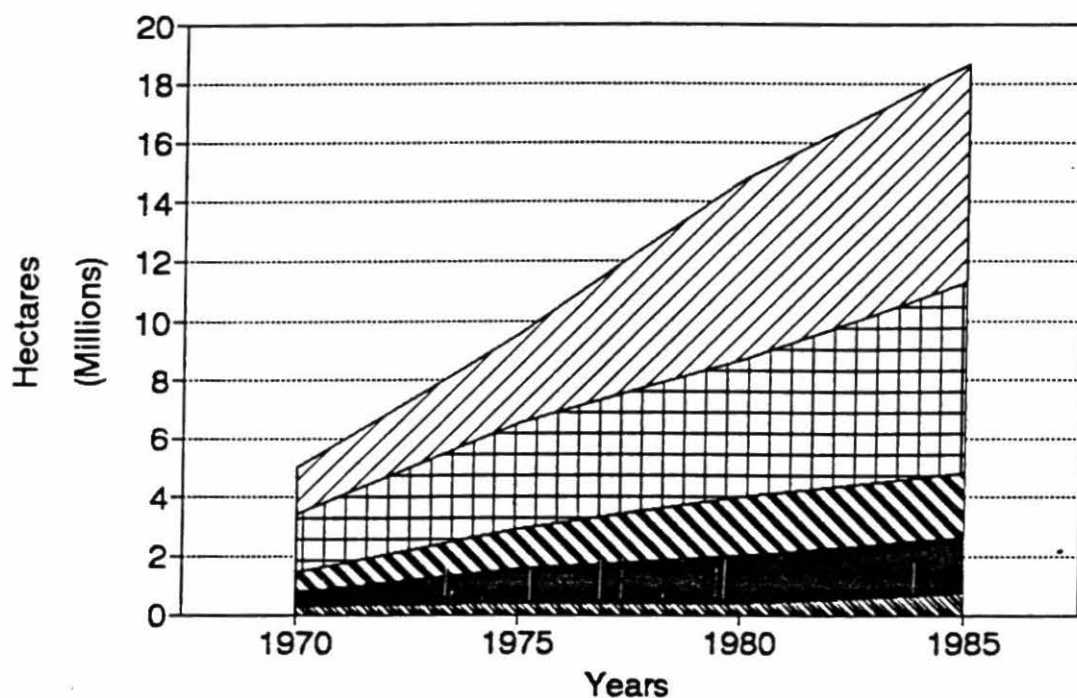
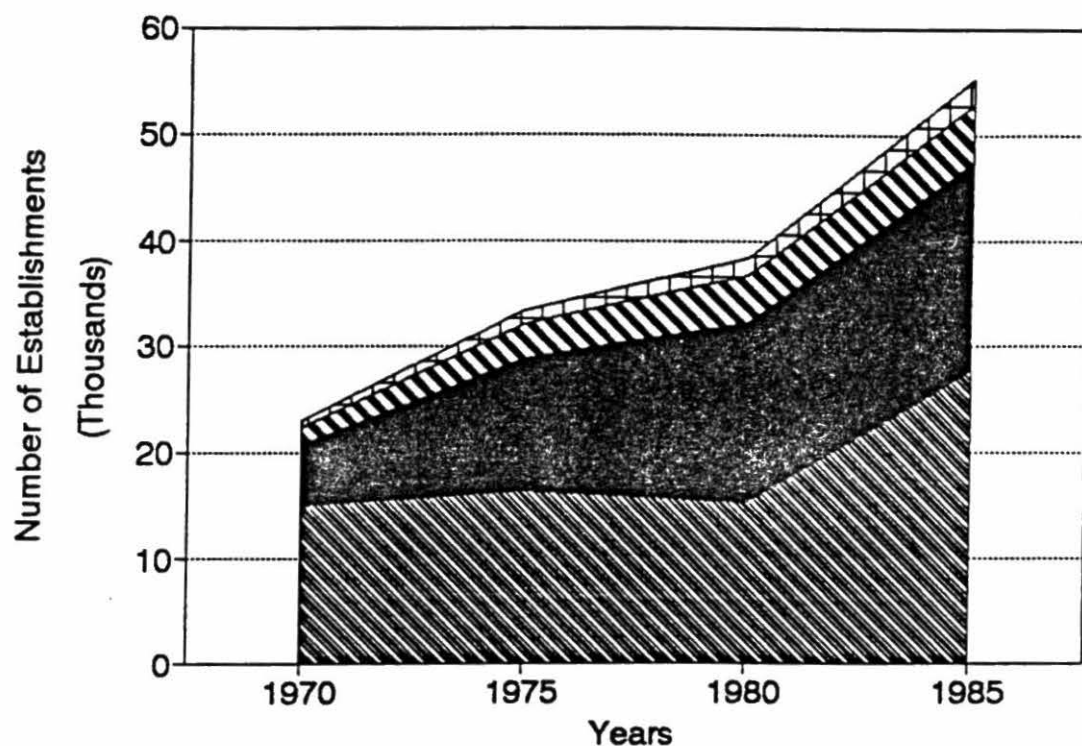


Fig M.14-PUBLIC COLONIZATION LAND TENURE

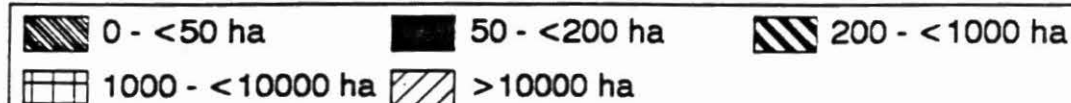
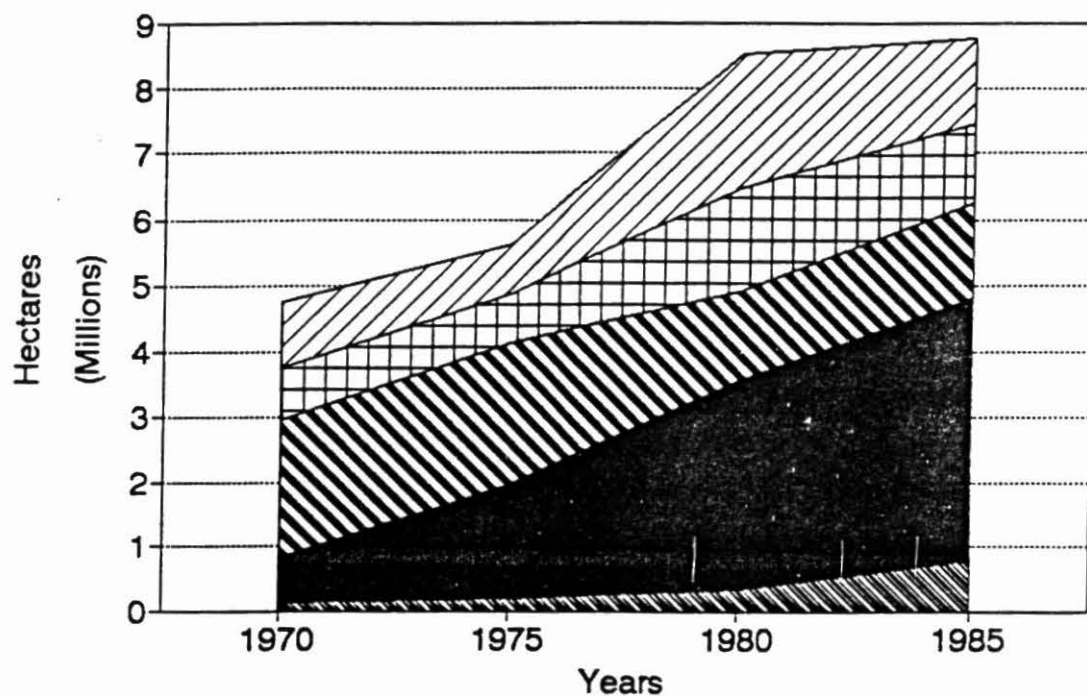
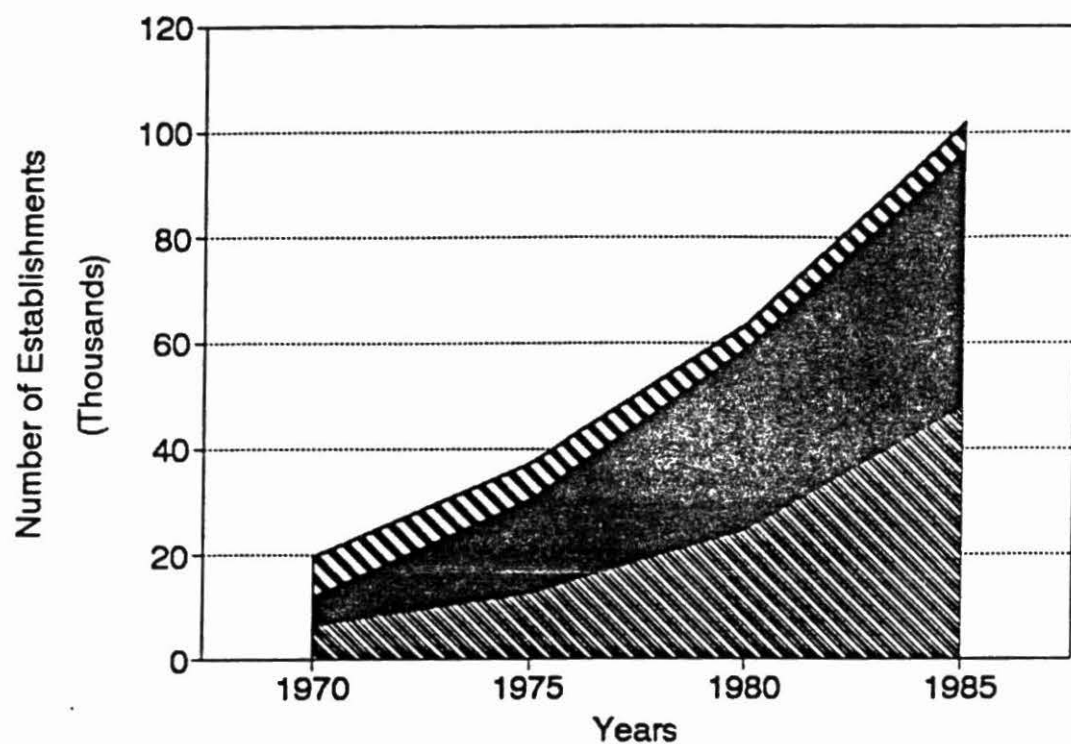


Fig M.15-PRIVATE COLONIZATION LAND TENURE

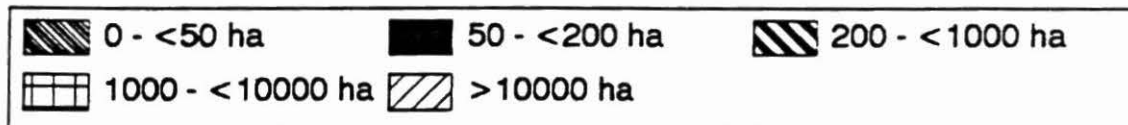
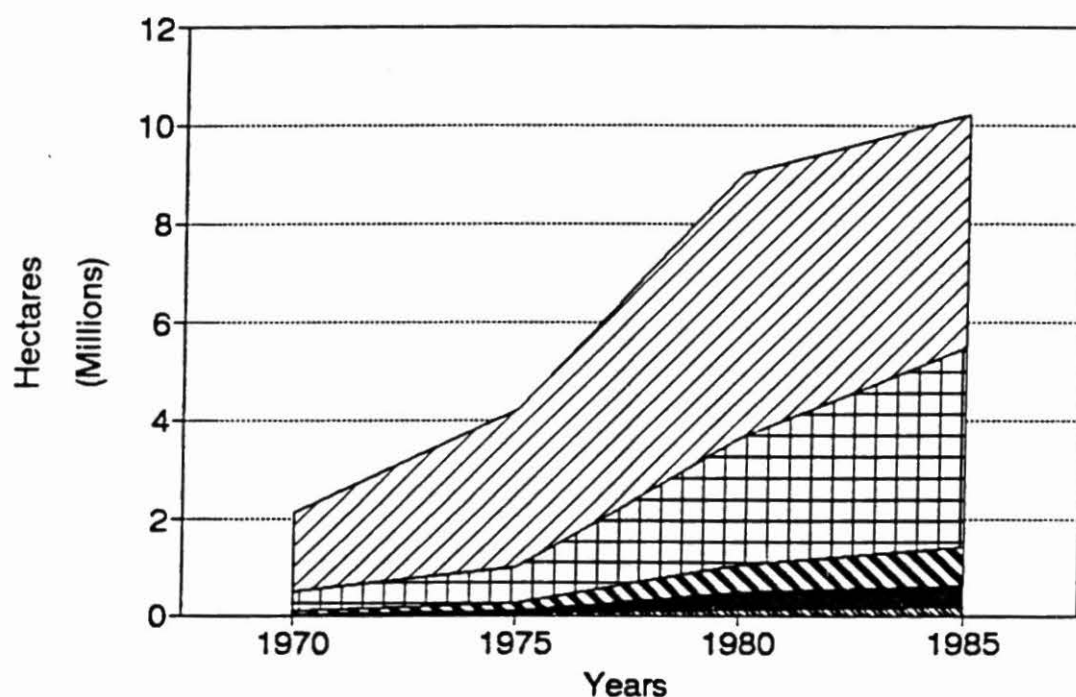
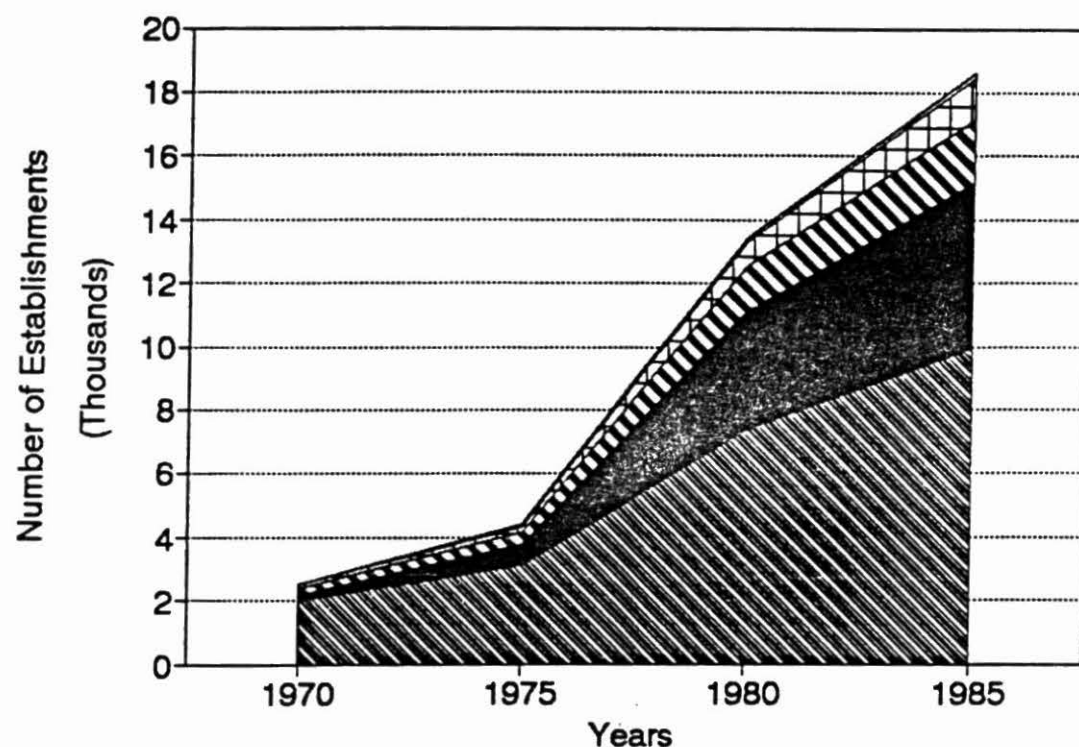


Fig M.16-MIXED COLONIZATION LAND TENURE

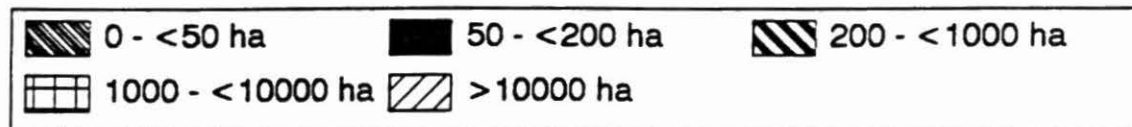
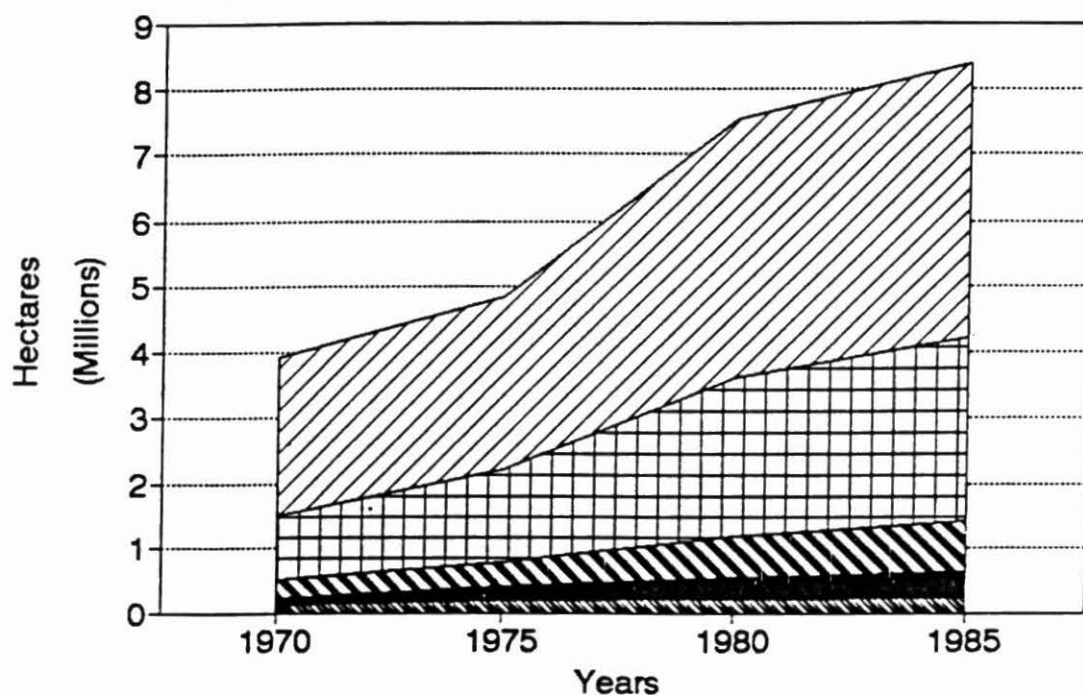
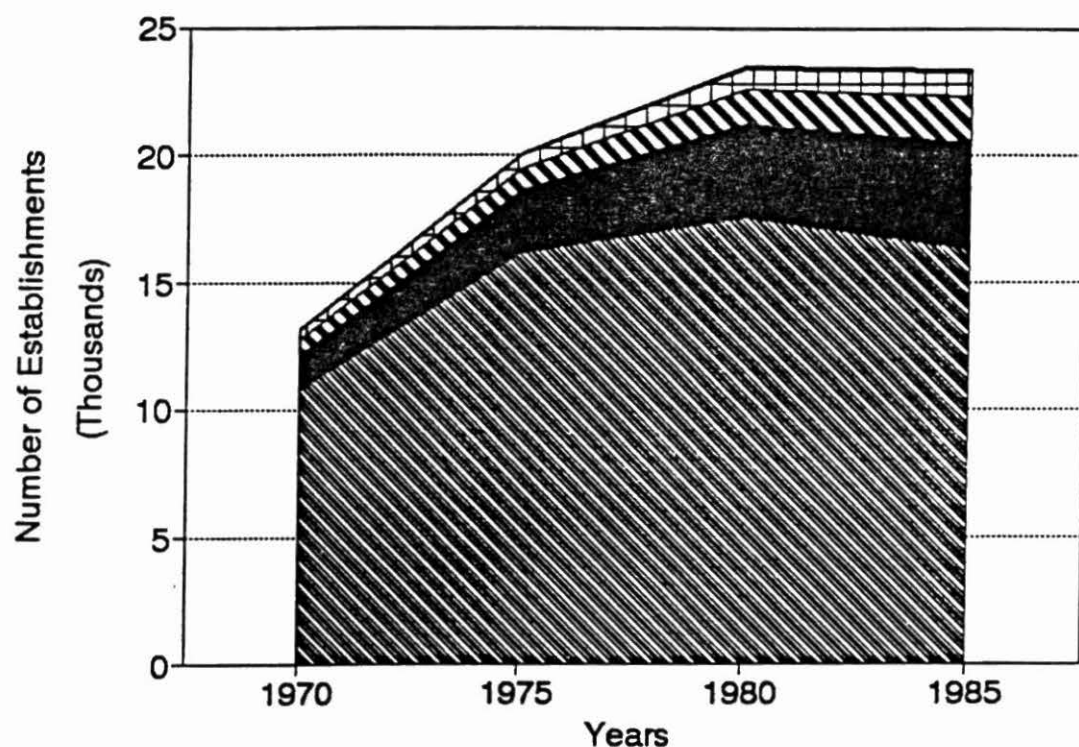


Fig M.17-PRODUCTION OF RICE
FOREST MARGINS, 1984-1990

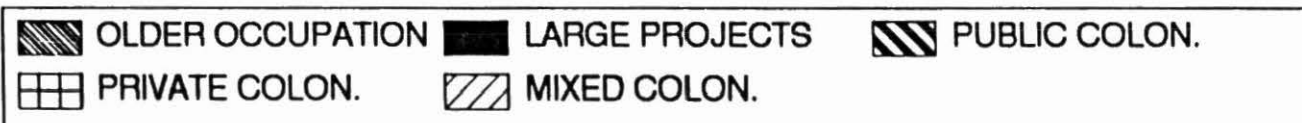
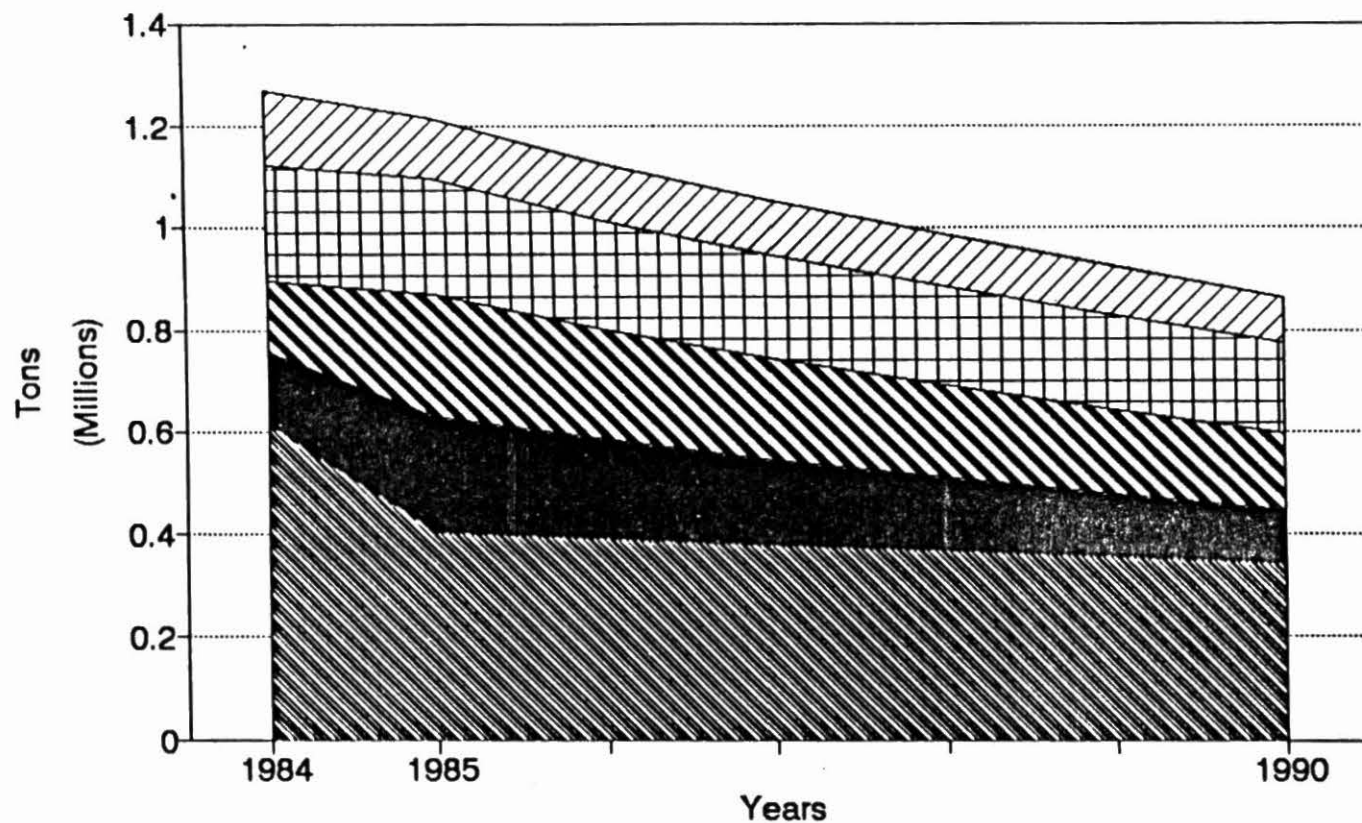
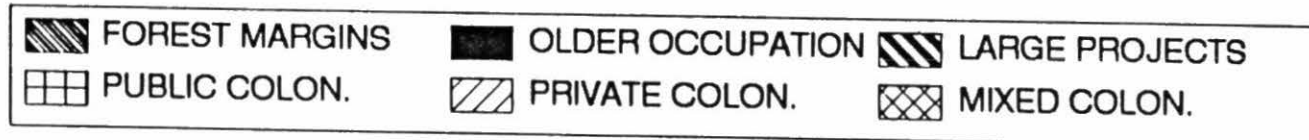
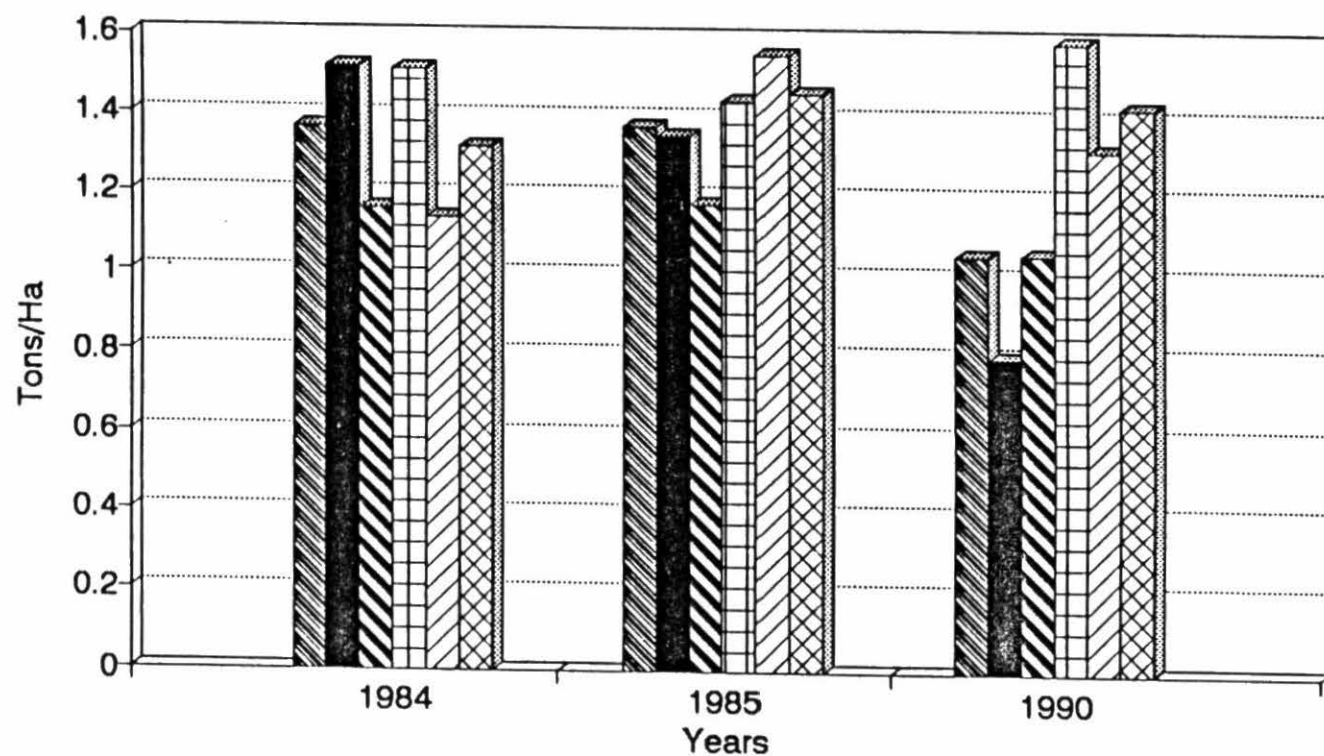
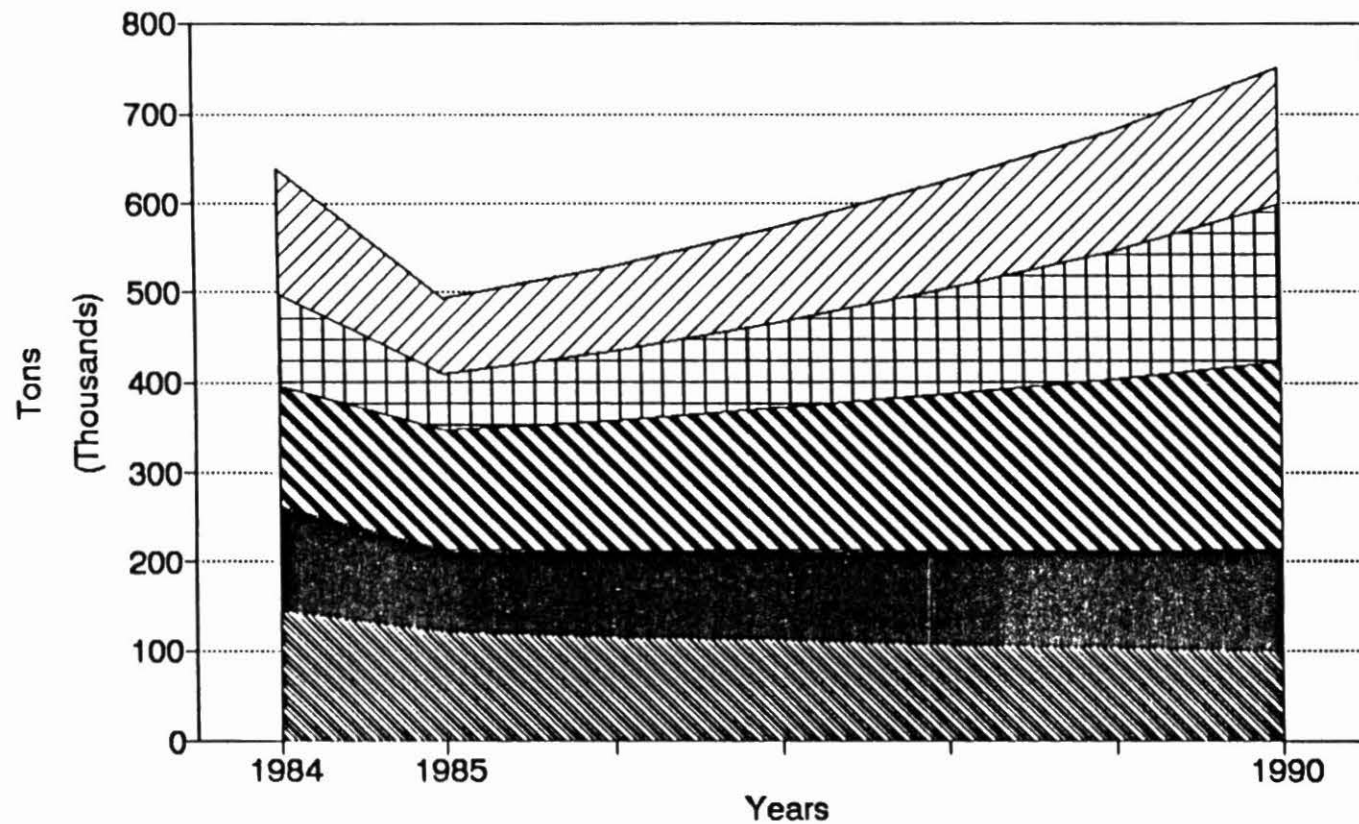


Fig M.18-YIELDS OF RICE
FOREST MARGINS, 1984-1990



**Fig M.19-PRODUCTION OF MAIZE
FOREST MARGINS, 1984-1990**



OLDER OCCUPATION	LARGE PROJECTS	PUBLIC COLON.
PRIVATE COLON.	MIXED COLON.	

Fig M.21-PRODUCTION OF SOYBEANS
FOREST MARGINS, 1984-1990

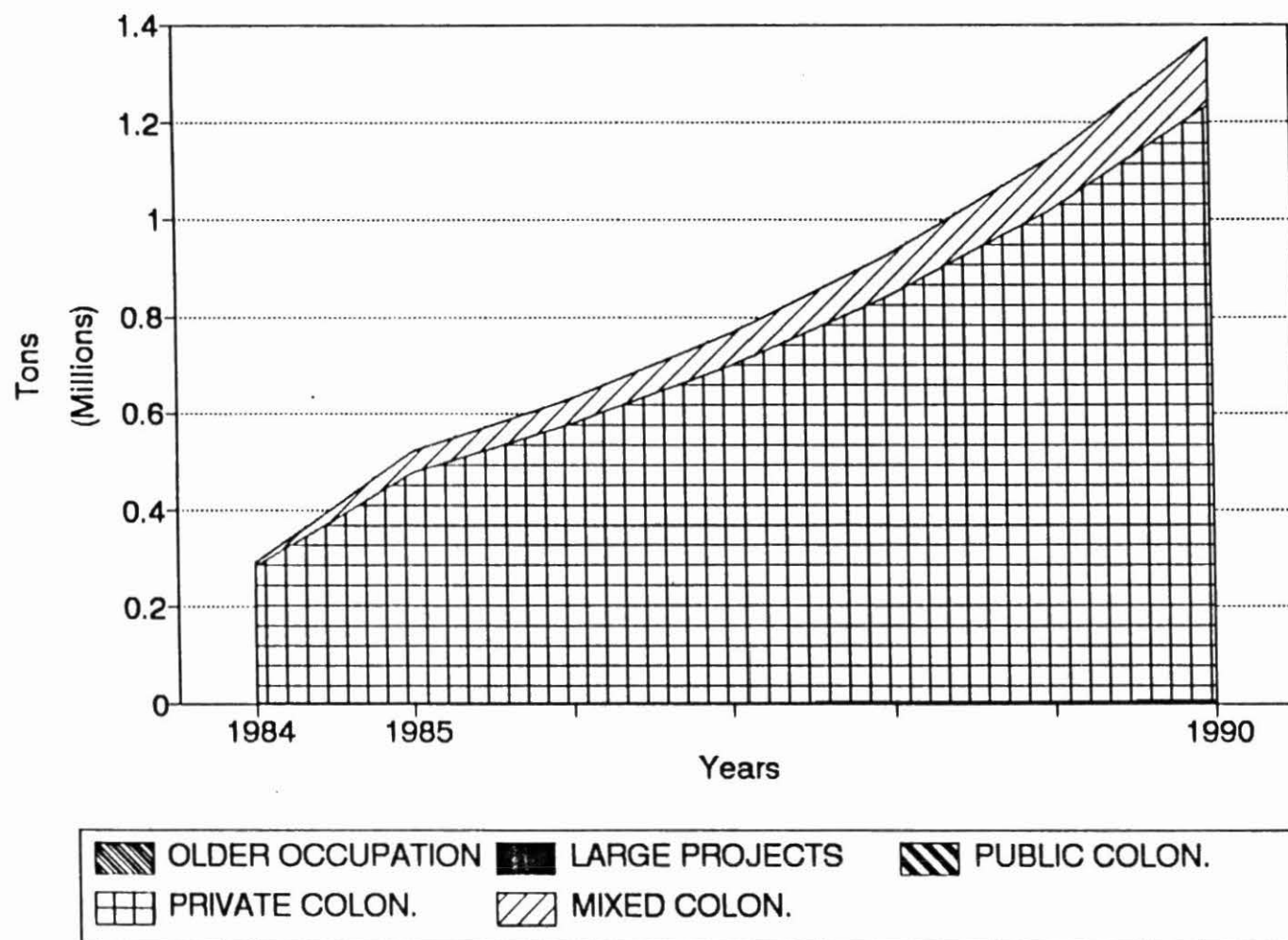
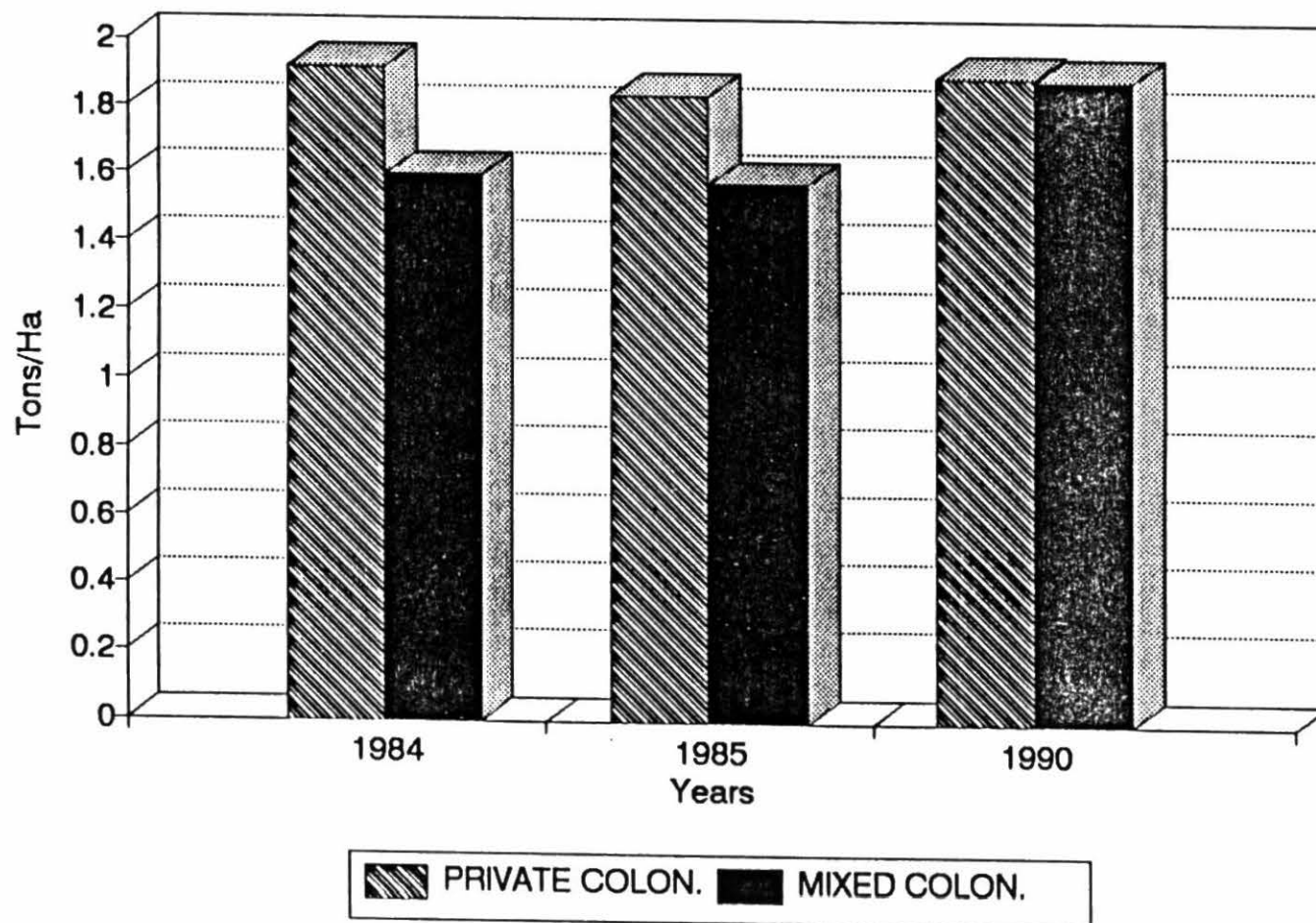


Fig M.22-YIELDS OF SOYBEANS
FOREST MARGINS, 1984-1990



**Fig M.23-PRODUCTION OF MANIOC
FOREST MARGINS, 1984-1990**

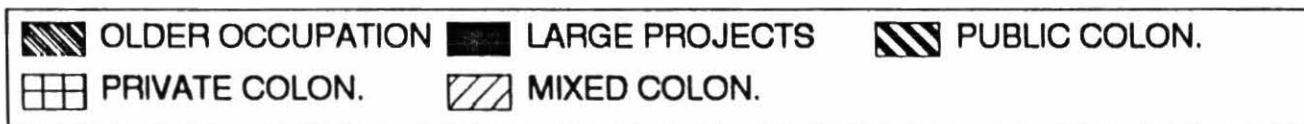
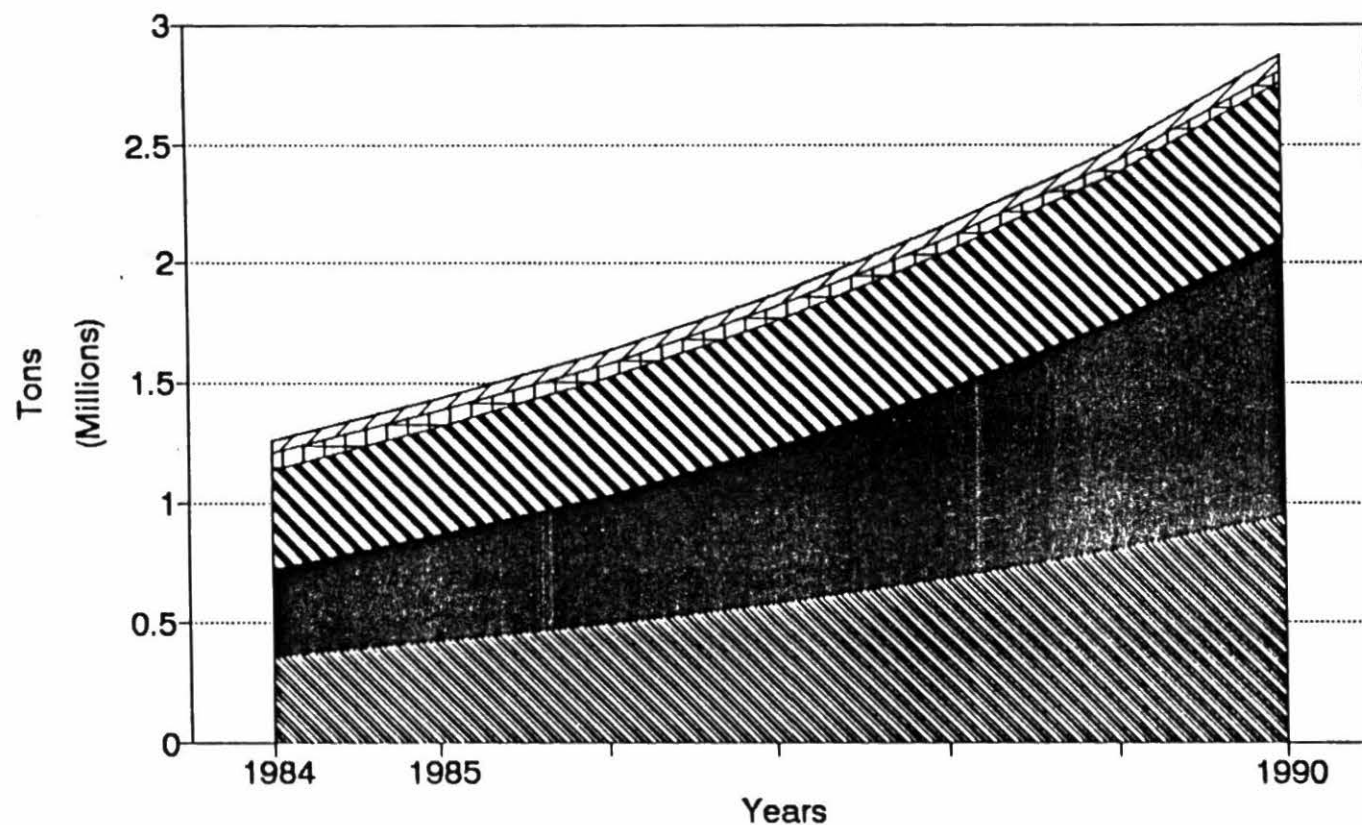


Fig M.24-YIELDS OF MANIOC
FOREST MARGINS, 1984-1990

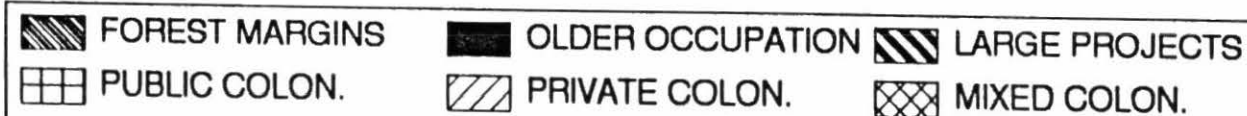
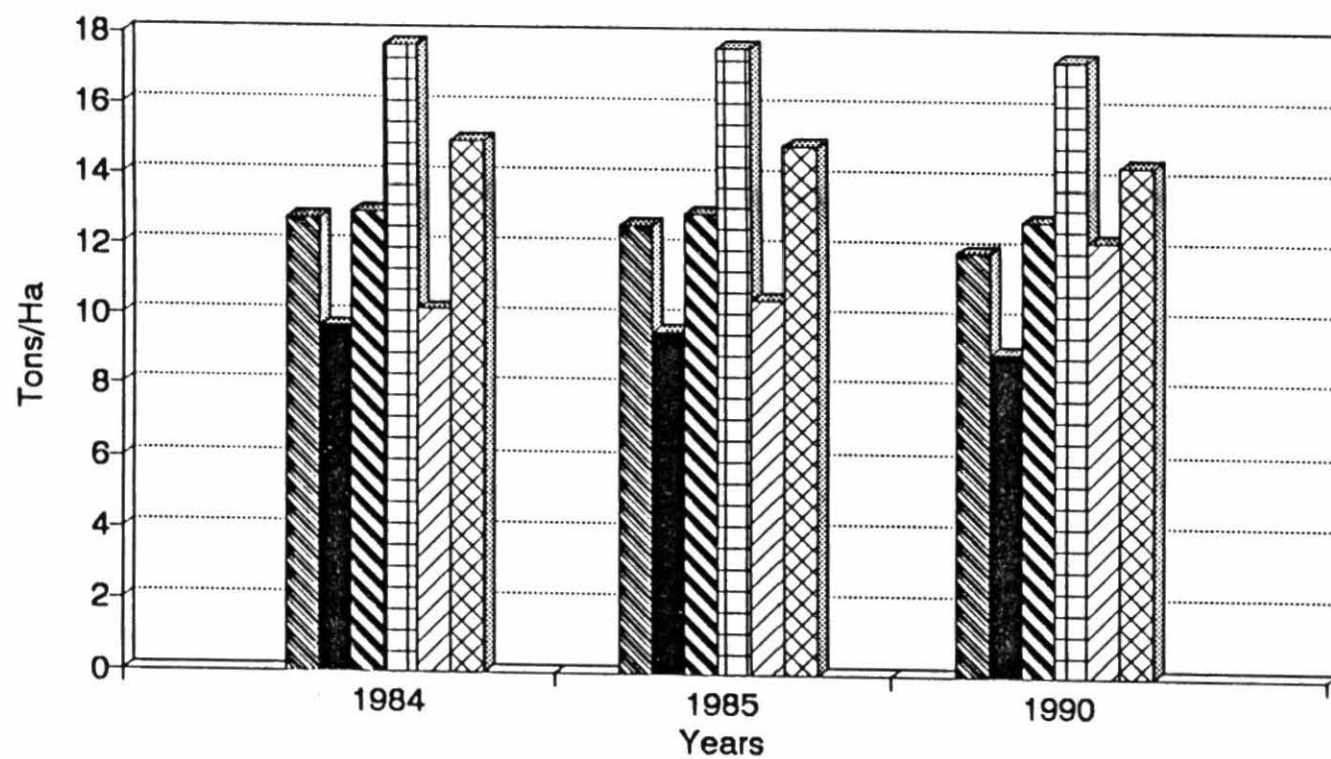
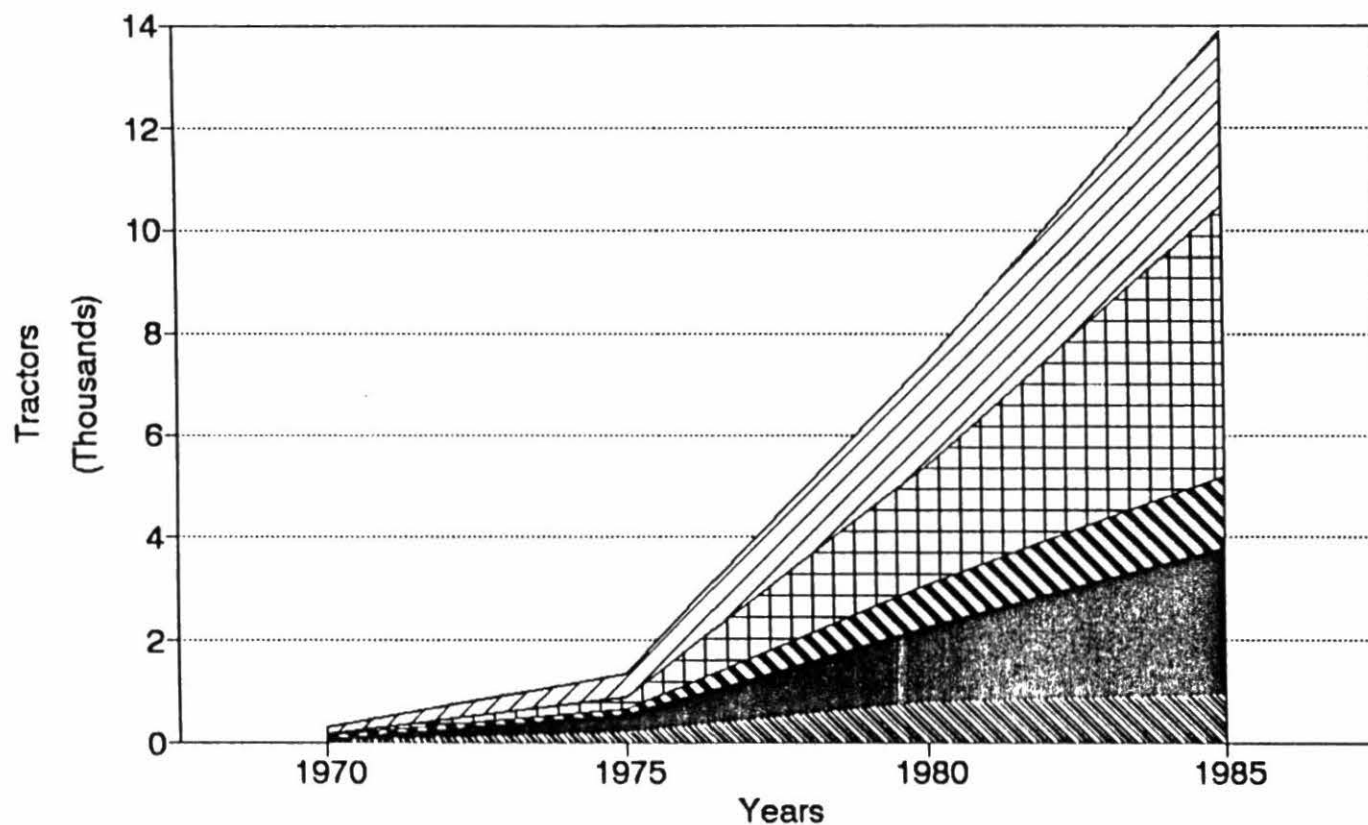







Fig M.25-NUMBER OF TRACTORS
FOREST MARGINS AND ZONES, 1970-1985



 OLDER OCCUPATION	 LARGE PROJECTS	 PUBLIC COLON.
 PRIVATE COLON.	 MIXED COLON.	

IV. Evolution of agriculture in savannas

IV.1. Regional and sectoral policies for the savannas.

This section examines regional and sectoral policies with impact on the evolution of agriculture in the savanna subregion. Since this is a less known area, we start with a brief historical overview of the opening and occupation of the subregion before 1970. This is followed by an analysis of the policies and of their main effects.

IV.1.1. A brief historical overview.

IV.1.1.1. The savannas' early settlement.

Until the early 1950s, the occupation of the savannas resulted from disconnected events that affected different parts of the subregion. The earliest settlement took place in an area reaching from the west of Cuiabá, in the south of today's Mato Grosso, to the center-west of today's Goiás. Near Cuiabá and in west Goiás, gold was discovered; in other parts, precious stones were found. As a consequence, the area received an inflow of population. Moreover, Cuiabá soon became an outpost for expeditions, aimed at exploring the center-west of Brazil in search for precious minerals. These expeditions were a factor in the incorporation of substantial areas to the territory of the then Portuguese colony of Brazil.

However, the modest reserves of precious minerals were soon

exhausted, and these remote areas regressed to a crude subsistence agriculture and to very extensive livestock explorations; in spite of the gold rush their population was extremely small and dispersed. The main link of the western parts of this region to the rest of the world was the Paran -Paraguai-Prata river system.

The southeast of Mato Grosso (the Rondon polis area) was also explored for precious minerals but little were found there; as a result, this area only began to receive a more significant inflow of population in the 1930s, when passable roads were built. And only quite recently has commercial agriculture begun expanding there.

The Campo Grande zone of today's Mato Grosso do Sul was explored early in the 17th century, from S o Paulo. However, precious minerals were not found and its settlement had to wait until the completion, in the 1920s, of the Estrada de Ferro Noroeste do Brasil -- a railroad link between Campo Grande and S o Paulo, through the Minas Gerais Triangle. The abundant natural pastures of the Campo Grande zone were an important factor in the expansion of a beef cattle sector there. Although quite extensive, from the beginning it was geared to markets outside the savanna areas; the Minas Gerais Triangle was the main marketing entrepot for this cattle.

The Minas Gerais Triangle and the south of Goi s have been

more intensively settled only since the construction, in the 1930s, of a railroad linking São Paulo to these areas (in 1935 it reached the city of Anápolis in center Goiás). However, these areas not only had fairly fertile lands -- in their river valleys and in the "Mato Grosso de Goiás" zone --, but were favorably located in relation to the growing markets of the Southeast; in the 1930s and 1940s, the agricultural frontier began expanding into these areas.

Nevertheless, a more substantial agricultural expansion there took place only in the early 1950s, with the construction of Brasília and of a highway system linking the new capital do the Southeast. Before this, agricultural expansion was modest but parts of this area, especially the Minas Gerais Triangle, developed an important cattle finishing sector. Even before the 1950s, it already was an important commercial entrepot; its area of influence encompassed a significant portion of the southern half of the savanna subregion.

Until quite recently, most of the "cerrado" areas of Tocantins, Maranhão and Piauí were virtually empty. This changed somewhat after the completion, in the late 1950s, of the Belém-Brasília highway, crossing Tocantins from north to south. However, parts of the north of Tocantins had already begun to receiving immigrants from Pará and Maranhão in the 19th century; they reached these areas through the Tocantins-Araguaia river system. Southwest Maranhão and the south of Piauí also received a trickle of settlers

from the overcrowded Northeast. However, this may change as the transportation system serving this area is improved; for instance, when the Norte-Sul and Carajás railroads organize themselves to operate with agricultural commodities.

Finally, until the late 1970s the savanna areas in the west of Minas Gerais and of Bahia were virtually empty. Only recently have then become a booming area for soybeans and their economy and population began stepping up.

IV.1.1.2. The settlement of the savannas' after 1950.

The construction of Brasília meant the creation of an enclave in an almost empty area. For this, substantial investments had to be made in the creation of a transportation system, linking the new capital with the developed southeast of Brazil. As a consequence, the expansion of the agricultural frontier was speeded up, reaching most of the more fertile lands in the Minas Gerais Triangle and the south and center of Goiás.

In the late 1950s, a highway from Brasília to the city of Belém in the northeast of the Amazon was completed, providing the first road link between the region and the dynamic Southeast. Later, this would create conditions for the expansion of speculative and peasant fronts in the eastern portion of the forest margins.

The western part of the savannas took more time to become integrated into the country's economy. The road construction surge of the 1950s and 1960s did not affect this region. The south of the Campo Grande area was barely touched by the surge, but the huge area to the north -- the savannas of the north of Mato Grosso do Sul and the south of Mato Grosso -- had to wait until the 1970s to begin developing. In that decade, highway construction established links between Cuiabá and Brasília and between Cuiabá and the Southeast of Brazil -- through the Rondonópolis, the southwest Goiás and the Campo Grande areas. Gradually new roads opened up other parts of the west of the savannas; some of them were part of the highway construction program aimed at connecting the Amazon to the center-south of Brazil, discussed in section III.2. This created favorable conditions for the expansion of the agricultural frontier in parts of the western savannas.

The expansion and improvement of the transportation system of the savannas was one factor in the recent transformation of its agriculture. In general, the transportation network of the savannas is very precarious but some of its areas saw significant improvements in this. Moreover, future investments in transportation will have a considerable impact on the areas affected.

An important role was also played by the already-examined general policies and by a specific set of regional and sectoral

policies aimed at the development of the "cerrados". These are analyzed below.

IV.1.2. Regional and sectoral policies.

In the 1970s and part of the 1980s, several development policies were created for the savannas or for specific areas within them. Some were not geared to agriculture but, when they improved the infrastructure, they had effects over the sector. The two policies with the highest impacts on agricultural expansion were the POLOCENTRO and the PRODECER programs. Together with other policies, two are examined in some detail below.

IV.1.2.1. POLOCENTRO and the agriculture of the savannas.

The poor results of the attempts to promote agricultural expansion in the Amazon and the desire to increase the economic density of central Brazil led the government to introduce, in the mid-1970s, a program for the expansion of modern agriculture in the "cerrados". Following the lead of a previous experiment by the state government of Minas Gerais (Salim, 1986), the Federal Government introduced, in 1975, the Program for the Development of the Cerrados (POLOCENTRO). POLOCENTRO was based on the growth poles conception; 12 savanna areas with some infrastructure and a good agricultural potential were selected to be part of the program and public investments were made to improve general conditions there. Moreover, their farmers became eligible to take part in an extremely generous subsidized credit program; under it they were

given access to investment and production credit at very low, fixed interest rates and with no correction of the principal for inflation. Since in the mid-1970s inflation was high and accelerating, and since the repayment periods were long (from one year for production credit up to 15 years for investment credit), POLOCENTRO credit became a virtual handout.

The main beneficiaries of the POLOCENTRO credit program were medium to large farmers of the affected areas. In the 1975-82 period in which the program was operational, POLOCENTRO approved 3373 projects, involving total financial resources of around US\$ 577 million; 81% of the beneficiaries operated farms larger than 200 hectares, absorbing 88% of the total volume of credit of the program. And farms larger than 1000 hectare, representing nearly 39% of the total number of projects, received more than 60% of the total financing (Fundação João Pinheiro, 1985, p. 55).

It is estimated that, between 1975 and 1980, POLOCENTRO was responsible for the direct incorporation of around 2.4 million hectares of savannas into agriculture; this represented approximately 31% of the total area added to agricultural establishments in the period in the POLOCENTRO regions (Silva, 1985). Of the program's area in farms, 35.4% were in Mato Grosso do Sul, 32.3% in Goiás-Tocantins (mostly in Goiás), 17.6% in Minas Gerais and 14.7% in Mato Grosso (including parts of the transition areas of this state's forest margins). POLOCENTRO's target was to have 60% of the financed areas producing plant crops (with emphasis

on food crops), and 40% in planted pastures. The outcome of the program inverted these proportions; moreover, the prevailing crops were soybeans (by a wide margin), and rice.

IV.1.2.2. The development of technologies for the savannas.

POLOCENTRO was successful in inducing the expansion of large-scale commercial agriculture in the "cerrados", not only directly, but as a result of the demonstration effect it provided. However, a fundamental factor in this has not yet been mentioned; it is the creation of viable technologies for productive cultivation of the "cerrados". POLOCENTRO provided important resources EMBRAPA needed to intensify the research, in the system it commanded, of such technologies. This was done with extreme success. It can be said that thanks to EMBRAPA's work, agriculture in parts of the savannas underwent sharp transformations more recently. One can question the social and distributive impacts of the EMBRAPA technological packages for the "cerrados", as well as of POLOCENTRO (Leal, 1985), but their positive effects on production and productivity are more difficult to dispute. Much more can still be done in terms of productivity, and especially of sustainability, but the advance already made has been considerable.

IV.1.2.3. The PRODECER program.

The Japan-Brazil Cooperative Program for the Development of the Cerrados (PRODECER) has also had an important demonstration impact on the expansion of agriculture in the "cerrados" of western

Minas Gerais, of Bahia and of parts of Brazil's Center-West region. Financed with resources from a loan by the Japanese government and from Brazilian sources, PRODECER promoted the settlement of experienced farmers from the southeast and south of Brazil, especially selected among medium sized farms in the target areas. PRODECER began in Minas Gerais, but it has expanded into other "cerrado" areas. Its main instruments were also broad credit lines, but being a non-governmental program (it is administered by an organization jointly managed by Brazilian and Japanese executives), credit is not subsidized. This notwithstanding, it has attracted a group of qualified farmers and results so far seem to have been quite good (Mueller, 1991). Funds are limited and so is the number of projects financed by PRODECER; however, the program's demonstration effect has been considerable.

IV.1.3.4. Effects on the savannas of the price support policy.

For years Brazil has had a comprehensive program of price support in agricultural markets, the main objective of which is to stabilize prices. Intra- and inter-annual price support is provided through interlinked subsidized storage loans to induce agricultural agents to hold stocks, avoiding large inflows of products to markets at the harvesting season, and a program for the acquisition of output at minimum prices.

The acquisition program has had a special impact on the agricultural expansion of the more remote areas, not only of the

savannas, but also of the private colonization zone of the forest margins. Until 1989, the acquisition price of a given commodity, established by the policy, was the same for the whole country. This was the case for many years. However, until the mid 1980s, the policy tended to set minimum prices at low levels relative to market prices and government purchases occurred only exceptionally. This changed in the mid 1980s; as a result of the fiscal crisis and of the pressure by the World Bank and the IMF, there was a sharp reduction in subsidized rural credit. To compensate the farmers for this, the levels of minimum prices were increased and, in 1985, the government began purchasing large amounts of agricultural commodities under the program -- especially soybeans, rice and corn (Delgado, 1990).

However, such purchases benefitted mostly producers of the more remote areas of the savannas and of the private colonization zone. The high transportation costs from these areas to the main ports, and processing and consumption centers considerably lower prices received by their farmers. When market prices are high relative to the minimum prices, government acquisitions are reduced; however, when they are low, government purchases become considerable. Moreover, they tend to concentrate on the more remote areas, due to the market price differentials created by distance. After 1985, the federal government was forced to acquire, under the program, large amounts of the savannas and of the private colonization zone agricultural products (Mueller, 1992). This

brought substantial losses for the government, in the form of price differentials, high transportation and storage costs and product deterioration resulting from inadequate storage facilities in these areas. Due to this program, the production of commercial agriculture was maintained artificially profitable in these remote areas.

The state of virtual bankruptcy of Brazil's public sector and the liberal stance of the administration which took office early in 1990 led to an attempt at changing the price support policy. For the 1990-91 harvest season, minimum prices were set at different levels for different regions, partially taking into account transportation costs. However, this was reversed for the 1991-92 harvest season, when minimum prices were again uniform; moreover, a program of subsidies for agricultural marketing in the more remote areas is being studied. If approved, the difference will be that, marketing in the remote areas will be done by private agents and not by the government; they will receive a subsidy in case of low market prices (Jornal do Brasil, March, 1st, 1992).

IV.1.3.5. The fuel price subsidy.

The more remote commercial farmers of the savannas and of the private colonization zone were subsidized in more ways than one. Under the program of unified fuel prices, fuels sold in the more remote areas of Brazil carry an equalization subsidy. Thanks to this, not only the products of the more remote areas are

transported at lower costs, but the diesel, fuel used by farmers in their operations, is artificially cheap (Silva, 1989).

The administration which took office in 1990 announced the elimination of fuel subsidies, but until now this has not materialized. The bad harvests of 1990 and 1991 led the government to reverse its initial hands-off stance in relation to agricultural policy. Now official support is not as strong as before, but it is still there, and the savannas' farmers can expect to continue receiving some measure of government backing.

IV.2. Trends in the area affected by agricultural processes

The savannas cover 155 million hectares of Brazil's territory, or 18.2% of the country's total. In 1970, only 52.8% of the subregion was in agricultural establishments, and only 23.5% of this area (or 12.4% of the savannas) had been affected by agricultural processes. From 1970 to 1985, the area in establishments experienced an increase of 27.4 million hectares (of 33.5%), not a very impressive increment; however, in the same period the area affected by agricultural processes increased 31.5 million hectares, or 163.7% -- in an average of 2.1 million hectares incorporated each year.

Examining the savannas' trends in the area affected by the main uses of land (Figure S.1), the large portion of incorporated

areas not in use (in fallow or for other reasons) is noteworthy. In 1970, these amounted to 7.4 million hectares, almost 39% of the affected area; this was more than the double of the total area in crops, including planted forests (3.1 million ha) and a little less than the area in planted pastures (8.7 million ha). In the subsequent census years, however, the cleared but unused lands increased at a much slower pace so that by 1985, its share declined to 20.3%, only a little higher than the share of the land in crops (18.9%).

Planted pastures experienced a remarkable increase, from 8.7 million hectares in 1970 to 30.9 million hectares in 1985. That year, the area in planted pastures represented 60.8% of the total area affected by agriculture, up from 45.1% in 1970. And the area in crops (including planted forests) experienced a sharp increment, from 3.1 million hectares in 1970 to 9.6 million hectares in 1985 -- a three-fold increase in 15 years. The proportion of the cleared area in crops increased from 16.1% in 1970 to 18.9% in 1985.

Examining the distribution of the cleared land between the four savanna zones we see Zone S.I (the area of modern, consolidated agriculture) both, with the largest share throughout the four census years, and with quite a sharp increase over time -- see Figure S.2. In 1970, its land area amounted to almost 10 million hectares but in 1985 it nearly reached 27 million hectares. Zone S.I's share remained almost constant in the two extreme years,

at a little less than 53% of the savannas' total.

In absolute terms Zone S.III, the peripheral frontier area, is the second more important zone, with an increase from nearly 4.2 million to 12.4 million hectares in the area affected by agriculture over the 1970-85 period -- an almost three-fold increase (Figure S.2). Zone S.II had a much smaller absolute increase in its affected area -- from 1.2 to 3.9 million hectares -- but it encompasses only 8.8% of the savanna subregion; and this represents more than 3 fold increase in 15 years.

Finally, Zone S.IV, with 4.7 million hectares of affected areas in 1970, remained almost at the same level until 1975, but increased afterwards, reaching almost 7 million hectares in 1985. However, to the contrary of the other areas, Zone S.IV did not even double its affected area in the 1970-85 period -- see Figure S.2.

Next we discuss in more detail the trends and the distribution in space of the main agricultural activities of the savanna subregion.

IV.2.1. Trends and spatial distribution of the area affected, by type of land use

Land use varies in space. Table IV.1 shows, for instance, that in 1985, Zone S.I, with 32.5% of the "cerrados", had, by far, the largest share of the area in crops (with 60.2% of the savannas'

total -- see also Fig. S.7), and in planted pastures (63.5% of the total -- see also Fig. S.8); but it only had 12.6% of the area opened but unused (see also Fig. S.9).

Table IV.1.

SAVANNA SUBREGION: Spatial distribution of the areas affected by agriculture, by zone and by type of land use - 1985 (in million ha)

ZONE		%Savannas Crops		%	Pl.Past.	%	Not Used	%
S.I	Modern	32.5	5.0	60.2	19.6	63.5	1.7	16.4
S.II	Expansion	9.2	0.9	10.8	2.1	6.8	0.5	4.8
S.III	Frontier	33.8	1.6	19.3	6.9	22.3	4.4	42.3
S.IV	Residual	24.5	0.8	9.6	2.3	7.4	3.8	36.5
SAVANNAS		100.0	8.3	100.0	30.9	100.0	10.4	100.0
% of Affected Area		16.7%		62.3%		21.0%		

SOURCE: IBGE - Agricultural Census, 1985

This is the more dynamic and modern segment of the savannas' agriculture, with strong and growing crop and livestock sectors. At the other extreme, Zone IV, encompassing 24.5% of the area in savannas, had only 9.6% of the area in crops and 7.4% of the planted pastures; but it had 36.5% of the cleared but unused lands (see also Figures S.7 to S.9). This is still a residual area with an agriculture of little significance and low productivity.

In 1985, Zone S.II, with 8.8% of the savannas had 10.8% of the cleared land in crops, only 6.8% in planted pastures and only 4.8% in unused land. These numbers confirm this as being mainly a plant crop area; we saw that earlier its agriculture began expanding quite recently and that it is strongly centered in soybean

production. Other plant crops have a lesser importance and, to the contrary of Zone S.I, beef cattle is not a significant segment. As for Zone S.III (with 33.8% of the savannas), in 1985 it had 19.3% of the subregion's land in crops, 22.3% of its planted pastures, but a significant 42.3% of its opened but unused lands. In relative terms, this zone is behind Zones S.I and S.II in crop and livestock production, but being a frontier area it will expand as conditions improve.

We should note the difference in the percentages of the opened but unused lands, between the areas of more advanced agriculture and the frontier and residual areas. We saw that Zones S.I and S.II had a fairly low proportion of the subregion's unused lands, while the reverse was true in the case of Zones S.III and S.IV. Apparently the opportunity cost of land in the latter is low and the diffusion of more advanced technologies is deficient, leading farmers to exploit their land in a more destructive fashion and to avoid expenditures in the recovery of degraded lands. In the more advanced areas, economic and technological conditions make it worth the farmers' while to undertake a more intensive exploitation of their land base.

Figures S.3 to S.6 provide elements for an analysis of the trends in land use in each of the savannas' four zones. Figure S.3 focuses on Zone S.I, the area of modern, consolidated agriculture; we observe for this zone a rapid increase of the area affected by

agriculture, from nearly 10 million ha in 1970 to almost 27 million ha in 1985. Its trends in the main uses of cleared land are interesting; there is an increase between 1970 and 1985 of the area in crops, from just over 2 million, to nearly 5 million ha; there is also a vigorous increment in the area in planted pastures, from 5.8 million ha in 1970 to almost 20 million ha in 1985. However, there is a slight reduction -- from 2 million ha in 1970 to 1.7 million ha in 1985 -- of the area cleared but not used (in fallow or for other reasons); this represents a very sharp **relative** decline in idle land. The high opportunity cost of land in Zone S.1 and the development of technologies for the "cerrados" led to a much more intensive use of its land more recently.

Examining the activity based in seeded pastures -- the land use of sharpest increase --, a comparison of Figures S.8 and S.10 reveals, on the one hand, the importance of the cattle sector in Zone S.I, and on the other, its vitality. Between 1970 and 1985, there was a 13.9 million ha increase in planted pastures and a 14.0 million increment in heads of cattle; in 1985, its area in seeded pastures encompassed 63.5%, and the cattle herd 64.0%, of the savannas' total.

Figure S.11 shows, in at a glance, the modernization of Zone S.I's agriculture. This area not only experienced a sharp increase in the number of tractors, from 10.8 thousand units in 1970 to over 65 thousand units in 1985, but the proportion of the savannas

tractors in this zone decreased only moderately, from 85% in 1970 to near 69% in 1985. Given that the tractor has been a fundamental element in the agricultural modernization of the savannas, this evolution accurately reflects Zone S.I's progress.

Figure S.4 show the trends in land uses in the area of low intensity but modern agriculture in the southeast of the savannas. Its total land area affected by agricultural processes increased sharply, from 1.2 million ha in 1970 to 3.9 million ha in 1985. The area in crops evolved from 263 thousand ha in 1970 to close to one million ha in 1985 -- an impressive 3.5 fold increment; the area in seeded pastures increased from 619 million ha in 1970 to 2.1 million ha in 1985 -- a 3.4 fold increment. And, as happened in Zone S.I, the area incorporated but not used changed little over time -- for the same reasons. It should be noted, however, that the evolution of the area in seeded pastures of this zone was not accompanied by a similar increase in cattle (compare Figures S.4 and S.10). Between 1970 and 1985, the area in seeded pastures had a 3.4 increase, while cattle numbers had only a 1.8 increase. Probably these pastures have been prepared only recently and there was not enough time to bring cattle into them.

Visually, the expansion in the number of tractors of Zone S.4 is not impressive -- see Figure S.11. However, there was a 13 fold increase between 1970 and 1985, from 866 to 11262 units; moreover, in 1985, this zone's share in the area in crops of the

savannas was 10.8%, while its share in the number of tractors was 11.9%. Based on this, we can say that its agriculture has modernized as sharply as that of Zone S.I.

The trends in land use of Zone S.III, pictured in Figure S.5, are interesting. Being a frontier area, its cleared land are almost tripled between 1970 and 1985, from 4.4 million ha to near 13 million ha. In this period, land in crops increased from 263 thousand ha to 1.6 million ha; seeded pastures evolved from 1.6 million ha to 6.9 million ha; and opened but unused land increased from 2.6 million ha to 4.4 million ha. The very small proportion of the total area devoted to crops (less than 7% as late as in 1985), and the large proportion of the opened but unused land (34.1% of the zone's total) are worth noting. Causes of the latter have already been indicated above. The low use of land for crops is a result of this zone's frontier character. Its agricultural areas are far from the main markets and their transportation and marketing systems are poor; as those are improved and as markets expand, there will be an intensification of plant crop production there. The high proportion of the affected land in seeded pastures (53% in 1985) is quite in line with this zone's frontier status. However, the trend in cattle numbers of Figure S.10 show a much smaller increase in animals than in seeded pastures. An explanation for this has been advanced in the analysis of a similar evolution in Zone S.II. Moreover, Zone S.III still has an extensive, low productivity beef cattle segment; its main production is probably

of lean animals to be sold to other areas for finishing.

The number of tractors in Zone S.III saw a sharp increase between 1970 and 1985, from 481 to 15165 units (see also Figure S.11). In 1985, this zone had an average of 0.9 tractors per 100 hectares in crops, much higher than that of Zone S.IV (0.5 units per 100 ha), but lower than those of Zones S.I and S.II (1.3 and 1.2 tractors per 100 ha in crops, respectively). We saw that this was a frontier area, with a small but growing agricultural segment; from the above, we conclude that this segment is also expanding with fairly advanced technologies.

Finally, Figure S.6 shows land use trends of Zone S.IV, the residual savanna area. It should be noted that the land cleared in this zone less than doubled between 1970 to 1985, from 3.7 million, to nearly 7 million ha. Land in crops increased little, from 319 thousand ha in 1970, to 776 thousand ha in 1985; seeded pastures increased from 2.9 million ha to 6.9 ha in the period; and the opened but unused land increased from 2.5 million ha in 1970 to 3.8 million ha in 1985. The proportion of land in crops is low (11.1% in 1985), and that of cleared but unused land is very high (54.5% in 1985). Moreover, the zone's cattle population is small (7.5% of the savannas' total in 1985; this year its proportion of the subregion's seeded pastures was 7.1%). It is an area of low growth and low productivity agriculture. It awaits exogenous events in order to begin changing more vigorously.

IV.3 Evolution of population and of agricultural employment.

IV.3.1. Trends in agricultural employment

Trends in labor use in the savannas' agriculture and in that of its four zones can be seen in Figure S.12 (based on data from the agricultural censuses). One cannot fail to be amazed by the very low increase in agricultural employment between 1970 and 1985. In this period, the number of persons working in the savannas agriculture increased from almost 1,4 million to only a little more than 2 million persons, a 49.5% increment in 15 years. In comparison, the area affected by agriculture increased 163.7%, the area in crops 172.5%, the cattle herd 128.8.1% and the number of tractors 660.4% in the same period. This contrasting behavior stems from the nature of the savannas' agricultural expansion, based as it was on the incorporation of modern technologies which, among other things, brought about sharp declines in the use of labor in agricultural operations.

The coefficients of Table IV.2 provide an indication of the labor-saving character of the savannas' agricultural expansion and modernization. These include: the number of workers per 100 hectare in cleared land and, the number of workers per 100 ha in crops. The coefficients indicate clearly the reduction of labor use which went with agricultural modernization, and this can be seen both in time and in space. For the savannas as a whole, for instance, the number of active persons per 100 hectares in cleared land (irrespective of

use) declined sharply, from 7.0 in 1970 to 4.0 in 1985; and the number of workers per 100 ha of cropland showed a reduction from 44.7 to 24.5 over the same period. A similar evolution in time took place, from the more advanced to the more backward zone of the savannas, in an indication of the penetration of labor-saving technologies everywhere.

Table IV.2

SAVANNAS AND ZONES - Labor use Coefficients: Workers per 100 Ha in Cleared Land; and Workers per 100 Ha in Crops. 1970 and 1985.

AREA	1970		1985	
	W/L	W/C	W/L	W/C
SAVANNAS TOTAL	7.0	44.7	4.0	24.5
Zone S.I	5.8	27.7	2.9	15.7
Zone S.II	11.4	52.2	5.8	25.4
Zone S.III	5.7	71.2	3.7	28.5
Zone S.IV	10.4	120.4	8.0	71.7

Source of basic data: IBGE, Agricultural Census of 1970 and 1985 (W/L = workers per 100 ha in cleared land; W/C = workers per 100 ha in crops)

An examination of cross-section coefficients reinforces the above conclusion. In both 1970 and 1985, the labor use coefficients of the more advanced zone were much lower than those of the frontier and residual zones. Looking at the 1985 data, for instance, we see that the number of workers per 100 ha of Zone S.I was 2.9 (against the subregion's average of 4.0), while that of Zone S.IV was 8.0; and Zone S.I's number of workers per 100 ha in crops went from 15.7 (against the savannas' average of 24.5) to 71.7 in Zone S.IV -- in quite a sharp contrast.

The apparently contradictory coefficients of Zone S.II can be explained by the particular characteristics of its agriculture. As seen, this zone saw the evolution of a rapidly-increasing modern crop sector but of a relatively small cattle segment; to establish a comparison, in 1985, Zone S.II's seeded pastures were 52.8% of its total affected areas, but this proportion for a Zone S.I was a much higher 73.1%. It should be noted that beef cattle production in the savannas is quite extensive -- meaning it uses much land and little labor to generate a unit of output -- much more so than in crop production. Thus, an area with a disproportionately large crop sector such as Zone S.II will have larger labor/land coefficients than a zone with a similarly modern crop sector but with a relatively larger livestock segment.

Therefore, agricultural expansion and modernization in the savannas has taken place with a reduced labor absorption; thus agricultural intensification in the "modern" areas and/or its expansion into the frontier and residual zones cannot be expected to bring about a considerable increase in rural employment. This characteristic of the savannas' agricultural evolution had effects on the evolution of its rural population, although this is not immediately apparent.

IV.3.2. Demographic trends.

The population of the savannas (Figure S.13) registers quite a substantial increase over the last 15 years, from 6.5 million, to

12.0 million (according to preliminary results of the 1991 census). The annual rate of growth of population was 3.43% for the 1970-80 period, and 2.52% in the 1980-91 period. The reduction experienced in the latter period is in line with a similar reduction in the rate of growth of the country's population (from 2.4% between 1970-80 to 1.9% between 1980-91). However, even in the 1980-91 period, the population growth of the subregion considerably exceeded that of Brazil; hence, the savannas continued to receive population from the rest of the country.

Looking at the disaggregated data, Zone S.I had the largest share of the savannas population, both in 1970 and in 1991 (61.6% in 1970 and 60.4% in 1991); in spite of the agricultural expansion of the other zones (particularly S.II and S.III), its 1991 share remained very high. The rates of growth of Zone S.I's population were 2.69% and 2.04% per annum between 1970 and 1980, and 1980 and 1991, respectively; these are not much lower than the subregion's average.

This evolution may seem to contradict last section's analysis of labor absorption. As seen, the Zone S.I's labor coefficients have declined dramatically and employment in agriculture had an increase of only 195.4 thousand persons between 1970 and 1985. However, this contrast is due to the fact that we are dealing with total population figures and not just rural population. This is because, at this writing, IBGE has not yet provided data the 1991

urban and rural population, making a meaningful analysis more difficult. It should be noted, however, that Zone S.I has a very substantial concentration of medium to large cities, most of which exhibited very rapid population increases in the 1970s and 1980s. For instance, if we take the 1991 population of Brasília and of the municipalities of Goiânia (with its Aparecida de Goiânia satellite), Anápolis, Campo Grande, Uberaba, Uberlândia and Rondonópolis -- all urban municipalities with medium to large cities, and all located in Zone S.I --, their combined total amounts to 4.2 million people, or 57.1 of this zone's entire population. The remainder were distributed within the rest of this large area. Furthermore, these urban municipalities had an increase of million inhabitants between 1970 and 1991, or ...% of Zone S.I's total increase.

This is not a recent phenomenon in Zone S.I. Analyzing the evolution of the rural population of the southern portion of Brazil's Center-West region -- including a large portion of Zone S.I (the south of Goiás and Mato Grosso do Sul --, Mueller (1983) established that, in the 1970s, its rural population had already experienced a considerable 31.7% decline, from 1.6 million to 1.2 million inhabitants. In contrast, its urban population increased 91.2% in the same period, from 1.9 million to 2.9 million inhabitants. The more recent trends have surely been the same, perhaps more strongly so.

The population of Zone S.II, the area of recent agricultural expansion and modernization, increased from 590.5 thousand inhabitants in 1970, to 771.5 thousand in 1980 and to 1.4 million inhabitants between 1970 and 1991. Its share in the savannas' total increased from 17.5% in 1970 to 22.4% in 1991. This zone's annual average rate of growth experienced a sharp increment in the last two decades, from 2.71% in the 1970s to 5.77% in the 1980-91 period. In part, and only indirectly, this was due to the recent rapid agricultural expansion of Zone S.II. We should have in mind, however, the fact that this zone includes Brasília's dormitory areas, which have recently had a rapid expansion. The municipality of Luziânia alone, had 207.3 thousand inhabitants in 1991, almost 15% of Zone S.II's total. Moreover, this zone also has a number of small to medium cities, which account for a large share of its population. The services these cities provide to agriculture are probably important in explaining their growth. We do not have the actual numbers, but we can be sure that the 93.1 thousand increase in agricultural workers between 1970 and 1985 had little to do with the demographic evolution experienced by Zone S.II.

Zone S.III's share in the savannas' population increased from 14.3% in 1970 to 16.0 in 1991. The actual numbers went from 933,7 thousand to 1.9 million in the period. In spite of the larger labor coefficients of Zone S.III, its absolute increase in agricultural workers was of nearly 210 thousand persons, only a small proportion of the total growth in population. It should be noted, however,

that this zone also had fairly large, predominantly urban units, especially the metropolitan area of Cuiabá (municipalities of Cuiabá and Varzea Grande, with 579.4 thousand inhabitants in 1991, or 31% of the zone's total).

Finally, in line with its stagnant character, Zone S.IV's population increased from 979.6 thousand inhabitants in 1970, to only 1.4 million inhabitants in 1991, or a mere 42.9% in 21 years. In the last two decades, its annual rates of population increase were only 1.94% and 1.52%, respectively, lower not only than the subregion's average but also than that of Brazil. In 1991, Zone S.IV had only 8.9% of the savannas' population and its demographic density was a very low 3.69 inhabitants per km². This is an isolated area, of very low economic and demographic dynamism.

IV.4 The land tenure structure of the savannas.

This section discusses the evolution and the recent pattern of land tenure in the savannas. We examine, first, the subregion as a whole, and afterwards, the four zones.

IV.4.1. Land tenure in the savannas.

Starting in 1970, the agricultural activity in the savannas underwent a sharp increase and considerable transformations. Despite the variations over time, however, land tenure did not experience major changes. Its basic characteristic is the

concentration of land in the hands of a small group of farm operators, prompted by the market opportunities which arose in the last 20 years and directed and stimulated by public policies such as those of section IV.2.

Table S.3 presents the proportions of the number and of the area of farms, of five class intervals and in the four census years; it allows us to examine the evolution of land tenure in the savannas.

Table S.3

Land Tenure in the Savannas, 1970-1985.

	0 a -50	50 a -100	200 a -1000	1000 a -10000	10000 and +	Total

Number of Establishments (%)						
SAVANNAS						
1970	54.29	25.02	16.43	4.07	0.19	100.00
1975	54.34	24.46	16.66	4.33	0.20	100.00
1980	50.16	24.57	20.38	4.66	0.23	100.00
1985	55.36	24.30	15.77	4.38	0.18	100.00
ADVANCED AGRICULTURE						
1970	51.45	27.08	16.61	4.63	0.24	100.00
1975	50.34	27.15	17.50	4.79	0.22	100.00
1980	40.19	27.21	27.10	5.30	0.20	100.00
1985	46.76	28.31	19.39	5.37	0.16	100.00
RECENT EXPANSION						
1970	40.45	32.76	21.23	5.38	0.18	100.00
1975	38.99	33.11	21.94	5.78	0.19	100.00
1980	38.86	33.27	22.08	5.60	0.20	100.00
1985	43.65	31.45	20.05	4.72	0.13	100.00
FRONTIER AGRICULTURE						
1970	47.97	25.25	21.36	5.11	0.31	100.00
1975	47.32	24.77	21.64	5.90	0.37	100.00
1980	43.38	26.63	22.74	6.75	0.49	100.00
1985	51.05	24.54	18.12	5.92	0.37	100.00

(continuation)

RESIDUAL						
1970	68.05	18.87	11.03	2.01	0.03	100.00
1975	70.26	17.46	10.14	2.07	0.07	100.00
1980	70.91	17.17	9.62	2.20	0.10	100.00
1985	72.32	17.07	8.48	2.03	0.10	100.00
Area (%)						
SAVANNAS						
1970	3.47	10.71	28.63	40.00	17.20	100.00
1975	3.15	9.89	28.34	41.13	17.50	100.00
1980	2.71	9.65	26.81	40.66	20.17	100.00
1985	3.15	10.42	27.71	42.60	16.12	100.00
ADVANCED AGRICULTURE						
1970	3.41	10.52	26.57	43.22	16.28	100.00
1975	3.30	10.37	27.72	43.59	15.01	100.00
1980	2.88	10.40	28.69	44.84	13.19	100.00
1985	3.06	10.80	30.55	44.74	10.85	100.00
RECENT EXPANSION						
1970	3.12	12.02	31.17	43.94	9.75	100.00
1975	2.89	9.49	31.28	45.14	11.19	100.00
1980	2.60	12.25	32.00	41.21	11.94	100.00
1985	3.46	13.05	32.79	42.45	8.25	100.00
FRONTIER AGRICULTURE						
1970	2.28	8.22	27.80	34.64	27.06	100.00
1975	1.92	7.44	26.13	38.20	26.31	100.00
1980	1.45	6.58	22.25	37.21	32.52	100.00
1985	2.06	7.65	22.82	41.99	25.48	100.00
RESIDUAL						
1970	6.17	14.88	34.94	35.94	8.07	100.00
1975	5.44	13.75	32.50	36.34	11.97	100.00
1980	4.94	12.35	28.03	36.58	18.10	100.00
1985	5.16	12.82	26.32	38.45	17.25	100.00

 SOURCE: IBGE, Censos Agropecuários, 1970-1985.

We see that, from 1970 to 1985, farms with less than 50 hectares represented more than 50% of the total number of farms, but the total area they commanded was only near 3% of the total area in farms. Figure S.14 shows an increasing trend in the numbers of small farms, in line with the subregion's agricultural

expansion; the same occurred with the total area of farms under 50 ha, but its share is so small that it is difficult to perceive this visually. At the other extreme, the share in the total farm number, of units larger than 1000 hectares was, in all four census years, a little more than 4%, while that of the total area was around 60%.

Examining changes over time, we should note the declining trend of the share in the total area of farms in the 200 to 1000 ha range, and the 1980-85 reduction, both in relative and in absolute terms, of the area in farms larger than 10000 ha. There was a compensating increase, both in the area and the share, of farms in the 1000 to 10000 range. Apparently, the agricultural expansion of the savannas brought about a more than proportional increase in large farms; and this was achieved, on the one hand, through an incorporation of smaller units, and on the other, by a fragmentation of very large farms.

IV.4.2. Land tenure of the four zones.

a. **The area of advanced agriculture.** Focusing Zone S.I (Table IV.3 and Figure S15) we see a land concentration pattern similar to that of the subregion as a whole. The proportion of very small farms is around the 50% mark, and that of the area of large and very large farms is extremely high. However, there are a few differences in the pattern and evolution of this zone's land tenure. First, in the 1970-80 period, there was a sharp absolute

and relative decline in the number of units with less than 50 ha, with a small recovery in 1980; since this interval's share in the total farm area declined only slightly, (see Fig. S.15), we conclude that there was an increase in the average size of Zone S.I's small farms.

Another interesting development was the considerable increase, since 1970, both in the share of the number and of the area of farms in the 200 to 1000, and in the 1000 to 10000 size intervals. The combined share in the number of farms of these two class intervals increased from 21.2% in 1970 to 24.7% in 1985, and their share in the total area went up from 69.8% to 75.3% in the same period. The increase in farm numbers occurred at the expense of the farms with less than 50 ha; the relative increase in the area took place at the expense of the 10000 and more farms.

The above evolution reveals that modernization in Zone S.I brought about an agglomeration of units in the lower class interval, and a subdivision of very large farms; today, units with areas between 200 and 10000 ha absorb a very large share of this zone's farm area. It is interesting to note, also, that the shares in the number and in the area of farms between 50 and 200 ha remained almost unchanged between 1970 and 1985.

b. The area of recent but modern expansion. The pattern and evolution of Zone S.II's land tenure presents similarities to those

of Zone S.I; the main differences are in Zone S.II's larger share of the number of farms in the 50 to 200 ha and 200 to 1000 ha intervals, and in its smaller share of the number of farms with less than 50 ha. Moreover, the proportions of the total area in the 50 to 200 ha and 200 to 1000 classes are also higher than in Zone S.I, the reverse being the case for the 10000 and larger interval. This zone's land tenure is also highly concentrated, but slightly less so than Zone S.I's.

Over time, however, Zone S.II does not show a clear-cut evolution as does Zone S.I,s; at any rate, modernization also led to a significant increase in medium to large farms similar to Zone S.I's, but in a smaller size range.

c. The area of frontier agriculture. The changes since 1970 in Zone S.III' land tenure does not follow a clear trend (see Table S.3). It is interesting to note that, in very general terms, this zone's land tenure pattern is similar to the savannas' average -- compare Figures S.14 and S.17). In 1985, Zone S.III's share of the number of farms in the 1000 to 10000 ha interval was larger than that of the savannas, the reverse being the case with the proportion of farm numbers in the less than 50 ha class; and the percentage of the area of farms in the more than 10000 ha interval is much larger than that of the subregion, at the expense of the three smaller area intervals.

Zone S.III's land tenure is more concentrated than the savannas' average but they exhibit similarities. These can be explained by the frontier character of Zone S.III, combining more advanced agricultural areas (not yet substantial) with large areas recently opened. Furthermore, especially after 1980, this zone's very large farms were partitioned for the formation, mostly, of units in the 200 to 10000 ha range.

d. **The stagnant, residual areas.** The residual character of Zone S.IV explains its somewhat different land tenure pattern. Figure S.18 reveals a very large share and a sharp increase, between 1970 and 1985, in the number of units with less than 50 ha units, and the other intervals showed little changes in absolute amounts; consequently their shares declined (see also Table S.3). We also see a substantial increase in the area of farms in the 1000 to 10000 ha interval, and less so, in the larger than 10000 ha interval; the absolute areas of farms in the 50 to 200 ha and 200 to 1000 ha intervals increased only slightly between 1970 and 1985, meaning a reduction in their shares of the total area in farms. This overall evolution indicates an increase in land tenure concentration of Zone S.IV.

Summing up, in 1970 all the savannas' zones had a highly concentrated land tenure, which changed little over time; modernization and expansion took place with only minor modifications. Moreover, there are differences between the four

zones, but they are not as pronounced as the differences between some of the forest margins' zones.

IV.5. Agricultural production and productivity

This section examines the agricultural production of the savannas. If in 1970 this area had an almost insignificant agricultural output -- except for some rice and for some livestock production --, today it has a considerable share of some of Brazil's most important crops. Moreover, the production of cattle, beef and milk is significant. We discuss the recent evolution and the 1990 pattern of production of the main agricultural crops, for the subregion as a whole, and for its four zones.

A word about the data used. We employed IBGE's 1984 and 1990 municipal estimates of area harvested and of output, and the same information from the 1985 agricultural census. It was impossible to compose disaggregated estimates for the years between 1985 and 1990, due to problems of establishing comparable areas -- the four zones -- for purposes of data organization. In 1985, IBGE (Brazil's statistical office) changed its regional division, from the old **microregional** pattern; this was observed in the presentation of the 1986-89 agricultural estimates at the municipal level. And in 1990, IBGE introduced a new regional division, but this time a map and a regional, subregional and municipal listing were issued, enabling us to compose comparable areas and to obtain their

production totals. For the 1985 census, part of the data was available under the old regional division, and part had to be processed, considerable difficulty, before the data could be conveniently organized.

IV.5.1. The savannas' aggregate production

Table S.4, below, compares the savannas' output and yield of the main agricultural crops for 1990 -- the last year for which municipal data were available --, with those of Brazil. Unfortunately, 1990 was not a good agricultural year for the savannas. There were climate-related problems, an intense fiscal crisis negatively affected the official structure of agriculture, and the uncertainty about the agricultural strategy of the federal administration, which went into office at the time the 1989/90 crop was being harvested (march of 1990); these factors had negative impacts on the subregion's performance. However, since most of them also affected the rest of the country's agriculture, the comparison can be meaningfully made.

Table S.4 reveals that in 1990, the savannas were responsible for a considerable proportion of the output of three of Brazil's more important commercial crops: soybeans (25.4%), maize (16.0%) and rice (13.2%). The shares in the output of the subsistence-type products -- beans and manioc -- were lower: 10.9.1% and 5.2%, respectively; and the output of coffee, a new crop, cultivated mainly in the Minas Gerais Triangle area, represented only 5.2% of

the national total.

Table S.4

Production and Yield of Soybeans, Maize, Rice, Beans, Coffee and Manioc: Brazil and the Savannas - 1990.

Crop	Production (1000 tons)		Savannas' %	Yield (kg/ha)	
	Savannas	Brazil		Savannas	Brazil
Soybeans	5048	19888	25.4	1500	1732
Maize	3403	21341	16.0	1950	1873
Rice	980	7419	13.2	930	1881
Beans	244	2230	10.9	690	477
Coffee	246	2926	8.4	1440	1007
Manioc	1259	24311	5.2	12700	12564

Source of basic data: IBGE, Produção Agrícola Municipal, 1990

The trends in the production of these crops can be seen in Figures S.19 to S.24. Focusing initially on commercial crops, we see soybeans increasing since 1984, but only slightly more recently. Moreover, changes in support policies for frontier agriculture -- especially the introduction of spatially differentiated minimum prices, taking into account transportation costs, and the threat (not materialized) of the elimination of fuel subsidies -- led to a decline in the savannas' 1991 soybean production. Data for the subregion are not available, but the three states with important areas in the savannas had sharp declines in the area planted in soybeans, between the 1989-90 and the 1990-91 harvest season. They were: Mato Grosso do Sul, from 1,2 million to 1.0 million ha; in Goiás, from 940.0 to 776 thousand ha; and in Mato Grosso (including also most of the soybean producing area of the forest margins), from 1.5 million to 978 thousand ha (CFP,

1990). For the 1991-92 harvest season, due to the pressure of the farm lobby, minimum prices were again set at the same level for all of the country. However, the available information is that there has not been an important reversal in this decline.

As for maize, production showed a strongly increasing trend since 1985, from a little over 2.6 million ha to 3.4 million ha. As it can be seen in Figure S.20, this increase took place almost exclusively in Zone S.I. This was mainly due to this area's smaller distances to markets and to its better marketing and transportation systems.

The production of rice has declined very markedly since 1985 (see Figure S.21), from just over 2 million tons in 1984 and 1985, to 974 thousand tons in 1990. Moreover, as shown in Table S.4, the rice yield of the savannas is about half of the national average; this is due to the fact that Brazil's main rice production, originating in the southern state of Rio Grande do Sul, is irrigated and presents a much higher average yield (4576 kg/ha in 1990) than that of the dryland "cerrado" rice. The difficulty in competing with irrigated rice, and the fairly recent practice of cultivating soybeans (instead of rice) in newly-cleared areas are important factors in this decline.

As for coffee, the savannas 1984-90 production increased sharply, from 118.4 thousand tons to 246.4 thousand tons in

1990. The considerably higher savannas yield, as compared to Brazil's average (respectively 1440 and 1007 kg/ha), should be also noted. However, the recent low world prices of coffee, the lack of official support in Brazil and the near collapse of the International Coffee Agreement are discouraging coffee cultivation in the savannas and there is talk of uprooting coffee trees in the Minas Gerais Triangle.

Looking at the subsistence crops, the production of beans shows an upward trend (Figure S.22); its output has increased, from 181.7 thousand tons in 1984 to 243.8 thousand tons in 1990. As for cassava, output declined somewhat between 1984 and 1990, from 1.30 million tons to 1.26 million tons. Beans are becoming a commercial crop, especially in Zone S.I (Goiás), where irrigated beans are on the increase, but manioc remains almost a purely subsistence, stagnated crop in the savannas.

Examining yields, the savannas' for maize is higher and that of soybeans slightly lower than the national average. As will be seen below, the more advanced agricultural areas have yields for soybeans and corn that compare favorably with the national averages. As for the "subsistence" crops, the yield of cassava, a stagnant, residual crop, is near Brazil's average but that of beans is much higher (691 against 447 kg/ha), in an indication of the commercial character of this crop in the savannas.

IV.5.2. The four zones' performance

This section briefly discusses the situation of the four savannas zones regarding their more important crops. Details about the evolution and present situation of each of these zones' output and yields can be seen in Figures S.19 to S.34; we underline only the main aspects.

a. **The area of advanced agriculture.** Figures S.19 to S.24 reveal that Zone S.I has been, by far, the savannas' main producer of soybeans (68.7% in 1990), of maize (81.8% in 1990), of beans (55.0% in 1990) and of coffee (almost the entire savannas' output). Its share in the subregion's rice output has declined since 1984, when it was 45.5% of the savannas' total; in 1990, it was only 36.5%. And the subregion's share of manioc production was only 36.2% in 1990.

Figure S.25 shows the increasing trend of Zone S.I's maize output, the almost stagnated evolution of soybeans, and a sharp reduction of rice production.

Regarding yields, Figures 29 to 34 show Zone S.I with considerable higher outputs per hectare than the savannas' average for its two main commercial crops: soybeans (1683 kg/ha against 1498 kg/ha, in 1990) and maize (2280 against 1950 kg/ha in 1990). Its cassava yields are also higher (Figure S.33), those for coffee and beans, near the subregion's average, and those for rice, lower.

In this area of growing modern agriculture, the productivity of important commercial crops is high and that of the other crops tends to be less expressive.

b. The area of recent but modern expansion. As we can see in Figures S.19 to S.24, Zone S.II is relatively important in soybeans, beans, maize and cassava -- despite the fact that is, by far, the smallest of the savannas' four zones. Its rice production has been declining since 1985, and that of coffee, although increasing, was very low even in 1990.

Worthy of notice in Figure S.26 is Zone S.II's considerable expansion of soybeans, the earlier mentioned decline in rice, and the slight increases in maize, beans and cassava.

As for yields, Figures S.29 to S.34 show Zone S.II with consistently lower productions per hectare than Zone S.I, the more advanced agricultural area; the only exception is in beans. Regarding the soybeans yield of 1990, however, that year zone II was particularly affected by a dry spell during the critical growing months of soybean. That year's pattern for Zone S.II's soybean yield, does not accurately reflect its potential.

c. The area of frontier agriculture. Figures S.19 to S.24 show Zone S.III with a reasonable share in the savannas' production of soybeans, rice, beans, manioc, and, to a lesser degree, of maize.

The evolution of the distribution of these crops within this zone - see Figure S.27 -- highlights the large but sharply declining participation of rice, slight changes in time in the output of maize and cassava, and the sharply increasing output of soybeans. It should be noted, however, that, even in 1990, the soybean crop was still modest (a little over one million tons).

The productivity patterns (Figures S..29 to S.34) show Zone S.III having consistently lower productivities than those of Zone S.I (and frequently of Zone S.II), but higher than those of Zone IV. The only exception is in rice (Figure S.31); however, this is a crop commonly employed in opening new areas, and the first two rice harvests frequently have high yields. These decline afterwards, particularly when the market prospects for the crop are poor and it becomes marginal; this seems to have been the case in the zones of more advanced agriculture. The higher yields for rice in Zone S.III are consistent with these events.

d. **The residual area.** Figures S.19 to S.24 show the almost negligible participation of Zone S.IV in the savannas' production of soybeans, maize and coffee; the modest participation in rice and beans, and the large participation in the output of cassava. Moreover, Figure S.28 shows a sharply declining production trend, after 1984, both for the zone's two main crops -- manioc and rice. The output totals of this area are small and, except for rice (see last section' explanation for this), its yields are quite low. As

mentioned before, being extremely remote and lacking in basic infrastructure, Zone S.IV -- or parts of it -- needs changes in this condition if its agriculture is to become significant.

IV.5.3 The cattle sector of the savannas

Unfortunately recent and more detailed data on the evolution of cattle ranching in the savannas are not available. The latest information on cattle numbers and on pastures are those of the 1985 agricultural census, and we lack the necessary microregional or municipal data on beef and milk production, to compose subregional aggregates of these variables; and information on the nature and transformation of cattle ranching in the savannas would also be most welcome. Table IV.5 organizes the main available data, parts of which have already been used in the previous sections' analyses; it presents the number of cattle, the area of planted pastures, and ratios between cattle and land for the last four census years.

Table IV.5

Evolution of Cattle Ranching in the Savannas, by selected Indicators, 1970-1985.

Year	Number (000s)	Rate of growth (%a.a.)	Planted pastures (000s)	Rate of growth (%a.a.)	Heads of cattle p/ ha in p.past.	Cattle per km ²
1970	16571	-	8713	-	1.90	10.7
1975	24958	8.2	13495	8.8	1.85	16.1
1980	31737	4.8	21810	9.6	1.46	20.4
1985	37951	3.6	31020	7.0	1.22	24.5

SOURCE: IBGE, Censos Agropecuários, 1970-1985.

This table prompts considerations concerning the evolution of the savannas' cattle sector:

a. The absolute 1970-85 increase in cattle numbers (21.4 million head) is quite impressive; the rates of growth were substantial if we consider that in 1970, the savannas were already an important cattle region. These rates decline in time, but even the 1980-85 annual rate (3.6%) was quite higher than the savannas' recent rate of growth of population.

b. Planted pastures experienced a very substantial increase, from 8.7 million ha in 1970 to 31 million ha in 1985. Moreover, planted pastures increased much faster than the number of heads of cattle. In the forest margins this was mainly caused by speculative activities, associated with fiscal incentives projects. In the savannas this was only partially true; undoubtedly POLOCENTRO played an important role in the high 9.6% 1975-80 annual rate of increase. However, the transformation and modernization experienced by cattle ranching in the savannas, were more important in determining the intense formation of planted pastures there. Since 1970 there was a steady shift from low productivity natural pastures to planted pastures, inducing the expansion portrayed in Table IV.5.

c. Cattle density in the savannas increased substantially between 1970 and 1985, from 10.7 to 24.5 animals per km². There

was, however, a sharp decline in the number of heads of cattle per hectare in planted pastures; last paragraph's comments indicate this can be expected in an area the cattle sector of which is experiencing sharp transformation and modernization.

d. We have already stressed the prevalence of Zone S.I in cattle production. In 1985 it accounted for 64.0% of the savannas' cattle numbers and 63.7% of its planted pastures. This zone is followed, far behind, by Zone S.III, with 19.7% of the savannas' cattle and with 22.3% of its planted pastures.

Summing up, the savannas constitute an important and rapidly growing cattle ranching area, one with a substantial potential for continued growth. This area's beef cattle industry has experienced considerable change over the last 20 years; it would be interesting to investigate in more detail the nature and the future direction of this change.

V. Conclusions

In the early 1950s, the immense contiguous areas of the forest margins and the savannas were virtually devoid of population. The construction of Brasília, in the southeast of the savannas, necessitated the formation of a transportation system; aside from serving the new capital city, the latter created conditions for an overflow of the agricultural frontier, from areas around the dynamic nucleus of Brazil in the southeast of the country, into the savannas. Later in the decade, the construction of a highway from Brasília to Belém, in the Amazon, prompted the occupation of parts of the forest margins.

In retrospect, the beginning of the occupation and agricultural expansion in the two subregions was basically spontaneous; however, until the late 1960s, this was quite modest. Around this time, important changes began occurring. In part, this was due to the economic expansion which Brazil was able to maintain until 1980. The overall climate of this period and the view that Brazil was destined to become a first-rate economy established an environment conducive to risk-taking. Expectations that easy speculative gains would result from pioneer ventures almost everywhere were also important in the move by private agents to incorporate large areas of land into agricultural ventures in the subregions. And these expectations were strongly advanced by a multitude of sectoral and regional development policies, which

provided subsidies and special conditions for initiatives in the two subregions. The period of crisis and stagnation of the 1980s changed the economic environment, but the opportunity to obtain gains from subsidy-tied ventures (especially in the forest margins), together with the opportunities created by the international market, aided by sundry policies (especially in the savannas), maintained the motivation to occupy and clear large areas of land.

An important element in the occupation of the two subregions was the evolution of land prices. A combination of the effects of general policies, of speculative effects associated with a high and unstable inflation, of subsidized rural credit policy, together with a booming situation in the world market of some commodities in parts of the period, and of incentive programs to induce the cultivation of certain commodities, were responsible for very significant increases in real agricultural land prices. These increases have stimulated the incorporation of land in the region which were, in parts of the frontier, motivated more by the prospects of speculative gains than by the possibilities of agricultural production.

In addition, the conservative modernization of the Brazilian agriculture, which began in the late 1960s, as part of the country's general development strategy, also produced important effects, especially in the forest margins subregion. One

consequence of conservative modernization was that large numbers of small farmers and rural workers were driven off the areas of more developed agriculture, generating growing flows of migrants, both to the large urban-industrial centers, and to areas in the agricultural frontier.

The forest margins and the savannas are contiguous areas and both constituted part of Brazil's agricultural frontier in the period covered by this study. However, to a large extent, the developments and processes affecting each subregion were quite different. Focusing initially on forest margins, the host of policies which evolved since the late 1960s, with the aim of incorporating the Amazon into the mainstream of Brazil's economy, had an enormous impact in this subregion -- not so much in terms of agricultural and livestock production, but of population movements, social transformation, occupation of land and alterations of the ecosystem. Public lands and colonization policies affected especially Rondônia and parts of the east-northeast areas of the subregion. The latter area has also been the locus of a large portion of the huge livestock ranches fiscal incentives projects; and the coincidence in space of the fiscal incentives agricultural projects and of a large inflow of destitute migrants, have generated conflicts and violence over land. Special policies and incentives also induced the expansion of a modern, medium-to-large farm agriculture in the center and north of Mato Grosso. And finally, the lack of success of the Northeastern development

strategy, together with the lure of some Amazonian policies, induced a growing inflow of peasants to the northern units of Maranhão.

Thus, there were definitely clear spatial differences within the forest margins, shaped by diverse historical contexts. This study's analysis allowed us to establish five clearly distinct zone in the subregion: 1. an area of high-intensity, low-technology agriculture in Maranhão (zone M.I); in 1985, all of that state's forest margin microregions were in this category. This is an area occupied for quite some time with settlers from Brazil's Northeast, and which today exhibits the forest margins' highest demographic density; 2. Zone S.II, in the west of the subregion, including Rondônia and part of Acre. In parts of this area, there evolved an agricultural structure of increasing intensity but with low technological levels. This zone has been the locus of destination of a large inflow of migrants from the center and south of Brazil, expelled by conservative modernization and lured by land in public colonization schemes. There are already areas in this zone with a high-intensity, no-technology pattern similar to that of Maranhão. 3. Zone M.III, in the center-north of the state of Mato Grosso. In terms of production, this is the most important agricultural zone of the forest margins; in it, most the majority of the Amazonian private colonization projects have been implanted, and their settlers are farmers from the southern states with experience in modern agriculture and some capital. 4. Zone M.IV, an area running

from the northeast of Mato Grosso through east Pará and north Tocantins, and including southern Maranhão, with an extensive agriculture and predominantly low-to-medium technical levels. This is the area in which most of the large fiscal incentive cattle ranches are located; it has also received a growing inflow of poor migrants (peasants and farm workers from deprived areas of Brazil). Since the legal status of an important portion of its lands is uncertain, there have been frequent disputes and violence. 5. Finally, the mixed colonization Zone M.V, a still sparsely-occupied area between Rondônia and the private colonization area of Mato Grosso, having a very low intensity and low-to-medium technical levels.

As for the savannas, although public policies had an important impact in its occupation, agricultural expansion and (in parts of the subregion) modernization, a fundamental role was played by the growth of domestic and foreign markets for the products of the subregion. The development of technologies to productively farm the savannas and the gradual expansion of transportation and marketing systems into parts of this area were important elements in the subregion's substantial growth in agricultural and livestock production since 1975. Today this area has an important share in Brazil's soybeans, maize, rice and cattle, beef and milk production. However, this evolution has not affected the savannas equally.

The study distinguished the following four agricultural systems in the savanna subregion: 1. a modern, high technology and dynamic system encompassing most of Mato Grosso do Sul, the Minas Gerais Triangle area, parts of the south and the center of Goiás and of the south of Mato Grosso Zone (S.I). 2. a fairly new system, with still low agricultural intensity but with high technical levels, encompassing the area surrounding Brasília, in Goiás, and the west of Minas Gerais. This is an area of recent agricultural expansion, in which production methods already arrived in a modern form (Zone S.II). 3. an area of recent agricultural frontier expansion, encompassing mostly agriculture of low intensity, and low to medium technical levels (Zone S.III). Most of it surrounds systems (1) and (2) but it also includes the west of Bahia. 4. the "almost empty" system composed of most of Tocantins, and the "cerrado" areas of Maranhão and Piauí. Agriculture there is still incipient and of low technical level (Zone S.IV). These are remote areas wherein conditions for the evolution of a more advanced commercial agriculture are still precarious.

Being based primarily on census data, complemented by those from other sources, our analysis may give the idea that the evolution of the forest margins' and the savannas' agriculture have been part of a more or less homogeneous process, without alterations over time. This is, however, not true; before finishing, it is important to stress that, recently, discontinuities have been introduced. Beginning in the early 1980s,

most of the regional development and sectoral programs with impact in the agricultural development of the two regions have been phased out or have remained virtually inactive; the fiscal crisis of the 1980s and the more liberal stance of the administration which took power in 1990 have reduced considerably the impetus to promote regional development with special programs such as those examined above. Moreover, the international commodity markets are not as active as before; now, their prices are low and international competition is increasing. All these changes introduced elements of uncertainty about the prospects, even of the more developed agricultural zones of the two subregions.

Recommendations:

This section lists a few research topics suggested by this study. Only a small number of the more evident themes are pointed out, but it is clear that the study has opened up many other areas which warrant further investigation.

1. The zoning of the forest margins and of the savannas of this study is preliminary. Aside from the general vegetation base underlying the spatial location of the two subregions, our zoning did not consider natural elements; it took into consideration almost exclusively, data from the agricultural census, which reflect socioeconomic processes. A revision of our zoning should take into account information on natural elements and on the

effects of human intervention upon them; it should also consider factors such as the transportation and marketing systems within the zones, as well as information on the processing agricultural commodities and the supply of agricultural inputs. Additional aspects should be taken into consideration in this effort:

a. As already stressed, this study's zones are very large areas; the revision should establish a subzoning, taking carefully into account the recent evolution (including the effects of the discontinuities mentioned above), and the prospects of the transportation and marketing systems within each zone.

b. We have pointed out that, while some of the zones defined by the study are well established, others are still being formed and may well change in the future. Being predominantly frontier areas, events such as the development of transportation systems and the introduction of special programs may substantially change the situation within these zones, altering their configuration.

c. An instance of aspects that should be reviewed is the inclusion of the private colonization zone in the forest margins. This zone is predominantly located in an area of ecological tension -- that is, of transition between tropical forest and savanna -- but its agricultural processes have been very similar to those of the savannas. A more detailed study would probably identify parts of this zone more akin to the savannas, and parts which correctly

belong in the forest margins. Procedures such as this would enable a better spatial delimitation of the forest margins and savannas zones.

2. A study of the environmental degradation by agriculture in the areas more intensely affected of the two subregions should be undertaken. Aspects of this, regarding parts of the forest margins, have been investigated and are widely known. However, a systematic study of the degradation produced by modern agriculture in the savannas has yet to be made. As for the forest margins, one should keep in mind the fact that large areas have been cleared and, what is more important, have received settlers from the rest of Brazil. The question is, can these migrants, and the Amazon entrepreneurs, be induced to exploit these areas in a sustainable fashion, or will they continue the shifting cycle of land occupation and degradation. In other words, what we are suggesting is a careful study of the sustainability of agriculture in the two subregions; for the savannas, the question is if its agriculture is sustainable and, if not, whether it can become so; and for the forest margins, can there be a sustainable agriculture in the already opened areas?

3. Technological development is an important element in a more rational -- one which is sustainable -- agricultural exploitation of the forest margins and of the savannas; a detailed review of technologies already developed and in the process of development for the two subregions would be very useful. This review should

look, not only at agroecological aspects, but also at the economic viability of these technologies. In other words, once identified the technologies with a large agroecological potential, their economic viability should be investigated. Moreover, some consideration should be given to the dissemination of new technologies in the two subregions' agriculture.

For the savanna's a few topics should be stressed:

a. there is frequent mention of erosion, soil compaction, silting of water bodies and environment poisoning by agrochemicals in the savannas' agriculture, but a more in-depth and systematic study is called for if we are to avoid broad, but almost meaningless generalization. And this study should explicitly include the socioeconomic processes generating environmental impacts.

b. For the savannas, a critical factor is the greater or lesser availability of transportation and marketing systems, and of host of agricultural services. A detailed study of these and of their impact on the agricultural development of the "cerrados" would be of considerable interest.

c. Some savannas' areas have agricultural systems which are already an extension of the main Brazilian agrosystem; they are already established and only extraordinary circumstances would make

them regress. However, there are other agricultural areas of the savannas for which the prospects are not as clear cut. An analysis should be made of the viability of these areas, having in mind the recent changes in policies, the fiscal crisis of the Brazilian government and the situation of the international commodity markets.

For the forest margins we present specific suggestions for the subregion's main zones:

Forest margins: issues requiring further research

a. **Older Occupation.** In this sub-region, the following elements should be highlighted: i. a substantial increase in lands left unused or fallow; ii. a significant increase in the productivity of rice on typically peasant-type plots); iii. a significant part of the incorporated area in the pasture category; iv. expansion of the total area of agricultural establishments accruing, in large part, to medium and large-scale establishments; v. rural employment at stagnated levels; vi. the sub-region is a source of net out-migration. These elements, taken in conjunction with other available information, indicate that the peasant economy is under stress in the region. It can be argued that there are three different dimensions to this "stress": agroecological, structure of landholding and demographic growth. Overall, the region has been little-studied, except in an anthropological

perspective (Musumeci, 1987) and warrants more detailed investigation, particularly as concerns the interrelation between these three dimensions.

b. Large Projects. The significant expansion of pasture land and heads of cattle is the distinctive feature of this subregion. It is crucial to investigate to what extent this expansion is related to "large project" government strategy and whether ranching is an ecologically viable undertaking in this region. (Hecht, 1982) The implication is that without subsidies, cheap lands, the rapid expansion of regional markets for wood and charcoal (which have obviously reduced the costs of seeding pasture) and the abundance of cheap labor, these relatively successful undertakings would unlikely be viable.

c. Private Colonization. Despite the evident success of soybeans in this region of ecological tension between forests and savannas, the economic viability of this region, in the absence of subsidies, is placed in doubt. Moreover, the ecological sustainability of the technological package applied to this region, subject to heavy rains and soil compaction, is also under question.

d. Public Colonization. Large migration flows and intense settlement by small and medium farmers have been considered to be economically and ecologically inviable in the region (Martine,

1987; Millikan, 1988; Martine, 1991). Indeed, low productivity and large distances to the main consumer centers reinforce this perception. Nevertheless, this region already aggregated some 100 thousand small and medium-sized establishments in 1985. The search for solutions which will guarantee the sustainability of these producers and the systematic search for approaches which the farmers themselves are generating are fundamental steps in overcoming the grave economic, social and ecological problems which government policy is largely responsible for having generated.

Fig S.1-USE OF AGRICULTURAL AREAS
SAVANNAS, 1970-1985

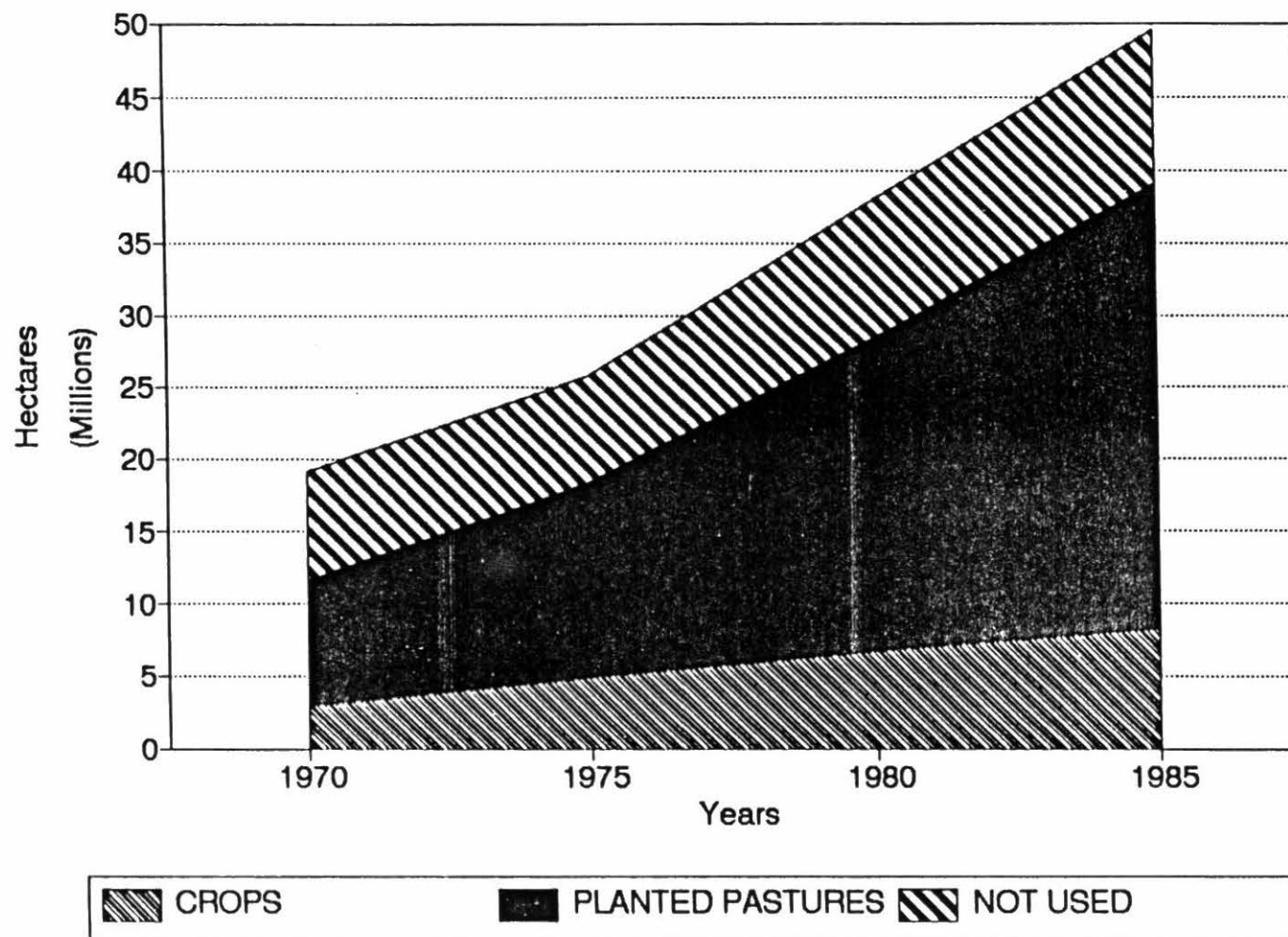
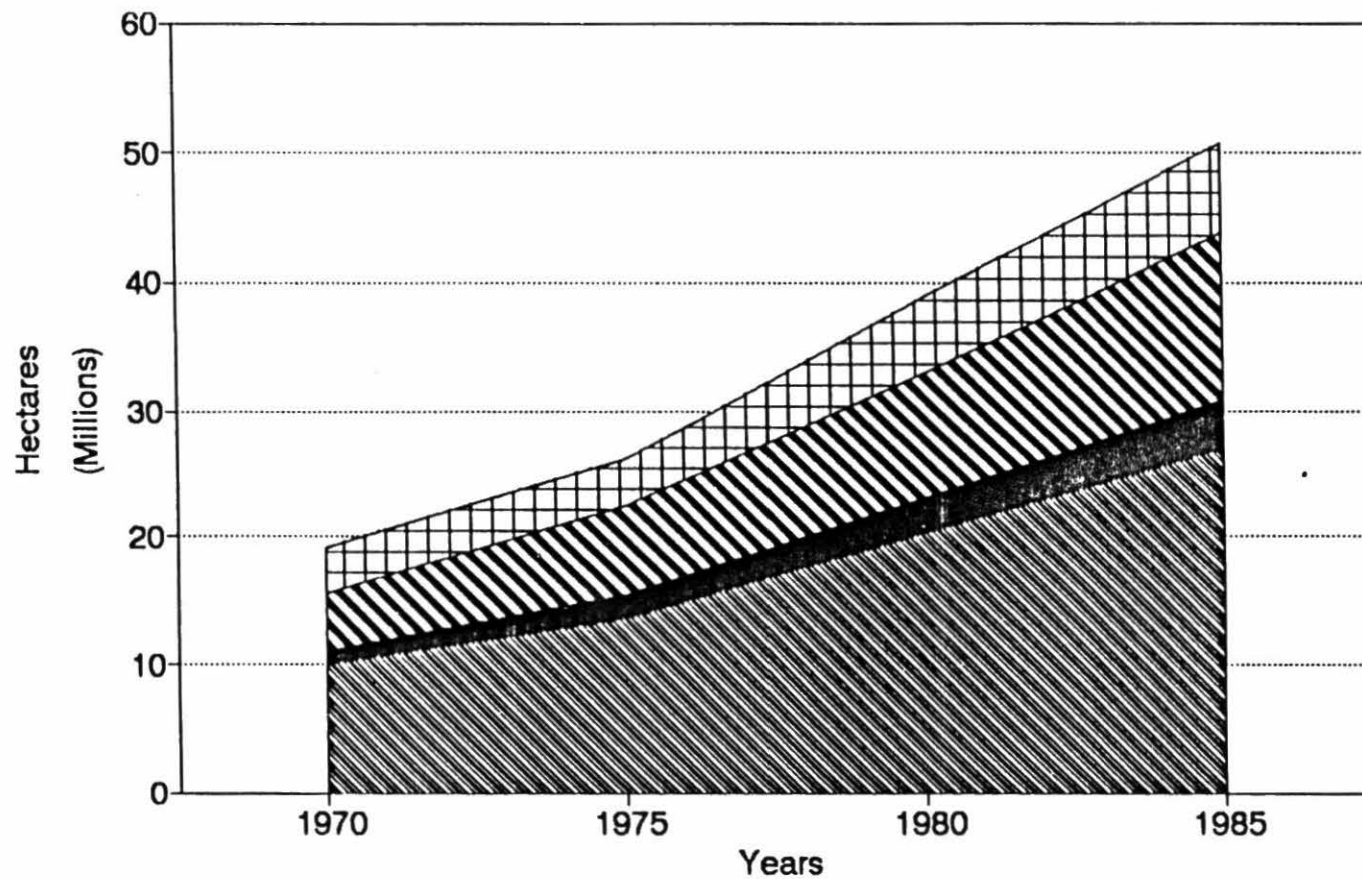


Fig S.2-THE AFFECTED AREA
SAVANNAS AND ZONES, 1970-1985



ADVANCED AGR. RECENT EXPANS FRONTIER AGR. RESIDUAL

Fig S.3-AREAS AFFECTED BY AGRICULTURE
ZONE S-I: ADVANCED AGRICULTURE

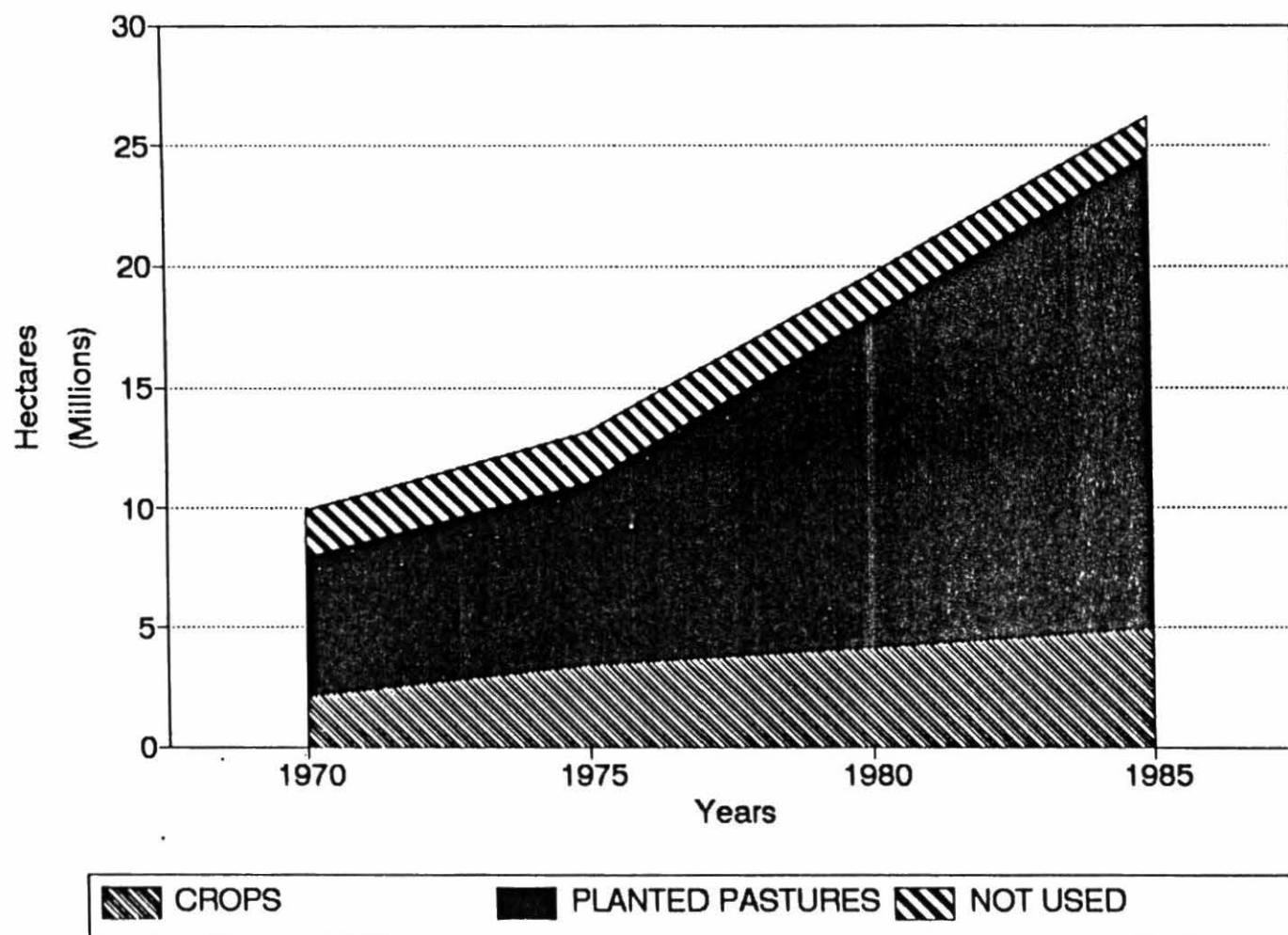


Fig S.4-AREAS AFFECTED BY AGRICULTURE
ZONE S-II: RECENT EXPANSION

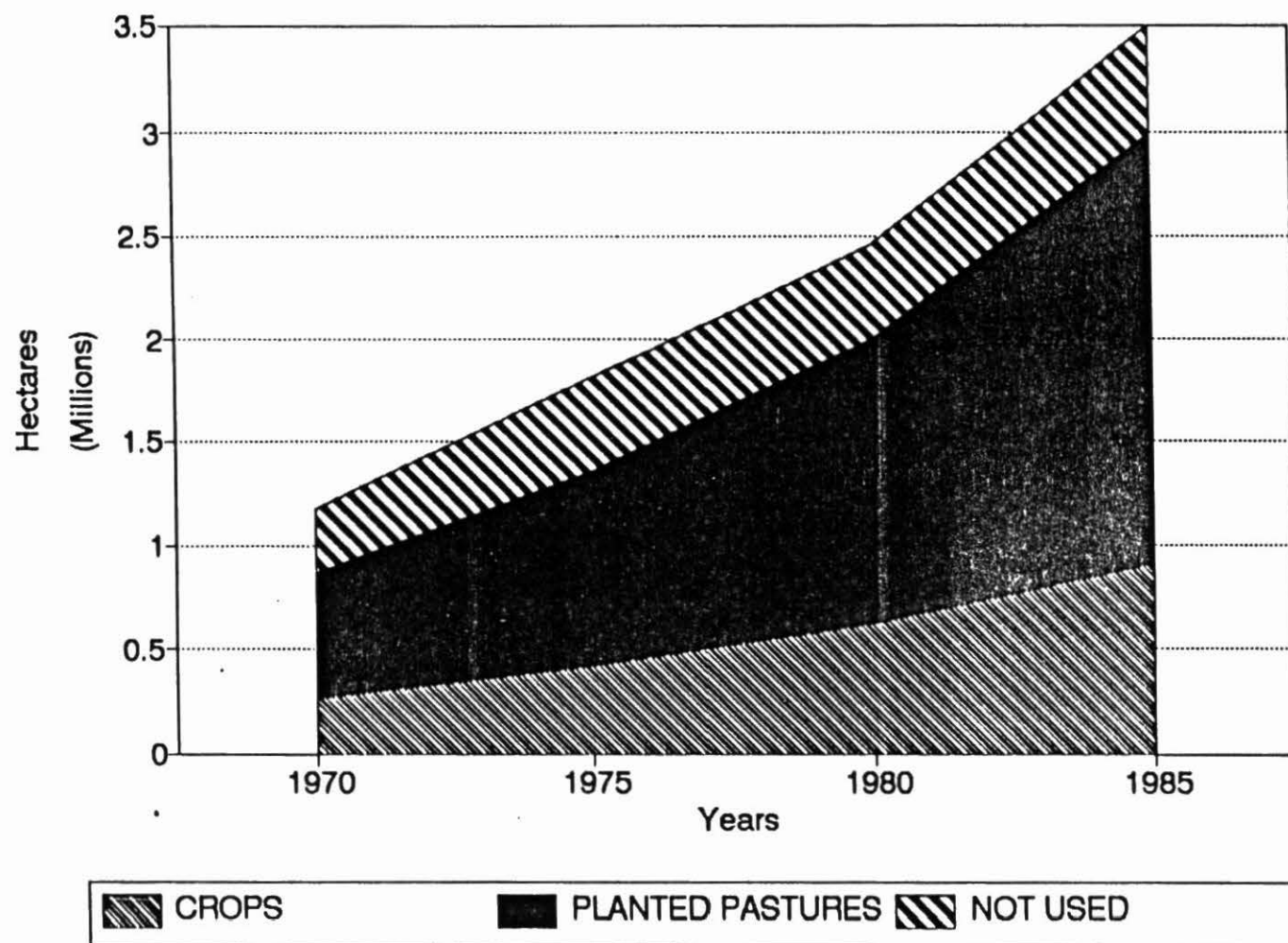


Fig S.5-AREAS AFFECTED BY AGRICULTURE
ZONE S-III: FRONTIER AGRICULTURE

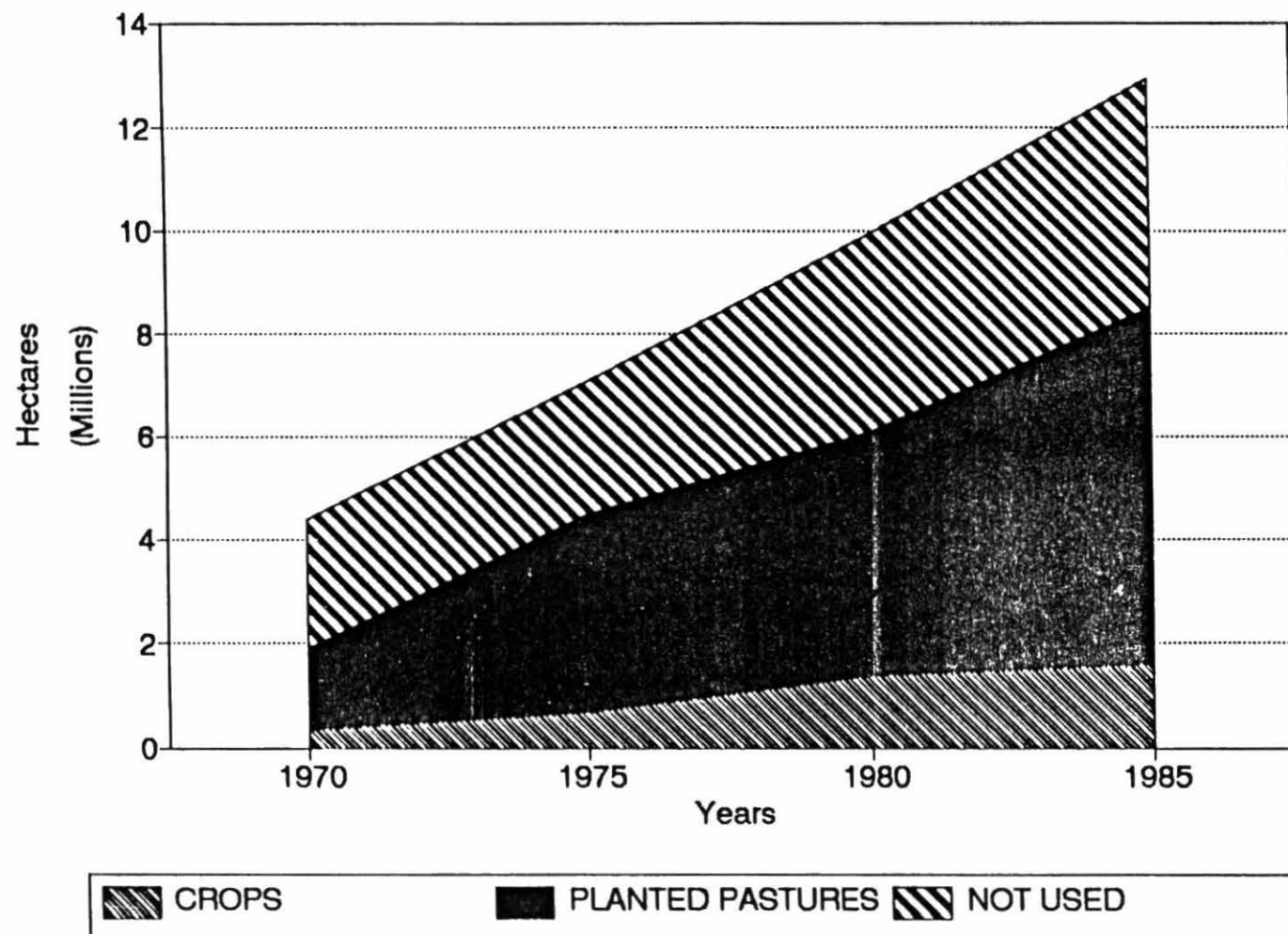


Fig S.6-AREAS AFFECTED BY AGRICULTURE
ZONE S-IV: RESIDUAL

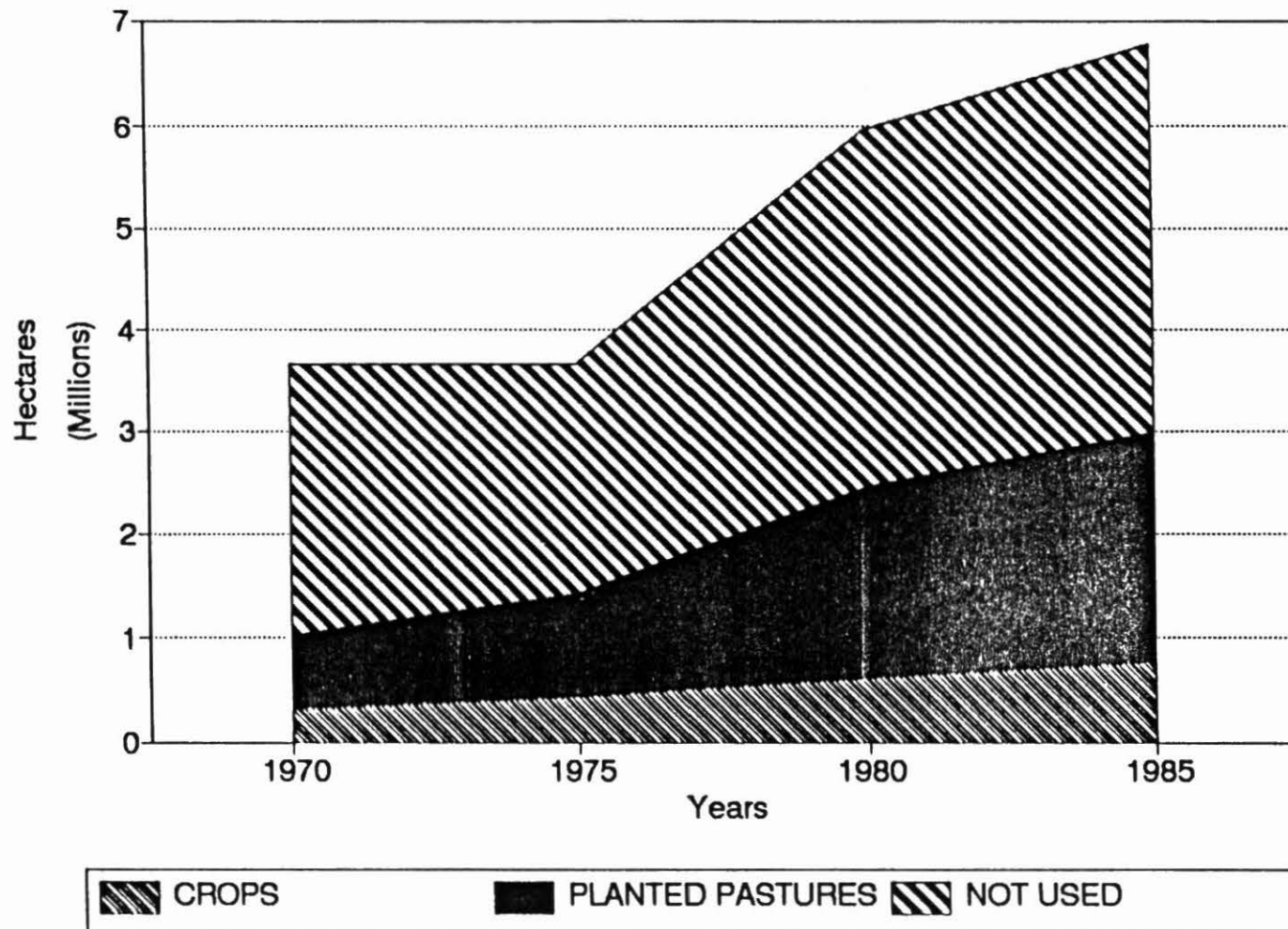


Fig S.7-AREA IN CROPS
SAVANNAS AND ZONES, 1970-1985

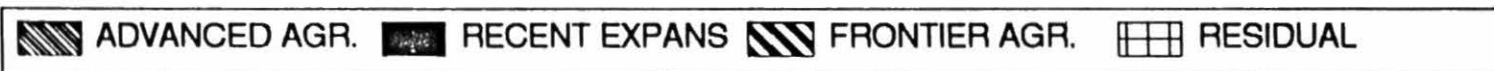
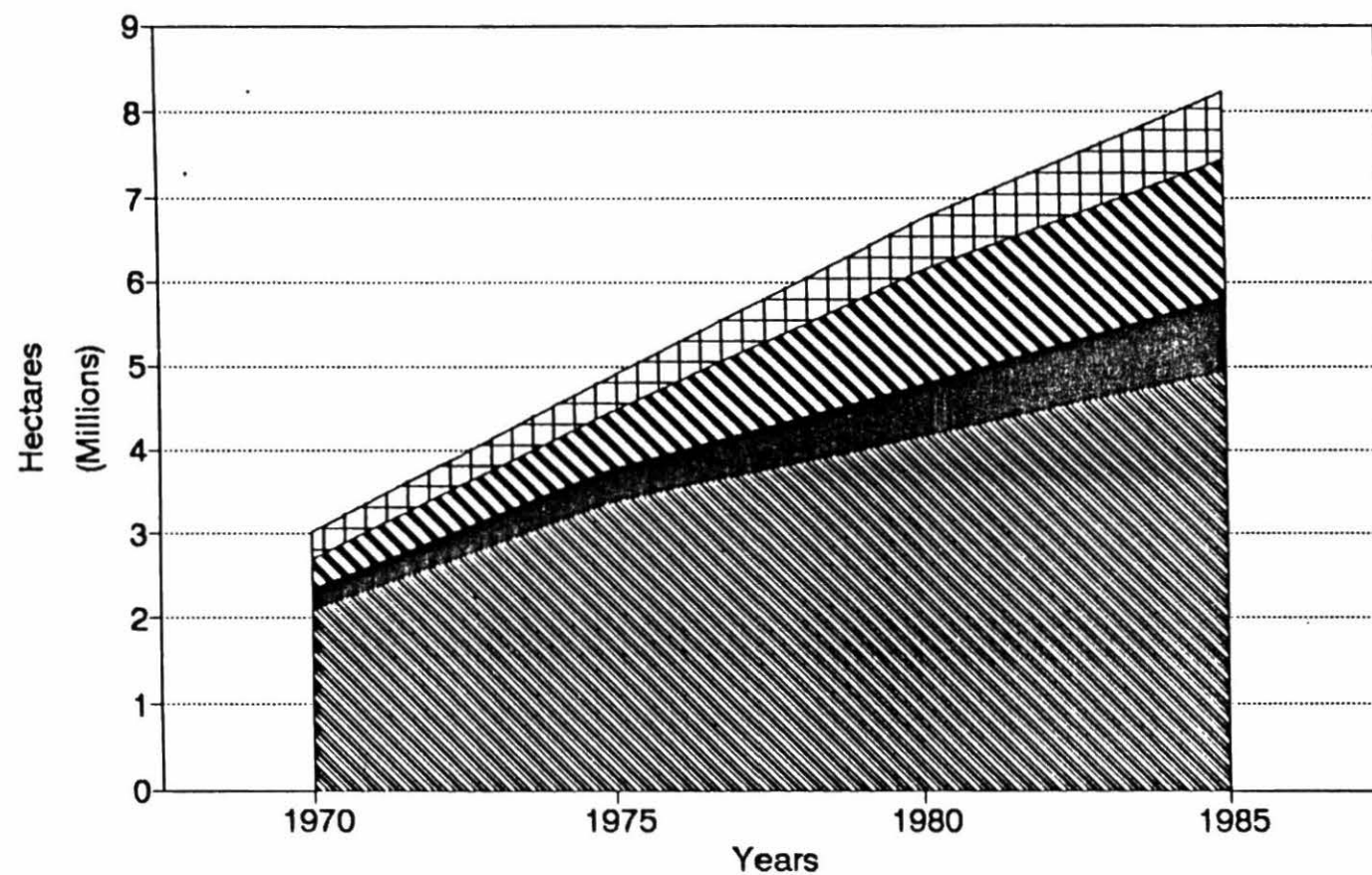
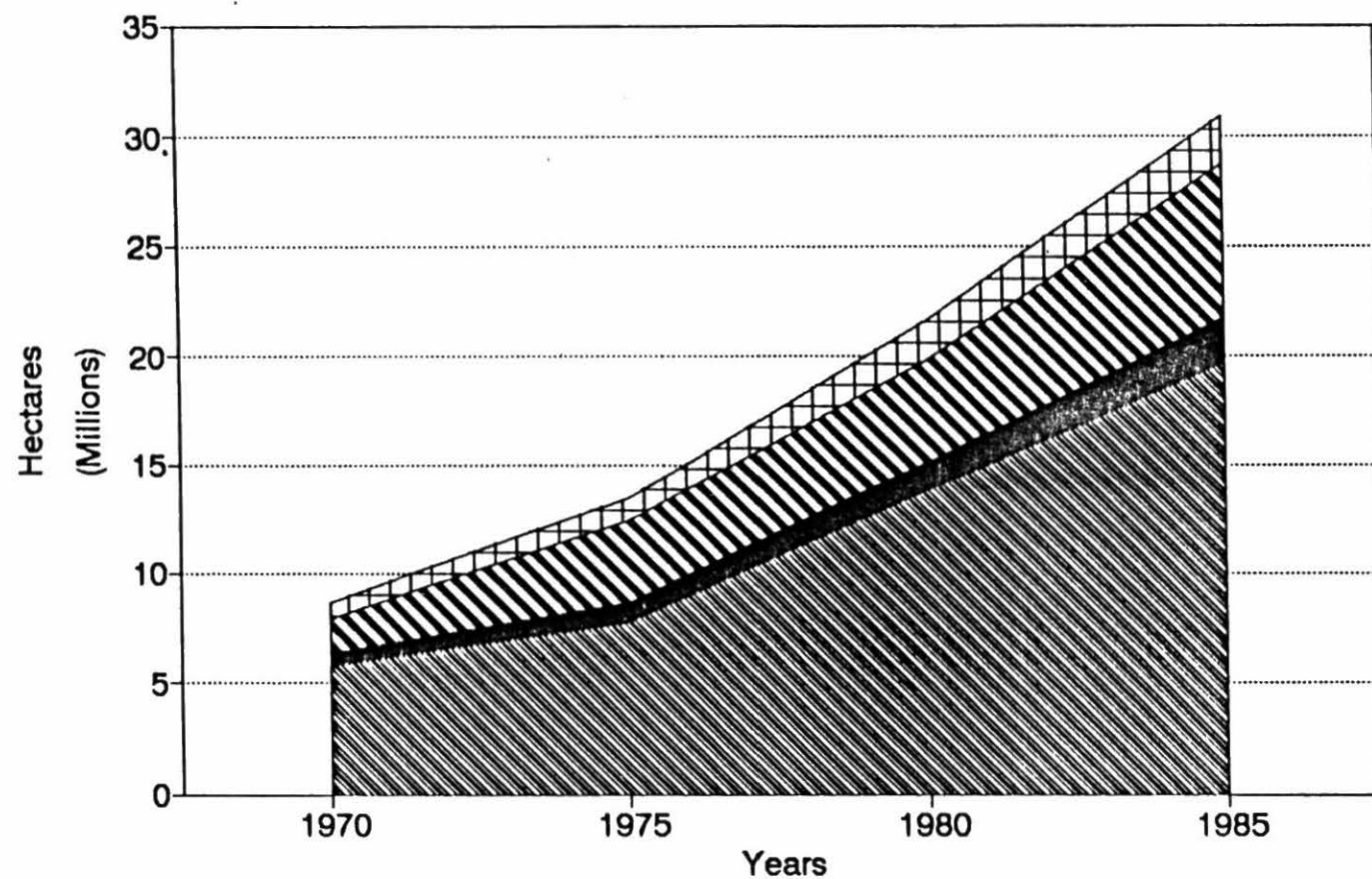


Fig S.8-AREA IN PLANTED PASTURES
SAVANNAS AND ZONES, 1970-1985



ADVANCED AGR. RECENT EXPANS FRONTIER AGR. RESIDUAL

Fig S.9-AREA CLEARED BUT NOT USED
SAVANNAS AND ZONES, 1970-1985

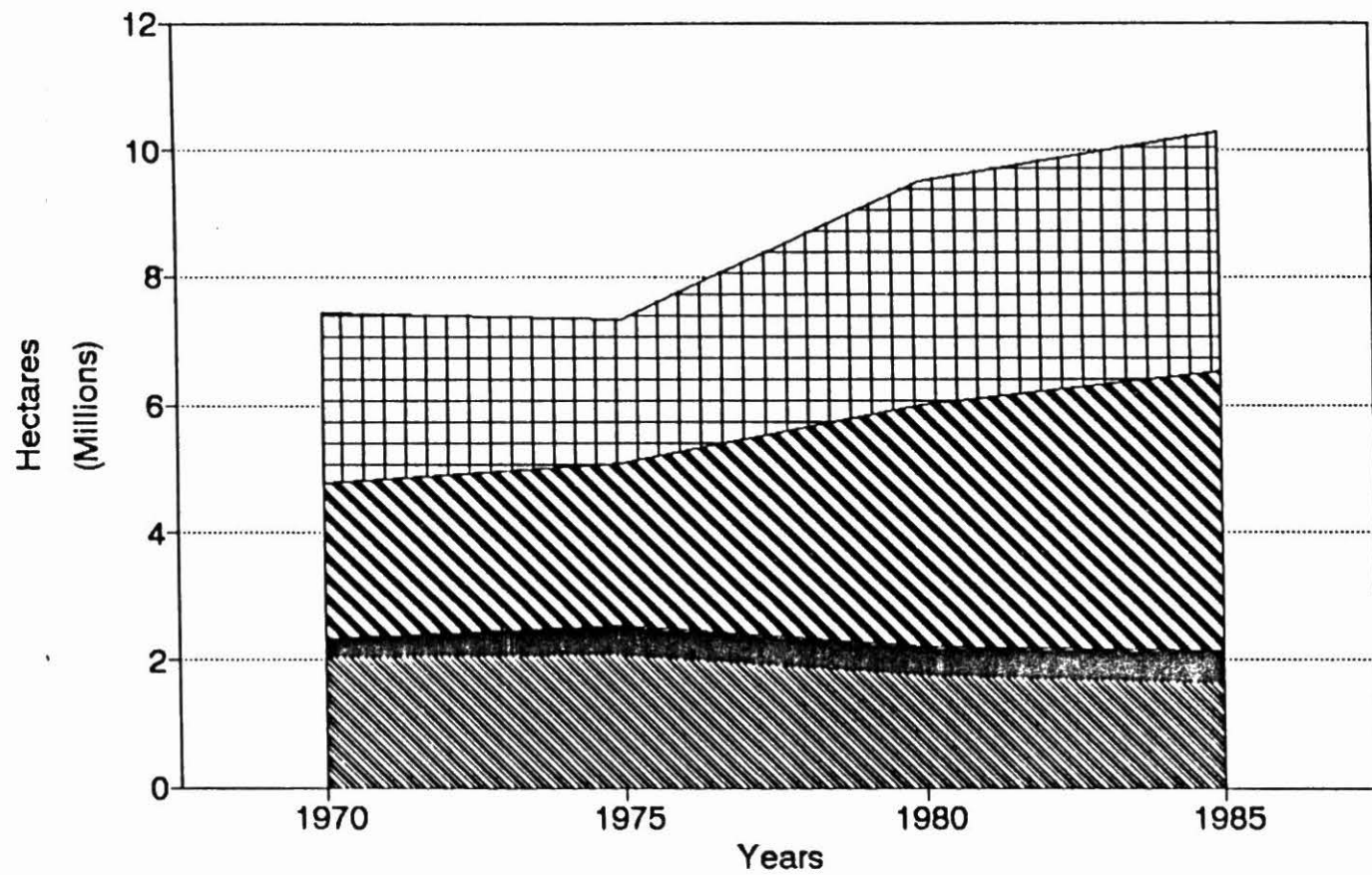
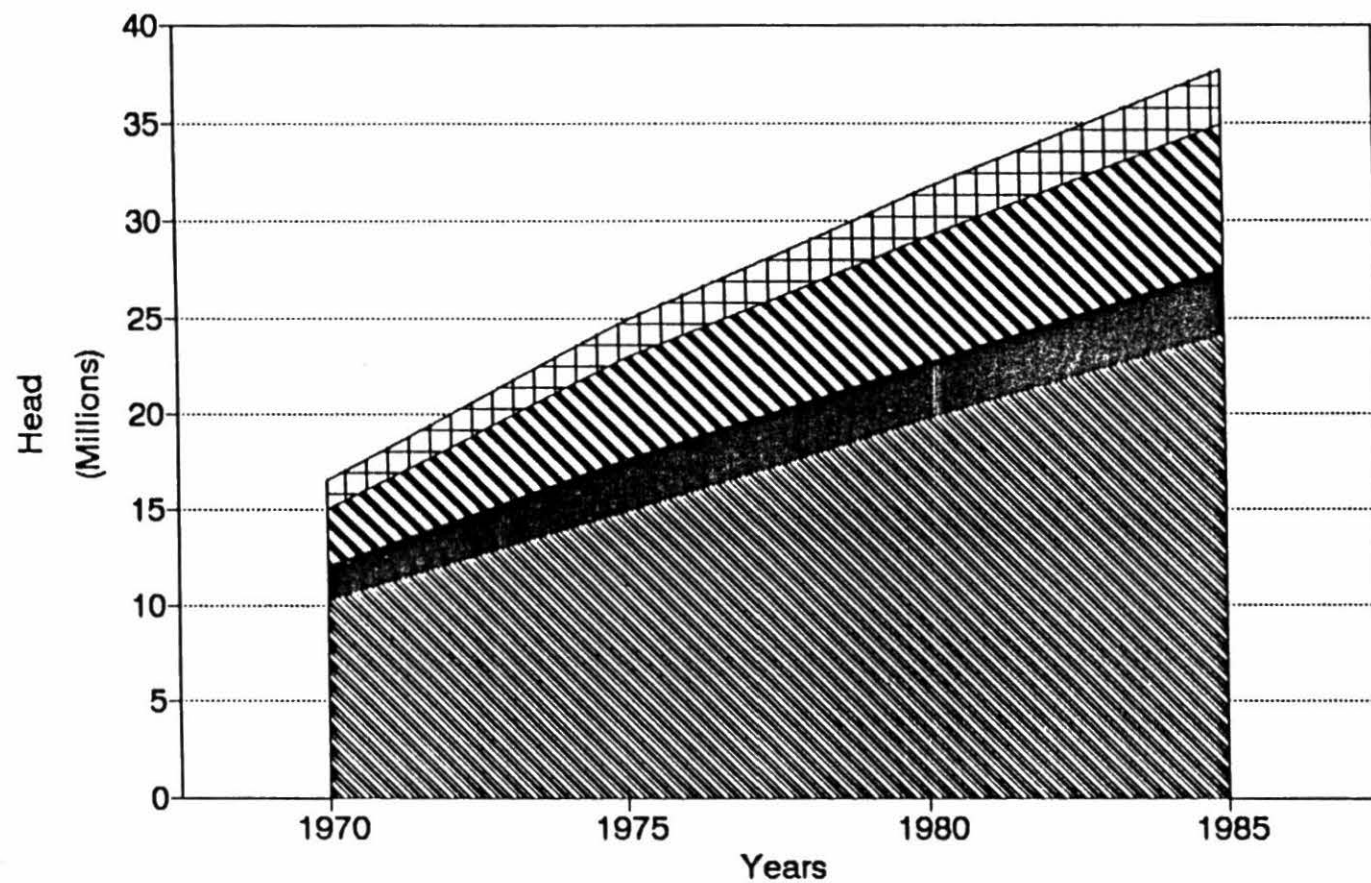
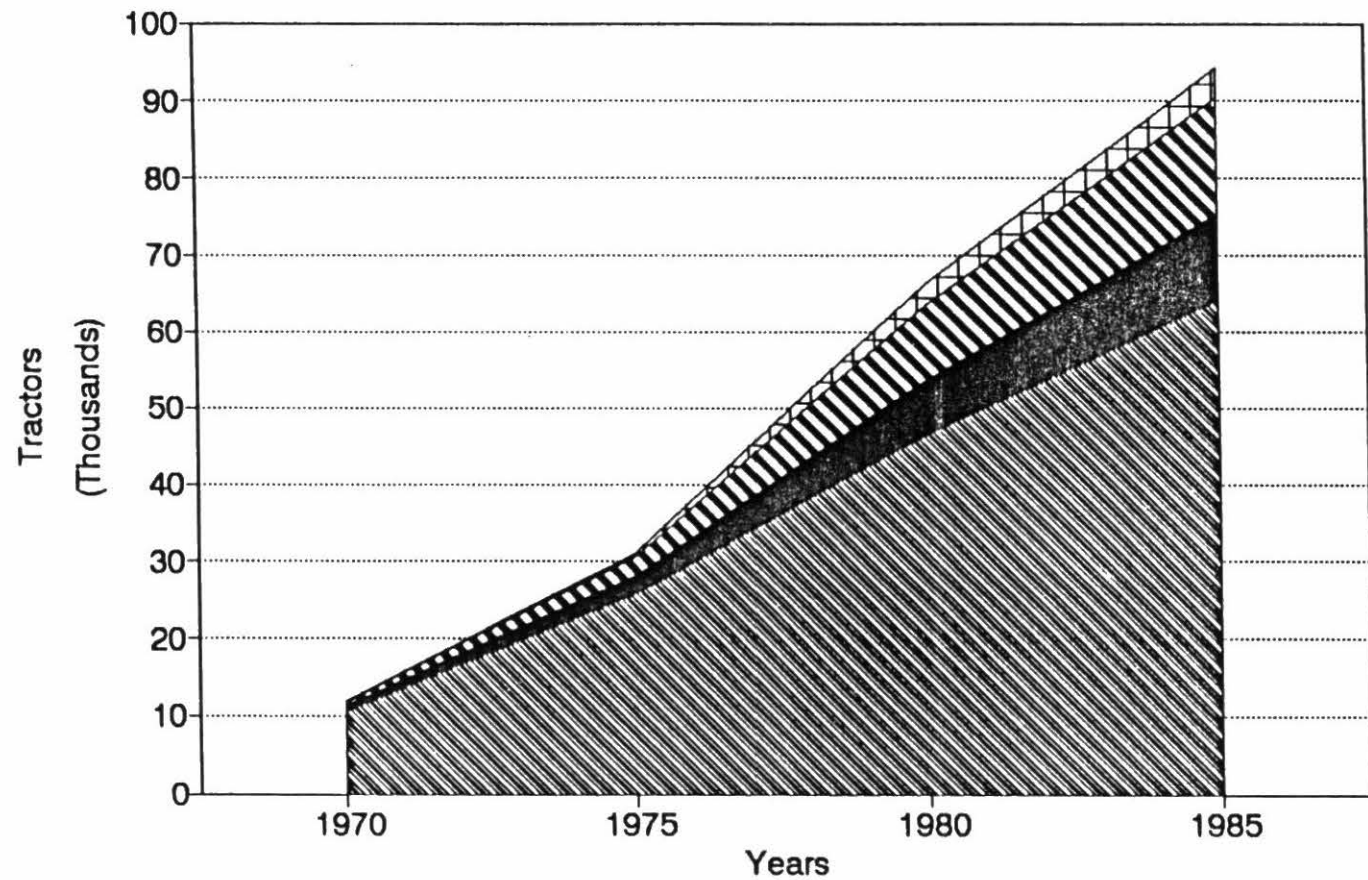


Fig S.10-THE BEEF CATTLE HERD
SAVANNAS AND ZONES, 1970-1985



 ADVANCED AGR.
  RECENT EXPANS.
  FRONTIER AGR.
  RESIDUAL

Fig S.11-NUMBER OF TRACTORS
SAVANNAS AND ZONES, 1970-1985



ADVANCED AGR. RECENT EXPANS FRONTIER AGR. RESIDUAL

Fig S.12-MANPOWER IN AGRICULTURE
SAVANNAS AND ZONES, 1970-1985

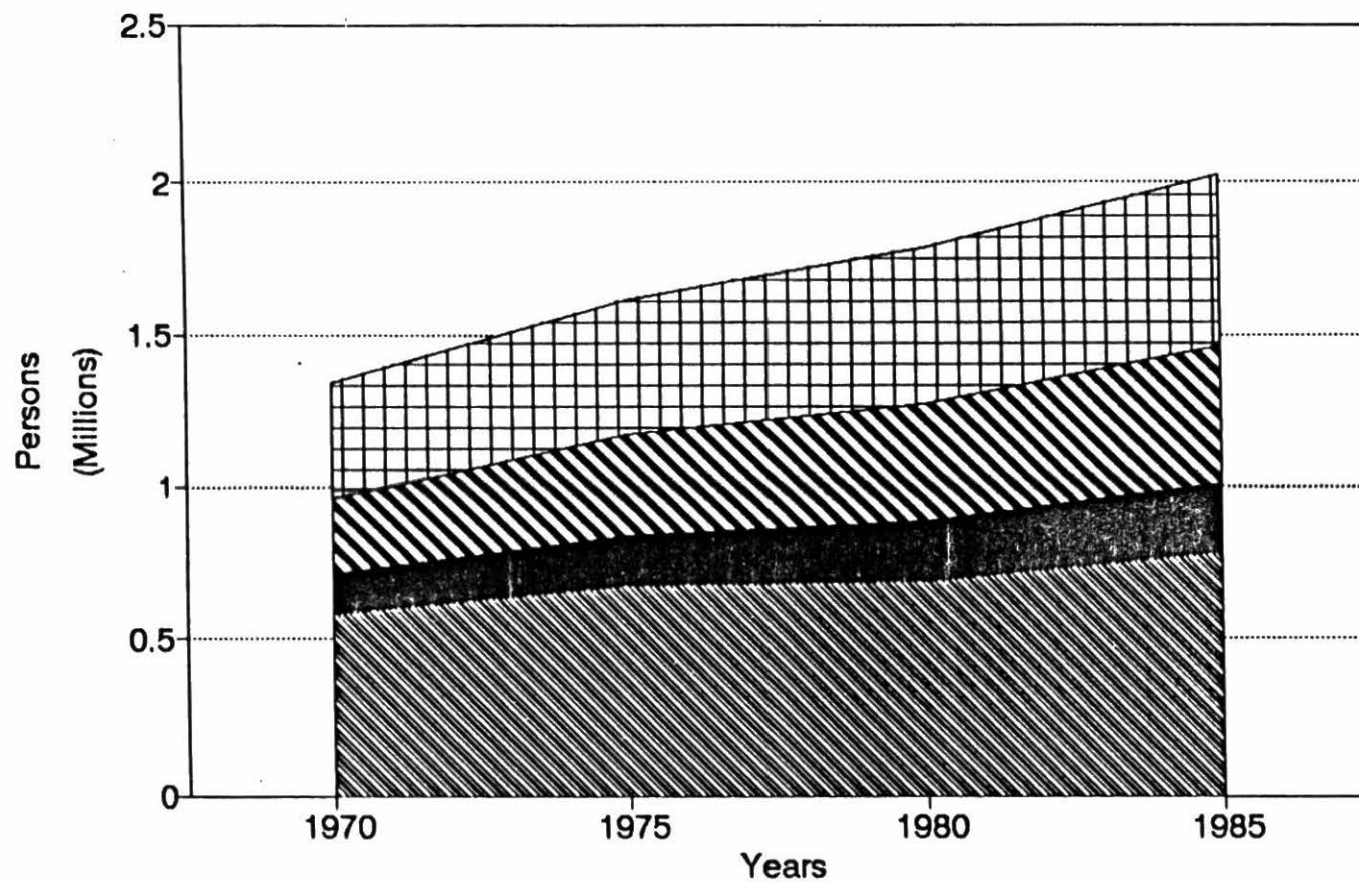
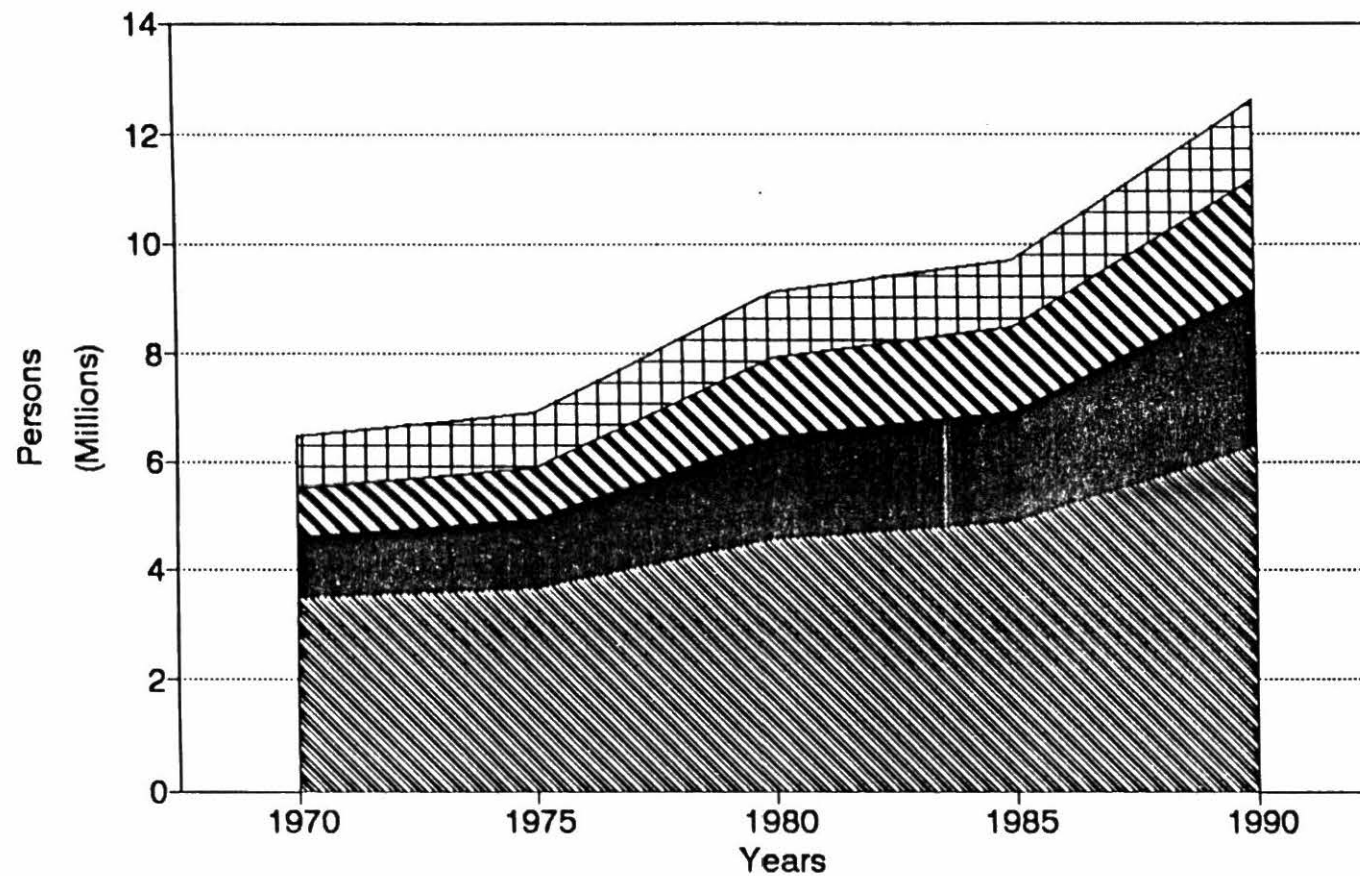


Fig S.13-POPULATION TRENDS
SAVANNAS AND ZONES, 1970-1990



ADVANCED AGR. RECENT EXPANS FRONTIER AGR. RESIDUAL

Fig S.14-SAVANNAS LAND TENURE

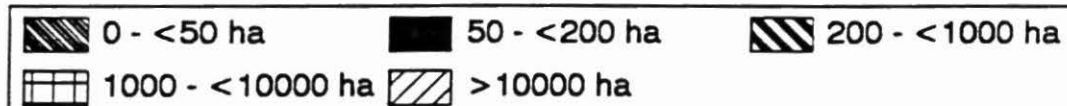
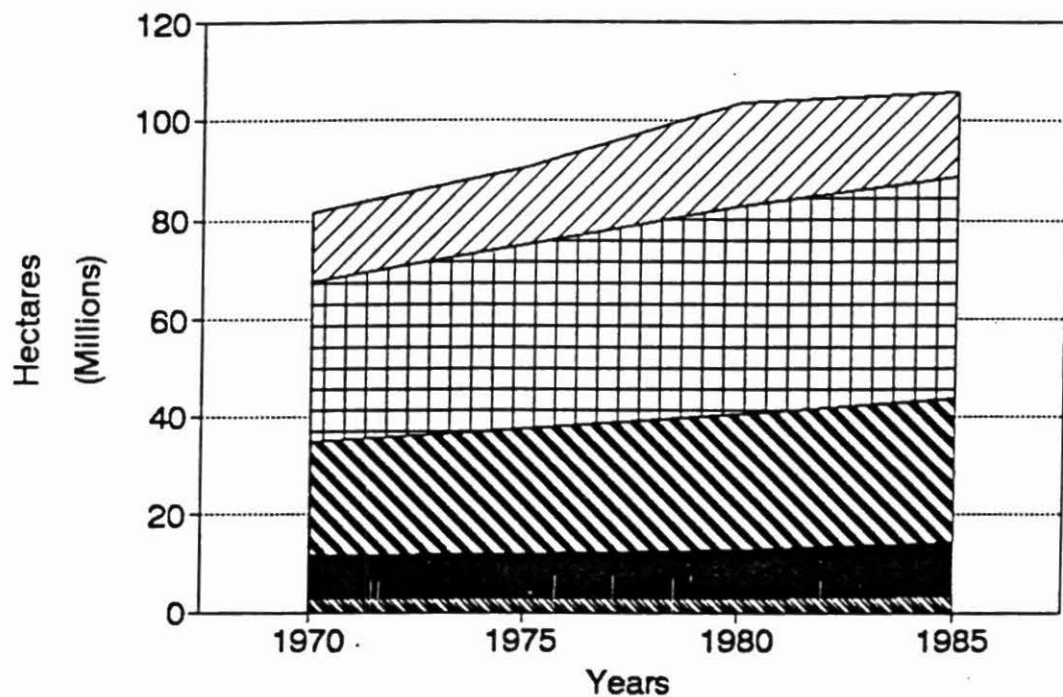
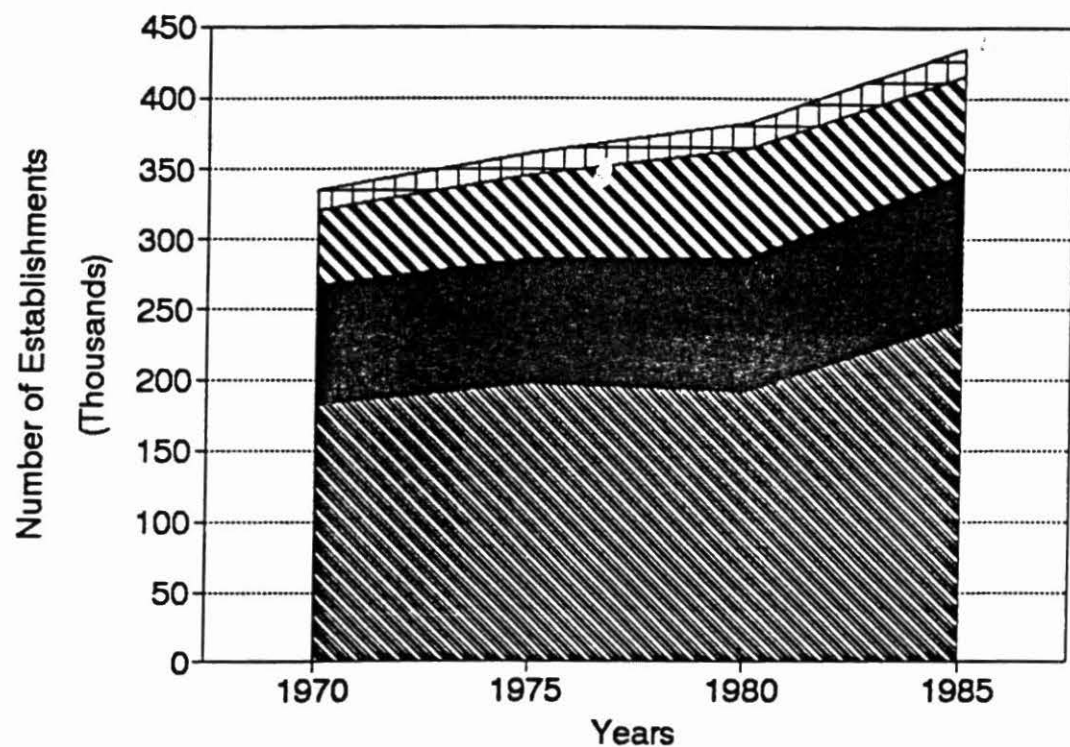


Fig S.15-ADVANCED AGRICULTURE LAND TENURE

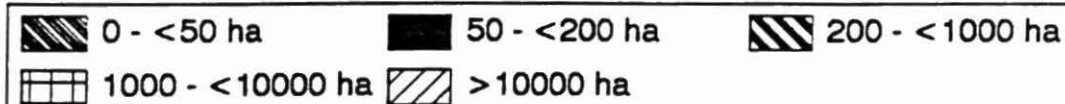
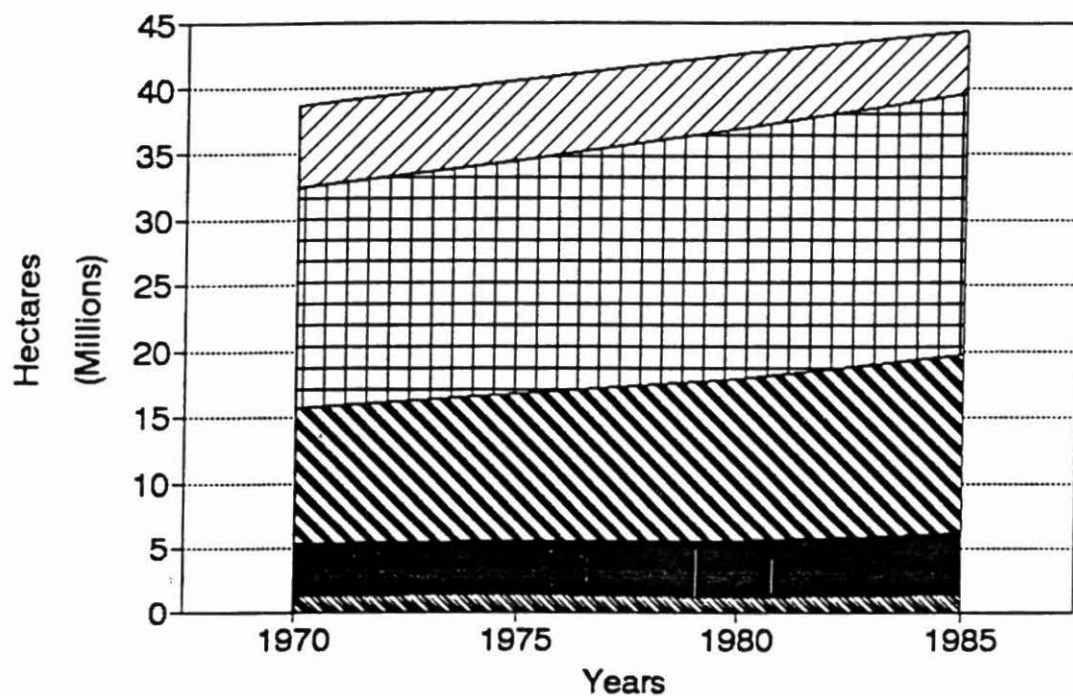
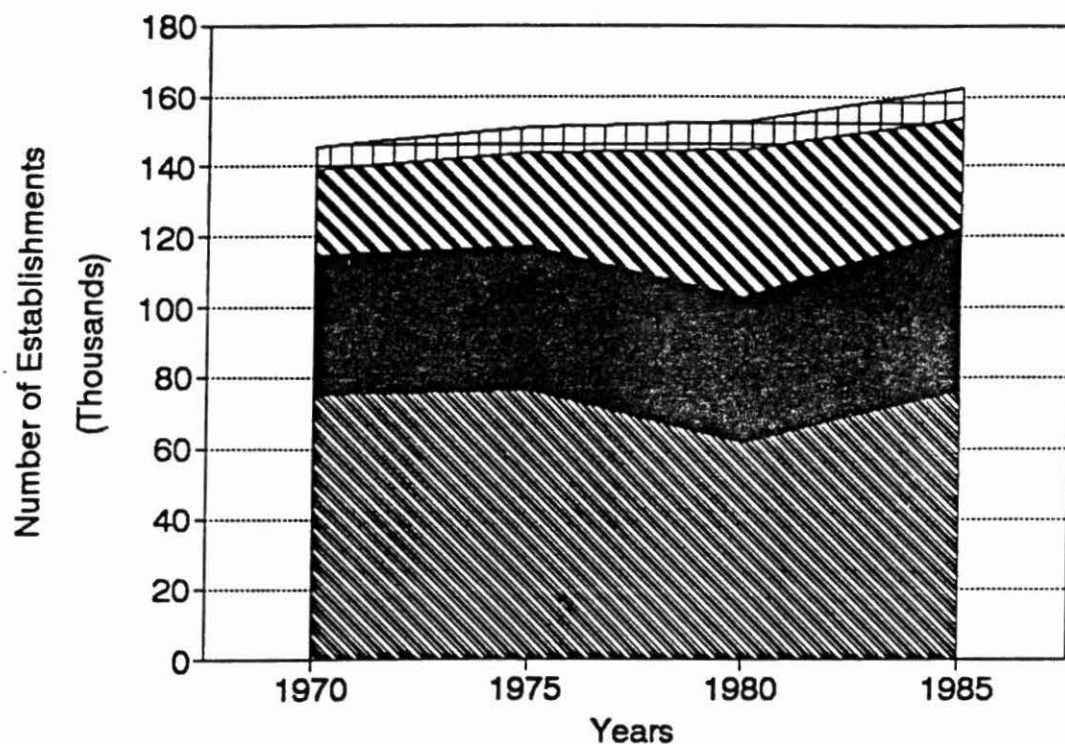


Fig S.16-RECENT EXPANSION LAND TENURE

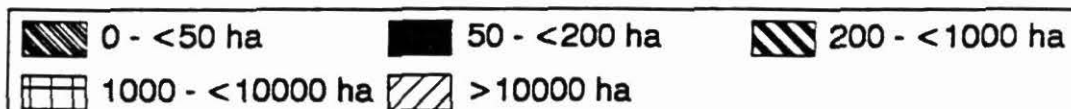
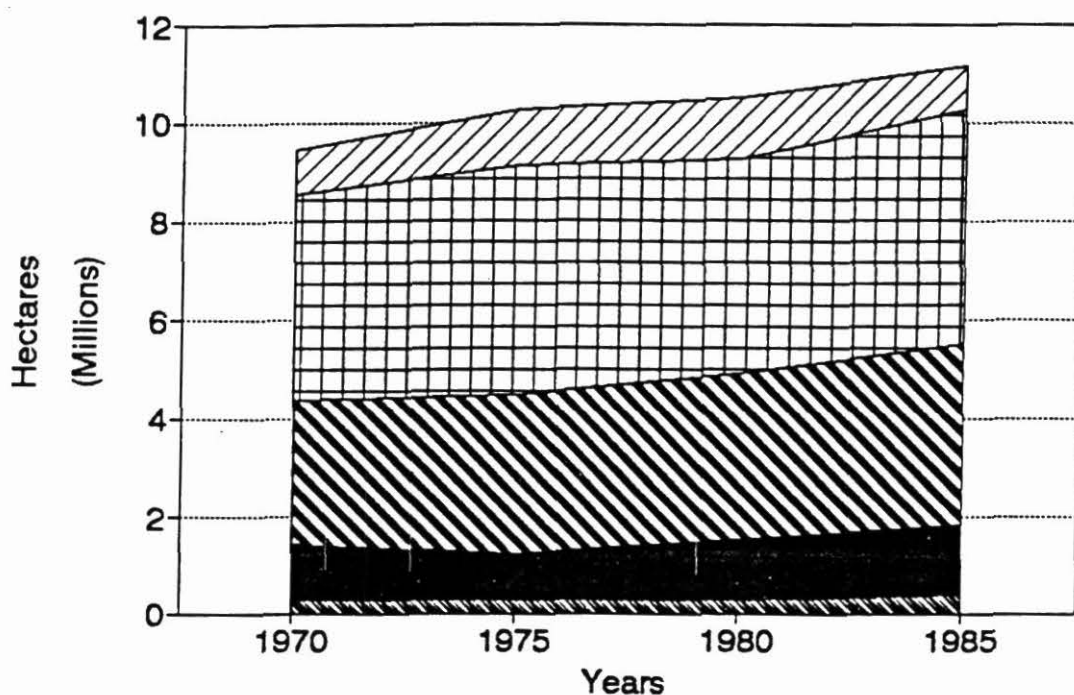
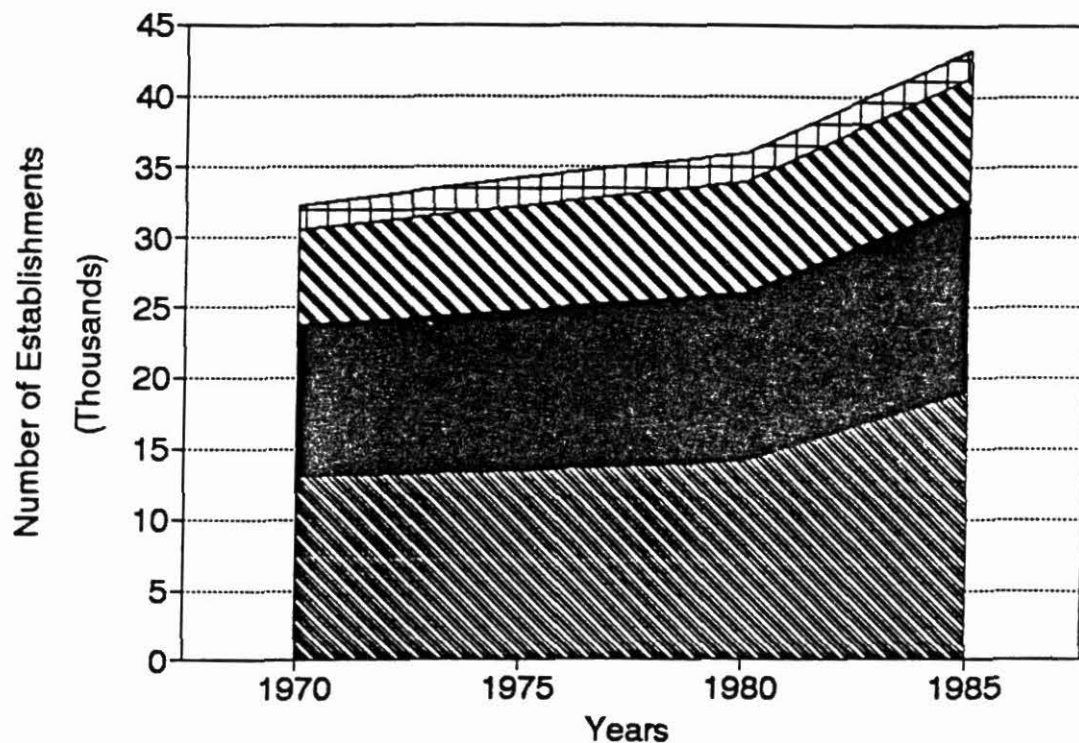


Fig S.17-FRONTIER AGRICULTURE LAND TENURE

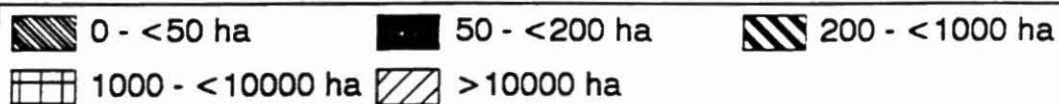
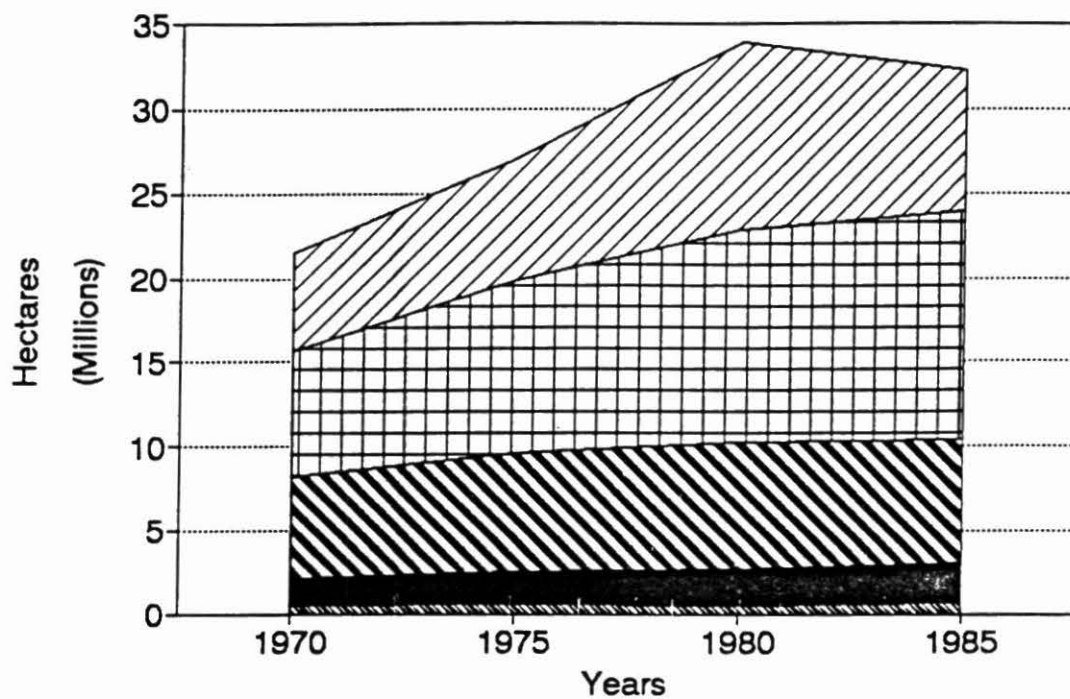
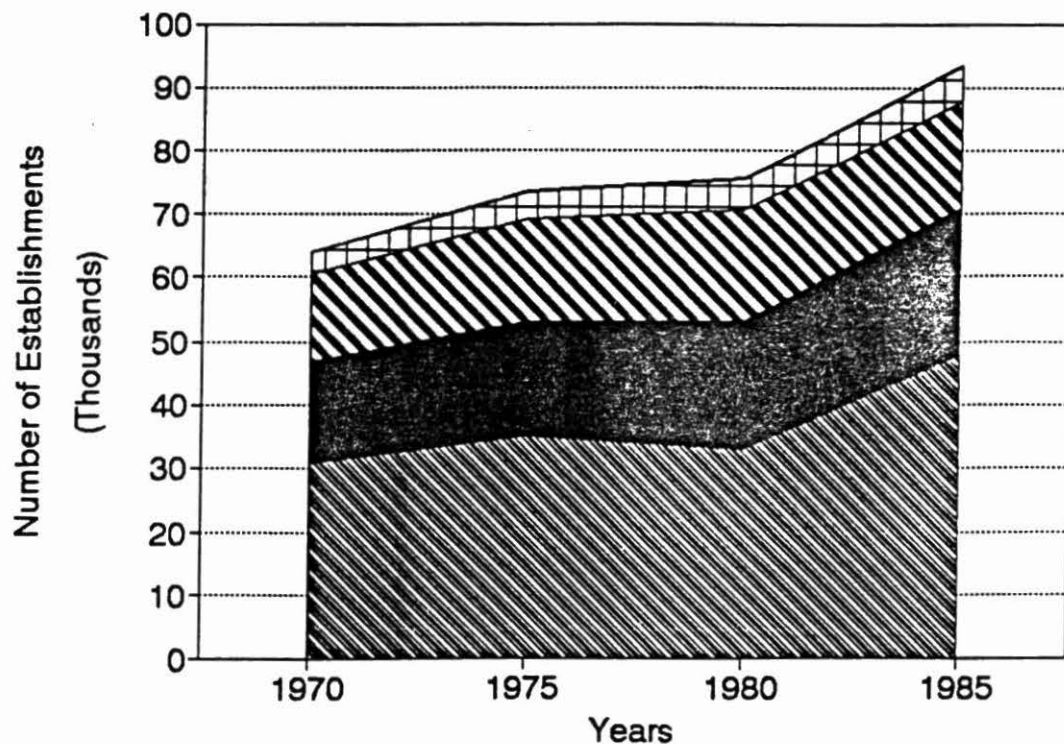


Fig S.18-RESIDUAL LAND TENURE

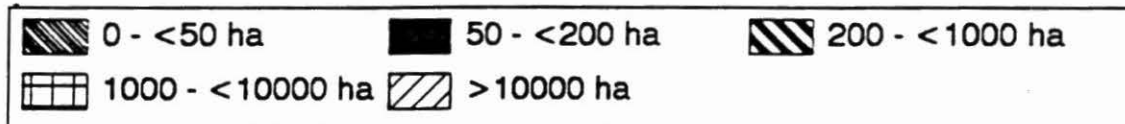
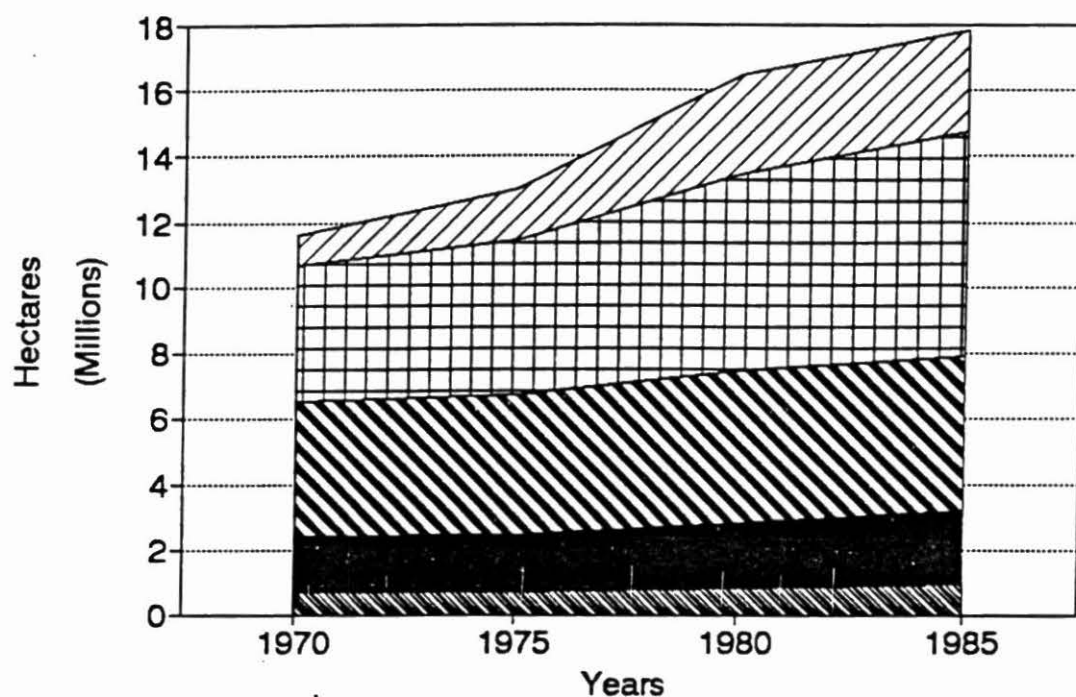
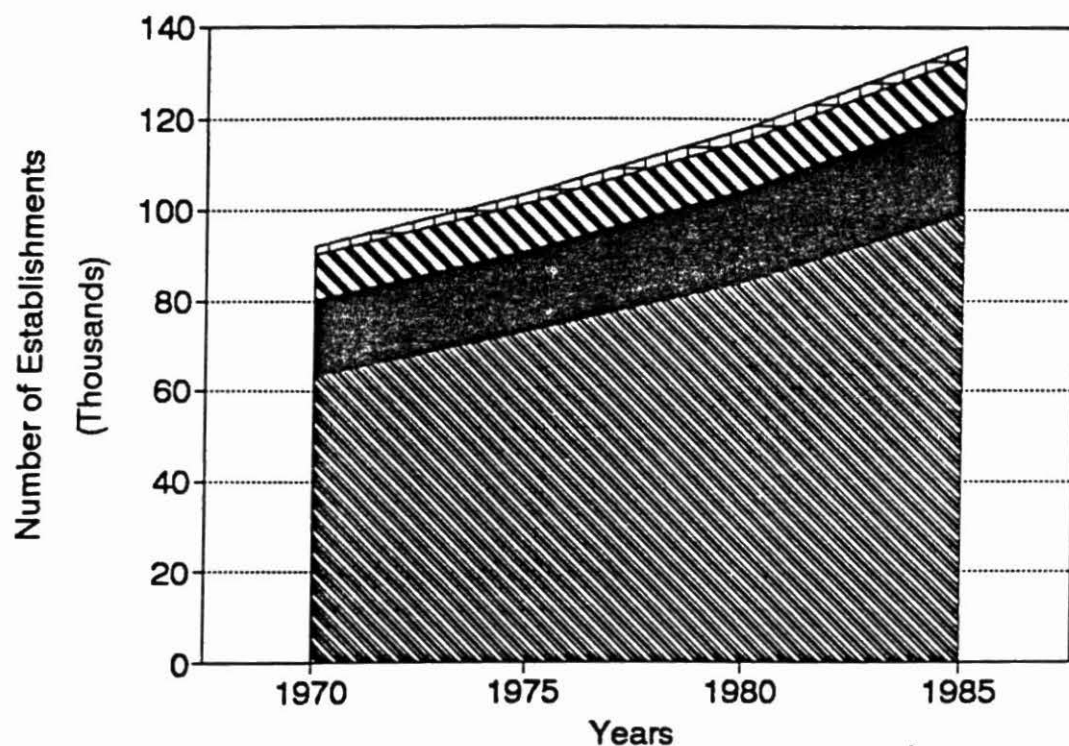


Fig S.19-PRODUCTION OF SOYBEANS
SAVANNAS, 1984-1990

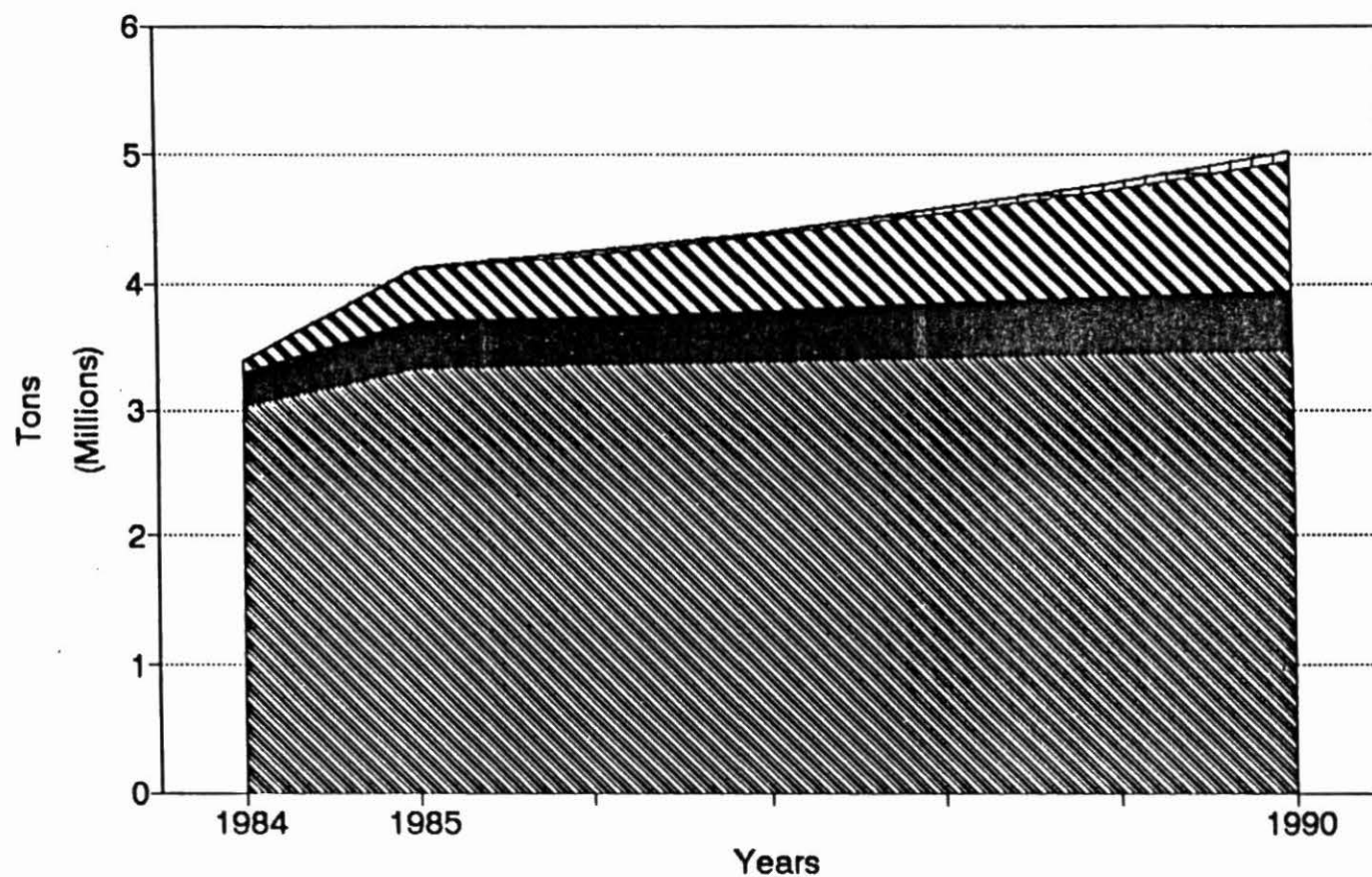


Fig S.20-PRODUCTION OF MAIZE
SAVANNAS, 1984-1990

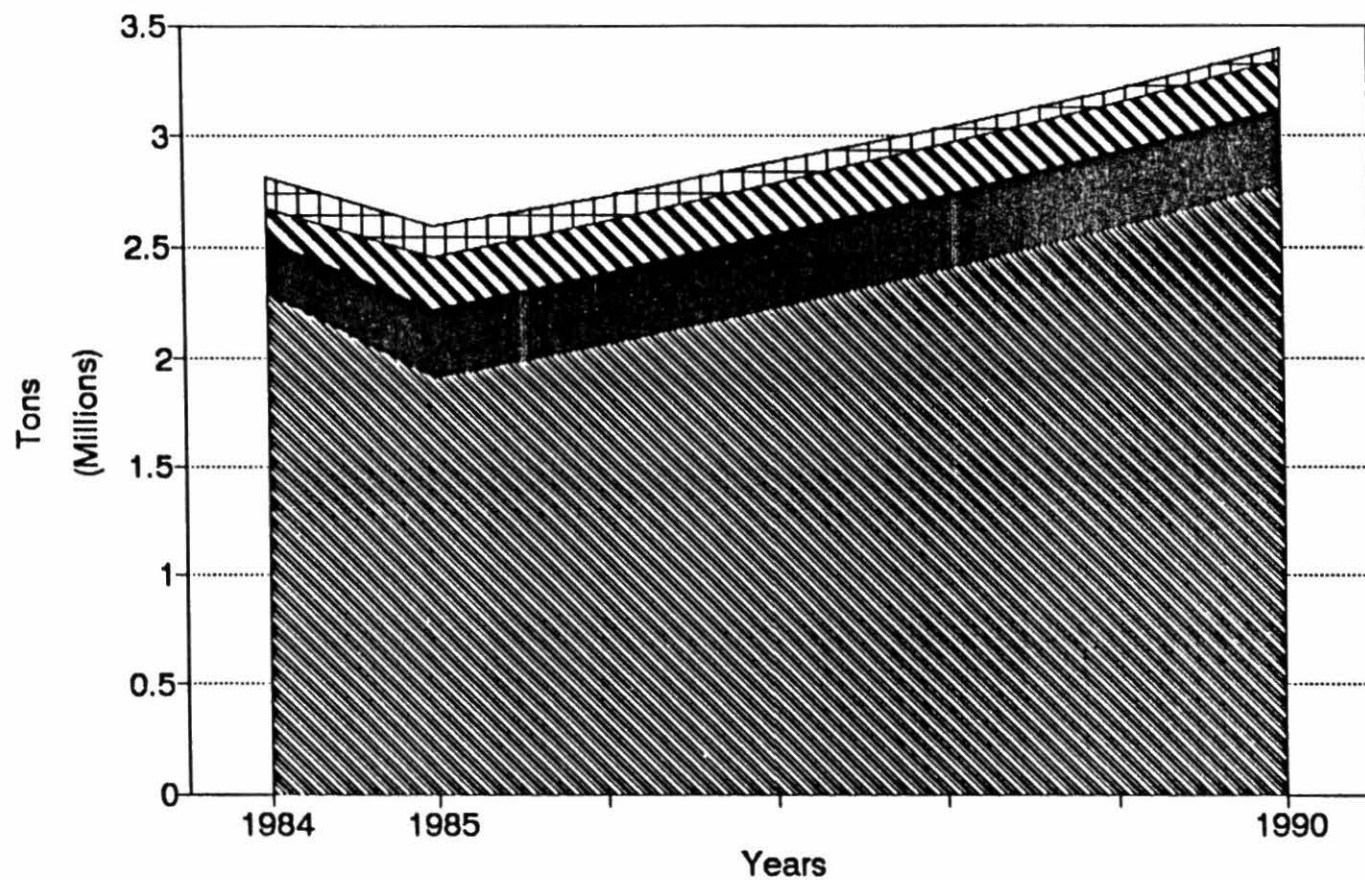
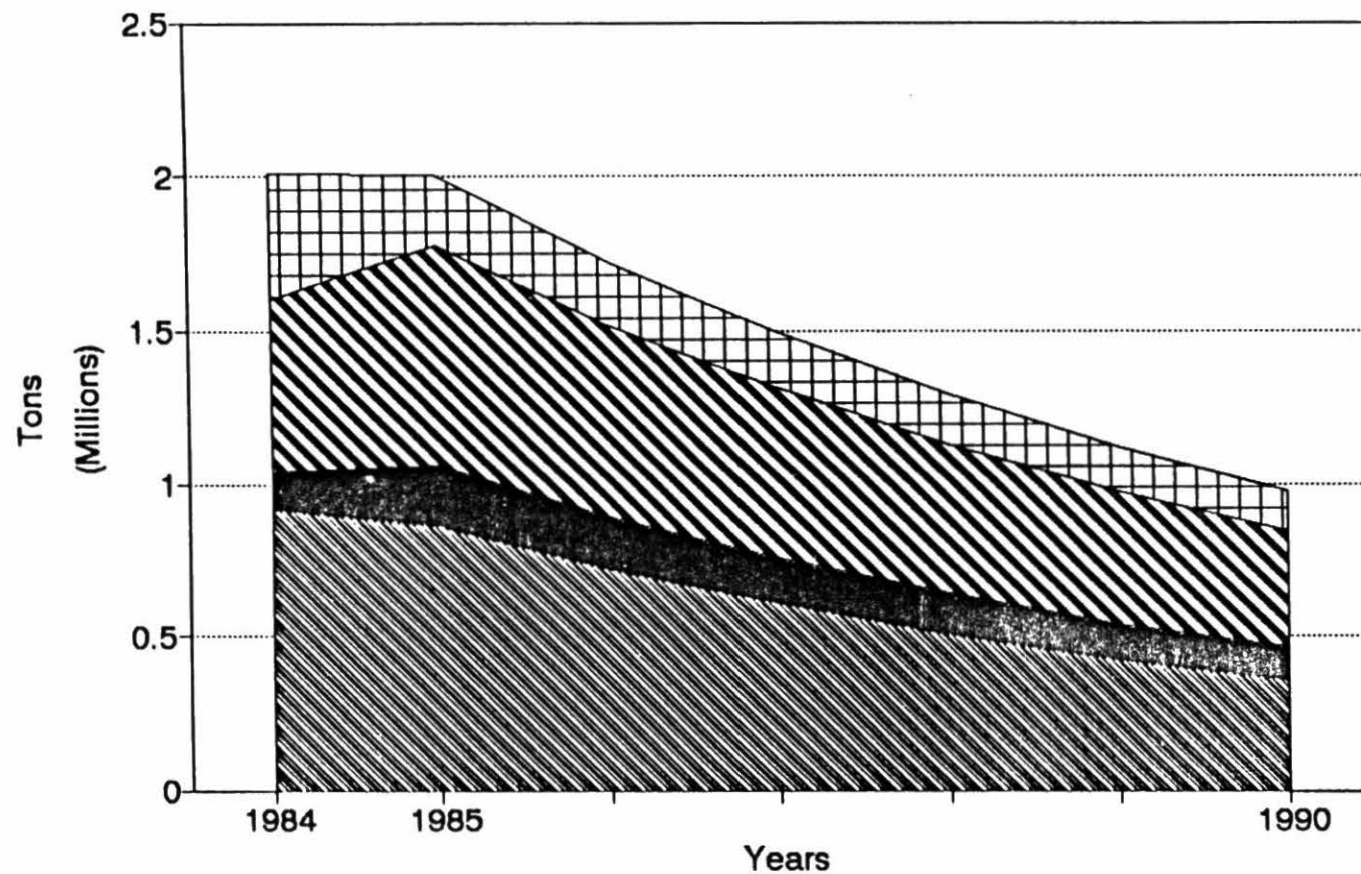
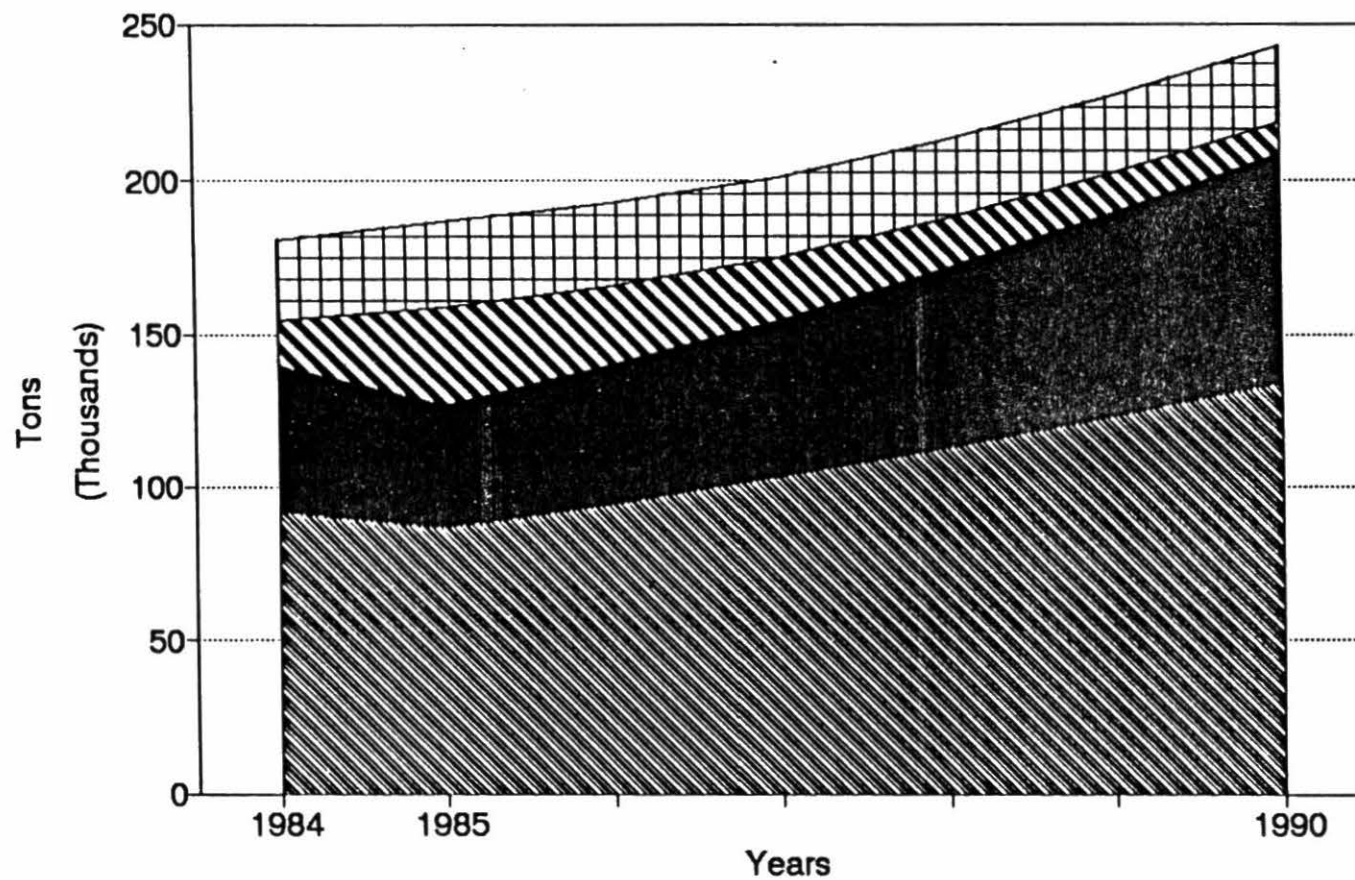


Fig S.21-PRODUCTION OF RICE
SAVANNAS, 1984-1990



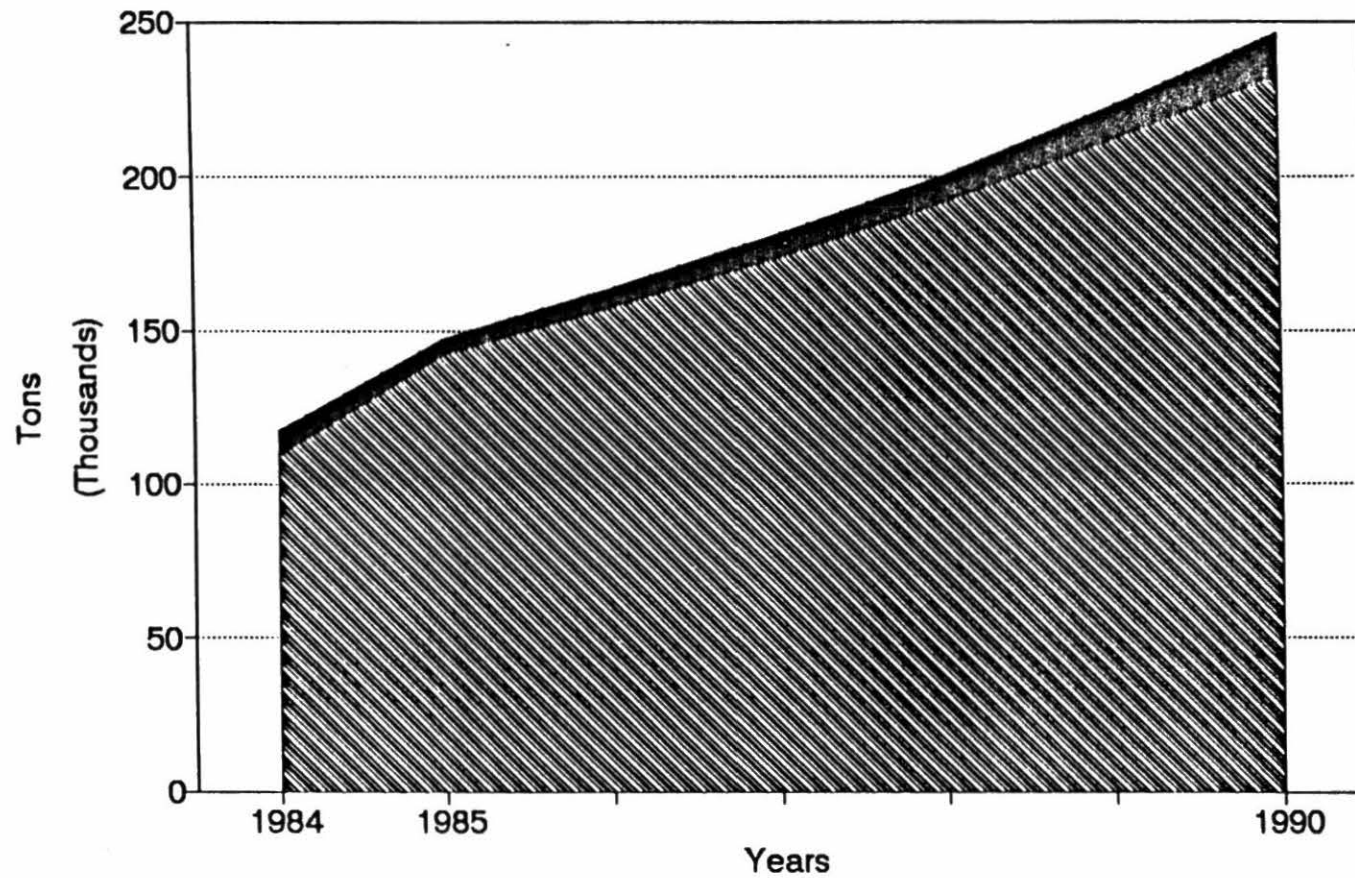
ADVANCED AGR. RECENT EXPANS FRONTIER AGR. RESIDUAL

Fig S.22-PRODUCTION OF BEANS
SAVANNAS, 1984-1990



ADVANCED AGR. RECENT EXPANS FRONTIER AGR. RESIDUAL

Fig S.23-PRODUCTION OF COFFE
SAVANNAS, 1984-1990



ADVANCED AGR. RECENT EXPANS FRONTIER AGR. RESIDUAL

Fig S.24-PRODUCTION OF MANIOC
SAVANNAS, 1984-1990

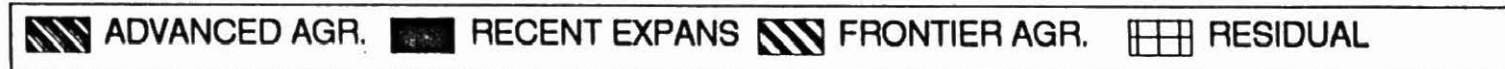
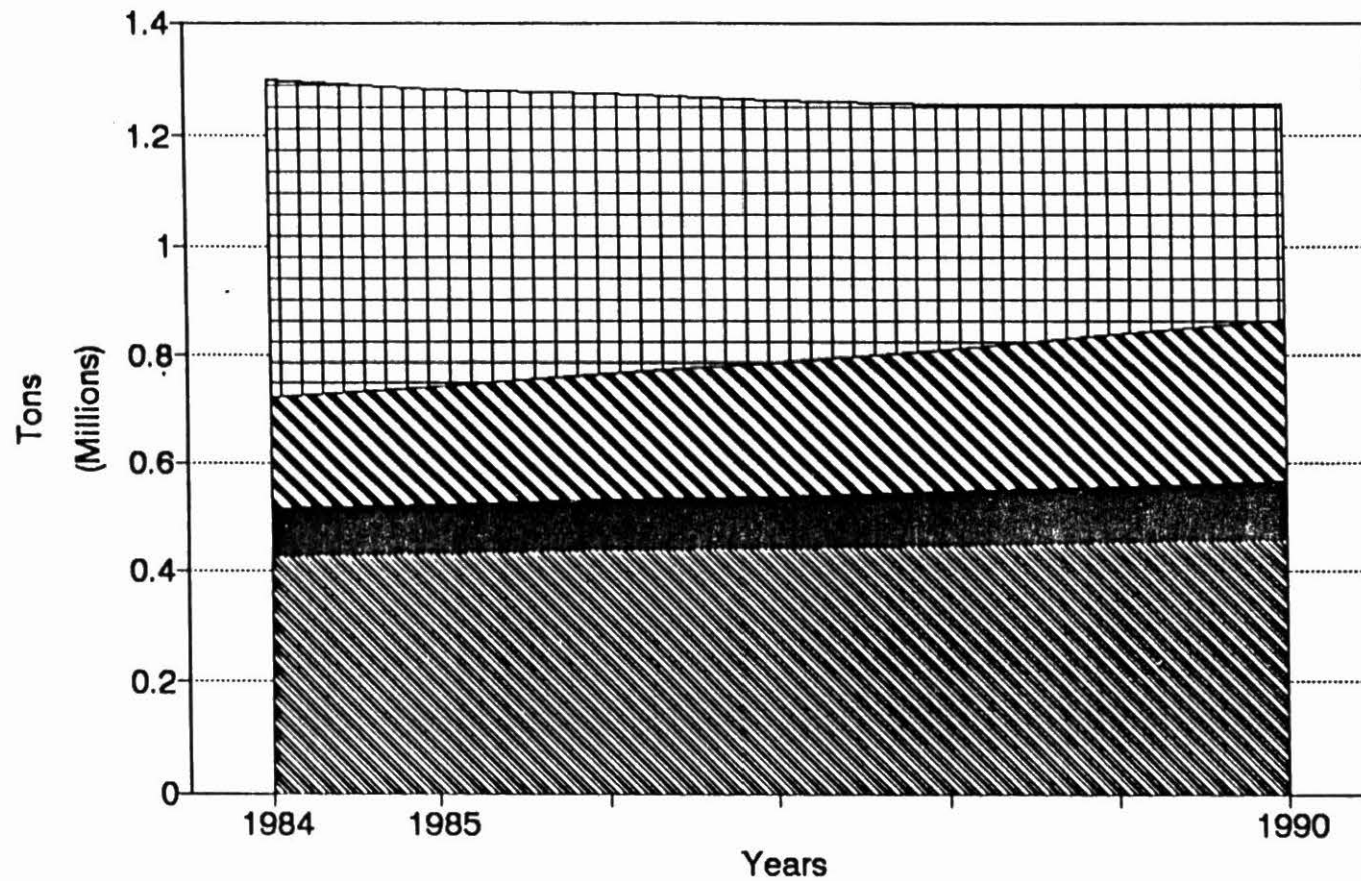


Fig S.25-ADVANCED AGRICULT.: PRODUCTION
SAVANNAS, 1984-1990

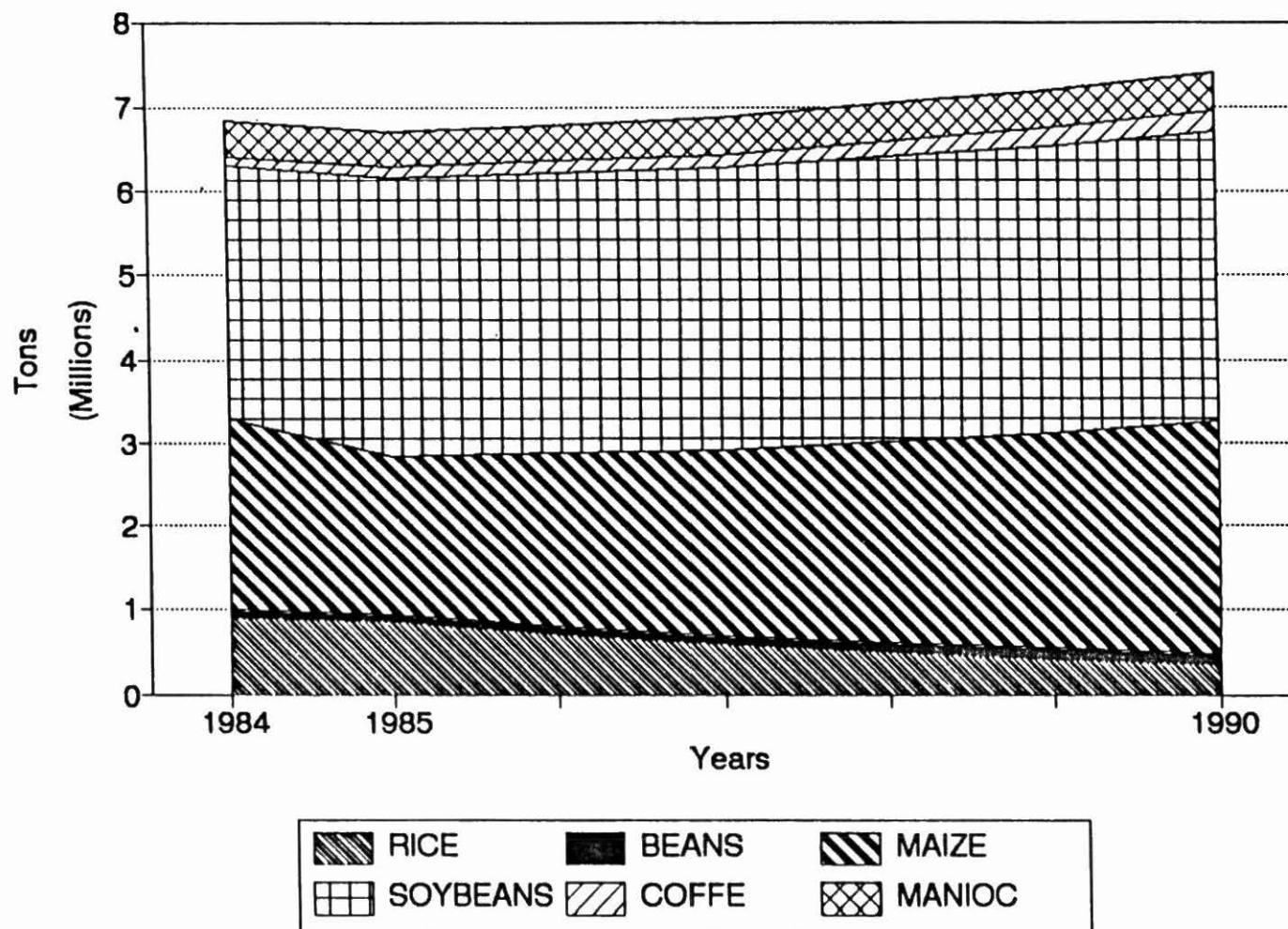


Fig S.26-RECENT EXPANSION: PRODUCTION
SAVANNAS, 1984-1990

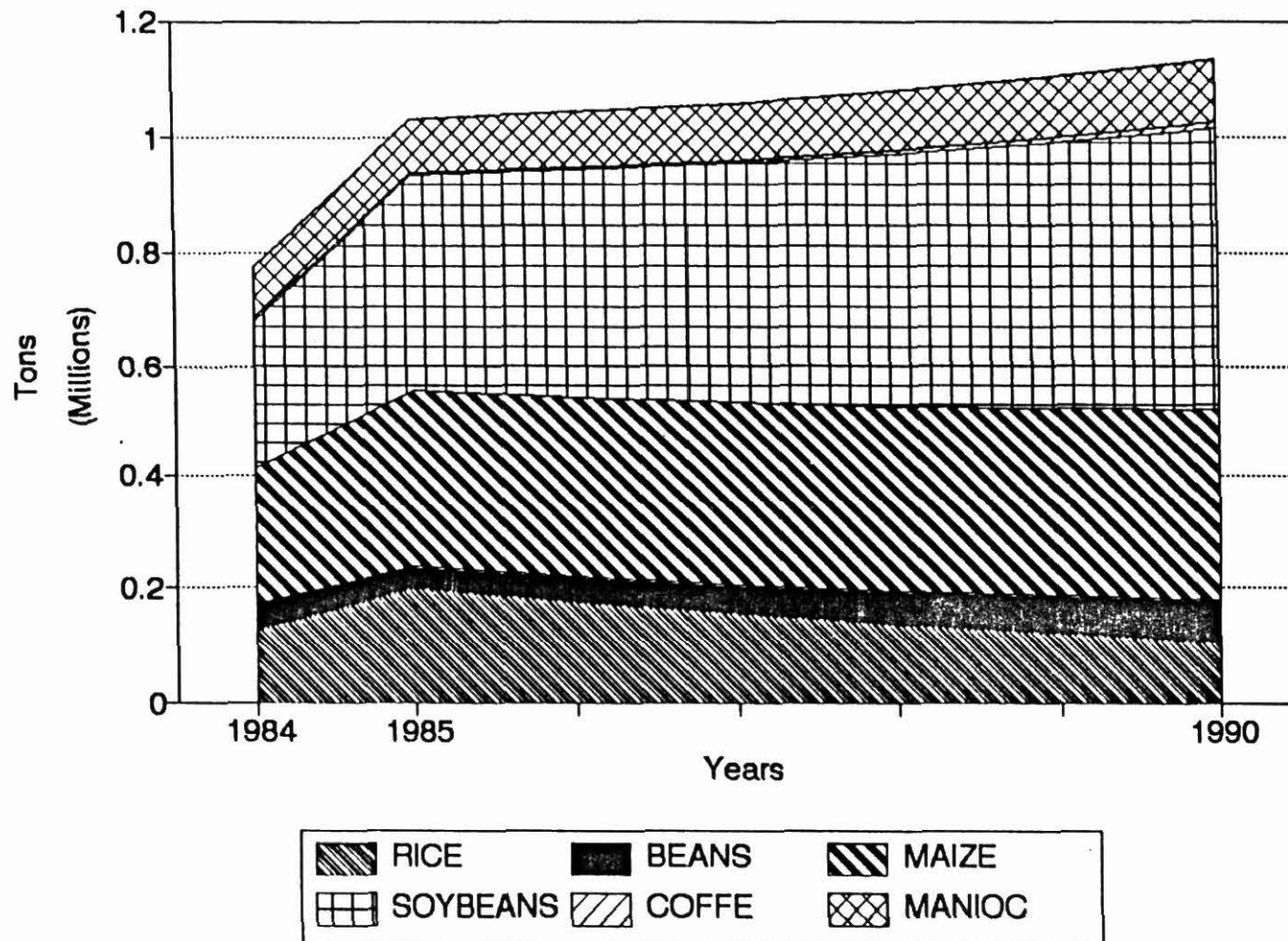


Fig S.27-FRONTIER AGRICULT.: PRODUCTION
SAVANNAS, 1984-1990

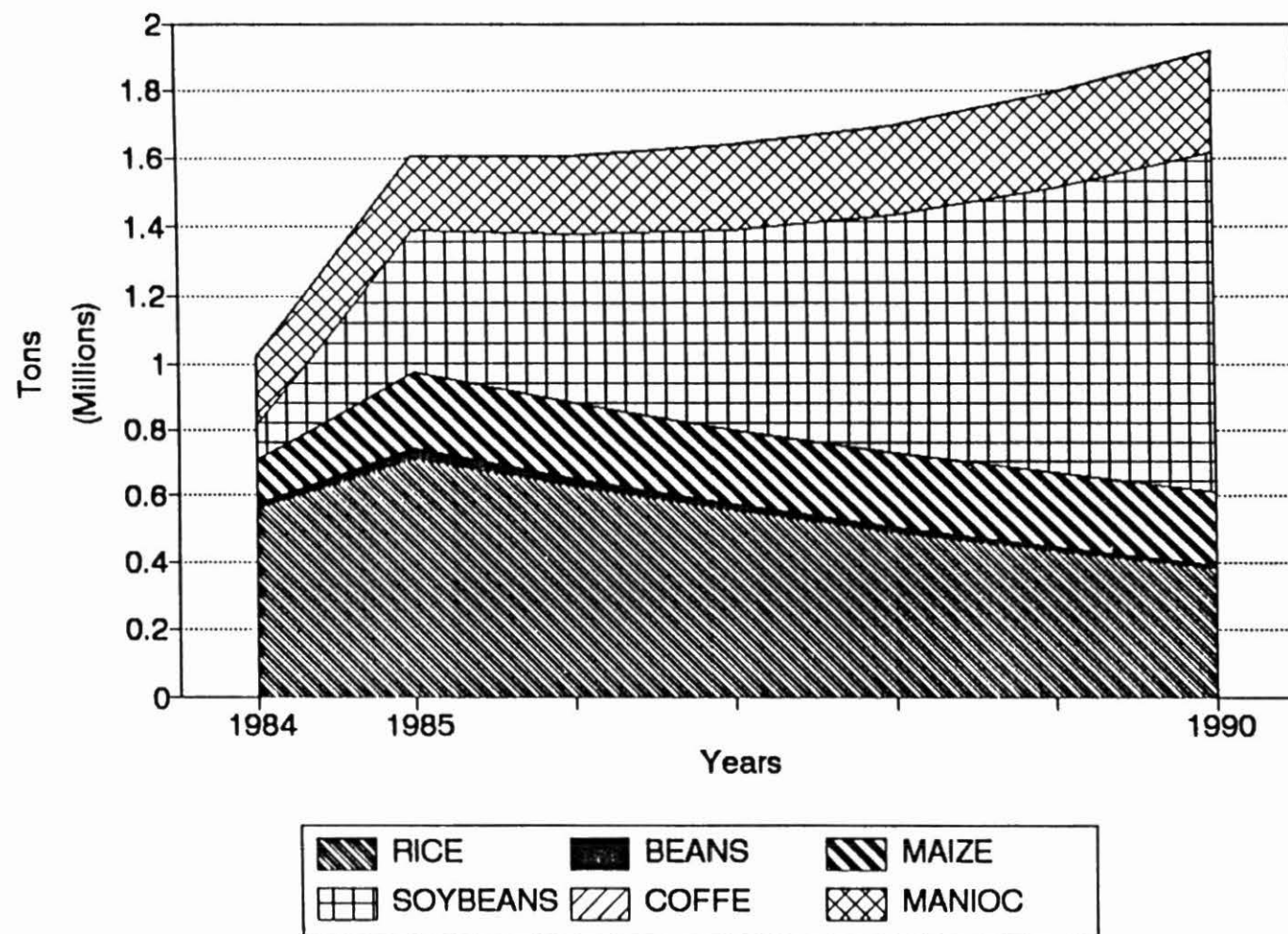


Fig S.28-RESIDUAL: PRODUCTION
SAVANNAS, 1984-1990

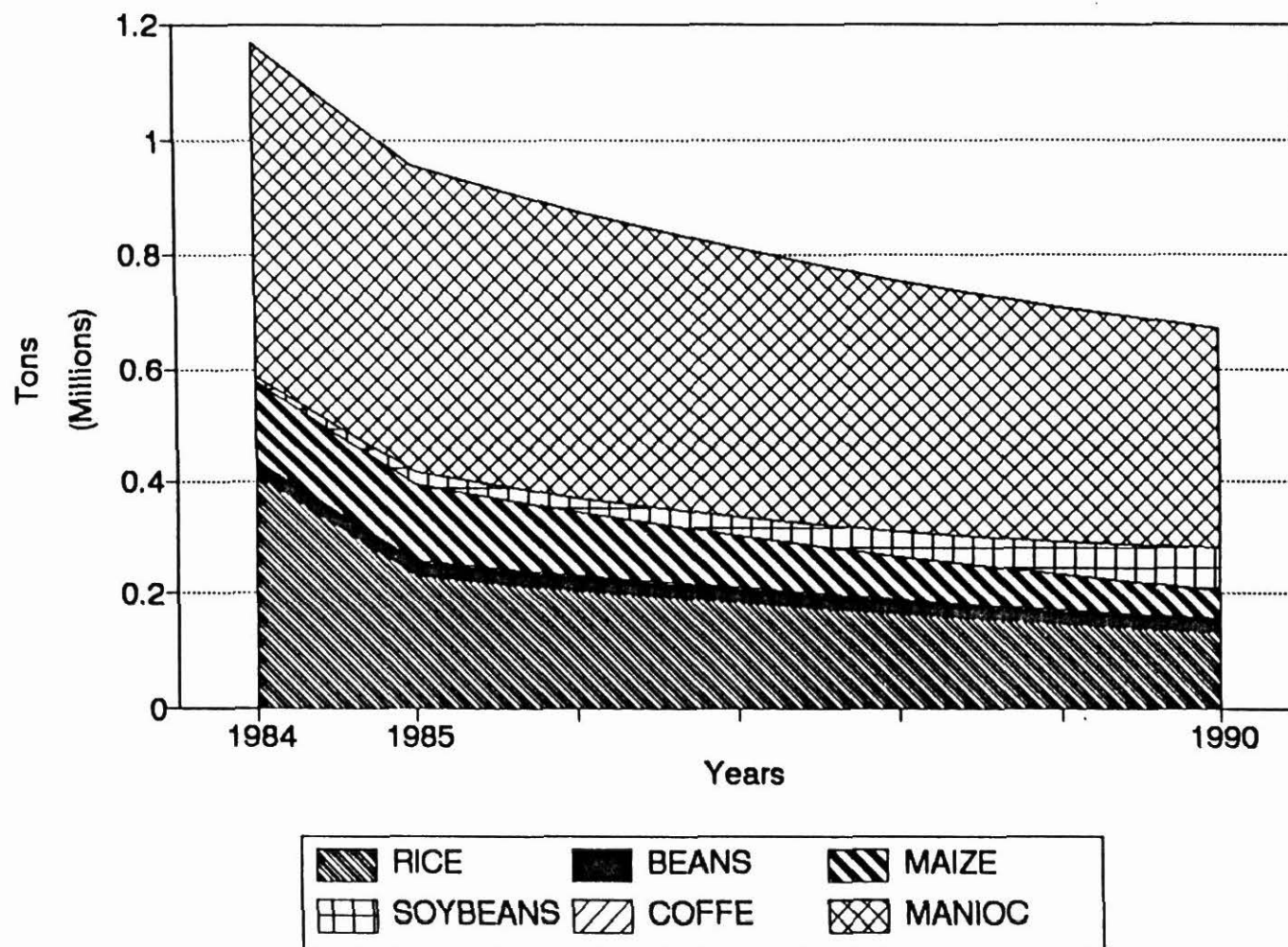
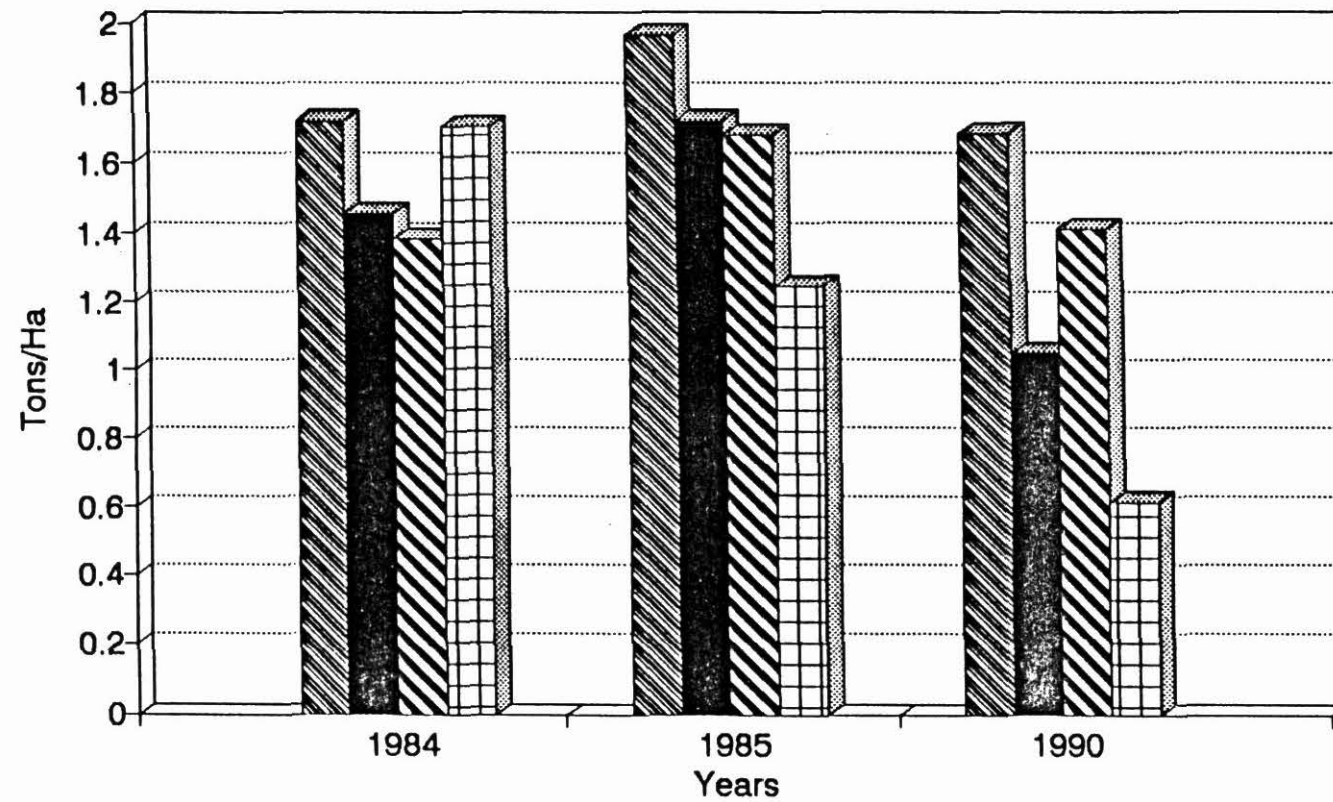
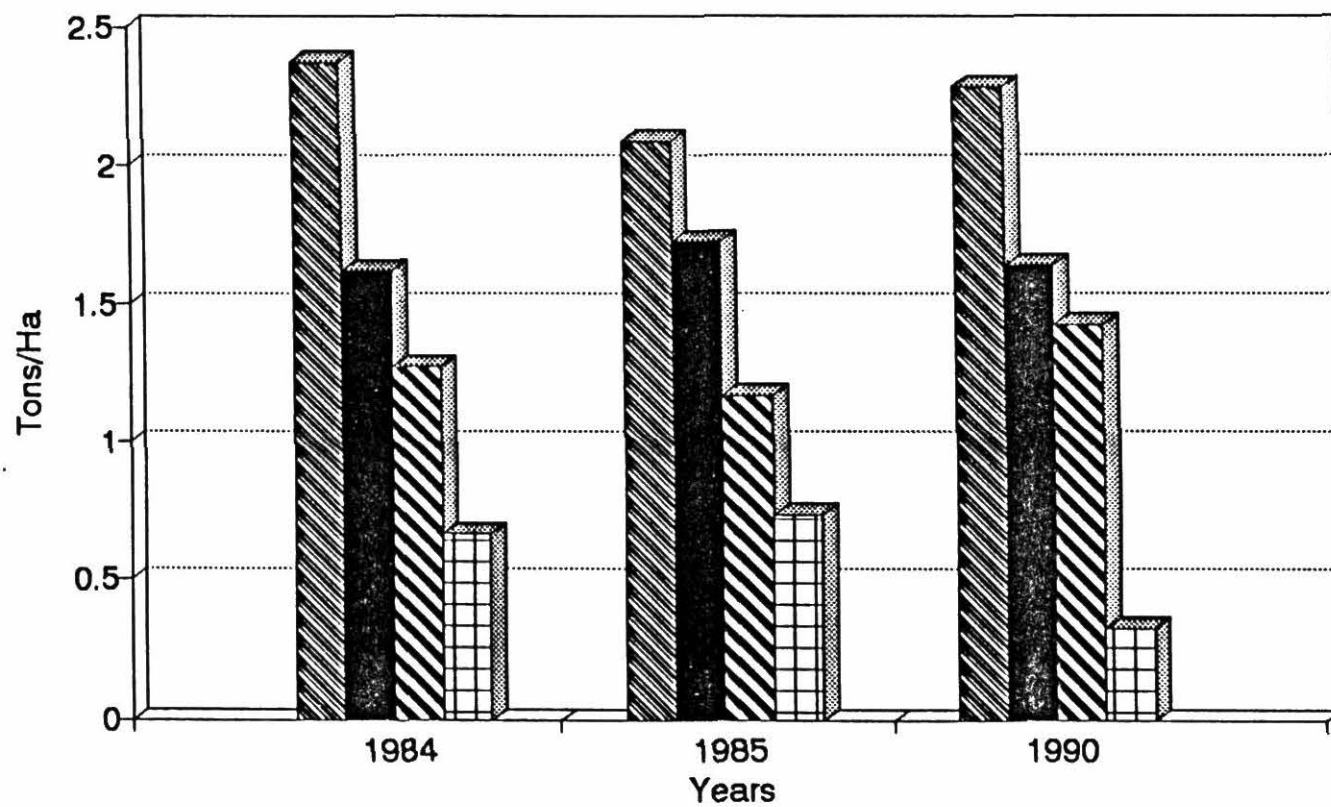


Fig S.29-YIELDS OF SOYBEANS
SAVANNAS, 1984-1990



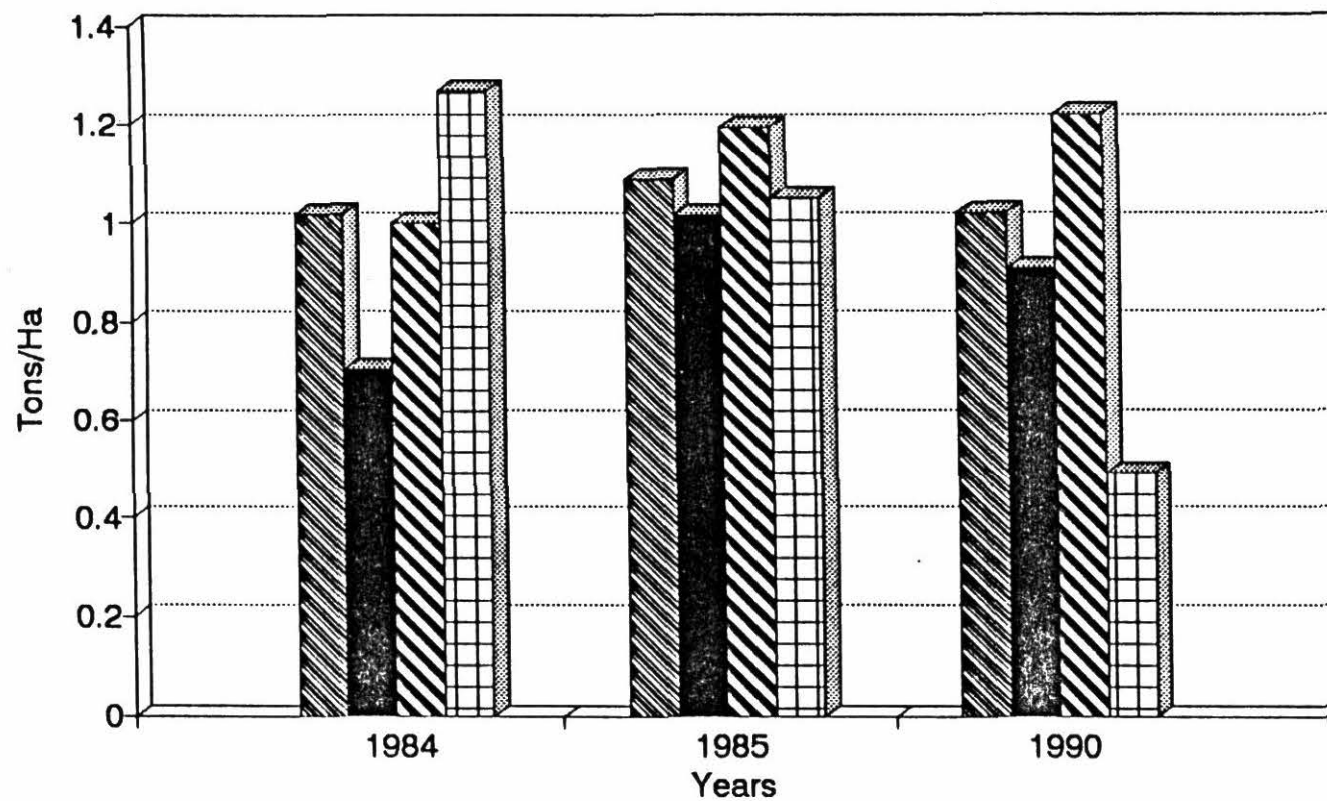
ADVANCED AGR. RECENT EXPANS FRONTIER AGR. RESIDUAL

Fig S.30-YIELDS OF MAIZE
SAVANNAS, 1984-1990



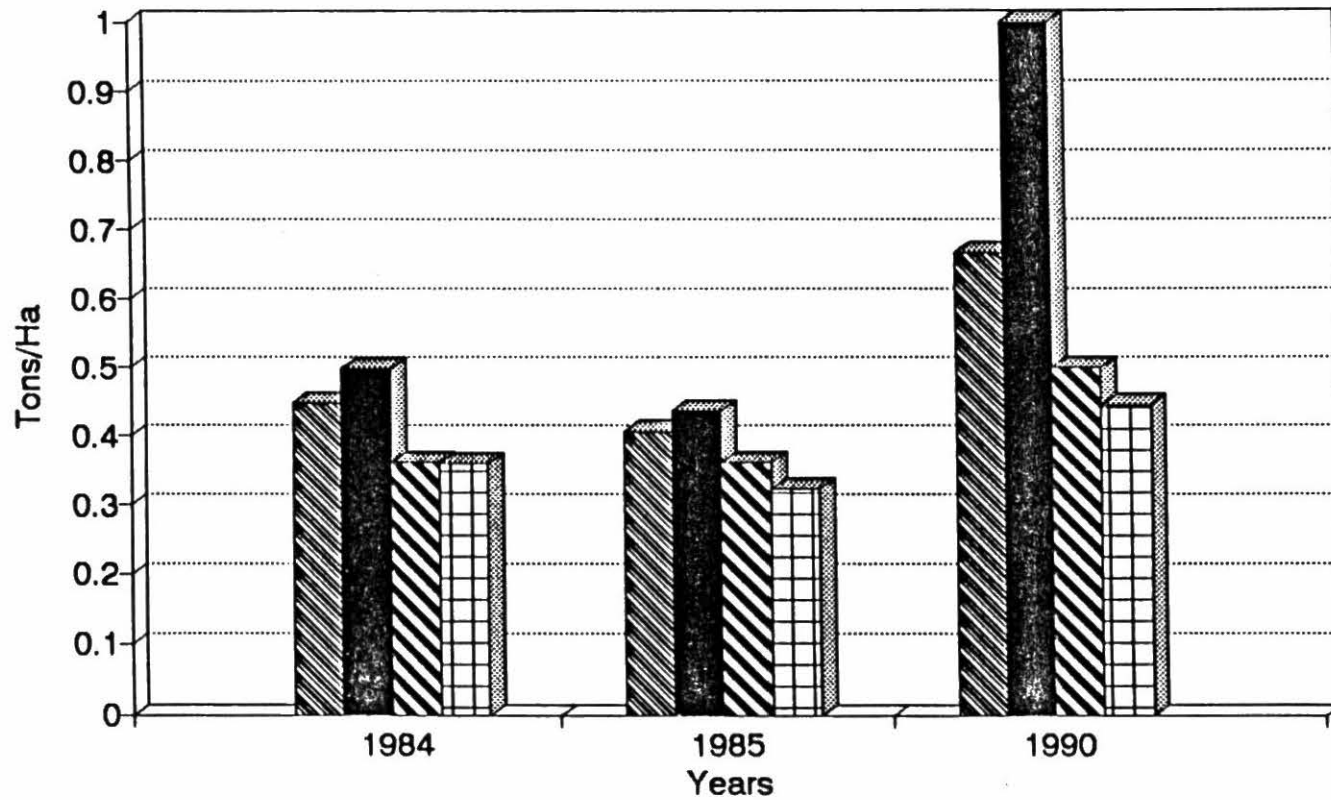
ADVANCED AGR. RECENT EXPANS FRONTIER AGR. RESIDUAL

Fig S.31-YIELDS OF RICE
SAVANNAS, 1984-1990



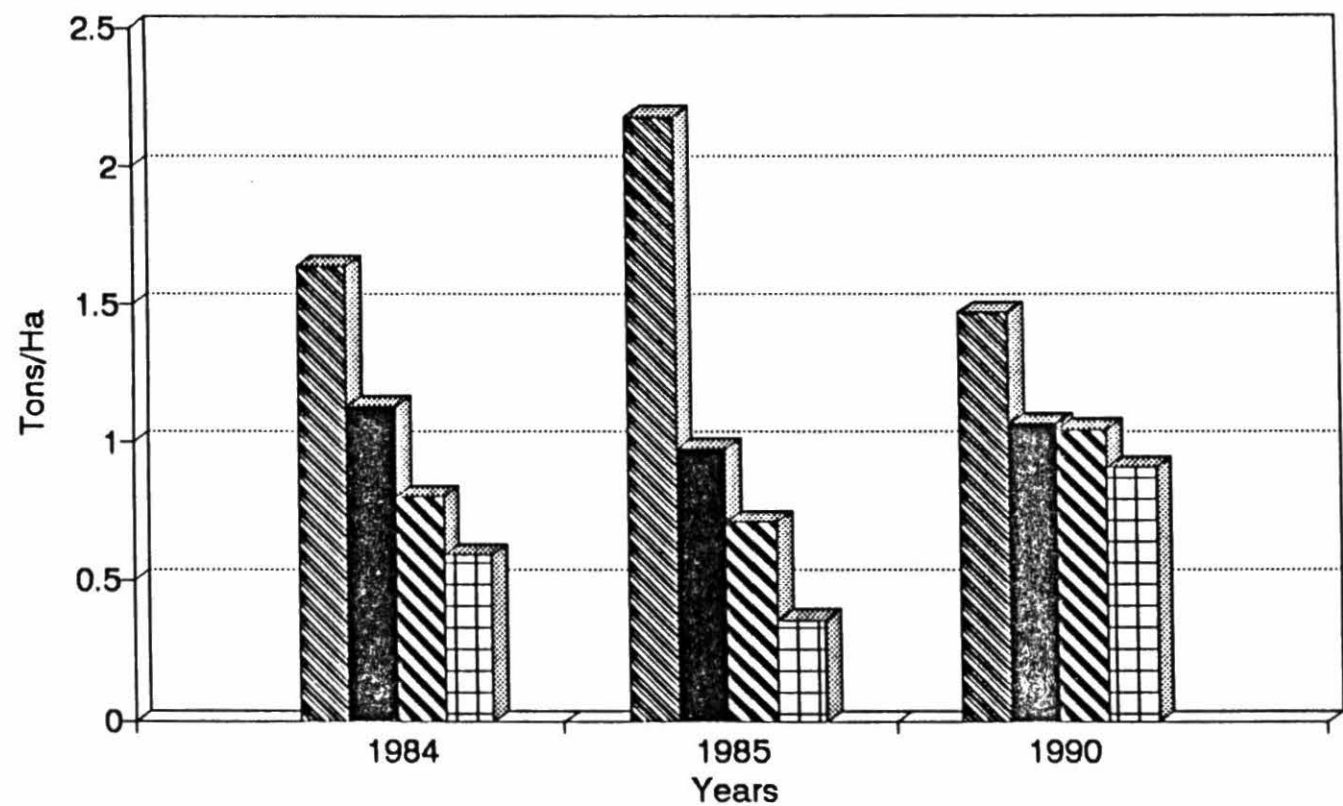
ADVANCED AGR. RECENT EXPANS FRONTIER AGR. RESIDUAL

Fig S.32-YIELDS OF BEANS
SAVANNAS, 1984-1990



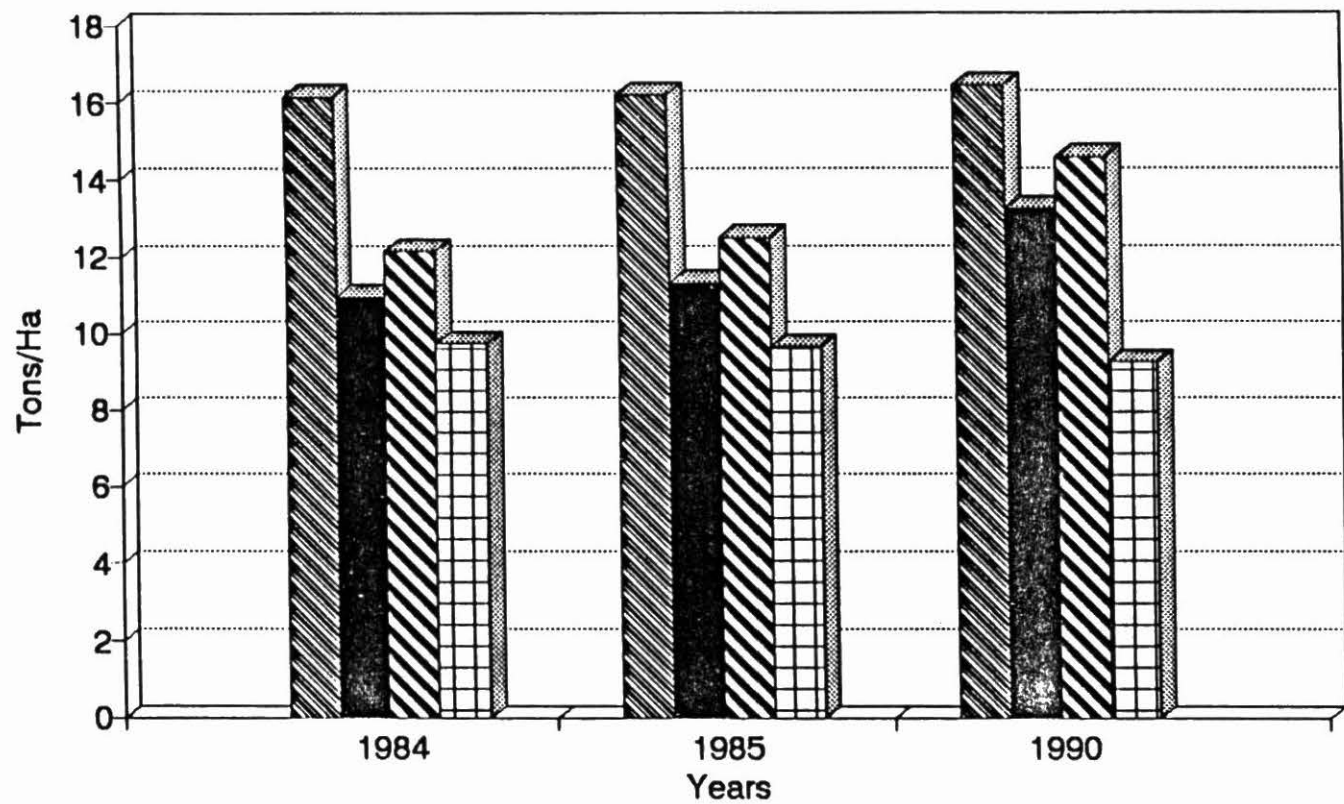
ADVANCED AGR. RECENT EXPANS FRONTIER AGR. RESIDUAL

Fig S.33-YIELDS OF COFFE
SAVANNAS, 1984-1990



ADVANCED AGR. RECENT EXPANS FRONTIER AGR. RESIDUAL

Fig S.34-YIELDS OF MANIOC
SAVANNAS, 1984-1990



ADVANCED AGR. RECENT EXPANS FRONTIER AGR. RESIDUAL

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