THE WORLD BANK

POLICY PLANNING AND RESEARCH STAFF

Environment Department

Government Policies and Deforestation in Brazil's Amazon Region

Dennis Mahar

June 1988

Environment Department Working Paper No. 7

ACKNOWLEDGEMENTS

The author is an Advisor on the Economic Advisory Staff of the World Bank. He wishes to thank various colleagues for the valuable comments they provided on earlier drafts of this paper, particularly Luis Coirolo, Louise Fox, Robert Goodland, Peter Knight, Maritta Koch-Weser, Ernst Lutz and Stephen Weissman. The author would also like to thank John McKenna, Richard Norgaard, Robert Repetto and John Wilson for their help in obtaining certain data and reference material. The Environment Department and Brazil Country Department of the World Bank supported the preparation of this paper from the outset and for that the author is grateful.

ABSTRACT

The paper analyzes the impact of government policies on the magnitude and rate of deforestation in Brazil's Amazon region. The main hypothesis is that efforts to slow or stop tropical deforestation through fiat only--for example, through the establishment of parks, reserves or the prohibition of certain types of economic activity--will be much less likely to succeed if the overall policy and regulatory frameworks give people incentives to do just the opposite. The paper first reviews the most recent estimates of deforestation in the region. These estimates indicate that almost 600,000 square kilometers of Amazon forest have already been cleared; an area larger than France. Moreover, 80 percent of this deforestation has occurred since 1980. The paper then traces the evolution of regional development policies for Amazonia over the past 25 years. This section shows that policies and programs emphasizing road-building, official settlement, and extensive livestock development have generally not been designed and carried out with due regard to their environmental consequences. The paper concludes with several recommendations on how current policies could be reformed in order to improve their environmental impacts.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

GOVERNMENT POLICIES AND DEFORESTATION IN BRAZIL'S AMAZON REGION

I. Introduction

The world's tropical rainforests are disappearing at an alarming rate. These forests, which once occupied 16 million square kilometers (km2) of the Earth's surface, today cover only 9 million km2. It is estimated that Latin America and Asia have already lost 40 percent of their original forests, and Africa a little more than half (Myers 1984). In many countries, the rate of deforestation is accelerating: most of the forested areas of Bangladesh, India, Philippines, Sri Lanka, and parts of Brazil, for example, could be gone by the end of this century. Only in the Congo Basin, and in some of the more isolated areas of Amazonia, does the forest remain largely intact.

Deforestation of this magnitude, while in some instances yielding considerable short-term benefits through timber exports and agricultural production on previously-forested land, has entailed huge (and largely unmeasured) long-term costs both to the people of the countries directly affected and to mankind as a whole. Among the more direct and visible costs of tropical deforestation are the losses of forest products such as timber, fuelwood, fibers, canes, resins, oils, pharmaceuticals, fruits, spices, animal hides, and so forth.1/ More indirect, but equally important, long-term costs include soil erosion, flooding, and the siltation of reservoirs and hydroelectric facilities; destruction of wildlife habitat; and climatic changes associated with the removal of protective forest cover in tropical regions. Perhaps the most important single long-term cost of deforestation, however, is the irreversible loss of biological diversity.

The total number of species on Earth is not known with any degree of certainty. However, most conservative estimates indicate that tropical rainforests contain about half of the Earth's 5-10 million species on just 7 percent of its land surface. The richness of life in these forests is remarkable. The Amazonian rainforests, for example, support 30,000 different plants versus an estimated 10,000 in all of

---

1/ Little is known about the extent of annual losses of forest products through deforestation. However, estimates for the Cote d'Ivoire and Nigeria suggest that 50-100 million m3 of quality logs--3-6 times the annual production of sawlog and veneer logs--are lost each year in these countries through clearing and burning (World Resources Institute 1986).

temperate South America. Northern forests, in contrast, normally contain only 10-15 different species. The variety of insect life in the rainforest is even more striking. At present, scientists have discovered and named roughly 1 million different insect species worldwide. However, one scientist, extrapolating from surveys of the rainforest canopy in Panama, estimates that there may be as many as 30 million insect species in tropical forests alone! (Wolf 1988: 104).

Many of the species native to tropical rainforests have proven to be invaluable to Man: for example, drugs (vincristine and vinblastine) developed within the past two decades from a wild periwinkle found in the forests of Madagascar have dramatically improved the effectiveness of treatment for leukemia and certain other forms of cancer. Since less than 1 percent of tropical plants have been screened for potentially useful properties, ongoing deforestation will result in the permanent loss of other species before their value to Man is recognized (World Resources Institute 1985). It has been estimated that more than 13,000 plant species in Latin American rainforests will become extinct by the end of this century if present rates of clearing continue; under a "worst case" scenario which assumes an acceleration in the rate of deforestation, as many as 60,000 species could suffer this fate (Wolf 1988: 103).

The proximate causes of tropical deforestation vary significantly among regions of the world, and even within countries. However, most experts on the subject agree that the spread of small-scale agriculture is the single most important of these. According to Myers (1986), this type of activity results in about 150,000 km2 of forest depletion annually.2/ Other major proximate causes include: commercial logging (45,000 km2/year), fuelwood gathering (25,000 km2/year) and cattle raising (20,000 km2/year). While it is useful to know these facts, it is far more important to be aware of the underlying causes of forest destruction. Holding the small farmer responsible for tropical deforestation would amount to "blaming the victim" as the real causes of the problem are likely to be poverty, unequal land distribution and low agricultural productivity combined with rapid population growth. To this list one must also add misguided public policies which either purposely or inadvertently encourage rapid depletion of the forest (see Collins 1986; World Resources Institute 1985).

The underlying causes of tropical deforestation have been under-researched and, as a result, are only imperfectly understood. The purpose of the present study is to, in a modest way, shed some further light on the subject by analyzing the effects of certain government

---

2/ The term "depletion" refers to both "deforestation" (a complete and permanent removal of all forest cover) and "major disturbances" (any modification of the forest, e.g., selective logging, leading to a pronounced impoverishment of the forest ecosystem). Annual depletion of tropical forests is estimated to be 200,000 km2 per year. Deforestation, as usually defined, amounts to about 70,000-90,000 km2 per year worldwide.

policies on deforestation in the Brazilian Amazon. The coverage is far from complete. The emphasis is on policies which encourage environmentally-unsound economic activities, and on those subregions of Amazonia now experiencing the most rapid deforestation. The equity aspects of these policies are also considered. The principal "message" to be conveyed in this paper is that attempts to reduce or stop tropical deforestation by fiat only--for example, through land-use zoning, legislation establishing national parks, or legal prohibitions of certain types of economic activity--are much less likely to succeed if nothing is done to remove economic incentives which encourage people to do the opposite.

II. Brazil's Amazonian Forests

Size

According to FAO estimates, Brazil contains about 3.5 million km2 of tropical forests (Guppy 1984: 930). This is equivalent to 30 percent of the world total, and more than the combined forested areas of Indonesia, Zaire, Peru, and Colombia. Almost all of the country's standing tropical forests are located in the Amazon Basin. As legally defined, Amazonia has an area of just under 5.0 million km2, or 58 percent of Brazil's total land area (see Map IBRD 20513).3/ About half of Amazonia (2.5-2.8 million km2) is comprised of terra firme (upland) areas where the original vegetation was tropical rainforest (Fearnside 1986). Perhaps another 500,000 km2 consists of transitional forests (U.S. Department of Energy 1986). There are in addition large areas of savanna (cerrado) in the southern reaches of "Legal Amazonia" in the states of Mato Grosso and Goias.

Biological Diversity

Amazonia has been characterized as the "single richest region of the tropical biome" (Myers 1984: 50). Indeed, the region's forests, air, soils and water literally teem with life. A single hectare of rainforest near Manaus (Amazonas), for example, yielded 179 tree species over 15 cm in diameter and 235 over 5 cm (Prance 1986). The quantity and variety of bird, fish and insect life is also unmatched. There are, for instance, 2,000 known species of fish in the waters of the Amazon Basin. This is eight times the number of species in the Mississippi River system and 10 times as many as are found in all of Europe. And

---

3/ Two geographical concepts of Amazonia are commonly used in Brazil. "Legal Amazonia", which is used for regional planning purposes, is comprised of seven states and territories (Para, Amazonas, Acre, Amapa, Rondonia, Roraima and Mato Grosso) and parts of two others (Goias and Maranhao). The definition used for statistical purposes (the "North Region" or "classic Amazonia") is comprised of only six states and territories and is smaller by 1 million km2. To the extent possible, the "classic Amazonia" concept will be used in this paper since it most closely corresponds to the area in rainforest.

this represents only the known species; experts think that the total may eventually reach 3,000 species. Scientists are in general agreement that deforestation is greatly reducing this natural variety, thus depriving some regional populations of their livelihoods4/ and mankind of as yet undiscovered medicinal plants or pest-resistant genetic materials.

Deforestation

Magnitude and rate. The first serious estimates of deforestation in the Brazilian Amazon were made in the early 1970s by staff of the Government's RADAM Project, which employed airborne side-looking radar to gather primary data. These estimates suggested that relatively little clearing of the forest had taken place. More comprehensive estimates of deforestation, derived from LANDSAT satellite images, became available a few years later. They indicated that roughly 30,000 km2, or about 0.6 percent of Amazonia (approximately 1.0 percent of the forest), had been cleared as of 1975 (see Table 1).

When these early LANDSAT images were first made public, they were cited as proof that the environmentalists--some of whom had predicted the demise of the Amazonian forest by the end of the century--had greatly exaggerated their case (Denevan 1973). Further consideration of these early data, however, make it clear that there was no cause for complacency. First, it is likely that the interpretations of LANDSAT data seriously underestimated the real extent of deforestation. "Very small" clearings were excluded from the calculations and, more importantly, the satellite photos made it difficult to distinguish secondary growth from primary forest. The 30,000 km2 Zona Bragantina of Para, for example, which had been entirely cleared for many years, is as large as the deforested area estimated on the basis of LANDSAT imagery for all of Amazonia in 1975 (Fearnside 1982, Sioli 1973). Second, the region-wide estimates obscured the fact that deforestation had been spatially concentrated, not randomly distributed. While certain parts of Amazonia were almost totally devastated during the 1970s, large tracts of forest remained virtually untouched.

Recent estimates based on LANDSAT data suggest that deforestation has accelerated sharply since the mid-seventies. As shown in Table 1, the deforested area increased to 125,000 km2 by 1980 and to almost 600,000 km2 by 1988. The latter is equivalent to 12 percent of Amazonia, and is larger than France. As in the past, deforestation has continued to be concentrated in certain subregions. In this regard, the situation in Rondonia and Mato Grosso--where nearly one-fourth of the forest has already been cleared--may be contrasted with the situation in

---

4/Michael Goulding, in a pioneering study of Amazonian fisheries (Goulding 1983), found that most of the commercial species feed on the fruits, seeds, insects and detritus from the annually-flooded forests. He concluded that the conversion of these forests to agricultural land or other purposes would greatly reduce the commercial catch as well as the quantity of species of less commercial importance.

Table 1: LANDSAT Surveys of Forest Clearing in the Brazilian Amazon

State or Territory	Area of State or Territory (Km2)	Area Cleared (Km2)				Percent of State or Territory Classified as Clear			
		By 1975	By 1978	By 1980	By 1988	By 1975	By 1978	By 1980	By 1988
Amapa	140,276	152.5	170.5	183.7	571.5	0.1	0.1	0.1	0.4
Para	1,248,042	8,654.0	22,445.3	33,913.8	120,000.0	0.7	0.8	2.7	9.6
Roraima	230,104	55.0	143.8	273.1	3,270.0	0.0	0.1	0.1	1.4
Maranhao	257,451	2,940.8	7,334.0	10,671.1	50,670.0	1.1	2.8	4.1	19.7
Goias	285,793	3,507.3	10,288.5	11,458.5	33,120.0	1.2	3.6	4.0	11.6
Acre	152,589	1,165.5	2,464.5	4,626.8	19,500.0	0.8	1.6	3.0	12.8
Rondonia	243,044	1,216.5	4,184.5	7,579.3	58,000.0	0.3	1.7	3.1	23.7
Mato Grosso	881,001	10,124.3	28,355.0	53,299.3	208,000.0	1.1	3.2	6.1	23.6
Amazonas	1,567,125	779.5	1,785.8	3,102.2	105,790.0	0.1	0.1	0.2	6.8
Legal Amazon (total)	5,005,425	28,595.3	77,171.8	125,107.8	598,921.5	0.6	1.5	2.5	12.0

Source: Fearnside (1986) and IBRD estimates.

Amapa where more than 99 percent of the forest is still intact. Although not fully revealed by the state-level data presented in Table 1, particularly intense clearing has taken place along the region's major overland access routes: the Belem-Brasilia highway and its zone of influence in southern Para and northern Goias, and the Cuiaba-Porto Velho highway and its associated feeder roads in Mato Grosso and Rondonia (Fearnside 1986b; Woodwell, Houghton and Stone 1986; and Fearnside and Salati 1985).

Proximate causes. These mainly include small-scale agriculture, cattle ranching, logging, road-building, hydroelectric development, mining, and urban growth. Unfortunately, it is not possible to estimate with any degree of precision the relative contribution to deforestation of each of these activities. Its seems clear, however, that the rapid expansion of the agricultural frontier over the past two decades has been the most important single factor. According to agricultural census data, the area under farms in Amazonia increased from 313,000 km2 in 1970 to over 900,000 km2 in 1985. This expansion occurred in virtually all of the region's states and territories. Moreover, consistent with the deforestation estimates derived from LANDSAT images, the census data show that the spread of agriculture was particularly rapid in Rondonia, northern Mato Grosso and Goias, and southern Para.

Details on agricultural land-use patterns for 1985 have not yet been published. However, the data summarized below in Table 2 indicate that approximately 145,000 km2 of Amazonia was in agricultural use, either for crops or livestock, as of 1980.5/ Pasture clearly emerges from these data as the predominant form of agricultural land use in the region and, therefore, cattle ranching would appear to be the major proximate cause of deforestation. Based on comparisons with the 1970 census data, the conversion of forest to pasture occurred at the rate of approximately 8,000-10,000 km2 per year during the 1970s. Most, but not all, of this pasture formation took place on large landholdings. In Para, Mato Grosso and Goias--the principal livestock states of Amazonia--70 percent or more of the artificial pasture in 1980 was located on farms with areas in excess of 1,000 ha.

5/The 1980 Census figure is 20,000 km2 larger than the total deforested area estimated through LANDSAT images for the same year (see Table 1). This discrepancy probably reflects the conservative bias in the LANDSAT estimates and the fact that some of the land converted to agricultural uses was not originally forested.

Table 2: Agricultural Land Use in Amazonia, 1980 a/

Use		Area (Km2)	(%)
Crops		49,851.1	5.9
. Annual b/	42,231.6		
. Perennial	7,619.5		
Pasture		94,098.1	11.1
Undisturbed c/		704,994.3	83.0
TOTAL		848,943.5	100.0

a/ "Amazonia" defined as North Region plus northern Mato Grosso and Goias.
b/ Includes fallow land.
c/ Forest, natural pastures, and land unsuitable for agricultural use (rivers, mountains, etc.)

Source: IBGE (1983).

Land devoted to annual cropping, the second most important form of agricultural land use, probably increased by about 2,000 km2 per year between 1970 and 1980. This is typically a small-farmer activity. However, farm plots devoted to annual crops are frequently sold or abandoned after only a few years of use as a result of rapidly-declining yields. These areas are then converted to pasture--often by larger landowners--or are quickly invaded by secondary growth known as capoeira. Given this traditional sequence of land use in Amazonia (i.e., from undisturbed forest to annual crops to pasture or secondary growth) it is likely that some of the deforestation attributed to livestock development has actually been caused by the spread of small-scale agriculture.

Logging has also grown rapidly in Amazonia over the past two decades. Between 1975 and 1985, regional roundwood production increased from 4.5 million m3 per year (14.3 percent of the national total) to 19.8 million m3 (46.2 percent of the national total). It is not clear, however, how much deforestation can be attributed to logging per se since much timber extraction in Amazonia is a by-product of land clearing for agricultural purposes. The typical sequence of events starts with loggers selectively cutting commercially-valuable species in newly-opened areas. Such trees usually represent only a very small proportion of the standing forest--as of the late 1970s only five species (out of an estimated 1,500) accounted for 90 percent of the region's timber exports (Browder 1987). The vast majority of the trees, which are unknown in extraregional markets and thus have little or no

commercial value, are then burned before the planting of crops. Except for the Jari project in northern Para, discussed below, practically no replanting is done. In Rondonia, where deforestation has been occurring at an extremely rapid pace in recent years, the 1980 agricultural census shows only 165 ha planted in trees!

III. The Evolution of Regional Policies

Government policies designed to open up Amazonia for human settlement, and to encourage certain types of economic activity, have played a major role in the deforestation process. In particular, massive road-building programs carried out in the 1960s and 70s made large areas of the region accessible by overland means for the first time, while government-sponsored settlement schemes simultaneously attracted migrants from Brazil's Northeast and South. Special fiscal incentives and subsidized credit lines, moreover, encouraged land uses such as cattle raising which allowed a relatively small population to have a large impact on the rainforest. Greater details on the objectives, content and results of these regional development policies, as well as their historical roots, follow.

The Rubber Boom

Official interest in Amazonia dates from the colonial period, when the Portuguese Crown exploited the region for its forest products and Indian slaves. However, the region remained relatively insignificant in economic terms until the last quarter of the nineteenth century. At that time Amazonia experienced nearly a half century of rapid economic growth (roughly 1870 to 1912) based on a near-monopoly position in the world market for wild rubber, a product highly-valued as an industrial input after Charles Goodyear's invention of the vulcanization process in 1839. The story of the turn-of-the-century rubber boom illustrates how an activity environmentally suited to the rainforest can at the same time be unsustainable economically. It thus provides an interesting counterpoint to the modern regional economy where some important activities, such as agriculture and cattle-ranching, are both environmentally and economically unsustainable in most of the rainforest area.

The Amazonian rubber boom brought a degree of prosperity to the region (if not to all the region's inhabitants) which had never even been dreamt of before.6/ To meet the growing demands of North American and European industry, hundreds of thousands of workers were contracted to gather latex in the forest while a new class of "rubber barons" built palatial mansions in the river cities of Manaus and Belem. Prices, which had fluctuated between $.75 and $1.50 from 1897 to 1908, rose to over $3.00 per pound by mid-1910 and rubber seriously challenged coffee for the lead position among Brazil's exports. But inevitably the high

---

6/According to one author, the regional per capita income increased from $49 in 1840 to $329 in 1910 (Santos 1980: 13.).

profits generated by wild rubber exports attracted the attention of foreign competitors. By the early 1900s the British had succeeded in establishing plantations in their Asian colonies where rubber could be produced at only one-fourth of the cost incurred by Brazilian producers (Resor 1977).

Plantation-grown rubber started entering world markets in a major way in late 1910, dropping the price to $1.00 per pound by the end of the following year. The Brazilian Government futilely tried to save the local rubber interests through a so-called "Rubber Defense Plan". Among other things, the plan called for the provision of cash premiums to persons planting rubber trees and building rubber processing plants; a drastic reduction in export taxes on rubber (which were viewed as a major impediment to sales); and the abolition of import taxes on inputs to the rubber industry. Despite these official attempts to prop up the regional economy, rapidly-increasing Asian production flooded world markets and prices plummeted to $.63 per pound by 1914. For Brazil and Amazonia, the boom was over: between 1910 and 1934, the region's share of the world rubber market fell from 60 percent to 1 percent and has remained at insignificant levels ever since (Mahar 1978). The fatal flaw of the Government program was linking the prosperity and future development of Amazonia to the export of one forest product, a product sold on a market in which Brazil could not effectively compete.7/

"Operation Amazonia"

Following the collapse of the rubber economy, Amazonia entered a long period of economic and demographic stagnation. As of 1960, the region had only 2.5 million inhabitants, and a per capita income just half the level reached in 1910 (Santos 1980). With the coming to power of a military Government in 1964, however, Amazonia once again gained public attention. In a series of legislative acts and decrees enacted in 1966 and 1967 (cumulatively known as "Operation Amazonia"), the new Government firmly committed itself to the development and occupation of the region, as well as the eventual integration of Amazonia with the rest of Brazil. Included among these plans were: an ambitious road-building program aimed at linking Amazonia with the Northeast and South, agricultural colonization schemes, and fiscal incentives for attracting new industrial and agricultural enterprises. An administrative structure, including a regional development agency (Superintendency for the Development of Amazonia, or SUDAM) and a regional development bank (Bank of Amazonia, or BASA) were created to coordinate the implementation of these plans.

7/Starting in 1927, Henry Ford attempted to establish rubber plantations of the East Asian type on a 2.5 million acre tract--called Fordlandia--in the state of Para. Despite $9 million in investments, the project ultimately failed because of labor problems and an inability to control the insects and diseases which continually attacked the trees. All Ford properties in Amazonia were sold to the Brazilian Government for a mere $250,000 in 1945 (Galey 1977).

The motives behind "Operation Amazonia" were to a large part geopolitical. Brazil's military leaders, becoming aware that several neighboring countries (particularly Peru and Venezuela) were already well-advanced in programs to occupy and develop their respective Amazon regions, were anxious to assure national sovereignty by establishing self-sustaining settlements in frontier areas. Since it was believed that vast quantities of natural resources still remained hidden in the forest, this posture is understandable. But little thought was given to the design and implementation of an economic development strategy responsive to the unique physical and human environments of Amazonia. The import-substitution industrialization model adopted at first was lifted virtually unaltered from the country's Northeast, a region different in almost every respect from Amazonia.

The Belem-Brasilia Highway

As of 1960, Amazonia had only 6,000 km of roads, of which less than 300 km were paved. Except by air and long sea routes, the region was virtually cut off from the rest of Brazil. Intraregional travel was also difficult and the sparse populations tended to cluster in the region's two major cities, Belem and Manaus, and in small towns and villages scattered along the Amazon River and it's 1,100 tributaries. While this centuries-old isolation from the more dynamic South had arguably retarded the region's economic development, it had also protected the rainforest from destruction. The physical isolation of Amazonia--and the protection this provided to the rainforest--came to an end in 1964 with the completion of a 1,900 km all-weather highway connecting the new capital city of Brasilia, located in Brazil's heartland, with Belem, located at the mouth of the Amazon River.

Large numbers of migrants in search of land and employment entered the region via the Belem-Brasilia highway (BR-010). So did large firms wishing to establish cattle ranches in order to take advantage of the cheap land and generous tax and credit incentives offered by the Government. Official estimates suggest that the total human population of the zone of influence of the highway (which includes some area outside of Amazonia) increased from 100,000 in 1960 to some 2 million ten years later. The same source estimates that the cattle population increased from practically nothing to 5 million during the decade (cited in Goodland and Irwin 1973). Although these official estimates unquestionably exaggerate both the size and growth rate of the human and cattle populations[8], there can be no doubt that the surge of migration and economic activity stimulated by the Belem-Brasilia highway contributed to widespread deforestation. One traveller along the highway around 1970, noting the devastation and apparent abandonment of the land on either side, described the area around Paragominas in southern Para (the site of numerous SUDAM-approved cattle ranches) as a "ghost landscape" (Paula 1971).

8/M.T. Katzman (1977), for example, estimates that the road attracted at most 320,000 new settlers between 1960 and 1970.

Environmental degradation, moreover, was not confined to areas adjacent to the main highway. The increase in population associated with the Belem-Brasilia highway quickly generated demand for secondary and feeder roads, which in turn attracted more population, and so on. LANDSAT photos vividly illustrate the impact on the rainforest of one such highway (PA-150) opened to traffic in the late 1960s. In one 47,000 km2 area of southern Para (small by Amazonian standards, but about the size of Switzerland) traversed by this road, LANDSAT photos show the cleared area increasing explosively from 300 km2 in 1972 (0.6 percent of the area), to 1,700 km2 in 1977 (3.6 percent), to 8,200 km2 (17.3 percent) in 1985 (see Map IBRD 20512). Although the relative contribution of different activities to this deforestation is not known with precision, it is virtually certain that the conversion of forest to pasture has been a leading cause. The policy of providing incentives for cattle ranching in Amazonia is therefore discussed in greater detail below.

Incentives for Livestock Development

As noted above, one of the key objectives of "Operation Amazonia" was to attract private enterprise to the region. This was to be achieved through increasing public expenditures on infrastructure--for example, roads, airports, telecommunications--and special fiscal incentives and credit lines for firms willing to establish operations in Amazonia. The package of fiscal benefits available to qualifying firms was extensive and included "holidays" from the corporate income tax for a period of 10-15 years, as well as exemptions from export taxes and import duties. Additional fiscal incentives were extended in 1967 to firms locating in western Amazonia to compensate for that subregion's alleged disadvantages (long distances from major markets, lack of adequate local labor force and necessary infrastructure, and so forth) in attracting private enterprise. Through these fiscal incentives, the city of Manaus became a "free trade zone", with a local economy based on the sale of imported goods to tourists and the development of various "screwdriver industries" (Mahar 1976).

Investment tax credits. The most powerful of the incentives allowed registered Brazilian corporations to take up to a 50 percent credit against their federal income tax liabilities if the resulting savings were invested in projects located in "Legal Amazonia" and approved by SUDAM. Investment projects could be new enterprises or simply the expansion or modernization of existing enterprises. Under the 1963 legislation which created the investment tax credit legislation, only industrial projects were eligible; in 1966, eligibility was expanded to include projects in the agricultural,

livestock and service sectors.9/ Depending upon the priority assigned to a given project by SUDAM, tax-credit funds could constitute up to 75 percent of investment. Although project selection and ranking procedures have changed several times over the years, rankings have tended to be positively related to use of regional inputs, employment generation, level of technology, contribution to the balance of payments, and location in priority areas. Since 1979, the approval of livestock projects in areas of rainforest (floresta densa) has been officially prohibited.

The tax-credit mechanism proved very attractive to investors and by late 1985 some 950 projects had been approved by SUDAM. Of this total, 631 projects were in the livestock sector (Garcia Gasques and Yokomizo, 1986: 51). SUDAM-approved livestock projects have now been established in all parts of "legal Amazonia" although about three-fourths have located in southern Para and northern Mato Grosso. These projects have probably been the single most important source of deforestation in these two subregions. However, their relative contribution to deforestation in Amazonia taken as a whole has clearly been much smaller, probably less than 10 percent of the total.

The size of the SUDAM-approved cattle ranches is extremely large by any standard. They presently cover a total area of 8.4 million ha, or an average of about 24,000 ha per ranch.10/ Several ranches are in excess of 100,000 ha. The Suia-Missu ranch of northern Mato Grosso, the largest of the group, covers 560,000 ha (Branford and Glock, 1985: 109). Despite the large size of these ranches, they generate relatively little employment, except during the initial stage of felling and burning the forest. At full development, these ranches typically employ only one person per 250-300 ha of pasture (Garcia Gasques and Yokomizo, 1986: 77). In areas of Amazonia with peasant economies based

---

9/The tax-credit mechanism underwent a further modification in 1974. The new legislation, which applies currently, allowed firms only a 25 percent credit against their income tax liability. It also called for the establishment of the Amazon Investment Fund (FINAM), a type of mutual fund managed by BASA. Today, firms taking advantage of the tax credit initially receive shares in FINAM. The fund, in turn, acquires shares of stock in firms carrying out projects approved by SUDAM. Investors may hold or sell their shares in the Fund or trade them for corporate stock held by FINAM. Investors with their own projects may directly acquire shares of their own stock. All corporate stock acquired from the FINAM portfolio is nonnegotiable for a period of four years (for details, see BASA, 1981).

10/This may be compared with the average farm establishment in Amazonia (1985) which comprises only 90 ha.

on extractive activities, the conversion of forest to pasture has actually had negative employment effects.11/

Livestock projects have over the years absorbed about 44 percent of the SUDAM-administered tax-credit funds. In absolute terms, total disbursements to the owners of these projects have amounted to approximately US$ 700 million equivalent (Browder 1987). Despite this huge subsidy, only 92 livestock projects have been awarded "certificates of completion" by SUDAM. Moreover, the performance of most of these completed projects has fallen far short of expectations. In a sample of nine such projects, selected as part of a field survey carried out by the Institute of Economic and Social Planning (IPEA), the average level of production was found to be less than 16 percent of that originally projected; three of the nine projects visited were not producing anything (Garcia Gasques and Yokomizo,1986: 56). Data gathered by the IPEA team on 26 livestock projects still "under implementation" provide little basis for optimism that performance levels will improve in the future. Average production levels of projects in this group (all of which have been under implementation for a minimum of seven years) are running at only 9 percent of projections; 12 projects (with an average of 16 years under implementation) were found to have no marketed output whatsoever.

The IPEA study attributes the poor performance of SUDAM-approved livestock projects largely to administrative and management problems such as inadequate purchases of breeding stock, frequent changes in project ownership, delays in the release of fiscal incentive funds, cost escalation, and weak supervision on the part of SUDAM. Surely these problems constitute part of the explanation. However, a recent study argues convincingly that cattle ranching under conditions commonly prevailing in Amazonia is intrinsically uneconomic (Hecht, Norgaard, and Possio, n.d.).

To reach this conclusion, the authors developed a simulation model for a "typical" 20,000 ha cattle ranch for which 75 percent of investment is provided by tax-credit funds. Internal rates of return (IRRs) to the investor's own resources ("fresh money") and to all resources were then calculated under various assumptions regarding technology employed, intensity of grazing, and rates of land appreciation. The results under two different scenarios are summarized in Table 3. They clearly show that livestock activities in Amazonia are profitable to corporations only when official subsidies and/or capital gains from land appreciation are present. The results also demonstrate

---

11/Bunker (1981) has described how this process took place in the area around Santarem in the state of Para. In this subregion, pasture formation involved the felling of stands of Brazil-nut trees which had long provided employment and income for the surrounding peasant communities. Ranchers selected these areas because they were the only terra firme lands with titles which could be used as guarantees for bank credit. The result of this process has been the migration of former Brazil-nut gatherers to nearby towns where they now depend on temporary employment on the cattle ranches.

that the IRR to a ranching corporation's own resources can be improved substantially through overgrazing. Indeed, it may be noted that cattle-ranching can only be made profitable through overgrazing when cattle prices are low and when there is no land price appreciation. Overgrazing, however, degrades the pasture and ultimately undermines the long-term viability of the ranch. While it is technically possible to recuperate degraded pastures, the continued availability of tax-credit funds for land clearing, road and fence building and pasture development, makes it more profitable for a corporation to form new pastures than to maintain existing ones.

Table 3: Internal Rates of Return to a Typical SUDAM-Approved Livestock Project Under Two Scenarios a/
(percentages)

	Land Value Increase		
	0%	15%	30%
HIGH CATTLE PRICES			
Appropriate Grazing Intensity	16	18	24
. Corporation resources b/	-1	2	9
. All resources c/			
Overgrazing	23	24	27
. Corporation resources	-2	0	4
. All resources			
LOW CATTLE PRICES			
Appropriate Grazing Intensity	-3	6	17
. Corporation resources	-14	-6	5
. All resources			
Overgrazing	16	18	23
. Corporation resources	-10	-7	-1
. All resources			

a/ Low input prices assumed in both scenarios
b/ Ignores capital expenditures financed through fiscal incentives and official credit.
c/ Fiscal incentives and official credit treated as if they were corporation's own capital.

Source: Adapted from Hecht, Norgaard and Possio (n.d.).

The findings of the simulation exercise described above have been largely borne out by field observations. On the environmental issue, Goodland rates cattle ranching as "the worst . . . of all conceivable alternatives" for Amazonia on the basis of its high potential for degrading the soil (Goodland 1980: 18). Although some researchers debate this point, a comprehensive soil survey (involving 80 samples per age class of pasture) carried out in major cattle areas in eastern Amazonia lends it strong support. The results of this survey indicate that changes in soil chemistry following the conversion of forest to pasture are "relatively neutral for N and K, negative for P and C, and mildly positive for Ca, Mg and pH" (Hecht 1985: 677). The upshot is that the clearing of forest renders the potential of the soil low to marginal for pasture formation, particularly if physical changes in soil properties (particularly compaction) and weed invasion are also considered. In practical terms, this means that stocking rates, which may be maintained at one animal per ha during the initial years of pasture formation, typically decline to 0.25 animals per ha after the fifth year.

While encountering a few projects whose owners were seriously interested in developing sustainable beef production, the IPEA team confirmed in their field investigations that many projects were being exploited solely for their fiscal benefits. In visits to projects located in southern Para it was found that persons with five or six projects approved by SUDAM had received tax-credit funds without ever having initiated project implementation. After the tax-credit funds had been fully disbursed, these projects were either sold or abandoned (Garcia Gasques and Yokomizo, 1986: 67). In other cases, entrepreneurs intentionally delayed project implementation in order to obtain additional tax-credit funds from SUDAM through successive project "reformulations". Changes in project ownership were found to be very frequent among the livestock projects in the sample survey; some had been sold up to six times since their approval by SUDAM. Since a transfer of ownership also transfers the right to receive tax-credit funds, the IPEA team inferred from the high frequency of sales that many purchasers were primarily interested in the expectation of official subsidies, not in beef production.

Investors interested in land appreciation have also used the legitimacy conferred by a SUDAM-approved project to control huge tracts of land. According to the IPEA study, one group in southern Para controls a 330,000 ha parcel on which five projects have been approved for fiscal incentives. Effective control over land is particularly important in Amazonia where legal rights are vague and where squatting by migrants is common. To discourage the latter practice, one rancher visited by the IPEA team had rented plots along the borders of his property to small farmers to form a sort of cordon sanitaire. Other ranchers have employed more violent means to keep prospective settlers off their land (Branford and Glock 1985). Although hard data on the returns from land speculation in Amazonia are not available, anecdotal evidence suggests that vast fortunes have been made, especially by those who entered the market in the 1960s (Branford and Glock 1985: 49-51). But even relative latecomers could have done well in this regard. For example, investors who purchased average pastureland in Para in 1977

could have sold it ten years later for a respectable real gain of almost 100 percent on their initial outlay even if they had produced nothing during the intervening period (FGV/CEA 1985 and unpublished data).

The environmental damage associated with cattle ranching, which (including operations not benefitting from fiscal incentives) may account for as much as two-thirds of total deforestation in the region (see Table 2), has not gone unnoticed by Government authorities. During the "Parliamentary Commission on the Devastation of Amazonia and its Implications" held in 1978-79, for example, the role of the SUDAM-approved livestock projects was frequently mentioned in this respect. However, in his deposition to the Commission, a former Superintendent of SUDAM stated that projects receiving tax-credit funds had only cleared 12,000 km2, an area which in his opinion was "insignificant in the immensity of Amazonia" (Brazil 1978). An effort to halt further deforestation was mounted in 1979 when SUDAM officially declared its intention not to approve any new livestock projects in rainforested areas. In order to implement this new policy, satellite images were used by SUDAM as part of the project evaluation process during 1979-80. According to the IPEA study, ". . . this practice was abandoned and projects approved without it", in subsequent years (Garcia Gasques and Yokomizo 1986: 80).

Subsidized credit. Although livestock ranches benefitting from SUDAM-administered fiscal incentives have contributed in a major way to deforestation in southern Para and northern Mato Grosso, they have not played a dominant role in this regard elsewhere in the region. Probably 90 percent of total pasture formation in Amazonia to date has been carried out by firms or individuals who have not received fiscal incentive funds. Clearly, other factors have also played a role. One possibility, which is frequently mentioned in the literature, is the availability of subsidized rural credit (Browder 1987, Ledec 1985). Subsidized credit lines, like the fiscal incentive funds, increase private rates of return to investment and, as such, encourage activities--and by extension, deforestation--which would not be undertaken if credit were priced at market rates.

Subsidized rural credit has long been used by the Brazilian government as a means of compensating agriculture for foreign exchange overvaluation, import controls and other pro-industry macroeconomic policies. However, after 1974, in an attempt to stimulate the economy following the first oil crisis, the volume of subsidized rural credit increased dramatically. This increase in volume, moreover, was accompanied by a widening of the unit subsidy element. By the end of the 1970s, official rural credit was available at an average rate of -40 percent (World Bank 1984: 61). Although farmers and ranchers located in Amazonia continued to be allocated only a small proportion of this credit (less than 2 percent of the national total), they fully participated in the growth in its volume. Agricultural interests in Amazonia were also provided access to special new credit lines reserved for Brazil's underdeveloped regions.

As shown in Table 4, the volume of subsidized rural credit committed to Amazonia increased almost tenfold in real terms between 1974 and 1980. In almost all years, the bulk of this credit was allocated to crop production. However, the livestock sector also experienced major increases in the availability of subsidized credit after 1974. Much of this credit was extended through special lines with particularly attractive terms. For example, under POLAMAZONIA, a regional development program (to be discussed in greater detail below), 20-year investment credit was made available to ranchers at a nominal annual rate of 12 percent. PROPEC (National Program of Livestock Development), which provided credit to ranchers in the more developed Center-South of Brazil at a nominal rate of 45 percent per annum, offered terms similar to those of POLAMAZONIA to ranchers located in the Amazon region.

Table 4: Amazonia: Commitments of Official Rural Credit, 1970-85
(Cz.$ million at 1985 prices)

Year	Total		Crops		Livestock	
	Cz. $	(%)	Cz. $	(%)	Cz. $	(%)
1970	106.0	100.0	78.2	73.8	27.8	26.2
1971	153.3	100.0	102.3	66.7	51.0	33.3
1972	264.2	100.0	157.2	59.5	107.0	40.5
1973	306.7	100.0	168.4	54.9	138.3	45.1
1974	203.9	100.0	118.7	58.2	85.2	41.8
1975	495.4	100.0	297.2	60.0	198.2	40.0
1976	899.5	100.0	417.4	46.4	482.1	53.6
1977	985.7	100.0	620.0	62.9	365.7	37.1
1978	1,332.0	100.0	901.8	67.7	430.2	32.3
1979	1,824.9	100.0	1,419.8	77.8	405.1	22.2
1980	1,882.6	100.0	1,724.5	91.6	158.1	8.4
1981	1,285.7	100.0	1,135.3	88.3	150.4	11.7
1982	870.5	100.0	637.2	73.2	233.3	26.8
1983	472.8	100.0	411.3	87.0	61.5	13.0
1984	198.2	100.0	175.4	88.5	22.8	11.5
1985	296.9	100.0	259.5	87.4	37.4	12.6

Source: IBGE (various years).

The effects of subsidized credit on the behavior of farmers and ranchers in Amazonia are difficult to quantify for several reasons. First, farm and ranch-level data--size of operation, area cleared, output, productivity, and so forth--on credit users are extremely limited. Second, it is likely that a significant part of subsidized credit directed to agriculture and livestock was instead diverted to other uses. Although little is known about the extent of credit diversion in Amazonia, World Bank analysts estimated it to be on the order of 20-30 percent of total rural

credit in the late 1970s (World Bank 1984: 49). Finally, the influence of interest rate subsidies is inextricably mixed with that of the macroeconomic and sectoral policies they were supposed to offset.

Despite the caveats mentioned above, certain general conclusions may be reached. The most important of these is that the availability of subsidized rural credit undoubtedly facilitated the acquisition and deforestation of large tracts of land in Amazonia, particularly in the latter half of the 1970s. (It is not possible, however, to specify how much less deforestation would have occurred in the absence of subsidized credit.) Moreover, the special credit lines which served to increase the unit subsidy element for undertakings in Amazonia vis-a-vis more developed regions of Brazil probably attracted some resources which would have otherwise been invested in farms and ranches located in the less fragile natural environments of the Center-South.

In addition to its negative environmental effects, subsidized credit clearly served to skew further the distribution of wealth in the region. Since the possession of a land title is normally a prerequisite for obtaining investment credit in Brazil, Amazonia's many sharecroppers, tenants and squatters in particular were effectively denied access to a large part of the subsidy. Moreover, those persons without access to credit were obliged to bear a disproportionate share of the costs--for example, high input prices and low output prices--of the policies subsidized credit was supposed to offset. Subsidized credit also reduced the chances of the landless to obtain titles by raising average land prices well above what could be earned from the land through agriculture or livestock.12/

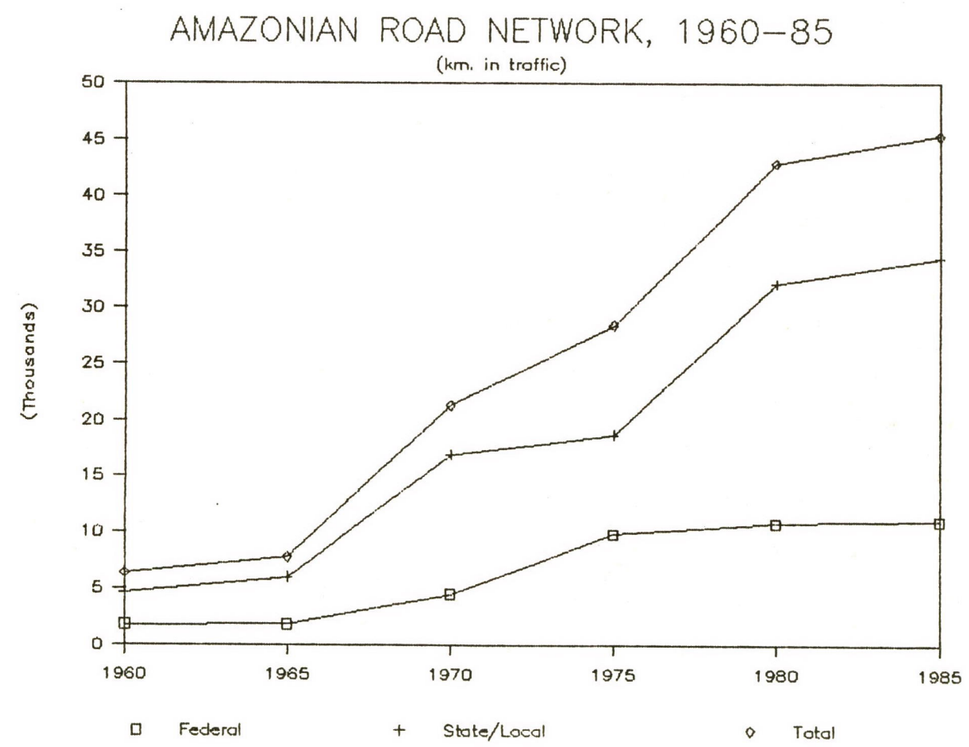
Since 1980, the volume of official rural credit has been drastically reduced in an effort to restore internal balance to the Brazilian economy. This policy change is clearly reflected in Table 4. Moreover, the subsidy element in this credit was eliminated completely in mid-1987. This is a most welcome reversal of the Government's long-standing policy on rural credit and, if sustained, will surely have beneficial macroeconomic, sectoral and environmental effects. The abrupt decline in the volume of subsidized credit in Amazonia has, however, disrupted some small and medium-scale agriculture in the region. This disruption may ironically have some negative environmental effects in the short-run. As will be discussed later in this paper, some farmers in Rondonia who had been advised by extension agents to adopt high-input tree crop production systems predicated on the availability of subsidized credit, now find themselves unable to afford fertilizers, herbicides and other needed inputs. Many of them have therefore reverted to less environmentally-sound activities such as slash-and-burn agriculture and extensive livestock raising.

12/Regressions based on data for six states (only one of which, Mato Grosso, is included in "Legal Amazonia") indicate that 67 percent of rural land price changes over the 1969-76 period can be explained by the intensity of credit use (World Bank 1984: 80-81).

The National Integration Program

As shown in Figure 1, the sharp increase in road-building of the late 1960s continued into the 1970s. Considerable impetus to this construction was provided by the National Integration Program (PIN), established in 1970.13/ Through PIN, resources were made available for the construction of some 15,000 km of roads, including an east-west (Transamazon) highway connecting Amazonia with the Northeast, and a north-south (Cuiaba-Santarem) highway linking it with the Center-South. Plans were also made to build a second east-west highway (North Perimeter) along

Figure 1



13/PIN was financed through a 30 percent share of the fiscal incentive funds. A companion program, known as PROTERRA (Land Redistribution Program), absorbed an additional 20 percent of these funds.

the northern bank of the Amazon River. A 20-km strip of land was to be reserved on either side of these highways for purposes of establishing agricultural settlement projects. In addition to road construction and settlement in Amazonia, PIN was to finance the irrigation of 40,000 hectares (ha) in the Northeast.

Most accounts hold that the decision to establish PIN resulted from President Medici's visit in 1970 to the chronically-poor Northeast to observe the effects of a particularly severe drought. The construction of an east-west highway, it was reasoned, would provide a short-term solution to the drought problem by creating jobs for displaced northeastern families. In the longer term, Government-sponsored settlements along the Transamazon highway were expected to alleviate population and social pressures in the Northeast while at the same time promoting the effective occupation of Amazonia. A second important motive for PIN was the hope that road construction would uncover valuable mineral deposits. The overriding motive, however, was national security and the fear of foreign domination in the region. Although xenophobia has always been an important theme in Amazonia, it reached a high pitch in the late 1960s as a result of publicity given to a quixotic scheme on the part of the U.S.-based Hudson Institute to dam the Amazon River to create a series of "Great Lakes", as well as by revelations that large tracts of land in the region had been sold to foreigners.

The first concrete result of PIN was the completion of the initial 1,200 km stretch of the Transamazon highway in late 1972.14/ This part of the highway, which intersects with both the Belem-Brasilia and Cuiaba-Santarem highways, was to be the site of the Government's attempt to settle some of the Northeast's "excess" rural population. Government plans called for settling 70,000 families between 1972 and 1974 (Mahar 1979). To carry out the settlement program, INCRA established a network of new villages, towns and cities (known, respectively, as agrovilas, agropoli, and ruropoli) at predetermined locations along the highway, and demarcated 100 ha farm lots nearby. The Government actively recruited colonists in both the minifundia areas of the South and the latifundia areas of the Northeast with massive propaganda campaigns promising attractive benefit packages. Included among these benefits were temporary (6-8 month) household subsidies averaging US$30 per month, guaranteed crop financing, and 20-year loans on generous terms for purchases of farm plots and housing (Smith 1982, Moran 1981).

Despite the huge amount of human and financial resources expended, the accomplishments of the PIN-financed road-building and directed settlement program were extremely modest. By the end of 1974, only about 5,700 families had been effectively settled along the Transamazon highway, less than 10 percent of the target set by the Government (Moran 1981). By the end of the decade, this total had risen to only 8,000 families, of which

---

14/An additional 1,000 stretch of the Transamazon was inaugurated in early 1974. The 1,800-kilometer Cuiaba-Santarem highway was completed in late 1976. Construction of the 2,500-kilometer Northern Perimeter highway was essentially abandoned in the late 1970s for financial and technical reasons.

just 40 percent had originated in the Northeast. The failure of the Transamazon settlement scheme to act as a safety valve for social pressures in the Northeast is clearly revealed by the demographic data. That is, the approximately 23,000 nordestinos accommodated in the settlement areas during the 1970s represented less than 1 percent of the Northeast's population growth (6 million) during the period (Smith 1981). Hopes that new natural resources would be uncovered during highway construction were also shattered early on. No sizable mineral deposits were discovered; as of the early 1980s, only one company was reported to be extracting minerals (tin ore) along the Transamazon (Smith 1981).

There are a number of reasons why the directed settlement schemes of the early and mid-1970s failed to create self-sustaining agricultural communities. Certainly, adverse environmental factors played a major role. Both the routing of the Transamazon highway and the layout of the colonization projects were done hastily with little regard to soil fertility or topography. Surveys have shown that only about 3 percent of the soils in the area of the Transamazon can be classified as naturally fertile. Moreover, most of the area traversed by the highway is hilly; extremes of relief from trough to hillcrest attain 40 meters within 0.5 km in some areas (Smith 1981). As a result of these factors, cleared land became subject to rapid erosion, necessitating expensive maintenance work on the highway and the burning of additional forest in order to restore lost soil fertility. The alteration of the forest also created favorable breeding conditions for the most common vector (the anopheles mosquito) for malaria. During the early 1970s, the rate of infection among the inhabitants in towns along the Transamazon was on the order of 20 percent (Moran 1981). Since the two peak transmission periods for malaria coincide with planting and harvesting seasons in the main settlement areas, it is likely that this debilitating illness significantly reduced agricultural yields on many farms (Smith 1982).

Institutional factors also played a role. Government planners and extension workers based the agricultural development of the settlement schemes on annual crops, particularly upland rice, which are generally considered to be environmentally and economically unsustainable in areas cleared from tropical rainforests, except under very favorable circumstances (Fearnside 1983, Goodland 1980). By and large, the circumstances under which the Transamazon settlers found themselves were anything but favorable. First, the colonization projects were located far away from major markets for agricultural commodities, thus putting settlers at a further competitive disadvantage vis-a-vis more efficient producers elsewhere in Brazil. Secondly, largely because of high transport costs, fertilizers, pesticides and herbicides were sold in the region at prices which put them beyond the reach of most small producers. Without these modern inputs, crops often succumbed to pests and diseases; and virtually the only way for farmers to maintain average yields was to fell and burn more forest. Finally, the frequent long trips to town and bureaucratic red tape required by the official banking system discouraged farmers from seeking rural credit. Moreover, it is reported that the Bank of Brazil provided more generous loans for farmers practicing agriculture on land converted from mature forest since crop yields in such areas tended to be higher than those in areas converted from secondary growth (Smith 1981). This practice, of course, encouraged further clearing of the forest.

Ironically, the failure of the PIN-financed road-building and settlement schemes to attract many migrants or to stimulate much economic activity had a beneficial effect on the environment. Substantial deforestation did occur but it was highly concentrated around the settlement areas of central Para. According to one estimate, only about 4 percent of the total deforested area in Amazonia as of the early 1980s can be directly attributed to Transamazon settlers (Browder 1987). Deforestation along the western reaches of the Transamazon highway in the state of Amazonas has been minor. Several other roads built during the 1970s--Cuiaba-Santarem, Porto Velho-Manaus, Northern Perimeter--have also had limited environmental impacts.

A major difference between the "national integration" highways and the highways built in the 1960s (Belem-Brasilia and Cuiaba-Porto Velho) is that the latter effectively linked the frontier with the country's urban-industrial centers while the former did not. According to one author, the ease of movement of commodities to and from these centers is "what counts most with regard to effects on settlement" and, by extension, on the environment (Sawyer 1984). The fact that no important mineral deposits or areas of fertile soils were discovered along the "national integration" highways also served as de facto protection for the rainforest.

The Cuiaba-Porto Velho Highway and POLONOROESTE

In 1968, just a few years after the completion of the Belem-Brasilia highway, the construction of another penetration road--the 1,500 km Cuiaba-Porto Velho highway (BR-364)--opened up the 243,000 km2 state (then a federal territory) of Rondonia for settlement. This part of western Amazonia had been a rich rubber-producing area during the turn-of-the-century boom and, starting in the mid-1950s, an important source of cassiterite (tin) and gold. Until the latter part of the sixties, however, Rondonia, like most other parts of Amazonia, was virtually inaccessible from the rest of Brazil by overland means: to reach the south of the country required a journey of several weeks by ship and boat along the Madeira and Amazon Rivers. Rondonia's population (comprised mainly of itinerant rubber-tappers and prospectors) totalled only 70,000 in 1960, and practically all of the rainforest, covering about 80 percent of the state, was still intact.

As in the case of the Belem-Brasilia highway, the completion of BR-364 was followed by a wave of migrants, land-grabbers (grileiros) and adventurers seeking plots of fertile land that were purportedly free for the asking.15/ The annual migratory flow, which had averaged perhaps 3,000 per year in the 1960s, increased ten-fold in the ensuing decade (IBGE 1979; World Bank 1981). This increasing volume of migration was also accompanied by major changes in the regional origins of the migrants. Whereas the vast majority of the state's original settlers were from the North and Northeast, most of the new contingent was comprised of experienced small-scale farmers from the southern state of Parana. Large numbers also came from the states of Mato Grosso, Minas Gerais, Espirito Santo and Sao Paulo.

15/About 10 percent of Rondonia's soils are considered to be of "good" quality. This appears to be considerably better than the average for Amazonia as a whole (World Bank 1981: 58).

Both "pull" and "push" factors explain the sharp increase in migration to Rondonia after 1970. Two pull factors have predominated. First, the Cuiaba-Porto Velho highway route by chance traversed a few areas of relatively fertile soils, a fact that was publicized (and exaggerated) both by the Government and by early settlers in their letters to family and friends back home. Second, a number of official agricultural colonization projects were established in which prospective settlers could obtain 100 ha lots at a nominal price along with basic services and infrastructure. The most important push factors have been related to fundamental changes in the rural economy in Brazil's Center-South--the rapid spread of mechanized soybean and wheat production and cattle raising, killing frosts in coffee-growing areas, and the fragmentation of landholdings--which drastically reduced employment opportunities in what were to become the major areas of out-migration.

Most of the new migrants were interested in entering one of the seven settlement projects established on 2.7 million ha by the National Institute for Colonization and Agrarian Reform (INCRA) between 1970 and 1975. In sharp contrast to the Transamazon experience, where the Government had actively recruited prospective settlers, the role of INCRA in Rondonia was essentially to provide lots, roads and other basic infrastructure to a population who had moved to the region spontaneously. As the size and speed of the migratory flow increased, however, the demand for space in official projects quickly exceeded the supply.

By 1977, INCRA had settled about 28,000 families; an additional 30,000 agricultural families had joined the marginal population of the newly-created urban areas while they awaited their lots, sometimes for as long as two years (Martine 1980: 89-90). Many others became sharecroppers on the land of established colonists or staked out claims on the fringes of the official projects, on Indian reservations and in forest reserves. INCRA expanded existing settlement projects, increasingly recognized small squatters' claims, and sold larger lots at public auction in an attempt to defuse mounting social tensions over land rights. Despite these efforts, the situation in Rondonia worsened in the late 1970s as continuing migration and budgetary cuts nearly paralyzed INCRA.

It is evident from the data on deforestation presented earlier that Rondonia's rapid population growth and uncontrolled settlement had (and is still having) devastating effects on the rainforest. The speed at which this deforestation took place was, in some areas of the state, truly astonishing. The cleared area in the 80,000 ha municipio (county) of Cacoal, for example, increased from 2,150 ha in 1975 to 66,950 in 1978! (Fearnside 1982). Most of the deforestation was the result of clearing for agricultural purposes in the official settlement projects established along the main highway (see Map IBRD 20511). However, owing largely to inadequate infrastructure, technical and financial assistance, agricultural research and marketing facilities, most of the early settlers engaged in traditional,

and environmentally-unsound, farming practices (Mueller 1980).16/ This usually involved the clearing and burning of a patch of forest and the cultivation of annual crops for 1-3 years depending on soil fertility. Pasture would then be established on the original patch and the cycle would begin again with additional forest clearance.

Through its role in providing access to remote areas, the rapid growth of Rondonia's feeder roads network--which increased more than five-fold between 1975 and 1980 alone--greatly facilitated the deforestation process (IBGE 1986). Moreover, the poor condition of these roads and of BR-364 (especially during the rainy season) made it difficult to transport commodities to market and thus, along with other factors, discouraged the cultivation of tree crops like cocoa, coffee and rubber which would have been far more appropriate from an environmental standpoint. Tree crops are strongly preferred over annuals and pasture because of their superior ability to protect the fragile soils of Amazonia from erosion. They also have some important socioeconomic advantages: their cultivation is labor-intensive and under reasonable market conditions can provide a decent standard of living for a farm family. The principal disadvantages of tree crops are their susceptibility to disease (such as the "witches' broom" fungus in cocoa and the leaf blight in rubber), their costly fertilizer requirements when grown on the poorer quality land typical of Amazonia, and generally weak international market prospects.

Recognition of the growing socioeconomic problems in Rondonia led to a proposal by Government to reconstruct and pave BR-364 as part of a larger program of integrated regional development. The overall program, which became officially known as the Northwest Brazil Integrated Development Program or POLONOROESTE in 1981, applied to a 410,000 km area (known as the "Northwest") including all of Rondonia and part of western Mato Grosso. The program was budgeted at US$ 1.5 billion, of which about a third was eventually provided by the World Bank (Mahar 1982). POLONOROESTE was expected to benefit some 30,000 families already settled in the subregion as well as an additional 15,000 families to be settled in Rondonia.

From the agricultural and environmental standpoints, the principal objective of POLONOROESTE was to reduce forest clearance on land without long-term productive potential and to promote, instead, a more widespread adoption on the part of migrants of sustainable farming systems based on tree crops. This was to be accomplished by carrying out land use surveys in order to separate high from low potential areas and, based on the findings of these surveys, to concentrate new access roads, social infrastructure, agricultural research and extension, input supplies, crop storage, marketing and farm credit in areas identified as having high potential (FAO/CP 1987). Environmental protection services in the Northwest were also to be strengthened.

16/A particularly critical issue was the slow pace at which land titles were awarded. As of end-1979, only about 40 percent of the farmers in official settlement projects held a definitive title to their land. Farmers without titles were ineligible to receive investment credit.

The available data clearly suggest that the actions carried out under POLONOROESTE so far have not succeeded in slowing down the pace of deforestation, nor have they appreciably altered traditional land-use patterns. As mentioned previously, the deforested area of Rondonia, which comprised 3 percent of the state in 1980 (see Table 1), increased to an estimated 24 percent by 1988. This implies that the average area deforested annually in this decade has been more or less equal to the total deforested area as of 1980! The expected major shift of farmland into tree crops, moreover, has not materialized. As shown in Table 5, there has been instead a rapid conversion of forest into pasture. As discussed previously, pasture is one of the least desirable forms of land use in Amazonia from the environmental point of view. The experience of the SUDAM-approved projects also strongly suggests that livestock activities provide little employment and are likely to be unsustainable in the long run.

A number of factors have contributed to the accelerated deforestation and inappropriate land use currently observed in Rondonia. A major proximate cause was the substantial jump in the migratory flow following the paving of BR-364 in 1984. About 160,000 migrants per year entered Rondonia in the period 1984-86 versus an average of 65,000 per year in the 1980-83 period. Although an appreciable number of these migrants have passed through Rondonia en route to newer frontier areas in the state of Acre to the west and the territory of Roraima to the north, the vast majority have stayed. As a result, the state's population has grown at an average annual rate of almost 14 percent since 1980, pushing the state's total population to an estimated 1.2 million in 1987. This rapid population growth greatly increased the already-high pressures on the forest. However, population growth alone does not explain the extremely rapid pace of deforestation nor farmers' preference for pasture formation over the cultivation of tree crops. One must therefore consider the role of certain institutional and policy factors.

Two institutional factors may be mentioned. First, the federal Institute of Forestry Development (IBDF) has not been able to enforce adequately the so-called "50 percent rule", which prohibits landowners in Amazonia from clearing more than half of their holdings.17/ It is reported that some settlers in Rondonia have already cleared as much as 90 percent of their lots. In addition to its being unenforceable, some scientists argue that the "50 percent rule" may intensify the damage to the environment it is designed to prevent (Goodland and Irwin 1975: 30). Animals and plants have a minimum area of habitat needed for their survival. For insects this minimum area may be measured in square meters; for larger mammals, such as the jaguar, 500,000 or more square kilometers may be necessary to support a genetically-viable population. The 50 ha reserve in a typical colonist's lot, therefore, will not sustain anywhere near the level of biological

---

17/The penalty for exceeding legal limitations on deforestation is a one-time fine of approximately US$ 1,000 equivalent. If the law were duly enforced, this fine would clearly constitute a strong disincentive to small farmers. The disincentive is much less for large landowners who may find it possible to sell timber cut from the 50 percent legal reserve for more than the value of the fine.

diversity found in undisturbed rainforest. On-farm reserves may also harbor plant and insect pests which attack the surrounding agriculture.

Table 5: Agricultural Land-Use in Rondonia, 1970-85 (Km2)

Year	Crops		Pasture	Forest a/	Total b/
	Annual c/	Perennial			
1970	323.7	127.2	410.1	15,031.1	16,316.4
(%)	2.0	0.8	2.5	92.1	100.0
1975	1,503.9	457.6	1,645.2	26,681.4	30,820.5
(%)	4.9	1.5	5.3	86.6	100.0
1980	2,425.8	1,701.8	5,101.8	41,461.1	52,236.3
(%)	4.6	3.3	9.8	79.4	100.0
1985	3,153.3	2,238.0	15,611.5 d/	39,903.7 d/	60,906.6
(%)	5.2	3.7	25.6	65.5	100.0

a/ Includes natural pastures.
b/ Area under farms at time of Census; includes land unsuitable for agricultural use.
c/ Includes fallow land.
d/ Estimated.

Source: IBGE (1987), Rondonia Secretariat of Planning, and author's estimates.

Second, the intensification of smallholder agriculture envisaged under POLONOROESTE was predicated on the assumption that subsidized credit would be made available to finance purchases of modern inputs. The use of fertilizers and other inputs was particularly important for those farmers settled by INCRA on poorer soils. However, early in the implementation of the program austerity measures resulted in a reduction in both the subsidy element and supply of credit (see Table 4). These measures effectively denied credit to most farmers in the Northwest. But even when credit was available, many farmers were reluctant to use it because they felt that the subsidy element was not high enough to offset the risks associated with the cultivation of tree crops (Wilson 1985). The problems caused by a lack of credit were further compounded by an extension service which continued promote high-input farm models in the settlement areas (FAO/CP 1987).

In addition to the institutional factors enumerated above, certain land and tax policies have encouraged (or at least have not discouraged) unnecessary deforestation and inappropriate land use. Indeed, without a substantial modification of these policies it is doubtful that land use patterns in the Northwest can be improved. The policy environment in Rondonia, however, is in many ways different than that prevailing in eastern Amazonia. Fiscal incentives for livestock development, for example, have not been an important factor: fewer than 20 of the 631 SUDAM-approved projects are located in the state. This is mainly the result of a 1971 law which provides that all land in Amazonia located within 100 km on either side of federal highways (such as BR-364), and within 150 km of an international boundary, falls under federal control. In effect, this law placed more than 90 percent of the Rondonia's area under the jurisdiction of INCRA. The policies of INCRA, therefore, have had a much greater impact on land use than those of any other government agency.

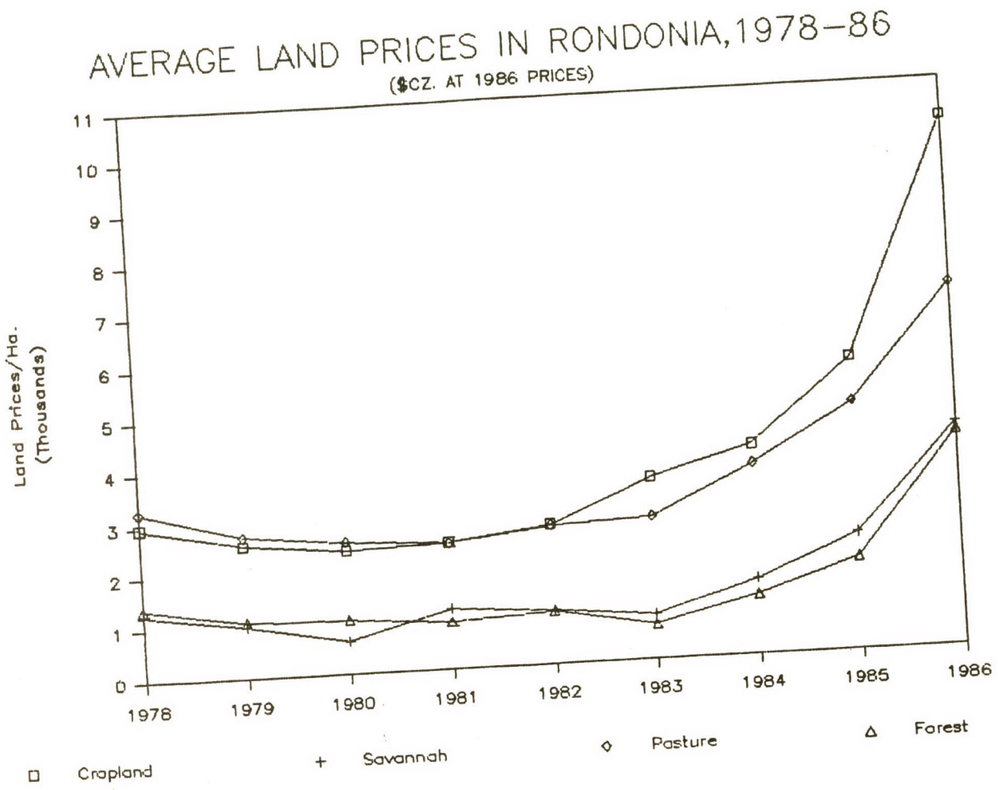
Some of INCRA's policies have encouraged inappropriate land use. Foremost among these is its policy of accepting deforestation as evidence of land improvement. Through this policy a migrant, situated in either an official settlement project or in an invaded area, can obtain rights of possession simply by clearing the forest.18/ Both good and poor quality land are deforested indiscriminately in this manner. The geographical extent of these rights are determined by multiplying the cleared area by three, up to a maximum of 270 ha. Once obtained, rights of possession can be sold either formally or informally depending on whether or not the migrant has occupied the land long enough to qualify for a definitive title. While some migrants with a serious interest in developing sustainable agriculture have benefited from this policy, many others have used it as a means of acquiring land for speculative purposes.

The potential gains from speculation would appear to be very high in Rondonia. As shown in Figure 2, real prices of land have soared in recent years largely in response to continued migration and the improvements in roads and other infrastructure financed through POLONOROESTE. Faced with the prospects of realizing large capital gains many migrants have decided to sell their lots. In the older settlement projects an estimated 80 percent have already sold out; in newer settlement areas turnover rates are in the range of 40-55 percent.

Calculations made by a FAO/World Bank Cooperative Program (FAO/CP) team, which recently reviewed the interim results of POLONOROESTE, show that it is possible for a speculator to net US$ 9,000 equivalent if he clears 14 ha of forest, plants pasture and subsistence crops for two years, and then sells the rights of possession acquired by doing so. This constitutes a large sum of money in Rondonia where daily farm wages average less than US$ 6.00 equivalent. Additional calculations by the FAO/CP team show that even bonafide farmers who have planted tree crops, but because of poverty cannot hold out until the trees are of bearing age, stand to make

18/Settlers wishing to engage in extractive activities--for example, rubber tapping or the gathering of Brazil-nuts--which did not disturb the forest are particularly disadvantaged by this policy.

Figure 2



handsome profits by selling their lots after a few years (FAO/CP 1987: Annex 5, Table 1). Under the Brazilian income tax, such gains on land sales are theoretically taxed at a flat 25 percent rate. However, few of these capital gains are taxed in practice, particularly in frontier areas, because of widespread "informal" land transactions and underreporting of sales prices.19/

19/ Binswanger (1987) argues that other provisions of the income tax code, which exempt virtually all agricultural income from taxation, tend to increase the demand for land on the part of higher income individuals. These provisions thus contribute to a more rapid conversion of forest to agricultural uses, land price appreciation, and increasing concentration of land ownership.

The rural land tax (ITR), administered by INCRA, also encourages deforestation, at least in theory. The ITR was created in 1964 with the laudable objective of encouraging more productive use of land. The tax presently is assessed at a maximum rate of 3.5 percent of the market value of the land; the required 50 percent forest reserve is exempted from taxation. Reductions of up to 90 percent in the basic rate are given according to: (i) the degree of utilization of land (i.e., the proportion cleared); and (ii) certain "efficiency" indicators--for example, crop yields, cattle stocking rates, rubber extraction per ha--established by INCRA. In practice, the ITR probably has little influence on patterns of land use, mainly because the landowners themselves declare the value of their land as well as the efficiency of its use. According to INCRA, only about half of all registered landowners in Rondonia paid any ITR in 1986; of those who did, the average payment was only US$ 5.00 equivalent!

The rapid pace of pasture formation (a process known as pecuarizacao) recently observed in Rondonia appears to be largely the result of migrants settling on poor quality land, combined with the institutional and policy factors discussed above. Without the resources to pay for fertilizers and other modern inputs needed for cultivating tree crops on the poorer soils, as well as for wage labor to help with planting and harvesting, settlers often find pasture formation the only option (short of selling their lots) available. Interviews with small farmers in Rondonia, moreover, indicate that they consider cattle to be a form of social security which in times of need can be sold to repay bank credit, finance medical care and schooling, and so forth (Milliken 1984). Speculators also prefer to keep their land in pasture rather than in crops because of the former's relatively low maintenance costs. Such persons can even avoid the initial financial outlays for clearing the forest and planting the pasture by having landless migrants perform these tasks in exchange for permission to cultivate the newly-cleared land for one or two seasons. The undertaking of field research aimed at better understanding the factors driving unproductive pecuarizacao and related land speculation, and the implementation of measures to halt these processes, should clearly be a major priority of both the state and federal authorities in Rondonia.

The "Big Projects" Era

In the mid-1970s, the Government essentially abandoned the road-building and directed settlement strategy embodied in PIN. The strategy which took its place--institutionalized in 1974 as the Program of Agricultural, Livestock and Mineral Poles in Amazonia, or POLAMAZONIA--emphasized the development of large-scale export-oriented projects in the livestock, forestry and mining sectors in 15 "growth poles" scattered throughout Amazonia. In essence, POLAMAZONIA was (it was abolished in 1987) a program of infrastructure development which, combined with existing fiscal and credit incentives, aimed at creating a more favorable investment climate in Amazonia for private enterprise. The small-scale farmer, although relegated to a lower priority in regional plans, was not totally neglected. However, recent official settlement programs have been almost exclusively concerned with accommodating through POLONOROESTE the surge of spontaneous migration to Rondonia.

One factor explaining the abrupt shift away from directed small-scale settlement was general disillusionment with the Transamazon experience and the realization in Government circles that Amazonia could not provide a quick fix to the demographic pressures and socioeconomic problems of the Northeast. Another important factor was the oil crisis of 1973 which hit Brazil, a major importer of this commodity, particularly hard. This external shock put into serious question the strategy of integrating Amazonia with the rest of Brazil on the basis of the automobile and truck. It also greatly increased the country's foreign exchange requirements to pay for oil imports and to service the rapidly mounting external debt. The Government felt that Amazonian exports of minerals, timber and agricultural products had the potential to make an important contribution to Brazil's annual foreign exchange earnings.

A major focus of current regional policy is the development of the mining and mining-related sectors of eastern Amazonia. Official interest in the mining potential of this subregion dates from 1967 when a U.S. Steel geologist accidentally discovered in the remote Serra dos Carajas (located 550 km south of Belem in the state of Para) a virtual mountain of high-grade (66 percent pure) iron ore, with estimated reserves of 18 billion tons. Subsequent prospecting in the area also uncovered extensive reserves of copper, manganese, cassiterite, nickel, bauxite and gold. In order to exploit this subregion's natural resources in a rational manner, the Government established the Greater Carajas Program (PGC) in 1980. The PGC is administered by an Interministerial Council headed by the Minister of Planning. The program area comprises 895,000 km2 (more than 10 percent of Brazil's total land area), and contains four of POLAMAZONIA's planned "growth poles". Within this area, firms approved by the Interministerial Council enjoy generous fiscal incentives, Government guarantees of foreign and domestic credit operations, and subsidized energy from the nearby Tucurui hydroelectric facility.20/

The first major project in the Carajas subregion, approved by the Economic Development Council in 1978, was aimed at exploiting the region's huge iron ore reserves. The iron ore project, which began implementation in 1983 and is now fully operational, was carried out under the responsibility of the Companhia Vale do Rio Doce (CVRD), a Brazilian parastatal mining enterprise. Besides development of the mine site, the project also involved the construction of a 890-km railroad from the mine head to Sao Luis (Maranhao), port facilities capable of handling the mine's 35 million ton per year output, and urban infrastructure. CVRD's concession area totals 4,290 km2, plus a narrow strip on either side of the railroad. The cost of the project, including contingencies, was around US$ 5 billion.

20/ The Tucurui facility, which began operating in 1984, currently generates about 2,000 MW of power. Its generating capacity could reach 7,960 MW at full development. The lake formed by the facility extends 200 km up the Tocantins River and covers an area of 2,435 km2. While it was originally intended to harvest the timber on the land to be inundated by Tucurui, the firm awarded the contract (CAPEMI, a military pension fund) to do so was inexperienced and eventually went bankrupt. As a result, millions of cubic meters of commercially-valuable timber were lost.

Financing was provided by CVRD itself (40 percent) and national and foreign creditors, including a US$ 300 million loan from the World Bank.

In contrast to most other projects in Amazonia, the Carajas Iron Ore Project was developed with close attention to its possible environmental impacts. CVRD had obviously learned from its own experience in southern Brazil, as well as from the experience of others in Amazonia, where mining has seldom been undertaken with due regard to the natural environment. Even before official approval of the Carajas project, CVRD commissioned a series of environmentally-related baseline studies of the proposed project area covering climatology, ecology, botany and related disciplines. The findings of these studies allowed the drafting of a manual establishing company policies regarding forest clearing, topsoil stockpiling, erosion control, vegetation regeneration, protection of fauna, and so forth, that eventually became the basis of the project's environmental components (Freitas 1982).

Between 1981 and 1985, CVRD spent around US$ 54 million on environmental activities related to the Carajas project (Kohlhepp 1987). These activities included, inter alia, land reclamation, the creation of protected natural reserves, and the promotion of environmental awareness and training. CVRD also tightly controlled physical access to the project area to prevent unplanned human occupation. In order to oversee the implementation of the project's environmental components, CVRD created an independent group (GEAMAM) consisting of nine senior scientists who would visit the project site periodically over a period of 15 years. In addition, internal environmental commissions (CIMAs), made up of CVRD employees and contractors and coordinated by an ecologist, were placed on site permanently to make sure that Government and company environmental guidelines were being adhered to (Freitas 1982).

In contrast to the orderly and environmentally-responsible development of the Carajas iron ore reserves, the situation in the PGC area outside of the CVRD concession has been chaotic. Migration to the Greater Carajas area has been intense in recent years, drawn by employment opportunities--for example, construction of the Tucurui dam and various civil works related to the iron ore project--as well as by the prospects of striking it rich in newly-discovered goldfields. The municipio of Maraba, which includes the Serra dos Carajas, more than doubled its population (from 60,000 to 134,000) between 1980 and 1985 alone. This new wave of migration has arrived in a subregion of Amazonia which, following the completion of the Belem-Brasilia highway, had already been subject to settlement and large-scale cattle ranching. The result of the recent spurt in population growth has been a worsening of the accelerated deforestation, environmental degradation and violent conflicts over land rights that have characterized much of the PGC area for many years (Branford and Glock 1985).

Despite its existence for the better part of a decade, the PGC has failed to come up with a realistic, environmentally-sound development plan for the overall subregion. In 1980, at the request of CVRD, Japanese consultants prepared a plan calling for the establishment by the private sector of various export-oriented projects in the mining, metallurgy, agriculture, livestock and forestry sectors. Investments of US$ 62 billion would have been necessary for the realization of this plan. Nowhere near

this amount of investment has materialized in the ensuing years. More recently, in 1983, the Ministry of Agriculture published a plan, costed at US$ 1.2 billion, proposing the division of the PGC into seven agricultural poles. Undertakings within these poles would include 238,000 ha of mechanized soybeans, 12,600 ha of sugarcane, and 417,000 ha of cattle pasture. In addition, the plan calls for 3.6 million ha to be set aside for eucalyptus plantations along the Carajas-Sao Luis railway to provide charcoal for metallurgical use (Hall 1987, Fearnside 1986c).

The PGC agricultural development plan has been severely criticized for being inequitable (only 17 percent of the land would be allocated to small producers) and for promoting forms of land use (e.g., cattle ranching, annual cropping, homogeneous tree plantations) which are likely to be unsustainable (Hall 1987, Fearnside 1986c). However, like the grandiose regional plan produced earlier by Japanese consultants, the agricultural plan will probably never be implemented in its entirety. On the other hand, plans to develop a metallurgical sector along the railway corridor on the basis of locally-produced iron ore and charcoal are moving ahead. Fifteen pig-iron and manganese iron projects had been approved for fiscal incentives by the Interministerial Council of the PGC by late 1987; at least two are expected to begin operations in 1988.21/ An equal number of projects are presently being considered for approval.

The long-term viability--economic, financial and environmental--of the metallurgy/charcoal projects has not yet been established. On the contrary, the available information casts considerable doubt on the whole enterprise. The implementation of proposed projects would, at a minimum, add appreciably to pressures on the forest. Preliminary estimates suggest that the pig-iron plants would, at full operation, require 1.2 million tons of charcoal per year. To satisfy this demand would require the cutting of between 90,000 and 200,000 ha per year of forest depending on tree stands, density of species used, and other factors. Since wood from the proposed eucalyptus plantations would not be available until the seventh year after planting, total deforestation attributable to the pig-iron plants would reach between 540,000 and 1.2 million ha. The environmental implications of such large-scale deforestation are clearly negative.

No analysis of the true economic costs of producing pig-iron using charcoal has been carried out. However, in financial terms (based on gross revenues from pig-iron exports of US$100-110 per ton), it is estimated that any fuel in the Carajas area which costs less than US$70 per ton

---

21/ The PGC offers several types of fiscal incentives to approved firms. The most generous of these allows firms for a period of 10 years to take a tax credit equal to 50 percent (reduced from 100 percent in 1985) of their corporate income tax liabilities on income earned within the PGC area if this money is reinvested in projects approved by the Interministerial Council. "Fresh money" must account for at least 25 percent of any new investments using tax credit funds. To date, the beneficiaries of tax credit provision have all been construction/engineering firms with profits from civil works activities in the PGC area. Other fiscal incentives offered by the PGC include exemptions from import duties and the federal excise tax (IPI).

charcoal equivalent would render the plants profitable. Charcoal produced from the virgin forest, which presently sells for US$ 27 per ton in the region, clearly falls into this category. A recent study commissioned by SUDAM reached a similar conclusion (SUDAM 1986). But market prices for charcoal reflect only the cutting and transportation costs for the wood used in its manufacture. Were the full environmental costs of deforestation to be included in the price of charcoal, it is by no means clear whether the plants would remain viable. A key question, therefore, is whether charcoal can be produced at competitive prices from exotic trees.

Unfortunately, the cost of producing charcoal from plantation-grown eucalyptus--on the scale envisioned and under the agronomic and climatic conditions prevailing in the Carajas area--is not known with certainty. However, the dismal historical experience with homogeneous tree plantations in Amazonia suggests that the cost will be high. In a recent article, Fearnside (1987) estimates that to supply the proposed pig-iron plants with charcoal entirely derived from plantation-grown eucalyptus would involve the planting of 2.6 million ha of trees. This is 35 times the size of the next largest eucalyptus plantation in Amazonia, the 76,000 ha planted on the Jari holdings in northeastern Para. The Jari project's tree plantations (like those of Henry Ford nearly a half-century earlier), despite massive injections of capital and intensive experimentation and research, proved to be far more expensive and less productive than originally thought and have yet to turn a profit (Fearnside 1987, Kinkead 1981, and footnote 8 above).

All in all, the experience accumulated so far during the "big projects" era suggests that the impact of Government policies on the Amazon rainforest has been generally negative. However, the implementation of the Carajas Iron Ore Project has shown that it is possible to exploit the region's resources in a manner which minimizes environmental damage. But it must be emphasized that the success of the iron ore project is largely attributable to the intrinsic nature of mining--usually a small area is involved and production is not dependent on environmental factors such as soils and climate--and to CVRD's environmentally-sensitive approach and its ability to control events in its concession area. These are circumstances which will not be easy to replicate elsewhere in Amazonia. This point is vividly illustrated by recent and projected developments in the Greater Carajas Region outside of the CVRD concession, in the areas of large-scale livestock development scattered throughout Amazonia, and in Rondonia.

IV. Conclusions and Recommendations

The main conclusion of this paper is that over the past 25 years the Brazilian Government's policies to develop the Amazon Region have rarely been designed and carried out with due regard to their environmental consequences. The felling of the rainforest, which began on a major scale during the 1970s, continues to take place at an accelerated pace in many parts of the region. The forests of Rondonia and parts of eastern Amazonia, in particular, are being cleared at explosive rates. Much of this deforestation has benefitted neither the regional population nor Brazilian society as a whole, except perhaps in the very short term. Despite decades

of intense development effort, Amazonia still only accounts for an insignificant 3 percent of the national income.22/

Many of today's problems can be traced back to the decision taken in the mid-1960s to provide overland access to Amazonia before there was sufficient knowledge of the region's natural resource base and how to develop it in a sustainable manner. This initial error was compounded by subsequent decisions to provide generous incentives to investors willing to undertake environmentally-questionable livestock projects and, more recently, smelting projects in the Greater Carajas Region. Official settlement projects have also contributed to deforestation although it would be wrong to place all of the blame for this on the settlers themselves. Settlers pushed by poverty and skewed land distributions in their regions of origin, have merely responded to incentives created by the Government in the form of access roads, titles to public lands, various public services and, in the case of the Transamazon scheme, subsistence allowances.

There is no doubt that rapid deforestation will continue if present policies remain unaltered. In areas where overland access already exists, much damage has already been done. In such areas, the Government should do what it can to promote the recuperation of degraded and/or abandoned lands and thus help to restore the forest's biological diversity. In cases where the land is presently occupied by small-scale agriculture, the best course of action would be to increase public support--both technical and financial--for those activities which can provide a decent living for a farm family and which also minimize additional environmental damage. Such activities might include tree crops cultivation, the gathering of forest products, subsistence livestock (dairy cows, pigs, chickens, etc.) or some mixed production system. Because of the relatively high costs of production inherent to a remote frontier area and the uncertain market prospects for many of Amazonia's key exports, this approach would probably require some degree of subsidization on the part of the Government. However, subsidies could be justified on both environmental and equity grounds.

A different policy should be developed for rainforest areas for which overland access does not yet exist. This policy would differ considerably from past policies which have focused on opening up Amazonia indiscriminately for small and large-scale agricultural and livestock development: in effect, it would introduce an alternative development model based on the region's comparative advantage in forest-based economic activities. Under this new approach, the Government would not construct any new roads or provide infrastructure or services (particularly land titles) in the region until detailed land-use surveys were carried out. Once the appropriate surveys were completed and the productive potential of the land known, physical access would be permitted only under special circumstances.

22/This figure was calculated using standard national accounting procedures which charge the depreciation of manmade assets (e.g, buildings and equipment) against current income, but not the depletion of natural resources (e.g., wildlife, minerals, trees). Were this anomaly corrected, the real level of income generated in Amazonia would undoubtedly be much lower.

(In this regard, it would be useful to improve fluvial transport facilities in these areas in order to reduce pressures for additional road construction.) Lands found to have limited agricultural potential--comprising virtually all of the terra firme of Amazonia--would under this policy be held in perpetuity as forest reserves closed to all development, or as sites for environmentally-benign activities such as rubber-tapping and Brazil-nut gathering, tourism, or sustained-yield logging.

Recent events in Brazil suggest that a change in regional development policy along the lines suggested above may be in the offing. The Government of Rondonia, for example, proposed in mid-1987 that the entire state be subject to agro-ecological zoning. The federal Government is considering the possibility of extending this concept to all of Amazonia. These are definitely steps in the right direction. However, it should be kept in mind that the Government first proposed agro-ecological zoning for Amazonia in the late 1970s. To this end, a special commission comprised of academics and Government representatives was set up to draft suitable legislation. The original draft legislation included a commitment to preserve 150 million ha of the region, of which 100 million ha were to be rainforest. The preservationist tone of this document was reduced considerably in subsequent revisions, reportedly due to intense lobbying efforts on the part of timber and cattle companies and private colonization firms. But in the event, no version of the legislation was ever approved by Congress.

The success or failure of the new attempts to apply agro-ecological zoning in Amazonia will largely depend on the technical quality of the proposals themselves, the strength and depth of political support for the concept, and the existence of an overall policy framework consistent with rational land use. While it is too early to pass judgement on the first two factors, it is clear from the analysis in this paper that the third is still not in place. Some recommendations on how the policy framework could be improved follow.

First, the Government should stop providing fiscal incentives for livestock projects in Amazonia. Disbursements to projects already under implementation should continue, but only in cases where SUDAM has confirmed by field visits that such projects are not located in rainforest areas. More than two decades of experience has shown that livestock projects have been responsible for much environmental damage while returning little in the way of production or employment. Livestock projects may also be criticized from the equity standpoint since most of the benefits from the fiscal subsidy have accrued mainly to a small group of wealthy investors who have used these resources to appropriate large tracts of land on the agricultural frontier. Clearly, SUDAM-approved livestock projects have not succeeded in generating the social benefits necessary to justify the continuation of Government subsidies.

The possibility of abolishing all regional fiscal incentives has been considered as part of Brazil's overall tax reform program. But owing to strong lobbying on the part of regional and extraregional special interest groups, there is apparently little likelihood that this will occur in the near future. With respect to the fiscal incentives for cattle ranching, the most powerful lobby group has traditionally been the

Association of Amazonian Entrepreneurs (AEA) based in Sao Paulo (Pompermayer 1984). Local political interests, however, have also shown little enthusiasm for eliminating what is viewed as an important source of investment capital for the region.

Second, the Government should declare a moratorium on disbursements of fiscal incentive funds for any projects in the Greater Carajas Region--such as the proposed pig iron plants--which would use charcoal derived initially from the rainforest as their principal energy source. Projects of this type have the potential to cause considerable deforestation in return for the production of relatively low-value products. Although these projects would in theory be obliged to replace the forest with tree plantations, previous undertakings of this nature (although not on the major scale envisaged) in Amazonia have never succeeded. Before a final decision is taken on these projects, further research should be carried out on the true economic costs (including the environmental costs) of the projects and the possibilities of employing alternative energy sources (e.g., electricity from Tucurui, natural gas, etc.)

Third, INCRA should modify its policy which recognizes deforestation as a form of land improvement and, as such, grounds for granting rights of possession. This policy has encouraged felling of forest in areas with little or no agricultural potential. It has also fueled land speculation. In future, INCRA should not grant rights of possession or definitive titles to any lots on poorer soils. In areas with poorer soils, but with potential for extractive activities, the granting of long-term concessions should be considered. INCRA has recently proposed a modification of its land-use policies along these lines. This new approach proposes to provide 20-30 year concessions to individuals (largely rubber-tappers already in the region) or producer associations undertaking environmentally-sound extractive activities in designated areas. This approach, which fits well with current proposals calling for agro-ecological zoning, should be encouraged.

Fourth, IBDF should consider abolishing the "50 percent rule". It has been shown to be unenforceable in the context of a frontier region like Amazonia, and provides little, if any, protection to the environment. In place of the "50 percent rule", legislation should be passed which expressly permits the formation of contiguous "block" reserves equal to 50 percent of the area under agriculture in a given region rather than 50 percent of each farmer's lot. Such reserves would help to maintain biological diversity, benefit agriculture, and increase the number of migrants which could be settled on already-occupied areas of better soils. Block reserves have been established on an exceptional basis in some of the newer settlement areas of Rondonia. Although some problems have been reported--for example, illegal invasions of the block reserves and disputes among settlers over their individual rights to use these reserves--the experiment should be closely monitored and evaluated in terms of its replicability in other parts of Amazonia.

Finally, the Government should increase its efforts to improve the administration of taxes which, if duly collected, could have beneficial effects on land use. A more effective administration of the 25 percent tax on capital gains from land appreciation, for example, could help dampen

speculative pressures. The progressive rural land tax (ITR) also has the potential to improve land use patterns by penalizing those who engage in environmentally-unsound activities. The structure of the tax would need to be modified in the Amazonian context, however, to allow land left in virgin forest to be considered "productive" and thus qualify for the lowest tax rate. Administration of this tax would also need to be vastly improved.

The above list of recommendations is not exhaustive. It has not, for example, dealt with possible measures to improve employment opportunities in northeastern and southern Brazil and hence reduce pressures on the rural poor to migrate to the Amazon frontier. Undoubtedly there is much that could be accomplished in this regard. However, if the policy reforms suggested above were to be combined with a well thought out and executed zoning plan for Amazonia, further economic losses and much unnecessary deforestation would be avoided in the future.

REFERENCES

Banco da Amazonia (BASA) (1981) FINAM: Legislacao Basica dos Incentivos Fiscais para a Regiao Amazonica. Belem.

Binswanger, Hans (1987) "Fiscal and Legal Incentives with Environmental Effects on the Brazilian Amazon". Mimeo. Agriculture and Rural Development Department, World Bank, Washington, D.C.

Brazil, Comissao Parlamentar de Inquerito sobre a Devastacao da Amazonia e suas Implicacoes (1978) Depoimento do Dr. Hugo de Almeida, Ex-Superintendente da SUDAM e Atual Presidente do IAA, Prestado no Dia 19 de Junho de 1978. Brasilia.

Browder, John O. (1987) "Public Policy and Deforestation in the Brazilian Amazon". In M. Gillis and R. Repetto (eds.) Public Policies and the Misuse of Forest Resources. London: Cambridge University Press (forthcoming).

Branford, Sue and Oriel Glock (1985) The Last Frontier: Fighting Over Land in the Amazon. London: Zed Books.

Bunker, Stephen G. (1981) "The Impact of Deforestation on Peasant Communities in the Medio Amazonas of Brazil", Studies in Third World Societies, Vol. 13, pp. 45-60.

Collins, Jane L. (1986) "Smallholder Settlement of Tropical America: The Social Causes of Ecological Destruction", Human Organization, Vol. 45, No. 1, pp. 1-9.

Denevan, William H. (1973) "Development and the Imminent Demise of the Amazon Rain Forest", The Professional Geographer, Vol. 25, pp. 130-35.

FAO/World Bank Cooperative Program (FAO/CP) (1987) "Brazil: Northwest I, II, and III Technical Review Final Report" Mimeo. Rome.

Fearnside, Philip M. (1987) "Jari aos Dezoito Anos: Licoes para os Planos Silviculturais em Carajas", pp. 291-311. In G. Kohlhepp and A. Schrader (eds.) Homem e Natureza na Amazonia. Tubinger Geographische Studien No. 95.

Fearnside, Philip M. (1986a) Human Carrying Capacity of the Brazilian Rainforest. New York: Columbia University Press.

Fearnside, Philip M. (1986b) "Spatial Concentration of Deforestation in the Brazilian Amazon", Ambio, Vol. 15, No. 2, pp. 74-81.

Fearnside, Philip M. (1986c) "Agricultural Plans for Brazil's Grande Carajas Program: Lost Opportunity for Sustainable Local Development?", World Development, Vol. 14, No. 3, pp. 385-409.

Fearnside, Philip M. (1983) "Development Alternatives in the Brazilian Amazon: An Ecological Evaluation", Interciencia, Vol. 8, No. 2, pp. 65-78.

Fearnside, Philip M. (1982) "Deforestation in the Brazilian Amazon: How Fast is it Occurring?", Interciencia, Vol. 7, No. 2, pp. 82-88.

Fundacao Getulio Vargas, Centro de Estudos Agricolas (FGV/CEA) (1985) Agropecuaria: Precos Medios de Arrendamentos, Vendas de Terras, Salarios, Empreitadas, e Transportes. Rio de Janeiro.

Freitas, Maria de Lourdes Davies de (1982) "Brazil's Carajas Iron Ore Project: Environmental Aspects". Mimeo. Rio de Janeiro.

Galey, John. (1979) "Industrialist in the Wilderness: Henry Ford's Amazon Venture", Journal of Interamerican Studies and World Affairs, Vol. 21, No. 2, pp. 261-89.

Garcia Gasques, Jose and C. Yokomizo. (1986) "Resultados de 20 Anos de Incentivos Fiscais na Agropecuaria da Amazonia", XIV Encontro Nacional de Economia, ANPEC, Vol. 2, pp 47-84.

Goodland, Robert J.A. (1980) "Environmental Ranking of Amazonian Development Projects in Brazil", Environmental Conservation, Vol. 7, No. 1, pp. 9-26.

Goodland, Robert J.A. and H.S. Irwin. (1975) Amazon Jungle: Green Hell to Red Desert ?. Amsterdam: Elsevier Scientific Publishing Co.

Goulding, Michael (1983) "Amazonian Fisheries", pp. 189-210. In E.F. Moran (ed.) The Dilemma of Amazonian Development. Boulder, Colo.: Westview Press.

Guppy, Nicholas (1984) "Tropical Deforestation: A Global View" Foreign Affairs,Vol. 62, No. 4 , pp. 928-65.

Hall, Anthony (1987) "Agrarian Crisis in Brazilian Amazonia: The Grande Carajas Programme", The Journal of Development Studies, Vol. 23, No. 4, pp. 522-52.

Hecht, Susanna B. (1985) "Environment, Development and Politics: Capital Accumulation and the Livestock Sector in Eastern Amazonia", World Development, Vol. 13, No. 6, pp. 663-84.

Hecht, Susanna B., R.B. Norgaard and G. Possio (n.d.) "The Economics of Cattle Ranching in Eastern Amazonia". Mimeo.

Instituto Brasileiro de Geografia e Estatistica (IBGE) (1987) Sinopse Preliminar do Censo Agropecuario--1985. Rio de Janeiro.

Instituto Brasileiro de Geografia e Estatistica (IBGE) (1983) Censo Agropecuario--1980. Rio de Janeiro.

Instituto Brasileiro de Geografia e Estatistica (IBGE) (Various years) Anuario Estatistico do Brasil. Rio de Janeiro.

Katzman, Martin T. (1977) Cities and Frontiers in Brazil. Cambridge, Mass.: Harvard University Press.

Kinkead, Gwen (1981) "Trouble in D.K. Ludwig's Jungle", Fortune, August 20 issue, pp. 102-17.

Kohlhepp, Gerd (1987) "Problemas do Planejamento Regional e do Desenvolvimento Regional na Area do Programa Grande Carajas no Leste da Amazonia", pp. 313-45. In G. Kohlhepp and A. Schrader (eds.) Homen e Natureza na Amazonia. Tubinger Geographische Studien, No. 95.

Ledec, George (1985) "The Environmental Implications of Agricultural Credit Programs: Preliminary Findings for Brazil". Berkeley, Cal. Mimeo.

Mahar, Dennis J. (1982) "Instituicoes Internacionais de Emprestimo Publico e o Desenvolvimento da Amazonia Brasileira: A Experiencia do Banco Mundial", Revista de Administracao Publica, Vol. 16, No. 4, pp. 23-38.

Mahar, Dennis J. (1979) Frontier Development Policy in Brazil: A Study of Amazonia. New York: Praeger Publishers.

Mahar, Dennis J. (1978) "Politicas do Desenvolvimento para a Amazonia: Passado e Presente", pp. 339-67. In W. Baer, P.P. Geiger and P.R. Haddad (eds.) Dimensoes do Desenvolvimento Brasileiro. Rio de Janeiro: Editora Campus.

Mahar, Dennis J. (1976) "Fiscal Incentives for Regional Development: A Case Study of the Western Amazon Basin", Journal of Interamerican Studies and World Affairs, Vol. 18, No. 3, pp. 357-78.

Martine, George (1980) "Recent Colonization Experiences in Brazil: Expectations versus Reality", pp. 80-94. In F. Barbira-Scazzocchio (ed.) Land, People and Planning in Contemporary Amazonia. Cambridge: Cambridge University Press.

Melillo, J.M. et al. (1985) "A Comparison of Two Recent Estimates of Disturbance in Tropical Forests" Environmental Conservation, Vol. 12, No. 1, pp. 37-40.

Moran, Emilio F. (1981) Developing the Amazon. Bloomington: Indiana University Press.

Millikan, Brent H. (1984) "Diagnostico de Dez Nucleos Urbanos de Apoio Rural". Del Mar, Cal. Mimeo.

Mueller, Charles C. (1980) "Recent Frontier Expansion in Brazil: The Case of Rondonia", pp. 141-53. In F. Barbira-Scazzocchio (ed.) Land, People and Planning in Contemporary Amazonia. Cambridge: Cambridge University Press.

Myers, Norman (1986) "Tropical Forests: Patterns of Depletion", pp. 9-22. In G.T. Prance (ed.) Tropical Rain Forests and the World Atmosphere. Boulder, Colo.: Westview Press.

Myers, Norman (1984) The Primary Source: Tropical Forests and our Future. New York: W.W. Norton.

Paula, Ruben D. de Garcia (1971) "A Rodovia Belem-Brasilia e os Fazedores de Desertos", A Amazonia Brasileira em Foco, No. 6, pp. 78-95.

Pompermayer, Malori J. (1984) "Strategies of Private Capital in the Brazilian Amazon", pp. 419-38. In M. Schmink and C.H. Wood (eds.) Frontier Expansion in Amazonia. Gainesville: University of Florida Press.

Prance, Ghillean T. (1986) "Introduction to Tropical Rain Forests", pp. 1-8. In G.T. Prance (ed.) Tropical Rain Forests and the World Atmosphere. Boulder, Colo.: Westview Press.

Resor, Randolph (1977) "Rubber in Brazil: Dominance and Collapse, 1876-1945", Business History Review, Vol. 51, No. 3, pp. 341-66.

Santos, Roberto (1980) Historia Economica da Amazonia: 1800-1920. Sao Paulo: T.A. Queiroz.

Sawyer, Donald (1984) "Frontier Expansion and Retraction in Brazil", pp. 180-203. In M. Schmink and C.H. Wood (eds.) Frontier Expansion in Amazonia. Gainesville: University of Florida Press.

Sioli, Harald (1973) "Recent Human Activities in the Brazilian Amazon Region and Their Ecological Effects", pp. 321-34. In B.L. Meggers, E.S. Ayensu and W.D. Duckworth (eds.) Tropical Forest Ecosystems in Africa and South America. Washington, D.C.: Smithsonian Institution.

Smith, Nigel J.H. (1982) Rainforest Corridors: The Transamazon Colonization Scheme. Berkeley: University of California Press.

Smith, Nigel J.H. (1981) "Colonization Lessons from a Tropical Forest", Science, Vol. 214, No. 4522, pp. 755-61.

Superintendencia do Desenvolvimento da Amazonia (SUDAM) (1986) Problematica do Carvao Vegetal na Area do Programa Grande Carajas. Belem.

U.S. Department of Energy (1986) A Comparison of Tropical Forest Surveys. Washington, D.C.

Wilson, John F. (1985) Ariquemes: Settlement and Class in a Brazilian Frontier Town. Ph. D. Dissertation, University of Florida.

Wolf, Edward C. (1988) "Avoiding a Mass Extinction of Species", pp. 101-17. In L.R. Brown (ed.) State of the World 1988. New York: W.W. Norton & Co.

Woodwell, George M., R.A. Houghton and T.A. Stone. (1986) "Deforestation in the Brazilian Amazon Basin Measured by Satellite Imagery", pp. 23-32. In G.T. Prance (ed.) Tropical Rain Forests and the World Atmosphere. Boulder, Colo.: Westview Press.

World Bank (1984) Brazil: Financial Systems Review. Washington, D.C.

World Bank (1981) Brazil: Integrated Development of the Northwest Frontier. Washington, D.C.

World Resources Institute (1986) World Resources-1986. New York: Basic Books.

World Resources Institute (1985) Tropical Forest: A Call for Action. Part I. Washington, D.C.

MAP SECTION

IBRD 20511

BRAZIL
RONDONIA DEFORESTATION
1983

- Deforested Areas
- Selected Roads
- Selected Earth Roads
- Natural Reserves and National Forest
- Amerindian Reservations
- Rivers
- Main Towns
- State Boundaries
- International Boundaries

0 50 100 KILOMETERS
0 20 40 60 MILES

AMAZONAS
BOLIVIA
MATO GROSSO

CUNIA ECOLOGIACL RESEARCH STATION
To Humaita
Porto Velho
Rio Jiparana
BR-364
Rio Preto do Candeias
NATIONAL FOREST
KARITIANAS
NATIONAL FOREST
Rio Machadinho
Rio Ji-Parana
JARU BIOLOGICAL RESERVE
KAXAPARI
Rio Madeira
BR-364
Abuná
Matum Paraná
To Rio Branco
Rio Abuna
KARIPUNAS
Rio Formoso
Rio Candeias
Ariquemes
RIBEIRÃO
LAJE
Guajara Mirim
Alto Candeias
Jaru
LOURDES
Ouro Preto
Ji-Paraná
URU - EU - WAU - WAU
URU-EU-WAU-WAU
PACAAS NOVOS
RIO NEGRO
Rio Pacaas Novos
NATIONAL PARK
SETE DE SETEMBRO
ROOSEVELT
Cacoal
Espigão d'Oeste
Pimenta Bueno
ARIPUANA
Rio Roosevelt
Rio Tenente Marques
PACAAS NOVOS
Rio Boteiro
RICARDO FRANCO OU GUAPORE
Rio Cautario
Rio São Miguel
RIO BRANCO
Rio Pimenta Bueno
Vila Urucumacua
Costa Marques
GUAPORE
Rio Branco
BIOLOGICAL RESERVE
BR-364
TUBARAO
RIO MEQUENS
Rio Verde
Pedras Negras
Vilhena
To Cuiaba
Vila Colorado d'Oeste
Rio Escondido
Rio Guapore

12°
10°
8°
66°
64°
62°
60°

FEBRUARY 1988