Government Policies and Deforestation in Brazil's Amazon Region

Dennis J. Mahar

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The cover photograph (by Douglas R. Shane/World Wildlife Fund) depicts the burning of rain forest in Rondônia, Brazil, to make way for rangeland.

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Acronyms and Abbreviations

AEA	Association of Amazonian Entrepreneurs
BASA	Bank of Amazonia
CVRD	Companhia Vale do Rio Doce
FAO	Food and Agriculture Organization
FAO/CP	Food and Agriculture Organization/World Bank Cooperative Program
FINAM	Amazon Investment Fund
IBDF	Institute of Forestry Development
INCRA	National Institute for Colonization and Agrarian Reform
IPEA	Institute of Economic and Social Planning
IRR	internal rate of return
ITR	rural land tax
PGC	Greater Carajás Program
PIN	National Integration Program
POLAMAZONIA	Program of Agricultural, Livestock, and Mineral Poles in Amazonia
POLONOROESTE	Northwest Brazil Integrated Development Program
PROPEC	National Program of Livestock Development
PROTERRA	Land Redistribution Program
RADAM	Radar in Amazonia Project
SUDAM	Superintendency for the Development of Amazonia

The world's tropical rain forests are disappearing at an alarming rate. These forests once occupied 16 million square kilometers of the earth's surface, but now cover only 9 million. 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, the Philippines, and Sri Lanka, and parts of Brazil's rain forest, for example, could be gone by the end of this century. Only in the Congo Basin and some of the more isolated areas of the Amazon Basin does the forest remain largely intact.

To be sure, deforestation of this magnitude has in some instances yielded considerable short-term benefits through timber exports and agricultural production on previously forested land. But it has entailed huge (and largely unmeasured) long-term costs for both the people of the countries directly affected and the human race 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, and animal hides. Less direct, but equally important, long-term costs are soil erosion, flooding, and the siltation of reservoirs and hydroelectric facilities; the destruction of wildlife habitat; and climatic changes associated with the removal of forest cover in tropical regions. Perhaps the single most important long-term cost of deforestation, however, is the irreversible loss of biological diversity.

No one knows how many species inhabit the planet. Tropical rain forests, however, are thought to contain about half of the earth's estimated 5 million to 10 million species on just 7 percent of its land surface. The richness of life in these forests is remarkable. The Amazon rain forests, for example, support 30,000 species of plant life, whereas only an estimated 10,000 species can be found in all of temperate South America. Northern forests, in contrast, normally contain only ten to fifteen species of plant. The

variety of insect life in the rain forest is even more striking. Scientists have discovered and named roughly 1 million insect species worldwide. One scientist, however, extrapolating from surveys of the rain forest canopy in Panama, estimates that there may be as many as *30 million* insect species in tropical forests alone (Wolf 1988, p. 104).

Many of the species native to tropical rain forests have proved invaluable to humankind: 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 other forms of cancer. Since fewer 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 humankind is recognized (World Resources Institute 1985). It has been estimated that 15 percent of all plant species in Latin American rain forests 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 two-thirds of the species could suffer this fate (Wolf 1988, p. 103).

The proximate causes of tropical deforestation vary significantly among regions of the world and even within countries. Most experts agree, however, that the spread of small-scale agriculture is the most important of these. According to Myers (1986), this type of activity leads to the depletion of about 150,000 square kilometers of forest every year.[1] Other major proximate causes are commercial logging (45,000 square kilometers a year), fuelwood gathering (25,000 square kilometers a year), and cattle raising (20,000 square kilometers a year). Such facts are useful to know, but it is far more important to be aware of the *underlying* causes of forest destruction. Holding the small farmer responsible for tropical de-

1. The term "depletion" refers to both "deforestation" (a complete and permanent removal of all forest cover) and "major disturbances" (any modification of the forest, such as selective logging, that leads to a pronounced impoverishment of the forest ecosystem). An estimated 200,000 square kilometers of tropical forest are depleted each year. Deforestation amounts to about 70,000–90,000 square kilometers a year worldwide.

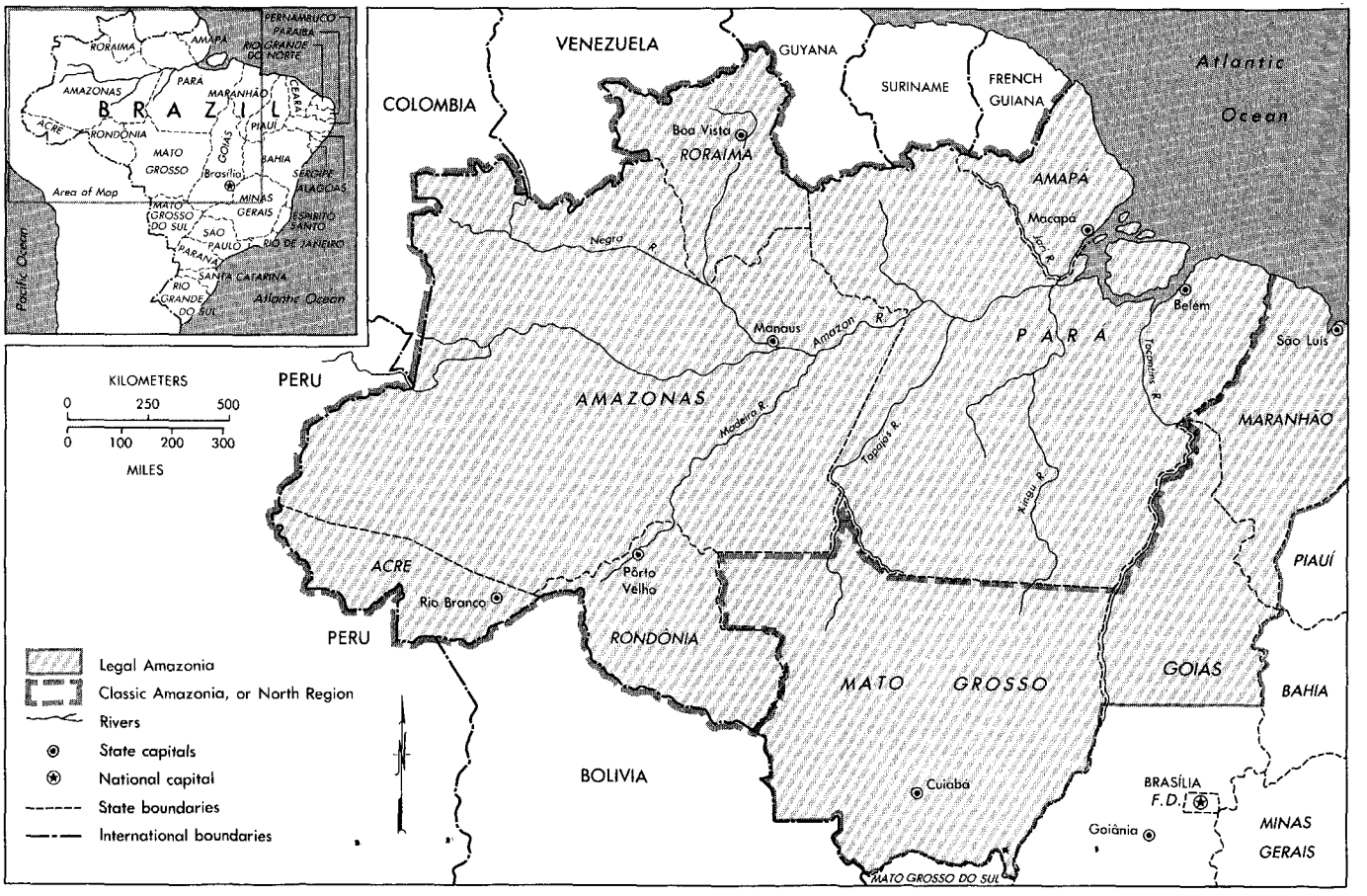
forestation is tantamount to "blaming the victim," because the real causes are likely to be poverty, unequal land distribution, and low agricultural productivity combined with rapid population growth. To this list one must add misguided public policies which purposely or inadvertently encourage rapid depletion of the forest (see Collins 1986 and World Resources Institute 1985).

The underlying causes of tropical deforestation have not been thoroughly researched and, as a result, are not completely understood. The purpose of this pamphlet is to shed further light on the subject by analyzing the effects of certain government policies on deforestation in the Brazilian Amazon. The coverage is far from complete. The emphasis is on policies which encourage economic activities that are detrimental to the environment and on those subregions that are now experiencing the most rapid deforestation. The equity aspects of these policies are also considered. The principal message 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 not likely to succeed if economic incentives encourage people to do the opposite.

Brazil's Amazonian Forests

According to estimates from the Food and Agriculture Organization (FAO), Brazil contains about 3.5 million square kilometers of tropical forest (Guppy 1984, p. 930). This is equivalent to 30 percent of the world total and is more than the combined forested areas of Colombia, Indonesia, Peru, and Zaire. Almost all of Brazil's standing tropical forests are in the Amazon Basin, a region commonly known as Amazonia. Two geographical concepts of Amazonia are used in Brazil—Legal Amazonia and Classic Amazonia (see map 1). As legally defined for purposes of regional planning and policy, Amazonia has an area of just over 5.0 million square kilometers, which is about 58 percent of Brazil's total land area. Legal Amazonia comprises seven states and territories (Acre, Amapá, Amazonas, Mato Grosso, Pará, Rondônia, and Roraima) and parts of two others (Goiás and Maranhão). Classic Amazonia (also known as Brazil's North region), as defined for statistical

Map 1. Amazon Region of Brazil



purposes, comprises only six states and territories and is 1 million square kilometers smaller. Because the focus of this pamphlet is on government policy, to the extent possible and unless otherwise stated, the designation "Amazonia" in this pamphlet refers to the legal definition. About half of Amazonia (2.5–2.8 million square kilometers) comprises upland areas (*terra firme* in Portuguese) in which the original vegetation was tropical rain forest (Fearnside 1986b). Perhaps another 500,000 square kilometers consists of transitional forests (U.S. Department of Energy 1986). There are in addition large areas of savanna (*cerrado*) in the southern reaches of Amazonia in Mato Grosso and Goiás.

Biological Diversity

Amazonia has been characterized as the "single richest region of the tropical biome" (Myers 1984, p. 50). Indeed, the region's forests, air, soils, and water literally teem with life. A single hectare of rain forest near Manaus, Amazonas, for example, yielded 235 tree species over 5 centimeters in diameter and 179 species over 15 centimeters in diameter (Prance 1986). The quantity and variety of bird, fish, and insect life are 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 ten times the number found in all of Europe. And this represents only the *known* species; experts think that the total may eventually reach 3,000 species. Most scientists agree that deforestation is greatly reducing this natural variety and is thereby depriving some regional populations of their livelihoods[2] and humankind of as-yet-undiscovered medicinal plants or pest-resistant genetic materials.

The Magnitude and Rate of Deforestation

The first scientific estimates of deforestation in Amazonia were made in the early 1970s by staff of the federal government's Radar

2. Michael Goulding, in a pioneering study of Amazonian fisheries (Goulding 1983), found that most of the commercial species feed on 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 Legal Amazonia

State or territory	Area (square kilometers)	Area cleared: Square kilometers				Area cleared: Percentage of state or territory			
		By 1975	By 1978	By 1980	By 1988	By 1975	By 1978	By 1980	By 1988
Acre	152,589	1,165.5	2,464.5	4,626.8	19,500.0	0.8	1.6	3.0	12.8
Amapá	140,276	152.5	170.5	183.7	571.5	0.1	0.1	0.1	0.4
Amazonas	1,567,125	779.5	1,785.8	3,102.2	105,790.0	0.1	0.1	0.2	6.8
Goiás	285,793	3,507.3	10,288.5	11,458.5	33,120.0	1.2	3.6	4.0	11.6
Maranhão	257,451	2,940.8	7,334.0	10,671.1	50,670.0	1.1	2.8	4.1	19.7
Mato Grosso	881.001	10,124.3	28,355.0	53,299.3	208,000.0	1.1	3.2	6.1	23.6
Pará	1,248,042	8,654.0	22,445.3	33,913.8	120,000.0	0.7	0.8	2.7	9.6
Rondônia	243,044	1,216.5	4,184.5	7,579.3	58,000.0	0.3	1.7	3.1	23.7
Roraima	230,104	55.0	143.8	273.1	3,270.0	0.0	0.1	0.1	1.4
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 (1986b) and World Bank estimates.

in Amazonia Project (RADAM), which employed airborne side-looking radar to gather primary data. These estimates suggested that relatively little clearing of the forest had taken place. Landsat satellite images provided more comprehensive estimates of deforestation a few years later. They indicated that roughly 30,000 square kilometers, or about 0.6 percent of Amazonia (and approximately 1.0 percent of the forest) had been cleared as of 1975 (see table 1). These early Landsat images 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). More recent data, however, make it clear that there was no cause for complacency.

Landsat images indicate that deforestation has accelerated sharply since the mid-1970s. As shown in table 1, the deforested area increased to 125,000 square kilometers by 1980 and to almost 600,000 square kilometers by 1988. The 1988 figure is equivalent to 12 percent of Amazonia and is larger than France. As in the past, deforestation has been concentrated in certain subregions. In Rondônia and Mato Grosso, for example, nearly one-fourth of the forest has already been cleared, whereas more than 99 percent of the forest is still intact in Amapá. Particularly intense clearing has taken place along the region's major overland routes: the Belém-Brasília highway and its zone of influence in southern Pará and northern Goiás, and the Cuiabá-Pôrto Velho highway and its associated feeder roads in Mato Grosso and Rondônia (Fearnside 1986c and Woodwell, Houghton, and Stone 1986; see also maps 2, 3, and 4).

Proximate Causes of Deforestation

The main proximate causes of deforestation in Amazonia are small-scale agriculture, cattle ranching, logging, road building, hydroelectric development, mining, and urban growth. Unfortunately, the relative contribution of each of these activities cannot be determined with any degree of precision. 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, farmland in Amazonia increased from 313,000 square kilometers in 1970 to more than 900,000 square

Table 2. Agricultural Land Use in Legal Amazonia, 1980

Use	*Area (square kilometers)*	*Percentage of area*
Crops		
Annual[a]	42,231.6	5.0
Perennial	7,619.5	0.9
Subtotal	49,851.1	5.9
Pasture	94,098.1	11.1
Undisturbed[b]	704,994.3	83.0
Total	848,943.5	100.0

a. Includes fallow land.

b. Forest, natural pastures, and areas unsuitable for agricultural use (such as rivers, mountains).

Source: IBGE (1983).

kilometers 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 Rondônia, northern Mato Grosso and Goiás, and southern Pará.

Details on agricultural land use in 1985 have not yet been published. The data in table 2, however, indicate that in 1980 approximately 145,000 square kilometers of Amazonia were used for agricultural purposes, that is, for raising either crops or livestock.[3] Because pasture has clearly been the predominant form of agricultural land use in the region, cattle ranching would appear to be the leading 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 square kilometers per year during the 1970s. Most, but not all, of this pasture formation took place on large landholdings. In Pará, Mato Grosso, and Goiás—the principal livestock states of Amazonia—70 percent or more of the artificial pasture in 1980 was on farms larger than 1,000 hectares.

3. The 1980 census figure is 20,000 square kilometers 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.

Land devoted to annual cropping, the second most important form of agricultural land use, probably increased by about 2,000 square kilometers per year between 1970 and 1980. This is typically a small-farmer activity. Frequently, however, farm plots devoted to annual crops are sold or abandoned after only a few years of use, owing to 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 (from undisturbed forest to annual crops to pasture or secondary growth), some of the deforestation attributed to livestock development was probably caused by the spread of small-scale agriculture.

Logging has also grown rapidly in Amazonia over the past two decades. Between 1975 and 1985, for example, regional roundwood production increased from 4.5 million cubic meters per year (14.3 percent of the national total) to 19.8 million (46.2 percent of the national total). It is not clear, however, how much deforestation can be attributed to logging, because much timber extraction in Amazonia is a by-product of land clearing for agricultural purposes. Typically, loggers begin by 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 1988). The vast majority of the trees have little or no commercial value outside the region and are burned before the planting of crops. Practically no replanting is done, except in the Jari project in northern Pará. In Rondônia, where deforestation has been occurring at an extremely rapid pace in recent years, the 1980 agricultural census shows only 165 hectares planted in trees!

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 key role in the deforestation process. In particular, massive road-building programs carried out in the 1960s and 1970s made large areas of the region accessible by land for the first time,

Box 1. The Amazonian Rubber Boom

Official interest in Amazonia dates from the colonial period, when the Portuguese Crown exploited the region for its forest products and Indian slave population. The regional economy remained relatively insignificant, however, until the last quarter of the nineteenth century, when the world demand for rubber soared following Charles Goodyear's invention of the vulcanization process in 1839. Owing to its near monopoly on wild rubber in the world's markets, Amazonia enjoyed nearly half a century (roughly from 1870 to 1912) of rapid economic growth. The story of the turn-of-the-century rubber boom illustrates how an activity that is environmentally suited to the rain forest can at the same time be economically unsustainable. It thus provides an interesting counterpoint to the modern regional economy in which some important activities, such as agriculture and cattle ranching, are both environmentally *and* economically unsustainable in most of the rain forest area.

The Amazonian rubber boom brought to the region (if not to all of the region's inhabitants) a level of prosperity that had never even been dreamed of before. To meet the growing demands of North American and European industry, hundreds of thousands of workers were contracted to gather latex in the forest. A new class of "rubber barons" built palatial mansions in the river cities of Manaus and Belém. Prices, which had fluctuated between

and government-sponsored settlement schemes simultaneously attracted migrants from Brazil's Northeast and South regions (see inset on map 3). Special fiscal incentives and subsidized credit lines encouraged land uses such as cattle raising, which allowed a relatively small population to have a large impact on the rain forest.

Operation Amazonia

In 1960, Classic Amazonia (where most of the rain forest is concentrated) had only 2.5 million inhabitants and a per capita income just half the level reached in 1910 at the height of the rubber boom (Santos 1980, also see box 1). When a military government came into power in 1964, Amazonia 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

$0.75 and $1.50 a pound from 1897 to 1908, rose to more than $3.00 a pound by mid-1910, and rubber challenged coffee for the lead position among Brazil's exports. But, inevitably, the large profits generated by exports of wild rubber attracted the attention of foreign competitors. By the early 1900s the British had established plantations in their Asian colonies that could produce rubber at only one-fourth the cost incurred by Brazilian producers (Resor 1977).

Plantation-grown rubber started entering world markets on a grand scale in late 1910, and by the end of the following year the price of rubber had dropped to $1.00 a pound. The Brazilian government made a futile attempt to save the local rubber interests through the so-called Rubber Defense Plan. Cash premiums were given to persons who planted rubber trees and built rubber processing plants, export taxes on rubber (which were viewed as a major impediment to sales) were drastically reduced, and import taxes on inputs to the rubber industry were abolished. These official attempts to bolster the regional economy did nothing to stanch the ever increasing flow of Asian production, however, and prices plummeted to $0.63 a 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 it has remained at insignificant levels ever since (Mahar 1978). The fatal flaw of the government program was in 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.

the rest of Brazil. These plans included an ambitious road-building program to link Amazonia with the Northeast and South, agricultural colonization schemes, and fiscal incentives to attract new industrial and agricultural enterprises. An administrative structure, which included a regional development agency (Superintendency for the Development of Amazonia, or SUDAM) and a regional development bank (Bank of Amazonia, or BASA), was created to coordinate the implementation of these plans.

The motives behind Operation Amazonia were largely geopolitical. Several neighboring countries (particularly Peru and Venezuela) had already initiated programs to occupy and develop their respective Amazon regions, and Brazil's military leaders were anxious to ensure national sovereignty by establishing self-sustaining settlements in frontier areas. Because vast quantities of natural resources were thought to remain hidden in the forest, this posture is understandable. But little thought was given to the need

for an economic development strategy that would be responsive to the unique physical and human environments of Amazonia. The first model adopted, which emphasized import substitution and industrialization, was lifted virtually unaltered from the country's Northeast, a region different in almost every respect from Amazonia.

The Belém-Brasília Highway

In 1960, Classic Amazonia had only 6,000 kilometers of roads, less than 300 kilometers of which 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, Belém and Manaus, and in small towns and villages scattered along the Amazon River and its 1,100 tributaries. Although this centuries-old isolation from the more dynamic South had arguably retarded the region's economic development, it had also protected the rain forest from destruction. The physical isolation of Amazonia—and the protection this provided to the rain forest—came to an end in 1964 with the completion of a 1,900-kilometer all-weather highway that connected the new capital city of Brasília in Brazil's heartland with Belém at the mouth of the Amazon River.

Large numbers of migrants in search of land and employment entered the region via the Belém-Brasília highway (BR-010). So did firms that wanted to establish cattle ranches 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 in the zone of influence of the highway (which includes some areas outside Amazonia) increased from 100,000 in 1960 to about 2 million ten years later (Resende 1973, p. 20). The same source estimates that the cattle population increased from practically nothing to 5 million during the decade. To be sure, these official estimates exaggerate both the size and growth rate of the human and cattle populations. M. T. Katzman (1977), for example, estimates that the road attracted at most 320,000 new settlers between 1960 and 1970. Nevertheless, there can be no doubt that the surge of migration and economic activity stimulated by the Belém-Brasília highway contributed to widespread

deforestation. One traveler around 1970, who noted the devastation and apparent abandonment of the land on either side of the highway, described the area around Paragominas in eastern Pará (the site of numerous SUDAM-approved cattle ranches) as a "ghost landscape" (Paula 1971).

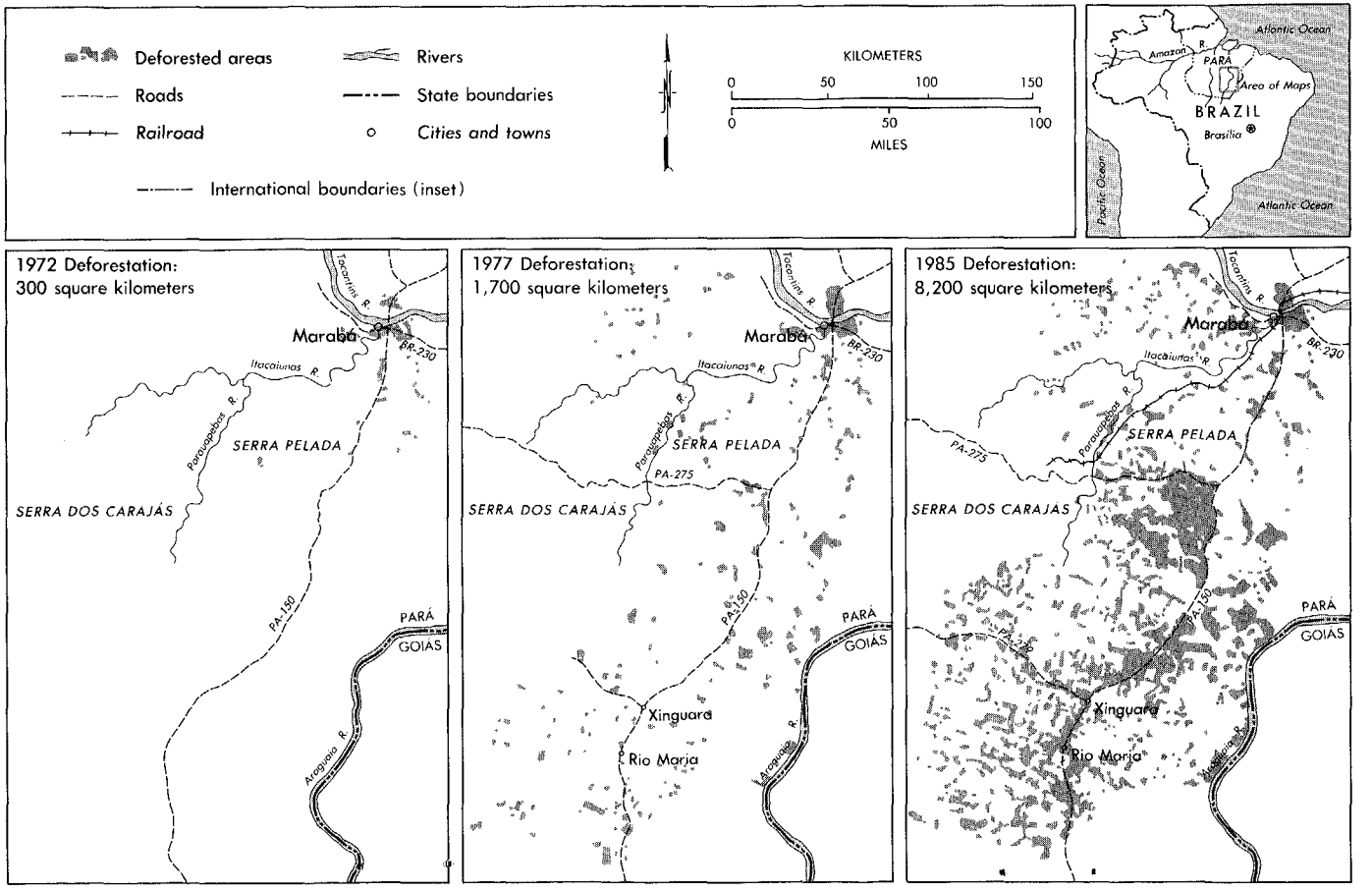
Environmental degradation was not confined to areas adjacent to the Belém-Brasília highway. The increase in population associated with the completion of the main highway quickly generated demand for secondary and feeder roads, which in turn attracted more population. Landsat photos vividly illustrate the impact on the rain forest of one such highway (PA–150) in southern Pará that was opened to traffic in the late 1960s. Within one 47,000-square-kilometer area (small by Amazonian standards, but about the size of Switzerland) traversed by this road, the cleared area jumped from 300 square kilometers in 1972 (0.6 percent of the area), to 1,700 in 1977 (3.6 percent), to 8,200 (17.3 percent) in 1985 (see map 2). Although the relative contribution of different activities to this deforestation is uncertain, the conversion of forest to pasture has undoubtedly been a leading cause.

Incentives for Livestock Development

As already noted, a key objective of Operation Amazonia was to attract private enterprise to the region. This was to be achieved through increased 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 ten to fifteen 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, such as the long distance to major markets, an inadequate supply of local labor, and the lack of necessary infrastructure (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

Map 2. Deforestation in Southeast Pará, 1972, 1977, and 1985



savings were invested in projects located in Amazonia and approved by SUDAM. Investment projects could be new enterprises or simply the expansion or modernization of existing ones. Under the 1963 legislation which created the investment tax credit, only industrial projects were eligible; in 1966 eligibility was expanded to include projects in the agricultural, livestock, and service sectors.[4] Depending on the priority assigned to a given project by SUDAM, tax credit funds could constitute up to 75 percent of investment. Although the criteria used in selecting and ranking projects have changed several times over the years, rankings have tended to be positively related to the following factors: 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 rain forest (*floresta densa*) has been officially prohibited, but this rule has been difficult to enforce.

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

The size of the SUDAM-approved cattle ranches is large by any standard. The ranches currently cover 8.4 million hectares and

4. The tax credit mechanism was further modified 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 four years (for details, see BASA 1981).

average about 24,000 hectares each. (In contrast, the average farm in Amazonia in 1985 comprised only 90 hectares.) Several ranches are larger than 100,000 hectares. The Suia-Missu ranch in northern Mato Grosso, the largest of the group, covers 560,000 hectares (Branford and Glock 1985, p. 109). Despite their size, these ranches 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 for every 250–300 hectares of pasture (Garcia Gasques and Yokomizo 1986, p. 77). In areas of Amazonia with peasant economies based on extractive activities, the conversion of forest to pasture has actually had negative employment effects. The felling of stands of Brazil nut trees around Santarém in Pará, for example, deprived the surrounding peasant communities of employment and income (Bunker 1981). The former Brazil nut gatherers migrated to nearby towns, where they now depend on temporary employment on the cattle ranches. Ranchers had selected these areas for pasture formation because they were the only *terra firme* lands with titles which could be used as guarantees for bank credit.

Over the years, livestock projects have absorbed about 44 percent of the tax credit funds administered by SUDAM. In absolute terms total disbursements to the owners of these projects have amounted to the equivalent of approximately US$700 million (Browder 1988). Despite this huge subsidy, only ninety-two livestock projects have been awarded certificates of completion by SUDAM. Moreover, most of the completed projects have performed far below expectations. A field survey by the Institute of Economic and Social Planning (IPEA) found that the average level of production in a sample of nine such projects was less than 16 percent of that originally projected; three of the nine projects visited were not producing anything (Garcia Gasques and Yokomizo 1986, p. 56). Data gathered by the IPEA on twenty-six 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 at least seven years) are running at only 9 percent of projections; twelve projects (with an average of sixteen years under implementation) were found to have no marketed output whatsoever.

Table 3. Internal Rates of Return to a Typical SUDAM-Approved Livestock Project under Two Scenarios
(percent)

Scenario	Increase in land value		
	0 percent	*15 percent*	*30 percent*
High cattle prices			
Appropriate grazing intensity			
Corporation resources	16	18	24
All resources	−1	2	9
Overgrazing			
Corporation resources	23	24	27
All resources	−2	0	4
Low cattle prices			
Appropriate grazing intensity			
Corporation resources	−3	6	17
All resources	−14	−6	5
Overgrazing			
Corporation resources	16	18	23
All resources	−10	−7	−1

Notes: Low input prices are assumed in both scenarios. Data for corporation resources ignore capital expenditures financed through fiscal incentives and official credit. Data for all resources treat fiscal incentives and official credit as if they were the corporation's own capital.

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

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. A recent study, however, argues convincingly that cattle ranching under conditions commonly prevailing in Amazonia is *intrinsically* uneconomic (Hecht, Norgaard, and Possio n.d.).

Using a simulation model for a typical 20,000-hectare cattle ranch for which 75 percent of investment is provided by tax credit funds, the authors calculated internal rates of return (IRRS), to both the investor's own resources ("fresh money") and all resources, under various assumptions regarding technology employed, intensity of grazing, and rates of land appreciation. The results under two scenarios are summarized in table 3. They show that livestock

activities in Amazonia are profitable to corporations *only* when official subsidies or capital gains from land appreciation are present, and that the IRR to a ranching corporation's own resources can be improved substantially through overgrazing. Indeed, when cattle prices are low and land values have not appreciated, cattle ranching can be made profitable only through overgrazing. Overgrazing, however, degrades the pasture and ultimately undermines the long-term viability of the ranch. Although 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.

The findings of the simulation exercise described above have been largely confirmed by field observations. On the environmental issue, Goodland (1980, p. 18) rates cattle ranching as "the worst . . . of all conceivable alternatives" for Amazonia on the basis of its high potential for degrading the soil. Although some researchers debate this point, a comprehensive soil survey (involving eighty samples per age class of pasture) carried out in major cattle areas in eastern Amazonia lends it strong support. The survey indicates 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, p. 677). In other words, the clearing of forest renders the potential of the soil low to marginal for pasture formation, especially if physical changes in the soil (particularly compaction) and the invasion of weeds are also considered. In practical terms this means that stocking rates, which may be maintained at 1.00 animal per hectare during the initial years of pasture formation, typically decline to 0.25 animal per hectare after the fifth year.

The IPEA field survey found few ranch owners who were seriously interested in developing sustainable beef production and confirmed that many projects were being exploited solely for their fiscal benefits. In visits to projects in southern Pará, the IPEA team discovered 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, p. 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. Because 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 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 Pará controls a 330,000-hectare 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 squatting by migrants is common. To discourage migrants from settling on his land, one rancher visited by the IPEA team had rented plots along the borders of his property to small farmers. Other ranchers have employed more violent means to keep prospective settlers off their land (Branford and Glock 1985). Although data on the returns from land speculation in Amazonia are not available, anecdotal evidence suggests that huge fortunes have been made, especially by those who entered the market in the 1960s (Branford and Glock 1985, pp. 49–51). But even relative latecomers could have done well. For example, investors who purchased average pastureland in Pará 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 (including operations not benefiting from fiscal incentives) may account for as much as two-thirds of the deforestation in the region (see table 2) and has not gone unnoticed by government authorities. The Parliamentary Commission on the Devastation of Amazonia and Its Implications, for example, frequently cited the role of the SUDAM-approved livestock projects during its proceedings in 1978–79 (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 rain forest areas. To implement this policy, SUDAM used satellite images as part of the project evaluation process in 1979–80. According to the IPEA study, however, "this practice was abandoned and projects approved without it" in subsequent years (Garcia Gasques and Yokomizo 1986, p. 80).

SUBSIDIZED CREDIT. Although livestock ranches benefiting from SUDAM-administered fiscal incentives have been major contributors to the deforestation in southern Pará and northern Mato Grosso, they have not played a dominant role in the deforestation elsewhere in the region. Probably 90 percent of all 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 played a role. One possibility frequently mentioned in the literature is the availability of subsidized rural credit (Browder 1988 and Ledec 1985). Subsidized credit lines, like the fiscal incentive funds, increase private rates of return to investment and thereby 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 way to compensate agriculture for foreign exchange overvaluation, import controls, and other pro-industry macroeconomic policies. After 1974, however, in the wake of government efforts to stimulate the economy following the first oil crisis, the volume of subsidized rural credit increased dramatically. This increase in volume was accompanied by a larger unit subsidy. By the end of the 1970s, official rural credit was available at an average rate of −40 percent (Knight and others 1984, p. 61). Although farmers and ranchers 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 credit lines reserved for Brazil's underdeveloped regions.

As shown in table 4, the volume of subsidized rural credit com-

Table 4. Commitments of Official Rural Credit in Classic Amazonia, 1970–85

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

Source: IBGE (various years).

mitted to Classic 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. But the livestock sector also received large increases in subsidized credit after 1974. Much of this credit was extended through special lines with particularly attractive terms. For example, under a regional development program known as the Program of Agricultural, Livestock, and Mineral Poles in Amazonia, or POLAMAZONIA, twenty-year investment credit was made available to ranchers at a nominal annual rate of 12 percent. The National Program of Livestock Development (PROPEC), which provided credit to ranchers in Brazil's more developed South and Southeast at a nominal rate of 45 percent per year, offered terms similar to those of POLAMAZONIA to ranchers located in the Amazon region.

The effects of subsidized credit on the behavior of farmers and ranchers in Amazonia are difficult to quantify for several reasons. First, data about the farms and ranches—such as size of operation, area cleared, output, and productivity—are extremely limited.

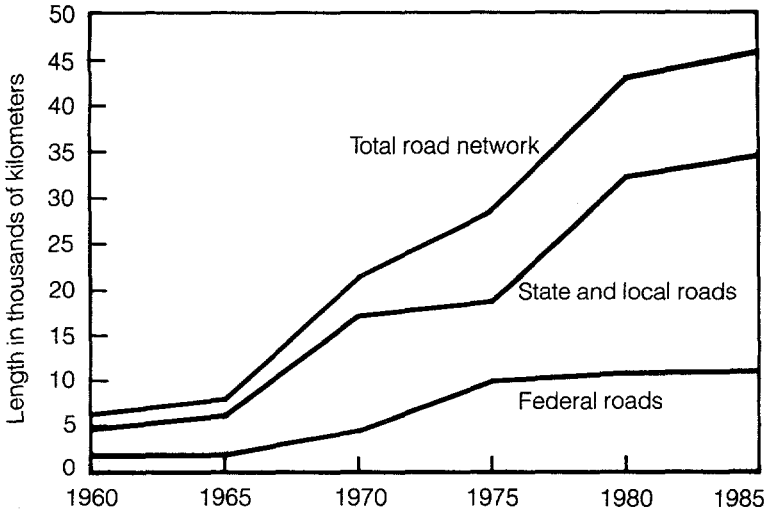
Second, a significant part of subsidized credit directed to agriculture and livestock was probably diverted to other uses. Although little is known about the extent of credit diversion in Amazonia, World Bank analysts estimated it to be on the order of 20–30 percent of total rural credit in the late 1970s (Knight and others 1984, p. 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 these caveats, certain general conclusions are clear. The availability of subsidized rural credit undoubtedly facilitated the acquisition and deforestation of large tracts of land in Amazonia, particularly during the latter half of the 1970s. (How much less deforestation would have occurred in the absence of subsidized credit is unknown, however.) Moreover, the special credit lines which increased the unit subsidy element specifically for undertakings in Amazonia as opposed to the more developed regions of Brazil probably attracted some resources which would have otherwise been invested in farms and ranches in the less fragile natural environments of the South and Southeast.

In addition to its negative environmental effects, subsidized credit clearly served to skew further the distribution of wealth in the region. Because 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 farming or ranching. Regressions based on data for six states (only one of which, Mato Grosso, is included in Amazonia) indicate that 67 percent of the change in rural land prices in 1969–76 can be explained by the intensity of credit use (Knight and others 1984, pp. 80–81).

Since 1980 the volume of official rural credit has been drastically reduced in an effort to restore internal balance to the Brazilian economy (table 4). Moreover, the subsidy element in this credit

Figure 1. Amazonian Road Network, 1960–85

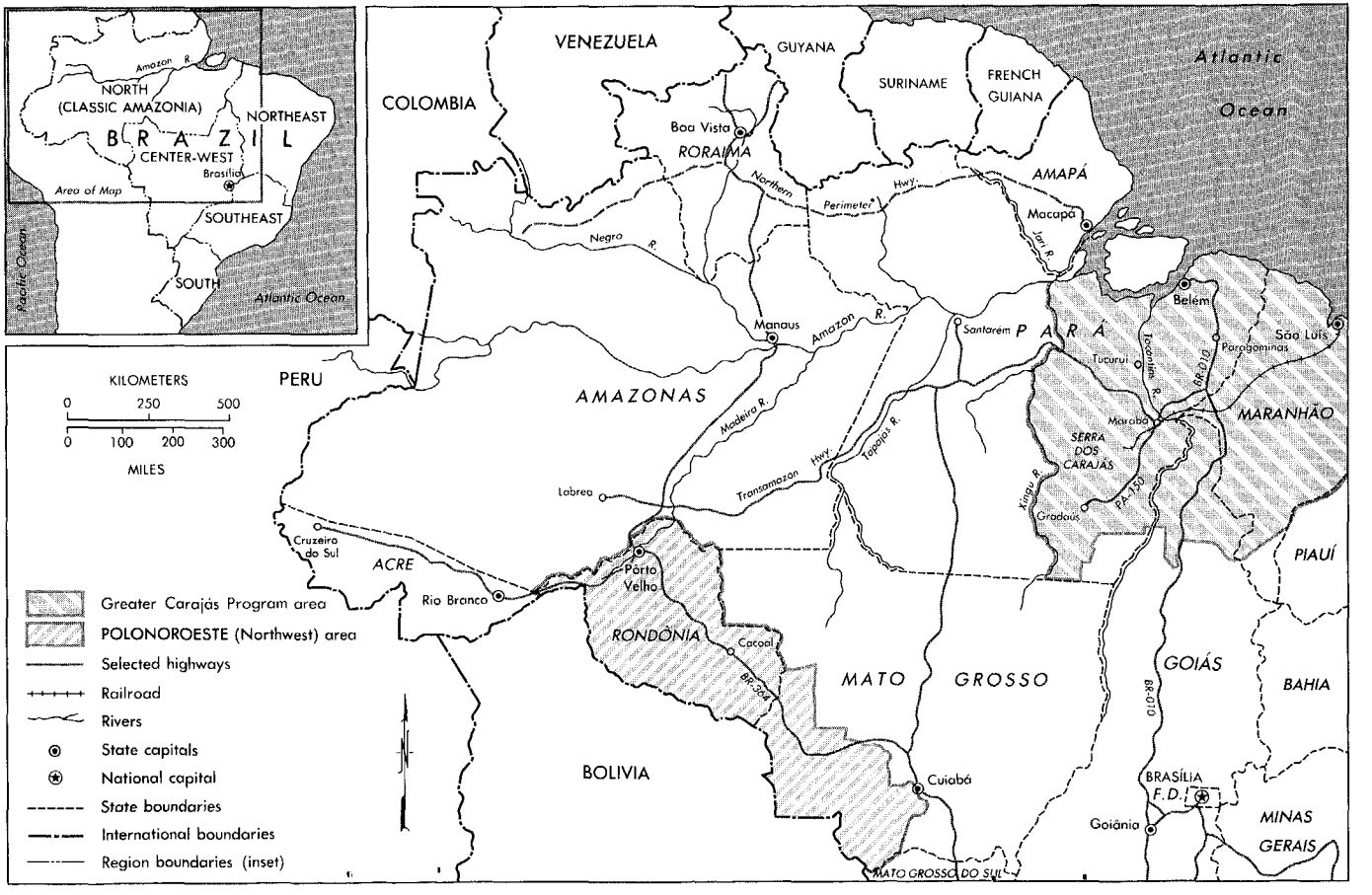


was eliminated completely in mid-1987. If sustained, this most welcome reversal of the government's long-standing policy on rural credit will surely have beneficial macroeconomic, sectoral, and environmental effects. The abrupt decline in the volume of subsidized credit in Amazonia has, however, disrupted some small- and medium-scale agriculture in the region. This disruption may ironically have some negative environmental effects in the short run. Some farmers in Rondônia who had been advised by extension agents to plant tree crops now find themselves unable to afford the necessary fertilizers, herbicides, and other inputs. Many have therefore reverted to activities that are more damaging to the environment such as slash-and-burn agriculture and extensive livestock raising.

The National Integration Program

As shown in figure 1, the road-building boom begun in the late 1960s continued into the 1970s. Considerable impetus to this construction was provided by the National Integration Program (PIN), which was established in 1970 and financed through a 30 percent share of the fiscal incentive funds. (A companion program, the

Map 3. Amazonia: Main Federal Highways



Land Redistribution Program, or PROTERRA, absorbed an additional 20 percent of these funds.) Through PIN, resources were made available for the construction of some 15,000 kilometers of roads, including an east-west (Transamazon) highway connecting Amazonia with the Northeast and a north-south (Cuiabá-Santarém) highway linking it with the South and Southeast (map 3). Plans were also made to build a second east-west highway (Northern Perimeter) along the northern bank of the Amazon River. A 20-kilometer strip of land was to be reserved on either side of these highways for agricultural settlement projects. In addition to providing funds for road construction and settlement in Amazonia, PIN was to finance the irrigation of 40,000 hectares in the Northeast.

Most accounts hold that the decision to establish PIN resulted from President Emílio Garrastazú Médici'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 and at the same time promote the effective occupation of Amazonia. Another motive for PIN was the hope that valuable mineral deposits would be uncovered during road construction. The overriding motive, however, was national security and the fear of foreign domination in the region. In the late 1960s such xenophobia intensified amid publicity given to a quixotic scheme by the U.S.-based Hudson Institute to create a series of "Great Lakes" by damming the Amazon River as well as 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-kilometer stretch of the Transamazon highway in late 1972.[5] The government hoped to settle some of the Northeast's "excess" rural population alongside this part of the highway, which inter-

5. An additional 1,000-kilometer stretch of the Transamazon was inaugurated in early 1974. The 1,800-kilometer Cuiabá-Santarém 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.

sects both the Belém-Brasília and Cuiabá-Santarém highways. Plans called for settling 70,000 families between 1972 and 1974 (Mahar 1979). To carry out the settlement program, the National Institute for Colonization and Agrarian Reform, or INCRA (now known as the Ministry of Agrarian Reform and Development, or MIRAD) established a network of new villages, towns, and cities at predetermined locations along the highway and demarcated 100-hectare farm lots nearby. The government actively recruited colonists in both the South and the Northeast using massive propaganda campaigns that promised attractive benefit packages. The benefits included temporary household subsidies averaging the equivalent of US$30 a month for six to eight months, guaranteed crop financing, and twenty-year loans on generous terms for purchases of farm plots and housing (Smith 1982 and 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 the total had risen to only 8,000 families, and just 40 percent of these had come from the Northeast. The demographic data point up the failure of the Transamazon settlement scheme to act as a safety valve for social pressures in the Northeast: the approximately 23,000 Northeasterners 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. 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 highway (Smith 1981).

The directed settlement schemes of the early and mid-1970s failed to create self-sustaining agricultural communities for several reasons. Certainly, adverse environmental factors played a large role. Both the routing of the Transamazon highway and the layout of the colonization projects were done hastily and with little regard for soil fertility or topography. Only about 3 percent of the soils in the area of the highway can be classified as naturally

fertile, and most of the area is hilly; extremes of relief from trough to hillcrest attain 40 meters within 0.5 kilometer in some areas (Smith 1981). As a result of these factors, cleared land eroded rapidly, which necessitated expensive maintenance work on the highway and the burning of additional forest to restore lost soil fertility. The alteration of the forest also created favorable breeding conditions for the *Anopheles* mosquito, the most common vector of 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 peak transmission periods for malaria coincide with the planting and harvesting seasons in the main settlement areas, it is likely that this debilitating disease 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 areas on annual crops, particularly upland rice, which are generally considered to be environmentally and economically unsustainable in areas cleared from tropical rain forests, except under very favorable circumstances (Fearnside 1983 and Goodland 1980). By and large, the Transamazon settlers found circumstances that were anything but favorable. First, the colonization projects were far away from major markets for agricultural commodities; this put settlers at a further disadvantage compared with more efficient producers elsewhere in Brazil. Second, largely because of the high cost of transport, fertilizers, pesticides, and herbicides were sold in the region at prices 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 to farmers growing crops on land converted from mature forest because the yields tended to be higher in such areas than 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 set-

tlement 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 concentrated around the settlement areas of central Pará. According to one estimate, only about 4 percent of the deforested area in Amazonia in the early 1980s can be directly attributed to Transamazon settlers (Browder 1988). Deforestation along the western reaches of the Transamazon highway in Amazonas has been minor. Several other roads built during the 1970s—Cuiabá-Santarém, Pôrto Velho–Manaus, and Northern Perimeter—have also had limited environmental impacts.

An important difference between the highways built by PIN in the 1970s and those built in the 1960s (Belém-Brasília and Cuiabá–Pôrto Velho) is that the earlier routes effectively linked the frontier with the country's urban and industrial centers. 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). That no important mineral deposits or areas of fertile soils were discovered along the PIN-financed highways also helped to protect the rain forest.

The Cuiabá–Pôrto Velho Highway and POLONOROESTE

In 1968, just a few years after the completion of the Belém-Brasília highway, the construction of another road—the 1,500-kilometer Cuiabá–Pôrto Velho highway (BR-364)—opened up the 243,000-square-kilometer state (then a federal territory) of Rondônia for settlement. This part of western Amazonia, which had been a rich rubber-producing area in the boom years at the turn of the century, became an important source of cassiterite (tin) and gold in the mid-1950s. Until the latter half of the 1960s, however, Rondônia, like most other parts of Amazonia, was virtually inaccessible by land. To reach the southern part of the country one first had to journey northeast for several weeks, by boat and ship on the Madeira and Amazon rivers. In 1960, Rondônia's population (mostly itinerant rubber tappers and prospectors) numbered only 70,000, and practically all of the rain forest, which covered about 80 percent of the state, was still intact.

As in the case of the Belém-Brasília highway, the completion of BR-364 was followed by a wave of migration. The migratory flow to Rondônia, which had averaged perhaps 3,000 per year in the 1960s, increased tenfold in the ensuing decade (IBGE 1979; Mahar and others 1981) as migrants, land grabbers (*grileiros*), and adventurers flocked to the area seeking plots of fertile land that were purportedly free for the asking.[6] At the same time, the regional makeup of the newcomers changed. Whereas the vast majority of Rondônia's original settlers had come from the North and Northeast, most of the new contingent were experienced small-scale farmers from the southern state of Paraná. Large numbers also came from Mato Grosso, Minas Gerais, Espírito Santo, and São Paulo.

Both "pull" and "push" factors explain the sharp increase in migration to Rondônia after 1970. Two pull factors have predominated. First, the Cuiabá-Pôrto Velho highway happened to traverse a few areas with relatively fertile soil, a fact that was publicized (and exaggerated) both by the government and by early settlers in their letters to family and friends. Second, 100-hectare lots, along with basic services and infrastructure, could be obtained at a nominal price in several agricultural colonization projects in Rondônia. The most important push factor has been the drastic reduction in employment opportunities in the South and Southeast brought on by fundamental changes in the rural economy of those regions, including the rapid spread of a mechanized system of soybean production, killing frosts in coffee-growing areas, and the fragmentation of landholdings (see box 2).

Most of the migrants hoped to settle in one of the seven colonization projects that INCRA established on 2.7 million hectares between 1970 and 1975. In contrast to the its role in the settlement of areas along the Transamazon highway, INCRA did not actively recruit settlers for Rondônia; its mandate was to provide lots, roads, and other basic infrastructure for a population that had moved to the region spontaneously. As the size and speed of the

6. About 10 percent of Rondônia's soils are considered to be of good quality; this appears to be considerably better than the average for Amazonia as a whole (Mahar and others 1981, p. 58).

Box 2. The Rondônia-Paraná Connection

The mid-1960s signaled the beginning of a rapid modernization of Brazil's agricultural sector, a process which had profound effects on the structure of production, landownership, employment, and the volume and direction of internal migration. To a large extent this modernization was induced by government policies that expanded the volume of subsidized credit for the purchase of improved seeds, farm implements, fertilizers, pesticides, and insecticides. Agricultural modernization was also encouraged by an expansion and redirection of the country's research and extension services. Strong international markets for primary commodities provided additional impetus. Although agricultural modernization has now spread throughout much of Brazil, some of the earliest and most profound effects of this process were felt in the southern state of Paraná.

In the late 1920s the northern part of Paraná constituted Brazil's agricultural frontier. To promote settlement of this area, the state government sold about 12,000 square kilometers to a British company—Paraná Plantations Limited—for subsequent resale to prospective settlers in small and medium-size lots (Margolis 1973). By the 1940s and 1950s this colonization effort had achieved its goal of establishing a prosperous and egalitarian (by Brazilian standards) rural society that was based on the production of coffee and food crops such as maize, rice, and beans. In fact, by the 1959–60 harvest, Paraná had surpassed São Paulo as Brazil's top coffee-producing state. Shortly thereafter, however, a series of problems, including soil depletion, plant diseases, overproduction, and lowered producer prices, precipitated an abrupt decline in the region's coffee-based economy. The national government accelerated this decline in the mid-1960s by financing a coffee eradication program that allowed farmers to be paid for cutting down their coffee trees. Under this program more than 400 million coffee trees were eliminated in Paraná between 1961 and 1969 (Oliveira 1978).

Although the government encouraged new coffee plantings during the early 1970s, the structure of Paraná's rural economy was irrevocably altered. The state's coffee economy was largely unsuited for the agricultural mechanization then being promoted through increasing volumes of subsidized

migratory flow increased, however, the demand for space in official projects quickly exceeded the supply.

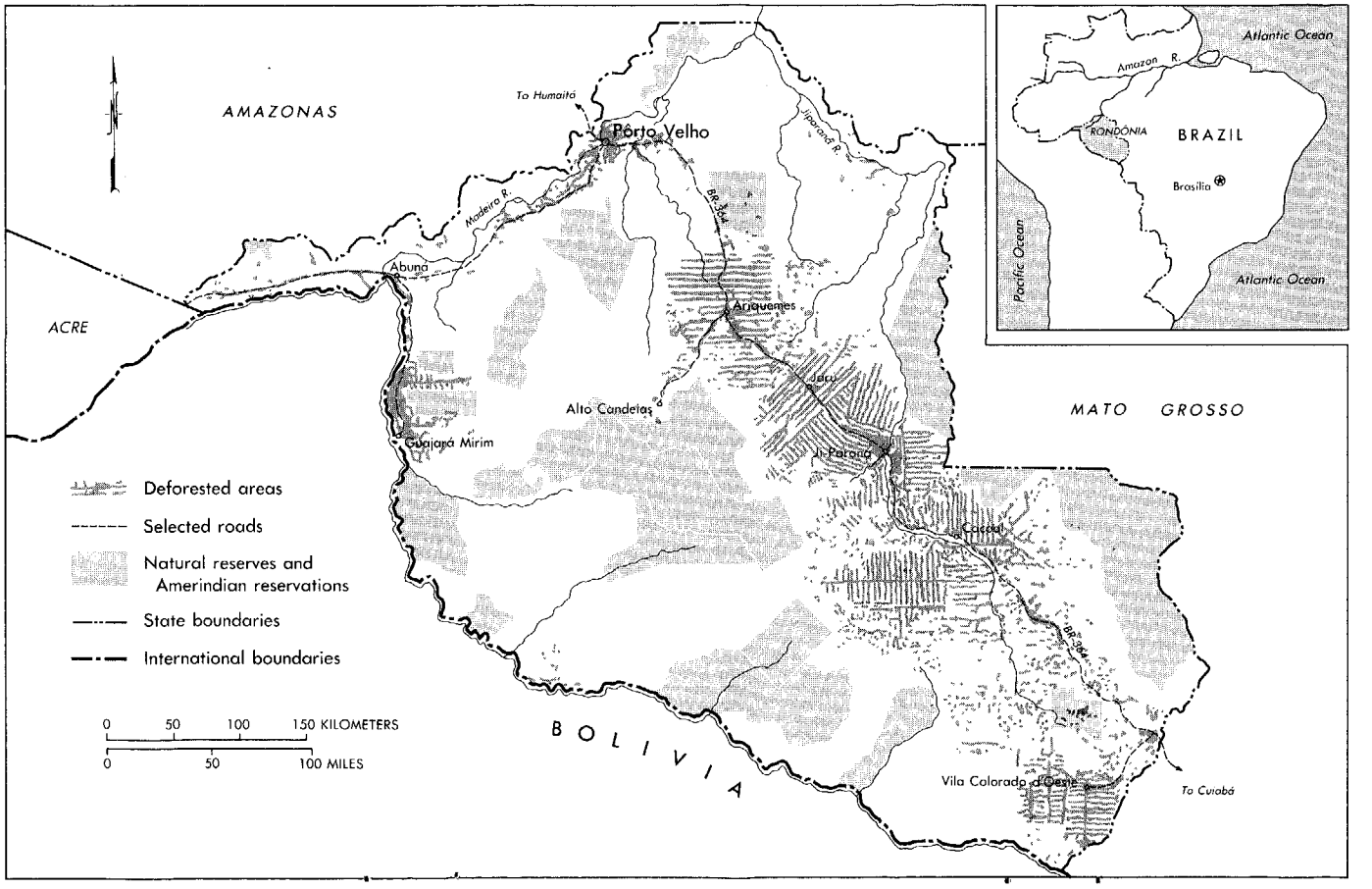
By 1977, INCRA had settled about 28,000 families; an additional 30,000 agricultural families had joined the marginal population of the newly created urban areas while they awaited their lots, sometimes for as long as two years (Martine 1980, pp. 89–90). Many others became sharecroppers on the land of established colonists

credit and was further devastated by a major frost in 1975. Many former coffee-growing areas were converted to a mechanized system of soybean cultivation that required larger farms and fewer labor inputs. Data on land distribution and use give some idea of the extent of this transformation. Between 1970 and 1980 the number of farms smaller than 50 hectares fell by 109,000 units, a combined loss of 890,000 hectares in this category; in contrast, farms larger than 1,000 hectares increased by 450 units, a gain of more than 1.0 million hectares (Carnasciali and others 1987). During this same period the land area devoted to coffee production fell from 1.2 million hectares to 630,000, and the land in soybeans rose from 172,000 hectares to 2.3 million. Many agricultural laborers, especially sharecroppers and tenants, lost their only source of income in the process. As a result, net migration out of the rural areas of Paraná reached 2.5 million in the 1970s compared with a net gain of some 170,000 in the previous decade (Martine 1988).

Labor released through the process of agricultural modernization went in several directions. Perhaps the majority migrated to cities in Paraná and other southern states in search of jobs in industry and the service sector. Others remained in the agricultural sector as wage-earning day laborers (*boias frias*) and lived on the fringes of urban areas. Still others set off for the new agricultural frontier of Rondônia. The available data indicate that between 25 and 30 percent of the migrants to Rondônia over the past decade came from Paraná. Indeed, interest in migrating to Rondônia was so great that several bus companies set up ticket agencies in the main areas of outmigration. Although many of those who migrated from Paraná to Rondônia were undoubtedly lured by the prospect of fertile soils, cheap land, and government-financed infrastructure and services, the push exerted by the agricultural transformation of Paraná was also strong. One researcher, who interviewed migrants in a large settlement project in central Rondônia, found that more than 70 percent of those from Paraná had left the state either as a result of mechanization or because they could not support their family on a small piece of farmland, two closely related aspects of agricultural modernization (Calvente 1980).

or staked out claims on the fringes of the official projects, on Indian reservations, and in forest reserves. To defuse mounting social tensions over land rights, INCRA expanded existing settlement projects, recognized small squatters' claims, and sold large lots at public auctions. Despite these efforts the situation in Rondônia worsened in the late 1970s as continuing migration and budgetary cuts nearly paralyzed INCRA.

Map 4. Deforestation in Rondônia, 1983



Rondônia's rapid population growth and uncontrolled settlement has had devastating effects on the rain forest (table 1). The speed at which this deforestation took place was, in some areas of the state, truly astonishing. The cleared area in the 80,000-hectare county (*município*) of Cacoal, for example, increased from 2,150 hectares 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 along the main highway (see map 4). Owing largely to the inadequacy of infrastructure, technical and financial assistance, agricultural research, and marketing facilities, however, most of the early settlers engaged in traditional and environmentally unsound farming practices (Mueller 1980).[7] These usually involved the clearing and burning of a patch of forest and the cultivation of annual crops for one to three years, depending on soil fertility. Pasture would then be established on the original patch, and the cycle would begin again with the clearing of another patch of forest.

By providing access to remote areas, Rondônia's network of feeder roads—which increased more than fivefold 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 such as cocoa, coffee, and rubber. From an environmental standpoint, tree crops are strongly preferred over annuals and pasture because of their superior ability to protect fragile soils from erosion. They also have important socioeconomic advantages: their cultivation is labor-intensive, and under reasonable market conditions they can provide a decent standard of living for a farm family. The principal disadvantages of tree crops are their susceptibility to disease (such as witches' broom fungus in cocoa and leaf blight in rubber), their costly fertilizer requirements when grown on the poor land typical of

7. A particularly critical issue was the slow pace at which land titles were awarded. As of the end of 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.

Amazonia, and their generally weak prospects in international markets.

The growing socioeconomic problems in Rondônia led the government to reconstruct and pave BR-364 as part of a larger program of integrated regional development. The overall program, which covered the Northwest region of Brazil—a 410,000-square-kilometer area that includes all of Rondônia and part of western Mato Grosso—became officially known as the Northwest Brazil Integrated Development Program, or POLONOROESTE, in 1981 (map 3). Budgeted at US$1.5 billion, about a third of which was eventually provided by the World Bank (Mahar 1982), POLONOROESTE was expected to benefit the 30,000 or so families already settled in the Northwest as well as 15,000 families waiting to be settled in Rondônia.

A principal objective of POLONOROESTE was to reduce forest clearance on land with little long-term agricultural potential and to promote, instead, sustainable farming systems based on tree crops. The plan was to conduct land use surveys to identify areas with high potential and then to concentrate new access roads, social infrastructure, agricultural research and extension, input supplies, crop storage, marketing, and farm credit in those areas (FAO/CP 1987). Environmental protection services in the Northwest were also to be strengthened.

The available data indicate that the actions carried out under POLONOROESTE have neither slowed the pace of deforestation nor appreciably altered traditional patterns of land use. As mentioned previously, the deforested area of Rondônia, 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* area already deforested by 1980! Moreover, the expected shift of farmland into tree crops has not materialized. Instead, as shown in table 5, there has been a rapid conversion of forest into pasture, one of the least desirable forms of land use in Amazonia from the environmental point of view. The experience of the SUDAM-approved projects strongly suggests that livestock activities provide little employment and are likely to be unsustainable in the long run.

Table 5. Agricultural Land Use in Rondônia, 1970–85
(square kilometers)

Year	Crops		Pasture	Forest[b]	Total[c]
	Annual[a]	Perennial			
1970	323.7	127.2	410.1	15,031.1	16,316.4
Percent	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
Percent	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
Percent	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
Percent	5.2	3.7	25.6	65.5	100.0

a. Includes fallow land.
b. Includes natural pastures.
c. Area under farms at time of census; includes land unsuitable for agricultural use.
d. Estimated.
Source: IBGE (1987), Rondônia Secretariat of Planning, and author's estimates.

Several factors have contributed to the accelerated deforestation and inappropriate land use currently observed in Rondônia. An important proximate cause was the substantial jump in the migratory flow that followed the paving of BR-364 in 1984. About 160,000 migrants per year entered Rondônia in 1984–86, compared with an average of 65,000 per year in 1980–83. Although an appreciable number have moved on 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, Rondônia's population has grown at an average annual rate of almost 14 percent since 1980; in 1987 the population was estimated at 1.2 million. This rapid growth in population greatly increased the already heavy pressures on the forest. But population growth alone can explain neither the extremely rapid pace of deforestation nor farmers' preference for pasture formation over the cultivation of tree crops. The role of certain institutional and policy factors must therefore be considered.

Two institutional factors may be mentioned. First, the federal Institute of Forestry Development (IBDF) has not been able to enforce the so-called 50 percent rule, which prohibits landowners in

Amazonia from clearing more than half of their holdings.[8] Some settlers in Rondônia are reported to have cleared as much as 90 percent of their lots. In addition to its being unenforceable, some scientists argue that the rule may intensify the damage to the environment it is designed to prevent (Goodland and Irwin 1975, p. 30). Animals and plants need a certain amount of space to survive. For insects the minimum area needed may be measured in square meters; for large mammals, such as the jaguar, 500,000 or more hectares may be necessary to support a genetically viable population. The 50-hectare reserve in a typical colonist's lot, therefore, will not sustain anywhere near the level of biological diversity found in undisturbed rain forest. In addition, the on-farm reserves may harbor plant and insect pests which attack the surrounding agricultural areas.

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 who were settled by INCRA on poor soils. Early in the implementation of the program, however, austerity measures forced a reduction in both the subsidy element and the supply of credit (see table 4). As a result, most farmers in the Northwest were unable to obtain credit. 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 the lack of credit were compounded by an extension service which continued to promote farm models with large input requirements (FAO/CP 1987).

In addition to these institutional factors, certain land and tax policies have encouraged (or at least have not discouraged) unnecessary deforestation and inappropriate land use. Indeed, unless these policies are substantially modified, it is doubtful that land

8. The penalty for exceeding legal limitations on deforestation is a one-time fine equivalent to approximately US$1,000, a prohibitive sum for small farmers. Large landowners, however, may be able to sell timber cut from the 50 percent legal reserve for more than the value of the fine.

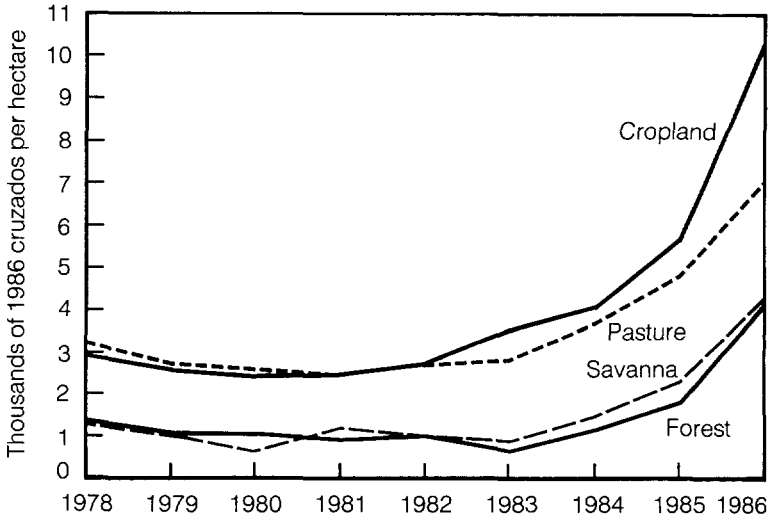
use patterns in the Northwest can be improved. The policy environment in Rondônia differs in many ways from that in eastern Amazonia. Fiscal incentives for livestock development, for example, have not been an important factor: fewer than 20 of the 631 SUDAM-approved projects are in Rondônia. This is mainly the result of a 1971 law which provides that all land in Amazonia located within 100 kilometers of a federal highway (such as BR-364), or within 150 kilometers of an international boundary, falls under federal control. In effect, this law placed more than 90 percent of the area of Rondônia under the jurisdiction of INCRA. The policies of INCRA, therefore, have had a much greater impact on land use than those of other government agencies.

Some of INCRA's policies have encouraged inappropriate land use. Foremost among these is its acceptance of deforestation as evidence of land improvement: a migrant in an official settlement project or an invaded area can obtain rights of possession simply by clearing the forest.[9] Both good and poor lands are deforested indiscriminately as a result. The geographical extent of these rights are determined by multiplying the cleared area by three, up to a maximum of 270 hectares. Once obtained, rights of possession can be sold either formally or informally, depending on whether the migrant has occupied the land long enough to qualify for a definitive title. Although some migrants with a serious interest in developing sustainable agriculture have benefited from this policy, many others have used it simply to acquire land for speculative purposes.

The potential gains from speculation would appear to be very high in Rondônia. 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. The prospect of realizing large capital gains has induced many migrants to sell their lots. In the older settlement projects an estimated 80 percent of the lots have al-

9. Settlers who wish to engage in extractive activities that do not disturb the forest—for example, rubber tapping or the gathering of Brazil nuts—are particularly disadvantaged by this policy.

Figure 2. Average Land Prices in Rondônia, 1978–86



ready been sold; in newer settlement areas turnover rates range from 40 to 55 percent.

Calculations made by the FAO/World Bank Cooperative Program (FAO/CP), which recently reviewed the interim results of POLONOROESTE, show that it is possible for speculators to net the equivalent of US$9,000 if they clear fourteen hectares of forest, plant pasture and subsistence crops for two years, and then sell the rights of possession acquired by doing so. This constitutes a large sum of money in Rondônia, where the average daily farm wage is equivalent to less than US$6.00. Additional calculations by the FAO/CP show that even bona fide farmers who plant tree crops stand to make handsome profits by selling their lots after a few years (FAO/CP 1987, annex 5, table 1). In theory, such gains on land sales would be taxed at a flat rate of 25 percent. In practice, however, few of these capital gains are taxed, particularly in frontier areas, because many land transactions are handled informally and sales prices are underreported. Binswanger (1987) argues that, by exempting virtually all agricultural income from taxation, provisions of the income tax code tend to increase the demand for

land among individuals with high incomes. These provisions thus contribute to a more rapid conversion of forest to agricultural uses as well as to land price appreciation and concentration of land ownership.

The rural land tax (ITR), which is 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 is currently 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 the degree of utilization of land (that is, the proportion cleared) and certain "efficiency" indicators—for example, crop yields, cattle stocking rates, rubber extraction per hectare—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 Rondônia paid any ITR in 1986; the average payment of those who did was equivalent to only US$5.00!

The rapid pace of pasture formation (a process known as *pecuarização*) recently observed in Rondônia appears to be largely the result of the institutional and policy factors discussed above combined with one more factor: the poor quality of the land in the settlement areas. Without the resources to pay for the fertilizers and other modern inputs needed to cultivate tree crops on poor soil as well as for wage labor to help with the planting and harvesting, settlers often find that pasture formation is their only option (short of selling their lots). Interviews with small farmers in Rondônia 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 because the maintenance costs are lower than for crops. 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. Both the state and federal authorities in Ron-

dônia should give priority to the collection and analysis of field data on the factors driving unproductive *pecuarização* and related land speculation as well as to the implementation of measures to halt these processes.

The Era of Big Projects

In the mid-1970s the government essentially abandoned the road-building and directed settlement strategy embodied in PIN and focused instead on the development of large-scale export-oriented projects in the livestock, forestry, and mining sectors in fifteen "growth poles" scattered throughout Amazonia. The Program of Agricultural, Livestock, and Mineral Poles in Amazonia, or POLAMAZONIA (it was established in 1974 and abolished in 1987) was essentially a program of infrastructure development which, combined with existing fiscal and credit incentives, sought to create 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. Recent official settlement programs, however, have been almost exclusively concerned with accommodating through POLONOROESTE the surge of spontaneous migration to Rondônia.

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 requirements for foreign exchange to pay for oil imports and to service the rapidly mounting external debt. The government felt that exports of Amazonian minerals, timber, and agricultural products could make an important contribution to Brazil's annual foreign exchange earnings.

Current regional policy has focused on 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 Carajás (located 550 kilometers south of Belém in Pará) a virtual mountain of high-grade (66 percent pure) iron ore, with estimated reserves of 18 billion tons. Subsequent prospecting in the area uncovered extensive reserves of copper, manganese, cassiterite, nickel, bauxite, and gold. To exploit the area's natural resources in a rational manner, the government established the Greater Carajás Program (PGC) in 1980. The PGC is administered by an interministerial council headed by the minister of planning. The program area comprises 895,000 square kilometers (more than 10 percent of Brazil's total land area, see map 3) 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 Tucuruí hydroelectric facility.[10]

The first major project in the Carajás subregion set out to exploit the region's huge reserves of iron ore. Approved by the Economic Development Council in 1978 and carried out under the responsibility of Companhia Vale do Rio Doce (CVRD), the Carajás Iron Ore Project began implementation in 1983 and is now fully operational. Besides development of the mine site, the project also involved the construction of a 890-kilometer railroad from the mine head to São Luís in Maranhão, port facilities capable of handling the mine's annual output of 35 million tons, and urban infrastructure. CVRD's concession area totals 4,290 square kilometers, plus a narrow strip on either side of the railroad. The cost of the project, including contingencies, was around US$5 billion. Financing was provided by CVRD (40 percent) and national and foreign creditors, including the World Bank, which provided US$300 million.

10. The Tucuruí facility, which began operating in 1984, currently generates about 2,000 megawatts of power. Its generating capacity could reach 7,960 megawatts at full development. The lake formed by the facility extends 200 kilometers up the Tocantins River and covers an area of 2,435 square kilometers. The original intention was to harvest the timber on the land to be inundated by Tucuruí, but the firm that was awarded the contract to do so was inexperienced and eventually went bankrupt. As a result, millions of cubic meters of commercially valuable timber were lost.

Unlike most other projects in Amazonia, the Carajás Iron Ore Project was developed with close attention to its possible effects on the environment. 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 for the natural environment. Even before the Carajás project had been officially approved, CVRD commissioned a series of environmental baseline studies of the proposed project area. The studies covered climatology, ecology, botany, and related disciplines and provided a framework for the development of company policies regarding forest clearing, topsoil stockpiling, erosion control, vegetation regeneration, protection of fauna, and other environmental matters. Spelled out in a manual, these policies 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 Carajás project (Kohlhepp 1987). These activities included land reclamation, the creation of protected natural reserves, and the promotion of environmental awareness and training. Physical access to the project area was tightly controlled to prevent unplanned human occupation. To oversee the implementation of the project's environmental components, CVRD created an independent group of nine senior scientists who were to visit the project site periodically over fifteen years. In addition, internal environmental commissions 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 adhered to (Freitas 1982).

In contrast to the orderly and environmentally responsible development of the Carajás iron ore reserves, the situation in the PGC area outside of the CVRD concession has been chaotic. Migration to the Greater Carajás area has been intense in recent years. For example, the *município* of Marabá, which includes the Serra dos Carajás, more than doubled in population (from 60,000 to 134,000) between 1980 and 1985. Some of the migrants have been drawn by the opportunities for employment—for example, in con-

nection with the construction of the Tucuruí dam and various civil works related to the iron ore project; others by the prospect of striking it rich in newly discovered goldfields. Because this subregion of Amazonia had already been subjected to settlement and large-scale cattle ranching once before, following the completion of the Belém-Brasília highway, the recent spurt in population growth has exacerbated the problems that have characterized much of the PGC area for many years—accelerated deforestation, environmental degradation, and violent conflicts over land rights (Branford and Glock 1985).

Although the program has been in existence for the better part of a decade, the PGC has yet 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 that called on the private sector to develop export-oriented projects in the mining, metallurgy, agriculture, livestock, and forestry sectors. The plan would have required investments of US$62 billion, however, and nowhere near this amount has materialized. In 1983, the Ministry of Agriculture published a US$1.2 billion plan to divide the PGC area into seven agricultural poles. Undertakings within these poles would include 238,000 hectares of soybeans, 12,600 hectares of sugarcane, and 417,000 hectares of cattle pasture. In addition, 3.6 million hectares along the Carajás–São Luís railway would be set aside for eucalyptus plantations which would provide charcoal for metallurgical use (Hall 1987 and Fearnside 1986a).

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 (such as cattle ranching, annual cropping, and homogeneous tree plantations) which are not likely to be sustainable (Hall 1987 and Fearnside 1986a). Like the grandiose plan prepared earlier by Japanese consultants, the agricultural plan will probably never be implemented in its entirety. But 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.[11] Another fifteen projects are currently under consideration.

The long-term viability—economic, financial, and environmental—of the metallurgy and charcoal projects has not yet been established. On the contrary, the available information casts 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, between 90,000 and 200,000 hectares of forest would have to be cut each year, depending on tree stands, density of species used, and other factors. Because wood from the proposed eucalyptus plantations would not be available until the seventh year after planting, the total deforestation attributable to the pig iron plants would reach between 540,000 and 1.2 million hectares. 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 made. It is estimated, however, that (based on gross revenues from pig iron exports of US$100–110 per ton) any fuel in the Carajás area which costs less than US$70 per ton of charcoal equivalent would render the plants profitable. Charcoal produced from the virgin forest, which currently sells for US$27 per ton in the region, clearly falls into this category. A recent study commissioned by SUDAM (1986) reached a similar conclusion. 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 that the plants

11. The PGC offers several types of fiscal incentives to approved firms. The most generous of these allows firms for a period of ten 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 credits have all been construction or engineering firms with profits from civil works projects in the PGC area. Other fiscal incentives offered by the PGC include exemptions from import duties and the federal excise tax (IPI).

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 Carajás area—is not known with certainty. The dismal historical experience with homogeneous tree plantations in Amazonia suggests that the cost will be high, however. In a recent article Fearnside (1987) estimates that to supply the proposed pig iron plants with charcoal derived entirely from plantation-grown eucalyptus would involve the planting of 2.6 million hectares of trees. This is thirty-five times the size of the largest eucalyptus plantation in Amazonia, the 76,000 hectares planted on the Jari holdings in northeastern Pará. The Jari project's tree plantations, 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 and Kinkead 1981).

All in all, the experience accumulated during the era of big projects suggests that the impact of government policies on the Amazon rain forest has been generally negative. The Carajás Iron Ore Project, however, 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 circumstances will not be easy to replicate elsewhere in Amazonia. This point is vividly illustrated by recent and projected developments in the Greater Carajás area outside of the CVRD concession, in the areas of large-scale livestock development scattered throughout Amazonia, and in Rondônia.

Conclusions and Recommendations

Over the past twenty-five years the Brazilian government's policies to develop the Amazon region have rarely been designed and carried out with due regard for their environmental consequences.

The felling of the rain forest, which began on a large scale during the 1970s, continues at an accelerated pace in many parts of the region. The forests of Rondônia and parts of eastern Amazonia, in particular, are being cleared at explosive rates. Much of this deforestation has benefited neither the regional population nor Brazilian society as a whole, except perhaps in the very short term. Despite decades of intense development, Amazonia still accounts for only an insignificant 3 percent of the national income.[12]

Many of today's problems can be traced to the decision in the mid-1960s to provide overland access to Amazonia—a decision made before enough was known about 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 Carajás area. Official settlement projects have also contributed to deforestation, although it would be wrong to place all of the blame on the settlers. Pushed by poverty and skewed land distributions in their regions of origin, the settlers 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 abandoned lands and thus help to restore the forest's biological diversity. In areas where the land is being used for small-scale agriculture, the best course of action would be to increase public support—both technical and financial—for

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

those activities which can provide a decent living for a farm family and also minimize additional environmental damage. Such activities might include the cultivation of tree crops, the gathering of forest products, subsistence livestock (dairy cows, pigs, and chickens, for example), or some mixed production system. Because the costs of production are relatively high in remote frontier areas and the market prospects for many of Amazonia's key exports are uncertain, this approach might require some degree of subsidization by the government. Such subsidies could be justified on both environmental and equity grounds, however.

A new policy should be developed for rain forest 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 that emphasizes the region's comparative advantage in forest-based economic activities. Under this approach the government would not construct any new roads or provide infrastructure or services (particularly land titles) 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. (To reduce pressures for additional road construction, it would be useful to improve water transport facilities in these areas.) Lands found to have limited agricultural potential—virtually all of the *terra firme* of Amazonia—would 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 Rondônia, for example, proposed in mid-1987 that the entire state be subject to agroecological zoning. The federal government is considering the possibility of extending this concept to all of Amazonia. These are definitely steps in the right direction. It should be kept in mind, however, that the government first proposed agroecological zoning for Amazonia in the late 1970s. A special commission composed of academics and gov-

ernment representatives was set up to draft suitable legislation. The original draft legislation included a commitment to preserve 150 million hectares of the region, 100 million hectares of which were to be rain forest. The preservationist tone of the document was softened considerably in subsequent revisions, reportedly as a result of intense lobbying by timber and cattle companies and private colonization firms. In the event, no version of the legislation was ever approved by Congress.

The success or failure of the new attempts to apply agroecological zoning in Amazonia will depend largely on the technical quality of the proposals, the strength and depth of political support for the concept, and the existence of an overall policy framework consistent with rational land use. It is too early to pass judgment on the first two factors, but it is clear from the analysis in this pamphlet that a suitable policy framework is still not in place. Some recommendations on how the current policy framework could be improved follow.

First, the government might consider eliminating fiscal incentives for livestock projects in Amazonia. Disbursements to projects already under implementation could continue, but only in cases where SUDAM has confirmed by field visits that such projects are not located in rain forest areas. More than two decades of experience have shown that livestock projects have been responsible for much environmental damage and yield little in the way of production or employment. Livestock projects may also be criticized on equity grounds because most of the benefits from the fiscal subsidy have accrued 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, this is unlikely to occur in the near future. The most powerful lobby group supporting the fiscal incentives for cattle ranching has traditionally been the Association of Amazonian Entrepreneurs (AEA), which is based in São Paulo (Pom-

permayer 1984). Local political interests have also shown little enthusiasm for eliminating what is viewed as an important source of investment capital for the region.

Second, the government might consider declaring a moratorium on disbursements of fiscal incentive funds for any projects in the Greater Carajás area—such as the proposed pig iron plants—which would use charcoal derived from the rain forest as their principal source of energy. Projects of this type threaten to cause considerable deforestation and in return would yield products of relatively little value. Although these projects would in theory be obliged to replace the forest with tree plantations, previous attempts to establish large-scale tree plantations in Amazonia have never succeeded. Before a final decision is made on these projects, further research should be carried out on their true economic costs (including the environmental costs) and on the possibility of using alternative energy sources such as electricity from Tucuruí or natural gas.

Third, INCRA might consider modifying its policy of recognizing deforestation as a form of land improvement and, as such, as 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 the future INCRA should not grant rights of possession or definitive titles to any lots on poor soils. In areas with poor 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. It plans to provide twenty- to thirty-year concessions to individuals (mostly rubber tappers already in the region) or producer associations that undertake environmentally sound extractive activities in designated areas. This approach, which fits well with current proposals calling for agroecological zoning, should be encouraged.

Fourth, IBDF might consider abolishing the 50 percent rule. It has been shown to be unenforceable in a frontier region such as Amazonia and provides little, if any, protection to the environment. In place of the rule, legislation should be passed which expressly permits the formation of contiguous "block" reserves equal to 50 percent of the total 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 who could be settled on better soils in already occupied areas. As part of an experiment, block reserves have been established in some of the newer settlement areas of Rondônia. Although some problems have been reported—for example, illegal invasions of the reserves and disputes among settlers over their individual rights to use them—the experiment should be closely monitored and evaluated for its replicability in other parts of Amazonia.

Fifth, 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 has the potential to improve land use patterns by penalizing those who engage in environmentally unsound activities. The structure of the tax would have to be modified for Amazonia, however, to allow land left in virgin forest to be considered productive and thus to qualify for the lowest tax rate. Administration of this tax would also have to be vastly improved.

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

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