THE CAUSES OF DEFORESTATION IN THE BRAZILIAN AMAZON

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The present rate and probable future course of forest clearing in Brazilian Amazonia is closely linked to the human use systems that replace the forest. These systems, including the social forces leading to particular land use transformations, are at the root of the present accelerated pattern of deforestation and must be a key focus of any set of policies designed to contain the clearing process. The present extent and likely changes in the various agricultural systems found in the region are reviewed elsewhere (Fearnside, nd-a). Cattle pasture is by far the dominant land use in cleared portions of the terra firme (unflooded uplands), not only in areas of large cattle ranches, such as southern Pará and northern Mato Grosso, but also in areas initially felled by smallholders for slash-and-burn cultivation of annual crops, such as the Transamazon Highway colonization areas in Pará (Fig. 4.1). Pasture is even dominant in areas like Rondônia where government programs have intensively promoted and financed cacao and other perennial crops (Léna, 1981; Furley and Leite, nd). The forces leading to continued increase in pasture area, despite the low productivity and poor prospects for sustainability of this use system, are those that most closely affect the present rate of deforestation.

The extent and rate of deforestation in Brazil's Amazon rainforest is a subject of profound disagreement among both scholars and policy makers in Brazil and elsewhere. Equally controversial is the question of whether or not potential future consequences of deforestation are sufficient to justify the immediate financial, social, and political costs of taking measures to contain the process. The lack of effective policies to control deforestation in the Amazon today speaks for both the preference among decision makers for minimizing such concerns and the strength of forces driving the deforestation process. Here it is argued that deforestation is rapid and its potential impact severe, amply justifying the substantial costs of speedy government action needed to slow, and at some point stop, forest clearing.

4.1 EXTENT AND RATE OF DEFORESTATION

The vast areas of as yet undisturbed forest in the Brazilian Amazon frequently lead visitors, researchers, and government officials to the mistaken conclusion that deforestation is a minor concern unlikely to reach environmentally significant proportions within the "foreseeable" future. Such conclusions are unwarranted; they also have the dangerous effect of decreasing the likelihood that timely policy decisions will be made with a view to slowing and limiting the process of deforestation. Not only is better monitoring information needed for describing the process, but also better understanding of underlying causes of deforestation. Such understanding would allow more realistic projections of future trends under present and alternative policy regimes, and permit identification of effective measures to control the process.
The most recent available survey of deforestation covering the entire Brazilian Amazon was made by Brazil's National Institute for Space Research (INPE) based on LANDSAT satellite images taken in 1978 (Tardin et al., 1980). The same study also interpreted images from 1975. The survey's finding that only 1.55% of the area legally defined as Amazonia had been deforested up to 1978 contributed to the popular portrayal in Brazil of deforestation as an issue raised only by "alarmists." The INPE figure underestimates clearing because of the inability of the technique to detect "very small" clearings and of the difficulty of distinguishing second growth from virgin forest. For example, the Zona Bragantina, a 30,000 km² region surrounding the town of Bragança in northeastern Pará that was completely deforested in the early years of this century (Egler, 1961; Sioli, 1973), is larger than the area indicated by 1975 images analyzed in the INPE study as deforested in Brazil's entire Legal Amazon, and is almost four times the area indicated as cleared in the state of Pará (Fearnside, 1982). Regardless of any underestimation due to image interpretation limitations, the conclusion that the area cleared through 1978 was small in relation to the 4,975,527 km² Legal Amazon is quite correct.

Unfortunately, the small area cleared by 1978 is a far less important finding than another less publicized one apparent from the same data set (Carneiro et al., 1982): the explosive rate of clearing implied by comparing values for cleared areas at the two image dates analyzed, 1975 and 1978. If the growth pattern over the region as a whole was exponential during this period, the observed increase in cleared area from 28,595.25 to 77,171.75 km² implies a growth rate of 33.093% year⁻¹, and a doubling time of only 2.09 years. Deforestation rates vary widely in different parts of the region, being highest in southern Pará, northern Mato Grosso, and in Rondônia and Acre. An analysis of a longer time series of LANDSAT images from one of these areas, Rondônia, is presented elsewhere (Fearnside, 1982). Comparisons of cleared areas for 1973, 1975, 1976, and 1978 in two areas of government-sponsored colonization by farmers with 100 ha lots, and in two areas dominated by 3000 ha cattle ranches, indicate that deforestation in these areas may have been progressing in an exponential fashion during the period, although data are too few for firm conclusions (Fearnside, 1982).

LANDSAT image interpretation by the Brazilian government for the state of Rondônia as a whole (243,044 km²) indicates that cleared areas rose from 1,216.5 km² in 1975 (Tardin et al., 1980) to 4,184.5 km² in 1978 (Tardin et al., 1980) to 7,579.3 km² in 1980 (Carneiro et al., 1982) to 13,955.2 km² in 1983 (Brazil, Ministério da Agricultura, 1985; Fearnside and Salati, nd). The cleared area therefore increased from 0.50% to 3.12% of Rondônia's total area in only five years, and jumped to 5.74% in the succeeding three years. It should be remembered that limitations of the image interpretation methodology mean that the true cleared areas were probably larger than these numbers imply. Even with this limitation, the clearing estimates reveal not only that
deforestation proceeded rapidly throughout the period, but that it showed no signs of slowing as of 1980 (Fig. 4.2) and continued through 1983 at a faster-than-linear pace.

LANDSAT data from 1980 images (Brazil, Ministério da Agricultura, IBDF, 1983) reveal that strong exponential growth in cleared areas over the 1975-1980 period also occurred in Mato Grosso and Acre, while increase was roughly linear in Pará, Maranhão and Goiás (Fearnside, 1984a, nd-b). No 1980 data are yet available for Roraima, Amazonas or Amapá.

Some of the forces behind deforestation are linked to positive feedback processes, which can be expected to produce exponential changes. Roadbuilding, for example, is closely tied to the rate of arrival of new immigrants: more and better roads attract more immigrants, while the presence of a larger population justifies the construction of still more and better roads (Fig. 4.3). In Rondônia the population has been growing even more rapidly than in other parts of the region because of the flood of new immigrants from southern Brazil (Fig. 4.2). Projections of unchanging exponential rates for deforestation into the future, even in deforestation foci like Rondônia, are hazardous as anything but illustrations because there are many other factors affecting the process. As the relative importance of different factors shifts in future years, some of the changes will serve to increase deforestation rates, while others will slow them. Within completely occupied blocks of colonist lots, for example, clearing of virgin forest proceeds roughly linearly for about six years, after which a plateau is reached (Fearnside nd-c). The rate at which an individual lot is cleared is increased by such events as the arrival of road access and turnover in the lot's occupants (Fearnside, 1980a, nd-c) (Fig. 4.3).

At present, regional scale clearing statistics appear to be dominated by immigration, along with other forces that accelerate deforestation such as the positive effect of improved road access on market availability and land value appreciation. In the future, the behavior of the population already established in the region should gain in relative importance. Other reasons for an eventual slowing (but not halting) of clearing include poorer soil quality and inaccessibility of remaining unoccupied land, the finite capacity of source areas to supply immigrants at ever increasing rates, decreased relative attractiveness of Amazonia after this frontier of unclaimed land "closes," and limits of available capital, petroleum and other inputs that would be necessary if rates of felling should greatly increase (Fearnside nd-d). However, nothing short of a comprehensive program of government actions based on conscious decisions can be expected to contain deforestation before the region's forests are lost (Fearnside nd-b).

The accelerating course of deforestation cannot be adequately represented by any simple algebraic formula such as the exponential equation, nor can its eventual slowing be expected to
follow a smooth and symmetrical trajectory such as a logistic growth path. The complex interacting factors bearing on the process are more appropriate for analysis with the aid of computer simulation (Fearnside, 1983a). An idea can be gained of the relationships of the factors involved by examining more closely some of the causes of deforestation in Amazonia.

4.2 CAUSES OF DEFORESTATION

Present causes of deforestation can be divided, somewhat artificially, into proximal causes (Table 4.1) and underlying causes (Table 4.2). Proximal causes motivate land owners and claimants to direct their efforts to clearing forest as quickly as possible. The underlying causes link wider processes in Brazil's economy either to the proximal motivations of each individual deforester, or to increases in numbers of deforesters present in the region.

Some of the principal motives for deforestation apply most forcefully to large landholders, especially those motives connected to government incentive programs. These represent forces relatively easily controlled by governmental actions, as has already occurred to a small degree (see note, Table 4.1). Deforestation is also linked to longstanding economic patterns in Brazil, such as high inflation rates, which have shown themselves to be particularly resistant to government control (Fig. 4.4).

Changes in agricultural patterns in southern Brazil have had heavy impacts. The rise of soybeans has displaced an estimated 11 agricultural workers for every one finding employment in the new production system (Zockun, 1980). Sugarcane plantations, encouraged by the government for alcohol production, have likewise expelled smallholders. Replacement of labor-intensive coffee plantations with mechanized farms raising wheat and other crops, a trend driven by killing frosts and relatively unfavorable prices, has further swollen the ranks of Amazonian immigrants (Sawyer, 1982).

Within Amazonia, most evident are the forces of land speculation (Fearnside, 1979a; Mahar, 1979), the magnifying effect of cattle pasture on the impact of population (Fearnside, 1983b), and the positive feedback relationship between roadbuilding and population increases (Fearnside, 1982).

Profits from sale of agricultural production are added to speculative gains, tax incentives and other forms of government subsidy in making clearing financially attractive. Small farmers often come to the region intent on making their fortunes as commercial farmers, but they gradually see the higher profits to be made from speculation as their neighbors sell their plots of land for prices that dwarf the returns realized from years of hard labor. Agriculture then becomes a means of meeting living expenses while awaiting the opportunity of a profitable land sale and a move to a more distant frontier. Although individual
variability is high, most aspire to produce enough to live well by the standards of their own pasts while awaiting an eventual sale. Farmers usually see such sales as providing the reward for "improvements" made on the land during their tenure, rather than as speculation. Larger operators are more likely to begin their activities in the region with speculation in mind but are likewise always careful to describe themselves as "producers" rather than speculators.

Subsistence production is always a contributor to forest clearing, although it is not presently the major factor that it is in many other rainforest areas, as in Africa (Myers, 1980, 1982). The speculative and commercial motives for clearing in Amazonia mean that the relationship of commodity prices to clearing is positive for most of the farmers involved. In areas of the tropics where cash crops are grown primarily for supplying subsistence needs, the relationship can be the reverse: a positive feedback loop exists whereby falling prices for a product mean that larger areas must be planted for the farmer to obtain the same subsistence level of cash income, while the resulting increased supply of the product further drives prices down (Gligo, 1980: 136; Plumwood and Routley, 1982). For most Amazonian farmers, however, desire for cash so greatly exceeds the income-producing capacity of the farms that only the restraints of available labor and capital limit the areas cleared and planted (Fearnside, 1980b).

Future deforestation trends should reflect changes in the balance of forces listed in Tables 4.1 and 4.2, as from declining impact of new arrivals relative to the resident population. Future trends can also be expected to show the effects of projected major developments (Table 4.3). As timber export, presently a negligible factor, becomes more important, outright deforestation will be supplemented by the often heavy disturbances following selective felling that presently characterize much of the forest conversion in Asia and Africa. Charcoal production, especially that derived from native forest, is foreseen as a major factor in the southeastern portion of the region in the coming decades.

Large firms, such as lumber companies requiring marketable timber, or steel manufacturing industries requiring charcoal, pose the additional problem of playing more active and forceful roles in seeing that environmental conflicts of interest are resolved in their favor. Chances are higher, as compared to the case of relatively small investors, that concessions will be made at the expense of previous governmental commitments to reserves of untouched forest. This recently occurred in the case of timber concessions operating in the area now flooded by the Tucurui Hydroelectric Dam: despite not having fulfilled its role in removing forest from areas to be flooded, the concessionnaire was reportedly granted logging rights to 93,000 ha in two nearby Amerindian reservations when commercially valuable tree species proved less common than anticipated in the reservoir area,
Future deforestation appears likely to proceed at a rapid rate. Although limited availability of fossil fuel, capital, and other resources should eventually force a slowdown, this cannot be counted on to prevent loss of large areas of forest. Even at rates slower than those of the recent past, the forest could be reduced to remnants within a short span of years. The deforestation process is subject to control and influence at many points. Decisions affecting rates of clearing must be based on understanding of the causes of deforestation. Such decisions are taken, either actively or by default. They define areas to undergo agricultural or other development, and reserves where such development will be excluded. Making timely choices of this kind depends on decision makers' conception of the likely course of deforestation. Understanding the system of forces driving the process is also essential for evaluating the probable effectiveness of any changes contemplated.

4.3 POLICY IMPLICATIONS

The negative consequences of deforestation (Fearnside nd-d) should give pause to planners intent on promoting forms of development requiring large areas of cleared rainforest. Nevertheless, such plans continue to be proposed and realized. Part of the problem is a lack of awareness among decision-makers of the magnitude of the eventual costs implied by these actions, but such lack of knowledge explains only a part of the reluctance to take effective actions to contain and slow deforestation. At least as important is the distribution of the costs and benefits, both in time and space. Most of the costs of deforestation will be paid only in the future, while the benefits are immediate. Many of the costs are also distributed over society at large, while the benefits accrue to a select few. In the many cases where land is controlled by absentee investors there is even less reason for negative consequences within the region to enter individual decisions. In other cases the costs are highly concentrated, as when indigenous groups are deprived of their resource base, while the perhaps meagre benefits of clearing are enjoyed by a constituency that is both wider and more influential.

Brazil's national government has the task of balancing the interests of different generations and interest groups. At the same time, the Amazon has long suffered from exploitation as a colony whose products serve mainly to benefit other parts of the globe, most recently and importantly the industrialized regions of Brazil's Central-South. The unsustainable land uses resulting from this kind of "endocolonialism," as Sioli (1980) calls it, require that decision-making procedures guarantee the interests of the Amazon's residents when conflicts arise with more influential regions of the country. Clear definitions of development objectives are essential as a prerequisite for any planning (Fearnside, 1983c). I suggest that development alternatives be evaluated on the basis of benefits to the residents of the Amazon
region and their descendants. Coherent policies must include the maintenance of the human population below carrying capacity, the implantation of agronomically and socially sustainable agroecosystems, and limitations on total consumption and on the concentration of resources. The inclusion of future generations of local residents in any considerations means that greater weight must be accorded the delayed costs implied by such potential consequences of deforestation as hydrological changes, degradation of agricultural resources, and sacrifice of as yet untappable benefits from rainforest. The folly of present trends toward rapid conversion of rainforest to low-yielding and short-lived cattle pasture is evident, at least with respect to the long-term interests of Amazonia's residents (Fearnside, 1979b, 1980c; Goodland, 1980; Hecht, 1981).

4.4 CONCLUSIONS

1.) Deforestation in the Brazilian Amazon is proceeding rapidly. The future course of rainforest clearing depends on a complex network of interacting factors. Forces such as a positive feedback relationship between roadbuilding and land clearing can be expected to increase deforestation, while factors such as the increasing importance of resident population relative to the influx of immigrants should act to slow, but not stop, the process. Rapid deforestation will probably continue in the coming years.

2.) Many government policies affect deforestation, including those related to land tenure, reserve protection, investment incentives, and inflation.

3.) Policies designed for the long-term benefit of the Amazon's residents and their descendants must include measures to slow and contain deforestation. Such measures must be based on sound understanding of the forces motivating deforestation, as well as a clear definition of development goals. The current pace of deforestation in the region suggests that, if they are to be effective, any measures must be implemented quickly.

ACKNOWLEDGEMENTS

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Table 1. Proximal causes of deforestation

<table>
<thead>
<tr>
<th>PRINCIPAL PRESENT MOTIVES</th>
<th>LINK TO DEFORESTATION</th>
<th>RELATIVE IMPORTANCE BY SIZE OF HOLDING</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Small Properties</td>
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<tr>
<td></td>
<td></td>
<td>Large Properties</td>
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</tbody>
</table>

1.) Land speculation.

| Clearing establishment of proprietary claims, raises resale value of land. | Important in squatter areas and for tentatively documented colonists in official settlement areas. | Important in areas held by grileiros (land grabbers) as well as in legally documented areas (difficult to defend from squatters). |

2.) Tax incentives.

| Businesses can avoid paying taxes owed on enterprises elsewhere in Brazil if money is invested in Amazonian ranches (Bunker, 1980; de Almeida, 1978; Fearnside, 1979a; Mahar, 1979). | Not a factor. | Important in projects approved by the Superintendency for the Development of Amazonia (SUDAM) (mostly in Pará) or by the Superintendency for the Manaus Free Trade Zone (SUFRAMA) (in Amazonas).@7oa@8o |

Tax penalties.

| Higher taxes on "unused" (i.e. uncleared) land (Brazil, Ministério da... | Not important. | May become important. |
3.) Negative Financing of government-approved ranching projects at nominal interest rates lower than inflation. Not a factor. Important. As with tax incentives, most important in southern Pará.

4.) "Chronograms" for Government-approved ranching projects must adhere to a schedule for clearing to qualify for continued incentives. Not a factor. Important in SUDAM and SUFRAMA project areas, but many ranches receive subsidies without full compliance.

5.) Special Important in Important for relatively few large crop loans. Cacao, coffee, rubber, black pepper, sugar colonization areas. Annual crops are financed in some areas. These crops would not be attractive without the favorable loan terms.

6.) Export- Beef, and to Important among Important, although
able production. a lesser extent cacao, upland rice, and other crops, are sold in other regions or countries. small farmers who depend on cash crop sales for year-to-year survival. Speculative benefits come as a windfall for these, although a significant number of lots are owned by non-resident speculators for whom agricultural production is a minor consideration. often larger holdings are integrated into more diversified investment portfolios. In the case of operations largely motivated by subsidies and speculative opportunities, sale of production, even if meagre, adds to the profit from clearing.

7.) Subsistence production. Relatively minor. Minor, especially in government colonization areas, where most clearing is for cash crop planting. Not significant.

New incentives for cattle ranches from the Superintendency for Development of the Amazon (SUDAM) were suspended in 1979 for areas classified as "high forest," but new projects continue to be approved for "transition forest" areas, and the hundreds of previously approved projects in the high forest areas continue to receive incentives for clearing, most of which has yet to be done.
<table>
<thead>
<tr>
<th>Cause</th>
<th>Link to Deforestation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) Inflation.</td>
<td>a.) Speculation in real property, especially pasture land.</td>
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<td></td>
<td>b.) Increased attractiveness of low-interest bank loans for clearing.</td>
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<tr>
<td>2.) Population growth.</td>
<td>a.) Increased demand for subsistence production (minor factor).</td>
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<td></td>
<td>b.) Increased capacity to clear and plant, both for subsistence and cash crops.</td>
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<td></td>
<td>c.) Increased political pressure for road building (feeds back to item 4).</td>
</tr>
<tr>
<td>3.) Mechanization of agriculture in southern Brazil and absorption of small holdings by large estates in the south and northeast.</td>
<td>a.) Immigration of landless laborers (increasing felling both as squatters and as workers on other properties).</td>
</tr>
<tr>
<td></td>
<td>b.) Immigration of smallholders to purchase land (both augment item 2).</td>
</tr>
<tr>
<td>4.) Road building and improvement.</td>
<td>a.) Immigration to Amazonia (feeds back to item 2).</td>
</tr>
<tr>
<td></td>
<td>b.) Increased clearing by persons already present.</td>
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<tr>
<td>5.) Low land prices.</td>
<td>a.) Extensive land uses (e.g. pasture).</td>
</tr>
<tr>
<td></td>
<td>b.) Little concern for sustainability of production.</td>
</tr>
<tr>
<td></td>
<td>c.) Attraction of smallholders to immigrate</td>
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</table>
d.) Little motivation for landholders to defend uncleared areas from squatters.
e.) Greater potential speculative gains.

a.) Tendency of Amazonian interior residents to support incumbent governments provides incentive to increase political representation of these areas by creating new territories and states, justified by population growth achieved through colonization programs and highway construction.
b.) During specific periods of social tension in non-Amazonian portions of Brazil, as in 1970, road building and colonization programs in Amazonia have been seen as ways to alleviate pressure for land reform (e.g. Ianni, 1979). The effect of publicity surrounding the programs appears to be more important than actual population flow.

7.) International geopolitics.

Government leaders frequently justify road building and colonization near international borders as protecting the country from invasion (Kleippenning, 1975, 1977; Tambs, 1974). These claims can be effective in rationalizing government programs desired for other reasons (Fearnside, 1984b; Kleippenning, 1977: 310).

8.) Concentration of land tenure in Amazonia.

Displaces population when squatters' claims or small holdings are taken by large ranches. Displaced persons move to clear new areas.
9.) Fear of forest. Deep-seated psychological aversion to forest and fear of dangerous animals impedes forested land uses. This fear is especially powerful among recent arrivals from other regions (e.g. Moran, 1980: 99).

10.) Status from cattle. Longstanding Iberian tradition of according higher social status to ranchers than farmers leads to preference for pasture independent of expected profit (Denevan, 1982; Smith, 1982: 84).

11.) Availability of alternative investments elsewhere. Heavy discounting of expected future costs and returns for investments in the Amazon, leading to little concern for sustainability of production systems (see Clark 1973, 1976).

12.) Distribution of environmental costs of deforestation over society at large. Increases relative economic attractiveness to individual investors of land uses requiring large deforested areas, as compared to intensive use of small clearings or sustained management of standing forest (see Hardin, 1968).

13.) Unsustainable land use choices for cleared areas. Clearing more area to substitute for no-longer-productive land.

14.) Low labor requirement of predominant land use (e.g. pasture). a.) Small population can clear and exploit a large area. b.) Little contribution to solving problems of unemployment, underemployment, and landlessness, which encourage further deforestation.
15.) Low agricultural yields.

a.) Increased area needed to supply subsistence demand (relatively minor).

b.) Money from government subsidies spent on unproductive ranches and other projects fuels inflation by increasing purchasing power of beneficiaries, without contributing corresponding amounts of production to the economy (feeds back to item 1).
Table 3. Expected additional motives for future deforestation.

<table>
<thead>
<tr>
<th>Motive</th>
<th>Reason expected</th>
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<tbody>
<tr>
<td>1.) Timber export.</td>
<td>Expected to increase with coming end to Southeast Asian rainforests now supplying world markets (Fearnside and Rankin 1982).</td>
</tr>
<tr>
<td>2.) Charcoal production.</td>
<td>Expected to increase for steel production for the Grande Carajás Project, in south-eastern Pará. Both native forest harvest and plantations are planned.</td>
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<tr>
<td>3.) Support of mineral development sites.</td>
<td>Expected to accompany developments at Carajás, Trombetas, Serra Pelada, and elsewhere.</td>
</tr>
<tr>
<td>4.) Hydroelectric projects.</td>
<td>Planned projects at Balbina (Rio Uatumã) Samuel (Rio Jamari) and Itapunara (Rio Jari) would total 4445 km² of reservoir area (Goodland, 1980), plus additional unknown areas from 2 dams on the Rio Xingú and up to 4 additional dams on the Rio Tocantins (Goodland, 1980)@7oa@8o. Existing dams in the region at Curuá-Unã (Rio Curuá-Unã) and Paredão, also known as Coary Nunes (Rio Araguari), and Tucuruí (Rio Tocantins) total 2539 km². Some new area will be cleared by persons displaced by the dams, as well as by expected support communities. Fluctuations in released water volume, as at Balbina, will also kill substantial forest areas downstream of the dams. Forest loss from hydroelectric projects, however, is small when compared with losses to ranching or other activities.</td>
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</tbody>
</table>
Ultimate goals for the Rio Tocantins and its tributaries reportedly call for construction of 8 large dams (including Tucuruí) plus 19 smaller ones, while the Río Xingú would eventually have 9-10 large dams (Caufield 1982).
FIGURE LEGENDS

Fig. 4.1. Brazil's "Legal Amazonia."

Fig. 4.2. Growth of population and deforested area in the state of Rondônia. Deforested area is growing even more rapidly than population in this focus of rainforest clearing in Amazonia. Ten-year interval populations are from census data compiled by the Brazilian Institute for Geography and Statistics (IBGE) (Saunders, 1974; Brazil, Presidência da República, IBGE, 1982: 74); 1976 intercensal estimate is by IBGE (Mesquita and Egler, 1979: 73). Deforestation estimates for 1975 and 1978 are from Tardin et al. (1980); 1980 estimate is from Brazil, Ministério da Agricultura IBDF (1983).

Fig. 4.3. Causal loop diagram of the relationship between roadbuilding and deforestation. Signs by arrow heads indicate the direction of change that would result from an increase in the quantity at the tail of the arrow. Roads and population form a positive feedback loop. Roads also increase land values, leading the original colonists to sell their land to newcomers who clear more rapidly. Improved transport for agricultural production makes farming more profitable, leading colonists to clear and plant larger areas.

Fig. 4.4. Causal loop diagram of the relationship of inflation to deforestation for cattle pasture. High inflation leads to land speculation as a means of preserving the value of money. Pasture is planted to secure these investments against squatters or other claimants. The low production of beef from pastures on these soils means that the money invested in ranching is increasing the demand for products in the marketplace without contributing anything that can be bought. The increase of demand over supply raises prices, contributing to still higher inflation.
Fig. 2

The graph illustrates the relationship between population growth and deforestation. The x-axis represents the years from 1950 to 1985, while the y-axis shows population size in 10^3 inhabitants. The graph shows a significant increase in population growth from 1950 to 1975, followed by a sharp increase in deforestation.