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How Much are the Rainforests Worth?

by Philip M. Fearnside

Do the consequences of deforestation outweigh the immediate economic gain? Almost certainly, contends Philip Fearnside in his recent study, when one realizes what those consequences are. But many obstacles, he notes, stand in the way of winning that case. The forces that propel deforestation are a complex mix of direct self-interests and broader economic processes. Policies, once implemented, can set up vicious cycles from which it is difficult to escape — new and better roads encourage the influx of immigrants, the presence of migrants stimulates new efforts at road-building. Trade-offs must be weighed: large-scale sugar plantations, to ease Brazil's energy crisis through alcohol production, drove many small farmers off the land and into the virgin forests. "Nothing short of a comprehensive programme of government action based on conscious decisions," Fearnside argues, can be expected to halt deforestation before the Amazonian forests are lost. Dr. Fearnside is a resident researcher at the National Research Institute for Amazonia in Manaus, Brazil. — **Editor**

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 transformation, 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.

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. Pasture is even dominant in areas like Rondônia where government programmes have intensively promoted and financed cacao and other perennial crops. 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 the 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. But I would argue 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 to stop — forest clearing.

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 accompanying the process, but also better understanding of the underlying causes of deforestation. Such understanding would allow more realistic projections of future trends under present and alternative policy regimes, and permit identifi-

cation of effective measures to control the process.

The most recent available survey of deforestation covering the entire Brazilian Amazon was made by Brazil's Institute for Space Research (INPE) based on LANDSAT satellite images taken in 1978. The survey's finding that only 1.55 per cent of the area legally defined as Amazonia had been deforested up to that time contributed to the popular portrayal in Brazil of deforestation as an issue raised only by "alarmists". The INPE figure underestimates clearing due to inability of the technique to detect "very small" clearings and to the difficulty of distinguishing secondary growth from virgin forest.

For example, a 30,000 square kilometres (km^2) region surrounding the town of Bragança in northeastern Pará that has been deforested since the early years of this century, is larger than the area indicated by 1975 images analysed in the INPE study to have been deforested in Brazil's entire Legal Amazon, and almost four times the area indicated as cleared in the state of Pará. 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 km^2 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: the explosive rate of clearing implied by comparing values for cleared areas at the two image dates analysed, 1975 and 1978. If the growth pattern was exponential over the region as a whole during this period, the observed increase in cleared area from 28,595.25 to 77,171.75 km^2 implies an exponential growth rate of better than 33 per cent, and a doubling time of only a little over two years. Deforestation rates vary widely among different parts of the region, being highest in southern Pará, northern Mato Grosso, and in Rondônia and Acre. Comparisons of cleared areas for 1973, 1975, 1976, and 1978 in two areas of government-sponsored colonization by farmers with 100-hectare lots, and in two areas dominated by 3,000-hectare 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.

LANDSAT image interpretation by the Brazilian Government for the state of Rondônia as a whole indicates that cleared areas rose from 1,216.5 km^2 in 1975 to 4,184.5 km^2 in 1978 to 7,579.3 km^2 in 1980. The cleared area therefore increased from 0.5 per cent to 3.1 per cent of Rondônia's total area in only five years, but 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.

Forces Behind Deforestation

Some of the forces behind deforestation are linked to positive feedback processes, which can be expected to produce exponential changes. In Rondônia the population has been growing even more rapidly than in other parts of the region due to the flood of new immigrants from southern Brazil. Projections of unchanging exponential rates for deforestation, even in deforestation foci like Rondônia, are hazardous due to the 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. The rate at which an individual lot is cleared is increased by such events as the arrival of road access and turnover of the lot's occupants.

At present, regional scale clearing statistics appear to be dominated by immigration, along with other forces such as the positive effect of improved road access on market availability and land value appreciation leading to accelerating deforestation. In the future, the behaviour 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 to available capital, petroleum and other inputs that would be necessary if rates of felling should greatly increase.

The accelerating course of deforestation cannot be adequately represented in 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. An idea can be gained of the relationships of the factors involved by examining more closely some of the causes of deforestation in Amazonia.

Causes of Deforestation

Present causes of deforestation can be divided, somewhat artificially, into proximal causes and underlying causes. 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, especially those motives connected to government incentive programmes, apply most forcefully to large landholders. These represent forces relatively easily controlled by governmental actions, as has already occurred to a small degree. Deforestation is also linked to long-standing economic patterns in Brazil, such as high inflation rates, which have shown themselves to be particularly resistant to government control.

Changes in agricultural patterns in southern Brazil have had heavy impacts. The increase in soybean production has lead to the displacement of an estimated 11 agricultural workers for every one finding employment in the new extensive production systems. Sugar-cane plantations, encouraged by the Government to enter into alcohol production, have likewise expelled smallholders. Replacement of labour-intensive coffee plantations by mechanized farms raising wheat and other crops, a trend driven by lethal frosts and relatively unfavourable prices, has further swollen the ranks of Amazonian immigrants.

Within Amazonia, most evident are the forces of land speculation, the magnifying effect of cattle pasture on the impact of population, and the positive feedback relationship between road-building and population increases.

Profits from sale of agricultural production are added to speculative gains, tax incentives and other forms of government subsidy to make 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 neighbours sell their plots of land for prices that dwarf the returns realized from years of hard labour. 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. 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. For most Amazonian farmers, however, desire for cash so greatly exceeds the income-producing capacity of the farms that only the restraints of available labour and capital limit the areas cleared and planted.

Future deforestation trends should reflect changes in the balance of many forces — popula-

[illegible] enabling export potential, subsistence needs, and a host of other factors. Future trends can also be expected to show the effects of projected major developments. 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 a large charcoal supply, pose the additional problem of playing more active and forceful roles in seeing that environmental conflicts of interest are resolved in their favour. 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 Tucuruí hydroelectric dam. Despite not having fulfilled its role in removing forest from areas to be flooded, the concessionaire was reportedly granted logging rights to 93,000 hectares in two nearby Amerindian reservations when commercially valuable tree species proved less common than anticipated in the reservoir area, according to the head of the firm involved.

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 an understanding of the causes of deforestation. Such decisions are taken, either actively or by default, for all areas undergoing agricultural or other development, as well as in defining reserves where such development will be excluded. Making timely choices of this kind depends on decision-makers' conceptions 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.

Policy Implications

The negative consequences of deforestation 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, negative consequences within the region have even less reason to enter individual decisions. In other cases the costs are highly concentrated, as for indigenous groups deprived of their resource base, while the perhaps meagre benefits of clearing are enjoyed by a constituency that is both wider and more influential.

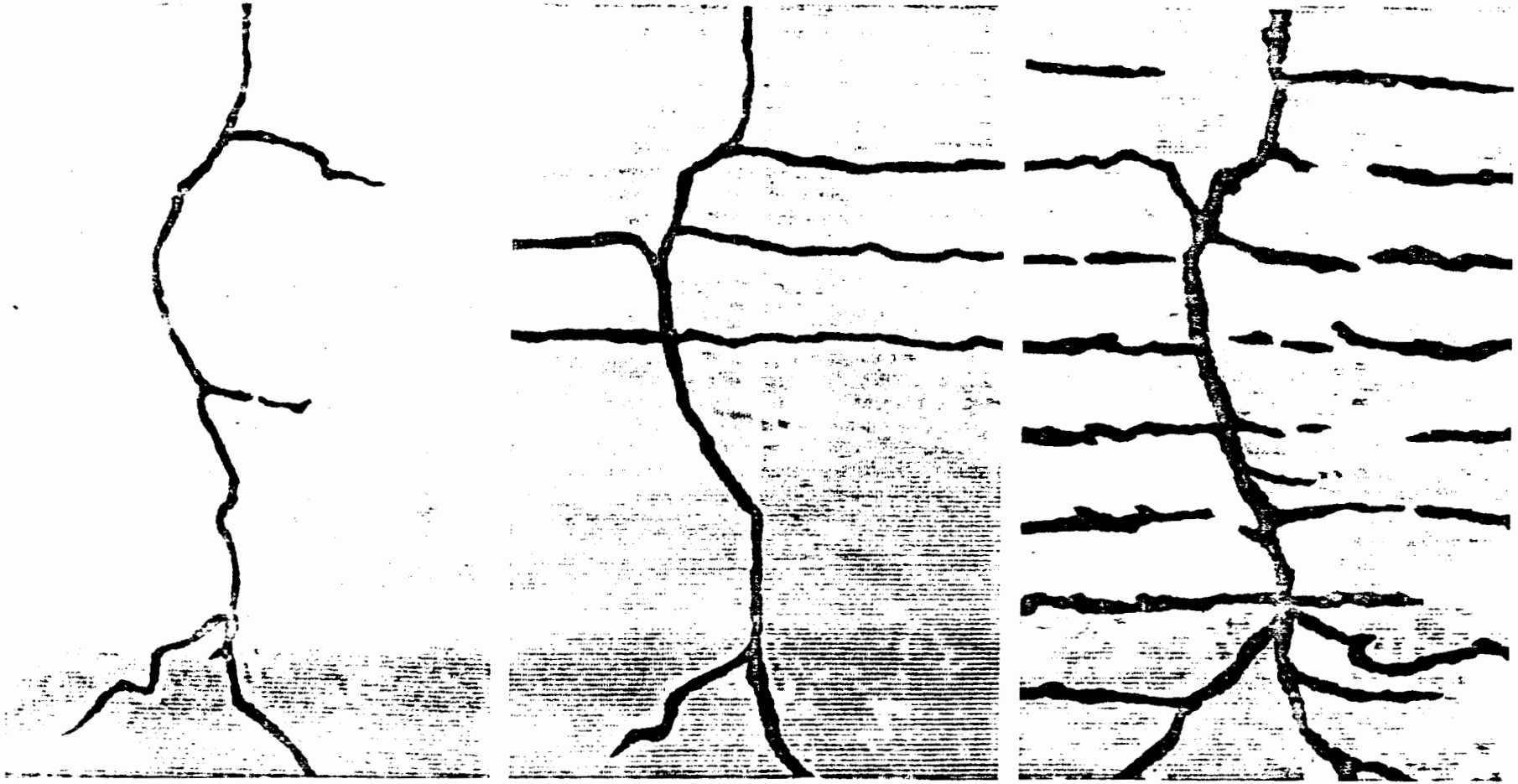
Brazil's national Government has the task of balancing the interests of different generations and interest groups. At the same time, the Amazon has long suffered from exploitation as a colony whose products serve mainly to benefit other parts of the globe, most recently and importantly the industrialized regions of Brazil's Central-South. The unsustainable land uses resulting from this kind of "endocolonialism" 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 the development objectives are essential as a prerequisite for any planning. Development alternatives should 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 agro-ecosystems, 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 untapped benefits from the rainforest. The folly of present trends toward rapid conversion of rainforest to low-yielding and short-lived cattle pasture is evident, at least when decisions are based on the long-term interests of Amazonia's residents. ■

The Pace of Destruction

10 Years Ago

5 Years Ago

Present Day



The graphics above show the extent of forest destruction over a ten-year period in a section of the state of Rondônia in Brazil. Adapted from "The Warnings From the 21st Century" broadcast by NHK, Japan's National Broadcasting Corporation.