DEFORESTATION AND AGRICULTURAL DEVELOPMENT IN BRAZILIAN AMAZONIA*

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Efforts to control the process of deforestation will be ineffective unless they are founded upon a correct understanding of the forces that motivate forest destruction. The deforestation process varies greatly in different parts of the region (Fig. 1). Forest is converted to a variety of other uses, often for ulterior reason rather than the direct products of the new undertaking (Fearnside, 1986a).

Cattle Ranching

Cattle pasture dominates land use in deforested areas of Brazilian Amazonia, greatly magnifying the impact of a small human population on the forest (Fearnside, 1983a). The yield of beef is minuscule because of a steady decrease in pasture grass productivity caused by decline in available phosphorus in the soil, soil compaction, erosion, and invasion by inedible weeds (Fearnside, 1979a, 1980a; Hecht, 1981, 1983). The beef is almost all consumed within Brazil: the presence of hoof-and-mouth disease (afthosis) blocks exports of frozen beef to North America and Japan, thus sparing Amazonia the awesome force that international markets exert in Central America through the "hamburger connection" (see Myers, 1981; Nations and Komer, 1983). Maintaining pasture productivity past the first decade or so requires inputs of phosphates (Serrão and Falesi, 1977, Serrão *et al.*, 1979). The level of inputs required could not be justified without massive subsidies and, on the vast scale of Amazonian pastures, are limited by the dimensions of this nonrenewable resource (Fearnside, 1985a; see also Fearnside, 1987a). Amazonia has no known phosphate deposits, with the exception of a small deposit of phosphate-bearing bauxite on the coast of Maranhão (de Lima, 1976) and a hopeful but as yet unquantified find north of the Amazon River near Maicuru, Pará (Beisiegel and de Souza, 1986). Given the poor agronomic performance and unpromising long-term prospects of pasture, the reasons for this land use dominating the landscape lie elsewhere.

One reason is the generous suite of financial incentives granted to large ranchers by the Brazilian government through the programs administered by the Superintendency for the Development of Amazonia (SUDAM) and the Superintendency for the Manaus Free Trade Zone (SUFRAMA). These programs not only grant exemption from income tax on the ranching operations themselves but also allow the enterprises to invest in the ranches the money that the firms would otherwise pay as income tax on unrelated operations elsewhere in the country (Bunker, 1980; Hecht, 1985; Mahar, 1979; Fearnside, 1979b). Special loans are granted with interest rates below the rate of Brazilian inflation (making the interest negative in real terms). The loan programs create an additional motive to establish ranches as a front for receiving subsidized capital that, apparently, is sometimes in part diverted to more lucrative activities elsewhere (Mahar, 1979). Government subsidies account for up to 75% of the investment in the ranches (Kohlhepp, 1980): 71).

Programs for subsidizing ranches grew rapidly in the 1970s, but have ceased to expand since. In 1979 SUDAM announced that no "new" incentives would be granted in the "high forest" area of the Legal Amazon, but maintained the program of "old" (already approved) incentives for the over 300 projects underway in the high forest region, plus the possibility of "new" incentives for the wide area officially classified as transition forest along the southern fringe of the region. Most of the "transition forest" area is, in fact, an interdigitation of high forest with scrubland *(cerrado)* vegetation, rather

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than an intermediate vegetation type. LANDSAT imagery of this region reveals that ranchers preferentially clear the higher biomass forest (Dicks, 1982).

Subsidized ranching is still an important factor in deforestation, but the country's economic crisis has reduced the amount of money available for this purpose. Because the strictures are mandated by lack of money rather than by basic policy decisions on the worth of pasture, the flow of funds to the ranchers can be expected to resume once Brazil's economy recovers. Brazil's president was recently quoted as saying that he didn't "even want to hear" about the possibility of discontinuing the ranching subsidy programs *(Isto É,* 15 July 1987: 65).

Much clearing by both large and small landholders is done without benefit of the subsidy programs. Even in the heavily-subsidized ranching area on the Belém-Brasília Highway during the height of the SUDAM program only about one-half of the clearing enjoyed fiscal incentives (Tardin *et al.,* 1978; see Fearnside, 1979b). The explanation for the bulk of the pasture is the key role of this land use in land speculation (Fearnside, 1979c; 1987b; Hecht, 1985; Hecht et al., 1988). The value of land in Amazonia has been steadily increasing at a rate higher than Brazilian inflation, yielding handsome returns to anyone that can hold onto a claim and sell it to someone else. For example, during the 1970s land values in Mato Grosso were increasing at an average annual rate of 38% *after* correction for inflation (Mahar, 1979: 124); pastureland on the Belém-Brasília Highway has similarly outstripped inflation (Hecht, 1985). Part of the reason for the land value increase is desire for investments in real property as a shelter from inflation — serving a role as a store of value (similar to gold bullion) rather than functioning as an input to production. Individual properties increase several fold in value when they gain access to a road (a benefit provided by the Brazilian taxpayers and international banks that fund the highway construction program). A similar jump in value occurs when a land claim is legitimized by a "definitive title". Replacing the forest with pasture is the cheapest way to occupy the area and protect it from takeover by squatters, neighboring ranchers, or government agrarian reform programs. Pasture also counts as an "improvement" *(benfeitoria)* to justify the granting of a definitive title. Ironically, the investments in unproductive ranching enterprises are a significant factor in fueling Brazil's inflation (Gall, 1980), thus forming a vicious cycle leading to more and more pasture (Fearnside, 1987b).

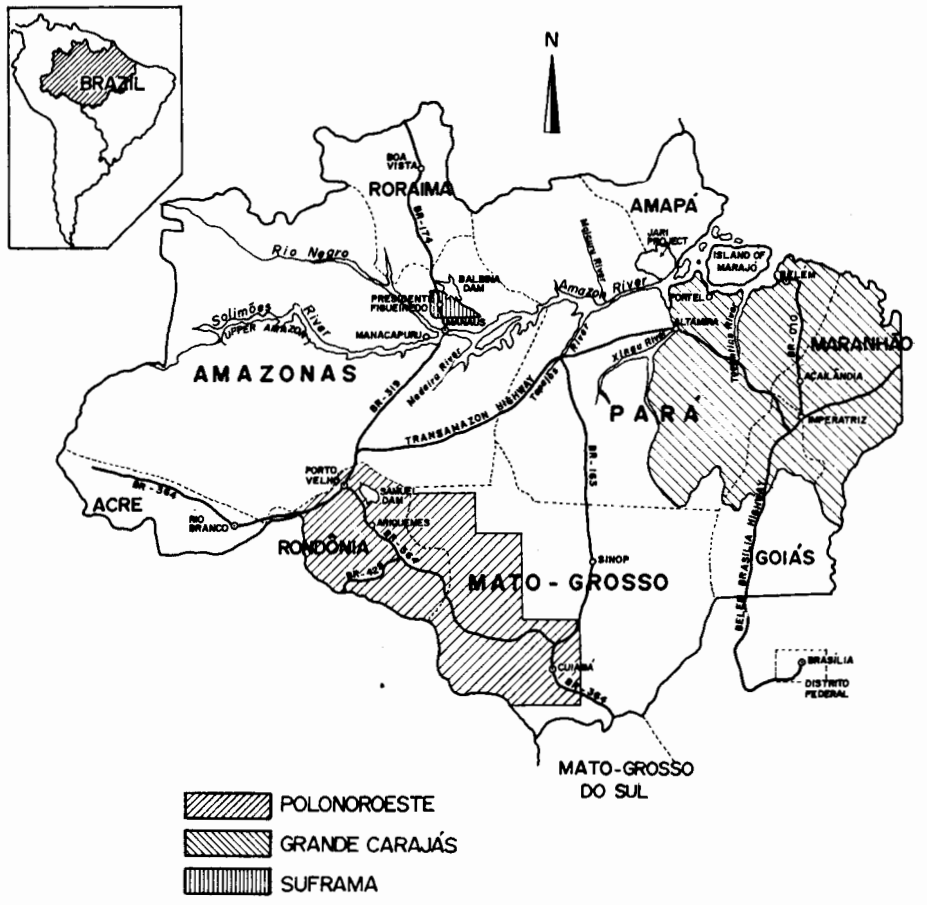

Fig. 1. Brazilian Amazonia.

Agribusiness

Agribusinesses account for a small portion of the cleared area relative to pasture, but one that could expand significantly. Large-scale plans exist for financing mechanized agriculture and associated industries in the Grande Carajás area (Brazil, Ministério da Agricultura, 1983; see Fearnside, 1986b; Hall, 1987). Much of the agricultural portion of the program is currently on hold awaiting funding; in contrast, the portions of the Grande Carajás scheme related to charcoal production have been rapidly expanding.

Silviculture

The silviculture plans in Carajás illustrate a common feature in Amazonian development: the phoenix from the ashes" phenomenon. The plan to use charcoal for processing iron ore was originally announced in 1982 by Nestor Jost, then head of the Grande Carajás Interministerial Program (Fearnside and Rankin, 1982a). A 2.4 million hectare *Eucalyptus,* plantation scheme was announced, together with a plan to collect charcoal made from native forest by ranchers, farmers, and even indigenous tribes. The scheme was greatly reduced in the 1983 "Programa Grande Carajás-Agrícola" plan (Brazil, Ministério da Agricultura, 1983; see Fearnside, 1986b). Suddenly the charcoal plan reappeared on a huge scale, with a charcoal demand that would require over 700,000ha of *Eucalyptus* — almost ten times the area of Jari's managed plantations (Fearnside, 1987c, 1988, 1989). The plan has subsequently grown even bigger with pig-iron production expected to total 2.8 million metric tons annually Fonseca, 1987: 32), which corresponds to maitaining 787 x 10^3 ha of *Eucalyptus* (slightly over 10 times the plantation maintained at Jari) or to deforestating 82 x 10^3 ha of native forest per year. Pig-iron production began in

Açailândia, Maranhão on 8 January 1988.

The silvicultural plantations at the Jari Project, used to produce pulp manufactured in the estate's own mill, were initiated by the Northamerican shipping magnate D. K. Ludwig in 1968. Many features of the site, the project's founder and the concessions granted by the Brazilian government make it unlikely that similar undertakings will multiply in the region (Fearnside and Rankin, 1980, 1982b, 1985). Ludwig sold a controlling interest in the estate to a consortium of Brazilian firms in 1982; the price paid was a small fraction of the cost of establishing the enterprise. Jari has suffered a number of biological problems, including poor growth of some of the first plantations that were located on inappropriate soil, much lower growth rates overall than originally anticipated and losses to a variety of pests and diseases (especially the fungus *Ceratocystis fimbriata* in Jari's hallmark tree species: *Gmelina arborea*). The dramatic rise in pulp prices that Ludwig foresaw for the 1980s has not yet materialized. Although a profitable kaolin (China clay) mine in the estate has permitted the project as a whole to cover its operating expenses (but not its burden of debt service), the silviculture sector has been losing money: in 1985 the loss was US$47 million (Fearnside, 1988). While some of Jari's early problems can be attributed to uninformed decisions on the part of Ludwig himself, the continuing biological problems of the plantations in no way reflect poorly on the quality of management but rather indicate that large-scale silviculture in Amazonia is much more expensive and much more difficult than many planners might think. It is foolhardy to imagine that a plantation scheme in Carajás ten times larger than the one at Jari can operate without major difficulties.

The likely result in Carajás is that charcoal production will be supplied from native forest for as long as accessible stands remain in existence. The initial decision to implant the pig-iron smelters, apparently taken without benefit of any analysis of the environmental impacts of supplying the charcoal, could lead to the entire economy of the affected area being pulled into feeding these enterprises with wood, much as a bird is drawn into feeding a cuckoo's chick in its nest (see Fearnside 1987c).

When the first pig-iron smelter began production on 8 January 1988, the company (Companhia Siderúgica Vale do Pindaré) had drawn up a forestry management plan for producing wood for charcoal in the future. However, at the time that I visited the operation two weeks later, it had not yet purchased a tract of land for implanting the management scheme. Clearly the management schemes are neither sufficiently detailed to require knowledge of a specific tract of land nor are the tracts pre-requisites for beginning operation. The Carajás pig-iron scheme is the latest in a long list of development misadvenures in Amazonia where projects have been decreed before confirming their sustainability and level of impact (Fearnside, 1985b).

Alcohol

Alcohol is one product for which great potential has been proclaimed for development by agribusinesses *(e.g.* Abelson, 1975). The efforts to exploit this potential have so far met with mixed success. The Abraham Lincoln Sugar Cane Project (PACAL), begun in 1972 on the Transamazon Highway 90km west of Altamira, Pará, has experienced a long series of problems. Originally for sugar, the mill now produces only alcohol. The site was located in an area that agricultural zoning had previously shown to be climatically inappropriate for sugar cane (Moraes and Bastos, 1972: Fig. 8). The cane grown at the site has a low saccharose content, which has caused much of the production of surrounding farmers to be rejected by the mill, leading to severe social tensions. The social tension has been aggravated by grave administrative, technological and human-relations mistakes, for example telling farmers to harvest their cane on a specified date whereupon the promised transportation is not delivered and the cut cane quickly loses its sugar content. On several occasions the area's farmers have not been paid for many months after delivering their cane to the mill. A succession of firms running the operation have failed to establish a working relationship with the farmers, and have resorted to violence to keep the farmers in line. A larger cane alcohol project, with financing from the World Bank, is now being implanted by Alcobrás in Acre; the first 5000ha plot of this 20,000ha scheme is nearing completion. Cane from the Alcobrás estate will be supplemented with purchases from local farmers. Social problems have already begun in the Acre scheme in the aftermath of expelling 80 families of rubbertappers and small farmers from the area. A 5000ha cane plantation and alcohol distillery began production in late 1988 in President Figueiredo, north of Manaus.

Manioc (cassava) alcohol produced in Amazonia, seen by Abelson (1975) as a potential solution to the coming end to fossil petroleum, has not proved the panacea that it was originally hoped to be. Producing alcohol from manioc is more expensive than producing it from sugar cane, in part because of the energy supplement the bagasse from the cane contributes to the process. At Sinop in northern Mato Grosso an agrochemical firm has produced manioc alcohol from tubers both grown on their own estate and purchased from surrounding farmers. Sweet potatoes and sorghum have also been used. In 1987 the firm discontinued using manioc because of the costs and uncertainties of using migrant labor force to harvest the tubers. The firm now uses sorghum grown in mechanized plantations on the estate for producing alcohol for use in beverages — a higher value product than the fuel alcohol obtained from manioc or sweet potatoes. The market limitations on expanding plantations of this kind are, however, much more severe than is the case for fuel crops.

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Perennial crops

Market limits severely limit the areas to which many of the crops can expand that are favored by agribusinesses. Because Amazonia is so large, any significant portion of the re-

gion planted to perennial crops would saturate world markets for these commodities. The prices of most products are already low from the farmers' point of view, with financial losses and changes in land use resulting whenever the prices dip. Cacao, for example, has been falling in price since its high in 1977, with the exception of a brief rise after the 1982/83 El Niño-provoked droughts in Africa destroyed cacao plantations there. A long-term fall in cacao prices was foreseen by World Bank economists *before* the major cacao planting effort in Rondônia was launched under the POLONOROESTE project (International Bank for Reconstruction and Development, 1981).

Plant diseases severely curtail the potential for conversion of large areas to perennials (Fearnside, 1980b, 1983b, 1985a). Cacao and rubber are both native to Amazonia, and consequently have all the diseases to which they are heir waiting to attack them. Witches' broom disease *(Crinipellis perniciosa)* in cacao and South American leaf blight *(Microcyclis ulei)* in rubber already have devastating effects on plantations. These diseases do not exist in Africa and southeast Asia, thus giving a competitive advantage to planters in those places. Other important perennials such as coffee, black pepper and oil palm suffer from diseases that have followed them from the continents in which these crops originated. Coffee is attacked by rust *(Helmileia vasatrix)*, black pepper by the Margarita disease fungus *(Fusarium solani* f. *piperi)* and oil palm by a recently arrived shoot die-back. Disease has an unfortunate relationship with markets that reinforces the effect of either falling or rising prices. Because it costs money and effort to control disease, farmers are less motivated to make these outlays when the product price is low, thereby allowing the infestation to become worse and making it even more expensive to bring the disease under control.

Deforestation in the Cuyubim Colonization Project in Rondônia.

Várzea *development*

The irrigated rice scheme at Jari is a unique attempt to use the Amazonian *várzea* (floodplain) for agribusiness ventures. When Jari abandoned rice cultivation in 1988, the plantation had 4,150 ha of rice; plans to expand to 12,700 ha never were realized (Fearnside, 1988; Fearnside and Rankin, 1980, 1982b, 1985). The expansion of irrigated rice to much wider areas in Amazonia, either by mechanized agribusiness as at Jari or by small farmers, is technically possible but appears unlikely under present economic conditions (see Fearnside, 1987a).

Water buffalo raising for production of milk, cheese and meat has been expanded at Jari to utilize 50,000ha. Large ranchers in other *várzea* areas of the lower Amazon, such as the Ilha de Marajó, have also adopted this method of exploiting the *várzea*. Water buffalo have been promoted by the Brazilian Enterprise for Agriculture and Cattle Ranching Research (EMBRAPA) in *várzeas* in the Amazon and Solimões (Upper Amazon) Rivers in the state of Amazonas, but have not yet reached the scale of lower Amazon developments. The "Estrada da Várzea", constructed in 1988 in the state of Amazonas, will bring settlement to infertile *terra firme* (upland) areas as a side effect of roadhuilding activity justified on the strength of the várzeas production potential, especially for water buffalo. Buffalo represent a means of using the *várzea* by large operators — competing with the subsistence and fiber crops of the small farmers that traditionally occupy this zone. Neither buffalo ranchers nor small farmers "own" the *várzea*, since all land within 50m of a river's high-water mark belongs to the Brazilian Navy.

Lumbering

Lumbering is rapidly increasing in importance as a factor in Amazonian deforestation. Timber exploitation has, in the past, been much less prominent in Amazonia than in the tropical forests of Africa and southeast Asia because of the lower density of commercially-valuable trees in South America. The tropical forests of southeast Asia are dominated by a single family of trees; the Dipterocarpaceae. Despite a high diversity on the level of species, the wood of many of these is similar enough to be grouped into only six classes for the purpose of sawing and marketing — as though there were only six species rather than several hundred. Amazonian species, being less closely related to each other taxonomically, have a correspondingly more heterogeneous set of wood characteristics. Amazonian trees have so far defied efforts to group the species into a relatively small number of categories for processing and marketing purposes. Another disadvantage is the dark color of the wood of most Amazonian trees, in contrast to the light colors that dominate in southeast Asian hardwoods. The light colored woods are more easily substitutable for such temperate species as oak and maple in European and North American furniture manufacturing.

Decimation of the tropical forests of Africa is essentially complete from a commercial standpoint, while those of southeast Asia are rapidly nearing a similar end. Exports from Amazonia are therefore increasing. Timber removal from Amazonia has occurred through rapid proliferation of small sawmills, for example in Mato Grosso, Rondônia, Acre and Roraima. Many of these have moved from areas of Brazil where timber is already reaching its end, such as Espirito Santo and the Belém-Brasília Highway in Pará. A steady stream of trucks bearing either logs or rough-sawn lumber can be seen entering São Paulo from Amazonia.

Lumbering is becoming an important factor in incursions into indigenous areas in Rondônia, Acre and the western portion of Amazonas. Lumbering roads serve as entry routes for squatters who clear in the hope of securing land claims. Satellite imagery of Rondônia (AVHRR interpreted by C. J. Tucker at NASA, Greenbelt, Maryland, USA) shows that the burning of 1987 included areas in such Amerindian reserves as Pacaás Novas, Tubarões and Lajes. Several of these sites are known areas of logging penetration, such as the portions of the Pacaás Novas reserve supplying sawmills in Ouro Preto do Oeste.

Lumbering in the uplands *(terra firme)* is rapidly destroying stocks of some of the most valuable species, including "cerejeira" *(Amburana acreana)* and "mogno" *(Sweitenia macrophylla)*. In the flooded várzea forests — the first to be affected because of the ease of transporting logs by water — commercial species such as "ucuúba" *(Virola* spp.) are rapidly declining.

Some of the processing and logging is done by large firms such as Georgia Pacific, which has a series of approximately 60 properties near Portel, Pará (R. W. Bruce, pers. comm., 1988) totalling about 500,000ha (Cardoso and Müller, 1978: 161). The company's veneer plant at Portel produces 150,000m³ annually, and supplies approximately 25% of the North American market for tropical hardwood veneer. So far most of the wood is purchased from private loggers outside of the company's estate (R. W. Bruce, pers. comm., 1988). Most logging, however is done by thousands of relatively small Brazilian operators rather than by large multinationals. In Amazonia as a whole, at least half of the logging activity is believed to take place in "clandestine" operations outside of the control and tax-collection efforts of the Brazilian Institute for the Environment and Renewable Natural Resources (IBMARNR), which replaced the former Brazilian Institute for Forestry Development (IBDF).

The cutting of "noble" hardwoods is spreading rapidly as road access improves to previously-remote areas and as market pressure increases. The less-noble woods are also increasingly finding markets, and it is this sector that has the greatest potential for expanding the impact of wood harvest on deforestation. Contracts with less demanding markets such as China and India have been negotiated in some cases, for example, for wood from the Samuel Hydroelectric Project in Rondônia. Delegations from heavily deforested countries such as these have been visiting the region with increasing frequency in search of wood supply contracts. However, one contract to supply China with pig-iron (a product manufactured with charcoal) was recently cancelled by the Chinese *(A Crítica,* 8 August 1987).

Efforts continue to develop ways of using more of the forest's diverse species. The possibility that an entire forest can be simply ground up and shipped away for manufacture of chipboard or low-quality paper products is indicated by the use of this procedure in lowland Papua New Guinea. This is euphemistically called "total harvest" by the Japanese firms that practice it there (Routley and Routley, 1977). So far Amazonia has been spared the common sight in southeast Asia of mountains of wood chips being loaded onto ships for export. The dwindling of forest resources elsewhere, combined with continuing technological progress in using the available species, increase the likelihood of chipping becoming a factor in the destruction of Amazonian forests.

Chipping of selected native forest species is used as a supplement to plantation sources for pulpwood at Jari. The number of species used for this purpose has decreased from 80 in 1983 to 40 in 1986 (Fearnside, 1988: 18). The reduction in species used maintains a more consistently high quality in the pulp; for lower quality paper or cardboard such standards need not apply.

The use of wood chips for fueling thermoelectric plants is another possible contributor to deforestation. A series of wood-fueled power plants is under construction in the states of Amazonas and Rondônia. Two (Manacapuru, Amazonas and Ariquemes, Rondônia) are already functioning. The expansion of this use depends heavily on the price of oil. High oil prices made the initial plans a priority in the early 1980s, but subsequent decline in oil prices has removed much of this incentive. For example, the Balbina hydroelectric scheme had a 7.5 MW wood-burning thermoelectric plant to supply the construction site. This was deactivated and replaced with oil generators in September 1987, over a year before hydroelectric generation began. Two MW thermoelectric plants were to use wood from the area around the reservoir; the parts for these, which were already arriving at Balbina, were transferred to Manaus for conversion to an oil-fueled supplemenary plant here. The low price of oil is the key factor in the change of plans, not sudden awareness of the value of maintaining forest. Since the earth's stocks of petroleum are being rapidly depleted, oil prices are certain to rise in the future — thereby increasing the attractiveness of wood-fueled thermoelectric plants.

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Slash-and-Burn Agriculture

Shifting cultivation, with long fallow periods capable of regenerating the soil after a year or two of use under annual crops, is minimal as a factor in deforestation in Brazil. Only indigenous peoples and some *caboclo* farmers use this traditional practice. Pioneer agriculture, however, is a major and growing force in Brazilian Ama-

zonia. Pioneers coming to the region from other parts of the country fell and burn the forest in the same way as the first step in traditional shifting cultivation, but after the brief cropping period they either leave the field fallow for a short time (insufficient to regenerate the productive capacity of the sites), or, more frequently, plant the area in pasture. Shifting cultivation as a sustainable practice requires a complex set of cultural traditions in the form of folk knowledge and respected customs such that farmers do not reduce the fallow period and set in motion the degradation process. Even though the system could potentially support a sparse population in a sustainable fashion, it is doomed to fail for pioneers because of population pressure, demand for cash generation, cultural bias against those who have secondary forests, and/or speculative motives for planting pasture instead.

Slash-and-burn pioneer agriculture has long been a major factor in Amazonian portions of Peru and Ecuador, but has been overshadowed in Brazil by the rapid increase of pasture on large ranches. The importance of slash-and-burn is increasing relative to large ranchers because of the shortage of funds for financing ranchers and because of the increasing expulsion of small farmers from southern Brazil. Slash-and-burn is increasing fastest in Rondônia, Acre and Roraima. The potential for spread of this kind of clearing by small farmers is much larger than what has been experienced so far, but the future course of its expansion depends on political decisions to which strong opposition exists. A far-reaching agrarian reform plan was announced by Brazil's President Sarney in 1985. The original plan called for the land for redistribution to be disappropriated from large landholdings (Brazil, Ministério de Reforma e do Desenvolvimento Agrária, 1985: 30) If implemented in this way the plan would help slow deforestation. However, landowners have exerted strong pressure to (1) stop the plan altogether and (2) have the plan interpreted to require first the distribution of government land. Since virtually all of the land still in the public domain is located in Amazonia, such an interpretion would make agrarian reform a mere euphemism for colonization of the type that has given poor results on the Transamazon Highway, in Rondônia, and elsewhere. Colonists from southern states are already being resettled under the "agrarian reform" plan in such areas as Presidente Figueiredo, in the state of Amazonas. Carried to its logical conclusion, using Amazonia as an escape valve for settling landless people spells disaster in both sacrificing the forest and implanting a nonsustainable form of agriculture on a massive scale. Brazil's Legal Amazonia has an area of five million square kilometers; if the entire region (including reserves and already-occupied land) were divided equally among the country's 10 million landless families, each would receive only 50ha (half the area of lots on the Transamazon Highway). The inability of Amazonia to solve the social problems of other parts of the country must be recognized by national policy makers.

Further speeding the process of frontier expansion and deforestation are highways and settlements associated with mining, hydroelectric development, and military bases. Recent changes in the relative importance of the forces driving deforestation include increasing impact of logging (especially in Amerindian areas), increasing impact of small migrants relative to large ranchers, and decreased effect of fiscal incentives for large cattle ranches, The reduced availability of incentives is the result of Brazil's economic crisis rather than any fundamental policy change recognizing the unsuitability of the region's soils for development in the migrant source areas outside of Amazonia.

Decimation of the tropical forests of Africa is essentially complete from a commercial standpoint, while those of southeast Asia are rapidly nearing a similar end. Exports from Amazonia are therefore increasing.

Conclusions

Deforestation is accelerating in Brazil's Amazon Region as a combined result of a variety of forces linked to agricultural development in Amazonia and in other regions of Brazil. Most of the cleared area is converted to non-sustainable land uses such as cattle pasture. Efforts to contain deforestation and redirect development to sustainable land uses will only be effective if the underlying processes driving forest clearing are addressed. These include the expulsion of population from southern and northeastern Brazil by continued concentration of land in large holding and by substitution of labor-intensive crops by ranching and mechanized agriculture, and the use of pasture in Amazonia as an effective and cheap means of protecting land claim against invasion by squatters, expropriation, or loss to other ranchers or speculators. Roadbuilding and land speculation are linked to deforestation in a vicious cycle that leads to exponential increase in cleared areas. The points in the system most susceptible to government control are decisions on building or improving highways, the policy of recognizing land tenure claims based on pasture as a *benfeitoria* (improvement), and the priorities for agricultural and industrial pasture. The slowing of clearing driven by this force is therefore temporary, since money can be expected to flow into the ranching incentives again when Brazil's economy recovers from its current crisis. The rapid pace of deforestation means that actions must be quick and decisive if the process is to be altered before the forest is eliminated or reduced to insignificant remains.

Probable effect on deforestation must be assessed prior to development projects becoming "irreversible"; projects judged to provoke excessive clearing must be cancelled, rather than merely allotting additional funds to research, monitoring and palliative countermeasures. Brazil's "macro-zoning" plans must be implemented and respected, including parks and reserves of various types — such as extractive reserves for renewable exploitation of nontimber forest products. Defense of parks and reserves must be pursued with vigor, backed by adequate financial, legal and police resources.

Ultimately, new forms of economic calculation must be devised and used in judging development options and in distributing financial rewards, such that sustainable land uses that maintain the forest become profitable, and unsustainable and environmentally-damaging forms become unprofitable.

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