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BRAZIL'S AMAZON SETTLEMENT SCHEMES: CONFLICTING OBJECTIVES AND HUMAN CARRYING CAPACITY

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INTRODUCTION

The Brazilian government's decision to promote rapid settlement in the Amazon through road construction and colonization programs has contributed significantly to deforestation in rainforest areas without achieving many of its stated goals. An examination of the motives for this decision, the nature of colonization programs, and the competing claims of other occupation and exploitation patterns receiving government support over the past decade, will make clear some of the reasons for frequently expressed disillusionment with the results. Examination of appropriate development objectives for the region, and potential conflicts among these, is an essential first step in planning developments that sustain human welfare in the region and minimize the adverse effects of development. An important precondition for achieving such objectives is the maintenance of human population below carrying capacity, an unlikely event in the absence of planning based on adequate carrying capacity estimates. Such estimates must be made against the background of conflicting pressures within the region's development programs.

BRAZIL'S COLONIZATION OF THE AMAZON

MOTIVES

The drive to settle the Amazon is a continuation of earlier Brazilian government efforts to develop the interior, such as the construction of a new national capital at Brasília (1956-1960), and the building of the Belém-Brasília Highway (1957-1960). Following the entry of the present government in 1964, efforts were redoubled, with the opening of the Cuiabá-Porto Velho Highway connecting Mato Grosso with Rondônia in 1965, the improvement of the Belém-Brasília Highway for year-round traffic in 1964, the creation of the Superintendency for Development of the Amazon (SUDAM) in 1966, and the Manaus Free Trade Zone (SUFRAMA) in 1967. Colonization projects were also undertaken in the Amazon during this period (Tavares et al., 1972). Not until 1970, however, did the great push begin with the announcement of the National Integration Program (PIN) and the building of the Transamazon Highway.

During an emotion-charged speech to drought victims in Recife in northeastern Brazil, on June 6, 1970,(1) President Medici promised to do something about their plight. Ten days later plans for the National Integration Program and the Transamazon Highway were announced (Decree Law 1106). Bids were solicited from contractors for constructing the highway only two days later (Rebelo, 1973: 87). The highway was to stretch from Recife and João Pessoa on the Atlantic coast at the 'bulge' of Brazil to the Peruvian border near Cruzeiro do Sul in Acre: a total length of 5400 km, about 3000 km of which is in Amazonia (Fig. 1).

Social factors were emphasized as the offical justification for programs to develop the Amazon. Poverty in northeastern Brazil was the immediate issue, especially following the drought of 1970. Overpopulation was stressed as a root cause, although other problems such as extreme inequality in land tenure distribution were not addressed. The transfer of poor northeasterners to colonization areas along the Transamazon Highway was put forward as the solution. Some 65% (de Arruda, 1972: 5.9) to 75% (Brazil, Ministério da Agricultura, INCRA, 1972a: 1) were to come from

the northeast, although in fact only 30% of those settled in the Altamira area by the end of 1974 actually came from that region (Brazil, Ministério da Agricultura, INCRA, Coordenaria Regional do Norte CR-01, 1974).

A second official goal was economic benefit for the country. The colonists were to receive agricultural credit and technical assistance to enable them to produce a surplus for export to other parts of the country or to other nations. The road would also make timber and mineral resources accessible. One government pamphlet speaks of the "ecstatic panorama" of mineral wealth along the highway (Brazil, Ministério da Agricultura, INCRA (ca. 1972): 6). J.M.G. Kleinpenning (1979: 38) suggests that the initial stress laid on social motives was merely a "useful political maneuver" (see also Ianni, 1979), and that other motives, especially the achievement of economic growth, were more important.

A third motive is believed to be strategic geopolitical considerations (Kleinpenning, 1979; Lima, 1973). The fear that Amazonia is never far from invasion by foreigners is a recurrent one in Brazil. The four editions since 1957 of Artur César Ferreira Reis's (1972) A Amazônia e a Cobiça Internacional ('Amazonia and International Covetousness') testify to this. A casual suggestion attributed to a speech made by Harrison Brown, author of The Challenge of Man's Future (1954), that the population problems of India might be "solved" by moving populations to Amazonia (Reis, 1972) made headlines in Brazilian newspapers. In his book Principles of Political Economy, economist Kenneth Boulding suggested moving 200 million Asians to Amazonia contributing to concern in Brazil (Pinho Filho, 1979: 119). Rapid occupation of the area by Portuguese-speaking Brazilians was seen as the best defense against this potential influx of foreigners. One of the objectives proclaimed for the National Integration Program was to "mark, by the presence of Brazilian men in Amazonian lands, the conquest for themselves and for their country, of that which always belonged to them, so that no one would ever dare to contest them on this objective" (Brazil, Ministério da Agricultura, INCRA, 1972a: 1). More than the possibility of invasion from outside, Kleinpenning (1979: 38) stresses the strengthening of Amazonia as a base for Brazil's pursuing what he calls its own "sub-imperialistic motives" (see also Tambs, 1974).

Other motivations include the regime's desire for prestige, both international and national, and the pressures of national politics (Kleinpenning, 1979: 4).

> "Spectacular and exciting actions of government, such as the active development of the Amazon region and enthusiasm for it among larger sections of the population, can result in political conflicts being felt less severely for a time and in attention being temporarily diverted from such matters as lack of political freedom, torture, and social injustices" (Kleinpenning, 1979: 4).

In 1970 when these problems were at a high point, promotion of the Transamazon Highway in São Paulo and other places through billboards, advertisements in buses, on T-shirts, and so forth went far beyond the announcements needed to recruit prospective colonists. The flood of migrants to São Paulo from the northeast was seen by the public as the source of all urban ills, making a highly visible alternative popular (Katzman, 1976: 456). Political stability is seen as the goal of promoting enthusiasm and euphoria for projects such as the Transamazon Highway (Kleinpenning, 1979: 4).

It is perhaps ironic that the same solution had been considered by previous governments. In The Hungry Planet, published five years before the drought of 1970 and the Transamazon Highway, Georg Borgstrom (1965: 317) wrote:

> "Another catastrophe [drought] scourged this region [northeast Brazil] in 1957-58 when 70 percent of the crops were lost..... Each time this happens, agitators get new grist for their revolutionary mills.... One Brazilian secretary of finance came to talk the United States Government into financing the transfer of this population to the Amazonas."

The idea of transferring northeasterners to the Amazon after the recurrent dips in the short-term capacity of the area to support a human population is not new: Emperor Dom Pedro II offered drought victims free passage to the ports of Belém and Manaus following the drought of 1877 (Morais et al., 1970: 115).

It is fruitless to search for a single motive for initiating the highway construction and colonization programs in the Amazon. Many reasons undoubtedly contributed to the attractiveness of this course of action. The question of how colonists should be selected and colonization programs pursued hinges on the sometimes conflicting implications of the various motives. Many of the motives that contributed to decisions regarding past programs will be important as future programs are planned and executed.

COLONIZATION PROGRAMS

COLONIZATION PROGRAMS PRIOR TO 1970

Nonindigenous settlers have been colonizing the Brazilian Amazon since the sixteenth century. The major settlement pattern in most of the region has been sparse dotting of the riverbanks with villages or individual holdings of caboclos(2) who have traditionally supported themselves with subsistence plots of annual crops, mainly manioc, and by fishing, hunting, and extracting forest products such as Brazil nuts (Bertholetia exelsa), rubber (Hevea brasiliensis), and animal skins (Wagley, 1976; Moran, 1974).

Intensive settlement took place along the railway constructed from Belém to Bragança at the end of the nineteenth century. Agricultural colonies were established to supply agricultural products to the rubber boom city of Belém (de Camargo, 1948; Sioli, 1973; Penteado, 1967). The dense population in the Zona Bragantina practiced an accelerated shifting cultuvation with inadequate fallows, resulting in soil exhaustion and declining crop yields (de Camargo, 1948; Egler, 1961; Ackermann, 1966; Sioli, 1973, 1980). The decline of agricultural productivity, with subsequent population emigration and abandonment of much of this 30,000 km^2 area to second growth, is an example of what can occur if colonization programs in the Amazon exceed carrying capacity (see Penteado, 1967).

Other types of colonization have involved the establishment of more specialized groups, such as the colonies of Japanese immigrants, who have concentrated on growing black pepper (Piper

nigrum) and vegetables (see Fearnside, 1980a). Rubber plantations have also formed the basis for past colonization, aside from the thousands of scattered gatherers of rubber from wild trees in the forest. The Ford Motor Company established plantations at Fordlândia on the Tapajós River between Santarém and Itaituba in 1926 (later abandoned), and 100 km downstream at Belterra in 1934 (later turned over to the Brazilian government when failing as an economic venture) (Sioli, 1973).

The colonization of the Brazilian Amazon through planned small farmer settlements, as well as other types of settlements along new highways, dramatically accelerated in 1970 with the announcement of the National Integration Program.

THE NATIONAL INTEGRATION PROGRAM

The advent of the National Integration Program led to the creation of a new government organ for colonization, INCRA (the National Institute for Colonization and Agrarian Reform). INCRA set out to colonize areas in Amazonia by the establishment of PICs (Integrated Colonization Projects) and PADs (Directed Settlement Projects). The colonization of the Transamazon Highway is divided into three separately-administered areas: Marabá, Altamira, and Itaituba, all established in the early days of the National Integration Program. There are also five PICs in Rondônia (Brazil, Ministério da Agricultura, INCRA, 1972b; Valverde et al., 1979).

Directed Settlement Projects (PADs), a more recent form of planned colonization, do not provide as much supportive infrastructure for the settlers as do the PICs. The two PADs in Rondnia were established in 1974 and 1975. Another PAD is currently underway in Acre, a state in Western Amazonia bordering on Peru. The high cost of implanting and administering the PICs, together with the fact that colonists have shown themselves to be more than willing to migrate to the Amazon without the inducement of services offered by these projects, undoubtedly explains the current emphasis on PADs. Colonists to be accommodated in PADs are also expected to have greater financial resources than those in PICs (Neves and Lopes, 1979: 87).

The colonization programs in the three PICs of the Transamazon Highway were to settle 100,000 colonist families over a period of five years.(4) The colonization areas were laid out in accord with what INCRA called the "philosophy of rural urbanism" (4) (da Cunha Camargo, 1973). Colonists' lots are served by a hierarchy of three types of planned centers: the agrovila, a small village of about 50 houses layed out in a rectangle, the agrópolis, a town expected to service 22 agrovilas (Brazil, Ministério da Agricultura, INCRA, 1972a: 67) or 8-10 agrovilas (da Cunha Camargo, 1973: 16), and the rurópolis, a city to have a population of around 20,000 (Brazil, Ministério da Agricultura, INCRA, 1972a: 67). In reality only 29 agrovilas, two agrópolis and one rurópolis were ever actually built (Kleinpenning, 1979: 22). By December 1974, only 5717 families had settled on the highway (Smith, 1976) far short of the goal of 100,000 by 1976. New settlement of small colonist lots on the Transamazon Highway has remained at a virtual standstill since that time, although preparations were being made for regularizing squatter claims in an area east of the Altamira PIC in 1982.

The emphasis of colonization programs has changed regularly since the initial launching of

the National Integration Program. A major policy change occurred in 1974, when colonization by individuals on 100 ha lots was de-emphasized in favor of "colonization" by large corporations (O Estado de São Paulo, 24 May 1974: 11). These large corporations mainly cattle ranching operations, included both giant internationals and hundreds of Brazilian investors from urban areas in southern Brazil. Smaller ranches were sold by INCRA in the area beyond the strip of small colonist settlement on the Transamazon Highway. Ranches of 3000 ha each were sold in the area about 150 km west of Altamira beginning in 1974. Similar sales were made in Marabá and Rondônia. From 1977 onwards, 500 ha ranches--called glebas --were sold in strips about 30 km wide beyond the edges of the small colonist settlement between l2 and 85 km west of Altamira. Land is sold through the process of licitação, soliciting sealed tenders for individual parcels with a minimum bid of 2% of the official minimum monthly wage per hectare, or about US$ 1.08 per hectare.

Promotion of large cattle ranches led by SUDAM competed for land and financial resources with the small farmer colonization schemes planned by INCRA. In Brazil, the frequently opposing purposes of different government organs often exacerbate the problem of inconsistent development objectives. Conflicting mandates of official agencies stem from a long-standing tradition of allowing, or even encouraging, such interest groups to struggle among themselves for dominance, higher level decisions awaiting the outcome of these contests (Bunker, 1979). The tradition parallels the frequent practice of government authorities settling squatter or other land claims by allowing the interested parties to resolve the dispute by force before legitimizing the claim of the victor.

Colonization schemes by private cooperatives have been encouraged to avoid the many inefficiencies inherent in government colonization. Such a private colonization scheme was to be undertaken in an area south of the Transamazon Highway about 110 km west of Altamira, on the left bank of the Iriri River. It was announced in 1976 that this area would be colonized by COTRIJUI (Cooperative Tritícola Serrana), a cooperative of small farmers from the extreme south of Brazil, with each of the 2000 families receiving a 200 ha lot (O Estado de São Paulo, 21 May 1976). This plan replaced an earlier one to colonize the area through INCRA (Hirano, 1974). The cooperative has not been able to begin the proposed colonization project because of hostile Arara Indians living in the area. FUNAI (the National Indian Foundation) continues its efforts to dislodge the tribe, which on 22 February 1981, made its first peaceful contact with Luso-Brazilian culture since the Transamazon Highway was built through the tribe's lands 11 years previously (Veja, 11 May 1981: 72-76).

SPONTANEOUS SETTLEMENT

The largest part of the settlement in the Amazon today, as in the past, is done with no government or other planning whatsoever. Unplanned colonization by squatters, the traditional means of settlement, has engendered many bloody fights throughout Amazonia between squatters and either landowners holding documents for legal ownership, or the more feared grileiros, speculators making their living by contracting thugs (jagunços or pistoleiros) to drive small farmers off the land they occupy. Grileiros obtain official (often fraudulent) documents allowing sale of this land to ranching interests (Bunker, 1980; Martine, 1979, 1980; Martins, 1980; Wood and Schmink, 1979). Settlement of the Belém-Brasília Highway took place in this way, with the land first cleared by small farmers without documents, and later taken over by large ranchers (Valverde and Dias,

1967: 276). Sometimes the process worked in reverse, with absentee investors losing land they had bought to squatters (Sanders, 1971).

Official colonization programs cannot cope with even a small fraction of the influx of new migrants to the Amazon: of the 8000 persons who were registered crossing a government checkpoint entering Rondônia from the State of Mato Grosso in September 1979, 7000 settled in Rondônia. While the flow averages over 2000 families per month over a twelve month period, it is reduced but not stopped during the rainy season, with 3671 persons in 900 families entering during January and February 1980 (A Crítica, 12 March 1980, Cad. 1, p. 7). The flow of migrants increases yearly, the January-February flux at the checkpoint nearly doubling to 6435 persons in 1981 (Modesto, 1981: 26). Migration figures from the government checkpoint are substantially lower than actual flow, since many migrants pass uncounted. Through the end of 1977 INCRA had settled 12,660 families on 2,732,550 ha of land in Rondônia, as compared with a total between 5000 and 6000 families on 100-hectare lots in the three colonization areas of the Transamazon Highway. While Rondônia currently has the most INCRA-planned colonization projects of any part of the Amazon, lots in these projects are fully occupied, with the possible exception of one PIC (Sidney Girão), reportedly only half full due to its location in a remote and less fertile area where it was installed "apparently with the intent of occupying areas near the Bolivian border" (Mueller, 1980). The majority of new migrants settle in areas outside INCRA projects in the traditional pattern of spontaneous squatter settlements.

Against this background of rapidly changing social forces and official programs, thought must be given to how specific aspects of the government's guidance of development, such as settlement and population policies, would have to be oriented in order to achieve the wider goals of sustained human welfare often voiced by planners. Estimates of human carrying capacity, together with an understanding of how various factors interact to influence carrying capacity, are fundamental to any such planning (Fearnside, 1978, 1979a, 1983a, nd-a). One must begin with a clear statement of appropriate objectives for development.

APPROPRIATE OBJECTIVES

Appropriate objectives would include: (1) agronomic sustainability; (2) social sustainability; (3) unsubsidized economic competitiveness; (4) maximum self-sufficiency; (5) fulfillment of social goals; (6) consistency with maintaining areas in other uses; (7) retention of development options; (8) minimal effects on other resources; and (9) minimal macro- ecological effects. A detailed discussion of how current and proposed development types in the Brazilian Amazon can be evaluated on these criteria is given elsewhere (Fearnside, 1983b).

CONFLICTS OF OBJECTIVES

Ample room exists for conflicts among the development objectives outlined above, as well

as with others which can not in good conscience be included in a list of "appropriate objectives." Such other objectives might include maximizing the wealth of individual investors by producing the fastest possible return, and attempting to solve the problems of other regions at the expense of rainforest areas.

One frequent conflict is between individual and societal interests. The classic formulation of this conflict is the "tragedy of the commons" parable (Lloyd, l833; Hardin, 1968). The analogy is drawn with a village commons of the type existing in past centuries in the British Isles. Villagers could graze individually owned animals in a pasture which was the common property of all. Once the feeding capacity of the pasture had been reached, with the result that further increase in number of animals would lead to degradation of the pasture and lowered production, villagers would continue to stock additional animals with complete economic rationality. The fact that the full benefit of adding each additional animal to the pasture accrues to the individual, while the cost of lowered total production is spread over all villagers, means that it continues to be advantageous to each to increase his herd until the pasture is destroyed. The analogy applies directly to many common property resource situations, such as fisheries, or the family size limitation decisions emphasized by Hardin (1968). The essence of the argument, namely the balance of individual gain with shared costs, also applies to many environmental problems such as the climatic impact of some development options in rainforest areas. Even if the total costs of these impacts should be far greater than the total gains from the developments, the individual (or corporate) investor would continue to gain more than he or she loses by, for example, converting rainforest to cattle pasture.

Another type of conflict arises between individual profit seeking and the environmental and social concerns of society at large due to a basic lack of connection between the sustainability of a system and the investment patterns producing the highest economic returns. Investment decisions are made by comparing potential investments with returns obtainable from alternative investments in other parts of the larger economy, as reflected in the discount rate. Unfortunately, the rate of return that can be sustained by managing a renewable resource is limited by such biological rates as the growth rate of trees in a managed forest, which have no logical link with bankers' discount rates. If the discount rate is higher than the rate of natural regeneration, as is often the case, it is to the investor's advantage to simply destroy the resource as quickly as possible and reinvest the resulting profits in other enterprises (Fife, 1971; Clark, 1973, 1976).

The best known example is the whaling industry, where, despite numerous studies showing that continued high fishing pressure would lead to destruction of whale populations and an end to the industry, corporations continue to invest in whaling with the intention of simply scrapping equipment and reinvesting profits elsewhere at a later date (Clark, 1973). The problem is not a lack of knowledge, but the fundamental structure of economic decision making. This sad logic applies to many situations involving land use decisions in rainforest areas. The question of whether a pasture or a silviculture operation is sustainable may be of far less importance to the investor than might be assumed. There is also ample ground for hypocrisy on the question of sustainability: sustainability is nearly always declared as a development planning objective, but frequent conflicts exist between word and deed.

The question of discount rates poses a dilemma for development planning. High discount

rates lead to overexploitation of potentially renewable resources, while artificially low discount rates lead to investment in economically inviable projects and continuing the investment even when returns are poor. The latter problem has occurred with cattle pastures in the Brazilian Amazon, where generous tax and fiscal incentives programs and subsidized interest rates have led to vast areas being felled for pasture which would probably not have occurred had the projects been evaluated strictly on their own economic merits. The opportunity cost of capital is estimated at about 11% in most of Latin America by World Bank economists, and rates as high as 15% suggested as appropriate for Amazonian Brazil (Skillings and Tcheyan, 1979: 64). The actual discount rates used in economic calculations in the Amazon are undoubtedly far lower than the opportunity cost of capital, especially in the case of subsidized cattle ranching projects.

One mechanism suggested for incorporating social benefits in planning decisions is to employ a system of shadow prices in calculatitng the costs of proposed projects (Skillings and Tcheyan, 1979: 65-66). Shadow prices for labor lower than market values, and shadow prices for foreign exchange and fossil fuels at rates higher than market values, would result in favoring projects conforming to government goals.

Ideologies are singularly irrelevant to the problem of sustainable economic uses of natural resources. Adam Smith's "invisible hand" of traditional laissez faire capitalism, presumed somehow to guide economic developments which are the sum of many individuals each working for his or her own gain in such a way as to result in the best patterns for society as a whole, has proved itself incapable of dealing with the dilemmas posed by the "tragedy of the commons" and the discount rate problem. Likewise, the most fundamental tenets of Marxism are completely inconsistent with renewable use of natural resources. Marx's "labor theory of value," holding that the true value of any good is, or should be, proportional to the amount of human labor required to manufacture it, leads logically to the conclusion that a natural resource like the Amazon rainforest has no value, and therefore can be destroyed with impunity. Solutions to the dilemmas posed by natural resource management require pragmatic steps which cannot be derived from any ideology. Changes in the way financial analyses are made will have to come about if sustainable forms of development are to be made profitable and the present non-sustainable forms unprofitable.

Encouraging intensive developments on small areas is one way of relieving pressure on larger expanses of rainforest. The extremely low land prices in Amazonia is one impediment to adopting development options requiring larger capital and labor investments to make land produce on a sustainable basis. Clearly already deforested areas should be the sites for such intensive developments, not areas still under native forest. The sustainable management of natural regeneration forestry is a class of development options requiring a different set of economic guiding factors: low land costs and other capital demands. Development in Amazonia needs to be carried out in a mosaic of different patches of land, with different environmental quality restrictions, along the lines of the ecosystem development strategy proposed by E.P. Odum (1969; see also Margalef, 1968; Eden, 1978; Fearnside, 1979c). Different economic ground rules need to be instituted for each type of patch in such a mosaic strategy.

COLONIZATION PROGRAMS AND THE FULFILLMENT OF OBJECTIVES

SMALL FARMER COLONIZATION VERSUS OTHER USES

The changes in Brazilian government priorities in colonizing the Amazon are testimony to the conflicting objectives of development policies. Most important are conflicts between social objectives and others such as producing agricultural products for export to other regions or countries. To the extent that these objectives are attainable by any type of colonization, most social motives for colonization are best satisfied through small colonist settlement, in conjunction with other ancillary programs (Fearnside, nd-b). Most of the other types of activities being promoted, such as cattle ranching and silvicultural plantations, are seen as operations requiring the capital and organization of large corporations (see Fearnside and Rankin, 1980, 1982). Many appropriate objectives have not played prominent roles in planning decisions at any level. Whether small or large colonists are better in terms of these objectives depends entirely on the type of agricultural system promoted. Neither the annual crops favored by many small colonists, nor the larger cattle ranching schemes, have good prospects for sustainability (Hecht, 1981; Fearnside, 1979b, 1980b). Perennial crops, with somewhat better prospects, can be grown in operations of a wide range of sizes. Other operations, such as sustained exploitation of native forest, require organizational structures going far beyond the reach of small colonists as individuals but which do not pose insurmountable obstacles if cooperatives of other larger institutions provide organizational and equipment needs.

The problem of small versus medium or large colonists is related to land use allocation differences observed among colonist types within the small colonist settlement area on the Transamazon Highway (Fearnside, 1980c).(5) Smaller allocations of land to various crops by laborer-farmers as compared with other colonist types results in less agricultural surplus. These differences among colonist types have important implications for policies governing selection of prospective settlers.

Suggestions that former land owners be given preference (Moran, 1976, 1979, 1981) must be closely scrutinized. Objectives of colonization programs would have to be carefully assessed before recommendations following from such a finding could be formulated. If the principal objective of a settlement program is alleviating population pressure in the source areas, and more specifically reducing the numbers of landless poor, then laborer-farmers would logically be given preference over other types. If the measure of success for a program is production of an agricultural surplus for export to markets beyond the boundaries of the colonization area, then the larger areas allocated to crops among non-laborers would indicate these colonist types as preferable. From the point of view of designing future colonization programs, the fundamental conflict between the courses of action implied by the objective of agrarian reform and those implied by the objective of exportable production can only be resolved by a close examination of each program's objectives. Particularly important are land use differences within colonization areas that lead to contradictory recommendations for selection of settlers and other policies if project goals emphasize achieving an acceptable standard of living for the local populations, as opposed to supplying urban markets either inside the region or beyond (See Fearnside, 1980c: 137-138).

REDIRECTION OF DEVELOPMENT EFFORT

Several proposals have been made for redirecting development effort in the Brazilian Amazon to other regions or programs, each with different implications for development objectives. One suggestion (Goodland et al., 1978; Goodland and Irwin, 1977; Goodland, 1980) proposes channeling development away from rainforest areas in the Amazon to the central Brazilian scrubland or cerrado. Cerrado areas have the advantages of lower opportunity cost if destroyed, of being more resilient, better understood, and having less agricultural problems such as poor fertilizer response, excessive erosion, and heavy pest attack. Cerrado areas are also nearer to markets, and have better transportation and other infrastructure available. As a point of departure, the proportion of the resources devoted to Amazonian development motivated by desire to solve the problems of other regions might be better spent if applied directly to solving the problems in those regions. Not only is Amazonia incapable of solving problems of other regions on a long-term basis--even a dozen Amazonias could not solve problems which grow exponentially --but applying resources directly to problem areas is more effective on a short-term basis as well.

On a regional scale, it has been suggested that development efforts within the Amazon be concentrated in areas of second growth or degraded pasture (Rankin, 1979), in the more fertile várzea, or that efforts be concentrated on increasing production in land already under cultivation rather than on expanding the areas in production. All these options reduce motivation for felling rainforest, maintain options open, and minimize both negative effects on other resources and adverse macro-ecological effects. The várzea is particularly attractive, annual renewal of soil fertility through flooding being an even more important feature than the generally much higher fertility levels of várzea soils as compared with those of terra firme.

Concentrating effort on producing higher yields, and more sustainable yields, on the areas of várzea, second growth, degraded pasture, and already cultivated land would have to be combined with mechanisms to diminish the present strong motives for deforestation if pressure is to be relieved on rainforest areas. These motives include the very low land prices in Amazonia, and the land tenure customs and fiscal incentive structure. As of 1980 a new motivation has been added: a change in the structure of rural land tax laws in Brazil to tax undeveloped (i.e., uncleared) land at rates higher than those for "developed" land if more than a given percentage of a property is "undeveloped," and to increase the tax in successive years that land remains "unused" (Brazil, Ministério da Agricultura, INCRA, 1980).

Concentration of development in parts of Amazonia not presently under rainforest is consistent with a "dual strategy" for Amazonian development (Rankin, 1979). Under such a strategy, short-term and long-term plans would be separate, with present developments being restricted to non-forested areas, thus giving time for the research needed to develop sustainable and relatively non-destructive ways of making economic use of rainforest areas. The value of what a rainforest has to offer could be expected to increase enormously by postponing the use of these areas. Two items are essential in any long-term plans for utilizing rainforest areas in Amazonia: (1) demarcation and defense of adequate permanent reserves or different ecosystems in the area; and (2) solution of the underlying problems leading to ever-expanding destruction of the rainforest. Carrying capacity estimation is a part of the solution of these problems.

CARRYING CAPACITY AND DEVELOPMENT POLICY

Human carrying capacity estimates should be central to the formulation of development policies of all types in tropical rainforest areas. Janzen (1972a,b) recounts some of the long list of examples of ecosystem destruction in the tropics linked to exceeding human carrying capacity, and which can lead to lowered human carrying capacity through destruction of "natural capital." He aptly states:

> "... such a gloomy scenario should not obscure the obvious fact that there are ways to determine human carrying capacity of a habitat without such country-wide or global destruction. These methods are where the first priority should be placed in funding" (Janzen, 1972b: 86).

Carrying capacity has great value as a concept around which to organize development. The very nature of carrying capacity requires long-range planning, a feature so notably lacking from most of the development plans laid for rainforest areas. It also requires a holistic approach, taking into account many diverse factors often planned or studied as though they were separate and unrelated. Relationships between population density, levels of affluence, and income distribution come into sharp focus. The scales to which different objectives apply become explicit, be they rural farming populations, farmers plus urban centers within the region, or larger units still. The modeling procedure necessary to arrive at carrying capacity estimates brings many returns common to studies of systems in general. Finally, estimating the carrying capacity focuses attention on the reality of limits, countering the illusion that an infinity of resources and "agricultural potential" exists. The potential for producing affluence and for absorbing overflow from population growth and continued resource concentration in other regions is finite. Exponential growth within any area or region is incompatible with the very existence of limits such as carrying capacity, even without the overpowering influence of massive migrations from other regions so prominent in the Brazilian Amazon today.

The inseparability of land tenure patterns from carrying capacity becomes clear when carrying capacity estimates are attempted. The relative evenness of the resource distribution in the population has a close relationship with dietary and other consumption related carrying capacity measures for the part of the population at the bottom end of the distribution. Failure rates for this fraction of the population will be high, probably unacceptably high, with more uneven resource distribution.

Land tenure is also closely related to environmental quality criteria for carrying capacity. Maintaining patches of land in uncut forest requires that land tenure status be defined and inequalities be reduced. In the Brazilian Amazon, a long- standing tradition exists that land claims are established by deforesting and occupying a tract of land. The function of the legal system has largely been subsequent legitimization of these squatter claims after an area is settled. This practice provides a great motivation to deforest large areas. Laws aimed at maintaining the integrity of reserves and restricting deforestation are doomed to failure so long as this system prevails

(Fearnside, 1979c). The function of the squatter system as a safety valve for inequalities in the land tenure situation throughout Brazil means that these inequalities must be alleviated simultaneously with an end to the practice of legitimizing squatters' claims. Ecological reserves, Amerindian reserves, national parks, sustainable forest management operations, and other uses requiring standing forest will not become practical without both alleviating inequalities and an end to the squatter tradition of establishing land tenure, whether the "squatters" be poor caboclos or large enterprises.

The necessity of including population policy in development planning is a clear outgrowth of concern for carrying capacity. Such a policy includes all aspects of population: geographical distribution, age structure, rate of growth, and absolute size. The fact that exponential population growth is incompatable with limited resources is as true in the Brazilian Amazon as in any other part of the World, despite the size of the area. Brown (1974: 145) calculates that Brazil would have to double its 1974 food production by 1992 to keep pace with projected internal growth in demand, growing faster than population, which was doubling every 24 years in 1970 and 30 years in 1980. Most of the increase in agricultural production in Brazil has traditionally come from bringing new land under cultivation rather than increasing per hectare yields, with 84% of the increase between 1948 and 1962 having come from increases in cultivated area (United States, Department of Agriculture, 1965: 19, cited by Nelson, 1973: 21). This pattern cannot continue forever, given the finiteness of the country. Parts of Amazonia to feel the reality of these limits first will be immigration foci like Rondônia.

Realization of the need for a full population policy as a part of development planning has come about in some countries as a result of extremely simple calculations. In Egypt, a decision to reduce population growth was made following the realization that the increase in food production made possible by irrigation from the Aswan Dam would be entirely absorbed by the increase in population in the Nile River valley during the period the dam was under construction (Brown, 1974: 143). In Mexico a parallel turnabout in national development and population policy took place in 1972 when it was realized that great strides in food production between 1955 and 1970 were completely cancelled by population growth, and that the country had become a net importer of food (Brown, 1974: 174).

In the case of the building of the Transamazon Highway the discrepancy is even greater between official aspirations and actual results in reducing population-related poverty. The most publicized objective for building the highway was that of alleviating overpopulation in northeastern Brazil. The Brazilian Northeast had a population of approximately 25 million, growing at an annual rate of about 3%. This translates into a growth of 750,000 persons per annum, or an average of about 2055 persons per day at the time. Since all three colonization projects on the Transamazon Highway settled a total of only about 5000 families, this is equivalent to 30,000 persons at the average family size of six persons, or 14.6 days of population growth for the Northeast. Since only 30% of colonists settled in the Altamira area came from the Northeast (Brazil, Ministério da Agricultura, INCRA, Coordenaria Regional do Norte CR-01, 1974), a total of about 1500 families of Northeasterners were settled on the highway, assuming that the other two areas had the same proportion of Northeasterners as Altamira. This figure is equivalent to 9000 people, or 4.4 days of population growth for northeast Brazil.

The 4.4 days bought for the Northeast is very little. More significantly, little has been done with the time bought by the colonization programs plus the much larger flows of population to spontaneous settlement areas in Amazonia and urban centers throughout Brazil: population growth and land tenure concentration in rural areas of northeast Brazil continue, a decade after the drought of 1970. Of equal importance is the disquieting fact that no planning has been done to keep populations of settlers from outgrowing the carrying capacity of rainforest areas to which they have immigrated. Lack of such a provision has led to environmental degradation and human suffering in development projects in many parts of the tropics (Dasmann, l972: 788-89).

Planners and colonists alike look to the vast expanses of as yet uncut rainforest in the Amazon as the "solution" to any potential future problem--the "solution for 2001" as the Transamazon Highway was once dubbed (Tamer, l970). That exponential growth can quickly make a mockery of this logic can be made clear to anyone with a pocket calculator or a pencil and paper. Continuing such a trend quickly leads to filling any finite area, even an area as big as the Amazon (Fearnside, l982). What is truly important is not so much the question of how fast such areas are filling, how long such trends can continue until the last tree is cut and the last patch occupied, but rather the questions of how many people can be supported on a sustainable basis at a given standard of living (implying a given environmental quality) and distribution of income. One must assess what factors affect sustainable carrying capacities for humans, and how information about these factors can be obtained in a way usable by planners. Practical steps must be taken to avoid the human suffering that comes from outgrowing carrying capacity.

CONCLUSIONS

Settlement schemes and other facets of the occupation and human use of Brazilian Amazon region must be examined in terms of achieving overall goals of development policy. Inconsistencies have arisen from promoting production for export versus ameliorating social problems, orienting colonization and other developments to solving problems of other regions versus the Amazon itself, favoring large versus small properties and aiding wealthy versus landless colonists. A clear definition of goals is needed, as well as planning for a mosaic of land use types capable of satisfying a variety of needs in the region. Many current objectives are both inappropriate and unattainable, despite Amazonia's vast size. Suggested goals focus on long term welfare of the local population and their descendents. The design of sustainable developments is complicated by the fundamental structure of economic decision making, but efforts to make such plans based on explicit weighing of diverse factors and careful calculation of long range consequences is essential. In addition to inconsistent goals, Brazil's settlement schemes have suffered from short planning horizons and all but complete discounting of future costs. One important part of the interlocking complex of factors that must be addressed if long-term welfare of the region's inhabitants is to be assured is maintaining population density below carrying capacity.(6)

NOTES:

1. Speech reproduced in Tamer 1979: 249-253.

2. People of mixed Amerindian and Caucasian descent, or more generally, any Portuguese-speaking inhabitants of the Amazonian interior.

3. Early official references to a goal of one million families were quickly reduced by INCRA to the 100,000 figure (Kohlhepp 1980: 60).

4. Described by Sanders (1973); Wesche (1974); Goodland and Irwin (1975); Kleinpenning (1975); Smith (1976, 1981a,b) and Moran (1976, 1981).

5. A typology devised by Moran (1976, 1981) classifies colonists into laborer-farmers, independent farmers, artisans, and entrepreneurs based on previous land ownership or management experience, previous urban residence, past history of residential mobility, and ownership of durable goods on arrival. The first two criteria were used in simulated colonist behavior, laborer-farmers (colonists with neither previous land ownership nor urban experience) producing less surplus than other types (Fearnside 1980c, nd-a).

inhabitants is to be assured is maintaining population density below its maximum carrying capacity.[6]

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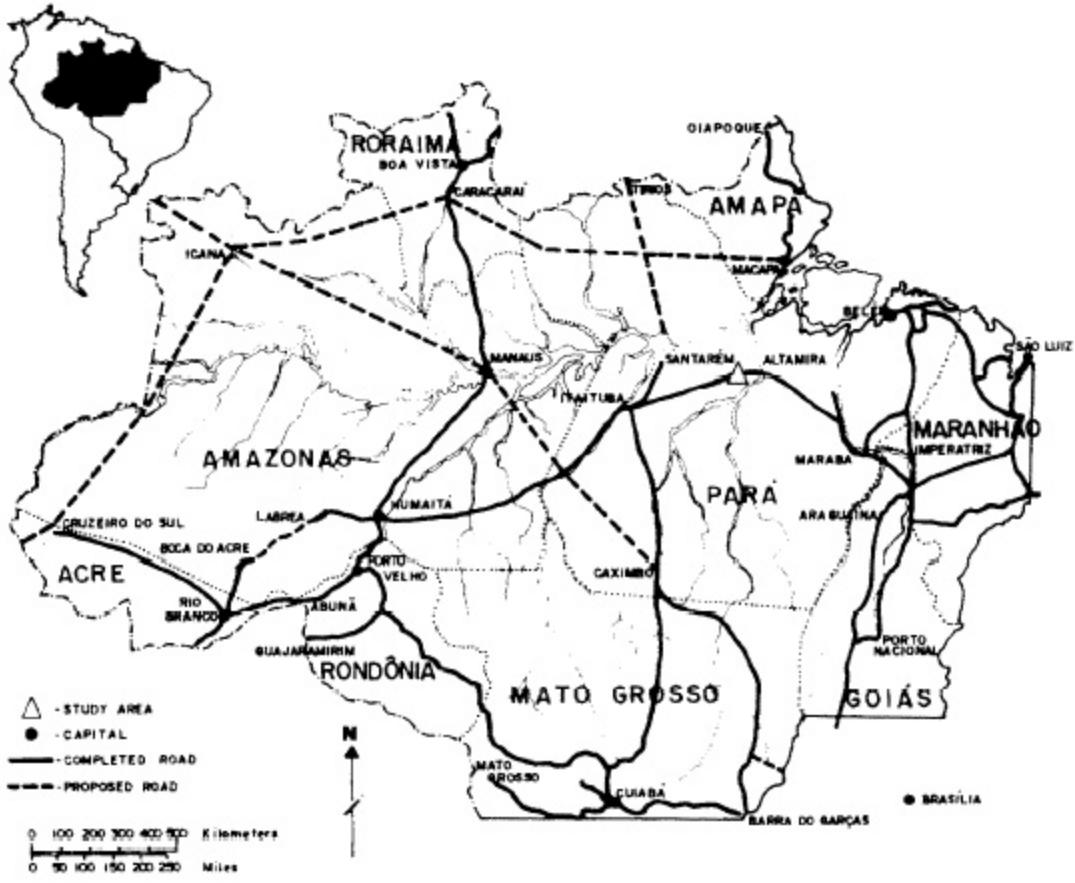
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RIO BRANCO
ABUNÃ
GUAJARAMIRIN
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GOIÁS
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