ROADS IN THE RAINFOREST

ENVIRONMENTAL COSTS FOR THE AMAZON

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Environmental Costs for the Amazon

"Future scenarios for the Amazon"
Project Report

IPAM - INSTITUTO DE PESQUISA AMBIENTAL DA AMAZÔNIA

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Executive Summary

The Brazilian government is making large-scale investments in development projects in the Amazon region through its Avança Brasil (Forward Brazil) Program. Among the government's goals for the next few years are the expansion of the paved road network into central Amazonia, and the construction of ports, waterways, railways and hydroelectric power plants. The Amazon region needs improvements in its infrastructure, but the proposed projects have the potential to cause large-scale ecological and social damage. Before implementing these projects it is necessary to conduct a thorough evaluation of their impact and to engage the projects' myriad stakeholders in a discussion of how best to minimize their negative effects. With this report, we hope to stimulate a discussion of the Avança Brasil program with the goal of avoiding the mistakes made in the past.

Based on our analysis of the historical relationship between highway paving and deforestation, we predict that the Avança Brasil Program will lead to the clear-cutting (deforestation) of 120,000 to 270,000 km2 of primary forest over the next 25 to 35 years. Forest clear-cutting for cattle pasture formation and slash-and-burn agriculture is only one of the large environmental changes that will be caused by Avança Brasil. The infrastructural investments of the Avança Brasil program could trigger three vicious feedback mechanisms of environmental impoverishment in the region.

In the first vicious feedback, the increased land supply along the highways will stimulate ranching and subsistence agriculture, contributing to an increase in accidental fires since these land uses depend upon fire as a management tool. Agricultural fires frequently escape from their intended boundaries, discouraging land managers from investing in tree crops, agroforestry systems, and other fire-vulnerable production systems. In sum, road paving favors cattle ranching and subsistence agriculture, which cause accidental fires, which stimulate more ranching and subsistence agriculture.

In the second feedback, selective logging and drought events increase the flammability of large areas of forest, and many forests catch fire. Once a fire has burned an Amazon forest, trees die and form gaps in the canopy when they crash to the ground, increasing the probability of further burning. Within the 50 km buffer along the roads to be paved according to the Avança Brasil plans there are 192,000 km2 of forests that became flammable during the severe drought episode of 1997 and 1998. These forests could catch on fire repeatedly if exposed to accidental fires.

In the third vicious feedback, expanded deforestation enhanced by the two previous feedbacks would inhibit rainfall, causing an increase in the occurrence of accidental fires. These, in turn, would reinforce phenomena that further inhibit rainfall. Rain is inhibited both by smoke and by the reduction in evaporation that results from deforestation and burning.

Without a corresponding increase in the State's capacity to plan and manage expansion in the deforestation frontier, road building and paving has the potential to impoverish large areas of the Amazon forest through the interaction of the three vicious feedback cycles described above. Besides the loss and impoverishment of forest areas, the increase in fire occurrence would lead to substantial increase in smoke related pollution, aggravating smoke related illness and the frequency of airport closings and road accidents. This process would also result in an increase in Amazonia's contribution to global warming.

Finally, the plans to build and pave roads in Amazonia could affect as much as one fourth of the indigenous lands, national parks and priority areas for biodiversity conservation. The immigration of colonists, ranchers and loggers stimulated by the proposed all-weather roads poses a risk to these lands. These areas have remained intact so far because they were "passively" protected by their inaccessibility.

The fact that Avança Brasil emphasizes the paving of existing roads, rather than construction of additional roads is a good sign, however. Among the government's planned projects there are several that could foreseeably stimulate forms of rural development leading to an enduring prosperity for the population of Amazonia, such as the paving of the Transamazon Highway (Marabá-Rurópolis). Nevertheless, in order to develop this potential it is necessary to make a substantial investment in mechanisms that would guarantee the participation of civil society in the evaluation, planning and execution of the Program.

Introduction

Large infrastructure investments in Amazonia have been planned for many years. The government has recently launched the Avança Brasil Program, which renews the efforts to develop the region. This document analyses some of the environmental effects of the planned investments with the purpose of stimulating a broader debate about the region's future.

Public Policy and Amazonia

Forty years ago the Brazilian government undertook a major development effort aimed at integrating Amazonia physically and economically with the rest of the country, based upon a model that emphasized occupation of the region. This integrationist project was justified by the military's perception that Amazonia would otherwise remain strategically vulnerable and economically under-utilized. At that time Amazonia was considered a "green hell" or a "demographic void".[1] In order to accelerate the integration of Amazonia into the dynamic centers of development in Brazil, public policy prioritized frontier expansion, through road construction, agricultural settlement programs, expansion of agriculture and cattle ranching, establishment of fiscal and credit incentives, and later through public investment in large projects (such as the Grande Carajás and Tucuruí).[2]

As a result of this occupation policy, the human population of the region grew from four million to ten million between 1970 and 1991, and thousands of families were resettled in the region. Cattle stocks grew from 1.7 million heads (1970) to 17 million in 1995. Also in this period, the production of iron ore, bauxite and gold of the region netted US$ 13 billion. The gross internal product of Amazonia, which was US$ 1 billion in 1970, had risen to US$ 25 billion by 1996. Nevertheless, in 1991, almost 60% of the Amazon population failed to earn a minimum living wage (< US$ 100 per month), and the illiteracy rate was 24%, one of the highest in the country, second only to that of Brazil's impoverished Northeast region. Amazonia's income distribution is also among the worst in the Brazil, a country known for its economic inequality.[3]

Although there is a need for an in-depth analysis of the social and economic effects of past investments, this is not the focus of this report.

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[1] B. Becker (1989), "Grandes Projetos e Produção do Espaço Transnacional: Uma Nova Estratégia do Estado na Amazônia", Revista Brasileira de Geografia, 51 (4):230-254; E. Castro and R. Acevedo Marin (eds.) (1994), Amazônia na Encruzilhada do Desenvolvimento, Belém, NAEA/UFPA/Falangola; V. R. Loureiro (1992), Amazonia: Estado, Homem, Natureza, Belém, Edições CEJUP.

[2] O. Valverde (1989) Grande Carajás: Planejamento da Destruição, São Paulo, USP/Editora Forense Universitária/UNB; M.C. Coelho e R. G. Cota (eds.) (1997), Dez Anos da Estrada de Ferro Carajás, Belém, UFPA/NAEA; J. Hebette (ed.) (1991), O Cerco está se Fechando, Belém, FASE/ NAEA/ UFPa/ Vozes.

[3] Atlas de Desenvolvimento Humano do Brasil (1997), Brasília, PNUD/IBGE/IPEA/Fundação João Pinheiro.

The main purpose of this report is to present some analyses of the potential environmental effects of the proposed infra-structural investments in Amazonia, in order to generate a broader national discussion of Avança Brasil for Amazonia. Public discussion of Avança Brasil has been practically non-existent within the governmental and civil society spheres in Brazil.

The current process of Amazon occupation and development has had serious environmental impacts, with deleterious effects for its population. During the three to four month burning season, as fire spreads across agricultural areas, most of the population breathes air that is more polluted than the air in downtown São Paulo. The constant risk of fire during each year's burning season diminishes the incentive that producers may have to invest in perennial cultures and other permanent production systems, since fire may escape from neighboring areas and destroy their investments.

The process of occupation of the region has already led to the elimination of 550,000 km^2 of forest through cattle ranching and agriculture,[4] releasing 2-4% of global carbon emissions to the atmosphere,[5] thus contributing to the greenhouse effect. The transformation of the Amazonian landscape into cattle pastures and scrub vegetation can also reduce rainfall in the region by decreasing evapotranspiration and solar energy absorption-the two ingredients of cumulus cloud formation.[6] The reduction of evaporation also reduces the capacity of the soil to store rainwater, thereby provoking flooding after rain events and other potential impacts on fisheries.

The rapid expansion of the frontier through road building and paving without a proportional investment in the capacity of the government to manage the region, resulted in unchecked and disorganized migration and settlement accompanied by uncontrolled extraction of natural resources (e.g. timber and gold). In turn, this has led to further dilution of the government's institutional capacity to manage the frontier.

Repeating Past Mistakes

The Brazilian government is now making critical decisions for the future of the Amazonia. These decisions can perpetuate the current model of predatory development, with the problems described above, or they can redirect development toward a sustainable pathway that reconciles the conservation of the natural resources with economic growth.

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[4] INPE (1998), *Desmatamento na Amazônia 1995-1997*, São José dos Campos, SP.

[5] R. Houghton et al. (2000), "Annual fluxes of carbon from deforestation and regrowth in the Brazilian Amazon", *Nature* ,**403**: 301-304; P.M. Fearnside (1997), "Greenhouse gases from deforestation in Brazilian Amazonia: Net committed emissions", *Climatic Change*, **35**: 321-360.

[6] C.A. Nobre et al. (1996), "Conclusions from Abracos" in", J.H. C. Gash et al. (eds.) *Amazonian Deforestation and Climate*, Chichester, UK, John Wiley and Sons; C. A. Nobre, P. Sellers, and J.Shukla (1991), "Amazonian deforestation and regional climate change ", *Journal of Climate* **4**: 957-988.

New road construction and paving will increase the paved road network in the region from 11,900 km to 18,145 km (Figure 1). These infrastructural investments, along with the construction of waterways, ports and railways, are intended to stimulate agro-industrial production in Amazonia, and enhance the profitability of agro-industrial production in Brazil's central west region reducing grain transportation costs (Table 1). These investments are also meant to help establish access to South American markets, consolidating the process of regional integration initiated with Mercosul. Until now, the government has implications of the projects proposed into consideration in the planning process proposed projects.

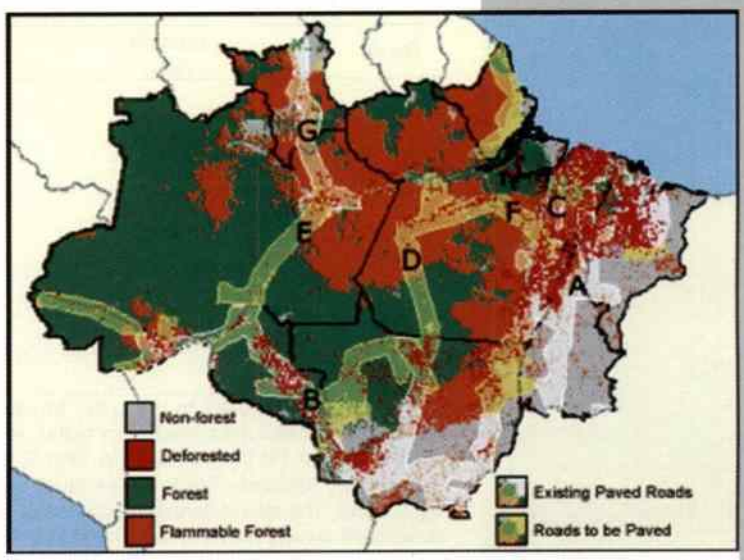

Figura 1. Map of the Brazilian amazon, showing roads already paved (in white) and roadas to be paved (in yellow) by the Avança Brasil Program. Three-fourths of the deforestation that occurred between 1978 and 1994 may be found within a 100-km buffer along the roads, 50 km on either side of the road (in red). Read more details on the box below.

Environmental Impoverishment Feedback Cycles

Roads that provide access to remote forest areas are the main factor driving the vicious feedback cycles that threaten Amazon ecosystems. Restricted access is the main impediment to the predatory exploitation of Amazon forests and the land that they cover; when this impediment is removed, large-scale forest conversion to pasture and itinerant agriculture ensues. This relationship can be seen by examining the geographical distribution of deforestation in Amazonia. Three-fourths of the deforestation that occurred between 1978 and 1994 may be found within a 100-km buffer along the roads (50 km on either side of the road).[7] Between 29 and 47% of the forests that existed within this buffer had disappeared within 20 to 35 years of road paving (by 1991) (Table 1).

Prior to 1991, deforestation along the roads paved in the 1960s and 70s varied between 28.7% (BR-364, "B"), 37.2% (PA-150, "C") and 47% (BR-010, "A"). The largest area of forest that depleted its soil water (up to 10m depth) during the severe drought of 1997/98 (in brown, Nepstad et al. 1999) became flammable and did not catch on fire due to the absence of ignition sources. These forests that become flammable during strong El Niño events comprised an area of 1.550.000 km2 in 1998, and could be subject to more frequent fires if agricultural activities occur closer to them. Along the Santarém-Cuiabá (D), the Transamazon (F) and the Humaitá-Manaus (E), there are 192,000 km² of forests that became flammable in 1998. The Manaus-Boa Vista highway (G) was only recently paved and has not yet caused any additional deforestation.The deforestation map is a composite of 208 Landsat TM images taken in 1991-1992 (the resolution is 28.5m). These images were made available by Michigan State University (D. Skole, Chomentowski **http://www.bsrsi.msu.edu/trfic/index.html)**. The total deforested area in this map is 367,000 km². According to INPE, the total deforested area by 1998 was estimated at 550,000 km² (INPE 1998). Data on road plans were based on the government's Plano Plurianual 1999-2003 (1999).

Table 1. Deforestation along paved roads in Amazonia

Road	Length (km)	Age of Frontier (years)	Deforested Area[1] km²	%
Belém-Brasília (BR-010)	1.514	~35	42.000	47
Cuiabá-Porto Velho (BR-364)	1.454	~25	31.000	28,7
PA-150	991	~20	32.000	37,2

1 Deforested area refers to the buffer 50 km along each side of the road. Percent deforested refers to the forest area inside this buffer, excluding Cerrado. The deforestation map is a composite of 208 Landsat TM images taken in 1991-2, the resolution is 28.5 m. The images were made available by Michigan State University (D. Skole, Chomentowski http://www.bsrsi.msu.edu/trfic/index.html). The total deforested area in this map is 367.000 km2. According to INPE, the total deforested area up to 1998 is 550.000 km2 (INPE 1998).

This historical relationship between roads and deforestation allows us to establish a preliminary projection of the impact of the paving of roads as proposed by the Avança Brasil. The total extent of these roads to be paved exceeds 6,245 km. Considering the forest area contained within the 50 km buffer adjacent to those roads in five stretches of road (totaling 4,199 km), it is possible to forecast that deforestation will affect an area between 120,000 and 270,000 km2 in the next 25 to 35 years (Table 2).

It is important to point out that this forecast could be overestimating deforestation; if migration and agricultural expansion rates slow down, or if the state's capacity to manage settlement and development along these roads increases in the future, the resulting deforestation would probably be lower than projected. On the other hand, the projection could be low, given that we are considering just the deforestation that would take place within the 100-km buffer, and that migration and agricultural expansion rates could be higher than the historic average. This report assumes in this initial calculation, that the relationship between roads and deforestation will follow the same pattern as in recent decades.

Deforestation (clearcutting) is the most obvious example of human disturbance of the forest, and has been monitored annually by the Brazilian National Institute for Space Research (INPE)[8]. The results of this monitoring, however, are incomplete, for they do not supply information about the level of impoverishment in the remaining forest areas, many of which have been severely altered by logging and fire.

[7] D. Alves (1999), "An analysis of the geographical patterns of deforestation in Brazilian Amazonia the 1991-1996 period," trabalho apresentado na Conference sobre Padrões e Processos de Uso da Terra e Mudança em Florestas na Amazônia, Março, Gainesville, FL.

[8] INPE (1998) Desmatamento na Amazonia 1995-1997, São José dos Campos, SP - INPE.

Table 2. Projected Deforestation in 50 km buffer along each side of roads to be paved in Amazonia and flammable area affected.

Road	Length (km)	Projected Deforestation[1] (25-35 years) (km^2)	(km^2)
Santarém-Cuiabá (from Santarém to border with MT) BR - 163	*1.147*	*22.000 – 49.000*	*49.000*
Humaitá-Manaus, BR – 319	*663*	*14.000 – 28.000*	*7.000*
Transamazônica (from Marabá to Rurópolis) BR – 230	*981*	*16.000 – 33.000*	*51.200*
Manaus - Boa Vista,[3] BR – 174	*613*	*16.000 – 35.000*	*5.000*
Outras	*2.046*	*40.000 - 94.000*	*34.000*
Total	***6.245***	***120.000 – 270.000***	***192.000***

1. Deforestation was calculated using minimum (28%) and maximum (47%) historically registered relationship along roads already paved (Table 1). For the minimum value, the already deforested areas within the buffer were subtracted from the estimates: [(forest area within 50 km buffer x 28%)-(already deforested area)]. For the maximum value, we multiplied the forest area within the buffer by the deforestation rate along BR-010: Forest area within 50 km buffer X 47%.
2. Forest area within the 50-km buffer where soil water was exhausted during the 1997-8 El No (Figure 1). 3. This road was already paved in 1997/98.

There have been few attempts, if any, to forecast the implications of human influence on the forest. Considering the scale of the projects outlined by the Avança Brasil program, it is now necessary to go beyond the monitoring of current human effects on the forest, and to look toward the future. What are the processes that will be unleashed by the paving of 6,245 km of roads in the Amazon?

Below, we describe the three main vicious feedback loops leading to environmental impoverishment that will be provoked by these projects.

Feedback Cycle # 1: Accidental Fire and Land Improvements

Cattle ranching and slash and burn agriculture in Amazonia are dependent upon fire as a management tool. But these management fires escape control and affect areas that were not meant to burn.[9] For this reason, producers become discouraged and lose their incentive to invest in agroforestry systems and other types of permanent agriculture, in fencing, in buildings, and in forest management for timber production, given the high risk of losing it all to accidental fire. The expansion of the road network will favor an increase in extensive production systems such as subsistence agriculture and cattle ranching, which in turn increase the incidence of accidental fires and reinforce the existence of extensive production systems such as subsistence agriculture and cattle ranching. This is the first vicious feed-back cycle that could accelerate deforestation in large-scale (Figure 2).

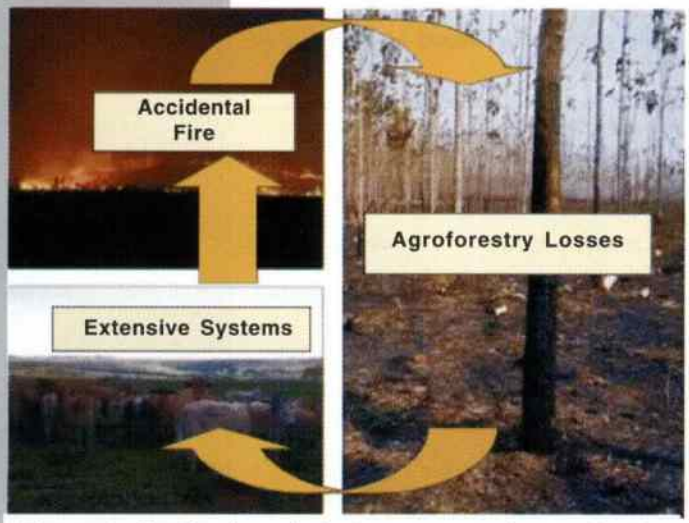

Figure 2. Feedback cycle between extensive production systems, accidental fire, and damages to intensive production systems. Fire used in the establishment of cattle pasture and farm plots, and in pasture management, often burn beyond their intended boundaries, damaging perennial crops, agroforestry systems, and forest management systems. These losses encourage producers to continue using extensive production systems, perpetuating the cycle.

Feedback Cycle #2: Logging, drought and forest fires.

The deforestation caused by cattle ranching and slash and burn agriculture is just one of the large-scale land use changes that can be unleashed by Avança Brasil. The increase in logging activities, impoverishing nearly as much forest each year as deforestation,[10] will also be stimulated by the expansion of the road network, since highways decrease the cost of timber transportation.[11]

Approximately 90% of logging activities are illegal,[12] and the expansion of the road network will dilute the government's capacity to monitor logging operations. Timber extraction creates a large number of clearings in the forest, opening the canopy and increasing the amount of light that penetrates to the forest interior. It also increases the amount of fuel (combustible material) on the forest floor.[13] These changes result in a considerable increase in forest susceptibility to fires and discourage investment in sustainable timber extraction practices by loggers in the region. This opinion is clearly voiced by many in the sector, including the former president of the Paragominas Timber Producer's Union, Mr. Sydney Rosa (currently the mayor of Paragominas, in the state of Pará).

Amazon forests become flammable not only due to the results of logging activities, however.

Severe drought can also provoke litterfall, opening the canopy and increasing temperature inside the forest, increasing the

"...how can I make any money from forest management if I have to protect my forest from fire every year?"

Sydney Rosa

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[9] D. Nepstad, A. Moreira, e A. Alencar (1999), *A Floresta em Chamas: Origem, Impactos e Prevenção de Incêndios Acidentais na Amazônia*. Brasília, PPG-7 - Banco Mundial. 147 paginas.

[10] D. Nepstad et al. (1999a), "Large-scale impoverishment of Amazonian forests by logging and fire", *Nature* **398**: 505-508

[11] S. Stone (1998), "Using a geographic information system for applied policy analysis: the case of logging in the eastern Amazon", *Ecological Economics*, **27**: 43-61.

[12](EMBRAPA/CPATU) J.N. Nascimento (1998).

[13] C. Uhl and J.B. Kauffman (1990), "Deforestation, fire susceptibility and potential tree responses to fire in the eastern Amazon ", *Ecology* **71** (2): 437-449; "Efeitos do fogo nas florestas" *Ciência Hoje* **27** (157): 40-43

forest's flammability potential even further.[14] The most severe droughts in Amazonia are associated with El Niño episodes, which have become more frequent and more severe in the last 15 years. This increase may be related to the accumulation of greenhouse gases in the atmosphere, and could therefore grow worse with time.[15] By the end of the severe drought provoked by the 1997-98 El Niño episode, we estimate that almost half of Amazon forests (1,550,000 km^2) had exhausted soil water to a depth of ten meters, making these forests highly susceptible to fire (Fig. 1).

Over 192,000 km^2 of the forests that became flammable during this intense drought episode are within the 100 km buffer along the roads (50 km on each side) that would be paved through Avança Brasil (Figure 1, Table2). These forests remained protected from fire thus far because they were not exposed to ignition sources. However, as the roads become paved, and accidental fires caused by agricultural activities increase, these forests could experience large-scale fires. The total area of Amazon forests that caught fire in 1998 is unknown, but the figure could be considerable. In Roraima alone, over 10,000 km^2 of intact forests burned, and that was probably just a fraction of the total area affected by forest fires in Brazil.[16,17]

The immediate environmental impacts of forest fires are only part of the story. Forest fires increase the likelihood of future forest fires.[18] Fire begets fire. Once an area burns, up to 40% of adult trees can die. This tree mortality increases considerably the likelihood of a second fire. Eventually, the forest stops being a forest, as the successive fires allow the invasion of the understory by grasses, making the area even more flammable.

In sum, the expansion of the road network, if not implemented within effective policies for governing land use activities and natural resource conservation, creates an incentive for logging, which in turn increases the susceptibility of the forest to fire. Furthermore, severe

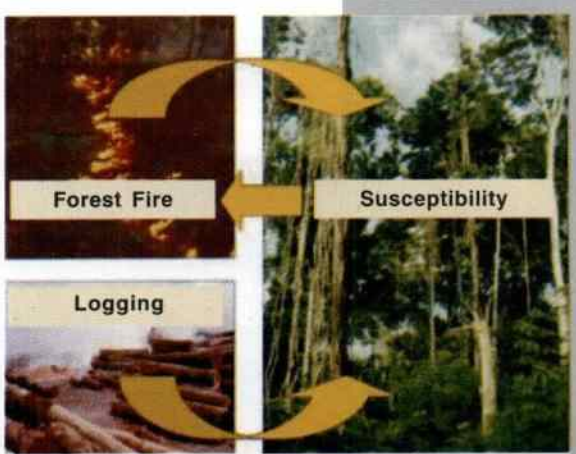

Figure 3. Vicious feedback cycle between forest understory fire, selective logging, and forest flammability. Both understory fire and logging open the canopy and increase the fuel load on the forest floor, increasing forest vulnerability to fire.

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[14] D. Nepstad et al (1999a), (199b), op. cit.

[15] A. Timmermann et al. (1999), "Increased El Niño frequency in a climate model forced by future greenhouse warming", *Nature*, **395**: 694-697; K. Trenberth and T. Hoar (1996), "The 1990-1995 El Niño-Southern Oscillation event: Longest on record", *Geophysical Research Letters* **23** (1):57-60.

[16] Shimabukuro et al. (2000), "Roraima: o incêndio visto do espaço". *Ciência Hoje* **157**: 32-34.

[17] Nepstad et al. (1999a), op. cit.

[18] M. Cochrane et al. (1999), "Positive feedbacks in the fire dynamic of closed canopy tropical forests", *Science*, **284**: 1832-1835; M. Cochrane and M. Schulze (1999), "Fire as a recurrent event in tropical forests of the eastern Amazon: Effects on forest structure, biomass, and species composition", *Biotropica*,**31** (1):2-16; A. Holdsworth and C. Uhl (1997), "Fire in Amazonian selectively logged rain forest and the potential for fire reduction", *Ecological Applications* **7** (2): 713-725.

drought places a very large area of Amazonia under increased fire risk. And once burned, forests are even more susceptible to recurrent fires. This is the second vicious feedback loop that can be unleashed by Avança Brasil, and it has the potential to transform, in the future, extensive areas into impoverished scrub vegetation (Figure 3).

Feedback Cycle #3: Fire and the reduction of rainfall.

The government's current plans also represent a threat to the Amazon climate system, thereby threatening the region's ecosystems and agricultural production systems. Amazonia's climate is closely tied to the forest, which recycles about seven trillion tons of water through evaporation (called "evapotranspiration"). At the same time, the forest absorbs solar radiation,[19] which heats up the air around it, giving rise to the cumulus clouds that are responsible for much of Amazon rainfall. Extensive cattle ranching, slash and burn agriculture and forest fires inhibit rainfall because they substitute primary forests with pastures, crop fields, and secondary forests, which release less water to the atmosphere and absorb less solar radiation.

The smoke released from fires also contributes to this effect by saturating the atmosphere with an excessive number of condensation nuclei, thus inhibiting the formation of droplets that are heavy enough to fall to the ground as rain.[20] This is the third vicious feedback cycle by which fire leads to fire: deforestation and forest conversion inhibit the formation of cumulus cloud formation, and smoke inhibits rain droplet formation. The resulting drought contributes to increase the probability of forest fires. (Fig. 4).

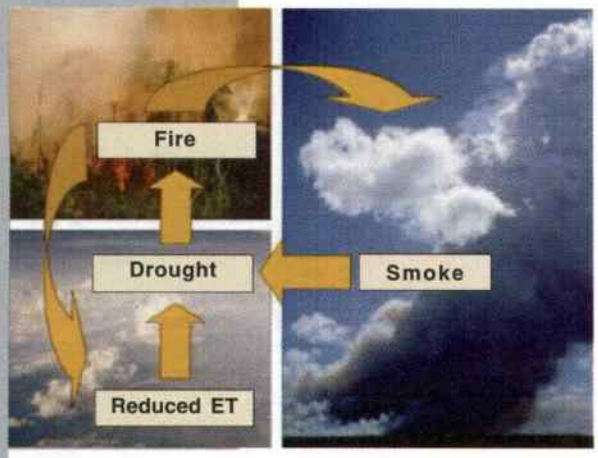

Figure 4. The vicious feedback cycle between land-use change, smoke emissions and rainfall inhibition. Smoke released by forest and management fires inhibit rainfall. The transformation of forests into pastures, and forests impoverished thrpugh logging or fire, may also inhibit rainfall by reducing evapotranspiration and the absorption of solar radiation by vegetation. El Niño episodes provoke droughts in Amazonia, and may increase in the future through global warming.

These three vicious feedback cycles could transform almost half of the Amazon forest in a landscape of cattle pastures and impoverished scrub vegetation because of the interaction between road paving, uncontrolled deforestation in the frontier, predatory logging, and changes in the region's climate. (Fig. 1-4). This transformation would lead to the deterioration in the quality of life in Amazonia due to the increase in air pollution during the three to four months of the dry season, exacerbating respiratory problems affecting the population.

[19] C. A. Nobre et al. 1991, op. cit.; C. A. Nobre et al. 1996, op. cit.

[20] D. Rosenfeld. (1999), "TRMM observed first direct evidence of smoke from forest fires inhibiting rainfall", *Geophysical Research Letters*, **26** (20): 3105-3108.

The possibility of expanding more sustainable production systems (such as agroforestry systems, perennial crops, and forest management) would be reduced even further as a result of this transformation, for the risk of losing investments in the land to accidental fire would grow higher.

In this rapidly extended frontier the capacity of national and state agencies, including the National Colonization and Agrarian Reform Institute (INCRA), the Brazilian Institute for the Environment and Renewable Resources (IBAMA), the National Health Foundation (FNS), the Unified Health System (SUS), and the educational and court systems would be further weakened in their efforts to attend to a sparse rural population, diminishing the prospects of future improvements in the quality of rural life. Rural exodus and the swelling of urban centers would tend to increase as a result of this inability to extend basic services to rural dwellers.

Threats to Indigenous Lands and Protected Areas

Roads bring colonists, ranchers, and loggers within close proximity of indigenous lands and biological reserves, threatening the integrity of these areas. As a preliminary assessment of the threat posed by the roads to be paved, we identified those indigenous lands, protected areas, and areas of high conservation value that are at least partially within the 50 km buffer on either side of the roads to be paved under the Avança Brasil plan.

This analysis reveals that 8% (31) of indigenous lands will be affected, 26 conservation areas (17%), and 18% (68) of the areas recently identified as high priority for conservation (Table 3, Figures 5, 6 and 7). The indigenous lands that will be directly affected are: São Marcos, Yanomami, Serra da Moça, Truaru, Sucuba, Raimundão, Canauanim, Tabalascada, Malacacheta, Wai-Wai, Waimiri-Atroari, Gavião, Paquiçamba, Arara, Koatinemo, Trincheira/Bacajá, Rio Jumas, Cachoeira Seca do Iriri, Kararaô, Parakanã, Mãe Maria, Apurinã do Ig, Tauamirim, Lago Capanã, Ariramba, Lago Jauari, Baú, Nove de Janeiro, Menkragnoti and Panará.

Table 3. Number of Protected Areas Affected by Roads to be Paved.

Type of Area	*Number of Affected Areas*	*% of Total*
Indigenous land	*31*	*12,0*
Federal Conservation Unit	*21*	*25,6*
State Conservation Unit	*8*	*2,7*
Critical Bidiversity Areas	*67*	*17,6*

Of the 81 federal conservation units, 18 (22%) will be directly affected, also four ecological stations (Caracaraí, Niquiá and Anavilhanas), three national parks (Viruá, Chapada dos Guimarães and of Amazônia), one biological reserve (Uatumã), one extractive reserve (Tapajós-Arapiuns), five national forests (Tapajós, Itaituba II, Itaituba I, Altamira and Humaitá), one ecological reserve (Sauim Castanheiras) and two research areas of the Forest Fragment Biological Dynamics Project.

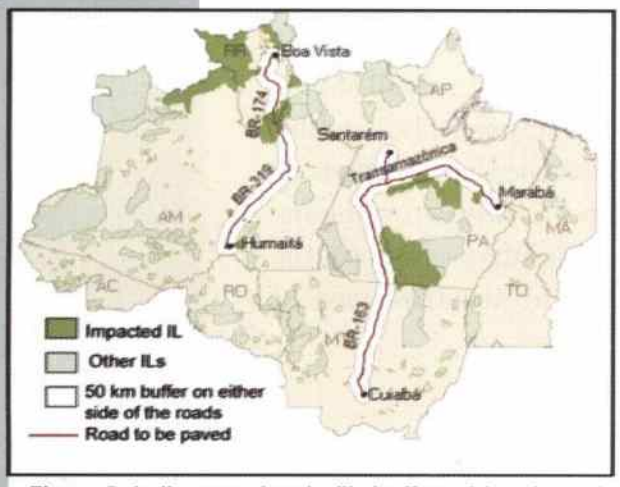

Figure 5. Indigenous Lands (ILs) affected by planned paving and/or pavement recuperation of roads included in Avança Brasil.

Among the existing 73 state conservation units in Amazonia, eight (11 %) would be directly impacted: six environmental protection areas (Caverna do Moroaga, Margem Esquerda do Rio Negro, Margem Direita do Rio Negro, Lago Cuniá, Cabeceiras do Rio Cuiabá and Chapada dos Guimarães), one state park (Rio Negro\Setor Sul) and one sustainable yield state forest (Rio Madeira).

These areas are currently protected by their remoteness; they are difficult to get to, and therefore uninteresting to ranchers, loggers and colonists. The capacity of federal and state agencies to protect these areas from illegal logging, ranchers and squatters and from accidental fires are insufficient and face serious problems. Very few of these areas, although created by law, have been established in practice, which means there is little monitoring or enforcement taking place on the ground. In many cases, they have already been invaded and are subject to illegal and predatory exploitation of resources. The roads that will be paved under the Avança Brasil Program will increase access to many of the indigenous lands and conservation units, placing in risk the region's biodiversity and the cultural integrity of indigenous peoples.

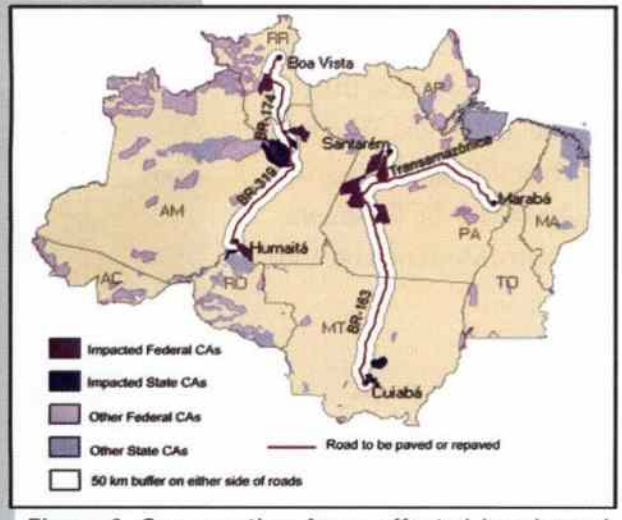

Figure 6. Conservation Areas affected by planned paving and/or pavement recuperation of roads included in Avança Brasil.

Besides affecting currently protected areas, the proposed projects will have have an impact on 68 areas that were recently declared of high interest for biodiversity conservation.

These areas were classified as such by 226 specialists according to criteria of species diversity, phyletic diversity, endemism, the presence of endangered/threatened species, performance of important ecological services, and exceptional biological phenomena (migration and special communities).[21] At least 18% of the 385 areas identified as critical for biodiversity conservation will be directly threatened by the paving of these roads.

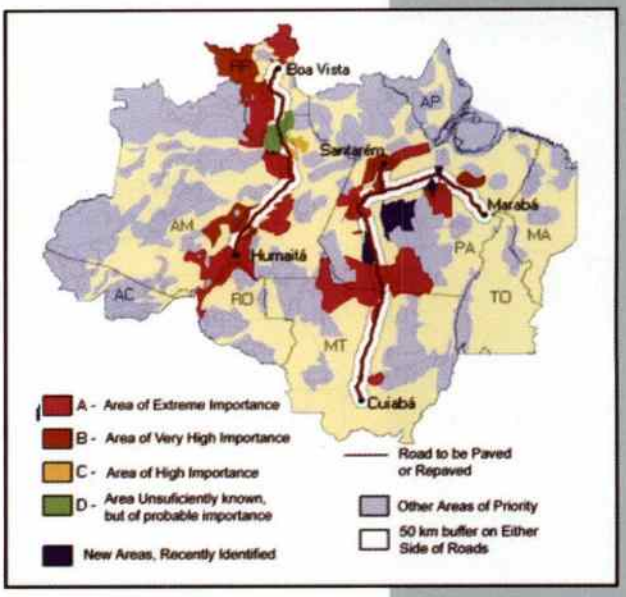

Figure 7. Areas prioritized for biodiversity conservation affected by planned paving and/or pavement recuperation of roads included in Avança Brasil.

What can be done?

An alternative to the continued reinforcement of these feedback cycles, fueled by the rapid expansion of the agricultural frontier, extensive production systems and chronic accidental fire risk, is the rejuvenation of frontiers that are already established (Figure 8).

This intensified use of old frontier involves investing in networks of local roads near urban centers, to facilitate commercialization of agricultural production[22] and the development of efficient credit and rural extension programs for small producers. This intensification would also have to include investments in education and health care. Investments in existing frontiers would require shifting the focus of the development model towards existing small towns to help them in the economic transition from raw material suppliers to producers of consumer products.

It is in healthy and economically viable small urban areas that local government and civil society have gained institutional capacity and the ability to direct the process of rural development.

This alternative model of Amazon development will require more than investment in existing frontier areas, however. It is also necessary to deliberately curb the rate of frontier expansion into regions of primary forest cover. Otherwise, the economic and social capital of existing rural settlements will drain off into the new frontiers, where access to new land and natural resources is cheap. This happens through two main processes. First, because the rapid opening of new frontier increases the supply of land, causing a decrease in land prices in older areas. As land prices decline, extensive production systems (cattle ranching, slash and burn agriculture, logging) are favored over intensive ones (perennial cultures, forest management, Figure 2).

[21] http://www.socioambiental.org/bio/index.htm

[22] R. Schneider (1994), *Government and the Economy on the Amazon Frontier*, Report No. 9104-BR, Washington, DC: The World Bank.

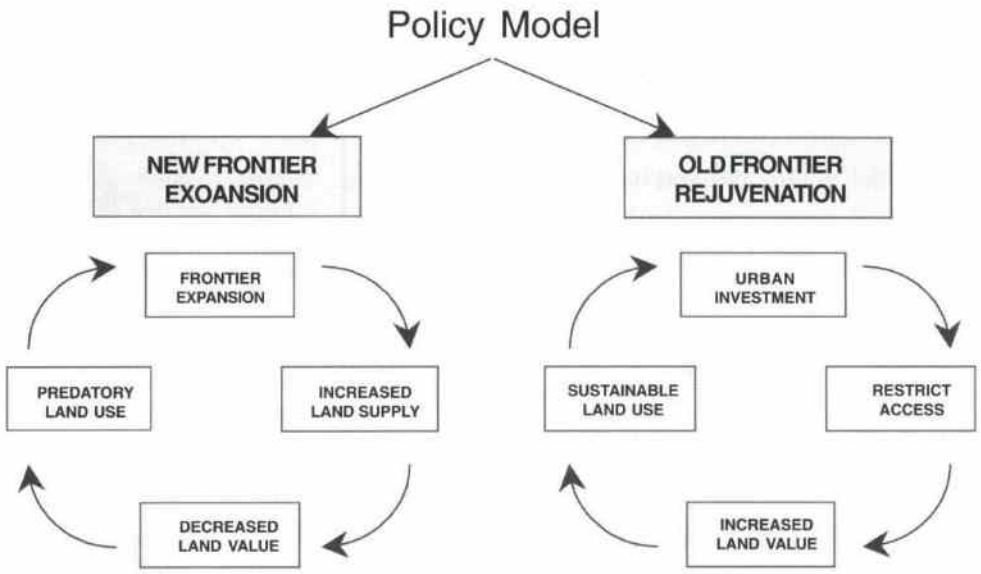

Figure 8. In the current development model (on the left), government stimulates frontier expansion through investment in roads and other infrastructure. These investments increase the availability of land, reducing its price, thus stimulating expansion of extensive production systems (e.g. cattle ranching, slash and burn agriculture, and logging) with low productivity. These systems are viable only where land is abundant and cheap. In an alternative Amazon development model (right), government stimulates economic activities that intensify older frontiers, checking the expansion process and reducing land availability on the market, thus creating an incentive for establishment of perennial cultures, forest management, and other sustainable production systems.

The second process that precludes renovation of older frontier areas is the dilution of the institutional capacity of government agencies related to rural development. Paving roads in new frontier areas means increasing the responsibilities of the agencies in charge of land titling, social services, environmental monitoring, and infrastructure maintenance.

If the new investments are not accompanied by matching investments in the government's institutional capacity, then the needs of society will not be met, and its interests won't be defended. The success of frontier intensification also depends on the consolidation of protected areas. Indigenous lands, extractive reserves, national and state parks and forests, and other types of protected areas restrict land supply, helping to keep the price stable. One fifth of Amazonia is comprised of indigenous lands, reducing the availability of land, since they cannot be sold. The consolidation of these areas ensures the rights of traditional populations and helps to conserve biodiversity.

Some of the investments outlined by Avança Brasil could contribute to the intensification of old frontier areas if they are well planned and executed. It would be important to prioritize those investments within the overall plan. The distinction between better and worse roads in Amazonia could be based upon an analysis not only of their environmental impact, but also upon the benefits that they will bring to the population already settled in the region.

Paving the Transamazon in the 800 km stretch between Marabá and Rurópolis (Figure 1), for instance, would benefit 11 towns with a combined population of 440,000. Migrants re-settled into this region in the early 1970s have developed diverse production systems based upon perennial cultures and agroforestry, and have become socially well-organized. Investments in this older frontier area might reduce the role of slash and burn agriculture and favor the expansion of more sustainable forms of agriculture. If the paving of the Transamazon highway were accompanied by matching investment in schools, health care, technical assistance for producers, environmental conservation, and consolidation of the four indigenous areas along the Transamazon (Mãe Maria, Parakaná, Trincheira/Bacajá, Paquiçamba), the effects of road paving on local development would be tangible, and would be more likely to lead to sustained and equitable growth. Investment in this old frontier can also be justified by the fact that the hydroelectric dam planned for the region (Belo Monte) will lead to an influx of migrants to the area in the near future.[23]

This example is in stark contrast to two other proposed road paving projects that would strongly contribute to agricultural frontier expansion (and not intensification): the Cuiabá-Santarém (BR-163) and the Humaitá-Manaus (BR-319, Figure 1, Table 2). In the 1,147-km stretch between Itaituba and the border with the state of Mato Grosso, BR-163 services only 76,000 people dispersed in the rural area, Itaituba, and three other municipalities (Jacareacanga, Trairão e Novo Progresso). Combined, the two roads cut through 1,800 km of forests with low population density and that are currently practically inaccessible. The main justification for paving these roads is to provide agro-industrial grain producers in Brazil's center west region with a way to reduce transportation costs for their grains. The main purpose of these roads is not Amazon development but, rather, the marketing of produce coming from central Brazil. Instead of bringing about the sustainable growth, paving these roads would lead to the diminution of the state's capacity in the region in face of increased predatory logging and land use.

These two roads would also directly impact ten indigenous areas, three national forests, one extractive reserve and a National Park. The Avança Brasil plan is largely focused on establishing poles of development favoring the production of grains in large-scale. This type of production could have a role in the development of the region, and could potentially contribute to sustainable development in Amazonia. Nevertheless, the expansion of agro-industrial production by itself could also catalyze investments with high social and environmental costs. Government needs to open to public participation the process of planning investments for the region to ensure that the model adopted is sustainable and benefits the population of Amazonia.

[23] G. Carvalho (1999), "Hydroelectric Development and Road Paving in Brazil's Transamazon Area", *Journal of Environment and Development*, Vol. 8 (4): 397-406.

The Benefits of Intensifying Existing Frontier Areas.

The intensification of the existing agricultural frontier will boost local employment and economic development to a degree unattainable through frontier expansion based on extensive production systems. Research carried out by IMAZON[24] in Paragominas, Pará, shows that economic intensification in old frontier areas through agro-forestry or combining agriculture and livestock as already practiced in some areas of this frontier town, increases earnings 3 to 26 fold in the agricultural, livestock, and logging sectors (Table 4). Similarly, the tax base generated by these activities increases significantly, as well as the number of jobs created in the local economy. This leads to further economic development and decreases the pressure for frontier expansion. This report has not calculated the benefits associated with reduction in smoke and accidental fires, which could add further value to frontier intensification.

Intensification consists mainly of increasing productivity of land use activities, resulting in greater production in a smaller area (and thus less deforestation). In the case of ranching, it is necessary to invest in fertilizing and tilling pastures, select grass species that are adequate and caring for the livestock's health. This method of production duplicates pasture productivity and does not require the use of fire, therefore reducing likelihood of accidental fires. In agriculture, intensification also results in the elimination of dependency on fire as is the case with perennial cultures (fruit, pepper) or agro-forestry combinations. In the case of logging, intensification means planning and managing timber harvesting in a way that allows for cutting-regrowth cycles.

Table 4 - Comparison of Economic Return from Extensive and Intensive Economic Activities in an established agricultural frontier (case study of Paragominas, Pará) [24]

	LOGGING*		CATTLE RANCHING		FAMILY AGRICULTURE	
	Extensive Logging cycle of 90 years	Intensive Logging Cycle of 30 years	Extensive Unreformed pastures	Intensive Reformed pastures	Extensive Slash and burn	Intensive Perennial cultures
			Dollars / hectare / year			
Income	*$31*	*$92*	*$31*	*$104*	*$90*	*$2.366*
Profit	$11	$28	$6	$55	$33	$802
Imposto	*$4*	*$11*	*$5*	*$18*	*$15*	*$367*
InicialInvestment	*$2.391*	*$2.503*	*$307*	*$539*	*$292*	*$2.695*
			Hectares / employed persons			
Jobs created	*540*	*154*	*29*	*29*	*16*	*1,4*

**Logging was analyzed without considering land investment and/or timber processing at sawmill.*

These intensified activities are invariably based on land investments with long term economic return, investment in basic resources and infrastructure, new technology, and especially in protection against accidental fire. Therefore, it is important that government plans offer direct and indirect support to these forms of land use. Paving or repaving roads in areas that are already settled is one direct incentive to more productive activities for those living in those regions. Credit lines, technical assistance, and better market facilities are among the policy tools that should be prioritized in Amazonia, instead of building and paving roads that will benefit a dispersed and small rural population.

Civil Society Participation

Due to the potential effects of the investments planned by the government under Avança Brasil, and the sheer volume of financial resources that are allocated for the program, it is necessary that civil society participate in the discussion. A national debate on the future and direction of public policy for Amazonia is urgently needed, and voices from civil society should be included in this debate. Amazonia's contribution to science and understanding of the region has grown much in the recent years. It is in this spirit that this document was written, to help fuel the debate about the region's future. Non-governmental organizations interested in rural development along with organized sectors of the Amazon population have accumulated much knowledge on how to deal with the forest and how to promote sustainable development. To ignore environmental issues associated with the expansion of the road network and consequently the agricultural frontier, is a risk and it could lead to Amazonia becoming relegated to the periphery permanently, simply being exploited for its natural resources, benefiting few and penalizing the majority.

IPAM

The Amazon Environmental Research Institute (IPAM), created in 1995, is a non-profit, non-governmental organization with headquarters in Belém (Pará, Brazil) and offices in Santarém (Pará) and Brasília (DF). IPAM unites scientists and educators that share a common compromise: contribute to the development of Amazonia in a manner in which the population needs and economic growth are compatible with the maintenance of the ecosystems integrity and functioning.

IPAM has the following objectives:

- Determine the ecological, economical and social consequences of development in Amazonia through the application of scientific and technological research.

- Develop and promote, in partnership with other institutions, environmental and socio-economical sustainable alternatives for Amazonian development.

- Foster training opportunities for scientists, educators and extension agents, promoting a comprehensive vision of environmental issues and sustainable land use systems.

- Strengthen society's ability to implement sustainable development alternatives.

The activities are structured under four research and education programs:

1) Forest Ecology

2) Forests and Communities

3) Várzea Management

4) Public Policies.

Each program is comprised by various research projects, which consider education and extension activities such as the training of students, professors, fisherman and small producers. The members of the Institute believe that scientific research can be an essencial tool to build an Amazonia developed and socially healthful.

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Instituto Socioambiental (ISA)

Is a non-profit civil association established to propose integrated solutions to social and environmental issues. Brazil shelters huge social and environmental diversity. There are over

two hundred indigenous peoples and other groups known as traditional populations, such as extrativists, descendents of African slaves (quilombolas) and fishermen, besides the diversity of origin and life styles of rural workers and urban populations. The Brazilian natural formation - savanna, wetlands, caatinga, fields and more than 3,5 million Km² of tropical forests in the Amazon and along the Atlantic Coast - comprises the wealthiest biodiversity of the planet.

Sociodiversity and biodiversity define Brazil in a world undergoing an increased process of globalization. However, predatory and socially exclusive development is damaging the country's heritage, corroding identity and worsening the sociological and environmental crisis facing Brazil. The passport to the future requires a new synthesis: socio-environmental sustainability.

The mission of Instituto Socioambiental is to defend social assets and rights, both collective and diffuse, relating to the environment, cultural heritage, and peoples rights. Produce studies, research, projects and programs which promote socio-environmental sustainability and protect the cultural and biological diversity of Brazil. ISA's works includes:

- *documentation and information*
- *training and capacity building*
- *geoprocessing*
- *inventories and inquiries*
- *consultancy services*
- *campaigns*
- *legal actions and legal advice*
- *monitoring of public policies*
- *formulation and management of projects*
- *environmental conservation*
- *recovery of degraded areas*

ISA's priority is to support actions that connect demonstration projects with working programs and partnerships. This approach allows us to develop activities that span the local, regional, national and international levels.

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Roads of destruction

Brazil's plans to expand the network of highways into the core of Amazonia could end the "passive" protection that difficult access provided to most of the Amazon forests, provoking a further increase in deforestation. This may result in a drier regional climate, which would encourage forest fires and contribute to large emissions of carbon into the atmosphere. It is possible, however, to blend economic development and forest conservation to attain sustainable development. Adequate policies, based on land use regulation and municipal governance, could reduce deforestation along these roads to 20%, and limit the occurrence of forest fires, allowing sustainable and equitable economic growth.

Biodiversity and traditional knowledge

The active participation of Brazilian society, including indigenous and traditional peoples, in determinig the course of national legislation on such issues as biodiversity, genetic resources, and traditional knowledge is vital to increase governance capacity. The current legislation contains serious obstacles to the participation of forest-based communities in the discussion of natural resources use. It does not protect traditional knowledge nor include the precautionary principle. Furthermore the legislation is provisory and, although active, still requires Congressional debate before approval. It is important to accelerate this process and include all relevant points of view.

A change is necessary

Although the Agenda-21 Brazil has been prepared by the Brazilian government, it is far from being implemented in the Amazon region. For example, public sector planning does not adher to principles outlined in the document. It is also necessary to change the current Brazil's model for energy generation, which is based on hydroelectric plants and has large impacts on the forest and its people, to incoporate other renewable sources.In addition, the International community must play its role: the Biodiversity and The Climate Change conventions have not incorporated the defense of traditional knowledge and native forests, respectively, into their negotiations. Good governance at local and international level, linked to the needs of the people, is essential for sustainable development.

AMAZONIA

FRONTIER GOVERNANCE AND SUSTAINABLE DEVELOPMENT

GLOBAL FORUM
Saturday, 24/08
4:00 - 6:00 pm

SIDE EVENT
Monday, 26/08
6:30 - 8:00 pm

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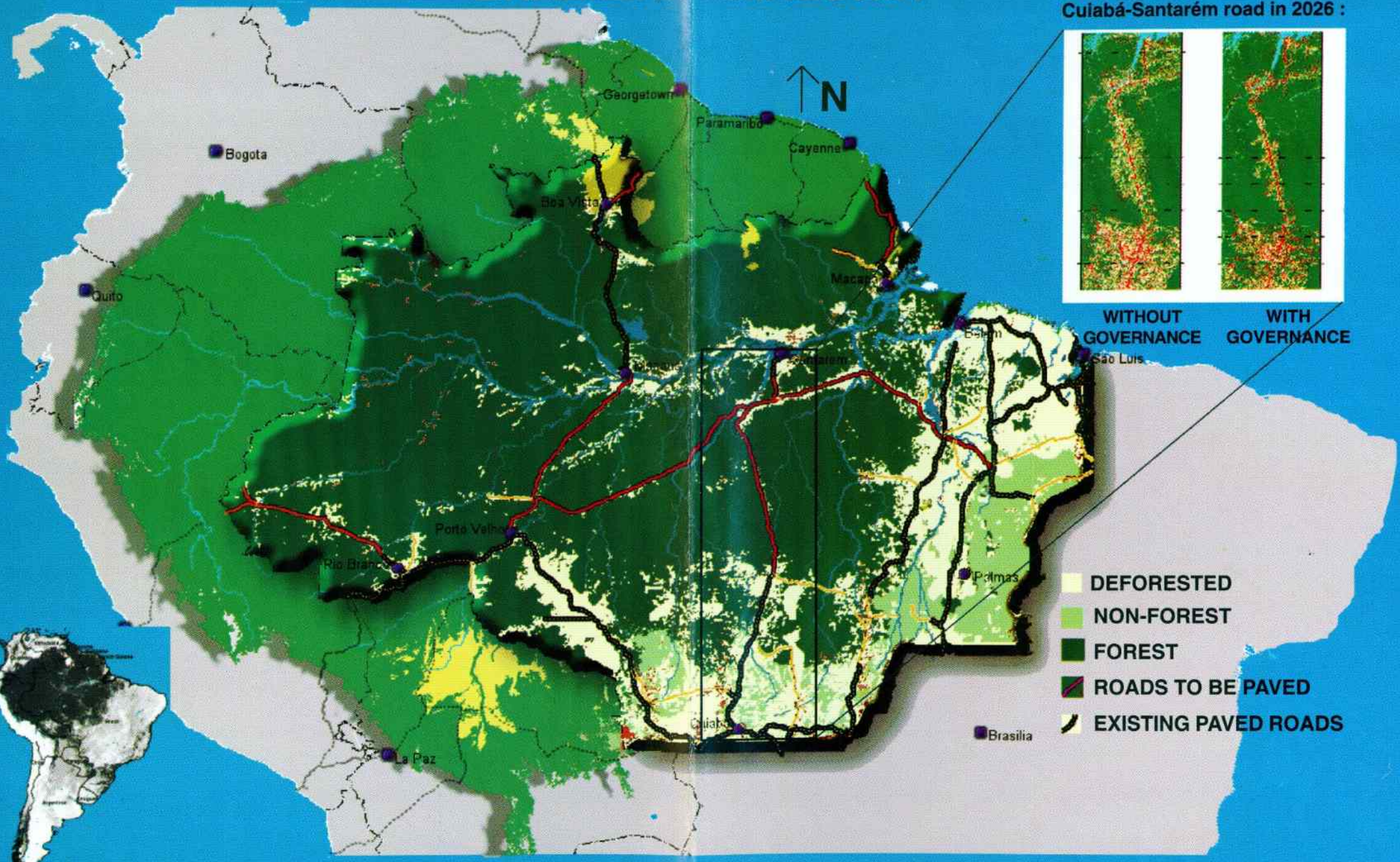
BRAZILIAN AMAZONIA



Fonte: IPAM, 1996

The Brazilian government is planning huge investments in the Amazon Region through its "Avança Brasil" (Forward Brazil) Program. One of its targets is to pave 6,245 km of roads. If this becomes a reality,and the historic pattern of environmental destruction following infra-structure improvements holds true, an area between 120,000 and 270,000 km² of forest will disappear within the next 25 to 35 years. In addition, one quarter of indigenous lands, national parks and areas for biodiversity conservation will suffer environmental damage.

Although investments in roads are important to the region, the way they have been planned could induce the extensive use of land, facilitate the occurrence of forest fires and provoke climate changes in the future.

It is urgent to begin a debate about the possible environmental and social costs of this program to the Amazon. With this goal in mind, the Amazon Institute of Environmental Research (IPAM) and the Instituto Socioambiental (ISA) are releasing this report.

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