INSTITUTE OF CURRENT WORLD AFFAIRS

GSH-15

Apartado 8-3870
San José, Costa Rica
July 1981

AMAZONIAN DEFORESTATION

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SUMMARY

The Amazon River drains parts of seven countries and covers an area only slightly smaller than the contiguous United States. Approximately 85% of the drainage area is in the lowlands, where vegetation varies from grass-dominated savannas to tall rainforest. This report focuses on the causes and consequences of Amazonian deforestation.

Various estimates suggest Amazonian forests currently occupy between 3 and 4 million square kilometers. The lack of data on forest types and deforestation makes it difficult to quantify the amounts and rates of loss of Amazonian forests. Nevertheless, estimates suggest between one-fifth and one-third of the Amazon Basin has already been deforested and that current loss is less than 0.5%/year.

Direct causes of tropical deforestation include road construction, colonization, slash and burn agriculture, agribusiness ventures and commercial logging. Government policies, or lack thereof, often promote or permit deforestation in the interest of short-term profits. The combination of rapid population growth and unequal land tenure is a major stimulus to advancing the agricultural frontier at the expense of tropical forests. The insatiable demand of developed countries for cheap commodities such as minerals, beef and timber also contribute to tropical deforestation.

The ecological consequences of tropical deforestation include accelerated loss of native species, global and regional climatic changes, soil degradation and watershed deterioration. These ecological consequences have profound social, cultural and economic implications for man. Tropical forests are a global patrimony that must be husbanded and used rationally. Man's voracious destruction of tropical forests may forever impoverish modern civilization.

INTRODUCTION

Despite the almost unimaginable vastness of Amazonian forests, the recent efforts to develop Amazonia are causing genuine concern not only in the international ecological community but also among national conservationists and ecologists as well. The pressures on Amazonian forests span a broad and interrelated spectrum of activities such as government road-building, spontaneous or directed colonization, timber exploitation and transnational agribusiness. Before describing how these activities affect tropical forests it is necessary to briefly describe what is happening in Amazonia.

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The mighty Amazon River drains the world's largest watershed--about 7.5 million square kilometers (ca. 2.9 million square miles, or only slightly smaller than the contiguous United States) of which 60% is in Brazil; it also includes substantial portions of Bolivia, Peru, Eucador and Colombia plus small parts of Venezuela and Guyana. Forty-two percent of Brazil is in the Amazon Basin. It is estimated that roughly 85% of the drainage area is in the lowlands (less than 500 m in elevation), thus the vast Amazon Basin extends far beyond the Brazilian border. With the diverse topography, climate and soils in the Amazon region, it is not surprising there are major differences in vegetation such as natural savannas, low park-like forest (cerrado), low dense sclerophyll forest (caatinga), mountainous cloud forest (ceja, yungas), seasonally inundated forest (varzea, igapó), and, of course, the tall rainforest (mata, selva). In fact, many of the major forest types vary considerably and often grade to other types. Yet it is the rainforest of the Amazon Basin that captivates developers and conservationists alike and it is the forest type meant when anyone speaks or writes of Amazonian forests. Rainforest is the popular name applied to virtually all of the forests of the Amazon Basin; however, most of the Amazon Basin experiences seasonal dry periods that tend to be more severe in eastern Amazonia. The varied forests of the Amazon Basin (hereafter termed Amazonian forests) are the focus of this report on Amazonian deforestation.

EXTENT AND STATUS OF AMAZONIAN FORESTS

Quantitative information on the extent and status of Amazonian forests is even more meager than what exists on forest types. Nevertheless, the paucity of data has not inhibited authors from making crude estimates. In his 1974 estimate of global forest resources, Reider Persson of the Swedish Royal College of Forestry provides forest area data that total 3,335,000 km^2 for the Amazon Basin. Adrian Sommer's 1976 assessment for FAO estimates 4,720,000 km^2 of tropical forests in South America. Exclusion of non-Amazonian areas reduces Sommer's estimate to 3.9 million km^2. In his 1980 report on Conversion of Tropical Moist Forests to the U.S. National Research Council, Norman Myers gives estimates that total 3,982,000 km^2 of Amazonian forests. These estimates suggest Amazonian forests still cover between 3 and 4 million square kilometers--roughly equivalent to 50-60% of the entire Amazon drainage area.

The estimate of slightly more than half of the Amazon watershed is forested tells us practically nothing as to how much Amazonian forest has been lost. It is certainly incorrect to assume 40-50% of the Amazon watershed has been deforested. The mountainous forests of the Andes, the cerrado vegetation on the Brazilian Planalto and the natural savannas substantially reduce the potential extent of Amazonian forests prior to modern man's onslaughts. But again, the lack of basic data precludes anything beyond guesses that between one-fifth and one-third of Amazonian forests have been deforested in this century.

Norman Myers' report suggests that over the past two to three decades conversion of Amazonian forests has averaged less than 20,000 km^2/year, of which about 2/3 is attributed to Brazil. Although some ecologists criticize Myers' report for including selective logging in his conversion calculations, timber exploitation is a minor contributor to deforestation in the Amazon Basin (see below). An abundance of anecdotal evidence indicates Amazonian deforestation increased considerably during the past decade; hence a 2-3 decade average is probably a poor estimate of the current rate of deforestation. Nevertheless, the 20,000 km^2/year figure is 0.67-0.50% of the estimated 3-4 million km^2 of <u>remaining</u> Amazonian

forests. Myers' and Sommer's independent conversion estimates for each country sharing the Amazon Basin are all under 0.5%/year. It is instructive to compare these Amazonian estimates with the authors' global averages (0.73% and 0.97%, respectively) of the annual loss of the world's tropical forests.

Partly due to the paucity of data, there is a general tendency to apply global deforestation rates to Amazonian forests, e.g. the loss of tropical forests, at a rate of 20-50 hectares/minute or annual rates of loss of 1-2% of tropical forests. An eminent U.S. ecologist published a 1-2% rate of deforestation for the Amazon Basin based on data from Venezuela's western llanos and the Brazilian states of Sao Paulo and Paraná--none of which is in the Amazon Basin. In his report on Conversion of Tropical Moist Forests, Myers concludes that conversion trends and patterns are highly differentiated, not only on a national level, but regional as well. He states that two Amazonian areas are undergoing broad-scale conversion at rapid rates: the Colombian areas of Caqueta and Putamayo and the Brazilian states of Pará, Mato Grosso and the Rondonia territory could lose appreciable tracts of forest by 1990. Areas undergoing moderate conversion at intermediate rates include Brazil's Acre state and Amapá territory, along the Trans-Amazonian highway and the accessible varzea forests, as well as the eastern lowlands of Ecuador and Peru. Areas apparently undergoing little change according to Myers include much of Brazil's western Amazonia.

It should be evident from this brief overview that significant deforestation is occurring in the Amazon Basin, but that it is impossible to quantify the rates at which Amazonian forests are being lost. There is no shortage, however, of ecologists and conservationists who strongly disagree with practically any estimate of deforestation in the Amazon Basin. Predictions range from "imminent demise by the year 2000" to "there are sufficient tropical forest resources to last 400 years". Warwick Kerr, former director of Brazil's Amazon Research Institute (INPA), is widely quoted that if present trends continue the Amazonian forest will have vanished by the end of this century. The Global 2000 Report predicts about half of the world's tropical forests will be lost by the year 2000. According to the U.S. Interagency Task Force on Tropical Forests, the 5.9 million km^2 of tropical closed forests in Latin America are expected to be reduced to 4.84 million km^2 by the year 2000; however, in a worst case scenario, the losses could reduce Latin American tropical forests to 2.83 million km^2 by the year 2000. Largely because of its vastness and inaccessibility the bulk of the residual tropical forests will be in the Amazon Basin. The following review of tropical deforestation may help to clarify why it is occurring in Amazonia.

CAUSES OF DEFORESTATION

The causes of tropical deforestation include such diverse actions as road building, resettlement projects, slash and burn agriculture, agribusiness enterprises and commercial logging. These immediate causes usually reflect government development policy, or lack thereof, and government, corporate or personal emphasis on short-term profits. Less obvious, but nonetheless real, factors contributing to tropical deforestation are rapid population growth and unequal land tenure in most tropical countries and the developed countries' insatiable demand for cheap commodities such as beef and timber.

Road Building. The fundamental role of roads in deforestation has been ignored in most writings on the threat to tropical forests. Penetration roads range from the 5,000 km Trans-Amazonian highway to temporary logging roads. The objective

is almost invariably to open an area for "development" or to integrate existing but isolated hinterland communities into the national economy. In some cases, e.g. manganese mining in Brazil's Amapá territory, a railway is built to extract a high-value resource.

The Trans-Amazonian highway was built by Brazil to funnel colonists from the overpopulated, drought-stricken Northeast into the Amazon Basin. The colonists laid waste to the forest along the highway and spur roads in order to establish legal rights to their holdings. Poor colonists and not-so-poor entrepreneurs were spurred on by Brazilian and foreign propaganda that the Amazon Basin would be transformed into the world's "bread basket". Those exaggerated claims ignored the generally poor Amazonian soils that will not sustain permanent agriculture (see next section). Agriculture, and not coincidentally deforestation, have flourished where the highways fortuitously encounter areas of good soil such as near Altamira (Pará) and in Rondonia.

After nearly a decade of major highway construction and great expectations, the repetitive failures of agricultural colonization caused the Brazilian government to become increasingly cautious in the late 1970's about Amazonian development. Scientific criticism and skepticism, such as Robert Goodland and Howard Irwin's book "Amazon Jungle: Green Hell to Red Desert?" helped change Brazil's development policy away from Amazonia to the Planalto.

Penetration roads are located and engineered without considering ecological constraints because politicians, engineers and even international lending agencies generally show little concern for soil productive capacity or environmental impacts such as deforestation and watershed degradation. President Fernando Belaunde of Peru is giving top priority to his 30 year dream of a highway along the Peruvian margin of the Amazon Basin. Belaunde's marginal highway is supposed to open vast areas for new farms, energy development, and exploitation of natural resources. Yet these high expectations sound hauntingly similar to those used in an earlier Belaunde administration justifying highway construction through the Huallaga valley. Agricultural colonization of the upper Huallaga valley has caused massive deforestation and soil erosion of the steep slopes. Soil deterioration leads to decreasing crop yields and thus is a contributing factor to the expansion of coca production in the Huallaga valley.

The extensive network of roads for petroleum exploration and production has facilitated considerable deforestation in northeastern Ecuador. Although the exploration/exploitation roads do not directly cause appreciable deforestation, the roads do serve as conduits for colonists. The government agencies responsible for road construction, timber concessions, and petroleum exploration show little concern and even less action about the destruction of forest resources that follow in the wake of development. From an environmental perspective the construction of roads from the densely populated Andean highlands down into the Amazon Basin is much more disastrous than in the lowlands. Penetrating the rugged terrain and high rainfall areas with roads leads not only to deforestation but to landslides and massive erosion that greatly increase the sediment load in the rivers. Deforestation of these high rainfall catchment areas reduces the moderating capacity of the watersheds to absorb high rainfall and release it slowly.

The political dominance of the Andean region has resulted in rather bizarre geographical alignments of provincial boundaries. Andean provinces from Bolivia to Colombia often extend onto the Amazonian slope or even down into the Amazon

Basin. Each province usually wants its own penetration road to exploit Amazonian resources. Even though the Andean highlands may represent only 15% of the entire Amazon drainage area, it is the most critical area for regulating river levels. The numerous roads descending the Andean slopes to the Amazon are causing serious environmental degradation that will certainly increase flood levels of Amazon rivers.

Agribusiness. With a few notable exceptions such as JARI, agribusinesses in the Amazon Basin are predominantly involved in the production of beef for the export market. Cheap, lean, pasture-fed beef can be imported by the U.S.A. and western Europe at low prices. The strong international market has stimulated many tropical American countries to actively encourage beef production for export. In contrast to the vast savannas and strong pastoralist tradition in Africa, natural grasslands are rare in the Amazon Basin. Where they do exist, such as the llanos de Moxo in the Bolivian Beni (see GSH-5), cattle production has traditionally supplied beef to the densely populated urban or mining centers in the Andes. The development of beef export in tropical America is based entirely on the conversion of forest to pasture.

As part of its Amazon development policy, Brazil used financial incentives to attract large cattle-ranching operations. Transnational and national companies responded voraciously to the attraction of cheap land, liberal tax breaks and the strong export market for beef. According to Clara Pandolfo, director of Brazil's Amazon Development Authority (SUDAM), 80,000 km^2 of Amazon forests were converted to pasture between 1966 and 1978. The cutting and burning of vast tracts of forest put so much smoke into the dry-season sky that pilots flying over active deforestation fronts had to use instruments during the day.

In the interest of cheap and quick establishment of pasture, most cattle operations made no serious attempt to harvest timber before cutting down the forest. This was due in part to the few commercial timber species in Amazonian forests and the great distances to Brazilian or foreign markets (see later section on timber exploitation).

Some early agribusinesses in the Amazon mechanically cleared the forest, ripping out or breaking the trees with enormous bulldozers. The trees, stumps, and large roots were bulldozed into wind-rows, allowed to dry and then burned. In addition to wind-rowing the trees, the bulldozers usually stripped the topsoil as well. On shallow and nutrient-poor soils, little topsoil was left to provide nutrients to the planted grass or crops. JARI's mechanical clearing of sandy soils so depleted the nutrients that the planted melina trees failed to grow (see GSH-11). Traditional manual clearing of forest is much less damaging to the topsoil.

Colonization. The standard colonization procedure of slash and burn agriculture is a major cause of Amazonian deforestation. It is simple, cheap and quickly establishes physical claim to land. The landless poor often immigrate to active frontiers of colonization where few land selection alternatives exist and land evaluation does not precede identification of the parcel to be claimed. Because colonists often come from a different ecological zone, they have minimal familiarity with anything but the most widespread and traditional crops such as manioc (= yuca, cassava, mandioca). Due to their precarious economic situation, colonists are invariably forced into a subsistence situation, hence the preference for the most traditional and least risky crops.

Tropical deforestation is often blamed on shifting agriculture or cultivation; however, few, if any, colonists practice shifting agriculture. Indigenous tribes

dwelling in tropical forests follow a system whereby small clearings for subsistance crops are rotated through the forest on a 15-30 year cycle. The small area of annual clearing followed by a lengthy fallow period permit the forest to recolonize the abandoned clearing and replenish the nutrient capital depleted by clearing, burning and cropping. Under the low population densities typical of forest tribes, shifting agriculture is a beautifully developed and ecologically sound system for using tropical forests without destroying them. It is incorrect to blame shifting cultivators for tropical deforestation or to confuse true shifting agriculture with the slash and burn agriculture practiced by colonists.

The preponderance of poor agricultural soils in the Amazon Basin precludes repetitive cropping or permanent agriculture. Yields decrease abruptly for second or third crops grown on the same parcel, forcing the colonist to slash and burn a new patch of forest in order to subsist. The worn-out parcels are usually abandoned or converted to pasture. In accessible areas the partially cleared and abandoned colonist farms are often consolidated into larger cattle ranches by entrepreneurs. Since cattle ranching is not a labor-intensive use of the land, many colonists move on to rejoin the colonization frontier.

The overwhelming majority of small-holder deforestation is attributable to spontaneous colonization, that is, where there is no government direction or control and little organization of the colonization process. Slash and burn agriculture along penetration roads and the inexorable advance of the agricultural frontier is usually completely uncontrolled. The absence of government involvement in most areas undergoing colonization means, of course, a lack of social services such as health and schooling, agricultural advice on crops and soil management, and often the inability to get cash crops to market. Vocal demands for access to markets is a frequent justification for penetration roads, but by the year the road arrives local yields have usually diminished appreciably and the colonists have sold out to the cattle rancher. The colonists move on to perpetuate the advancing of the agriculture frontier as well as the demands to the government for roads, services, etc.

Each government sharing the Amazon Basin has one or sometimes two agencies responsible for colonization. Their collective efforts and projects in directed colonization can be succinctly termed failures. Even the injection of substantial funds by international development agencies has not increased national capability to develop successful agricultural colonization in the Amazon Basin. It is impossible to review here the numerous and complex causes of the repetitive failures of directed colonization projects. Suffice it to say that international development agencies are beginning to realize that ecological considerations and constraints must be integrated into colonization projects. It is noteworthy that U.S. AID has recently realized that traditional agricultural colonization is not always the answer to Amazonian rural development, but that farm forestry and agroforestry are more ecologically compatible with the poor soils and can provide a more sustainable base for rural development.

It is extremely difficult to criticize the hungry, landless poor for attempting to subsist as agricultural colonists. In contrast to the ecological disaster caused by Amazonian deforestation for cattle ranching, the plight of agricultural colonists is a social as well as ecological tragedy. Unless the social and ecological problems of slash and burn agriculture are solved, colonists will continue to advance the agricultural frontier into the rapidly diminishing Amazonian forests.

Logging. Timber exploitation contributes negligibly to Amazonian deforestation. Of the several thousand tree species in Amazonian forests, fewer than one hundred are commercially exploited. Logging is, by necessity, selective and causes only modest alteration in forest structure. Selective logging disturbance is quickly healed by the forest. As the intensity of logging increases, however, felling and extraction cause significant damage to the soil and remaining trees.

Despite the vast Amazonian forests, Brazil's forestry operations are far to the south in subtropical and warm temperate regions. The strong domestic market for wood is largely supplied by southern plantations and few remaining forests. Only 4% of Brazilian sawn timber is exported (log export is prohibited), of which 29% comes from Amazonian forests. Fuelwood--both firewood and charcoal--accounts for about 80% of Brazil's wood harvest, but fuelwood is not transported out of the Amazon region.

Plantation forestry in the Amazon Basin is becoming increasingly attractive because of fast growth rates and the low cost of land. Essentially all the plantations are being established in savannas or degraded pastures, hence plantation forestry seldom causes Amazonian deforestation. The one major exception is JARI where over 1,000 km^2 of native forest have been converted to melina and pine plantations to supply a pulp mill (see GSH-12). As JARI continues to expand the area in plantations toward a projected 2,000 km^2, all the native timber is used for saw timber or fuelwood.

CONSEQUENCES OF DEFORESTATION

Species Extinction. Tropical rainforests are the most species-rich communities on earth with an estimated 3 to 4 million species, yet only about one in six is known to science. Of the three main tropical regions, the Amazon Basin is the richest in species. For example, a one hectare plot of forest near Manaus in central Amazonia contains more species of trees than occur in the Carolinas; the species of fish in the streams of the Amazon probably exceed the number of fish species in the Atlantic Ocean.

Deforestation destroys the complex and highly-evolved communities of species that not only comprise Amazonian forests, but are dependent on them as well. Even though our knowledge of tropical forest communities is abysmal, it is highly probable that the extensive deforestation of Rondonia, Acre and southeastern Pará is already causing extinction of species. Once a species is extinct, all potential uses and values of that species are foreclosed.

Tropical species are important sources of and have tremendous potential to provide food crops, medicines and pharmaceutical compounds, raw materials, biological pest control, etc. The genetic resources of wild relatives have to be frequently bred into improved crop plants for disease or pest resistance. The loss of wild relatives may make it exceedingly difficult for crop geneticists to stay ahead of the pests and diseases continually probing the world's major crops. Norman Myers estimates that half of the prescription drugs on the world market are based on or derived from chemical compounds in plants, yet only a few percent of Amazonian species have been screened for useful chemical compounds. Tropical trees appear to be exceptionally rich sources of chemical compounds for treating cancers. The intricate biological interactions among organisms in tropical forests may be important sources of highly specialized parasitic species that will be useful in the biological control of agricultural pests.

Tropical forests are veritable storehouses of genetic resources that have already contributed greatly to man's well-being and offer much more for the future. Yet tropical deforestation is destroying this global patrimony at an alarming rate. Peter Raven, director of the Missouri Botanical Garden, predicts that if present tropical deforestation trends continue one million species could be extinct by the year 2000. Though some may quibble with the predicted rates of tropical forest destruction and species extinction, there is no doubt they are occurring and will increase as we approach the 21st century. Man's destruction of tropical forests may forever impoverish modern civilization.

Climatic Changes. Large-scale tropical deforestation may cause local, regional and global changes in climate that could adversely affect agriculture and ocean level. Brazilian researchers have learned that Amazonian forests are the source of appreciable local rainfall; evapotranspiration of water from the forest may provide up to 50% of the water returned to the forest in local rainfall. The conversion from forest to agricultural crops or pasture reduces the amount of water vapor transpired by the plants and increases the reflectivity of the land surface, both of which combine to make the site effectively drier. If the Amazon Basin is dependent on local moisture for up to half of its rainfall, extensive deforestation could significantly lessen rainfall and seriously affect the agricultural development of Pará, Rondonia, Acre, etc.

The increase of carbon dioxide in the atmosphere has generated considerable controversy about its effect on global climate. Although the burning of fossil fuels is the major source of the increased concentrations of atmospheric carbon dioxide, some scientists also include tropical deforestation as a source of atmospheric carbon dioxide (see GSH-7). Others argue that the tropics are a "sink" for atmospheric carbon dioxide because of the extensive abandonment of agricultural lands to secondary vegetation. (Mature forest is in dynamic equilibrium, i.e. neither a source nor a sink of carbon dioxide.) As deforestation increases and population pressure continues it seems impossible for the Amazon Basin not to be an increasing source of atmospheric carbon dioxide.

Several scientists believe that the increasing concentration of atmospheric carbon dioxide will have a "greenhouse effect" on the earth. A global warming trend would initiate melting of polar ice caps that would raise sea levels. Less certain is how global warming would alter rainfall regimes, but some scientists believe the subtropical high pressure zones would move poleward causing less rainfall in major agricultural regions such as midwestern U.S.A.

Other Ecological Implications. Amazonian deforestation will have adverse effects on the regional environment. The relentless advance of the agricultural frontier will continue to destroy Amazonian forest resources and degrade the soils. Recent studies of Amazonian soils indicate only 0.3% of the Brazilian Amazon has soils suitable for permanent agriculture. Most of the excellent agricultural soils occur in the varzea, the seasonally flooded forest along major rivers. Diking and drainage of the varzea soils for agriculture may have serious consequences for fish species dependent on the varzea. The exclusion of substantial area from annual flooding may actually increase the height of flooding with serious consequences for down-stream communities or costly breaching of the dikes.

Deforestation increases runoff and erosion that in turn cause increased streamflow and sediment loads. The incredibly high erosion rates of deforested land rapidly fill downstream reservoirs, aggrade streambeds and expand deltas. Rapid runoff can cause violent fluctuations in stream level leading to dry-season shortages and higher wet season floods. Because of their important regulatory functions, Andean watersheds are extremely critical to moderating the flow of major Amazonian rivers, thus deforestation of Amazonian tributaries will have disastrous downstream consequences.

Received in Hanover 9/14/81