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RISKS OF DEFORESTATION IN AMAZONIA

Philip M. Fearnside
Instituto Nacional de Pesquisas
da Amazônia - INPA
C.P. 478
69011-970 Manaus-Amazonas
Brazil

Tel: 55 (92) 642-3300 R. 314
Fax: 55 (92) 236-3822
After Aug. 1994: 642-3028

Temporary address:

106 Lakeside Court
Clemson, South Carolina 29631
U.S.A.
Tel: 1 (803) 654-7652
Fax: 1 (803) 654-5426

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The Brazilian government has succeeded in selling the world a great myth: that deforestation in Amazonia is under control. Although clearing rates declined from 1987 to 1991 (the last year for which LANDSAT satellite data have been released), this decrease is not a change that is likely to last for long, nor is it something for which the government can legitimately claim credit. The forces driving deforestation remain in place, and even were the Brazilian government able to arrive at a rational decision as to the maximum permissible extent to which deforested areas should be allowed to expand, much of the clearing process is outside of the government's control and so could be expected to continue regardless of the environmental risks of forest loss. On the bright side, many of the forces behind deforestation could be influenced by government actions should the government decide to do so, and the predominant role of large ranches in Amazonian clearing means that the social cost of substantially reducing clearing would be much lower in Brazil than in most other tropical countries.

I.) IS DEFORESTATION UNDER CONTROL?

The rate of deforestation in the Legal Amazon as a whole declined significantly between 1987 and 1991. The annual rate of 11,100 km^2 in 1991 was only half the 20,300 km^2/year average rate between 1978 and 1988. It should never be forgotten, however, that the lower deforestation rate of 11,100 km^2/year is still a huge area destroyed each year, virtually all for unsustainable uses such as cattle pasture and with very little benefit for the people of the region. An annual rate of 11,100 km^2, or 1.11 million hectares (ha), represents an average of over 3000 ha per day, or over 2 ha per minute.

Decline in deforestation rates from 1987 through 1991 does not represent a trend that can be extrapolated into the future until the deforestation problem simply disappears, as some officials have claimed. Lower rates are mainly explained by Brazil's deepening economic recession over this period. Ranchers simply do not have money to invest in expanding their clearings as quickly as they had in the past. In addition, the government has lacked funds to continue building highways and establishing settlement projects. Probably very little of the decline can be attributed to Brazil's repression of deforestation through inspection from helicopters, confiscating chainsaws and fining landowners caught burning without the required permission. Changes in policies on granting fiscal incentives also do not explain the decline. The decree suspending the granting of incentives (Decree No. 151) was issued on 25 June 1991--after almost all of the observed decline in deforestation rate had already occurred. Even for the last year (1991), the effect would be minimal, as the average date for the LANDSAT images for 1991 was August of that year.

Not only past but also potential future effect of the decree

on incentives (Decree No. 153 of 25 June 1991) is much less than many believe. The decree is a modification of a previous decree (Decree No. 101 of 17 April 1991, which "regulates" Law No. 8167 of 16 January 1991), and only covers those incentives that were included in the previous decree (i.e., only new incentives). Since 1984, Brazilian government has not had funds available for many of the concessionary financing arrangements that were included in the incentives programs, even for ranchers that had been promised them.

The overriding importance of the economic recession means that deforestation rates can be expected to increase again once Brazil's economy recovers, unless the government takes steps now to remove the underlying motives for deforestation. Steps needed include: applying heavy taxes to take the profit out of land speculation, changing land titling procedures to cease recognizing deforestation for cattle pasture as an "improvement" (benfeitoria), removing the remaining subsidies, reinforcing procedures for the Environmental Impact Report (RIMA), carrying out agrarian reform both in Amazonia and in the source areas of migrants, and offering alternative employment in both rural and urban areas.

The notion that deforestation is the result of poor people clearing to feed themselves is promoted by politicians in Brazilian Amazonia to justify their claims that anyone suggesting that deforestation is harmful or should be reduced is against the people. Central government officials have also begun to blame the poor for clearing, using the (erroneous) argument that clearing by large ranchers has been controlled by suspending incentives, so that the remaining clearing is the work of small farmers. The social costs of greatly reducing the rate would therefore be much less than is implied by those who blame poverty for deforestation.

The question of who is to blame for tropical deforestation has profound implications for the priorities of programs intended to reduce forest loss. A common generalization is that the principal culprit is "shifted cultivators," meaning small pioneer farmers who migrate to tropical forest areas. Such generalizations fail to recognize that Brazil is different from many other locations. When Brazil's differences are recognized at all, they tend to be relegated to caveats attached to global generalizations. However, Brazil is too big to be relegated to a caveat.

The distribution of 1991 clearing among the region's nine states indicates that most of the clearing is in states that are dominated by ranchers: the state of Mato Grosso alone accounts for 26% of the 11.1 X 10^3 km^2 total. Mato Grosso has the highest percentage of its privately held land in ranches of 1000 ha or more: 84% at the time of the 1985 agricultural census. A moment's reflection on the human significance of having 84% of the land in large ranches (and only 3% in small farms) should give anyone pause. By contrast, Rondônia--a state that has become famous for

its deforestation by small farmers--had only 10% of the 1991 deforestation total, and Acre had 3%. Multiple regressions of deforestation rate and the numbers of properties identified in the 1985 agricultural census in each class (under 100 ha, 100-1000 ha, and over 1000 ha) among the nine states of the Legal Amazon can be used to derive coefficients indicating the number of hectares cleared per year per property. The number of properties in each class explains 74% of the variance in state-level deforestation rates both for 1990 and for 1991. In both years small farmers accounted for about 30% of deforestation activity, with 70% being done by ranchers.

II.) IS CLIMATE CHANGE A REAL RISK?

One of the impacts of deforestation is contribution to global warming. Global warming is one of the most serious problems facing the planet today. Brazil's official estimate indicates that deforestation in Brazil contributes 1.4% of the global total of carbon dioxide entering the atmosphere. However, this estimate omits a large portion (approximately 70%) of the emission from deforestation that occurs from decay of unburned biomass or from burning of biomass that is not combusted at the time of the initial clearing. Inclusion of this and other factors omitted in the official estimate approximately triples Brazil's contribution to over 4% of the global total. By underestimating global warming impact of deforestation, Brazil's official estimate implicitly understates the relative advantage of slowing deforestation versus planting Eucalyptus. Expansion of silviculture is currently Brazil's principal proposal for contributing to the fight against global warming.

A second climatic consequence of massive conversion to pasture would be a decrease in rainfall in Amazonia and in neighboring regions. Half of the rainfall in Amazonia is derived from water that recycles through forest as evapotranspiration, rather than from water vapor in clouds originating over the Atlantic Ocean. Four independent lines of evidence lead to this conclusion. First, water and energy balances derived from average charts of temperature and humidity indicate 56% of the precipitation as derived from evapotranspiration. Second, calculations of precipitable water and water vapor flux for a transect from Belém to Manaus indicate a contribution from evapotranspiration of 48%. Third, isotope ratios in water vapor samples in the same area indicate up to 50% as recycled through the forest, depending on the month. Fourth, the volume of water flowing out of the Amazon River can be compared with the volume of water falling as rain in the catchment basin. The volume of water in the rain is slightly more than double the amount leaving through the river, meaning that the approximately half (54%) that does not drain out through the river has been returned to the atmosphere as evapotranspiration.

Only by seeing the Amazon River at flood season can one fully

appreciate the immense volume of water involved: what one sees in the river is the same volume that is returning unseen to the atmosphere through the leaves of the forest. Since evapotranspiration is proportional to leaf area, the amount of water recycled through forest is much greater than that recycled through pasture, especially in the dry season when pasture is dry while forest remains evergreen. This is aggravated by much higher runoff under pasture. Soil under pasture quickly becomes compacted, inhibiting infiltration of rainwater into the soil. Rain falling on compacted soil runs off into streams and rivers, therefore becoming unavailable for later release to the atmosphere through transpiration.

The potential damage of lowered rainfall for the remaining natural ecosystems is indicated by seasonal and spatial patterns in water vapor sources found by Enéas Salati and coworkers. Importance of recycled water is greatest in the dry season, and increases as one moves farther away from the Atlantic Ocean. This means that in Rondônia and Acre, where rapid deforestation is taking place, the proportion of rainfall derived from forest could be much higher than the roughly 50% found in the Belém-Manaus transect. Greater dependence in the dry season means that conversion to pasture would cause this period to become longer and more severe, a change that could wreak havoc on the forest even if annual precipitation total were to remain unchanged.

Many rainforest trees are already at their limits of tolerance for drought stress. In patches of forest isolated by cattle pasture in the "Biological Dynamics of Forest Fragments" project being carried out near Manaus by the National Institute for Research in Amazonia (INPA) and the Smithsonian Institution, over 80,000 trees have been tagged and mapped by Judy Rankin-de-Merona. Trees on the edges of forest patches die at much greater rates than do those in continuous forest. Since many trees die "on their feet" rather than being toppled by wind, dry conditions in the air or soil near reserve edges provide a likely explanation for the mortality. Precipitation in Amazonia is characterized by tremendous variability from one year to the next, even in the absence of massive deforestation. Were the forest's contribution to dry season rainfall to decrease, the result would probably be a very severe drought once in, say, 20 or 50 years that would kill many trees of susceptible species. Since Amazonian forest trees live upwards of 200 years, the probability would be much higher that they would encounter an intolerably dry year sometime during their lifespan. The result would be replacement of tropical moist forest with more drought-tolerant forms of scrubby, open vegetation resembling the cerrado (scrubland) of central Brazil. Such a change could set in motion a positive feedback process leading to less dense forests that transpire less, increasing the severity of droughts, thereby causing even more tree mortality and forest thinning.

Severe droughts provoked by deforestation could lead to a surprisingly rapid demise for the remainder of the forest once a

substantial portion of the region had been converted to pasture. In Amazonia at present, burning is almost entirely restricted to areas where trees have been felled and allowed to dry before being set alight. Fire stops burning when it reaches the edge of the clearing rather than continuing into unfelled forest. This lucky situation need not necessarily continue unchanged. In forested areas that have been disturbed by logging along the Belém-Brasília Highway, fires from neighboring pastures have already been observed to continue substantial distances into standing forest. During 1982-83 (an unusually dry year because of the El Niño phenomenon) approximately 45,000 km^2 of tropical forest on the island of Borneo burned when fires escaped from shifting cultivators' fields. At least 8,000 of the 35,000 km^2 of this area in the Indonesian province of East Kalimantan was primary forest, while 12,000 km^2 was selectively logged forest. Devastation would be catastrophic should fires such as this occur in Amazonia during one of the droughts aggravated by drying from deforestation.

III.) HOW MUCH DEFORESTATION CAN BRAZIL GET AWAY WITH?

Sustainability of pasture, as well as its social and environmental impacts, are closely tied to the size that these areas are allowed to attain. A small area of pasture can be maintained on imported nutrient inputs while a large one cannot. A small area would cause climatic impacts that are within the capabilities of natural systems to correct or absorb, whereas a large area would at some point cross thresholds triggering processes that lead these equilibria to degenerate. The most worrisome characteristic of pasture is that there is no immediate limit to thwart its continued expansion. Unlike annual and especially perennial crops, market limits for the system's products are unlikely to halt its expansion. Availability of labor also does not restrain pasture as it does other crops because of low labor demands of the extensive systems used in Amazonia. Pasture's dominance among land use choices allows a small human population to have maximum impact on deforestation.

A relationship exists between the magnitude of an impact and the maximum probability of the impact occurring that society is willing to accept. Small impacts, such as failure of a given crop, may be acceptable even if they occur every year, but society should insist on there being only a very tiny probability of a major catastrophe, such as a year dry enough to allow fire to destroy large areas of standing tropical forest. This is analogous to precautions against major accidents at nuclear power plants: only infinitesimally small risks are acceptable to society. The acceptability of risk to society is not a scientific question, but rather a moral and political one that needs to be debated and decided in a democratic manner.

A relationship exists between the area deforested and environmental risk. Unlike the relation of acceptable risk to magnitude of impact, the relation of risk to deforestation is a

scientific question quantification of this relationship based on field studies should be a high priority. As deforested area increases, the probability increases of a major perturbation, such as a severe drought that exceeds the tolerance of many tree species that are adapted to a relatively stable climate.

The maximum permissible extent of deforestation can be calculated from these relationships. Starting with the size of the impact that would be provoked by perturbation from deforestation, one can determine the corresponding maximum acceptable level of risk to society. One can then determine the percentage of the forest that could be cut and still stay within the bounds of this acceptable level of risk. Currently available data are insufficient to quantify these relationships and thereby specify a maximum permissible extent of deforestation. We know enough, however, to draw some practical conclusions concerning government policies affecting deforestation.

We know that forests have great benefits (for which no one is currently paying anything) and that deforested areas in Amazonia quickly become degraded cattle pasture of little benefit to anyone. This makes wise decision-making much easier than it would be had some marvelous sustainable and socially desirable land-use been discovered for vast areas of deforested land. Such a wonder crop has not been discovered, and perennial crops with better prospects for agronomic sustainability (like the Cacao that Paulo de Tarso Alvim often recommends as a remedy for Amazonian problems) cannot expand significantly beyond their current areas without immediately saturating world markets for these commodities, thereby driving prices below their present already-low levels and making the operations financially inviable. The environmental services of forest are Amazonia's most valuable product. Ways must be found to base maintenance of both the forest and the human population on the value of these services, rather than attempt to generate revenue by expanding cleared areas.

Obviously, the Brazilian government should discourage further deforestation. Heavy taxes should be levied on land sales so as to remove the profits from land speculation (clearing allows speculators to maintain their claims to land with a view to later sale). Ceasing to use clearing as a measure of "improvement" for granting land titles would be another obvious step that would cost no money. A high-level decision to <u>not</u> open up currently inaccessible areas by further expanding the highway network would also be a key step that is entirely within the government's capability; it would save Brazil a lot of money as well.