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11

Can Pasture Intensification Discourage Deforestation in the Amazon and Pantanal Regions of Brazil?

Philip M. Fearnside

Cattle pasture is the predominant land use in deforested areas in the Brazilian Amazon (Fearnside 1990, 1996). Any policy changes that affect the motivations to expand this land use would therefore have a key role in shaping the future course of deforestation. Intensification of pasture management, especially through application of phosphate fertilizers, has been subsidized by the Brazilian government as a means of reducing deforestation. The assumptions underlying this strategy require careful examination.

The Rationale for Intensification

The logic of subsidizing intensification is summarized by Serrão and Homma (1993, 319–20) of the Brazilian Enterprise for Agriculture and Cattle Ranching Research (EMBRAPA): "With technological intensification and consequent improvement in the sustainability of forest-replacing pastures, . . . productivity from cattle raising operations in the Amazon can be doubled or tripled. Therefore, from a technical point of view, no more than 50 percent of the area already used for cattle raising is actually necessary to meet the regional demand for beef. . . . If this is correct, . . . a considerable amount of already degraded pastureland can be reclaimed or regenerated toward forest formation and biomass accumulation."

Pasture intensification is done through applications of fertilizers and herbicides, replanting with better grass varieties, genetic improvement of cattle herds, and better regulation of stocking densities and rotation schedules. Intensification is promoted both in ranches cut from Amazon forest and those in the Pantanal wetlands of Mato Grosso and Mato Grosso do Sul (map 11.1). In the case of the Pantanal, EMBRAPA has

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Map 11.1. Brazilian Legal Amazon and Pantanal regions

more distant deforestation frontiers, because Amazonian ranchers, who have a higher shadow price for the land, buy out small farmers with offers of attractive sums (Schneider 1994). This difference in shadow price would increase even more if improved technologies were available, to which ranchers would be likely to have better access (Kaimowitz 1996, 56). When small farmers are bought out, deforestation rates on the purchased properties approximately double (Fearnside 1984).

An alternative response to income gained from intensification is to invest the profits in other promising activities (such as expanding extensive ranching)—but these activities usually involve cutting down more forest. An example is the investment of income from successful cocoa harvests in Rondônia in expanding extensive cattle pastures, rather than putting the money back into the environmentally more desirable perennial crop (see

Fearnside 1987a). Another is the use of profits from timber to keep the ranching industry going in Paragominas, Pará (Mattos and Uhl 1994).

The argument that increasing the productivity of pastures will "limit future use of forest for new pasture" has recently been made by Faminow (1998, 232). The assumption is that, with higher productivity, either ranchers would be satisfied with their profits or the market for beef would be saturated such that further clearing is unprofitable. I have often questioned the notion that Amazonian small farmers would stop clearing if only their stomachs could be filled by improved yields (for instance, Fearnside 1987a, 1998a). The idea of ranchers limiting their expansion because they are satisfied with their level of material existence would be even more far-fetched. Markets, on the other hand, can eventually become saturated, but pasture is likely to be able to expand tremendously, and at great environmental cost, before market forces would restrain this process. The beef demand in the Amazon that was assumed by Serrão and Homma (1993, 319–20) to set the upper limit on the extent of Amazonian ranching is hardly the ceiling imagined. Beef can be consumed in the rest of Brazil and beyond, despite restrictions on the export of frozen beef to many countries due to aphthosis (hoof-and-mouth disease) in South America. More importantly, ranchers base their deforestation decisions on many motives other than beef sale.

Pasture Is Not for Beef Alone

The logic of intensification as a strategy for slowing deforestation rests on the assumption that the primary motive for expanding pasture is to produce beef. Various indications point to other motives as critical in the behavior of Amazonian ranchers. Perhaps the clearest indication is the case of the Agriculture and Ranching district of the Manaus Free Trade Zone (SUFRAMA). In the state of Amazonas, which is dominated by the state capital at Manaus (1999 population approximately 1.6 million), only 25 percent of the beef consumed is produced in the state (Faminow 1998, 132). The SUFRAMA agriculture and ranching district, located on the outskirts of Manaus and protected from competition by vast distances to competing producer areas, is notorious for having become a sea of secondary forest when government subsidies dried up beginning in 1984. If beef production were so profitable, why haven't these ranches remained active over the period since 1984, during which time the population of Manaus has approximately doubled, along with its attendant beef demand? The case of Manaus fits a picture that includes deforestation motives other than the beef market: Motivation for maintaining the

SUFRAMA ranches would have depended almost solely on beef profits because the timber value of these forests is relatively low, because pasture is not needed to maintain possession of the land since the ranches are part of a government-organized scheme with proper surveying and documentation (unlike the legal free-for-all of southern Pará), and because the threat of invasion by landless migrants has (until very recently) been quite remote.

Land speculation and government financial incentives add to the profitability of felling for pasture, even in the face of negligible production of beef (Browder 1988; Fearnside 1980, 1987b; Hecht 1993; Hecht et al. 1988). Faminow (1998) has presented a contrary view (for a rebuttal, see Fearnside 1999a). Faminow (1998, 125 and 131) believes instead that demand for beef and milk in Amazonian cities is the key factor motivating pasture conversion. The case of Manaus belies the generality of such an interpretation.

Perhaps the clearest sign that land speculation has been a significant force in deforestation is the pattern of deforestation since Brazil's July 1994 *Plano Real* economic package was instituted, greatly reducing the rate of inflation. Landsat imagery indicates a tremendous initial jump in the deforestation rate in 1995, to 29×10^3 square kilometers per year, versus 15×10^3 square kilometers per year in 1994 (Brazil, INPE 1998); the jump is best explained as the result of a much larger volume of money becoming available for investment following institution of the Plano Real. The 1995 peak was followed by a substantial decline, to 14×10^3 square kilometers per year in 1996 and 13×10^3 square kilometers in 1997; according to a preliminary estimate, the decline was followed by an increase to 17×10^3 square kilometers per year in 1998 (Brazil, INPE 1999). The 1995–97 decline in deforestation rates accompanied a drop in land prices of over 50 percent during the same period—a price decrease that is best explained as the result of the greatly reduced rate of inflation having eliminated the role of land as an inflation hedge. The association of falling land prices with reduced deforestation rates suggests that a significant part of the deforestation that was taking place in prior years was motivated by speculation.

It is important to remember that speculation takes place on the basis of whole properties rather than just the portion of each one that has been converted to pasture. The forested portions of the properties, including the timber stocks they contain, represent a significant value. The pasture provides an effective guarantee of continued possession of the entire property, therefore providing an important motivation in addition to beef production. If a property were offered for sale without a portion of it being under pasture, even if degraded, the remaining forest would have a lower sale value because of the need for a prospective buyer to either make heavy expenditures in clearing part of the forest or risk losing possession of the property.

Money laundering offers another potential motivation for investment in expanding Amazonian cattle pasture. "Dirty" money gained through drugs, corruption, and many other illegal sources can be converted into "clean" money by investing in Amazonian business ventures, such as gold mining dredges and cattle ranches, even if they are unprofitable based on the face value of return on investment. The logic is illustrated by the case of former federal deputy (congressperson) João Alves, who gained notoriety in Brazil's 1993 federal budget scandal (ISTOÉ 1993). João Alves won approximately fifty-five times in Brazil's national lottery because he had bought many thousands of tickets in order to convert an estimated U.S.$50 million in illegally gained cash into legally recognized winnings. The small percentage of money invested in lottery tickets that will, on average, return to a bettor as winnings would make investments in financially unpromising Amazonian ranching schemes seem like excellent deals.

Cattle Density, Pasture Productivity, and Clearing

In an analysis of 191 municipalities (*municípios*) in the Brazilian Amazon, Reis and Margulis (1991, 358) found a strong positive relationship between cattle density per square kilometer and rate of deforestation. However, this econometric analysis indicated that annual cropping had a greater elasticity than the size of the cattle herd, both when the analysis was done using areas of annual crops (Reis and Margulis 1991) and using their production in tons (Reis and Margulis 1994, 186). Cline (1991) believes that collinearity among the various variables is the likely explanation for Reis and Margulis's 1991 finding of a relatively low contribution from the cattle herd (explaining only 10 percent of the deforestation in simulations for 1980–85).

One would expect a close association between cattle and deforestation because of the known association between property size and deforestation, and because of the obvious fact that large ranches tend to plant more pasture than small farms (although small farmers also plant pasture). Evidence that most clearing is done by medium and large ranches includes regressions of the deforestation rate on the area of private land in different property sizes in the Amazonian states, adjusted for the differences in the sizes of the states. Such regressions explain 74 percent of the variance in deforestation rates for 1990 and 1991, and indicate that small farmers account for only 30.5 percent of the total deforestation (Fearnside 1993). Another explanation is revealed in interviews conducted by Nepstad et al. (1999) on 202 properties in the "arc of deforestation" from Paragominas to Rio Branco, which indicated that only 25 percent of the clearing was in properties of 100 hectares or less. An indirect indication is provided by the sizes of clearings measured on Landsat imagery for 1995–97 (Brazil, INPE 1998, 1999). These measurements indicate that the percentage of clearings smaller than 15 hectares in area was 21 percent in 1995, 18 percent in 1996, and 10 percent in 1997. The 15-hectare cutoff is well above the approximately 3 hectares per year that small farmer families can clear using family labor. These values offer only an indirect indication of the role of small farmers because the values omit small clearings—the limit of detection is 6.25 hectares at the 1:250,000 scale used for image interpretation. Note that the areas refer to the size of clearings, not to the size of the properties in which they are located.

In a study of farming in Rondônia, Jones and his colleagues (1995) found that "productivity of land in cattle appears to be essentially unaffected by clearance rates." One can deduce from this finding that the opposite also applies, that is, that changes in cattle productivity do not affect farmers' land-clearing behavior. Dale and coauthors (1993, 1002) found that good soils have the largest number of beef cattle in Ouro Preto do Oeste, Rondônia, but Jones et al. (1995) have found that soil quality is unrelated to deforestation rate at the site.

Future Prospects of Intensification

Economic Competitiveness

One sign that bodes poorly for intensification is the minimal extent of unsubsidized pasture using higher-input systems. Hecht (1992) points out the lack of response to technology improvement in the Paragominas area. A dramatic demonstration of this occurred in 1995, when the Plano Real economic package (inaugurated in July 1994) suddenly made much larger amounts of money available for investment. Rather than a boom in adoption of improved pasture management, the response of Amazonian ranchers was a tremendous increase in deforestation rates. The annual deforestation rate more than doubled, from 14×10^3 square kilometers per year in 1994 to 29×10^3 square kilometers in 1995 (Brazil, INPE 1998).

In the Altamira area of Pará, Castellanet and colleagues (1994) found that the predictions of Boserup (1965) regarding population density and intensification were borne out in the case of pasture management. In other words, landowners in Altamira are *not* intensifying their pastures. Boserup (1965) provides the classic presentation of the relationship of population density changes to land use intensities, where producers in sparsely populated regions such as the Amazon tend to adopt extensive rather than intensive technologies, only shifting to more intensive methods when the density of settlement increases.

Phosphate Limits

EMBRAPA has recognized that added phosphorus is necessary to maintain pasture productivity, and in 1977 changed its previous position that pasture improves soil, recommending instead that productivity be maintained by applying 200 to 300 kilograms per hectare of phosphate fertilizer (50 percent simple superphosphate, 50 percent hyperphosphate) (Serrão and Falesi 1977, 55), to supply 50 kilograms per hectare of diphosphorus pentoxide (P_2O_5) (Serrão et al. 1978, 28). This recommendation was subsequently modified to 25 to 50 kilograms per hectare of P_2O_5 (Serrão et al. 1979, 220), but more recent recommendations have been for the original 50 kilograms per hectare (Correa and Reichardt 1995).

Low levels of available phosphorus in the soil have been found to limit growth of pasture grasses in Paragominas (Serrão et al. 1978, 1979). Problems limiting reliance on phosphate fertilizers are the cost of supplying phosphate and the absolute limits to minable stocks of this mineral. A report on Brazil's phosphate deposits published by the Ministry of Mines and Energy indicates that only one small deposit exists in the Amazon (actually two close together, Serra de Pirocaua and Ilha Trauira), located on the Atlantic coast near the border of Pará and Maranhão (de Lima 1976; see also Fenster and León 1979). In addition to the deposit's small size, it has the disadvantage of being made up of aluminum compounds that render its agricultural use suboptimal, but not impossible if new technologies were developed for fertilizer manufacture (Santos 1981, 178). An additional deposit has been found on the Maecuru River, near Monte Alegre, Pará (Beisiegel and de Souza 1986), but estimation of its size is still incomplete. Almost all of Brazil's phosphates are in Minas Gerais, a site very distant from most of the Amazon.

Brazil as a whole is not blessed with a particularly large stock of phosphates—the United States, for example, has deposits about twenty times larger—and Brazil's reserves total only 1.6 percent of the global total (de Lima 1976, 26). Continuation of post–World War II trends in phosphate use would exhaust the world's stocks by the middle of the twenty-first century (U.S. CEQ and Department of State 1980). Although simple extrapolation of these trends is questionable because of limits to continued human population increase at past rates, the conversion of a substantial portion of the Amazon to fertilized pasture would greatly hasten the day when phosphate stocks are exhausted in Brazil and the world. Brazil would be wise to ponder carefully whether its remaining stocks of this limited resource should be allocated to Amazonian pastures (Fearnside 1997).

A rough calculation can be made of the adequacy of Brazilian phosphate reserves to sustain pastures in the Amazon. Brazilian reserves of phosphate rock total 780.6×10^6 tonnes, with an average P_2O_5 content of 12 percent (de Lima 1976, 24), not counting the Maecuru deposit still being assessed. Discounting the loss of 8 percent of P_2O_5 in transforming rock to phosphate fertilizer (de Lima 1976, 10), this amount represents 86.2×10^6 tonnes of P_2O_5. The five largest companies have reserves totaling 67.1×10^6 tonnes of P_2O_5 (after corrections for losses), which current extraction rates would exhaust in only thirty years in a projection that includes no expectation of phosphate use for pasture fertilization (Albuquerque 1996, 56 and 99). The 54.7×10^6 hectares of forest cleared by 1998 in the Legal Amazon (Brazil, INPE 1998) would consume 1.1×10^6 tonnes of P_2O_5 annually if maintained in pasture. This amount assumes that pastures are fertilized once every 2.5 years (Serrão et al. 1979, 220) at the 50-kilogram-per-hectare dose of P_2O_5 per fertilization, considering a minimum critical level of 5 parts per million P_2O_5 in the soil rather than the traditional critical level of 10 parts per million, which would require annual doses of fertilizer to maintain. If the entire 400×10^6 hectares of originally forested area in the Legal Amazon were fertilized at the rate recommended for pasture, it would require 8.0×10^6 tonnes of P_2O_5 annually. If all of Brazil's phosphate reserves were devoted to this purpose, they would last seventy-nine years in maintaining the currently deforested area (an area the size of France) under pasture, and only eleven years if the remainder of the originally forested area were also converted to pasture (table 11.1). However, Brazil's fertilizer deposits are already almost totally committed to maintaining agricultural production outside the Legal Amazon (Fearnside 1998b).

Nothing obliges Brazil to rely solely on domestic phosphate supplies, although global supplies are also finite. For high-priority uses, phosphates

Table 11.1. Phosphate requirements for maintaining pasture in the Brazilian Amazon

Phosphate Deposits	
Brazilian phosphate deposits (10^6 t rock)	780.7
Deposits, corrected for 8% loss	718.2
P_2O_5 at 12% (10^6 t P_2O_5)	86.2
Fertilizer Dosages	
Frequency of fertilization (years)	2.5
Fertilizer dose/fertilization (t P_2O_5/ha)	0.05
Fertilizer dose/year (t/ha P_2O_5)	0.02
Requirement for Area Already Cleared	
Area of forest cleared by 1998 (10^6 ha)	54.7
Fertilizer consumption/yr in area cleared by 1998 (10^6 t P_2O_5)	1.1
Time that stock would last (years)	79
Requirement If Whole Forest Is Cleared	
Area of original forest in Legal Amazon (10^6 ha)	400
Fertilizer consumption/yr if whole forest cleared (10^6 t P_2O_5)	8.0
Time that stock would last (years)	11

are already imported to the Amazon from abroad. The Jari project now uses phosphates from North Carolina, United States. In the case of the soybean and irrigated rice project in Humaitá that became a top political priority in the state of Amazonas prior to the 1998 gubernatorial elections, nitrogen-phosphorus-potassium (NPK) fertilizer was imported from Israel for distribution to the farmers.

Global Warming Mitigation

Could intensification of pasture management be subsidized with the objective of sequestering carbon in the soil as a global warming mitigation measure? This would give subsidization programs access to much greater volumes of money; for example, the United States is expecting to spend U.S.$8 billion annually on "flexibility mechanisms" such as the Clean Development Mechanism (CDM) in order to meet its commitments under the Kyoto Protocol (see Fearnside 1998b). Intensification of Amazonian pasture management has been proposed for its carbon benefits in surface soils (Batjes and Sombroek 1997; Cerri et al. 1996), but the effectiveness of such measures depends greatly on assumptions regarding previous land use and subsequent management (Fearnside and Barbosa 1998). Most importantly, funds intended to avert global warming would be much better spent on measures to slow the rate of deforestation. Slowing the rate of deforestation would not only be the most cost-effective use of funds for mitigating climate change, but would also bring many additional benefits in maintaining forests intact (Fearnside 1995).

Understanding Deforestation

Understanding of the causes of Amazonian deforestation is still in an embryonic state, in part because of the lack of concerted research efforts on the causes of deforestation on a scale commensurate with the importance of the problem. I have always been impressed by the disparity between modeling efforts in the field of climate change and those for tropical deforestation. The half-dozen major global circulation models (GCMs) used for estimates of climatic changes consist of approximately 300,000 lines each of computer code, run on a "super computer," and have a full-time team of programmers maintained over several decades to continually test and improve the model. By contrast, efforts to model tropical deforestation are usually the efforts of individuals or small groups working with minimal resources. Despite these limitations, progress continues to be made on modeling deforestation (see reviews by Kaimowitz and Angelsen 1998, and Lambin 1994). Perhaps if understanding the dynamics of deforestation were given a priority on a par with that accorded climate change, we would be closer to having predictive models. We would need functional (in other words, causal) models that are spatially explicit and include location-specific representation of the behavior of different social groups. Only when such models provide adequately reliable scenarios under a range of alternative policy regimes would it be possible to tap the major financial resources that could become available should, for example, policy changes to slow deforestation be accepted as a means of avoiding greenhouse gas emissions under the terms of the Kyoto Protocol (that is, with "verifiability" of "additionality").

A danger exists that controversy among researchers over the causes of deforestation will be seized upon as an excuse to postpone doing anything about the problem. Ample precedents exist, such as the tobacco industry lobby's delaying for decades action by any government to discourage smoking on the strength of an alleged "controversy" over whether smoking causes cancer, or similar successes by fossil fuel lobbies to delay and weaken action on global warming. In the case of Amazonian deforestation, we already know enough to identify some of the critical drivers that should be the targets of immediate government action. These drivers include policies governing land-tenure establishment, levying and collecting of taxes to remove the profits from land speculation, strengthening of environmental impact assessment requirements for proposed development projects, and limiting the construction of highways (Fearnside 1989). Subsidizing pasture intensification is not recommended as a strategy to slow deforestation.

Conclusions

Subsidizing the intensification of pasture management in the Brazilian Amazon is not likely to result in the deforestation rate reductions foreseen by proponents. In addition, limits on financial resources and on physical inputs such as phosphates are unlikely to permit maintenance of vast areas of pasture under these systems. The search for effective measures to discourage deforestation should focus on the suite of motivations that lead ranchers to invest in forest clearing, including factors unrelated to producing beef. Factors such as land speculation and land tenure security can override expected effects of subsidizing pasture intensification.

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