RURAL DEVELOPMENT FORESTRY NETWORK

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SUMMARY

This research analyzes the underlying microeconomic reasons for the deforestation and burning process used by producers located along Cuiabá-Santarém Highway, between Santarém and Rurópolis, Pará State, Brazil. The results showed that the deforestation and burning process depends principally on the land use system, number of sons, age of owner, the cost of deforestation, number of familial out migrants from the farm. The deforested areas differ for each farmer; some have a great propensity to deforest in the beginning and then stabilize, while others deforest more slowly. The results showed that more deforested areas are from secondary vegetation, contradicting the image that deforestation in the Amazon is exclusively of dense forests.

INTRODUCTION

There is great controversy both nationally and internationally regarding the actual area of dense forest that is being cleared and burnt every year in Amazonia.

In 1982 the journal *Interciência* printed the well-known polemic between Myers (1982) and Fearnside (1982) against Lugo and Brown (1982 a,b,c), concerning the first two authors' overestimation of the area of dense primary forest being cleared and burnt and the more moderate figure advanced by the latter two. More recently, debate has centred on monitoring the contribution of deforestation and burning to atmospheric CO_2 levels and their potential role in world climate change (Brown and Lugo, 1992; Fearnside, 1992).

Current observations in fact indicate that a large proportion of the areas cleared and burnt in Amazonia are those covered in secondary vegetation, which do not harbour great biodiversity. The subject must therefore be analyzed with caution.

There are two main types of shifting cultivation exerting deforestation pressure in Amazonia. There is that of the native groups — the Amerindians and **caboclos** (mixed-blood descendants of Indian and Europeans or Africans) — which is characterized by a long fallow period and low frequency of clearing and burning. And there are the shifting cultivation practices of small (colonist) farmers, in which fallows are short and clearing and burning frequent (Figure 1). When the level of technology remains constant, and population density rises in a particular area, fallow time is reduced causing a gradual drop in yield per unit area.

FIGURE 1: THE RELATION BETWEEN FALLOW TIME AND FREQUENCY OF SLASH-AND-BURN FOR SMALL FARMERS AND INDIGENOUS PEOPLES

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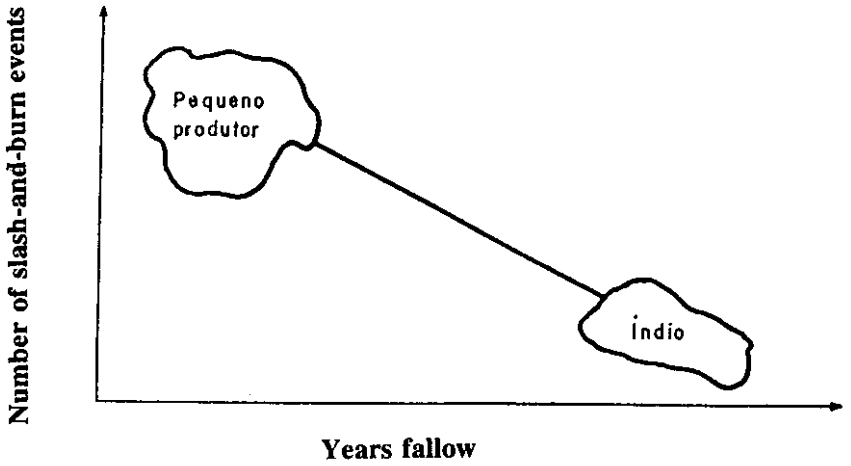

The poor living provided by farming, the lack of economic alternatives, the low levels of education, the deep-rooted farming traditions of rural people, and the shortage of capital and technology all make slash-and-burn methods predominant throughout Amazonia. The size of holdings is also an important determinant of the potential for sustainability. As plots are split up, a common occurrence in older communities and settlements, the fallowing cycle becomes shorter and shorter, and crop yields steadily decline.

There is also a widespread misconception in the academic world that land sale in Amazonia is a highly profitable speculative business. The vast supply of available land in most areas means that purchase of new, more distant areas is relatively easy. The return on property sold is soon swallowed up in the cost of setting up the new place, usually within the first year of farming. Even with large properties, land sale is not a speculative business offering large returns on investment (Homma et al., 1991).

The aim of the research reported on here was to analyze the microeconomic factors behind deforestation and burning in Amazonia. The study area chosen — the triangle formed by the towns of Altamira, Itaituba and Santarém in the state of Pará, Brazil — was chosen because its history of deforestation and burning can be readily reconstructed since it has taken place over only a little more than two decades.

METHODOLOGY AND DATA COLLECTION

Firstly, some reconnaissance visits were made to the proposed study area: this included a stretch of the Transamazonian Highway from Altamira to Rurópolis, and then from Rurópolis to Santarém on the Cuiabá/Santarém Highway. Visits were made along several feeder roads off these two highways in order to make personal contact with farmers and other informants, and to make a number of preliminary observations.

The second stage involved applying 71 questionnaires to small farmers located along the Cuiabá/ Santarém Highway from Santarém to Rurópolis and on the Transamazonian Highway 40 km east and 40 km west of Rurópolis, during November 1992. A list of information collected in this survey is found in Appendix 1. The geographical coordinates of most of the properties in the survey were taken with portable instruments, using Global Positioning System procedures.

It is planned that a further 300 questionnaires will be undertaken in order to determine geographical coordinates for each property, and analyze information on the environmental impact of farming in the region.

TYPES OF DEFORESTATION AND BURNING

Images of deforestation and burning in Amazonia have had a great impact on public opinion both within Brazil and abroad. It has been assumed that only dense forests are being affected, with devastating biodiversity losses, and that the process must be driven by folly. Preliminary results from the research conducted show instead that our ideas of deforestation and burning in Amazonia need to be clarified.

First of all, there are several different kinds of clearance carried out by farmers. The main ones are:–

- clearance of dense forest;
- clearance of **capoeirão**, old secondary forest, over 10 years old;
- clearance of **capoeira**[1], secondary forest, from 4 to 10 years old;
- clearance of **capoeirinha**, scrub, from 2 to 4 years old;
- clearance of **juquira**, young scrub, under 2 years old;

There are also different types of burning in which plant biomass is consumed:–

- burning-over of cut areas of dense forest;
- burning-over of cut areas of secondary vegetation of various ages;
- wildfire in dense forest;
- wildfire in secondary vegetation;
- wildfire in croplands;
- burning of (sugar) canefields;
- burning of crop remains;
- burning of pasture land;
- burning of roadside vegetation;
- burning of sawmill waste;
- others.

It should be stressed that the burning of pasture land is a traditional management practice in rural Amazonia. Fire is used chiefly to remove unpalatable plants, stimulate pasture regrowth, destroy pests, such as the pasture-bug *Deois incompleta* Walk., and to form fire-breaks, safeguarding contiguous areas where fire is to be used, and protecting fences from accidental fires. Uhl and Buschbacher (1991) note that areas that have been logged, and areas of dense or secondary forest beside pasture `mosaics' are the most susceptible to forest fires.

[1] In its widest sense, **capoeira** simply means secondary vegetation.

METHODS AND PROCESSES OF FOREST CLEARANCE

Methods of forest clearance vary. In dense forest, tools like chainsaws and axes are needed. Large-scale undertakings sometimes use bulldozers. Secondary vegetation can be cut with axe and sickle. Some farmers clear the forest with large chains; others use large mowers or scythes for secondary vegetation and scrub. In such cases the idea is simply to clear the area or reclaim pasture areas invaded by weeds. Small farmers use simpler tools to clear **capoeira**: axe, sickle and machete. Both dense forest and secondary vegetation can be cleared with bulldozers, mowers, chains and scythes without the need for burning-over.

Forest clearance among small producers was observed to proceed in bursts or stages, confirming Fearnside's (1986/87) results in Rondônia. It is greatest at the outset, when they first arrive in the area, and levels off after five to six years (Figure 2). Thus there are different ways in which deforestation is carried out on farmers' properties:–

Farmer A is keen to clear the forest quickly;

Farmer D devotes himself to extractive activities, and clears less forest;

Farmers B and C represent intermediate positions.

FIGURE 2: AREA CLEARED (CUMULATIVE) OVER TIME

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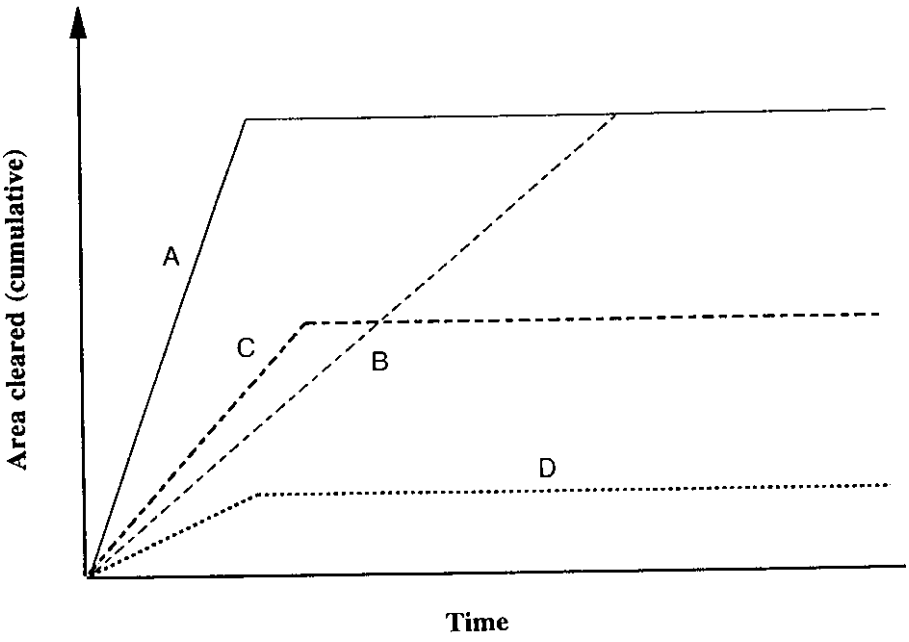

The costs of clearance, for example, have a lot to do with how fast it is carried out. When a farm is sold, the new owner tends to restart the slash-and-burn process, increasing the area already available for farming or pasture. Measures to keep farmers on their land are therefore extremely important in reducing slash-and-burn in Amazonia. On some properties, where two or more families live on the same plot or where plots are combined, open areas tend to increase. Such deforestation generally takes place from the front of the property towards the rear in successive clearance operations, when the farmer `tidies up the loose ends'. After a time, properties often consist of a mixture of secondary forest at various stages of growth, and of dense forest.

When they started work on their properties, the majority of the farmers interviewed had no notion of the value of the natural resources available on their land, (for example, the different tree species present, their value and uses), and they only gradually take over these resources. This suggests that agro-ecological/economic zoning at the individual farmer level is more important than macroeconomic area planning in Amazonia, which has been stressed in the past. Farmers should be encouraged to make better use of already modified areas and to allow damaged ecosystems to recover, by encouraging the reforestation of riverbanks, for example. Indeed, the economic cost of production itself, ought to bring about the effective zoning of productive activities.

THE MICROECONOMICS OF SLASH-AND-BURN AGRICULTURE

Capoeira costs half as much to clear as dense forest since it does not require chainsaws, fuel or machine maintenance. But using a chainsaw to clear dense forest costs half as much as doing it manually (with axes, sickles and machetes), and increases labour productivity sevenfold. The large stock of available **capoeira** resulting from deforestation in previous years means that farmers are currently using these areas. On some properties, this available secondary vegetation has been cleared and burnt some four or five times.

According to the farmers interviewed, the average age of **capoeira** cleared and burnt is 4.2 years. In terms of crop yields, rice does best in areas of recently cleared dense forest or old secondary growth. Maize and beans do well in **capoeira**. Cassava is more problematic. Farmers' responses indicate that they find cassava yields in newly-cleared forest areas disappointing, because so many roots still exist in the soil, and hinder tuber growth. But low yields also occur in low fertility soils previously under **capoeira**.

REASONS FOR BURNING

Given the low levels of capital availability and the fact that farmers do not have access to alternative forms of soil preparation, burning is justified as the least burdensome method of preparing the soil, compared with other methods which involve carting out the biomass of tree-trunks and branches. Burning provides a free fertilization with various nutrients, especially potassium, as well as helping control weeds and pests. Another advantage of burning **capoeira** is the speed and ease with which branches are removed. By contrast, there is a much higher cost of weeding, removal of unwanted plant remains and pest control during cultivation of the soil. Cultural factors associated with land use should also be borne in mind, as should the fact that

timber is seen in these conditions as being free and of little or no commercial value.

THE DEFORESTATION PROCESS OF SLASH-AND-BURN FARMING

At the micro-level, the major problem with slash-and-burn is that a stable equilibrium is very difficult to achieve. As the number of family dependants rises, larger areas must be cleared to provide a minimum level of subsistence. When children grow up they generally leave the property and their labour is no longer available, or needed. With this loss and the farmer's advancing years, the average area cleared and burnt tends to drop to the lowest level needed for the remainder of the family. It should also be noted that rural fund (FUNRURAL) benefits equivalent to one minimum wage per person paid to the farmer and his wife become an important means of survival, improving standards of living and reducing deforestation and burning.

In addition to this family cycle, there is often a steady inflow of settlers to a particular area, reducing the land available. Once plots are so close that they are all small, dense forest areas soon run out, and consequently areas of **capoeira** are cleared 4 or 5 times until they begin to show problems of decreased crop yield.

The recent interest of smallholders in keeping cattle has resulted in the clearance of land for pasture, after **capoeira** has been cut and planted with annual crops. Cattle ranching in these conditions always begins as some form of share-cropping, such as a half-share system or the granting of pasture in exchange for calves to overcome the lack of starting capital. Such operations are likely to affect the long-term sustainability of pastures, land availability, the need to combine plots, fallow lengths of remaining **capoeira** and annual food crop yields.

The fall in annual crop yields has not been met by any viable technological innovation, owing to the high cost of inputs relative to product prices, the lack of credit and the lack of management knowledge. As a result, this type of farming collapses, and other kinds of producers arrive who are interested in either livestock or perennial crops like black pepper, oranges and passion fruit.

There should be an optimum age for **capoeira** to be cleared and burnt. As the same soil is re-cultivated in successive cycles, fallow time should be lengthened to allow a greater build-up of biomass. The recovery period of **capoeira** is of vital importance in increasing soil fertility, with direct effects on crop yields. Wild forest fires in areas of secondary vegetation have held back their recovery significantly and contribute to instability.

When children grow up and leave home but remain in the rural environment, a side effect is the need to bring more land into production. Together with migratory movements, this tends to cause new areas of dense forest and/or **capoeira** to be occupied.

The spread into new areas also happens when certain crop cycles reach an end, as with pepper groves. Despite the market crisis and diseases, black pepper is still economically attractive, and is especially suited to family labour. In certain regions, the pepper production curve is bell-shaped: after an expansion phase it reaches a peak and then begins to fall. At a certain point on the curve the crop ceases to be economically viable, and the land is freed for new crops and new cycles of clearance and burning.

Another characteristic of dense forest slash-and-burn is the symbiosis between loggers and smallholders. The demand for hardwoods has resulted in the opening of new feeder roads into the forest, attracting a mass of small farmers. This partnership cuts extraction costs for the logger and simultaneously opens up new areas for the farmers involved. A large part of the area of dense forest currently being cleared in Amazonia is most likely to be due to this form of expansion. In the first phase the most valuable timber species are taken out. When these are exhausted loggers may return for other less valuable species, depending on transport costs.

The small proportion of **capoeira** along the expanding agricultural frontier means new areas of dense forest have to be incorporated. The opposite may occur in areas that have been occupied longer, where there are no stretches of dense forest left and clearance is exclusively of **capoeira**.

SUGGESTIONS FOR MORE EFFECTIVE SLASH-AND-BURN AGRICULTURE

A reduction in the annual rate of deforestation and burning in Amazonia will depend therefore on technologies adapted to the social and economic conditions of rural producers.

These need to be firstly simple and cheap technologies that aim to hasten **capoeira** recovery by increasing biomass volume, such as use of ground-cover plants or mulches and organic composting. At the other extreme are capital-intensive techniques requiring mechanization of farms and the use of modern inputs. Both options should be able to maintain soil fertility and prolong agricultural activities in the same area. If a smallholder clears and burns two hectares (of dense forest or **capoeira**) for farming, cultivates it for two years and then leaves it fallow for 10, this means that 12 hectares of forest will be needed before he returns to the original fields. If, instead of two years, new technologies allowed cultivation for three years, adding just one extra year of use, the total area required to complete the cycle would be eight hectares, reducing the area cleared and burnt by a third.

Secondly, there is a need for a reconsideration of burning practices. Much of the burning in Amazonia come from wildfires started by fire spreading from burnt-over areas (in dense forest, **capoeira** or agricultural land) whether set accidentally or deliberately. There is thus a great need for research into more suitable techniques for controlling this farming practice. The illegality of clearing and burning forest tends to make it a furtive and careless operation instead of a controlled one. Many farmers are indeed afraid the fire will spread to neighbouring areas and try to keep the flames down by burning after rain; but this merely produces yet more smoke.

Other technological options depend on the capacity of research to develop varieties that give higher yields and tolerate low soil fertility. It is more feasible for producers to adopt a new variety than techniques that recommend, for instance, modifying soil structure. In a wider sense, research should be trying to offer new economic alternatives, with perennial crops such as rubber, and the domestication of some of the non-timber forest products. The cattle ranching option being adopted by a broad range of better-off smallholders should be accompanied by technologies allowing pasture land to be used longer.

TIMBER EXTRACTION

Another activity causing forest reduction in Amazonia is the `mining' of natural timber stocks to feed sawmills. The state of Pará exploits native timber more ruthlessly than anywhere else in Brazil. No less extensive is the demand for wood for charcoal production to fuel the needs of steel mills set up under the Greater Carajás Programme. This is in addition to firewood for domestic use and industrial consumption (including bakeries and thermoelectric power stations). The medium- to long-term solution here would in part be to encourage plantations of hardwood species for timber. The demand for timber is growing and research efforts in this area should aim at species domestication where possible. Commercial energy needs will eventually need to be met in other ways as well.

CONCLUSION

According to data from INPE (National Institute of Space Research), overall deforestation of dense and secondary forest in Amazonia is in fact now falling off dramatically. Roughly 2.5 million hectares were cleared in 1989, 1.4 million in 1990 and 1.1 million in 1991. The economic crisis and cut-backs in rural credit and fiscal incentives must have contributed to the contraction of agricultural activities. All the farmers interviewed were concerned about forest clearance and burning in Amazonia, but continued these practices in order to survive and because of a lack of economic alternatives.

There are in the region some 500 000 smallholders who clear two to three hectares of land and cultivate it for two or three years until the cassava harvest is over. Therefore there is a demand for about 500 000 hectares of forest or **capoeira** every year. In this context, innovative approaches to deforestation and burning should form part of national environmental policy.

Since INPE began to monitor forest clearance and burning in Amazonia by satellite in 1975, over 43 million hectares have been cleared and burnt in the region. The old hypothesis that natural regeneration in these areas would compensate for the demand for new agricultural land in primary forest has had to be set aside — at least temporarily — in the face of overwhelming in-migration in the area. The populations of the municipalities through which the Transamazônica and Cuiabá/ Santarém Highways pass in Pará state, have practically doubled from one census to the next: from 263,347 inhabitants in 1970 they increased to 540,021 in 1980, and to 1,096,277 in 1991. However it is to be hoped that with the large stock of dense forest areas that have already been cleared and the reduced influx of migrant farmers, a balance may be achieved between the areas of dense forest and **capoeira** being cleared and the areas of **capoeira** recovering as fallow.

Among the proposals that have been advanced to reduce deforestation in Amazonia, the World Bank has suggested a drastic cut in economic incentives for productive activities, as well as a ban on the building of roads and other infrastructure (World Bank, 1990). In order to counterbalance this, the proposal includes exploiting and enhancing the value of forest products. However, the level of technological development and the aspirations of the communities involved leads one to believe that it would not be possible to survive on timber and non-timber products alone, given the size of the population. More sensible measures, in our opinion, would be to improve farming practices and infrastructural services.

Thus although reports of primary forest deforestation have been exaggerated, it should not be supposed that no deforestation is occurring. Rather the deforestation process tends to conform

to the mechanisms described above. The constant influx of migrants, local population growth, the exhaustion of dense forest in areas already settled, the decrease in suitable stocks of **capoeira**, and falling crop yields, all lead to the forest clearance in new areas.

APPENDIX 1: SOME TECHNICAL AND SOCIO-ECONOMIC INDICATORS OF PROPERTIES ALONG THE CUIABÁ-SANTARÉM HIGHWAY — NOVEMBER 1992

VARIABLES	NO OF PRODUCERS	MEAN	STANDARD DEVIATION
Mean area of property (ha)	64	121.91	167.04
Area of property cleared when owner began activities	51	17.70	29.78
Number of times he cleared forest to form new areas	23	5.09	4.33
Area of dense forest cleared last time (ha)	41	4.83	4.91
Area cleared and burnt every year (ha)	60	4.42	3.35
Fallow time for **capoeira** (years)	69	4.21	1.71
Number of children who have left the property	69	2.00	2.54
Family members migrating to other rural areas	69	0.85	1.23
Family members migrating to towns	69	1.06	1.81
Percentage of owners who have lived in towns	62	0.56	0.50
Percentage of owners who have lived in rural areas	65	0.78	0.41
VARIABLES	**NUMBER OF PRODUCERS**	**MEAN**	**STANDARD DEVIATION**
Percentage of owners who were born in rural areas	67	0.76	0.43
Percentage of income from outside property	68	0.48	0.50
Number of children who migrated and send income	69	1.78	2.50
Number of adult workers on property	69	1.78	2.50
Number of properties owner has lived on within last 20 years	62	2.11	1.27

Number of families on property	69	1.65	1.09
Number of persons living on property	69	8.16	6.48
Number of owner's children	65	6.57	4.07
Length of time at current property	68	14.21	10.07
Owner's formal education (years)	67	2.45	3.53
Number of non-working dependants	67	4.25	4.01
Man-days to clear 1 ha dense forest with chainsaw	13	7.92	2.43
Man-days to clear 1 ha dense forest without chainsaw	15	13.00	4.41
VARIABLES	**NUMBER OF PRODUCERS**	**MEAN**	**STANDARD DEVIATION**
Man-days to clear 1 ha **capoeirão** with chainsaw	9	9.39	4.11
Man-days to clear 1 ha **capoeira** without chainsaw	15	11.47	5.58
Man-days to clear 1 ha **capoeirão** with axe, sickle and machete	2	5.50	2.12
Man-days to clear 1 ha **capoeirinha** with axe, sickle and machete	2	5.50	2.12

REFERENCES

BROWN, S and **LUGO, A E,** (1992), `Aboveground biomass estimates for tropical moist forests of the Brazilian Amazon, *Interciência*, 17(1): 8-18.

FEARNSIDE, P M, (1982), `Rebuttal to the Lugo-Brown Critique of "Deforestation of the Amazon"', *Interciência*, 7(6): 362.

FEARNSIDE, P M, (1986), `Derrubada da floresta e roçagem de crescimento secundário em projetos de colonização na Amazônia brasileira e a sua relação à capacidade de suporte humano', *Acta Amazônica*, Manaus, 16/17, supplement: 123-41.

FEARNSIDE, P M, (1992), `Forest biomass in Brazilian Amazônia: comments on the estimate by Brown and Lugo', *Interciência*, 17(1): 19-27.

HOMMA, A K O, TEIXEIRA FILHO, A R and **MAGALHAES, E P**, `Análise do preço da terra como recurso natural durável: o caso da Amazônia', *R. Econ. Social. Rural*, 29(2): 103-16.

LUGO, A E and **BROWN, S**, (1982a), `conversion of moist tropical forests: a critique, *Interciência*, 7(2): 89-93.

LUGO, A E and **BROWN, S**, (1982b), `Rebuttal to the "Response to the Lugo-Brown critique by Myers"', *Interciência*, 7(6): 360.

LUGO, A E and **BROWN, S**, (1982c), `Deforestation in the Brazilian Amazon, *Interciência*, 7(6): 361-2.

MYERS, N, (1982), `Response to the Lugo-Brown of "conversion of topical moist forests"', *Interciência*, 7(6): 358-60.

UHL, C and **BUSCHBACHER, R**, (1991), `Queimada', *Ciência Hoje*, p. 84-88, December.

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