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The Evolution of Colonist Farming Systems at the Forest Frontier – Is there hope of more sustainable land use in Amazonia?

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The Farming Frontier in Amazonia

The expansion of the agricultural frontier in Amazonia has been a concern of both environment and development specialists, and the focus of many studies. The cycle of fertility decline, pasture degradation and poor economic opportunities which leads poorer farmers to sell their land to cattle ranchers and then move to start new farms in newly colonised areas, is a recognised general pattern. The existing literature highlights a number of environmental constraints and institutional and policy failures, such as perverse subsidies and lack of clearly defined property rights, which fuel this movement of small farmers. However, very few studies have focused on the farming systems of smallholder colonists and examined the opportunities for increasing the sustainability of their farming practices and intensifying land use. The research reported here is based on a three year study of the constraints to intensification; which examines the role of livestock in the development of smallholder systems, and the integration of sub-components of farming systems, with a particular focus on farmers' perceptions and practices in maintaining soil fertility and resource flows.

The research provides insights in the following areas:

- The diversity of farming systems in different ecological conditions and ages of the frontier;
- The importance of forest products in smallholder livelihoods;
- Detailed farmer knowledge of soil types, but diverse views of processes;
- Different patterns and perceptions of nutrient flows on farms, but little nutrient cycling;
- Weed control as a key constraint for farmers and as an indicator of sustainability.

The Development of Farming Systems at the Frontier

Slowing the expansion of the agriculture frontier may be dependent on the successful intensification of small farms. This necessitates greater nutrient cycling than is currently practised in most systems. Livestock may be the key factor in this cycling yet few studies have focused on the role of livestock in the multiple use systems at the frontier. Furthermore the integration of forest and forest products may also be significant for small farmers, yet conventional wisdom indicates that farmers see no value in the forest and have no incentive to conserve it.

For some authors the rapid rate of turnover and movement of families in colonist areas are evidence of the unsuitability of the land in the Amazon for agricultural production, at least using the technology available in the region. However, signs of peasant agriculture stabilisation in some areas of 'old' frontier (20 to 25 years of colonisation) have been identified in the Amazonian Brazilian states of Rondônia, Mato Grosso and Pará. In order to encourage this stabilisation to become more widespread, it is necessary to understand how effectively land use systems can integrate resource use and manage fertility for the long-term support of smallholder livelihoods in Amazonian frontier conditions, so that appropriate innovations and technical support can be implemented.

Evolutionary Models of Frontier Development

The research site, Marabá in southern Para State, is one of the most dynamic pioneer frontiers in Brazilian Amazonia. In the late 1960s the region, which covers 29,000 km^2, was very isolated and almost completely covered by forest. The economy was dependent on the extraction of Brazil-nuts, and population density was very low. Since then a number of large-scale development and infrastructure projects, including a major road, have stimulated the migration of families from different parts of the country. Some 20,000 smallholder farmers have settled in the region in the last three decades, and forest cover has been reduced by 30 percent. Other major land uses are cattle ranching and Indian reserves.

Although there is great diversity in the region, a general pattern of evolution of farming systems can be characterised, as described in Box 1 by Muchagata (1997). Figure 1 shows how this evolution is reflected in different patterns of enterprises on different farms.

Integration of Forest, Crops and Pasture

Focus of the Research

The research itself aims to address two key issues:

- to analyse and model forest, crop and livestock resource interactions within smallholder production systems and farmer perceptions of these systems;
- to identify key indicators which will determine the long-term viability of enterprises.

The research project has developed a participatory methodology which aims to reveal farmers' perceptions and understandings of resource flows and sustainability, through workshops, on-farm monitoring in three communities and in-depth interviews or focus group discussions.

Key Findings

Use and Values of Forest Products

The research shows that farmers utilise a wide range of plant and animal species. Surveys conducted in six different localities of the region indicate that 142 plant species and 42 animal species are used and provide families with food, fuel, raw materials for construction and utensils, medicines, and in addition provide an important source of income (Muchagata, 1997).

Edible species represent the most visible use of forest products in farming life. The forest also represents a living pharmacy for colonists, as other health services are very difficult to come by in remote regions. Some 24 species are commonly used for medicinal purposes, treating complaints ranging from snake bite to malaria, toothache and diarrhoea. The most important marketed products include Brazil nuts *(Bertholletia excelsa)*, cupuaçu *(Teobroma grandiflorum)*, babaçu *(Orbignya mariana)* and various timber species. However, markets in general are very poorly developed, and there is a great reliance on intermediate traders ('middlemen') to access markets. Prices are very unstable, and communications and information poor. Many products for which markets exist but which are perishable (i.e. many fruits) cannot be sold as transport is unreliable and inefficient. One of the critical livelihood roles of these products is to provide cash and subsistence when the farm or market cannot provide them, for example before planting and in heavy rains.

A detailed analysis was made of the economic value of different forest products to families in two of the study sites. The value of edible plant and animal species harvested, medicines used, fuel and other raw materials derived from the forest was estimated. This found that the average value of these products was US$622 and US$796 respectively in two communities. Variations are related both to the pattern and length of settlement, and also to the relative wealth of households and their access to resources. It was found that forest products were most important to poorer families, where forest products account for up to 58 percent of their gross household income. These findings show that the forest holds significant values for colonist farmers, and may be especially important for poorer households.

Farmer Knowledge of Resources and Flows

Forest

Research found that colonist farmers have detailed knowledge of forest ecosystems. After a relatively short time of living in the region - say 5 years - farmers know a good deal about the different forest products and their uses. Farmers are also very aware of the environmental and ecological functions performed by forest and recognise their importance for maintaining ecological stability and biodiversity. For example farmers have detailed knowledge of the interactions of different forest species and were able to provide details on the flowering and fruiting sequences of 38 different species, and the animal species attracted to them at different times in their fruiting and flowering periods.

Soil types and fertility

In a series of workshops farmers were asked to describe soils on their farms. Details of the topography and position where the soil was found, the number and size of layers, soil texture, presence of stones, biological activity and number of roots, and the crops associated with each type of soil, which crops are more suitable for each soil, the normal crop yields, best time for sowing, how long the soil retains moisture, and ease of weeding were sought. 143 different soil types were distinguished. Sketch maps produced by farmers are not very different from maps of soil surveys conducted in the localities. In fact, farmers perceive more subtle changes and variations in soil than the scientific classification captures. The quality of information provided by farmers varies as a function of the type and extent of contact they have with different soil types. Information was more detailed where farmers had been settled for longer, and for soils that are cultivated frequently. For example, 24% of the soil types distinguished by farmers were later classified as hydromorphic; although these soils only occur in small areas, they are described in great detail by farmers.

Few farmers attribute causes of changes in soil fertility to soil erosion or leaching. Many believe that it is exposure to the sun ('the sun heats the soil') that degrades soil. The main indicator for farmers that soil has become less fertile is not the decline of soil productivity, but the presence of weeds. This means farmers stress the decrease in their work productivity, which declines when more labour is required for weeding. For farmers this represents a more important fertility indicator than soil productivity itself.

Box 1: Evolution of frontier farming systems

First phase - installation:
A plot or *lote* (approximately 3ha) is cleared in the forest using slash-and-burn system, and the first rice crop is established on *roça* or crop field. Forest products play a critical role at this time, both for subsistence and as an important source of revenue. Labour may be sold to neighbour fazendeiros. Land tenure is insecure and *lote* boundaries are not clearly defined. Farmers seek to establish pasture to add value to the land.

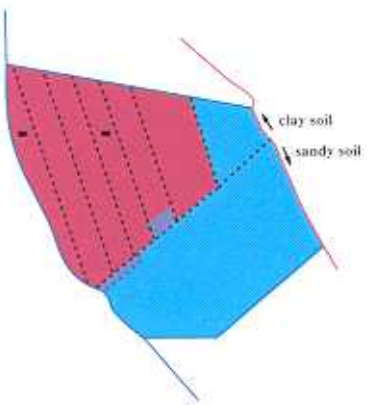
Second phase - system diversification:
4-5 years after colonisation the *lote* has changed significantly. The homestead is improved with cassava, beans, and maize produced, mainly for household consumption but any surplus sold. Forest remains important, but most *lotes* have some pasture, depending on the farmers' strategy, and some fallow land. Farmers with more initial capital may have acquired up to 10-15 cattle.

Third phase - system specialisation:
Cattle may become the main productive activity (given no significant economic constraints) and the farm is dominated by pasture. Infrastructural developments may mean that farmers are able to sell milk or cheese to supplement the sale of calves. The herd may be up to 120 animals. Crops such as rice or cassava are grown for subsistence, and the forest remains a nutrient reserve. However, the area of forest is reduced each year, and this imposes serious restrictions on the sustainability of the farming system.

Figure 1: Land Use Patterns on Frontier Farms

Key
All sketches scale 1:10,000

- river
- road
- lote boundaries
- plot division
- house
- forest
- forest-crop-psture
- forest-crop-fallow-pasture
- forest-crop-fallow
- perennial crop
- pasture existent prior to arrival
- fallow existent prior to arrival

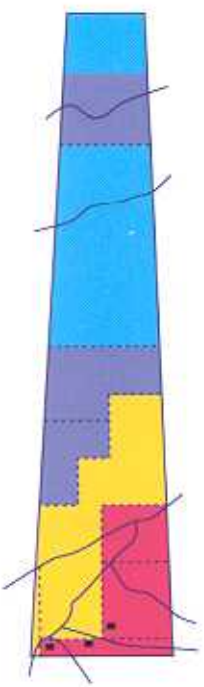


Sapecado

50 ha, 7 years of colonisation.

The farmer originally planned to plant pasture after rice and to sell the *lote* later for a higher price. He used the clay soil, where rice yields are higher. However, he bought cattle two years ago and obtained credit, changing his mind about moving. Now, with most of the clay soil in pasture he has to use the sandy area, and will have to work with cassava.

Average deforestation rate: 3.0 ha/year.

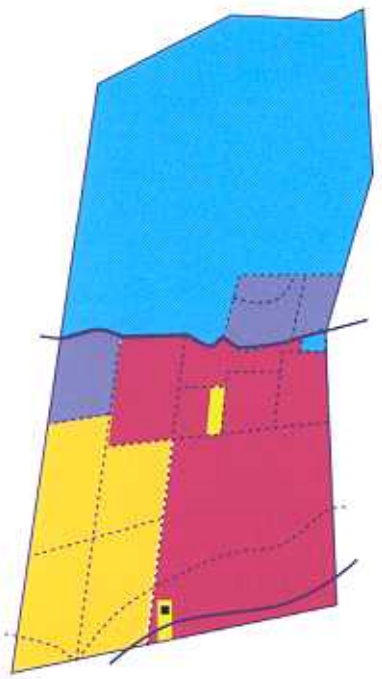


Sítio Novo

93 ha, 16 years of colonisation.

The farmer occupied the *lote* from the front to the end. He developed pasture and bought cattle in the 8th year of occupation. The rotation is rice-cassava/3 years fallow / rice-cassava / pasture. The *roça* at the end of the *lote* was done due to rumours about a road, which has never been built.

Average deforestation rate: 4.7 ha/year.



Santa Maria

185 ha, 20 years of colonisation.

The farmer has built up a herd of 56 cattle, after starting with 10 cattle in his 3rd year in the area, and planting pasture direct after rice and cassava. Two years ago he started to develop perennial crops. The decision about areas to clear is related to availability of water and distance to road.

Average deforestation rate: 4.9 ha/year.

Resource and nutrient flows

Farmers drew diagrams to show the main flows of materials and nutrients between the components of their farming systems. The resulting diagrams in general show very diversified farming systems. The interactions between the different sub-systems (crops-livestock-forest) are shown as important but the representations reveal that nutrient cycling is poor. Few farmers cited the contribution of nutrients from forest burning, the crucial factor in nutrient conversion within these systems. There is practically no use of manure, and external inputs of nutrients come exclusively from the use of mineral salt for cattle. Only in one site are some farmers using fertiliser for perennial crops, and this is because they are part of a heavily subsidised government project.

Farmers often cited fallow as a practice with negative effects on fertility. Fallow is always considered a source of weeds and sometimes also of pests. Farmers living in older areas declared they would like to have less land in fallow, which would result in less work associated with weeding. Forest is preferable, or pasture.

The majority of farmers believe that fire is a beneficial practice. Fire is seen to have a number of advantages: it combats harmful organisms and brings 'strength' to the soil. On the other hand, a minority of farmers perceive fire as a detrimental practice that increases weed invasion, and makes soil drier and harder.

Farming systems and sustainability

When discussing the future of their farming systems under current management conditions, the majority of farmers think that they will not be able to sustain cropping in the near future. Many farmers believe that the area will become a *'sertão'*, a savannah, and as this continues, the most feasible option will be to move to other areas. In contrast some farmers think that pasture has the potential to be a sustainable system, and that the key for that is to be able to control weeds. This is in line with recent research findings which indicate that the limiting factor in pasture management is weed control not fertility. Other critical factors identified are the proximity to markets and the area of forest remaining on farms.

Sustainable Land Use and Secure Livelihoods

Farmers perceive constraints to sustainability as centering on issues of markets for their products; maintaining forest cover; stopping pasture degradation; minimising labour inputs. There is poor nutrient cycling and poor integration between sub-components in these farming systems. Opportunities should be enhanced and incentives provided by the following means:

Adding value to forest products: Much of the literature still portrays colonist farmers as a large part of the "problem" in deforestation yet our findings suggest forests are valuable to farmers – as source of nutrients, subsistence and market products. But there needs to be means by which value can be added, especially access to reliable markets and stable prices, information, infrastructure and services to add value and durability through processing.

Pasture management: Weeds are a major problem in pasture management and the more intensive and rotational grazing is required in order to maintain pasture – however this may be constrained by labour requirements in the short-term. Forage legumes may be used in pastures, to stop weed growth, to add nitrogen, and to provide fodder.

Dairy products: Markets for dairy products are key factors in determining whether farms move from an extensive to more intensive and specialised system of livestock production. In some regions small dairy co-operative and marketing schemes have been very successful and are extremely influential in enhancing value of livestock production.

Livestock husbandry: More intensive systems of production require changes in technology and knowledge. Keeping of records, more selective breeding strategies and pro-active health interventions are necessary. Farmers demand more technical information and access to inputs (nutritional supplements, vaccines and medicines) in order to make investments in livestock worthwhile.

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