Published as:
van Leeuwen J.; Pereira, M.M.; Costa, F.C.T. da; Catique F.A. 1994. Transforming shifting cultivation fields into productive forests. I Congresso Brasileiro sobre Sistemas Agroflorestais, Porto Velho. Anais, Colombo, PR: EMBRAPA-CNPF, v.2: 431-438.

TRANSFORMING SHIFTING CULTIVATION FIELDS INTO PRODUCTIVE FORESTS

Johannes van Leeuwen[1], Márcio M. Pereira[2], Fernanda C.T. da Costa[3],Francisco A. Catique[2]

[1]Instituto Nacional de Pesquisas da Amazônia (INPA)
[2]Bolsista do RHAE-CNPq [3]Bolsista do CNPq

ABSTRACT - The planting of tree seedlings can transform shifting cultivation fields into new forests, which combine the recuperation of soil fertility with production. This is an important alternative to the common practice of abandoning *terra firme* fields after two to four years of cropping. A large number of tree species is of interest for these forests. Grouping these species into small, medium-sized and large trees, eases the design of species combinations. The combination should allow for a continuous flow of useful products through the years. First results with participative design and establishment on fields of volunteers are encouraging.

Key terms: agroforestry, shifting cultivation, fallow, smallholders.

A TRANSFORMAÇÃO DE ROÇAS DA AGRICULTURA ITINERANTE EM FLORESTAS PRODUTIVAS

RESUMO - O plantio de mudas pode transformar as roças da agricultura itinerante em novas florestas, que combinam a recuperação da fertilidade do solo com a produção. Trata-se de uma alternativa importante à prática comum de abandonar roças de terra firme depois de dois a quatro anos de cultivo. Um grande número de espécies arbóreas é de interesse para essas florestas. Agrupando essas espécies em árvores de tamanho pequeno, médio e grande, facilita-se o delineamento de combinações de espécies. A combinação deve permitir um fluxo contínuo de produtos úteis através dos anos. Os primeiros resultados com o delineamento participativo e a instalação em roças de voluntários são encorajadores.

Palavras-chave: Termos para indexação: sistemas agroflorestais, agricultura itinerante, pousio, pequenos produtores.

INTRODUCTION

Agroforestry is generally considered an important land use option for the Amazon, but proven technologies for its promotion are almost not available.

Agroforestry is an extremely broad concept embracing very different systems as: home-gardens, improved fallow, perennial crops with "shade" trees, pasture with trees, alley-farming, etc. Several hundred plant species, most of them trees, which can be combined in an infinitude of ways, are of potential interest. However, for most species, little or no agronomic or silvicultural information is available.

The great many options and the lack of detailed information make it very difficult to develop strategies for the promotion of agroforestry.

This paper relates participative on-farm research which aims to develop, on a short-term basis, concrete agroforestry proposals. It will be limited to presenting proposals on the transformation of shifting cultivation fields into new "forests" of economic interest. PADOCH & DE JONG (1987) consider this succession as, perhaps, the most important system for the humid tropics.

MATERIAL AND METHODS

With the help of the extension service EMATER, two small *terra firme* (upland) agricultural settlements in the municipality of Manacapuru (Amazonas, Brazil) were selected for our work. The settlements are about two hours travel, by asphalt road and ferry, from the city of Manaus. They were chosen as they are recent settlements without acute land tenure problems, and are representative of the expanding smallholder agriculture around Manaus. At the same time, their relatively easy access allows intensive accompaniment.

The settlements were made possible by the opening up in 1986 of two secondary roads which give access to the land. In most cases farming started several years later. In 1993 each settlement contained 30-40 small farms.

Land use problems and possibilities for the inclusion of more trees into the farming system were discussed during farm visits and meetings with the local community. During these meetings, farmers interested in participating in the research were identified.

A questionnaire for the description of the farms and their forms of land use was developed, tested and improved.

Farms belonging to 21 volunteers were visited several times and described in detail with the help of the questionnaire. Relatively stable farms were chosen for further work.

A list of interesting tree species was prepared. The species included are supposed to grow reasonably well on the nutrient poor *terra firme* soils, and to be of economic interest. Important information sources on species were: FAO (1987), CAVALCANTE (1991), LOUREIRO, SILVA & ALENCAR (1979), many helpful farmers, researchers, extension officers and

observations by the authors.

For each selected farm a special agroforestry proposal was elaborated in cooperation with the farmer. Final decisions stayed with the farmer. As the project aims to do research and not extension, only those proposals which could be expected to provide new information, were followed up.

In the 1992/93 rainy season the different agroforestry systems were installed on seven farms. Land and labor was furnished by the farmer, while the project provided most of the planting material, technical advice and, in most cases, assisted in marking the planting sites.

The plots are managed by the farm family. At regular intervals the plots are described and measured. Evaluation of the systems will be based on farmer acceptance, economic aspects and the evolution of soil fertility and bio-diversity.

RESULTS AND DISCUSSION

Of the 21 farms described, 20 belong to smallholders with relative few means -- although there are important differences among them -- the other being owned by a business man with important means to invest in his farm. This paper refers only to the 20 small-holdings.

Five of the farms were found also to cultivate land in the *várzea* (flood land). The data presented here are restricted to the *terra firme*, as *várzea* land use problems are very different. *Várzea* soils are much more fertile, but crop loss by early or high flooding is a serious risk.

Table: **Land use of 20 *terra firme* smallholder farms**

Land use	**Number of farms**	**Mean area** (ha)	**Amplitude** (ha)
Cassava	19	2.41	0.3-6.5
Semi-perennials (pineapple, passion fruit, sugar cane)	8	0.64	0.1-4.5
Home garden (many tree species, mostly for fruit)	20	1.50	0.4-3.5
Perennial plantation (*cupuaçu*, annatto, citrus)	7	0.44	0.5-3.0
Pasture	1	0.05	1.0
Capoeira (forest regrowth after cropping)	14	1.59	0.5-6.0
High forest	18	8.01	0.5-29.0
Young home garden or perennial plantation with cassava (negative, as counted twice in previous categories)	9	- 0.74	0.05-6.5
FARM SIZE	20	13.90	3.0-40.0

Notes on the table

1. The scientific names of the mentioned species are: cassava (*Manihot esculenta*), pineapple (*Ananas comosus*), passion fruit (*Passiflora edulis*), sugar cane (*Saccharum officinarum*), *cupuaçu* (*Theobroma grandiflorum*), annatto (*Bixa orellana*), citrus (*Citrus spp.*).

2. Although a land use may not occur on all farms, its mean surface was obtained by dividing by twenty the total area encountered on twenty farms, as this gives an idea of the "average" land use.

3. The cultivated areas per farm are relatively high as in several cases a farm is used by more than one household, *e.g.*, parents and married children.

4. In fact all families grow cassava as the only family without cassava grows this crop in the *várzea*.

5. Besides bitter and sweet cassava, very small quantities of cowpea (*Vigna unguiculata*) and horticultural crops are sometimes grown in the same field.

The question of sustainability of these farms depends mostly on the fields with cassava and semi-perennials which exhaust the soil in 2-4 years and have to be replaced by newly cleared forest areas (high forest or *capoeira*). The average farm has 3.05 ha under cassava and semi-perennials (2.41 + 0.64), and 9.60 ha under forest (8.01 + 1.59). The relation of land under cassava and semi-perennials to the sum of land under cassava, semi-perennials and forest is approximately one to four. In other terms the percentage of land under cultivation, the so-called R-index (RAINTREE & WARNER 1986), is approximately 25. Although it might seem that the farms have much land under forest which they can rotate with cassava and semi-perennials, this is not the case. In an equilibrium situation the nutrient-poor soils of the humid tropics need very long periods to recover their fertility (MUTSAERS 1981; NYE & GREENLAND 1960).

Sustainability can be improved by increasing the importance of productive agroforestry, in detriment to the area occupied by cassava and semi-perennials.

Agroforestry should contribute substantially to the recovery of soil fertility. It needs, therefore, to use a high number of trees in order to develop a high biomass and a permanent, dense root web which will increase nutrient storage and cycling. High litter production will protect the soil against erosion and extreme temperatures. Resulting higher organic matter will increase water and nutrient storage capacity and phosphorus availability of the soil.

A mixture of different species involves less economic risks and may lead to a more efficient use of light, nutrients and water. It may also decrease the risks of pests and diseases.

A combination of early and late producing species which guarantees a yearly production, and begins production a few years after installation, is important to keep the farmer interested. The system should be easily integrated into actual land use and need little labor for installation and early maintenance.

The transformation of fields with cassava or semi-perennials into mixtures of useful tree species of different precocity fits these conditions. To reduce costs the trees should be planted together with cassava or other crops. If this is done in the first year of cropping, the trees will be well developed when the field is no longer used.

The proposal advanced here is in agreement with the observation of RAINTREE & WARNER (1986 p. 44, figure 1) that in the case of a R-index equal to 25, forest fallow has to be substituted by economically enriched fallow.

A system with several spacings and canopy layers

Thirty one species were selected for use. Most produce fruit, some fruit and timber, some only timber.

To simplify working with such a high number of species, they were divided in three groups. The first group contains species such as *cupuaçu*, guava (*Psidium guayava*), *guaraná* (*Paullinia cupana* var. *sorbilis*) and citrus. Species of this group stay small, often start fruiting quite early and can be maintained at a relative dense spacing.

The second group contains broad leaved fruit species such as avocado (*Persea americana*), *biribá* (*Rollinia mucosa*) and jackfruit (*Artocarpus integrifolia*) and palms such as pejibaye (*Bactris gasipaes*) and *tucumã* (*Astrocaryum vulgare*). These species develop into "medium sized" trees, need generally a larger spacing than the first group, and, in most cases, fruit production starts later than in the first group.

The third group contains species such as Brazil nut (*Bertholletia excelsa*), *piquiá* (*Caryocar villosum*), *cardeiro* (*Scleronema micranthum*) and mahogany (*Swietenia macrophylla*). Brazil nut and *piquiá* produce interesting fruit and valuable timber, while *cardeiro* and mahogany are only of interest for their timber. Species of this group develop into large trees, which in the later stages generally will need very large spacings. Fruiting often starts very late. Brazil nut starts fruiting after 8 to 12 years and *piquiá* after 10 to 15 years.

To simplify the spatial combination of the different groups, the larger spacings should "fit" into the smaller spacings. A simple solution is to use for the medium-sized species a spacing twice as large as that of the small species, and for the large trees a spacing two or more times that of the medium-sized ones. One of the possible solutions is 5 x 5 meter for the small species, 10 x 10 for the medium-sized

species and 20 x 20 for the large species. Other solutions are: 4 x 4, 8 x 8 and 16 x 16 meter or 4 x 4, 8 x 8 and 24 x 24 meter. Many more solutions are possible, including less straightforward ones.

By combining species of the three categories the plantation may develop three different canopy layers: a low canopy layer of trees of the first group, a medium height canopy layer of trees of the second group and a top layer of trees of the third group. Some species will start producing earlier, others somewhat later, and still others quite late, guaranteeing a yearly harvest which begins a few years after installing the plantation. Light demanding smaller species may stop producing when the larger species create too much shade, causing a form of succession in the system.

At the moment, our list contains 8 small species, 20 medium-sized species, of which 7 are palms, and 9 large species. The composition of the list is in no way definitive, as the knowledge on most species is very incomplete. The placement of a species in one of the categories is to a certain degree subjective. The economic importance of the different species varies. For certain species, the use of a relatively large number of trees per farm seems justified, while for other species it may be advisable to use only a small number of trees.

The design of agroforestry systems combining several tree species showed that species choice varies a lot from farmer to farmer. Some farmers preferred to exclude, for instance, *cupuaçu*, which in other cases constituted the most important species. Several accepted to include timber trees, while others declined.

Four plots were installed in cassava fields, two in pineapple fields and one in a young *capoeira*. In this way the fields are transformed into a forest of greater economic value.

Important information on farmers' knowledge and practices was obtained. The knowledge on tree species characteristics, seedling production and planting techniques vary greatly from farmer to farmer. Direct seeding of tree species proved to be an important farmers' practice, which gave very good results, especially with rapid germinating species as *cupuaçu*. The planting on a rainy day of on-farm produced, bare-root seedlings in the shade of cassava was another interesting technique.

CONCLUSIONS

Under actual land use forest is cleared for annual or semi-perennial crops. After two to four years of cropping the field is no longer productive and is left fallow or abandoned.

When tree seedlings are planted in these fields together with the crops, if possible, in the first year, the field is transformed into a new forest which combines the recuperation of soil fertility with the production of economically interesting tree products.

This is an important alternative to the very common practice of abandoning *terra firme* fields after two to four years of cropping.

Smallholders are receptive to this approach and show much interest in the planting of fruit trees. Some also are interested in the installation of timber trees.

Assistance in the marking of the planting sites and the availability of seedlings are important stimuli.

A uniform prescription cannot be given as preferences for species and future plans for the field vary greatly between farmers.

Methods developed and accumulated species information can be useful elsewhere in the Amazon to identify adequate agroforestry proposals.

CITED LITERATURE

CAVALCANTE, P.B. (1991) **Frutas comestíveis da Amazônia.** Belém: CEJUP, 5. ed., 279 p.

FAO (1987) Especies forestales produtores de frutas y otros alimentos, 3. Ejemplos de América Latina. **Estudio FAO Montes** n. 44/3, 308 p.

FLORES PAITÁN, S. (1983) Agroforesteria en la Amazonia Peruana, investigaciones em marcha de la Universidad Nacional de la Amazonia Peruana. Turrialbia: CATIE. 3 p. [mimeografado]

LOUREIRO, A.A., SILVA, M.F. da, ALENCAR, J.da C. (1979) **Essências madeireiras da Amazônia.** Manaus: INPA. 2 v.

MUTSAERS H.J.W., (1981) Crop ecology and agroforestry. In: WIERSUM K.F. (ed.). **Viewpoints on agroforestry.** Wageningen: Agricultural University, p. 123-128.

NYE, P.H., GREENLAND D.J. (1960) The soil under shifting cultivation. Commonwealth Bureau of Soils. **U.K. Technical Communication**, n. 51, 156 p.

PADOCH, C., JONG, W. de (1987) Traditional agroforestry practices of native and ribereno farmers in the lowland Peruvian Amazon. In: GHOLZ H.L. **Agroforestry: realities, possibilities and potentials.** Dordrecht: Martinus Nijhoff, p. 179-194.

RAINTREE, J.B., WARNER, K. (1986) Agroforestry pathways for the intensification of shifting cultivation. **Agroforestry systems**, v. 4: p. 39-54.

Acknowledgements

- This work is partly inspired by the work of Dr. Salvador

Flores Paitán in Iquitos, Peru, by means of information brought by Charles Clement and others.
- INPA, CNPq and the Max Planck Institute of Germany gave important support.
- Valuable information was given by many farmers, extension officers of EMATER, researchers of INPA, FUNTAC, and the EMBRAPA Centers of Belem, Manaus, Porto Velho and Rio Branco.
- Mark van der Woude and Cornelie L. Hemmes made an important contribution as trainees.
- Useful comments on this paper were given by Robert Miller and by João Batista Moreira Gomes, who also participated in part of the field work.