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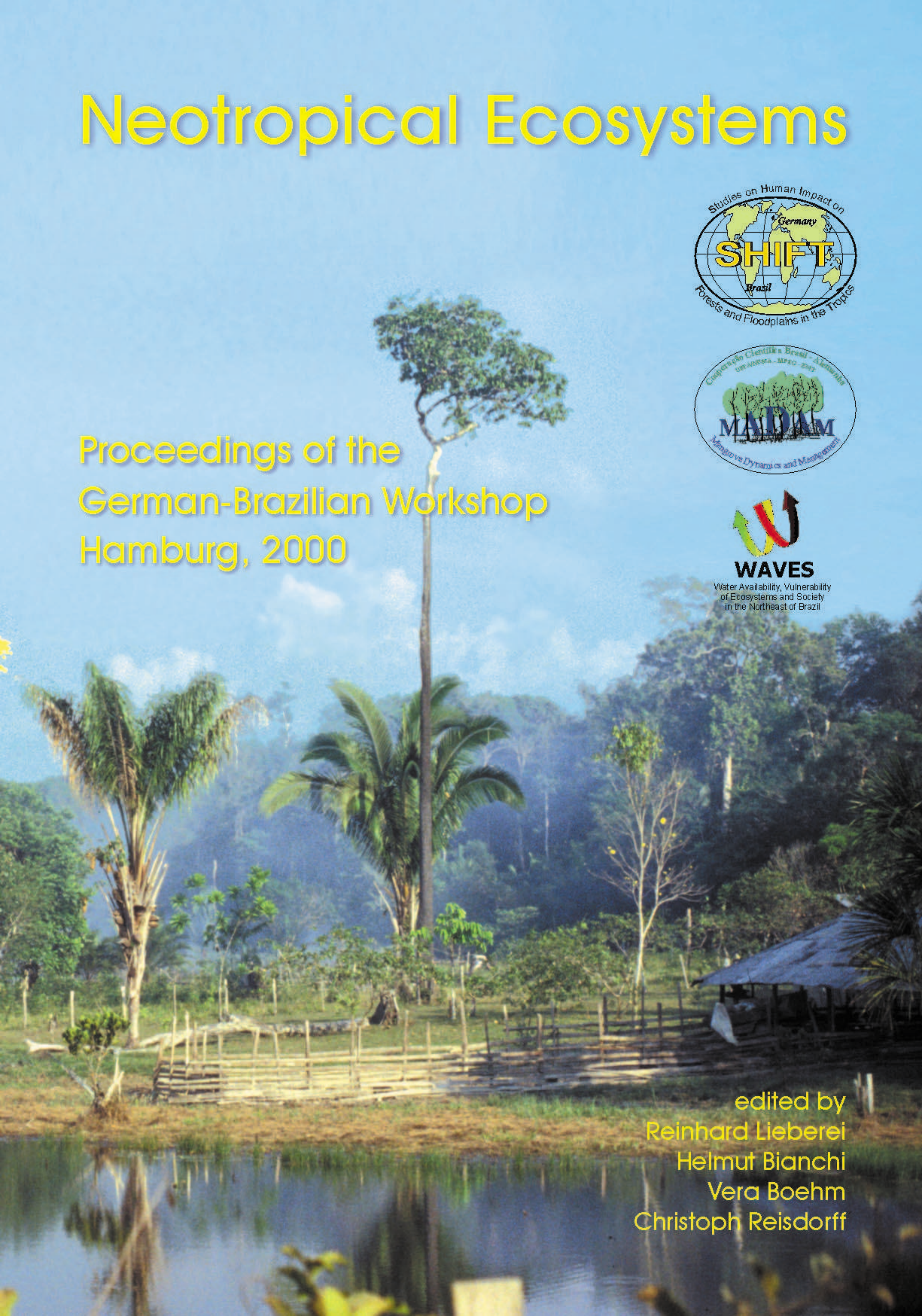

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Enriching Fallow Vegetation in the Eastern Amazon of Brazil: Towards Improving Land-Use

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Abstract

During the last 120 years, factors as rudimental technology, demographic growth, land use intensification and lack of adequate agricultural polices are contributing to shorter the fallow periods used in slash-and-burn agriculture in the Eastern Amazon of Brazil. Because of this, a decline of the agricultural productivity has been observed caused by soil fertility decrease and losses of nutrients due to the insufficient time for fallow biomass accumulation. Thus, extensive forest areas are disappearing and increasing abandoned land. This unstable land use can collapse the family agriculture. Therefore, it is necessary to improve shifting cultivation technologically seeking to increase its productivity and sustainability. Fallow enrichment with fast growing trees can improve the stability of the system due to biomass and nutrients accumulations in a short period. Experience in Igarapé-açu (State of Pará, Brazil) showed in 2-year enriched fallow, a biomass equivalent to that found in old fallow vegetation (five years), without committing the enriched fallow biodiversity in relation to traditional fallow. The fallow vegetation enrichment followed by slash-and-mulch (without burning it), if repeated in the log run, could be capable to improve the soil organic matter, providing better agricultural productivity. The potential of fallow vegetation enrichment assumes considerable dimension, as it is observed that only the State of Pará has more than one million hectares of temporary crops and fallow land. However, to be positive in the technology transfer it is necessary to have farmer's participation.

Keywords

Fallow vegetation, Leguminous tree, Amazon region, Fallow enrichment.

1 Slash-and-Burn Agriculture in the Eastern Amazon of Brazil

The slash-and-burn agriculture practiced in the Eastern Amazon of Brazil uses rudimental technology offering little opportunity to the small landholder to accumulate capital and to improve livelihood. Moreover, the lack of adequate agricultural polices, demographic growth, the division of the family's land and consequently its intensified use, and the new market for agricultural products (SILVA et al., 1998) have contributed to the shortening of the fallow periods. The results are a loss of nutrients and decrease in soil fertility due to insufficient time for the accumulation of fallow vegetation biomass. These factors are providing land use instability, resulting in abandoned areas.

For the small landholder the fallow vegetation is an important source - among others - of firewood, charcoal, medicinal plants, and opportunity for hunting. From the researcher's point of view, the fallow vegetation facilitates the recovery of the biogeochemical stability. In order to develop appropriate management strategies to avoid land degradation caused by agricultural activity, it is important to know the function of fallow vegetation. The previous land use and management as well as the duration of land cultivation have a major influence on the type and vigor of the fallow vegetation (DANTAS, 1989; DENICH, 1989; UZÊDA, 1995; VIEIRA, 1996; BAAR, 1997). Soils of fallow vegetation at different ages compared to soils of the forest have not shown clear differences in fertility (FALESI, 1976; VIEIRA, 1996). Soil productivity is generally considered the main limiting factor for maintaining the sustainability of the slash-and-burn systems. Two important effects have to be considered in relation to the use of fire in shifting cultivation. First, during the burn of biomass there is a considerable loss of nutrients, mainly nitrogen (HÖLSCHER et al., 1997). Two aspects represent the second effect. Initially, there is a momentary improvement of soil fertility provided by the ash from the burn (FALESI, 1976; SEUBERT et al., 1977; KATO, 1998a and 1998b). But this soil improvement will support only one or two cropping periods. Nutrients losses also occur during the agricultural land-use cycle caused by leaching and crop exportation (HÖLSCHER, 1995; KATO, 1998a and 1998b). This suggests that the main role of fallow systems is the biomass accumulation as a source of nutrients. When the small landholder shortens the traditional fallow period, there will not be enough time for biomass accumulation and nutrient re-establishment to a level that provides adequate food production for the small holder. In the long run, this will bring the slash-and-burn system to collapse. Fallow management must, therefore, contribute to the efficient maintenance of the nutrients in the system. The planting of fast growing and nitrogen fixing trees as an enrichment of fallow vegetation, can improve the biomass production and its nutrients stock. This type of land management could be a promising means to alleviate the pressure on the primary forest and allow its conservation. Thus, increasing the technological foundation of the slash-and-burn agriculture could increase its productivity, sustainability, and contribute to food security in the Eastern Amazon of Brazil (Bragantina region, State of Pará) and the Amazon region.

2 Enriched Fallow Vegetation Approach

The enrichment of fallow biomass, conserving the fallow vegetation as a base for biodiversity and keeping the short fallow time, was studied in the Eastern Amazon of Brazilian based on a traditional slash-and-burn system of maize (cultivar BR 106, planted in January 1995 at 1.0 m x 0.5 m; SOUZA et al., 1999) and cassava (cultivar "olho verde", planted in February 1995 at 1 m x 1 m). The leguminous trees *Acacia angustissima* Kuntze, *Clitoria racemosa* G. Don, *Inga edulis* Mart. and *Acacia mangium* Willd. were planted after maize harvest (June 1995) and four months after cassava had been planted (February 1995) at spacing of 1 m x 1 m, 2 m x 1 m and 2 m x 2 m, with exception of *Sclerolobium paniculatum* Vogel which was planted only in 2 m x 1m. Trees and cassava grew together for eight months until the cassava be harvested (February 1996). After the

Enriched Fallow Systems	Number of trees ha^{-1}	Biomass of Evaluated Compartment ($t\ ha^{-1}$)				Total
		Tree	Capoeira	Litter*	Root	($t\ ha^{-1}$)
A. angustissima	10000	14.4 ± 1.8	7.2 ± 0.6	7.8 ± 0.5	7.8 ± 0.3	37.2
	5000	17.4 ± 1.8	8.7 ± 0.8	9.5 ± 0.3	nd	35.7
	2500	15.4 ± 1.9	12.3 ± 1.8	8.0 ± 0.7	4.3 ± 0.9	40.0
C. racemosa	10000	11.6 ± 3.5	8.1 ± 0.4	6.6 ± 0.7	2.9 ± 0.4	29.2
	5000	6.9 ± 1.2	14.7 ± 1.0	7.9 ± 0.6	nd	29.5
	2500	4.1 ± 0.8	14.6 ± 1.1	7.1 ± 0.9	3.5 ± 1.2	29.4
I. edulis	10000	14.3 ± 2.5	5.4 ± 1.0	11.5 ± 0.9	4.3 ± 0.4	35.5
	5000	13.5 ± 2.7	6.0 ± 0.3	10.8 ± 0.9	nd	30.3
	2500	9.8 ± 2.3	10.9 ± 1.0	9.6 ± 0.9	4.4 ± 0.7	34.7
A. mangium	10000	45.0 ± 10.0	5.5 ± 0.4	11.4 ± 0.3	3.1 ± 0.5	65.0
	5000	33.3 ± 8.4	6.6 ± 0.6	10.8 ± 0.4	nd	50.7
	2500	35.3 ± 12.1	10.7 ± 1.1	8.7 ± 0.4	5.9 ± 1.3	60.6
S. paniculatum	5000	12.7 ± 1.9	8.1 ± 1.4	11.3 ± 0.5	nd	32.1
Control		-	17.2 ± 1.5	6.8 ± 0.8	3.1 ± 0.7	27.1

*Including leguminous trees and fallow vegetation
nd: not determined

Tab. 1: Biomass of enriched fallow with *A. angustissima, C. racemosa, I. edulis, A. mangium, S. paniculatum* and control as a function of compartment (tree, capoeira, litter and root) and spacing (10000, 5000 and 2500 trees ha^{-1})

last cassava weeding (between October-November 1996) the fallow vegetation started growing as an enriched fallow. The study had 1-year cropping followed by 2-year-fallow (BRIENZA JÚNIOR, 1999).

It was quite evident that planting trees for enrichment altered the fallow vegetation biomass, as adding a new component to fallow ecosystem increased competition for site resources. All enrichment systems accumulated more biomass than the control with no enrichment (Tab. 1). The fallow enrichment system with 10,000 trees ha^{-1} produced the largest above-ground biomass, but caused fallow vegetation suppression. The largest biomass reduction was observed in the enriched system with *A. mangium* (57%) at the spacing 1 m x 1 m. The smallest reductions were registered in the systems with *C. racemosa* planted at the spacing of 2 m x 1 m (12%) and 2 m x 2 m (11%).

3 Scenario Projection

Solve the slash-and-burn problem has a significant impact on the landscape when the total number of farmers is taken into account. In the Brazilian Amazon, around 800,000 rural properties exist with temporary crops and fallow cultivated land (IBGE, 1996). An annual decrease of 10% of the total area under shifting cultivation would be expected by extending the cultivation period by one year through the appropriate technology (SERRÃO and HOMMA, 1993).

The normal fallow vegetation would take approximately five years to accumulate the same biomass as the enriched system with *A. mangium* in two years (Fig. 1). This would imply that 3-year-fallow could be saved. For the other enriched species, less time is saved: about one year for the system enriched with *A. angustissima, I. edulis,* and *S. paniculatum,* and down to 0.6 years for *C. racemosa.*

Based on Fig. 1, it seems obvious that the enrichment technique offers advantages. Even if one assumes that part of the increased biomass of the system with *A. mangium* could not remain on the field (energy and charcoal exploitation), a fallow reduction by one or two years would be a gain, if this can be attained without a lowering in crop productivity.

However, at this stage one should not indulge into speculations about the future consequences of fallow enrichment. It is necessary to keep in mind that so far, only one cycle of the system has been studied. In order to be positive about the sustainability of a system, one has also to study the impacts of changes on consecutive cycles. Attention should be paid to the following:

a) there is a lack of information on the amount of fallow biomass required for sustainability of the system. HÖLSCHER et al. (1997) in his study of the nutrient balance of a 9-year cycle demonstrated the deficit character of the system. One can doubt, therefore, that the common 2 + 4 year cycle is sustainable. If it is accepted that farmers today are not in a position to prolong the fallow period, other ways have to be found to supplement nutrient deficits. Fallow enrichment

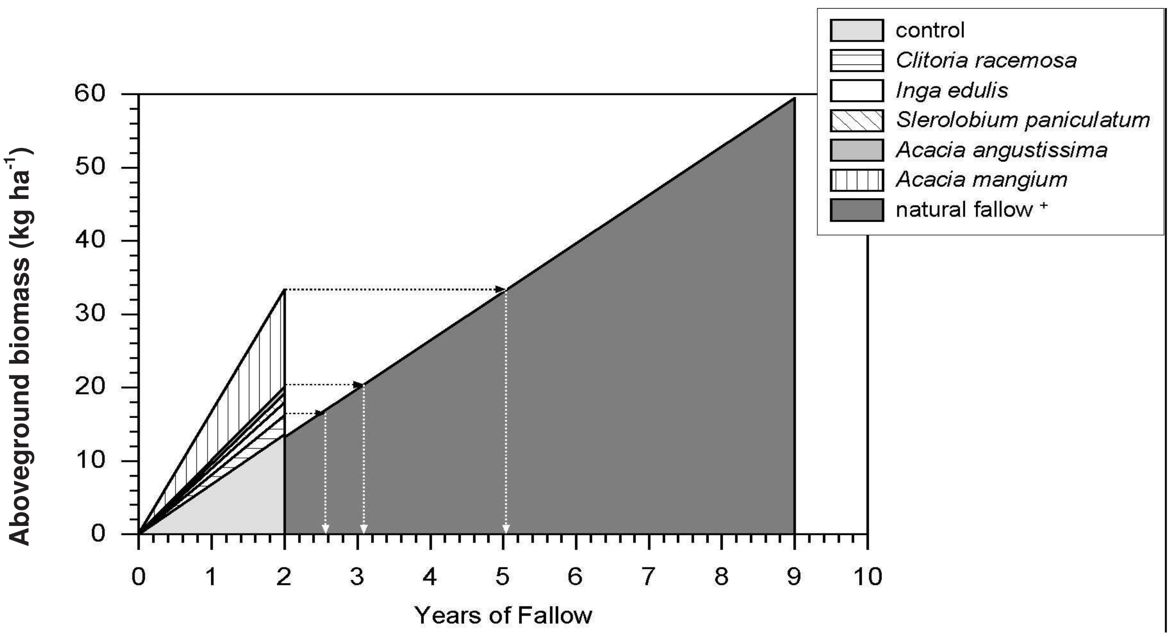

Fig. 1: Aboveground biomass (kg ha^{-1}) of enriched fallow vegetation by planting *A. angustissima, C. racemosa, I. edulis, S. paniculatum* and *A. mangium* and control compared to natural fallow data analyzed by different authors in the same region (+DENICH, 1989; NUNEZ, 1995; DIEKMANN, 1997; KATO, 1998a and 1998b; WIESENMÜLLER, 1999)

may be one way but it can probably not be the only one; and b) not all aims of the fallow system are met by the accumulation of biomass. NYE and GREENLAND (1960) mention as equally important to eliminate the weeds and their seed bank during the crop period. CLAUSING (1994) showed that the weed control is a function of fallow time. This point is important because of the labor requirement of weeding and the weed impact on crop production.

The analysis of the impact of enrichment on fallow time reduction showed that when a linear biomass accumulation of the control treatment in the first nine years was considered as a reference, the enriched fallow systems provide in a total of 3 years (1 year of cropping + 2 years of enriched fallow) a biomass accumulation equivalent to up to five years of traditional fallow time.

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