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## SECONDARY SUCCESSION FOLLOWING SLASH AND BURN AGRICULTURE IN NORTH-EASTERN INDIA

### I. BIOMASS, LITTERFALL AND PRODUCTIVITY

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#### SUMMARY

(1) The biomass, productivity and litterfall patterns during a 20-year fallow, subsequent to shifting agriculture were studied in north-eastern India.

(2) The early colonizers varied depending upon the type of vegetation before farming and the seed and rhizome sources in the soil, and these depended largely on the agricultural practices. Initially, weeds predominated, but a bamboo (*Dendrocalamus hamiltonii*) was an important component of 10–20-year old fallow; later this was replaced by shade-intolerant trees.

(3) The succession was accompanied by increased species diversity, reduced dominance, and increased above-ground net primary productivity which reached 1.8 kg m<sup>-2</sup> year<sup>-1</sup> in a 20-year old fallow.

(4) The above-ground biomass increased linearly with age up to 15 kg m<sup>-2</sup> in a 20-year old fallow. The rate of accumulation of biomass increased for 15 years, when it was 0.9 kg m<sup>-2</sup> year<sup>-1</sup>; it then declined slightly.

(5) Litterfall increased with the age of the fallow up to 1.0 kg m<sup>-2</sup> year<sup>-1</sup> in a 20-year old fallow.

#### INTRODUCTION

Over large areas of north-eastern India, slash and burn agriculture (known as 'Jhum') is practised and secondary successions on abandoned farms rehabilitate the land for renewed cropping. The structure and composition of the fallow vegetation indicate the site potential, soil fertility, and when the area should be farmed again. If the fallow is farmed after only 4–5 years, degradation takes place and crop yields decline (Toky & Ramakrishnan 1981).

The agricultural system involves cutting the vegetation, burning the debris and cropping for a year or more before abandoning the land and allowing a natural fallow to develop. The farmer then moves to other sites. The interval before returning to the same site used to be about 20–30 years but has recently been reduced to 4–5 years owing to an increase in human population density (Ramakrishnan & Toky 1978; Ramakrishnan *et al.* 1981). This recent shortening of the shifting agriculture cycle makes an understanding of the structure of the fallow vegetation, particularly its early phases, of considerable importance (Hall & Okali 1979).

Detailed studies on ecosystem structure and function during secondary succession after clear-cutting temperate forests are available (Bormann & Likens 1979), and some work on these aspects has also been carried out in the humid tropics (Bartholomew, Meyer & Laudelout 1953; Nye & Greenland 1960; Ewel 1971).

## STUDY AREA

The work was carried out at Burnihat in the Khasi Hills of Meghalaya (26°0'N, 91°5'E) at an altitude of about 100 m. The climate is a subtropical monsoon with an average rainfall of 2200 mm year<sup>-1</sup>; most rain falls from May to October. Average maximum and minimum temperatures (for 1971–81) are 25 °C and 12 °C, respectively, for November to February, and about 32 °C and 23 °C, respectively, for the remainder of the year. The soil is a red loamy laterite (oxisol) derived from metamorphic rocks. The surface soil has a high concentration of organic carbon and nitrogen but low concentrations of cations due to intense leaching. It has a pH of 7, but this declines to pH 5 at a depth of 40 cm (Ramakrishnan & Toky 1981).

## METHODS

*Site characteristics and phytosociology*

Vegetation analysis and studies on biomass and litterfall were carried out in three replicate sites for fallows aged 1, 10, 15 and 20 years and, for a 5-year old fallow, on three replicates of each of four different types, for vegetation of this age showed wide variation. Types I and III were developed under a 5-year fallow cycle, type II under a 10-year cycle, and type IV under a 30-year cycle. The fallows were aged on the advice of the village headmen. The sites ranged from 2.0 ha to 2.5 ha on slopes of 20°–40°. They were trapezoidal in shape, with the short side parallel to the contours at the top of the site. The sites were selected so as to have a similar topography and southerly exposure.

In each site, thirty 10 × 10 m quadrats were laid 10 m apart along a transect for trees and shrubs, and twenty-five 1 × 1 m quadrats were laid 25 m apart for herbaceous species. The frequency, density and basal area were recorded for herbaceous species in the 1- and 5-year old fallows and for trees, bamboos and other shrubs in the older fallows. The importance value index (IVI) (Curtis 1959), which is an integrated measure of the relative frequency, relative density and relative basal area, was calculated for each species. Species diversity was calculated using formula given by Margalef (1968)

$$\bar{H} = - \sum \left[ \left( \frac{ni}{N} \right) \log \left( \frac{ni}{N} \right) \right]$$

where,  $\bar{H}$  = Shannon index of general diversity,  $ni$  = importance value of each species, and  $N$  = total importance value of all species. Simpson's (1949) index of dominance of the community (C) was also calculated:

$$C = \sum \left( \frac{ni}{N} \right)^2.$$

These are useful parameters for the comparison of secondary successional communities and they help to evaluate the degree of dominance in particular species.

*Litter*

Ten 1 × 1 m litter traps with sides 15 cm high were laid out at random on each site. The traps had 1.5 mm-mesh nylon base. This sample size was found to be adequate as the standard error of the mean was usually less than 10% of the mean.

The litter was collected at monthly intervals (except during the humid months when 2-weekly collections were made) from August 1978 to July 1979. The litter was classified into leaves and twigs, and further subdivided into dicotyledons, bamboo, and other grass species. Flower, fruit and trash fall were very small and were discarded. The leaf and twig litter was dried at 80 °C for 24 hours and weighed. Student's *t*-test was used to determine significant differences between litterfall values.

#### *Biomass and productivity*

The biomass in the 1- and 5-year fallows was determined by a harvest method. During October and early November 1979, when most species were at their peak biomass, all plants from fifteen 1 × 1 m quadrats, placed 40 m apart along a transect in each site, were clipped at ground level and sorted into herbs, shrubs, tree saplings, and bamboos, and further categorized into main stem, branches, and leaves. They were oven dried at 80 °C for 24 hours and weighed.

The 10- to 20-year old fallows were dominated by bamboo (*Dendrocalamus hamiltonii*) and a few tree species. For the biomass estimation, individuals, of different size classes and selected on data from the vegetation description, were harvested. The bamboo shoots were divided into six diameter classes at 2-cm intervals from 7 cm to 19 cm. Five random replicates of each diameter class were cut at the ground level and the fresh weight biomass was obtained separately for bole, branches, and leaves. Dry weight was calculated on the basis of the weight of samples dried at 80 °C, as above. The average shoot density of each diameter class was then used to calculate the total biomass. Linear regressions between trunk diameter and various biomass components were calculated (Newbould 1967) for each tree species; these were based on the harvest of a sample of twenty trees, of dbh from 3 cm to 15 cm, and the determination of the dry weights of the bole, branches, and leaves.

The annual biomass increase on each site was determined from the difference between the standing biomass of two consecutive fallow ages; the annual litter production was added to this value to give the annual net production. We have no data on herbivory.

## RESULTS

### *Secondary succession pattern*

The pattern of secondary succession and the rapidity with which a forest community develops depends upon the degree of destruction of the pre-farming vegetation and of its propagules in the soil. During the first few years, when weed species predominate, there is considerable variation according to the agricultural cycle, weeding intensity, and available seed source as shown in Tables 1 and 2. Four types were distinguished.

In type I, *Eupatorium* or *Imperata* or both dominate the fallow. *Eupatorium odoratum* dominates under a 5-year fallow cycle, particularly where the rhizomes of *Imperata cylindrica* and *Sachharum spontaneum* are removed by constant hoeing; otherwise *Imperata cylindrica* may exist alone or may co-exist with *Eupatorium odoratum* (Table 2).

In type II, *Mikania micrantha* dominates the fallow under a 10-year cycle. Where *M. micrantha* is abundant it forms a thick mat on the ground and may smother the other herbaceous and shrub species (Table 1).

In type III, *Sachharum spontaneum* dominates the fallow under a 5-year cycle where cropping is usually for not more than one year and, therefore, its rhizomes have not been destroyed (Table 1). This type is infrequent.

TABLE 1. Abundance of predominant species in successional communities up to 5 years old in Meghalaya, north-eastern India, developed after slash and burn agriculture.  $n = 25$ .

Fallow type*	II		III		IV	
	Frequency† (%)	Density ( $m^{-2}$ )	Frequency† (%)	Density ( $m^{-2}$ )	Frequency† (%)	Density ( $m^{-2}$ )
<i>Mikania micrantha</i> H.B.K.	100	165.0				
<i>Panicum khasianum</i> Munro	25	2.2	27	2.4		
<i>Solanum torvum</i> Sw.	15	0.6				
<i>Eupatorium odoratum</i> Linn.	5	0.8	14	1.4	34	1.5
<i>Cassia tora</i> Linn.	10	1.5				
<i>Sachharum spontaneum</i> Linn.			40	6.2		
<i>Imperata cylindrica</i> Beauv.			13	1.5		
<i>Grewia elastica</i> Royle			7	0.3		
<i>Brachiaria distachya</i> (L.) Stapf.			7	0.6		
<i>Borreria hispida</i> K. Sch.					100	140
<i>Panicum maximum</i> Wall.					17	1.0
<i>Digitaria adscendens</i> H.B.K.					24	1.5
<i>Setaria palmifolia</i> (Koen.) Stapf.					15	0.8
<i>Paspalidium punctatum</i> (Burm.) A. Camus					10	0.6
						Basal area ( $cm^2 m^{-2}$ )
						112
						1
						2
						2
						1

\* See Table 2 for type I.

† In  $1 \times 1$  m quadrats.

In type IV, *Borreria hispida* dominates the fallow under a 30-year cycle. This stoloniferous species has both prostrate and erect branches; it roots at the nodes and so forms a mat which inhibits the establishment of other species. It usually occurs where *Imperata cylindrica* and *Eupatorium odoratum* are eradicated by weeding (Table 1).

The 5-year cycle is the most common and the general pattern of secondary succession is given in Table 2. The early colonizers, *Eupatorium odoratum* and *Imperata cylindrica*, are important components of the fallow for 5 years, after which they are replaced by *Dendrocalamus hamiltonii* and other woody species. *Dendrocalamus hamiltonii* is the most important species in 10- to 20-year old fallows (Table 2). The 15- and 20-year old fallows have many shade-intolerant tree species, which arise from seeds and from roots and stumps which have survived from the pre-farming era. The common species are *Bauhinia purpurea*, *Careya arborea*, *Cedrela toona*, *Dillenia indica*, *Schima wallichii*, *Terminalia balerica*, *Vitex glabrata*, *V. peduncularis* and *Wrightia tomentosa* (Table 2).

Species diversity was very low in the first 5 years; it increased considerably between 5- and 10-years, and showed further but less increase in the next 10 years (Fig. 1). Conversely, dominance was maximal in the early phases of succession and decreased sharply with the age of the fallow.

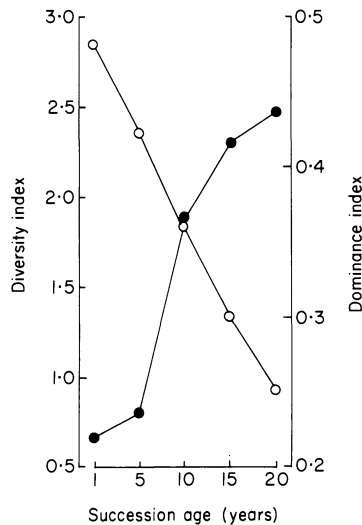


FIG. 1. Species diversity (●) and species dominance (○) in successional communities up to 20 years in Meghalaya, northeastern India.

#### Litter production

The total annual production of litter increased significantly with the age of the fallow and reached  $1.0 \text{ kg m}^{-2} \text{ year}^{-1}$  in the 20-year old fallow (Table 3). All differences between the fallows (except that between the 10- and 15-year old ones) were significant ( $P < 0.05$ ). *Eupatorium odoratum* contributed 70% of the total litter in the 5-year old fallow. Later, most litter was contributed by the bamboo *Dendrocalamus hamiltonii*, which accounted for 45% or more of the total litter in fallows of 10-years or more old. Litter from trees increased with successional age, and accounted for about half of the total in 10-year old and older fallows.

TABLE 2. Abundance of predominant species in successional communities up to 20 years Type I fallows.

Fallow age (years)	1			5		
	Frequency* (%)	Density (m <sup>-2</sup> )	Basal area (cm <sup>2</sup> m <sup>-2</sup> )	Frequency* (%)	Density (m <sup>-2</sup> )	Basal area (cm <sup>2</sup> m <sup>-2</sup> )
<i>Eupatorium odoratum</i> Linn.	100	18.7	190	100	25.3	426
<i>Imperata cylindrica</i> Beauv.	100	22.6	76	100	30.2	141
<i>Panicum khasianum</i> Munro	48	5.8	6			
<i>Setaria glauca</i> Beauv.	40	2.5	3			
<i>Grewia elastica</i> Royle	12	2.9	9			
<i>Cyperus globosus</i> Allioni	40	6.5	11			
<i>Panicum maximum</i> Wall.	24	15.4	11	60	15.2	12
<i>Ficus hispida</i> Linn.	20	2.2	10			
<i>Arundinella bengalensis</i> (Spreng.) Druce				80	42.2	61
<i>Callicarpa macrophylla</i> Vahl.				20	0.005	0.1
<i>Dendrocalamus hamiltonii</i> Nees & Arn.				8	0.08	0.7
<i>Carex cruciata</i> Vahl.				44	8.02	16
<i>Bauhinia purpurea</i> Linn.				20	0.003	0.1
<i>Dillenia indica</i> Linn.				28	0.008	0.1
<i>Antidesma diandrum</i> Roth						
<i>Careya arborea</i> Roxb.						
<i>Phyllanthus emblica</i> Wall.						
<i>Wrightia tomentosa</i> R. & S.						
<i>Vitex peduncularis</i> Wall.						
<i>Terminalia belerica</i> Roxb.						
<i>Lagerstroemia parviflora</i> Roxb.						
<i>Vitex glabrata</i> Br.						
<i>Dillenia pentagyna</i> Roxb.						
<i>Schima wallichii</i> Choisy.						
<i>Cedrela toona</i> Roxb.						

\* In 1 × 1 m quadrats.

† In 10 × 10 m quadrats.

Leaves accounted for 71–89% of the total litterfall in 5- to 20-year old fallows; in the 1-year old fallow they were the only form of litterfall. Litter of dicotyledonous twigs accounted for one-quarter of the total in 5-year old fallows; this was mainly derived from *Eupatorium odoratum* which was eliminated shortly after this stage.

### Biomass

The standing biomass in the successional communities increased significantly ( $P < 0.01$ ) with the age of the fallows with a maximum of 15 kg m<sup>-2</sup> in 20-year old fallow (Table 4). Herbs accounted for all the biomass on the 1-year old fallow; in subsequent years their contribution declined sharply to almost zero by year 10. The biomass

TABLE 3. Annual litterfall ± 95% confidence limits (g m<sup>-2</sup> year<sup>-1</sup>) in successional communities in Meghalaya, north-eastern India, developed after slash and burn agriculture. Values in parentheses are percentages of the total in each column.  $n = 10$ .

Litter category	Succession age (years)	1	5	10	15	20
Dicotyledon leaves		80 ± 10 (67%)	210 ± 30 (44%)	310 ± 50 (44%)	350 ± 60 (45%)	420 ± 70 (43%)
Bamboo leaves			10 ± 4 (2%)	320 ± 50 (45%)	320 ± 40 (42%)	430 ± 60 (44%)
Grass leaves		40 ± 6 (33%)	120 ± 20 (25%)			
Dicotyledon twigs			140 ± 30 (29%)	50 ± 10 (7%)	30 ± 8 (4%)	36 ± 6 (3%)
Bamboo twigs				30 ± 8 (4%)	70 ± 10 (9%)	90 ± 20 (10%)
Total		120 ± 20	480 ± 80	710 ± 120	770 ± 150	970 ± 180

old in Meghalaya, north-eastern India, developed after slash and burn agriculture.  
 $n = 25-30$ .

10			15			20		
Frequency† (%)	Density (m <sup>-2</sup> )	Basal area (cm <sup>2</sup> m <sup>-2</sup> )	Frequency† (%)	Density (m <sup>-2</sup> )	Basal area (cm <sup>2</sup> m <sup>-2</sup> )	Frequency† (%)	Density (m <sup>-2</sup> )	Basal area (cm <sup>2</sup> m <sup>-2</sup> )
44	0.009	0.3				44	0.018	0.4
90	0.38	13	96	0.45	32	100	0.56	45
64	0.007	1	60	0.01	1	68	0.02	1
60	0.009	0.3	68	0.02	1	72	0.03	2
44	0.005	0.5						
40	0.007	0.5	44	0.003	0.8	56	0.02	3
32	0.003	1						
28	0.003	0.4						
40	0.005	0.5	48	0.007	1	40	0.016	2
			60	0.008	2	52	0.008	0.2
			48	0.007	1			
			32	0.004	0.4	40	0.009	1
			36	0.008	0.7			
			12	0.004	0.4	20	0.006	0.6
						24	0.012	0.2

contribution by *Dendrocalamus hamiltonii* and by shrubs and trees increased with the age of the fallow up to 20 years.

In 10- to 20-year old fallows, the biomass contribution of the main stem and branches represented 93–95% of the total, whereas in 1- and 5-year old fallows leaves contributed 17–19% of the total biomass.

TABLE 4. Changes in standing biomass  $\pm$  95% confidence limits (g m<sup>-2</sup> year<sup>-1</sup>) of different categories in successional communities in Meghalaya, north-eastern India, developed after slash and burn agriculture. Values in parentheses are percentages of the total in each column.  $n = 15$ .

Category	Succession age (years)	1	5	10	15	20
<b>Bamboo</b>						
Main stem			200	2660	5090	6180
Branches			20	440	530	960
Leaves			10	130	280	350
Total			230 $\pm$ 50 (10%)	3230 $\pm$ 540 (56%)	5900 $\pm$ 920 (57%)	7490 $\pm$ 1340 (51%)
<b>Shrubs and trees</b>						
Main stem			600	1790	3170	5330
Branches				480	1000	1520
Leaves			20	230	280	400
Total			620 $\pm$ 110 (27%)	2500 $\pm$ 400 (43%)	4450 $\pm$ 900 (43%)	7250 $\pm$ 1350 (49%)
<b>Herbs</b>						
Main stem & branches		400	1060	10	10	10
Leaves		100	420	10	10	10
Total		500 $\pm$ 80 (100%)	1480 $\pm$ 200 (63%)	20 $\pm$ 3 (0.3%)	20 $\pm$ 4 (0.2%)	20 $\pm$ 4 (0.1%)
Total		500 $\pm$ 80	2330 $\pm$ 280	5750 $\pm$ 1100	10 370 $\pm$ 1700	14 760 $\pm$ 2560

TABLE 5. Changes in rates of accumulation of biomass, litterfall and net primary productivity in successional communities in Meghalaya, north-eastern India, developed after slash and burn agriculture.

Succession age (years) ...	1	5	10	15	20
Accumulation in bole and branches ( $\text{kg m}^{-2} \text{ year}^{-1}$ )	0.4	0.4	0.7	0.9	0.8
Litterfall ( $\text{kg m}^{-2} \text{ year}^{-1}$ )	0.1	0.4	0.7	0.8	1.0
Net primary production ( $\text{kg m}^{-2} \text{ year}^{-1}$ )	0.5	0.8	1.4	1.7	1.8
Biomass accumulation quotient (standing biomass/net primary productivity)	0.9	2.5	4.3	5.9	8.3

The rate of accumulation of the above-ground biomass was similar in 1- and 5-year old regrowth vegetation; it then almost doubled and reached a maximum of  $0.9 \text{ kg m}^{-2} \text{ year}^{-1}$  at 15 years of age (Table 5). Litterfall and net primary productivity both increased gradually with fallow age.

## DISCUSSION

### *Land-use pattern and secondary succession*

In slash and burn agriculture, when a forest is converted to cultivable land, not only is its original vegetation destroyed, but the site is subject to continuing perturbations due to fire, the introduction of crop species, weeding, hoeing and other disturbance to the soil when the crops are harvested. These result in a progressive reduction in species diversity and so the early successional stages contain few species but the number increases gradually as the secondary community develops (Ross 1954; Odum 1969; Whitmore 1975).

While land-use practice prior to the present study was known only from the farmers and the village headmen, the age of the fallow could be established also by observations on the vegetation. However, it was difficult to know the earlier history and, though all care was taken to ensure similarity in sites in terms of topography and aspect, it is suspected that the land-use history may have been different and may have affected the secondary succession. Nevertheless, the time since farming ceased is the predominant factor governing the succession in the region as a whole.

A remarkably linear relationship was observed during the 20-year period of the present study not only with respect to community structure, but also with respect to functional aspects like litter production and net primary productivity. This seems to be due to the great change in structure from the initial herbaceous species to bamboos and other woody species.

A variety of strategies is adopted by successional species among which stump, root and rhizome sprouts and invasion through seeds are common. The relative importance of different species and their strategies could vary depending upon the length of the agricultural cycle, the species composition and structure of the vegetation prior to clearing for cultivation, and the previous land-use history. In sites under a 5-year agricultural cycle with cropping for 1 year only, as in the present case, *Eupatorium odoratum* is a predominant component of early succession. The production of a large number of seeds, which are light in weight and wind dispersed, helps it to succeed as an early colonizer. The importance of this was stressed by Hayashi & Numata (1968) and Raynal & Bazzaz (1973), while Salisbury (1942) emphasized that species with lightweight, highly mobile

seeds, often invade highly disturbed ecosystems whereas species with heavier seeds, are often animal-disseminated and usually enter the succession at a later stage. On the other hand, *Imperata cylindrica*, which is also an early colonizer, has rhizomes which are protected from fire and are difficult to eradicate during cultivation. This strategy, along with the production of lightweight, wind-dispersed seeds, even under constant disturbance (K. G. Saxena & P. S. Ramakrishnan, unpublished) contribute to its success. These early species which adopt an exploitive strategy (Grime 1974; Harper & White 1974; Marks 1974) are able to attain dominance in abandoned fields that are temporarily enriched with nutrients and radiant energy. It should be mentioned that the concentration of nutrients in the soil is relatively high at the beginning of secondary succession; the first 5–10 years of regrowth of vegetation is a period of rapid depletion of soil nutrients (Ramakrishnan & Toky 1981). If the agricultural cycle is a short one of 4–5 years, which is usually the case, and it is imposed continuously, the succession is arrested at the weed stage with *Eupatorium odoratum* or *Imperata cylindrica* dominating the community. If the cycle is longer, during the second 5 years, the vegetation changes rapidly from weed colonizers to bamboo (*Dendrocalamus hamiltonii*) and other shade-intolerant tree species. *Dendrocalamus hamiltonii* plays an important conservational role as it is a rapid accumulator of potassium (Ramakrishnan & Toky 1981).

#### Litter production

The values of litter production (leaves and twigs) for successional communities in the present study fall within the published range recorded for mature and secondary tropical and subtropical forests (Table 6), although Laudelout & Meyer (1954) report higher values for mature forests in Zaïre.

The relatively high values of litter production in secondary successional communities in the present study as compared to 0.55 kg m<sup>-2</sup> year<sup>-1</sup> for a 50-year old one in the same area (Singh & Ramakrishnan 1982) is due to the fast developing vegetation during the early successional stages and subsequent rapid turnover of biomass. Further, in early fallows *Dendrocalamus hamiltonii* and a number of tree species are deciduous; in older forest most tree species are evergreen.

TABLE 6. The annual litter production (kg m<sup>-2</sup> year<sup>-1</sup>) for some tropical and subtropical forests.

Forest type	Leaf litter	Other litter	Total litter
Lowland rain forest			
Nigeria (Hopkins 1966)	0.68		
Brazil (Klinge & Rodrigues 1968)	0.56	0.18	0.74
Trinidad, <i>Mora excelsa</i> (Cornforth 1970)	0.69		
Malaya (B. A. Mitchell, quoted by Bray & Gorham 1964)			0.72
Zaïre, <i>Musanga cecropioides</i> (Laudelout & Meyer 1954)			1.49
Guatemala, secondary (Ewel 1976)			1.00
North-eastern Australia (Brasell, Unwin & Stocker 1980)	0.65	0.27	0.92
Montane rain forest			
New Guinea, 2500 m (Edwards 1977)	0.64	0.12	0.76
Jamaica, gap forest, 1550 m (Tanner 1980)	0.55	0.09	0.64
India, Nainital, 2050 m (Pandey & Singh 1981)	0.41	0.14	0.55
North-eastern India, 20-year fallow (this study)	0.85	0.12	0.97

*Biomass and production*

A large increase in the above-ground biomass with age up to 20 years was noted. The values are similar to the range given for many tropical and subtropical forests. The values ( $\text{kg m}^{-2}$ ) reported are: 3.2 for 6-year fallow in Benin, southern Nigeria (Nye & Hutton 1957); 14.0 for 18-year fallow in Yangambi, Zaïre (Bartholomew, Meyer & Laudelout 1953); 2.4–4.2 for 2–6 year old fallow and 37.0 for mature forest in Darien, Panama (Golley *et al.* 1975); and 31.0 for a montane rain forest in New Guinea (Edwards & Grubb 1977).

The community studied showed an increase in production up to 20 years; this may be due to the growth of exploitive species which utilize resources available after slash and burn, accelerated decomposition of forest floor organic matter, and high radiant energy. The rapid increase in production after 5 years appears to be due to a shift in structure from a predominantly herbaceous community to one with bamboo and other shade-intolerant tree species. Similar high rates of production in early successional stages have been reported by other workers; a maximum rate of increase of biomass of  $1.92 \text{ kg m}^{-2} \text{ year}^{-1}$  at 7–8 years in Izabal, Guatemala (Snedakar 1970); a maximum rate  $2.66 \text{ kg m}^{-2} \text{ year}^{-1}$  for 5–8 year old *Musanga cecropioides* in Yangambi, Zaïre (Bartholomew, Meyer & Laudelout 1953).

Recently, Aweto (1981), working on secondary successional fallows in south-western Nigeria, reported stabilization in species diversity and tree density in the seventh year of fallow. Our own studies indicate that diversity increases with the progress of the succession with a consequent decrease in dominance.

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