Journal of Tropical Ecology (1986) 2:249–256. With 2 figures

3 (a) (V)

XII

Changes in a secondary forest in southwestern Nigeria following a ground fire

AUGUSTINE O. ISICHEI, FRIDAY EKELEME *and* BAKARE A. JIMOH

Department of Botany, University of Ife, Ile-Ife, Nigeria

ABSTRACT. In January 1983, two 50 m × 50 m rain forest plots in the University of Ife campus in southwestern Nigeria were demarcated for a baseline study of species composition, litterfall and tree girth increments. By accident, a severe ground fire burnt one of the plots on 31 January, barely two weeks after litter traps had been set and species listing and first girth measurements completed.

The effect of this fire was assessed in the burnt plot after 14 months, in April 1984. The fire affected small trees especially, and there were indications that some species were more sensitive than others.

Manihot glaziovii, which was present in the plot and abundant in its vicinity before the fire showed a big increase in density after the fire because it was able to germinate in the openings created by the fire. These observations were related to succession, and it is concluded that the observation by some workers that the initial composition of a regrowth forest may be partly predicted from a knowledge of the seed bank in the soil may be applicable in the present case.

KEY WORDS: fire, tree mortality, Nigeria, rain forest.

INTRODUCTION

Fires are a rare occurrence in the tropical rain forest zone because of almost year-round wetness. The plants in the zone do not show adaptations for fire resistance such as are found in the savanna zone, which can be viewed as a fire-controlled system. In fact, sensitivity to fire has been used to characterize forest trees (Fosberg 1961).

Fire incidents are, however, on the increase in the forest zone because of the spread of the weed shrub, *Chromolaena odorata* (formerly *Eupatorium odoratum*: all plant names after Hutchinson & Dalziel 1954–1972) which colonizes cleared forest lands. Fires are commoner in drought years. The effects of such fires are usually devastating if reports from forest plantations in this zone are representative (e.g. Kio & Nnaobi 1983). The year 1982 was a drought year in most parts of Nigeria. For example, the annual rainfall in Ile-Ife (7° 32′ N, 4° 31′ E) in the rain forest zone for the period 1969–1973 averaged 1413 mm with no year receiving less than 1200 mm (Duncan 1974), while in 1982 and 1983 it averaged 800 mm. Following the 1982 drought there were reports of fires in tree plantations and natural forests in the rain forest zone throughout West Africa; these attracted so much concern that the Nigerian Federal Department of Forestry organized a national workshop to discuss forest fires (Kio &

Nnaobi 1983, Oni *et al.* 1983). Most of the workshop was devoted to tree plantations, and especially to the economic losses resulting from the fires. The present report assesses vegetation changes in a natural secondary forest, of estimated age between 30 and 40 years, following a fire early in 1983. This was a ground litter fire which affected tree boles and low crowns.

STUDY SITE

The University of Ife campus (7° 32′ N, 4° 31′ E) has patches of forest vegetation covering 12 km^2 out of a total area of about 60 km^2. Most of the forest is secondary regrowth with the oldest patches, in the inaccessible hill slopes, being about 40 years old. The forest sub-type is dry deciduous forest (Onochie 1979). White (1983) puts the Ife zone in the 'Guinea-Congolian drier forest types'.

The largest patch of forest is around the southernmost of the three hills on campus (Hill I, 410 m altitude). This patch accommodates the University's Biological Gardens, comprising a Zoo and a Botanical Garden; the forest was not cleared before their establishment so that tracts of natural forest are still protected within the Biological Gardens. A 50 m × 50 m area of forest adjacent to the Zoo was demarcated in mid-January 1983 for a baseline study of tree girth increases and litter desposition patterns. On 31 January 1983 the forest patch accommodating the Biological Gardens and the demarcated plot was affected by a severe all-night fire. Before the fire, species listing and girth measurments for woody plants over 2 m high in this plot had been completed. There was another plot marked out for study in another area of the campus but this was not affected by the fire.

It was felt that the January fire may have affected species composition and general vegetation structure in the 50 m × 50 m plot so a re-enumeration was carried out in April 1984.

METHODS

In January 1983 all woody plants ⩾2 m in height in the 50 m × 50 m forest plot were tagged with numbers and identified and their girths at breast height (gbh) measured. The distribution of the trees in girth-size classes was plotted from the enumeration. Basal area was calculated from the gbh. The enumeration and girth measurements and attendant calculations were repeated in April 1984, fourteen months after the fire.

RESULTS

Generally, the fire created openings in the community both at the ground and canopy levels because many small trees and a few large ones were destroyed. Most of the litter in the plot was completely burned or charred. Table 1 shows

Table 1. Demographic changes in the tree vegetation 14 months after a ground fire in a lowland rain forest plot in southwestern Nigeria

	Before fire	After fire
Total number of trees over 2 m high	378	798
Total number of species	37	40
Most abundant species	*Funtumia elastica*	*Manihot glaziovii*
and % of trees of that species	25.4%	81.0%
Basal area (m^2 ha^{-1})	21.40	32.16
Species contributing most to basal area	*Elaeis guineensis*	*Manihot glaziovii*
and % contributed	23%	44%

the demographic features of the plot before and after the fire. No species was lost as a result of the fire; instead, three new species were found in the plot after the fire. One of the three, *Carica papaya* (paw-paw), is usually characteristic of cultivated areas and in the present case appears to be a direct response to the perturbation. The others were *Dracaena arborea* and *Pleiocarpa pycnantha.*

There was a sharp increase in the number of individual trees from 378 before the fire to 798 after. Figure 1 shows the increase is, as expected, almost entirely due to more small trees. In girth-size class 0–20 cm there were 183 individuals before and 681 after the fire. Most of the new individuals were *Manihot glaziovii*; this had 23 individuals in the 0–20 cm girth-size class before the fire but 647 after (see Figure 2). Most of the new additions were as seedlings. In the 21–40 cm class, there were 115 and 55 pre- and post-fire individuals of all species respectively. The higher girth-size class were less dramatically affected but the distribution of individuals among various girth sizes after the fire is significantly different from that in the pre-fire vegetation ($P < 0.01$, Kolmogorov-Smirnov goodness of fit test).

That the fire effects were mainly on small trees is illustrated by changes in the abundances of *Funtumia elastica* in the various girth-size classes (see Figure 2) which before the fire was the most abundant tree species. Eight of the 38 individuals in the smallest class survived the fire, 11 of the 44 in the 21–40 cm class, while in the 41–60 cm class there was an increase from 13 to 14, a result of girth increase in the lower class or shrinkage in the higher class. There was also an increase, from one to four trees, in the 61–80 cm class. In the case of *Pycnanthus angolensis*, before the fire the third most abundant tree after *Funtumia* and *Manihot*, there was only one survivor out of twenty in the lowest class, five out of eight in the 21–40 cm class, and one out of the two in the 41–60 cm class.

Table 2 shows how the most abundant species (in terms of basal area) were affected by the fire. Trees with most of their individuals in the 0–20 cm girth class suffered the greatest losses. These include *Pycnanthus angolensis, Blighia unijugata* and *Funtumia elastica. Commiphora kerstingii* and *Ficus mucuso* were adversely affected even though only a few or none of the plants were in

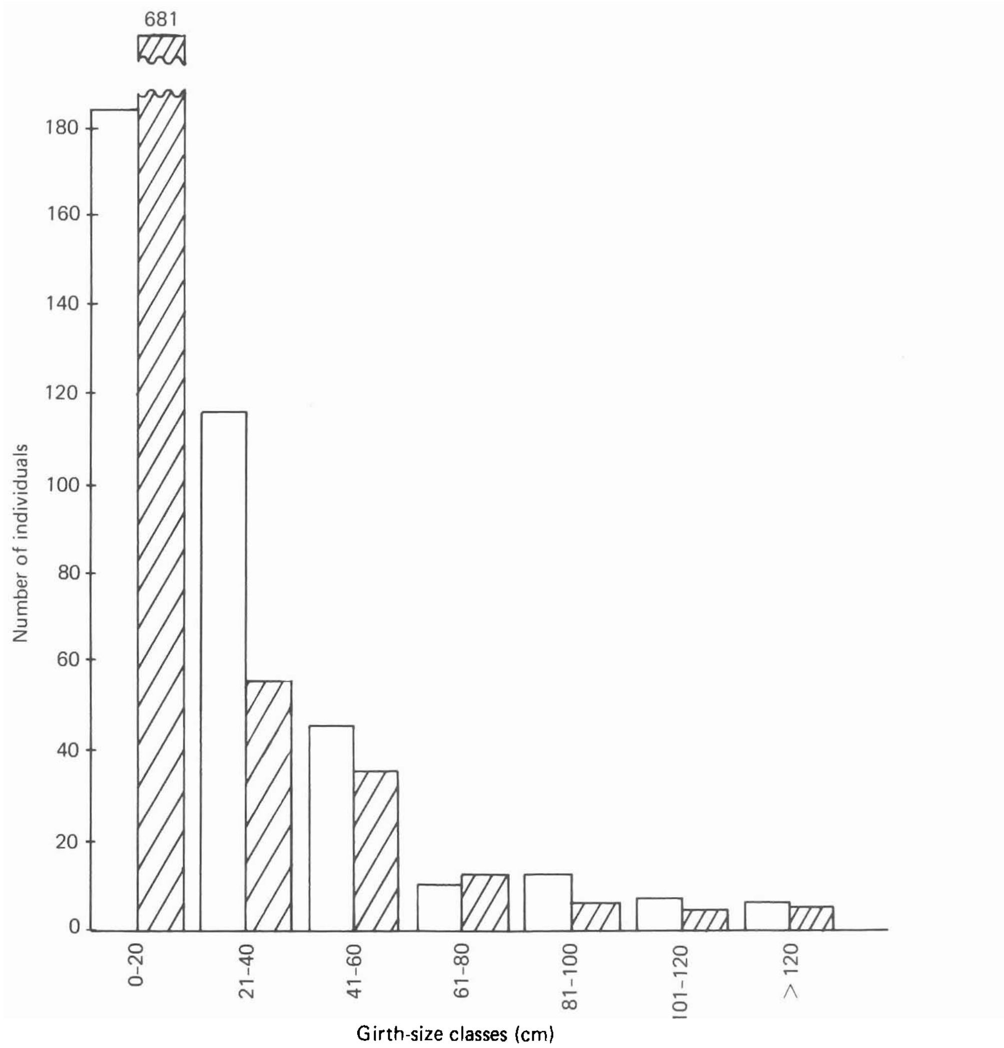

Figure 1. Distribution of trees within girth-size classes before and after a ground fire in a lowland rain forest plot in southwestern Nigeria. Open columns: before the fire (January 1983); hatched columns: after the fire (April 1984).

the smallest girth-size class; this may be because they may be more sensitive to fire. *Albizia zygia* appeared to be little affected by the fire.

The observed increase in the basal area (Table 1) was brought about mainly by the massive increase of *Manihot*. This increase contrasts with the other unburnt plot on campus where the basal area marginally rose from 41.92 m^2 ha^{-1} in 1983 to 42.53 m^2 in 1984. In this other plot, which is more mature, the smaller trees showed girth increases but the larger ones (>40 cm) showed a net decrease; the number of species remained at 30 while the number of individuals decreased from 250 to 243 because of loss of individuals of *Cola milleni* and *Napoleana vogelii*. *Cola milleni* had the highest number of individuals (45)

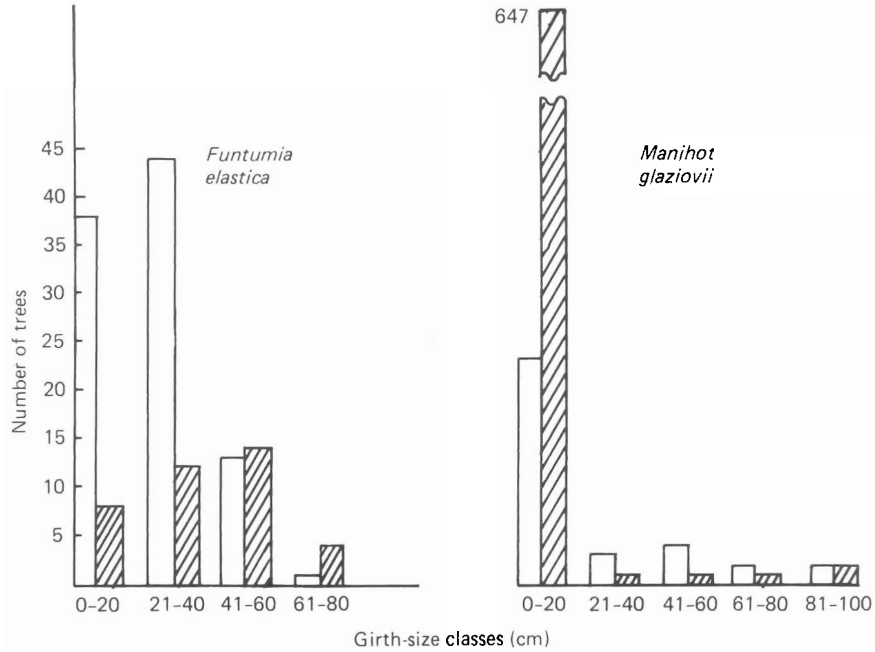

Figure 2. Changes in the abundances of *Funtumia elastica* and *Manihot glaziovii* in various girth-size classes after a ground fire in a lowland rain forest plot in southwestern Nigeria. Open columns: before the fire (January 1983); hatched columns: after the fire (April 1984).

Table 2. Changes in numbers of plants over 2 m high for each of the eleven most abundant tree species (in terms of basal area) following a ground fire in a lowland rain forest plot in southwestern Nigeria. (Figures in brackets indicate number of trees in the 0-20 cm girth-size class.) Of the species listed, only *Manihot glaziovii* acquired new individuals; for the remainder mortality rates are shown

Species	Number of individuals		% mortality
	before fire	after fire	
Elaeis guineensis	8(0)	4(0)	50
Funtumia elastica	96(38)	38(8)	60
Bombax buonopozense	4(1)	2(0)	50
Holarrhenia floribunda	12(2)	7(0)	42
Manihot glaziovii	34(23)	646(641)	–
Albizia zygia	11(3)	10(1)	9
Blighia unijugata	16(9)	5(0)	69
Commiphora kerstingii	9(1)	1(1)	89
Bosqueia angolensis	5(0)	3(0)	40
Ficus mucuso	16(3)	9(0)	44
Pycanthus angolensis	30(20)	7(1)	77
Other species	137(83)	66(29)	52
Total	378	798	

followed by *Alchornea laxiflora* (30) while *Brachystegia eurycoma* with 9 individuals had the highest basal area, 3.9 m^2 or 37.6% of the total. These values and relationships remained more or less the same in 1984.

DISCUSSION

The level of perturbation by fire depends upon the intensity of the fire. A major factor affecting intensity in the forest zone is the quantity of litter on the ground. The role of litter in forest combustion is emphasized by Oguntala (1983) when he stated: 'The effect of fire could be appreciated if it is noted that in 50-year old plantations litter depositions could reach 800–900 g m^{-2} providing enough fuel for speedy combustion.' Unfortunately, litter traps set up in the burnt area were only two weeks old when the fire occurred. But in the unburnt forest area within the campus litter deposition of 400 g m^{-2} for a 13-week period was recorded, indicating that the accumulation in the burnt forest might have been high. Forests are, however, not usually burnt so that even small fires can damage fire-sensitive trees.

In this study, there was evidence for selective destruction of trees in the smaller girth-size classes with less effect on the larger classes. This agrees with the observation of Hall & Swaine (1976) that dry, fire-zone sub-type forests which are prone to burning in Ghana are notable for the paucity of trees in the lower girth-size classes.

On the other hand, the mortality rates observed for *Funtumia elastica, Commiphora kerstingii* and to some extent *Ficus mucuso* may indicate that these species were especially sensitive to fire, but firm conclusions cannot be drawn from observations in the single plot used in this study. Hall & Swaine (1976) have, however, observed that thin-barked trees are more prone to fire damage but in the present case the fire may have been too severe to be species-selective. Because smaller trees are more likely to die in a fire, it is not safe to infer that some species with heavy losses are intrinsically more fire sensitive if they are represented only by small trees.

The age of our plot is not known exactly but the species composition before the fire indicates mid-succession. Exotics such as *Manihot glaziovii* and *Theobroma cacao*, usually indicative of early succession, were still present while species such as *Albizia zygia, Bosqueia angolensis* and *Pycnanthus angolensis* which could be found in dry-type high forests (see Hall 1977, Hall & Okali 1979) were also present but still small in size. The early to mid-succession species were, however, more abundant.

Manihot was present in the plot before burning (34 trees or 9% of the total number in the plot, 6% total basal area) and was abundant in the fallows in the vicinity of the Biological Gardens. Swaine & Hall (1983), working on early succession in the rain forest of Ghana observed that the composition of the initial regrowth vegetation following disturbance was principally determined by three factors: the pre-disturbance soil seed bank, the timing of disturbance in relation to availability of wind-dispersed seeds, and the initial immigration of shade tolerant primary species. *Manihot* is not wind dispersed and its presence cannot be attributed to immigration so that most of the proliferation must have come from the soil seed bank. As indicated by its prominence in the fallows, the tree is likely to be an important primary species in early succession in the Ife area.

The openings created by the elimination of some trees, litter and climbers must have contributed to the germination and fast growth of *Manihot.* Unfortunately, canopy cover was not measured in this study to support this assertion. According to Whatley & Whatley (1980) light-triggered changes in capacity for growth is an important attribute of many forest trees.

The proliferation of *Manihot,* an introduced species, is of interest in relation to succession in the Ife forest zone. There have been conflicting opinions as to which plants are dominant in fallows of the lowland rain forest. Hall & Okali (1979) reported earlier workers as associating fallows dominated by *Musanga cecropiodes* with richer, wetter soils and some other species with poorer soils. Clayton (1958) associated *Funtumia* species with clayey soils and *Morus mesozygia* with sandy soils, but Hall & Okali considered both species to reflect previous land use and associated *Rauvolfia vomitoria* with soil type. We are inclined to agree with the conclusion of Hall & Okali (1979) that several species, including *Funtumia elastica,* are very widely characteristic of fallows in the African forest region. The species composition of a fallow are, however, likely to vary depending on local climate, land use history and soil type.

ACKNOWLEDGEMENTS

We wish to thank Mr M. Latilo of the Natural History Museum, University of Ife for assistance with tree identification and the Director of the Museum for releasing him.

LITERATURE CITED

CLAYTON, W. D. 1958. Secondary vegetation and transition to savanna near Ibadan, Nigeria. *Journal of Ecology* 46:217-238.

DUNCAN, E. R. 1974. *Weather information from the University of Ife.* Faculty of Agriculture Research Bulletin No. 2, University of Ife Press, Nigeria. 15 pp.

FOSBERG, F. R. 1961. A classification of vegetation for general purposes. *Tropical Ecology* 2:1-28.

HALL, J. B. 1977. Forest types in Nigeria: an analysis of pre-exploitation forest enumeration data. *Journal of Ecology* 65:187-199.

HALL, J. B. & OKALI, D. U. U. 1979. A structural and floristic analysis of wood fallow vegetation near Ibadan, Nigeria. *Journal of Ecology* 67:321-346.

HALL, J. B. & SWAINE, M. D. 1979. Classification and ecology of closed-canopy forest in Ghana. *Journal of Ecology* 64:913-951.

HUTCHINSON, J. & DALZIEL, J. M. 1954-1972. *Flora of west tropical Africa* (revised by Keay, R. W. J. & Hepper, F. M.). Grown Agents for Overseas Governments, London.

KIO, P. R. O. & NNAOBI, C. H. 1983. An economic analysis of the effects of forest fires: a case study of plantation losses in the 1982/83 dry season in southern Nigeria. Unpublished paper presented at the workshop *Forest fires; ecology and environment,* Forestry Research Institute of Nigeria, 10-12 October 1983. Mimeograph, 25 pp.

OGUNTALA, A. B. 1983. An analysis of the litter fuel load in some Nigerian forests in relation to periodic fires. Unpublished paper presented at the workshop *Forest fires: ecology and environment*, Forestry Research Institute of Nigeria, 10-12 October 1983. Mimeograph, 23 pp.

ONI, O., IMASUEN, F. I., EHIWE, O. & ADEYANJU, B. A. 1983. Effect of forest fires on the performances of *Terminalia* spp. in a southern forest site in Nigeria. Unpublished paper presented at the workshop *Forest fires: ecology and environment*, Forestry Research Institute of Nigeria, 10-12 October 1983. Mimeograph, 12 pp.

ONOCHIE, C. F. A. 1979. The Nigerian rainforest ecosystem: an overview. Pp. 1-13 in Okali, D. U. U. (ed.). *The Nigerian rainforest ecosystem.* Nigerian National MAB Committee, Ibadan, Nigeria. 371 pp.

SWAINE, M. D. & HALL, J. B. 1983. Early succession on cleared forest land in Ghana. *Journal of Ecology* 71:601-627.

WHATLEY, J. M. & WHATLEY, F. R. 1980. *Light and plant life.* Studies in Biology No. 24, Edward Arnold, London, 91 pp.

WHITE, F. 1983. *The vegetation of Africa. A descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map of Africa.* UNESCO, Paris. 356 pp.

Accepted 21 May 1986