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Seed Bank Dynamics and Regeneration in a Secondary Lowland Rainforest in Nigeria

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Abstract: Seed bank dynamics and forest regeneration in a secondary lowland rainforest in Nigeria were studied with a view to determine the potential contribution of the soil seed bank to the regeneration of the forest. Six 25×25 m plots were used and in each plot, ten replicates top soil 0-15 cm were collected in March, June and October. The soil samples were subjected to seedling emergence for 20 months to determine density and species composition of the seed banks of the study plots. The results showed that there were more individuals in plot C (a disturbed plot) and herbaceous species dominated (more than 96%) the seed bank of all the study plots and across the seasons. Few woody species emerged in all the plots and there was significant difference ($p<0.05$) in density both between the plots and months. Similarity between seed bank and vegetation composition, no matter the forest state, is very low. The most frequent species in the vegetation are absent in the seed bank and vice versa. The seed bank is mainly composed of early successional species and seeds of primary forests are rare in the soil. The few woody species recorded indicate that the soil seed bank may not be an important conservation tool for the regeneration of the degraded forest, therefore reforestation is recommended for restoration of the degraded forest.

Key words: Seed bank, regeneration, forest disturbance, species composition, forest succession

INTRODUCTION

Forests worldwide are being continuously disturbed and are being consequently sent in the course of succession (Myer, 1988; Odiwe, 2000). Tropical forests are constantly being destroyed through anthropogenic activities like logging, shifting cultivation and other natural occurrences, after which the forests begin a natural regeneration through a series of vegetation stages. However, the floristic potential of a regenerating community is dependent on the viable seeds stored in the soil as seed banks (Hopkins and Graham, 1983). The seeds buried in the soil seed bank are kept in dormant state until appropriate germination requirements are met.

Various workers have reports on the dynamics of the seed bank and factors affecting the density and species composition of the seed bank. Seed banks are very vital for the restoration of plant communities by nature management authorities. Natural regeneration via the seed bank is important in the management and conservation of tropical rainforest for sustainable production of industrial wood and other products. However, there are difficulties when considering restoration of forest plant communities by buried seeds because most typical shade tolerant species do not form a persistent seed bank (Brown and Oosterhius, 1981; Halpern *et al.*, 1999; Bossuyt and Hermy, 2001), which results in a poor correspondence between vegetation and seed bank composition (Thompson and Grime, 1979; Staaf *et al.*,1987; Beatty, 1991; Warr *et al.*, 1994; Eriksson, 1995). On the contrary, seed banks in forests seem mainly an important source for the regeneration of ruderal species, which due to their competitive abilities, can have a negative influence on the diversity of forest species (Chambers and McMahan, 1994; Hermy, 1994; Halpern *et al.*, 1999).

According to Hall and Swaine (1980), the seeds of primary forest species are rare in the soil in the Ghanaian forests while Hopkins and Graham (1983) found that only a few large seeded primary forest species germinated in their study and these were those fruiting at the time of sampling. Rico-Gray and Gorcia-Franco (1992) have observed that herbs often dominate the seed bank of tropical deciduous forests while trees are poorly represented.

Recently, there is increasing interest in the composition of forest seed banks (Milberg, 1995; Buckley *et al.*, 1997; Dougall and Dodd, 1997; Kalamees and Zobel, 1998; Mitchell *et al.*, 1998; Falinska, 1999; Bossuyt and Hermy, 2001), but still forest seed banks have received relatively little attention in comparison with those of arable fields and grasslands (Warr *et al.*, 1994;

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Thompson *et al.*, 1997). This study concentrates on the density and species composition of the seed bank in the forests of different stages of succession and possibility of utilizing the seed bank for the restoration of the degraded forests.

The research questions of this study are:

- What is the species composition of the existing vegetation of the sites?
- What is the species composition of the soil seed bank of the sites?
- Are there difference in the seed bank density and composition seasonally?
- Are there similarities between seed bank and vegetation composition of the sites?
- What is the role of the seed bank in the regeneration of forest?

MATERIALS AND METHODS

The study was carried out in six plots (25 × 25 m) located in Ile-Ife area of southwestern Nigeria between latitude 7°31' N and 7°33' N and longitude 4°31' and 4° 34' E. On basis of an initial field reconnaissance survey of the Ile-Ife area, the six plots A and B were secondary forest (undisturbed/protected), C and D were disturbed secondary forest (forested plot consumed by a ground fire in 1983) while E and F were managed secondary forest plots (being periodically cleared to remove seedlings and saplings undergrowth).

The mean rainfall at Ile-Ife is about 1400 mm (five year mean). The rainy season lasts from mid March to later October and rainfall is bimodal with peak periods in July and September. Mean temperature in the area range from an annual minimum of 27 to 34°C.

The area is underlain by metamorphic rocks of the Precambrian Basement Complex. These rocks show great variation in structure, mineral composition and grain size (Smyth and Montgomery, 1962).

Tree and shrub density was estimated in each of the six plots by complete enumeration. Every tree and shrub ≥1 m was tagged with a number, counted and identified to species level.

Seed bank data were collected by a seedling germination method. Soil sampling for investigation of seed bank was done in March, June and October 1999, in order to increase the probability of finding species with different germination requirement (dry and rainy seasons). At each occasion, 10 samples per plot were taken at random with an auger of 8.5 cm diameter down to 15 cm depth, after removing the litter layer. The samples were spread on benches in the screen house for air drying. The soil samples were later spread in porous plates in the screen house where they were watered daily and monitored for emerging seedlings. The soil samples were used for seedling emergence test to determine the density and species composition of the seed banks of the study plots. Furthermore, another group of soil samples was collected at the same time as those used for seedling emergence which were used to carry out physical extraction of seeds.

Seedlings were identified as soon as possible after germination, using Hutchinson (1952-1972), counted and removed or transplanted in pots to allow further growth if they could not be identified immediately. Counts were weekly during 20 weeks. After a period of 8 or 9 weeks, when no further seedling emergence was recorded for more than 1 week, the soil samples were dried out and stirred up being sieved using set of sieves of sizes 0.5, 1.25, 1.5 and 2 mm to remove any ungerminated seeds in the soil.

The datasets for March, June and October were pooled, whereby seed densities were summed and expressed in seeds m^{-2}. The percentage and number of seedlings of all species per plot on each of the sampling occasion, the number of species per plot were determined. Variation in seedling emergence seasonally and total seed bank among the plots were determined using two way analysis of variance. Shannon-Weiner species diversity index and Sorenson (1948) index of similarly were also used to compare the similarity in species composition and species diversity respectively among the plots in each sampling occasion. The percentage contribution of each species to the seed bank were also determined seasonally. To assess the contribution of the seed bank to the various forest plant community, the occurring species in seed bank and the standing vegetation were compared.

RESULTS

Standing vegetation composition: There were 47 woody species recorded in the vegetation of plot A, 32 woody species in plot B, 53 woody species in plot C, 34 woody species in plot D, 18 woody species in plot E and 9 woody species in plot F. Some of the woody species common to most of the plots are: *Albizia zygia, Alchornea laxiflora, Antiaris africana, Celtis zenkeri, Deinbollia pinnata, Funtumia elastica, Lecaniodiscus cupanioides, Milletia* sp. *Napoleonia vogelli, Newbouldia laevis* and *Trilepsium madagascarensis* (Table 1).

Indices of similarity calculated revealed that plots E and F were most similar with a similarity index of 79% while plot D and F were least similar with a similarity index of 56% while values for other plots were intermediate (Table 2). The Shannon-Weiner species diversity index

Table 1: Density of woody species (per hectare) in the six study plots in a secondary lowland rainforest in Nigeria

	Plots					
Species	A	B	C	D	E	F
Afzelia africana		-	16	-	-	-
Albizia adianthifolia		-	48	-	-	-
Albizia zygia	48	-	112	176	16	16
Albizia glabberima		-	-	-	16	-
Alchornea laxiflora	464	-	112	176	16	16
Alstonia boonei	-	16	16	16	-	-
Anarcadium occidentalis	-	-	-	-	16	-
Anona muricata		-	-	-	16	-
Antidesma membranaceum	-	-	-	16	-	-
Antiaris toxicara		-	-	160	-	-
Antiari africana	160	64	32	112	-	-
Baphia nitida	48	96	96	-	-	-
Bauhinia monandria	-	-	-	-	48	-
Berlinia grandiflora	-	-	16	-	-	-
Blighia unijugata	-	-	48	-	-	-
Blighia sapida	32	-	176	96	-	-
Bombax buonopoense	-	-	16	-	-	-
Canarium schweinfurthii	-	-	-	-	16	16
Canthium hispidium	-	-	-	-	-	16
Capsicum frutensis	-	-	-	-	16	-
Carpolobia lutea	64	208	48	-	-	-
Celtis mildbraedi	16	-	-	-	-	16
Celtis zenkeri	48	-	160	32	16	-
Chassalina kolly	-	-	-	16	-	-
Chrysophyllum albidum	-	-	32	-	-	-
Cnestis ferruginea	32	-	-	-	-	-
Cola nitida	16	-	-	-	-	16
Cola millenii	96	32	32	16	-	-
Cola acuminata	-	-	-	-	-	32
Commiphora kerstingii	16	-	-	-	-	-
Crossonephlis africanus	-	16	-	-	-	-
Deinbollia pinnata	80	112	80	-	48	-
Discoglypremna caloneura	-	-	16	-	-	-
Diospyros nigeria	-	-	32	-	-	-
Dracaena arborea	-	-	112	-	-	-
Drypetes principum	16	-	-	-	-	-
Elais guineensis	160	48	-	-	-	16
Eriocoelum macrocarpum	-	-	-	16	-	-
Eugenia uniflora	-	-	-	-	32	-
Ficus mucuso	32	64	112	-	-	-
Ficus capensis	-	-	-	16	-	-
Funtumia elastica	848	992	432	176	-	-
Garcina polyantha	16	-	-	-	-	-
Glyphaea brevis	16	-	16	-	-	-
Harungana madagascariensis	-	16	-	-	-	-
Holarrhena floribunda	-	16	-	-	32	-
Khaya grandifolia	16	-	-	-	-	-
Laccodiscus sp.	-	-	32	-	-	-
Lannea sp.	-	-	64	-	-	-
Lecaniodiscus cupanioides	80	64	218	208	-	-
Manihot glaziovii	-	-	48	16	-	-
Measopsis emnii	16	-	-	-	-	-
Microdesmis puberula	336	-	176	160	-	-
Milletia thonningii	-	-	32	-	-	-
Milletia sp.	128	16	96	304	-	-
Milicia excelsa	16	16	-	-	16	-
Monodora tenuifolia	32	-	32	-	-	-
Monodora myristica	-	48	-	-	-	-
Morinda lucida	-	-	-	16	-	-
Musanga cercropiodes	16	16	-	-	-	-
Myrianthus arboreaus	32	80	32	-	-	-
Napoleonia vogelli	96	368	112	80	-	-
Newbouldia laevis	64	48	624	192	-	-
Olax subscorpoida	64	80	32	-	-	-
Olyanthes sp.	16	-	-	-	-	-
Ouratea myrioneura	16	-	-	-	-	-
Pavelta corymbosa	-	-	32	16	-	-
Phyllanthus odontadenius	-	-	16	-	-	-
Piptadeniastrum africanum	-	-	32	-	-	-
Protemagabaria stapfiana	-	-	-	32	-	-
Pterocarpus sp.	16	-	48	-	-	
Pterocarpus santalinoides	32	-	32	-	-	-
Pycnanthus angolensis	16	96	-	16	-	-
Napoleonia imperialis	-	-	-	-	16	-
Rauvolfia vomitoria	-	-	16	32	-	-
Ricinodendron heudelotti	64	48	-	-	-	-
Rinorea bidenta	-	496	-	-	-	-
Rothmannia longiflora	16	-	16	-	-	-
Slacia pallescen	-	-	16	320	-	-
Securinega virosa	-	-	-	-	32	16
Spathodea campanulata	-	-	-	-	-	16
Spondias mombin	-	-	-	-	32	-
Sterculia tragacamiha	32	16	-	16	-	-
Stronbosia pustulata	32	-	-	-	-	-
Tabernaemontana pachysiphon	16	16	16	16	–	
Terminalia catappa	-	-	-	-	16	-
Terminalia superba	-	-	-	-	16	-
Tetrachidium didymostermom	144	-	-	-	-	-
Tetrapleura tetraptera	-	-	48	-	-	-
Theobroma cacao	16	-	-	-	-	-
Trema orientalis	-	16	-	-	-	-
Trichilia meganlatha	-	32	112	-	-	-
Trichilia monadelpha	-	-	16	-	-	-
Trichilia preuriana	-	-	80	48	-	-
Trichilia heudelotti	16	80	112	-	-	-
Trilepsium madagascarensis	32	128	192	80	-	-
Turaea vogelli	-	-	32	-	-	-
Vernonia amygdalina	-	-	-	-	-	16
Vocanga africana	-	-	-	32	32	-
Zanthoxylon rubescens	-	16	16	-	-	-
Total	3568	6866	4426	3056	416	160

Plots A and B: Undisturbed secondary forest, C and D: Disturbed secondary forest, E and F: Managed secondary forest

Table 2: The Sorenson's indices of similarity (%) of the woody species composition of the vegetation of the six study plots

Plots	A	B	C	D	E	F
A	-	-	-	-	-	-
B	77	-	-	-	-	-
C	69	78	-	-	-	-
D	67	73	65	-	-	-
E	66	75	67	64	-	-
F	63	69	64	56	79	-

Table 3: Shanon-Weiner indices of species diversity of the standing vegetation of the six study plots

Plot	H'
A	4.201
B	2.526
C	3.420
D	2.888
E	2.777
F	2.161

calculated revealed that plot A had the highest species diversity (H' = 4.201) while plot F had the lowest (H' = 2.161) while other plots had intermediate values (Table 3).

Seedling emergence: A total of 1745 seedlings or 10, 241 seeds m^{-2} emerged in plot A, 1069 seedlings or 6274 seeds m^{-2} emerged in plot B, 2073 seedling or 12,165 seeds m^{-2} emerged in plot C, 2891 seedlings or 16,966 seeds m^{-2} in plot D, 3727 seedlings or 21872 seeds m^{-2} in plot E and 3209 seedlings or 18,832 seeds m^{-2} in plot F. A total of 37 tree seedlings or 217 seeds m^{-2} emerged in each of plots A and B, 61 tree seedling or 358 seeds m^2 in plot C, 47 tree seedlings or 276 seeds m^{-2} in D, 34 tree seedlings or 200 seeds m^{-2} in plot E and 15 tree seedlings or 88 seeds m^{-2} emerged in plot F. Herbs dominated the seed density of the seed bank in each of the plots, 97.9% in plot A, 96.5% in plot B, 97.1% in plot C, 98.4% in plot D, 99.1% in plot E and 99.5% in plot F (Table 4).

A total of 41 species emerged in plot A consisting of 5 woody and 36 herbaceous species and 44 species emerged in plot C consisting of 7 woody species and 37 herbaceous species. In plot D, 45 species emerged consisting of 6 woody and 39 herbaceous species, 5 woody species and 38 herbaceous emerged in plot E and 3 woody species and 39 herbaceous species emerged in plot F. A comparison of the number of species among the plots using Analysis of Variance indicated that there was a significant difference ($p < 0.05$) in species number across the season but not among the plots.

Herbs dominated the seed bank in all the six plots. Some of the herbaceous species that emerged in all the study plots and in the three seasons were:

Table 4: Density of species (seedlings cm^{-2} and seeds m^{-2}) that emerged in the six study plots

	Plots A		Plot B		Plot C		Plot D		Plot E		Plot F	
Species	Seedling cm^{-2}	Seeds m^{-2}	Seedling cm^{-2}	Seeds m^{-2}	Seedling cm^{-2}	Seeds m^{-2}	Seedling cm^{-2}	Seed m^{-2}	Seedling cm^{-2}	Seed m^{-2}	Seedling cm^{-2}	Seed m^{-2}
Achryanthes aspera	-	-	-	-	-	-	-	-	-	-	01	06
Adaenia lobata	-	-	-	-	01	06	-	-	-	-	-	-
Ageratum conyzoides	01	06	06	35	11	65	04	23	-	-	01	06
Amaranthus spinosus	05	29	04	23	40	235	161	945	09	53	11	65
Aspilia africana	02	12	-	-	01	06	03	18	26	153	36	211
Borreria ocymoides	-	-	-	-	-	-	-	-	06	35	03	18
Brachiraria deflexa	-	-	03	18	31	182	10	59	03	18	01	06
Carica papaya	01	06	-	-	-	-	-	-	-	-	-	-
Cassia hirsute	-	-	-	-	-	-	01	06	-	-	-	-
Chromolaena odorata	98	575	93	546	94	552	87	511	34	200	77	452
Cissus sp.	01	06	-	-	-	-	01	06	01	06	-	-
Cleome ciliata	01	06	46	270	12	70	-	-	-	-	-	-
Cochorus tridens	-	-	-	-	01	06	-	-	-	-	01	06
Commelina nodiflora	-	-	-	-	-	-	-	-	02	12	14	82
Cordia sp.	-	-	08	47	10	59	-	-	09	53	02	12
Cynodon dactylon	01	06	03	18	13	76	-	-	45	264	64	376
Cyperus dactatylon	15	88	13	76	02	12	18	106	542	3181	573	3363
Desmodium scorparious	-	-	01	06	01	06	-	-				
Dioscorea bulbifera	-	-	04	23	-	-	08	47				
Drymaria kaudata	-	-	19	112	383	2248	08	47	36	211	03	18
Edegera batira	01	06	-	-	-	-	-	-	-	-	-	-
Elytraria lyrata	50	293	63	370	-	-	406	2383	400	2348	234	1373
Eragrostis tenella	13	76	20	117	11	65	14	82	51	299	-	-
Euphorbia heterophylla	31	182	16	94	06	35	06	35	03	18	05	29
Euphorbia hirta	15	88	12	70	-	-	-	-	-	-	01	06
Euphorbia hypsopifolia	51	299	35	205	23	135	-	-	02	12	-	-
Euphorbia prostata	10	57	14	82	584	3427	1506	8839	834	4895	22	129
Fern sp.	-	-	13	76	-	-	-	-	28	164	04	23
Ficus capensis	09	53	-	-	16	94	12	70	-	-	-	-
Ficus exasperata	06	35	03	18	07	41	02	12	04	23	05	29
Ficus mucuso	12	70	22	129	16	94	20	117	17	100	08	47
Gloriosa superba	-	-	-	-	-	-	-	-	01	06	-	-
Laportea aestuans	05	29	63	370	141	828	14	82	28	164	27	158
Leptochloa carulescens	21	123	43	252	149	874	133	781	28	164	27	158
Lindernian sp.	05	29	01	06	04	23	16	94	579	3398	571	3351
Manihot glaziovii	-	-	-	-	04	23	02	12	-	-	-	-
Mariscus sp.	-	-	-	-	-	-	-	-	04	23	46	270
Microdesmis puberula	-	-	01	06	-	-	-	-	-	-	-	-
Milicia excelsa	-	-	01	06	03	18	-	-	01	06	-	-
Mucuna sp.	05	29	21	123	06	35	09	53	-	-	-	-
Mussaenda elegans	-	-	-	-	-	-	01	06	-	-	-	-
Nelsonia cinensis	133	781	01	06	12	70	03	18	104	610	102	599
Oldelandia corymbosa	655	3844	233	1367	174	1021	128	751	80	470	418	2453
Olyra latiflora	-	-	-	-	-	-	-	-	31	182	31	182

Table 4: Continued

	Plots A		Plot B		Plot C		Plot D		Plot E		Plot F	
Species	Seedling cm^{-2}	Seeds m^{-2}	Seedling cm^{-2}	Seeds cm^{-2}	Seedling cm^{-2}	Seeds m^{-2}	Seedling cm^{-2}	Seed m^{-2}	Seedling cm^{-2}	Seed m^{-2}	Seedling cm^{-2}	Seed m^{-2}
Oxalis corniculata	206	1209	60	352	-	-	02	12	-	-	03	18
Panicum maximum	-	-	-	-	-	-	03	18	-	-	-	-
Peperomia pellucida	24	141	09	53	04	23	22	129	220	1291	573	3363
Pegularia daemia	-	-	-	-	04	23	-	-	-	-	-	-
Phyllantus amarus	12	70	16	94	04	23	07	41	09	53	-	-
Phyllantus muellericans	-	-	-	-	02	12	-	-	-	-	-	-
Phyllantus sp.	19	112	-	-	-	-	01	06	-	-	-	-
Physalis sp.	-	-	-	-	-	-	04	23	-	-	-	-
Pityrogrammia sp.	127	745	120	704	149	874	-	-	160	939	174	1021
Piper umbellifera	-	-	10	59	-	-	-	-	-	-	-	-
Platostome africanus	22	129	-	-	-	-	-	-	08	47	01	06
Pouzolzia guinensis	-	-	-	-	-	-	-	-	-	-	01	06
Setaria barbata	07	41	17	100	29	170	15	88	23	135	04	23
Setaria sp.	-	-	-	-	-	-	-	-	-	-	01	06
Sida pilosa	01	06	-	-	-	-	01	06	04	23	03	18
Smilax kraussiana	-	-	-	-	04	23	02	12	-	-	-	-
Solanum erianthum	01	06	-	-	01	06	-	-	-	-	03	18
Solanum torvum	57	335	48	282	52	305	69	405	05	29	08	47
Solanum nigrum	-	-	03	18	18	106	-	-	-	-	-	-
Spilanthes filicaulis	-	-	04	23	02	12	06	35	254	1491	06	35
Sporobolus festivus	01	06	-	-	-	-	-	-	22	129	14	82
Synedrella nodiflora	-	-	-	-	-	-	01	06	-	-	-	-
Talinum triangulare	77	452	10	59	28	164	81	475	90	528	120	704
Tectona grandis	-	-	-	-	-	-	01	06	-	-	-	-
Trema orientalis	09	53	02	12	05	29	09	53	03	18	-	-
Triumfetta rhombifolia	19	112	06	35	07	41	02	12	01	06	-	-
Urena lobata	-	-	01	06	-	-	-	-	-	-	-	-
Urera repens	-	-	01	06	07	41	13	76	02	12	03	18
Zehneria capillacea	-	-	-	-	-	-	01	06	-	-	-	-
	1745	10,241	1069	6274	2073	12164	2891	16966	3727	21872	3209	18832

Aspilia africana, Chromolaena odorata, Cyperus dactatylon, Cynodon dactylon, Elytraria lyrata, Euphorbia heterophylla, Euphorbia hypsopifolia, Euphorbia hirta, Laportea aestrans, Lindernian sp., *Oldelandia corymbosa, Peperoma pellucida* and *Solanum torvum*. Few woody species emerged in all the plots and in all the 3 reasons and these were early successional or pioneer species. These tree species were: *Cordia* species, *Ficus capensis, Ficus exasperata, Ficus mucuso, Microdesmis puberula, Milicia excelsa, Tectona grandis* and *Trema orientalis*.

There was a fluctuating trend in the density of the woody species that emerged from the seed bank of the 6 study plots as the season progresses (Table 5). The highest number of seedlings (102) was recorded at the middle of the rainy season (June collection), 97 seedlings at the early rainy season collection (March collection) and the lowest (31) seedlings at the late rainy season (October collection). Some of the woody species germinated in all the 3 season e.g., *Ficus capensis, Ficus exasperata, Ficus mucuso, Manihot glaziovii* and *Trema orientalis* (Table 5).

Trema orientalis had its density reduced as the seasons progresses while other species had fluctuating densities in the three seasons. Some of the woody species emerged in one of the three seasons e.g., *Microdesmis puberula* (June collection), *Carica papaya* and *Tectona grandis* (October Collection).

Table 5: Number of individuals and seasonal composition of woody species that emerged in the seed bank of the six study plots

	Period of sampling		
Species	March	June	October
Carica papaya	01	00	01
Cordia **sp.**	10	19	00
Ficus capensis	19	26	04
Ficus exasperata	17	03	06
Ficus mucuso	31	40	13
Manihot glaziovii	02	01	03
Microdesmus puberula	00	01	00
Milicia excelsa	03	02	01
Tectona grandis	00	00	01
Trema orientalis	15	10	03
Total	97	102	31

The result shows that there was a significant difference in the densities of the woody species seasonally ($p<0.05$) and among the plots ($p<0.05$).

The mean seed bank density when all the species (herbs and woody) are considered and when compared for all the plots and for all the seasons, it revealed that there was no significant difference seasonally and also among the plots. The index of similarity of the seed bank species composition of the six study plots when calculated using Sorenson's index of similarly showed that the plots B and C were the most similar (79%) while plots B and F were the least similar (52%) (Table 6).

Relations between seed bank and standing vegetation: Forty one species emerged from the seed bank of plot A consisting five woody species and three out of the five woody species had representatives in the standing vegetation, while two species (*Carica papaya* and *Trema orientalis*) had no representatives. In plot B, 42 species emerged consisting six woody species, five out of the six are in the standing vegetation. In Plot C, 44 species emerged consisting of seven woody species and three out of the seven woody species had representatives in the standing vegetation. The four species that were not represented arè *Cordia* sp., *Ficus exasperate*, *Milicis excelsa* and *Trema orientalis.* six out of the 45 species that emerged in plot were woody species and two of them *Tectona grandis* and *Trema orientalis* lacked representatives on the standing vegetation. In Plot E, 43 species emerged consisting of five woody species, three out of the five were found in the standing vegetation while the remaining two (*Cordia* sp and *Trema orientalis*) were absent. Plot F had only three woody species in its soil seed bank out of the 42 species that emerged and none of the woody species (*Cordia* sp., *Ficus exasperate* and *Ficus mucuso*) was represented in the standing vegetation. The level of correspondence of the seed bank and standing vegetation using woody species alone, for plots A, B, D and E was in the range of 60-83% while for plots C and F was 43 and 0%, respectively (Table 7).

Physical extraction of seeds: The density of seeds extracted using grade of sieves was compared with the density of seeds recovered through seedling emergence methods using two ways analysis of variance. The result showed that there was significant difference ($p < 0.05$) in the density of seeds recovered through seedling emergence as against physical extraction.

Table 6: Sorenson's indices of similarity (%) of the seed bank species composition of the six study plots

Plot	A	B	C	D	E	F
A	-	-	-	-	-	-
B	75	-	-	-	-	-
C	71	79	-	-	-	-
D	63	69	61	-	-	-
E	67	71	62	57	-	-
F	63	52	60	55	68	-

Plot A and B - Undisturbed secondary forest
C and D - Disturbed secondary forest (consumed by fire in 1983
E and F - Managed secondary forest

Table 7: Comparison of the number of woody species in the seed bank of the six study plots and those represented on the standing vegetation

Plot	Total No. of species that emerged from the seed bank	No. of woody species that emerged from the seed bank	No of woody species in the seed bank found in the standing vegetation	(%) of woody species in the seed bank found in the standing vegetation
A	41	5	3	60
B	42	6	5	83
C	44	7	3	43
D	45	6	4	67
E	43	5	3	60
F	42	3	-	00

DISCUSSION

There is a general uniformity in species composition of the standing vegetation for plots A to D except for the managed plots E and F. The differences in species composition observed between the unmanaged plots (A to D) and managed plots (E and F) could be attributed to the level of disturbance and successional ages of the plots. Chandrashekera and Ramarkishan (1993) have reported that level of disturbance and successional age of forests have effects in species composition. The few species and individuals observed in the managed plots (E and F) when compared to other unmanaged forest plots (A to D) may be due to the periodic clearing of the undergrowth in the managed plots which prevented new species seedlings saplings from growing into mature trees.

The high similarity index (79%) observed between plots E and F (managed plots) is an indication of the homogeneity in species composition between the plots while plots D and F with a low similarity index (56%) are the least similar in species composition. This many be due to perhaps the same management of plots E and F while plots D and F are subjected to different disturbances. The dominance of early successional species like *Albizia zygia, Funtumia elastica, Lecaniodiscus cupanioides* and *Newbouldia laevis*, in the various plots have been described by many workers as a feature of secondary regrowth forest (Hall and Okali, 1979). The high species diversity of plots A (H' = 4.201) and C (H' = 3.420) may be a reflection of high number and equitable distribution of species found in the plots as a result of their protection from human interference while the low species diversity index recorded in plots E (H' = 2.161) and F (H' = 2.777) may be due to the few species found in the plots as a result of regular and continuous clearing of the seedlings and saplings which might have prevented the establishment of new species in the plots.

The observed total seed bank densities of the plots in this study which ranged from 6,274-21,872 seeds m^{-2} was higher than values reported for other tropical forest of the world (Staaf *et al.*, 1987 (1, 757 seeds m^{-2}), Kjellsson, 1992 (13,286 seeds m^{-2}), Falinska, 1999 (3,050 seeds m^2). The higher seeds densities obtained can be ascribed to the preponderance of herbaceous species in the seed bank of the study plots and longer time allowed for the seedlings emergence (20 months) which probably gave room for more seeds to overcome their dormancy and germinate. The duration of seedlings emergence for other studies was shorter (Dalling and Denslow, 1998 (6 weeks); Miller, 1999 (59 days)).

Herbaceous species dominated the seed bank consisting more than 96% of the total seed densities of the seed bank in each of the six plots and across all the three seasons. This observation could be due to the openings in the forest canopy of the study plots which enhances the dispersal of seeds of these herbaceous species to the plots. Isichei *et al.* (1995) stated that opening of forest canopy allow germination of herbaceous species. The dominance of herbaceous species in the seed banks of forest soils recorded in this study has been reported by various workers (Miller, 1999; Cao Min *et al.*, 1997).

The presence of few woody species in the seed bank of the study may be due to the low seed production or the lack of definite (or no) dormancy mechanism in most woody species especially primary forest (Hall and Swaine, 1980). The percentage contribution of woody species to the density of the seed bank (0.5-3.5%) is in agreement with the result given for tropical lowland rainforest in Australia by Hopkins and Graham (1983) where primary forest tree seeds made up 0.9% of the seed bank density. In this study, there were more germinable seeds of woody species in the seed bank during the mid rainy season (June collection) than any other time and it agrees with the findings of Chandrashekera and Ramakrishnan (1993) which reported a high density of viable seed banks during the rainy season.

Index of similarity (52-79%) for the seed banks in this study indicates a high level of similarity in species composition of the seed bank of the study plots especially the unmanaged forest plots. The figures given by Miller (1999) (5- 43%) are lower compared to the figures given for this study (52-79%) and this could be an indication that seed bank of the study plots for the present study represent that of disturbed community not seriously disturbed.

The level of similarity of the woody species of the seed bank and standing vegetation in this study in plot A, B, D and E may be an indication that the seeds of the woody species actually come from the above ground standing vegetation while some other species may have come from the global seed rain (Archibold, 1989). The 0% (zero percentage) resemblance observed between the seed bank and the standing vegetation of plot F is in agreement with the result of several workers (William, 1993; Olmsted and Curtis, 1947). Rysdgreen and Hestmark (1997) in their study found a moderate resemblance between soil propagule bank and standing vegetation in the boreal forest while Dessaint *et al.* (1991) have reported a high correspondence (88.9%) between the species composition of the seed bank and that of the standing vegetation. Several other workers have reported on the dissimilarity between the seed bank and the standing vegetation (Hill and Steven, 1981; Pickett and Macdonell, 1989).

Interaction between Seed Bank and Standing Vegetation: There is a large discrepancy between seed bank and vegetation as suggested by Thompson and Grime (1979), Staaf *et al.* (1987), Warr *et al.* (1994). The early successional species and species of forest edges and clearings and disturbed environment are much m ore frequent in the seed bank than in the above ground vegetation. Very few of the total species are common to the vegetation and the seed bank and the most frequent species in the vegetation are absent in the bank and vice versa. This can be explained by the fact that only a few forest species produce long-living seeds and by the overwhelming production of long-lived seeds of pro-climax species (KJellsson, 1992; Warr *et al.*, 1994; Brumet and Van Oheimb, 1998).

The absence of the most abundant forest species from the seed bank could suggest that these species mainly reproduce vegetatively. Their absence in the seed bank can be explained by a potential clumped occurrence of seeds, just beneath the litter cover but not incorporated in the soil, so that small soil samples can fail to detect seeds. Also germination requirements may be not fulfilled, especially when they require shade for germination.

The density of seeds recovered from the seed bank of the study plots through physical extraction procedure using grades of sieves showed a figure lower compared to the density of seeds recovered through seedling emergence. The significantly higher density of seeds recovered through seedling emergence compared to physical extraction is an indication that physical extraction procedure is not an effective method for determining the number and species composition of the tropical soil seed bank and this is in agreement with the assertion of Swaine (Bossuyt *et al.*, 2000).

Harpern *et al.* (1999) have stressed that seedling emergence or germination method is the most feasible and commonly used technique for quantifying the potential of the seed bank to contribute to the standing vegetation.

CONCLUSIONS

There is a large discrepancy between seed bank and vegetation composition. There are few seed bank forming species in the standing vegetation. The seed bank is mainly composed of early successional species which temporarily occur in small-scale disturbances. There was a significant difference ($p < 0.05$) in the density of the woody species seasonally, with the highest density recorded in the mid rainy season (June soil collection) but there was no significant difference in the total seed bank (woody and herbaceous) density of the plots seasonally. The level of similarity between seed bank and the standing vegetation of the study plots (considering woody species alone) ranged from 60-83% in plots A, B, D and E but 0 and 43% in C and F respectively. Physical extraction method of assessing seed bank density gave a significantly lower seed density when compared to seedlings emergence method.

Disturbances promote germination of species typical of clearings and forest edges, which are in a large amount present in the seed bank.

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