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Tree species diversity and regeneration potential of soil seed bank in Akure forest reserve, Ondo state, Nigeria

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ABSTRACT: The relationship of soil seed bank and above vegetation of secondary forest of Akure forest reserve investigated in this study. This was carried out by assessing the seedling emergence of soil seed bank taken from the secondary forest. In the aboveground vegetation, all sapling below 10 cm (DBH <10 cm) within 100 cm by 100 cm quadrants were identified and their girths taken using digital Vernier caliper and all trees species (DBH >10 cm) within 50 m by 50 m plot size were also identified and diameter at breast height were measured. Data were collected from seeds emergence of soil seed bank and above vegetation, in strict nature reserve, four-five (45) woody species (40 trees and 5 shrubs) were encountered, a total of 5 families distributed into 7 species and 7 genera in sapling while seedling emergence were observed at different depths of soil seed bank; at 0-3 cm depth (1 fern, 1 climber and 7 herbs), 3-6 cm depth (5 herbs, 1 woody species, 1 climber, 1 fern), 6-9 cm depth (5 herbs, 1 tree and 1 ferns. The soil seed bank could thus play an important role in knowing the status of regeneration potential of this strict nature reserve forest. However, the high dominant species in the soil seed bank suggest that where such forest is disturbs the likely plants species to pioneer the succession and restorations are these herbaceous species encountered.

KEY WORDS: Diversity, Nigeria, Sapling, Seed emergence, Seedling, Soil seed bank, Strict nature reserve.

INTRODUCTION

The soil seed bank of any forest ecosystem is constituted by all viable seeds present on the soil as well as those associated with the soil humus/litter layer (Simpson *et al*., 1989). This presence of buried viable seeds in the soil is commonly associated with a phenomenon of dormancy, which prevents the seeds from germinating even under favorable environmental conditions. According to Thompson and Grime (1979) and Baker (1989), soil seed banks are the aggregations of viable seeds in the soil potentially capable of replacing adult plant and they play a great role in regeneration and species diversity of such forest, in other words its succession dynamics. According to Baker (1989), this aggregation of seeds corresponds to the seeds not germinated but, potentially capable of replacing or succeeding the annual adult plants, which had disappeared by natural death or due to anthropogenic activities, as well as perennial plants that are susceptible to plant diseases, animal consumption, and disturbance including those caused by man. Hence, investigating these soil seed banks is one of surest means of determining and designating the viable seed reservoir present in the soil of any forest ecosystem (Robert, 1981).

Adekunle (2013b) reported that in Nigeria, intact old-growth forests; where biodiversity is conserved for posterity are restricted only to the strict nature reserves (SNR's), biosphere reserve (BR's), the sacred groves and community forests which serve as refuges for animals driven by anthropogenic disturbances from other forests and free areas, as well as home for so many endangered indigenous plant species. The SNR is one of the prominent methods adopted for in-situ conservation of biodiversity in Nigeria and the world at large (Adekunle *et al.*, 2013a). Areas designated as SNRs are strictly protected for biodiversity conservation, as well as protection of geological features for perpetuity sake. According to Iyagin and Adekunle (2016), the objectives of strict nature reserves is to conserve regionally, nationally, or globally outstanding ecosystem and species; which can serve as reference areas for scientific research, hence, anthropogenic activities are prohibited in order to ensure the protection of conservation value.

In Africa and Nigeria in particular, there is a paucity of information relating to tree species diversity and succession dynamics of its natural tropical humid forests, owing to the fewness of studies/investigations relating to these subject matters. The Nigeria rainforest ecosystems are the most densely populated part of Nigeria and serve the bulk of the country's timber needs. These ecosystems have been under intense pressure stemming from a long history of unabated anthropogenic activities such as illegal logging and poaching activities, as well as conversion of forest lands for agriculture and developmental projects; dating back to pre-colonial times (Onyekwelu *et al*., 2008). The intense pressure on these forests led to their increasing disappearance; with a subsequent loss of biodiversity of both flora and fauna, thereby resulting in great hardship for the native dwellers that depend on these forests for their livelihood (Nwoboshi, 2000).

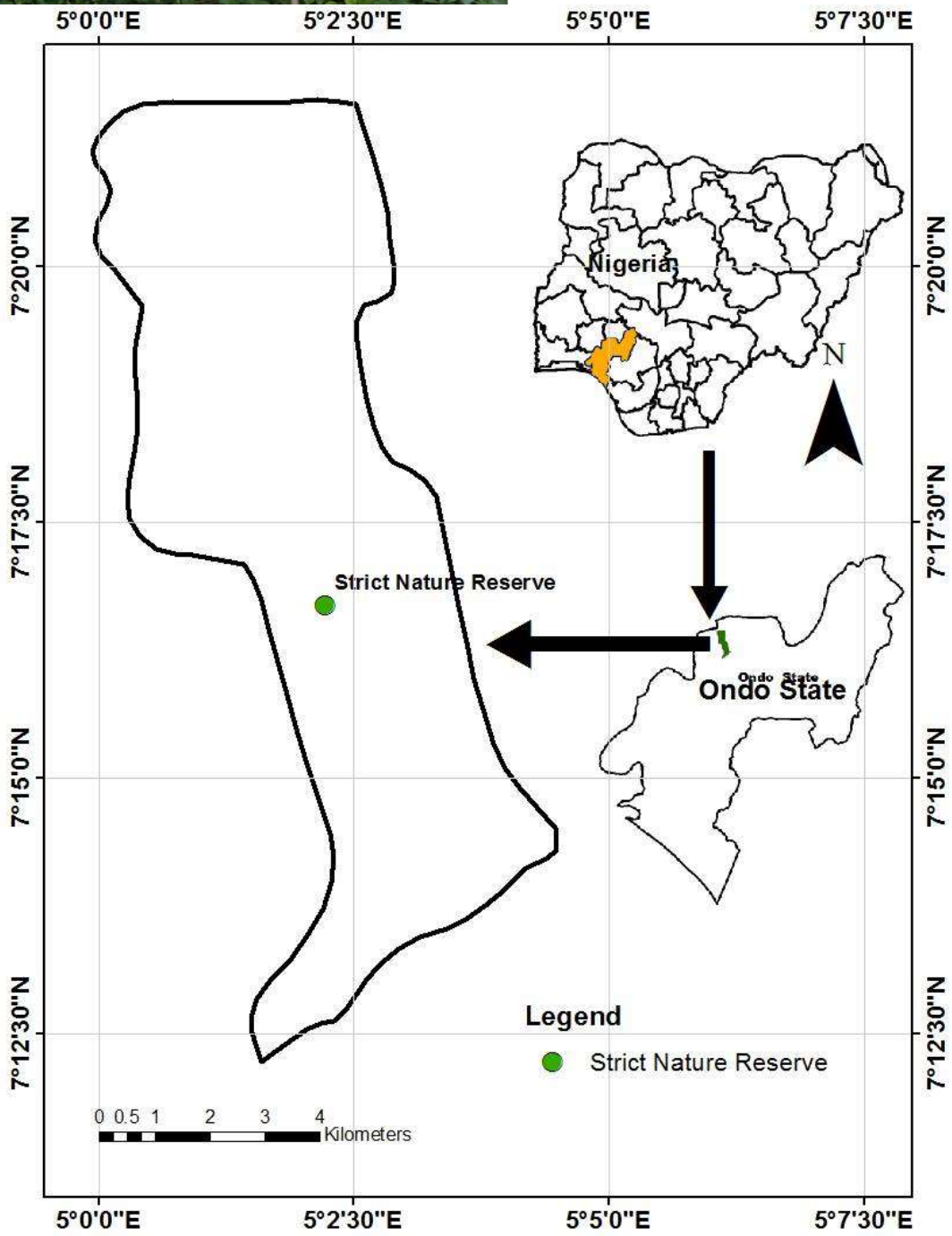

Fig. 1. Map and photo of Strict nature reserve Strict nature reserve.

Therefore, this study is carried out to examine the seed bank and regeneration potential by comparing the composition, abundance and diversity of the germinable seeds in the soil of the strict nature reserve in Akure forest reserve, Akure, Ondo State, Nigeria, which is one of the 445 gazetted forest reserves in Nigeria, distributed over the five main ecological zones of Nigeria as inherited from the colonial forest administration (NFP, 2006). This strict nature reserve at Akure forest reserve is a segment of the forest reserve, covering an area of about 32 hectares popularly known as the "Queen's plot" (Adeduntan, 2009).

MATERIALS AND METHODS

Study area

Akure Forest Reserve is situated between Aponmu and Obada communities in Akure South Local Government of Ondo State, Nigeria at latitudes 7° 16' 41.77 N and longitudes 5° 2' 2.01 E. The strict nature reserve (Queen's plots) as shown in Figure 1, is a part of the Akure Forest Reserves and was instituted in 1948, covering an area of about 32 hectares (Adeduntan, 2009); established with a view to preserving the genetic diversity of the forest ecosystem. Akure forest reserve has a tropical climate with prominent wet and dry seasons: the rainy season and the dry season. The rainy season generally occurs between March and October while the dry season occurs between November and February yearly. Also the mean annual temperature is about 26 ^{0}C (minimum 19 °C and maximum 34 °C) (Adekunle *et al*., 2013b).

Vegetation Sampling

The laying of the plots was carried out using the systematic line transects. A 500 m transect was centrally located in the forest where three sample plots of 50 m x 50 m were laid in alternate side at 100m internal. In each sample plot, all living trees with Diameter at Breast Height (DBH) ≥ 10 cm were tagged and identified. Samples of species whose identification were in doubt were collected, coded, pressed and taken to herbarium of the Federal University of Technology, Akure, Nigeria for proper identification. A small plot of 100 x 100 cm (1000 cm^2) was also located at the centre of each main plot for enumeration of sapling. The undergrowth (saplings) was identified and their girths were measured using electronic caliper.

Soil Sample Collection for Soil Seed Bank Study

Soil samples were collected in November 2016 and were studied for seven months through the rainy season. Soil samples for soil seed bank analysis were collected at 3 different depths: 0-3 cm, 3-6 cm and 6-9 cm from five locations in each plot. Soil samples from each depth were missed thoroughly to form a soil composite sample for the location. The soil from each plot and at different depths (0-3, 3-6 and 6-9 cm) were made free from roots and pebbles and spread in a potting medium which was made up of perforated plastic tray and spread cotton cloth with thickness of three centimeters to keep the sample moist always. The sample was taken to the greenhouse at the Department of Forestry and Wood Department's nursery, Federal University of Technology, Akure where they were incubated to stimulate seed germination. Emerging and readily identifiable seedling was counted, recorded and discarded. Species specimen whose identities were in doubt were collected, coded, pressed for identification and taken to the FUTA herbarium of the Federal University of Technology, Akure and IFE herbarium at Obafemi Awolowo University, Ile-Ife, Nigeria for proper identification. At every two weeks, the soil samples were stirred to stimulate seed germination and to encourage seed sprouting. All germinated seedlings were counted and identified.

Data Analysis

Appropriate formulae were used in basal area computation. Biodiversity indices were adopted to determine species abundance, evenness and to compare community diversity.

Forest Structure Analysis

(i) Basal area of all trees in the sample plots were calculated using the formula:

$$BA = \frac{\pi D^2}{4}$$

Where, BA = Basal area (m^2), D = Diameter at breast height (cm), and n = pie (3.142). The total BA for each plot was obtained by adding all trees BA in the plot.

(ii) Relative density (%) of each species was computed using the following equation of Brashesrs *et al.* (2004):

$$RD = \frac{n_i}{N} \times 100$$

Where, RD is the relative density of the species; n*i* is the number of individuals of species *i* and N is the total number of all individual trees.

(iii) Species relative dominance (%) of each species was estimated using the following equation:

$$RD_O = \frac{\sum Ba_i \times 100}{\sum Ba_n}$$

Where: Ba_i = basal area of individual tree belonging to species i and Ba_n = stand basal area.

(iv). Family Importance Value (FIV): This was used to estimate a family's share in the forest community. This is the sum of the relative dominance (RD_o), relative density (RD) divided by 2.

$$FVI = \frac{(RD + RDo)}{2}$$

(v). Importance Value Index (IVI): The sum of the RD and RDo divided by two gave the importance value index for each species (Brashears *et al*. 2004; Yang *et al*. 2008). This was used to express the share

of each species in the tree community (Rajkumar and Parthasarathy 2008).

$$IVI = \frac{(\mathrm{RD}\ x\ \mathrm{RDo})}{2}$$

Biodiversity Indices

(i) Tree species diversity; the following indices were employed, Shannon-Wiener diversity index (Shannon, 1948):

$$H' = -\sum_{i=1}^{S} p_i \ln(p_i)$$

Where H' = Shannon diversity index, S = the total number of species in the community, p_i = proportion S (species in the family) made up of the ith species and ln = natural logarithm.

(ii). The Species evenness (E), in each community Shannon's equitability equation adopted (Pielou, 1969).

$$E_H = \frac{H'}{H_{Max}} = \frac{\sum_{i=1}^{S} P_i \ln(P_i)}{\ln(S)}$$

RESULTS

Structural Characteristics of Strict Nature Reserve

The results of this study recorded 45 species, belonging to 19 families. Sterculiaceae had the highest number of species (9), followed by Fabaceae (Caesalpinoideae, Mimosoideae, and Papilionoideae) with 7 species. Other families which were relatively having the same number of species were Meliaceae (4), Apocynaceae (3), Euphorbiaceae (3), Sapotaceae (3) and Ulmaceae (3). The mean basal area of the woody species per hectare in respect of the above ground species composition showed that strict nature reserve had mean basal area of 142.02. *Mansonia altissima* (A. Chev.) A. Chev. *var. altissima* contributed the largest mean basal area of 14.171 m^2 ha^{-1} (9.98%), followed by *Celtis zenkeri* Engl, 7.004 m^2 ha^{-1} (4.93%) while the *Anthonotha macrophylla* P. Beauv with 0.752 m^2 ha^{-1} (0.53%) had the lowest contribution. Species with high relative density (RD) in this study included *Mansonia altissima* (A. Chev.) A. Chev., *Celtis zenkeri, Sterculia rhinopetala* K. Schum., *Cola gigantea* A. Chev., *Triplochiton scleroxylon* K. Schum, *Anonidium mannii* (Oliv.). Engl & Diels and *Entandrophragma utile* (Dawe & Sprague) Sprague. Result of importance value (*IVI*) of tree species indicated that *Mansonia altissima, Celtis zenkeri* and *Triplochiton scleroxylon*, have the highest importance value (*IVI)* in this study. The family importance value (*FIV*) among the families observed was reported to be high only in the family Sterculiaceae (27.25), followed Ulmaceae (12.9) (Table 1).

Sapling Composition and Density

The total of 5 families distributed into 7 species and 7 genera constituted the sapling population in the strict nature reserve with Rubiaceae family having the highest representation of 3 members (Table 2). The mean sapling density of the strict nature reserve is 21.29 stems ha^{-1} which comprises 7 species (5 woody and 2 herbs). Herbaceous species exhibited dominance in this site by constituting 56.36 % of the total plant species, followed by woody species (43.64 %). The species with the highest sapling density in this site were *Culcasia scandens* P. Beauv (5.53 m^2 ha^{-1}or 25.975%), *Pauridiantha hirtella* (Benth.) Bremek (2.78 m^2 ha^{-1} or 13.05 %) and *Brachystegia eurycoma Harms* (2.16 m^2 ha^{-1} or 10.14 %). The woody species here included *Brachystegia eurycoma, Chassalia kolly* (Schumach.) Hepper, *Diospyros nigerica* F. while, *Pauridiantha hirtella* and *Psychotria psychotrioides* (DC.) Roberty. The two herbs that emerged at the site were *Culcasia scandens* and *Palisota hirsuta* (Thunb.) K. Schum. The results (Table 3) of diversity measurements in the understory species (sapling) related to species abundance, species richness, species evenness, Shannon Wiener and Simpson's index, measures in strict nature reserve showed that Shannon's Species Diversity Index had 1.85. Pielou's Evenness Index had 0.75, species abundance (11 seedling/m^2), Species richness (3.84), Simpson's index (0.91)

The mean sapling density of the site A is 21.29 stems ha^{-1} (Table 2), which comprises 7 species (5 woody and 2 herbs). Herbaceous species exhibited dominance in this site by constituting 56.36% of the total plant species, followed by woody species (43.64%). The species with the highest sapling density in this site were *Culcasia scandens* (5.53 m^2 ha^{-1} or 25.975%), *Pauridiantha hirtella* (2.78 m^2ha^{-1} or 13.06%) and *Brachystegia eurycoma* (2.16 m^2ha^{-1} or 10.15 %). The woody species here included *Brachystegia eurycoma, Chassalia kolly, Diospyros nigerica, Pauridiantha hirtella* and *Psychotria psychotrioides.* The two herbs that emerged at the site were *Culcasia scandens* and *Palisota hirsuta.*

Seedling Emergence at 0-3cm, 3-6cm and 6-9cm depth in strict nature reserve

The soil samples collected at 0-3 cm depth (Table 4) showed that a mean total 71 seed/m^2 emerged. This comprised of 9 species (1 fern, 1 climber and 7 herbs) belonging to the 8 families. The site is dominated by herbs which constituted 76.76% of the total plant species. The site is also comprised of fern which accounted for 14.09% of the species identified. Some of the species found in this site included *Cyclosorus afer* (Christ.) Ching, *Chromolaena odorata* (L.) R. M. King & H. Rob, *Commelina diffusa* Burm. f, *Palisota ambigua* (P. Beauv.) C. B, *Palisota hirsuta, Euphorbia hirta* Linn, *Peperomia pellucida* (Linn.) H.B. & K, *Portulaca oleracea* Linn, *and Laportea aestuans* (L.) Chew

At 3-6 cm, a mean total of 31 seeds/m^2 germinated which comprised of 9 species (5 herbs, 1 woody species,

Table 1. Tree species diversity, relative frequency, volume and diversity index of the strict nature reserve (SNR)

Family	Scientific name	nha^{-1}	Baha^{-1}	RD	RD_0	IVI	FIV
Annonaceae	*Anonidium mannii* (Oliv.) Engl. & Diels	*10*	3.497	4.219	1.117	2.357	2.668
	Cleistopholis patens (Benth.) Engl. & Diels	*2*	4.409	0.422	0.566	0.119	0.494
Apocynaceae	*Alstonia boonei* De Wild.	*1*	0.884	0.422	0.057	0.012	0.239
	Alstonia congensis Engl.	*2*	0.473	0.844	0.173	0.073	0.509
	*Funtumia elastica (*Preuss) Stapf	*6*	0.695	2.532	0.416	0.526	1.474
Caesalpinioideae	*Anthonotha macrophylla* P. Beauv.	*1*	0.752	0.422	0.048	0.010	0.235
	Brachystegia eurycoma Harms	*3*	17.848	1.266	1.180	0.747	1.223
	Brachystegia nigerica Hoyle & A.P.D. Jones	*1*	7.890	0.422	0.507	0.107	0.465
Capparidaceae	*Buchholzia coriacea Engl.*	*1*	1.657	0.422	0.107	0.022	0.264
Combretaceae	*Terminalia ivorensis* A. Chev.	*3*	1.653	1.266	0.614	0.389	0.940
	Terminalia superba Engl. & Diels	*3*	9.228	1.266	0.893	0.565	1.079
Ebenaceae	*Diospyros dendo Welw.* ex Hiern	*3*	0.295	1.266	0.169	0.107	0.717
Euphorbiaceae	*Croton penduliflorus* Hutch.	*1*	0.005	0.422	0.060	0.013	0.241
	Margaritaria discoidea (Baill.) G.L. Webster var. *discoidea*	*1*	0.910	0.422	0.059	0.012	0.240
	Ricinodendron heudelotii (Baill.) Pierre ex Pax	*1*	0.094	0.422	0.255	0.054	0.339
Irvingiaceae	*Irvingia wombolu* Vermoesen	*1*	1.278	0.422	0.082	0.017	0.252
Meliaceae	*Entandrophragma angolense* (Welw.) C. DC.	*1*	0.968	0.422	0.062	0.013	0.242
	Entandrophragma utile (Dawe & Sprague) Sprague	*9*	0.602	3.797	0.438	0.832	2.118
	Khaya grandifoliola C. DC.	*3*	1.195	1.266	0.309	0.195	0.787
	Trichilia welwitchii	*2*	11.808	0.844	0.257	0.108	0.550
Mimosaceae	*Albizia zygia* (DC.) J. F. Macbr.	*3*	2.993	1.266	0.530	0.335	0.898
Moraceae	*Treculia africana* Decne. var. *africana*	*2*	1.405	0.844	0.273	0.115	0.558
	Trilepisium madagascariense DC.	*4*	2.056	1.688	0.528	0.446	1.108
Olacaceae	*Strombosia pustulata* Oliv.	*3*	0.391	1.266	0.202	0.128	0.734
Papilonoideae	*Pterocarpus mildbraedii* Harms	*1*	0.910	0.422	0.127	0.027	0.274
	Lonchocarpus sericeus (Poir.) DC.	*1*	0.023	0.422	0.059	0.012	0.240
	Pterocarpus osun Craib.	*1*	0.011	0.422	0.089	0.019	0.255
Sapindaceae	*Blighia sapida* Konig	*1*	0.868	0.422	0.056	0.012	0.239
Sapotaceae	*Chrysophyllum albidum* G. Don	*7*	3.790	2.954	0.862	1.274	1.908
	Chrysophyllum perpulchrum Mildbr. ex Hutch. & Dalz.	*1*	0.037	0.422	0.161	0.034	0.291
	Malacantha alnifolia (Bak.) Pierre	4	0.586	1.688	0.280	0.236	0.984
Steraculiaceae	*Cola acuminata* (P. Beauv.) Schott & Endl.	*3*	0.464	1.266	0.203	0.129	0.735
	Cola gigantea A. Chev. var. *gigantean*	*13*	21.863	5.485	1.908	5.233	3.697
	Cola heterophylla (P. Beauv.) Schott & Endl.	3	0.129	1.266	0.186	0.118	0.726
	Mansonia altissima (A. Chev.) A. Chev. var. *altissima*	*54*	14.171	22.79	5.015	57.13	13.90
	Pterygota macrocarpa K. Schum.	*1*	0.004	0.422	0.050	0.011	0.236
	Sterculia oblonga Mast.	*2*	0.151	0.844	0.105	0.044	0.474
	Sterculia tragacantha Lindl.	*1*	4.991	0.422	0.151	0.032	0.286
	Sterculia rhinopetala K. Schum.	*13*	0.033	5.485	1.244	3.413	3.365
	Triplochiton scleroxylon K. Schum.	*11*	8.148	4.641	3.026	7.022	3.834
Tiliaceae	*Desplatsia dewevrei* (De Wild. & Th. Durand.) Burret	*1*	0.088	0.422	0.247	0.052	0.334
Ulmaceae	*Celtis mildbraedii* Engl.	*2*	0.852	0.844	0.248	0.105	0.546
	Celtis philippensis Blanco *syn Celtis brownii* Rendle	*9*	3.884	3.797	0.963	1.829	2.380
	Celtis zenkeri Engl.	*40*	7.004	16.88	3.054	25.77	9.966
Verbenaceae	*Vitex rivularis* Gürke	*1*	1.031	0.422	0.066	0.014	0.244

nha $^{-1}$ number of stems per hectare, Ba -Basal area per hectare (m^2) while RD, RD_0, IVI, FIV as defined before

Table 2. Sapling Composition and Density.

Strict nature reserve (sapling)	Famiy	number of stems per hectare (nha^{-1})	Stem	percentage
*Brachystegia eurycoma (*T)	Caesalpinaceae	2	2.16	10.15%
Chassalia kolly (S)	Rubiaceae	1	1.64	7.70%
Culcasia scandens (H)	Araceae	3	5.53	25.98%
Diospyros nigerica (T)	Ebenaceae	1	1.11	5.214%
Palisota hirsuta (H)	Commelinaceae	1	6.47	30.39%
Pauridiantha hirtella (S)	Rubiaceae	2	2.78	13.06%
Psychotria psychotrioides(S)	Rubiaceae	1	1.6	7.52%
			21.29	100%

T= Tree, H= Herb, C= Climber, F= Fern, SNR (A) = Strict Nature Reserve, % - percentage.

Table 3. Sapling and Seedling measured in the study sites.

	No. of species	No. of family	Density	Sampson's index	Species richness	Species evenness	H Index	Abundance (m^2)
Sapling	7	5	7	0.91	3.84	0.77	1.85	11
Seedling	9	8	9	0.88	50.56	0.45	2.14	114

Table 4. Mean density (seeds/m^2) and percentage contribution (%) of each species in the seed bank of strict nature reserve at 0-3 cm, 3-6cm and 6-9cm

Family	Name	Habit	0-3cm	%	3-6cm	%	6-9cm	%
Thelypteridaceae	*Cyclosorus afer* (Christ.) Ching	F	10	14.09	5	16.13	3	25
Asteraceae	*Chromolaena odorata* (L.) R.M.King & H. Rob.	H	3	3.03	2	6.45	1	8.33
Commelinaceae	*Commelina diffusa* ssp. *diffusa* J.K.Morton	H	9	12.68	3	9.68	--	--
	Palisota ambigua (P. Beauv.) C.B.Clarke	H	2	2.02	--	--	1	8.33
	Palisota hirsuta (Thunb.) K.Schum.	H	6	6.06	2	6.45	--	--
Euphobiaceae	*Euphorbia hirta* Linn.	H	5	5.05	13	41.94	3	25
Piperaceae	*Peperomia pellucida* (L.) Kunth	H	15	21.13	2	6.45	1	8.33
Portulacaceae	*Portulaca oleracea* L.	H	7	7.07	--	--	2	16.67
Ulmaceae	*Celtis zenkeri* Engl.	T	--	--	2	6.45	1	8.33
Urticaceae	*Laportea aestuans* (L.) Chew	H	14	19.72	2	6.45	--	--
			71	100	31	100	12	100

T= Tree, H= Herb, C= Climber, F= Fern, SNR (A) = Strict Nature Reserve, % - percentage.

1 climber, 1 fern) belonging to 8 families. Herbaceous species exhibited dominance in this site by constituting 77.42% of the total plant species, followed by fern species (16.13%), and woody species (6.45%). Some of the herbaceous species here included *Chromolaena odorata, Commelina diffusa, Palisota hirsuta, Euphorbia hirta, Peperomia pellucida* and *Laportea aestuans* among others. The only fern that emerged at the site was *Cyclosorus afer* while *Celtis zenkeri was* the only woody species present.

A mean total of 12 seeds/m^2 emerged in site A at 6-9 cm which consisted of 7 species belonging to 7 families. The species included 5 herbs, 1 tree and 1 fern. The herbaceous species dominated the seedbank of site A with a total of 8 seeds/m^2 which accounted for 66.67% of all the total species in the site. Woody species accounted for 8.333% of the seed density while fern species contributed 25% to the total seed density of site A.

A herbaceous species *Peperomia pellucida* had the highest seed bank density at depth 0-3 cm with a total density of 24 seeds/m^2 (19.72%) and at depth 3-6 cm, *Euphorbia hirta*, a herb, had the highest seedbank density of 13 seeds/m^2 (41.94%) while at 6-9 cm, *Cyclosorus afer* and *Euphorbia hirta* had the highest seed bank density of 3seeds/m^2 (25%) in the collection.

DISCUSSION

The species composition of the soil seed bank studied across different soil depth revealed that herbs and shrubs dominated the first two layers of soil depth investigated with a sparse representation of a single woody species in the last two layers of soil. Also the undergrowth sapling composition of the forest encountered in this study, revealed that the species encountered were not successive native plants which are indicators of a disturbed forest, thereby confirming the forest to be in a stable state. Furthermore, the soil seed bank was found to be dominated by these successive native plants which had a high seed density across the soil depths investigated; bringing to light the potential successors of the forest vegetation as well as the possible changes in species composition and structure that will take place over time as the present conditions prevalent in the stable forest changes.

This study confirmed the results obtained in several studies, where there is a marked difference in the species composition of soil seed banks and that of the above vegetation (Major and Pyott, 1966; Abrams, 1988; D' Angela *et al*., 1988; Bakker, 1989; Warr *et al*., 1993; Oke *et al*., 2006; Okunola and Oke, 2008). Also the results indicate that members of Sterculiaceae (*Cola acuminata* (P. Beauv.) Schott & Endl., *Cola gigantea* A. Chev., *Sterculia oblonga* Mast, *Sterculia tragacantha* Lindl, *Cola heterophylla* (P. Beauv.) Schott & Endl, *Mansonia altissima* (A. Chev.) A. Chev., *Pterygota macrocarpa* K. Schum, *Sterculia rhinopetala* and *Triplochiton scleroxylon*) and Fabaceae family (*Pterocarpus mildbraedii* Harms, *Lonchocarpus sericeus* (Poir.) DC., *Pterocarpus osun* Craib, *Albizia zygia* (DC.) J.F. Macbr, *Anthonotha macrophylla, Brachystegia eurycoma* and *Brachystegia nigerica* Hoyle & A.P.D. Jones) family and species like *Celtis zenkeri* consist of important parts of the floristic composition of the strict nature reserve.

However, *Celtis zenkeri* and *Mansonia altissima* were observed to have higher importance value indices (IVI) than the rest of the species observed. This finding is in agreement with the result of Adekunle *et al* (2013b) on the same species. This could be a good indication that the conservation measure given to the forest favored these species to dominate the forest compared to other species with lower importance value (i.e. *Anthonotha macrophylla, Pterygota macrocarpa, Alstonia boonei* De Wild, *Croton penduliflorus* Hutch, *Margaritaria discoidea* (Baill.) G.L. Webster var. discoidea, *Entandrophragma angolense* (Welw.) C. DC., *Lonchocarpus sericeus* (Poir.) DC.). Also, the regeneration potential of all the tree species encountered in this study at the "Queens Plot" SNR assessed through sapling enumeration (Table 3), indicated the absence of saplings of all species except those of *Brachystegia eurycoma* and *Diospyros* spp which were sparingly found as presented in the Table 1 and which were of extremely low dominance compared to those of *Celtis zenkeri* and *Mansonia altissima* in the above vegetation.

More so, even though *C. zenkeri* and *M. altissima* has

a higher IVI at present, the structure as well as species composition of the stable forest will drastically change over time should any occurrence take place such as natural death of some species of the above vegetation, a natural disaster, or even human interference which would cause an opening favoring the rapid growth of the understorey vegetation (saplings), hence the various tree species without representatives in the sapling composition of the forest will be gradually succeeded over time by those of *Brachystegia eurycoma* (Caesalpinaceae) and *Diospyros nigerica* (Ebenaceae) with representatives amongst the saplings with a corresponding upcoming of saplings of other plants species such as shrubs and herbs which also constitute the sapling population. Furthermore, the absence of regeneration and seedling emergence of most species whose seeds were found in the soil seed bank of the strict nature reserve is an indication that the forest have indeed reached a stable condition, consequently inhibiting the seedling emergence of these species and causing them to remain dormant for several years in the soil; a condition expected to be in place until the forest cover is opened bringing about conditions favorable for seed germination and seedling emergence.

Also the sapling composition (Table 2) of native plants (i.e. saplings already existing in the stable SNR) which dominate saplings of the undergrowth shows that the species encountered were not successive native plants (i.e. species saplings that come up only when the forest is disturbed) such as herbaceous dicots and shrubs domiciled in the seed soil bank. Perera (2005) described these successive native plants as non-forest early colonizers (or agricultural weeds) present in the soil seed bank which germinate and establish well under favorable conditions associated with disturbed forests or open areas. In other words, if the forests were to be disturbed, these successive native plants identified in this study would have made appearance in the early stages of succession and hence constitute a part of the undergrowth. This is clearly indicated in the result obtained from the seedling emergence at the various soil depths (Table 4) which shows that these successive native plants (herbs) mostly dominated the soil seed bank of all the three depths except in depth 3-6 cm and 6-9 cm where *Celtis zenkeri* was found to have germinated similar observations were also reported by Perera (2005) and Mamo *et al.* (2012) for humid sub-tropical forests.

The high seed density of the soil samples in this study as determined from the seed emergence from the collected soil samples is in consonance with the observations of Perera (2005) and Chandrashekara and Ramakrishnan. (1993) who reported that the soil seed bank collected at the beginning of the rainy period for seedling emergence from tropical humid forests proved to posses high seed density, since most of the monocots and herbs produce mature fruits within that period. Furthermore, the general decline in seed density with increasing soil depth as well as the low presence of seeds of woody species to the soil seed bank observed in this study correlates with the findings of other researchers for different forests (Gonzalez-Rivas, 2005; Teketay, 2005; Pickett and McDonnell 1989; Saulei and Swaine 1988).This implies that the first few centimeters of soil accommodate the most number of seeds and hence has a critical influence on the structure and composition of the successional species for any forest ecosystem.

CONCLUSIONS & RECOMMENDATIONS

This study has provided base line information on the species diversity and regeneration potential of soil seed bank of the "Queens Plot" strict nature reserve in Akure forest reserve, Ondo state Nigeria. The study has proven that there is a marked difference in the vegetative species composition of soil seed bank and that of the above vegetation. Also, a majority of the species occupying the above vegetation were found to have a lower importance value index as well as poor representation amongst the sapling population of the forest.

The tree species with poor representation in the soil seed bank should be considered as uncommon and endangered. Therefore further studies spanning over a longer period of time should are recommended in order to determine if there will be variations or improvements in the soil seed bank composition with a view to predicting future succession dynamics of the forest ecosystem.

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LITERATURE CITED

Abrams, M.D. 1988. Effects of burning regime on buried seed banks and canopy coverage in Kansas tall grass prairie. Southwest Nat. **33(1):** 65-70.

Adeduntan, S.A. 2009. Diversity and abundance of soil mesofauna and microbial population in South-Western Nigeria. Afr. J. Plant Sci. **3(9):** 210-216.

Adekunle, V.A.J., A.O. Olagoke and L.F. Ogundare. 2013a. Logging impacts in tropical lowland humid forest on tree species diversity and environmental conservation. Appl. Ecol. Env. Res. **11(3):** 491-511.

Adekunle V.A.J., A.O. Olagoke and S.O. Akindele. 2013b. Tree species diversity and structure of a Nigerian Strict nature reserve. International Society for Tropical Ecology **54(3):** 275-289.

Bakker, J.P. 1989. Nature Management by Grazing and Cutting. Kluwer Academic Publishers, Dordrecht.

Brashears, M.B., M.A. Fajvan and T.M. Schuler. 2004. An assessment of canopy stratification and tree species diversity following clearcutting in central Appalachian hardwoods. Forest Sci. **50:** 54-64.

Chandrashekara, U.M. and P.S. Ramakrishnan. 1993. Germinable soil seed bank dynamics during the gap phase of a humid tropical forest in the western ghats of Kerala, India. J. Trop. Ecol. **9(4)**: 455-467

D'Angela, E., J.Facelli and E. Jacobs. 1988. The role of the permanent soil seed in early stages of post agricultural succession in the Inland pampa Argentina. Vegetatio **74(1):** 39-45.

Gonzalez-Rivas, B. 2005. Tree species diversity and regeneration of tropical dry forests in Nicaragua. Ph.D. Thesis, Swedish University of Agricultural sciences, Department of Silvicluture, Umea.

Iyagin, E.O. and V.A.J. Adekunle. 2016. Assessment of Tree Growth Variable and Soil Chemical Properties of Tropical Rainforest Ecosystem, Southwest Nigeria, In: the Proceeding of the 5th biennial conference of the Forest and forest products society. 135-140

Mamo, K., K. Markku, Y. Eshetu and L. Mulugeta. 2010. Soil seed bank and Seedlings bank Composition and diversity of Wondo genet moist afromomntane forest South Central Ethiopia. Int. J. Bot. **8(4):** 170-180.

Major, J. and W.T. Pyott. 1966. Buried viable seeds in two California bunch grass sites and their bearing on the definition of a flora. Vegetatio **13(5):** 253-282.

NFP. 2006. Approved National Forest Policy, 2006. Federal Ministry of Environment Abuja. 22p.

Nwoboshi, L.C 2000. The nutrient factor in sustainable forestry, Ibadan University press. University of Ibadan, Ibadan, Nigeria. Pp 4.

Oke, S.O., O.T. Oladipo and A.O. Isichei. 2006. Seed bank dynamics and regeneration in a secondary lowland rainforest in Nigeria. Int. J. Bot. **2(4):** 363-371.

Okunola, K. A and S.O. Oke. 2008. Seed Bank Dynamics in Altitudinal Gradient on an Inselberg in a Nigerian secondary Forest. Research Journal of Environmental Sciences **2(2):** 81-90.

Onyekwelu, J.C., R. Mosandl and B. Stimm. 2008. Tree species diversity and soil status of primary and degraded tropical rainforest ecosystems in South-Western Nigeria. J. Trop. For. Sci. **20(3):** 193-204.

Perera, G.A.D. 2005. Diversity and dynamics of the soil seed bank in tropical semi-deciduous forests of Sri Lanka. Tropical Ecology **46(1)**: 65-78.

Pickett, S.T.A. and M.J. McDonnell. 1989. Changing perspectives in community dynamics: a theory of successional forces. Trends Ecol. Evol. **4(8)**: 241-245.

Pielou, E.C. 1969. An Introduction to Mathematical Ecology, Wiley, NewYork.

Robert, H.A. 1981. Seed banks in soils. Advances in Applied Biology **6:** 155.

Shannon, C.E. 1948. A mathematical theory of communication. Bell System Technical Journal **27(3):** 379-423

Simpson, R.L., M.A. Leck and V.T. Parker. 1989. Seed banks: general concepts and methodological issues. Ecology of Soil Seed Banks. Academic press. Inc., San Diego, CA. 3-9

Saulei, S.M. and M.D. Swaine. 1988. Rain forest seed dynamics during succession at Gogol, Papua New Guinea. J. Ecol. **76(4)**: 1133-1152.

Teketay, D. 2005. Seed and regeneration ecology in dry Afromontane forests of Ethiopia: I. seed production-population structure. Trop. Ecol. **46**: 29-44.

Thompson, K and J. P. Grime. 1979. Seasonal variation in the seedbank of herbaceous species in ten contrasting habitat. J. Ecol. **67(3):** 893-921.

Warr, S.J., K. Thompson and M. Kert. 1993. Seed banks as a neglected area of biogeographic research: A review literature and sampling techniques. Prog. Phys. Geogr. **17(3):** 329-347.