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Soil Seed Bank Dynamics of a Riparian Forest and its Adjacent Upland Vegetation

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Abstract

The present study was conducted to determine the densities and soil seed bank composition of a riparian forest and its adjacent upland vegetation for a better understanding the potentials of the soil seed banks in facilitating succession towards a more natural forest of native tree species. Three contiguous 20 m x 20 m plots were systematically established on both riparian forest and upland vegetation. Species enumeration, identification and distribution into families of the standing vegetation were carried out. Furthermore, five replicates soil samples were collected at two different depths (0-15 cm, 15-30 .The seedling emergence test was carried out for six months in the greenhouse to determine the species composition and the density of the seed in both vegetation types. The results of the seedling emergence revealed that more seeds were deposited at the upper depth (0-15 cm) than the lower depth 15-30 cm in the two vegetation types in both dry and rainy season. There was low similarity in species composition between the standing vegetation and soil seed bank in each of the two vegetation types. Herbaceous species recorded the highest number of seedlings as compared to the other habit. The low similarity between seed bank and standing vegetation of the riparian forest and the adjacent upland vegetation suggested that soil seed bank was insignificant in their restoration.

Keywords: depth, re-vegetation, riparian forest, soil seed bank, species diversity

Introduction

Riparian forests are one of the biospheres' most complex ecological systems but also are important for maintaining the vitality of landscape and its rivers (Naiman and Decamps, 1990; 1997). Vegetation in riparian areas is generally characterized by its high species richness and has unique characters making it different from the upland vegetation (Naiman *et al*., 1993). Despite their limited area extent, riparian areas promote many ecosystem functions vital to the health and productivity of forested watersheds (Gregory *et al*., 1991). The riparian areas regulate the flow of water, sediments, and nutrients across system boundaries; they also contribute with organic material to the aquatic system, increase bank stability, reduce erosion, and provide key wildlife habitat (Gregory *et al*., 1991). Moreover, because of their functional importance, riparian areas play important roles in reducing many of the negative impacts of land use on aquatic systems as well as protecting species diversity, providing potential dispersal corridors for wildlife, and reducing flood waters (Ilhardt *et al*., 2000).

On restored sites, target species can establish in the plant community through dispersal from source plant communities, or through germination from viable seeds in the soil seed bank (Bakker and Berendse, 1999). This soil seed bank can also contain seeds of non- target species, which may rather hamper the establishment of target species by interspecific competition (Bossuyt *et al*., 2002). In order to understand the soil seed bank dynamics in degraded forests, which include gains through seed rain, losses due to seed predation, seed death and transfer into the active seed bank to germinate and form a seedling bank, is necessary before deciding whether intervention is needed to assist the natural regeneration process (Augusto Uasuf *et al*., 2009).

Nowadays there is an increasing demand for reliable information on seed banks, both for scientific purposes and as a decision tool in habitat and landscape management, particularly restoration projects (Holzel and Otte, 2004). Despite the importance of the soil seed bank as a determinant of the flora in many systems, little research has been conducted on the seed banks of riparian forests especially in southwestern Nigeria. The present study attempts to assess the soil seed bank composition and its role in the restoration of degraded riparian and upland vegetation. The main objectives were: to determine the species composition and density of the seed bank in both vegetation types; to compare the seasonal variation of the soil seed bank of the standing vegetation in both the riparian and upland vegetations and to note the effect of depths on the soil seed bank in the two vegetation types.

Materials and Methods

The studied areas

The study was carried out within Obafemi Awolowo University (OAU) community in Ile-Ife (7^0 31'N and 7^0 32'N latitude, 4^0 31'E and $4^0$32'E longitude), Osun state, Nigeria. Ile-Ife is in the lowland forest zone according to Keay (1959), semi deciduous moist forests Charter (1969). The area lies in the dry

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Table 1. Mean density of woody species (per hectare) in the two vegetation types

No .of entry	Species names	Family	Riparian forest	Upland vegetation
1.	*Albizia adianthifolia*	*Mimosoideae*	50	33
2.	*Albizia lebbeck*	*Mimosoideae*	-	8
3.	*Albizia zygia*	*Mimosoideae*	117	408
4.	*Alchornea cordifolia*	*Euphorbiaceae*	375	133
5.	*Alchornea laxiflora*	*Euphorbiaceae*	-	375
6.	*Allophyllus africanus*	*Sapindaceae*	8	-
7.	*Alstonia boonei*	*Apocynaceae*	17	-
8.	*Anchomanis difformis*	*Arecaceae*	-	50
9.	*Anthocleista djalonensis*	*Loganiaceae*	108	-
10.	*Anthocleista vogelii*	*Loganiaceae*	-	8
11.	*Antiaris africana*	*Moraceae*	17	50
12.	*Azadirachta indica*	*Meliaceae*	50	258
13.	*Baphia nitida*	*Papilioniaceae*	17	8
14.	*Blighia sapida*	*Sapindaceae*	-	16
15.	*Bombax buonopozense*	*Bombacaceae*	33	8
16.	*Bridelia ferruginea*	*Euphorbiaceae*	8	17
17.	*Canthium vulgare*	*Rubiaceae*	50	-
18.	*Carpolobia lutea*	*Phytolacaceae*	33	-
19.	*Cassia siberiana*	*Cealsapinaceae*	25	-
20.	*Ceiba pentandra*	*Bombacaceae*	25	-
21.	*Celtis zenkeri*	*Ulmaceae*	25	-
22.	*Cnestis ferrugiana*	*Connaraceae*	8	17
23.	*Deinbollia maxima*	*Sapindaceae*	8	-
24.	*Deinbollia pinnata*	*Sapindaceae*	17	-
25.	*Delonix regia*	*Cealsapinaceae*	-	150
26.	*Drypetes* sp	*Euphorbiaceae*	8	-
27.	*Ficus capensis*	*Moraceae*	50	-
28.	*Ficus* sp	*Moraceae*	-	17
29.	*Funtumia elastica*	*Apocynaceae*	33	-
30.	*Glyphaea brevis*	*Tiliaceae*	17	-
31.	*Harungana madagascariensis*	*Apocynaceae*	-	8
32.	*Hedranthera bacteri*	*Apocynaceae*	-	5
33.	*Hipocratea* sp	*Celastraceae*	7	
34.	*Holarrhena floribunda*	*Apocynaceae*	475	92
35.	*Icacina tricantha*	*Icacinacaceae*	-	250
36.	*Lannea welwitschii*	*Anacardiaceae*	8	-
37.	*Leea guinensis*	*Leeaceae*	8	-
38.	*Mallotus oppositifolius*	*Apocynaceae*	-	83
39.	*Margaritaria discoidea*	*Euphorbiaceae*	50	225
40.	*Markhamia tomentosa*	*Bignonaceae*	8	-
41.	*Microdesmis puberula*	*Pandaceae*	8	-
42.	*Monodora tenuifolia*	*Annonaceae*	-	8
43.	*Morinda lucida*	*Rubiaceae*	28	8
44.	*Napoleona imperialis*	*Lecythidaceae*	8	33
45.	*Napoleonaea vogelli*	*Lecythidaceae*	-	33
46.	*Newbouldia laevis*	*Bignonaceae*	25	66
47.	*Ochna* sp	*Ochnaceae*	-	40
48.	*Piptadeniastrum africanum*	*Mimosaceae*	8	-
49.	*Psidium guajava*	*Myrtaceae*	17	8
50.	*Rauvolfia vomitora*	*Apocynaceae*	8	33
51.	*Rothmania longiflora*	*Apocynaceae*	-	8
52.	*Sphenocentrum jollyanum*	*Menispermaceae*	-	33
53.	*Spondias mombin*	*Anarcadiaceae*	-	50
54.	*Sterculia tragacantha*	*Sterculiaceae*	-	50
55.	*Terminalia superba*	*Combretaceae*	8	-
56.	*Tetrapleura tetraptera*	*Mimosaceae*	-	17
57.	*Trema orientalis*	*Ulmaceae*	-	8
58.	*Trichilia* sp	*Meliaceae*	-	8
59.	*Vitex doniana*	*Verbanaceae*	-	8
60.	*Vitex grandifolia*	*Verbanaceae*	17	-
61.	*Voacanga africana*	*Apocynaceae*	-	8
62.	*Xylopia paviflora*	*Annonaceae*	-	8
	TOTAL		1749	2235

deciduous forest zone (Onochei, 1979). According to White (1983) the vegetation was described as Guineo-Congolian drier forest type.

The mean annual rainfall is about 1400 mm and the mean maximum temperature of 33 °C is recorded between February and March while the mean minimum temperature of 27 °C is recorded between July and September (Oke and Isichei, 1997). Two distinct vegetation types (riparian forest and upland vegetation) were selected in OAU community base on their vegetation physiognomy.

Table 2. Climber species in the two studied standing vegetation system

No of entry	Species names	Family	Riparian forest	Upland vegetation
1	*Combretum* sp	*Combretaceae*	+	-
2	*Hippocratea* sp	*Celastaceae*	+	-
3	*Sabicia calcycina*	*Sterculiaceae*	-	+

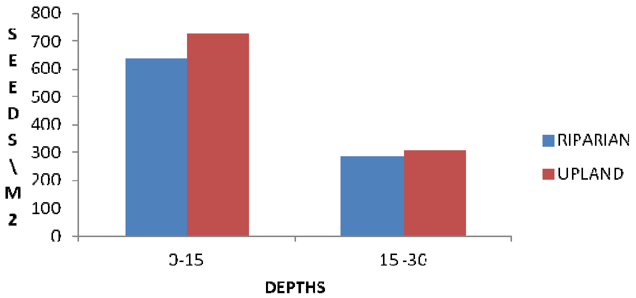

Fig. 1. Seed density at different depths in the two vegetation types in dry season

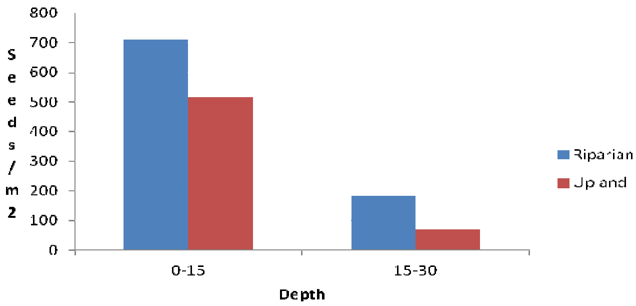

Fig. 2. Seed density at different depths in the two vegetation types in rainy season

Soil samples and the species identification

Three sample plots 20 m x 20 m each were selected within each vegetation type. All the woody species (trees and shrubs) greater than or about one meter in height on the selected plots were identified to species level and completely enumerated. The identification followed the Flora of West Africa (Hutchinson and Dalziel, 1954-1972). Unidentified plants were collected dried and pressed for identification by a taxonomist in IFE Herbarium. In each of the six plots, five replicate soil samples were randomly collected at two depths (0-15 cm, 15-30 cm) using a soil auger. Soil samples were collected in March 2011 for dry season collection while the rainy season collection in June 2011. Sixty samples (60) were collected in each of the riparian and upland vegetation in each season making a total of 120 samples collected from both sites in the two seasons (rainy and dry season). The soil samples collected were spread in porous plates for seeds germination under nursery conditions in the greenhouse where they were watered daily and monitored for seedling emergence. As seedlings emerged, the seedlings in each plate were identified, counted and removed. The seedling emergence test was terminated at the end of six months for soil samples collected from each of the six plots in both dry and rainy seasons. The number of seedlings that emerged per m^2 were counted using the method of Mayor and Pyott (1966).

The statistical analyses

Sorenson index of similarity (Sorensen, 1948) was used to compare the species composition between the extent vegetation and the soil seed bank. Two-way analysis of variance (ANOVA) was used to test for any significant difference in soil seed bank of the two vegetation types in different seasons and different depths

Results

Species composition of the standing vegetation

In the riparian forest thirty-eight woody species were encountered while forty woody species were encountered in the upland vegetation. A total of sixty-two woody species were observed in the two vegetation types (Table 1). Climber species observed in the two vegetation types include *Combretum sp, Hippocratea sp* and *Sabicia calcycina* (Table 2).

Seedling emergence at 0-15 cm depth

In the dry season, a total mean of 107 seedlings or 640 seeds/m^2 emerged in the riparian forest at 0-15 cm depth (Table 3). Thirty-four species emerged in this site consisting of three woody species namely *Alchornea cordifolia, Harungana madagascariensis* and *Trema orientalis.*

In upland vegetation, a total mean of 121 seedlings or 728 seeds/m^2 emerged (Table 4). Forty-one species emerged in this site consisting of two woody species namely *Grewia orientalis* and *Trema orientalis.*

In the rainy season, 708 seeds/m^2 emerged in riparian forest at 0-15 cm depth (Table 3). Ten species emerged from this site comprising of two woody species which are *Mallotus oppositifolius* and *Elaies guineensis.* They constituted about 25.77% of the total seed bank density while others which were herbaceous made up 74.23% of the total seed bank. In upland vegetation, 516 seeds/m^2 emerged. Twenty species emerged in upland vegetation with only one woody species (*Elaeis guineensis).*

Seedling emergence at 15-30 cm depth

In the dry season, 286 seeds/m^2 emerged in the riparian forest (Table 3). Fifteen species emerged in which only one woody species *Trema orientalis* was identified. In upland vegetation, 310 seeds/m^2 emerged (Table 4). Nineteen species emerged from this site where *Grewia orientalis* was the only woody species present in the vegetation and it constituted 1.94% of the total seed bank density while the remaining herbaceous species made up 98.06% of the total seed bank.

In the rainy season, 182 seeds/m^2 emerged in the riparian forest, (Table 3). Four species emerged with only one woody species. The woody species (*Mallotus oppositifolius*) accounted for 3.30% of the seed bank while herbaceous species made up 88.30% of the seed bank density. A mean of 70 seeds/m^2 emerged in the upland vegetation (Table 4). All the five species that emerged from this site were herbs. The results show that there was a significant difference ($p < 0.05$) in the density of seedlings at the two different depths. Soil seed bank density was also significantly different in the two vegetation types ($p < 0.05$) in rainy and dry season. A graphical representation showing seed density at different depths in the two vegetation types in rainy and dry season is presented below in Figs. 1 and 2.

Table 3. Mean density (seeds/m^2) and percentage contribution of each species in the seed bank of riparian forest in both dry and rainy season at 0-15 cm and 15-30 cm

S/N	Species	Dry season (seeds/m^2)				Rainy season (seed/m^2)			
		0-15 cm	% seed bank	15-30 cm	% seed bank	0-15 cm	% seed bank	15-30 cm	% seed bank
1	*Adenia sp.*	06	0.93	-	-	-	-	-	-
2	*Ageratum conyzoides*	06	0.93	06	2.10	-	-	-	-
3	*Alchornea cordifolia*	06	0.93	-	-	-	-	-	-
4	*Asystasia gangetica*	06	0.93	-	-	-	-	-	-
5	*Borreria ocymoides*	84	13.1	70	24.5	-	-	-	-
6	*Borreria verticilata*	166	25.9	34	11.9	-	-	-	-
7	*Cercurinegia sp*	06	0.93	-	-	-	-	-	-
8	*Chromolaena odorata*	176	27.5	34	11.9	92	13	06	3.30
9	*Chromolaena veronica*	06	0.93	-	-	-	-	-	-
10	*Cissampelos owariensis*	06	0.93	72	25.2	-	-	-	-
11	*Cormelina sp*	08	1.25	-	-	-	-	-	-
12	*Croton lobatus*	06	0.93	-	-	-	-	-	-
13	*Cyperus dactylon*	-	-	-	-	30	4.24	-	-
14	*Dissotis idanrensis*	-	-	-	-	190	26.8	34	18.7
15	*Dissotis rotundifolia*	32	5.00	-	-	-	-	-	-
16	*Elaies guineensis*	-	-	-	-	166	23.4	-	-
17	*Eleusine indica*	22	3.44	-	-	-	-	-	-
18	*Fleurya aestuans*	24	3.75	16	5.59	-	-	-	-
19	*Gouania longipetala*	06	0.93	12	4.20	-	-	-	-
20	*Harungana madagascariensis*	06	0.93	-	-	-	-	-	-
21	*Mallotus oppositifolius*	-	-	-	-	38	5.37	06	3.30
22	*Mariscus alternifolius*	-	-	-	-	06	0.85	-	-
23	*Oldenlandia corymbosa*	-	-	-	-	174	24.6	136	74.7
24	*Oplismenus burmanni*	08	1.25	-	-	-	-	-	-
25	*Peperomia pellucida*	06	0.93	-	-	06	0.85	-	-
26	*Phyllanthus niruri*	08	1.25	06	2.10	-	-	-	-
27	*Poulzolzia guineensis*	06	0.93	-	-	-	-	-	-
28	*Schrankia leptocarpa*	08	1.25	06	-	-	-	-	-
28	*Solenostemon rotundifolius*	06	0.93	-	-	-	-	-	-
30	*Spilanthes sp.*	06	0.93	-	-	-	-	-	-
31	*Synedrella nodiflora*	-	-	-	-	06	0.85	-	-
32	*Talinum triangulare*	-	-	-	-	06		-	-
33	*Terminalia ivorensis*	06	0.93	-	-	-	-	-	-
34	*Trema orientalis*	06	0.93	06	2.10	-	-	-	-
35	*Vigna gracilis*	06	0.93	06	2.10	-	-	-	-
	Total	640	100%	286	100%	708	100%	182	100%

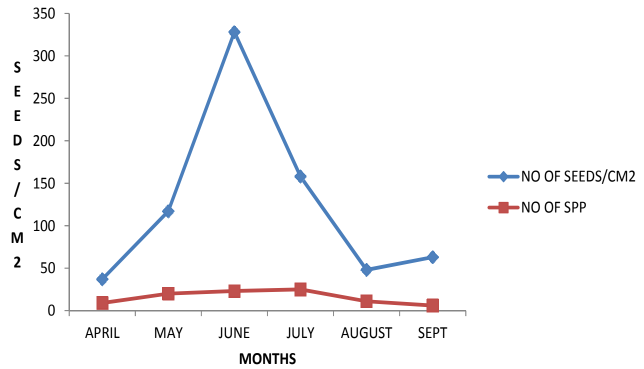

Fig. 3. Monthly emergence of seedlings and species at both depths from the dry season in riparian forest

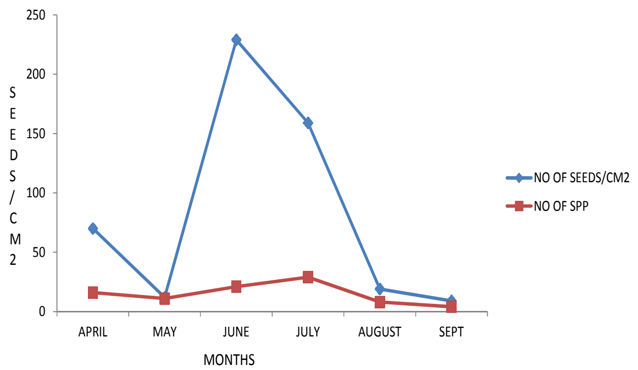

Fig. 4. Monthly emergence of seedlings and species at both depths from the dry season in upland vegetation

Seed bank and seasonal dynamics

Total seed density ranged from720 seeds/m^2 to 1242 seeds/m ^{2} in the dry season (fig. 4) and 354 seeds/m^2 to 924 seeds/m^2 in the rainy season in upland vegetation (fig. 6). The seed density was higher in the dry season than in the rainy season. Total seed density ranged from 468 to 1344 seeds/m^2 in the dry season (Fig.5) and 564 to1338 seeds/m^2 in the rainy season in riparian forest (Fig.3). The seed density was higher in the dry season than in the rainy season.

Standing vegetation and seedbank

Fifty one species emerged from the seed bank of riparian forest consisting of four woody species namely *Alchornea cordifolia, Trema orientalis, Elaeis guineensis, Mallotus oppositifolia*. Nevertheless, only one of the woody species that emerged from the seed bank (*Alchornea cordifolia*) was observed among the established woody vegetation while other woody species were absent in the standing vegetation.

Table 4. Mean density (seeds/m²) and percentage contribution of each species in the seed bank of upland vegetation in both dry and rainy season at 0-15 cm and 15-30 cm depth

S/N	Species	Dry season (seeds/m²)				Rainy season (seed/m²)			
		0-15 cm	% seed bank	15-30 cm	% seed bank	0-15 cm	% seed bank	15-30 cm	% seed bank
1	*Ageratum conyzoides*	28	3.85	12	3.87	-	-	06	1.87
2	*Andropogon sp*	06	0.82	-	-	-	-	-	-
3	*Aneilla sp.*	22	3.02	08	1.94	-	-	-	-
4	*Aristolochia ringens*	10	1.37	-	-	06	1.16	-	-
5	*Aspillia africana*	-	-	-	-	06	1.16	-	-
6	*Asystasia gangetica*	06	0.82	06	1.94	-	-	-	-
7	*Blumea lacera*	-	-	-	-	06	1.16	-	-
8	*Borreria ocymoides*	96	13.2	92	29.7	-	-	-	-
9	*Borreria verticilata*	60	8.24	18	5.81	-	-	-	-
10	*Chromolaena odorata*	216	29.7	72	23.2	226	43.8	20	28.6
11	*Croton lobatus*	10	1.37	06	1.94	-	-	-	-
12	*Desmodium sp*	32	4.40	06	1.94	06	1.16	-	-
13	*Dissotis idanrensis*	-	-	-	-	26	5.04	-	-
14	*Dissotis rotundifolius*	06	0.82	-	-	-	-	-	-
15	*Elaeis guineensis*	-	-	-	-	122	23.6	-	-
16	*Eleusine indica*	62	8.52	34	11.0	-	-	-	-
17	*Euphorbia germinus*	06	0.82	-	-	-	-	-	-
18	*Euphorbia heterophyla*	06	0.82	-	-	-	-	-	-
19	*Euphorbia migrant*	-	-	-	-	06	1.16	-	-
20	*Faroa pasilla*	-	-	-	-	16	3.10	-	-
21	*Fleurya aestuans*	50	6.87	20	6.45	-	-	-	-
22	*Fluggea virosa*	-	-	-	-	06	1.16	18	25.7
23	*Grewia orientalis*	06	0.82	06	1.94	-	-	-	-
24	*Ipomoea involucrata*	06	0.82	-	-	-	-	-	-
25	*Mariscus alternifolius*	-	-	-	-	16	3.10	-	-
26	*Mimosa pudica*	-	-	-	-	14	2.71	-	-
27	*Oldenlandia corymbosa*	-	-	-	-	16	3.10	18	25.7
28	*Peperomia pellucida*	06	0.82	-	-	06	1.16	-	-
29	*Phaelopsis barteri*	-	-	-	-	06	1.16	06	8.75
30	*Phylanthus niruri*	14	1.92	06	1.94	-	-	-	-
31	*Physalis micratal*	-	-	-	-	06	1.16	-	-
32	*Schrankia leptocarpa*	06	0.82	-	-	-	-	-	-
33	*Solenostemon rotundifolius*	06	0.82	-	-	-	-	-	-
34	*Spamicosa aximoides*	-	-	-	-	06	1.16	-	-
35	*Spilanthes sp.*	10	1.37	06	1.94	-	-	-	-
36	*Spigelia anthelmia*	28	3.85	06	1.94	-	-	-	-
38	*Synedrella nodiflora*	-	-	-	-	06	1.16	-	-
39	*Talinum triangulare*	06	0.82	06	1.94	06	1.16	-	-
40	*Trema orientalis*	12	1.64	-	-	-	-	-	-
41	*Veronica abyssinica*	06	0.82	-	-	-	-	-	-
42	*Vigna gracilis*	06	0.82	06	1.94	08	1.55	-	-
	Total	728	100%	310	100%	516	100%	70	100%

Table 5. Summary of mean density of seeds/m² at different depths in both seasons in the two vegetation types

Season	Depth (cm)	Riparian	Upland
Rainy	0-15	708	516
	15-30	182	70
Dry	0-15	640	728
	15-30	286	310

In the upland vegetation, forty one species emerged from the soil seed bank in both seasons at different depths, consisting of only four woody species namely *Trema orientalis, Elaeis guineensis, Harungana madagascariensis and Grewia orientalis. Trema orientalis* and *Harungana madagascariensis* were only the two woody species that had representative in the standing vegetation (Fig. 7).

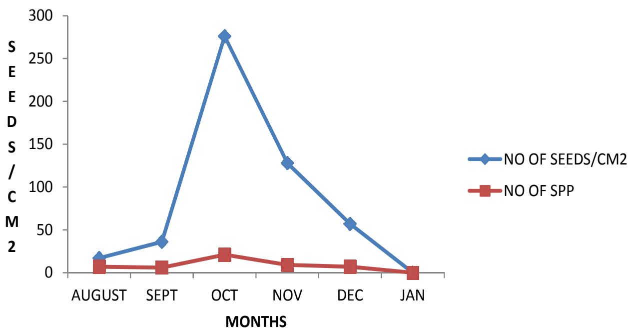

Fig. 5. Monthly emergence of seedlings and species at both depths from the rainy season in riparian forest

Discussion

Species composition of the standing vegetation

The density of the woody species varied considerably in the two vegetation types under consideration. There were more woody species in the upland vegetation than the riparian forest. This could be as a result of multiple natural disturbance regimes such as flooding, debris torrents, channels migration and landslides as well as trees-falls that occur in riparian areas compared to upland vegetation where tree-falls take is the only disturbance (Gregory *et al.*, 1991, Naiman *et al.*, 1993).

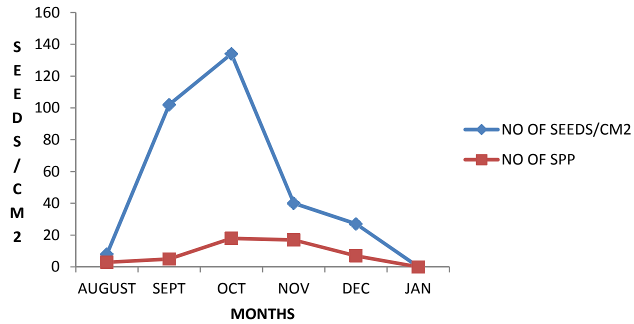

Fig. 6. Monthly emergence of seedlings and species at both depths from the rainy season in Upland vegetation

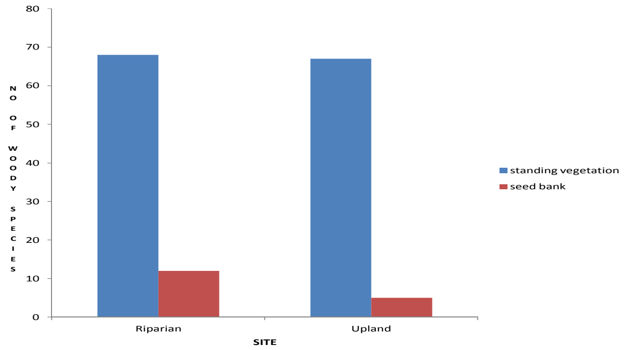

Fig. 7. Number of woody species in both standing vegetation and seed bank of the two vegetation types

Numerous factors such as interspecific interactions, habitat modification, seedling bank, availability of resources, disturbance may influence the vegetation composition in these forests (Conell, 1989; Dalling *et al*; 2002). The current study came in contradiction to the report of Correll (1997) who reported that vegetation density was higher in riparian forest compared to adjacent upland vegetation.

Seed bank density in the riparian forest and adjacent upland vegetation.

The mean seed bank density of these study sites ranged from 70 to728 seeds/m^2 and was lower than the values reported for some other forest of the world. For instance, Teketay and Gransterom (1995) recorded 12,300 seeds/m^2 in their study of an Afro-Montane forest in Ethiopia. The lower seed density obtained in this study can be ascribed to the modes of production of seeds and their dispersal (Grombone-Guaratini, 2004). Herbaceous species recorded the highest number of seeds as compared to the other life forms at different depths and seasons in both the riparian forest and adjacent upland vegetation. The contribution of woody species was low in both the riparian forest and adjacent upland vegetation types; perhaps the herbaceous species could produce persistent seed banks. This is in agreement with Zheng *et al.* (2004) who observed that herbaceous species dominated the soil seed banks. Also Taye (2006) observed that the soil seed bank of Harena forest was dominated by herbaceous species. Oke *et al.* (2006) also observed that herbaceous species dominated the seed bank of a secondary low forest in Nigeria.

The presence of few woody species like *Alchornea cordifolia, Trema orientalis, Elaeis guineensis, Mallotus oppositifolia, Harungana madagascariensis and Grewia orientalis* in the soil seed bank of the riparian forest and the adjacent upland vegetation may be that majority of the forest canopy species of the forest do not have viable seeds in the soil seed bank or that the viable seeds of the canopy species do not meet their germination requirement under glasshouse conditions.

Seasonal dynamics of soil seed bank

The seed bank density was higher in rainy season (2700 seeds/m^2) than in dry season (2508 seeds/m^2). This result was similar to that reported by Grombone-Guaratini and Rodrigues (2002), who found that the seed density during dry season was lower than in rainy season in a seasonal semi deciduous forest. Seed banks may exhibit higher density and diversity in areas of variable hydrologic conditions (La Peyre *et al.*, 2005) and substrate heterogeneity, such as those found in the riparian corridor (Schneider and Sharitz 1986). This might be responsible for the high density of soil seed bank of the riparian forest assessed in this study in rainy season soil collection. In contrary, the seed densities of upland vegetation in the dry season (2922 seeds/m^2) were higher than that of rainy season (1644 seeds/m^2). This is in agreement with Grombone-Guaratini *et al.* (2004) who reported that seed density in dry season was higher than that of rainy season in the seed bank of a gallery forest in Southeastern Brazil. The increase in seedling density during dry season in upland vegetation may be that most seeds in the soil seed bank met favourable environmental conditions to enhance their germination at this period, because favourable weather is a critical factor that determines the fate of seeds stored in the seed bank, whether to germinate or remain dormant. Various researchers have reported similar results on the seasonal dynamics of soil seed bank: Oke *et al.* (2007); Coffin and Lauenroth (1989); Butler and Chadzon, 1998).

Soil seed bank and soil depths

The seed density decreased with increase in the depth in this study. This implies that the seed density relates inversely with the soil depth.. A depth related decrease in soil seed bank has been documented (Roberts, 1972; Russiet *et al.*, 1992). The results from this study showed that the rate of seedling emergence was higher at 0-15 cm depth than 15-30 cm. This observation is in agreement with Cox and Martin (1984); Malik *et al* (2006); Bossuyt *et al.* (2002) This pattern can be attributed to historical changes in above-ground vegetation and seed bank regime (McGraw, 1987), seed mass and shape (Bekker *et al.*, 1998), as well as the vertical transport of seeds by earthworms, burrowing rodents and ants (Willems and Huijsmans, 1994) and probably differences in the slope of the landscape and local edaphic conditions of where the seeds land during dispersal.

Conclusions

Herbaceous species recorded the highest number of seedlings as compared to the other habit and few woody species emerged from the seed bank of the two study sites. The dissimilarity between seed bank and above-ground vegetation of riparian forest and the adjacent upland vegetation of the present study area has revealed that soil seed bank is insignificant in the restoration of degraded riparian forest and upland vegetation.

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