Regular Article
pISSN: 2288-9744, eISSN: 2288-9752
Journal of Forest and Environmental Science
Vol. 38, No. 3, pp. 141-151, September, 2022
https://doi.org/10.7747/JFES.2022.38.3.141

JFES
Journal of Forest and Environmental Science

Natural Regeneration Potential of the Soil Seed Bank of Land Use Types in Ecosystems of Ogun River Watershed

Israel Olatunji Asinwa[1,*] and Samuel Olalekan Olajuyigbe[2]
[1]*Rainforest Research Station, Forestry Research Institute of Nigeria, Ibadan 200109, Nigeria*
[2]*Department of Forest Production and Products, University of Ibadan, Ibadan 200005, Nigeria*

Abstract

Soil seed banks as natural storage of plant seeds play an important role in the maintenance and regeneration of watershed. Natural regeneration potential of the soil seed bank of Land use types (LUTs) in Ogun River watershed (ORW) was investigated. ORW was stratified using proportionate sampling technique into Guinea Savannah (GS), Rainforest (RF) and Swamp Forest (SF) Ecological Zones (EZs). Three LUTs: Natural Forest (NF), Disturbed Forest (DF) and Farmland (FL) were purposively selected in GS: GSNF, GSDF, GSFL; RF: RFNF, RFDF, RFFL and SF: SFNF, SFDF, SFFL, respectively. Systematic line transects was used in the laying of the sample plots. Sample plots of 25 m×25 m were established in alternate positions. Ten 1 m×1 m quadrats were randomly laid for soil core sampling from previously randomly selected ten plots. The core samples (10) were pooled per plot in each LUT and placed in individual trays. Ten trays with sterilized soil were used as control. The trays were watered regularly and checked for seedlings emergence fortnightly for 18 months. The experimental design used was 3×3 factorial experiments. ANOVA, Diversity index (H') and Similarity index (SI) were used to analyze the data. There was significant difference in seedling emergence among ecological zones and land use types ($p<0.05$). A total of 4,400 seedlings emerged from the soil samples. All species were distributed among 32 families. FL in the RF had the highest number of germinated seeds (705±37.33 seedlings) followed by DF in the RF (701±49.6 seedlings). The lowest emergence was in NF of the SF (199±28.41 seedlings). DF in the RF had highest number of species (34) distributed among 22 families. Emergence from soil seed bank of NF in ORW was generally with more of tree species than herbs that were predominant in FL and DF.

Key Words: land use types, soil seed bank, degradation, emergence, management

Introduction

Various land use practices at the forest and watershed have had severe consequences on watershed especially in the tropics (Asinwa and Olajuyigbe 2019). The biodiversity is being lost at an alarming rate and an appreciable number of forest species are threatened globally as a result of degradation. Human beings have become a major driving force with vast implications on changes in watershed ecosystems. (Huber et al. 2005; Millennium Ecosystem Assessment 2005; Jaji et al. 2007; Asinwa and Olajuyigbe 2019). Land use activities in watersheds are very vital because they affect surface and ground water. Surface water is affected when land use changes the volume of water running off the land and the quantity as well as concentration of material that can contaminate water that this runoff carries

Received: March 18, 2022. Revised: July 30, 2022. Accepted: July 30, 2022.

Corresponding author: Israel Olatunji Asinwa

Rainforest Research Station, Forestry Research Institute of Nigeria, Ibadan 200109, Nigeria
Tel: +2348035519395, E-mail: israelasinwa@gmail.com

(Tong and Chen 2002). Groundwater on its own is affected when land use changes the amount of water infiltrating the surface (Di et al. 2005).

According to (Food and Agriculture Organization 2012), the concern of land use is the purpose for which the land is used by the inhabitant of a particular community. It is defined as anthropogenic activities that have direct relationship with land by making use of its resources and thus having impacts on them. Land use and land cover change is now one of the major independent themes in the global change, climate change, earth systems and sustainability research programs (Gutman et al. 2004). There has been documentation of several environmental impacts of land use change in urban, suburban, rural and open space areas. Awoniran et al. (2011) observed that land use changes occurred as a result of urbanization and industrialization pressures which interns led to degradation of agricultural lands and the forest. Consequently, there were unprecedented changes in the hydrological balance of the area, increase in the risk of floods and landslides, air and water pollution among others. Other conspicuous impacts are soil erosion, sedimentation and mainly extinction of indigenous flora species (Gutman et al. 2004). The effects of land use/landover change (LULCC) are becoming more pronounced on the changes in ecosystems (Lambin and Geist 2007). The intergovernmental panel on climate change (IPCC) estimates that the cutting down of forests for varying human activities contributes close to 20% of the overall greenhouse gases that are entering the atmosphere, making the goal of reducing deforestation and watershed degradation an urgent and immediate one (United Nations Development Programme 2009).

Regeneration of tree species is hindered by natural and anthropogenic disturbances of the watershed due to forest canopy opening which dries out the soil rapidly and inhibits germination of viable seeds that are in the soil seed bank. The disturbances also enhance washing away of seeds in the soil seed bank and seedlings through run-off and result in growth of invasive weeds and other herbaceous plants which usually interfere with regeneration and impede recovery of trees and shrubs (Simard et al. 2001). Soil seed bank analysis of Ogun river watershed is therefore crucial to determine its regeneration potentials.

Soils are good reservoirs for seeds. However, it is not automatic that seeds that fall from parent trees to the floor will germinate successfully and establish within the forest floor (Rogers and Hartnett 2001). Plant species requires moist mineral soils to germinate. After germination, the seedling needs large amount of light and moisture for successful establishment (Kim et al. 2001). Availability of seeds and their germination vary with time, depending on length of fruiting season of trees, viability potentials, intensity of predation/disease attack and timing of germination (Rogers and Hartnett 2001).

Soil seed banks as natural storage of seeds of plants play an important role in the maintenance and regeneration of watershed (Asinwa et al. 2021). It has been considered an important factor in the regeneration of most ecosystems. Therefore, investigation of effects of land use practices on regeneration potentials of watershed is pertinent for provision of baseline data that will be useful for policy makers and stakeholders to formulate policy that will favour protection and management of watershed.

Materials and Methods

Ogun River is located in the Southwestern part of Nigeria, between latitudes 8°41' N and 9°10' N and longitudes 3°28' E and 4°8' E (Asinwa et al. 2021). The river flows through three Southwestern States (Oyo Ogun, and Lagos) before discharging into the Lagos Lagoon. Ogun River took its source from Igaran Hills at an elevation of about 530 m above mean sea level and flows directly south-

Fig. 1. Natural regeneration of the soil seed bank of three land use types in Ogun RiverWatershed.

wards over a distance of about 480 km before discharging into the Lagos Lagoon. Its major tributaries are the Ofiki and Opeki rivers (Bhattacharya and Bolaji 2010) (Fig. 1).There are two seasons, a dry season (from November to March) and a wet season (from April and October). Mean annual rainfall ranges from 900 mm in the north to 2000 mm towards the south. The estimate of total annual potential evapotranspiration is between 1,600 and 1,900 mm (Ikenweiwe et al. 2007). The three major vegetation zones that the river meanders through include the guinea savannah in the north, the rain forest in the central part and the swamp forests in the southern coastal and flood plains, next to the lagoon (Bhattacharya and Bolaji 2010). The geology is a rock sequence that starts with the Precambrian Basement; which consists of quartzites, biotite schist, hornblende-biotite, granite and gneisses. (Ikenweiwe et al. 2007).

Sampling procedure

The study area was divided into different ecological zones (guinea savannah, rain forest and swamp forests). The guinea savannah covers 68.5% (about 329 km) of the total length of the river while rain forest and swamp forest cover 27.5% (132 km) and 4% (19 km) respectively (Berga et al. 2006). Based on proportion to size, each ecological zone was purposively sampled by selecting four (4), two (2) and one (1) study locations in the guinea savannah, rain forest and swamp forest ecological zones respectively representing about 1% of coverage area of each ecological zone (Table 1). Having considered activities on the land cover, each location in the three ecological zones was stratified into Natural Forest (NF: relatively less disturbed forest), Disturbed Forest (DF) and Farm land (FL) for natural regeneration potentials' investigation. The disturbed Forest of the study area comprised forest where indiscriminate logging activities have been carried out as evident in the higher number of stumps per hectare. Other human activity that was prominent in the DF was charcoal production. The Farmland comprised of arable land of minimum of two years cultivation with mainly maize and cassava. The tree density in the DF was 114±30 trees/ha while FL had 46±22 trees/ha as scattered farm trees (Asinwa and Olajuyigbe 2019).

Systematic line transects was used in the laying of the sample plots in the selected locations along the river. A set back of 10 m from the riverbank was measured and then two transects of 1000 m in length parallel on either side of the river were laid. Then, sample plots of 25 m×25 m were established in alternate positions along the two transects at 100 m interval (8 sample plots per transect and a total of 16 sample plots in each of NF, DF and FL.

Ten out of the sixteen plots laid in each land use type were randomly selected for soil seed bank analysis. Ten 1 m×1 m quadrats were randomly laid for soil core sampling which was carried out in the onset of rainfall in the middle of month of March when most of the plant seeds have been dispersed. In each quadrat, the litter layer was removed and then soil core samples were collected at random points with an auger (5 cm diameter×15 cm depth with equivalent of 0.006 kg/ha). The core samples (10) were pooled per plot in each land use type in the three ecological zones as described by Thompson (1993). Rhizomes and

Table 1. Geo-referenced coordinates of sampled locations along the Ogun River water course (sampling based on area covered by the river in each ecological zone)

		GPS Coordinates	
Ecological zones	Locations/villages	Latitude	Longitude
Guinea savannah	Ago Fulani (A 1)	8°49' and 8°47'N	3°40' and 3°43'E
	Budo Ago (A 2)	8°06' and 8°03'N	3°31' and 3°34'E
	Odo Ogun (A 3)	7°53' and 7°49'N	3°43' and 3°45'E
	Laagbe (A 4)	7°45' and 7°43'N	3°46' and 3°48'E
Rain forest	Olokemeji (B 1)	7°20' and 7°50'N	3°53' and 3°58'E
	Elekuro (B 2)	7°08' and 7°05'N	3°19' and 3°17'E
Swamp forest	Igahun (C 1)	6°42' and 6°38'N	3°23' and 3°20'E

Table 2. Analysis of variance (ANOVA) of seedling emergence in different land use types of ecological zones in Ogun River Watershed

Variables	SV	Df	SS	MS	F-cal	p-value
Seedling emergence	Ecozones	2	4,370,000	2,185,000	128,984.65	0.000*
	Land use	2	215,000	107,500	6,345.93	0.000*
	Ecozones×Land use	4	20,500	5,125	302.54	0.000*
	Error	4,391	74,400	16.94		
	Total	4,399	4,679,900			

*Significant at $p < 0.05$.

Table 3. Family distribution of plant species in the soil seed bank of various land use types along Ogun River Watershed

Family	Guinea savannah			Rain forest			Swamp forest		
	NF	DF	FL	NF	DF	FL	NF	DF	FL
Achanthaceae	1	1	-	1	1	-	2	2	2
Amaranthaceace	-	1	1	1	1	1	-	1	1
Annonaceae	1	1	-	-	-	-	-	-	-
Arecaceae	-	-	-	-	-	-	1	-	-
Asteraceae	-	2	3	1	3	3	-	2	2
Athyriaceae	1	1	1	-	-	-	-	-	-
Caesalpiniacea	-	1	1	1	1	1	2	1	1
Combretaceae	1	1	-	-	-	-	1	1	1
Commelinaceae	-	1	2	2	2	2	2	2	2
Compositae	-	1	1	-	1	1	-	1	1
Connaraceae	-	-	-	1	1	-	1	1	-
Cucurbituceae	1	2	1	1	2	1	1	1	1
Cyperaceae	1	1	1	-	1	1	1	1	-
Euphorbiaceae	2	4	2	2	4	2	3	5	3
Gnetaceae	1	1	-	1	1	-	-	1	1
Laminaceae	-	-	-	-	-	-	1	1	1
Leguminosae	2	2	-	4	3	2	1	1	-
Melastomatacea	1	1	1	1	1	1	1	1	1
Mimosaceae	1	1	1	1	1	1	-	-	-
Pandaceae	-	-	-	-	-	-	1	1	-
Passifloraceae	1	1	1	1	1	1	1	1	1
Phytolaccaceae	1	1	1	1	1	1	1	1	1
Piperaceae	-	1	1	1	1	1	-	1	1
Poaceae	2	4	4	2	5	5	2	5	4
Portulaceaea	1	1	1	-	-	-	-	1	1
Sapindaceae	1	1	-	1	1	-	-	-	-
Solanaceae	-	1	1	-	1	1	1	-	-
Taphorbiaceae	1	1	1	1	1	1	1	1	1
Tiliaceae	-	-	-	-	1	-	-	-	-
Urticaceae	-	-	-	1	1	1	-	-	-
Verbanaceae	-	1	1	-	-	-	1	-	-
Zingiberaceae	1	1	1	2	2	1	1	-	-

NF, natural forest; DF, disturbed forest; FL, farm land.

roots were carefully removed from the pooled soil samples and placed in individual 20 cm×30 cm×1 cm trays (contained 0.024 kg/ha). To prevent possible contamination of the samples, they were kept inside screen house which allowed free air and moisture exchange. To check for contamination, 10 trays with sterilized soil were used as control randomly among the experimental trays (Fig. 1).The trays were watered regularly in order to induce germination, and checked for seedlings emergence fortnightly for 18 months. Seedlings were identified and those that could not be identified were transplanted into a polythene pots to encourage further growth until identification was possible. The trays were monitored for 18 months to allow germination of persistent seeds after transient seeds might have germinated earlier.

Analysis of variance (ANOVA) was used to test for differences in seedling emergence among the three ecological zones and land use types with the use of 3×3 factorial experiments in Completely Randomized Design where the first factor was the three (3) ecological zones and the second factor was three (3) different land use types.

Shannon–Wiener diversity index (H') (Eqn. 1) and Sorensen's species similarity index (SI) (Eqn. 2) were used to analyze the data:

Shannon–Wiener diversity index (H')

$$H' = -\sum_{i=1}^{s} P_i \mathrm{Ln}(P_i) \quad (1)$$

Sorensen's species similarity index (SI) between any two sites was calculated using:

$$SI = \frac{2a}{a+b} \times 100 \quad (2)$$

Where:
a=number of species at sites a
b=number of species at sites b
c=number of species common to sites a and b

Results

Family distribution of plant species and Diversity Indices of Emerged Seedlings from the seed bank of various land use types along Ogun River Watershed after 18 months

There was significant difference in seedling emergence among ecological zones and land use types ($p<0.05$) (Table 2). A total of 4,400 seedlings emerged from the soil samples collected from the various land use types. All species were distributed among 32 families (Table 3). Farmland (FL) in the Rain Forest had the highest number of germinated seeds (705±37.33 seedlings) followed by DF in the Rain Forest (701±49.6 seedlings). The lowest seedling emergence was observed in NF of the Swamp forest (199±28.41 seedlings). Disturbed Forest in the Rain Forest had the highest number of species (34) distributed among 22 families while DF in the Guinea savannah had 32 distributed among 22 families. The lowest number of species (15) distributed among 13 families were found in NF of Guinea savannah (Table 4).

Table 4. Diversity indices of emerged seedlings from the seed bank of various land use types along Ogun River Watershed after 18 months

Ecological zones	Land use types	Number of seedlings	Number of species	Number of family
Guinea savannah	NF	235±23.1	15	13
	DF	592±36.7	32	22
	FL	670±27.01	28	20
Rain forest	NF	376±31.52	22	18
	DF	701±49.6	34	22
	FL	705±37.33	26	18
Swamp forest	NF	199±28.41	18	14
	DF	378±39.22	30	20
	FL	544±42.9	24	17

NF, natural forest; DF, disturbed forest; FL, farmland.

Table 5. Plant species composition in soil seed bank of Guinea Savannah along Ogun River Watershed

Species/growth habit	Family	Cumulative no of emerged seedlings		
		NF	DF	FL
Trees				
Albizia ferruginea (Guill. & Perr.) Benth	Leguminosae	9	2	-
Anogeissus leiocarpa (DC) Guill & Perr	Combretaceae	23	3	-
Cleistopholis patens (Benth) Engl. & Diel	Annonaceae	18	2	-
Daniellia oliveri (Rolfe) Hutch. & Dalziel	Leguminosae	21	2	-
Lecaniodiscus cupanioides Planch.ExBenth.	Sapindaceae	11	-	-
Shrubs				
Acanthus montanus (Nees) T. Anderson	Acanthaceae	9	7	-
Mallotus oppositifolius (Geiseler) Müll.Arg.	Euphorbiaceae	8	6	3
Securrinega virosa (Roxb.) Baill.	Euphorbiaceae	11	12	-
Herbs				
Ageratum conyzoides L.	Asteraceae	-	23	34
Amaranthus spp L.	Amaranthaceace	-	24	11
Andropogon spp L.	Poacea	8	56	78
Aspilia africana (Pers.) C. D. Adams	Asteraceae	-	42	46
Bruchiaria lata (Schumach.) C.E.Hubb.	Poaceae	-	30	14
Centrosema spp (DC.) Benth.	Leguminosae	-	10	8
Chromolaena odorata (L.) R.M. King & H.	Asteraceae	-	60	94
Commelina prostate H & H	Commlinaceae	-	10	11
Costus afer L.	Zingiberaceae	11	9	9
Cyprus difformis L.	Cyperaceae	10	10	9
Diplazium Sammath (Kuhn.) C. Chr.	Athyriaceae	9	9	11
Eleusine indica (L.) Gaertn.	Poaceae	-	8	14
Euphorbia hirta L.	Euphorbiaceae	-	10	12
Euphorbia hypossifolia L.	Euphorbiaceae	-	7	8
Heterotis rotundifolia (Sm.) Jacq.-Fél.	Melastomatacea	9	8	6
Mimosa pudica L.	Mimosaceae	-	7	8
Panicum maximum Jacq.	Poaceae	6	26	33
Passiflora foetida L.	Passifloraceae	11	9	13
Perperomia pellucida (L.) HBK.	Piperaceae	-	8	6
Petiveria alliacea L.	Phytolaccaceae	8	7	5
Phyllantus amarus Schum. & Thonn.	Euphorbiaceae	12	14	28
Physalis micrantha L.	Solanaceae	-	28	11
Portulaca olerecea L.	Portulaceaea	6	30	10
Polisota hirsute (Thunb.) K Schum.	Commelinaceae	-	43	46
Stachytarpleta cayennensis (Rich.) Vahl	Verbenaceae	-	13	29
Tridax procumbens L.	Asteraceae	-	35	104
Climbers				
Gnetum africanum Welw.	Gnetaceae	17	6	-
Luffa cylindrical (Linn) Mj Roem.	Cucurbitaceae	-	5	-
Momordica charantia L.	Cucurbituceae	18	11	9

NF, natural forest; DF, disturbed forest; FL, farm land.

Table 6. Plant species composition in soil seed bank of Rainforest along Ogun River Watershed

Species/growth habit	Family	Cumulative no of emerged seedlings		
		NF	DF	FL
Trees				
Albizia lebbeck (Guill. & Perr.) Benth	Leguminosae	13	3	1
Brachystegia nigerica Hoyle &A.P.D. Jones.	Leguminosae	7	-	-
Cassia siamea Lam	Leguminosae	8	2	-
Lecaniodiscus cupanioides Planch.Ex Benth.	Sapindaceae	11	4	-
Piptadeniastrum africanum (Hook.f.) Brenan.	Leguminosae	38	7	1
Shrubs				
Acanthus montanus (Nees) T. Anderson	Acanthaceae	11	7	-
Alchornea cordifolia (Schum and Thonn) Muell. Arg.	Euphorbiaceae	21	10	-
Cnestis ferruginea Vahl ex DC.	Connaraceae	12	7	-
Glyphaea brevis	Tiliaceae	-	9	-
Mallotus oppositifolius (Spreng.) Monachino	Euphorbiaceae	-	4	-
Herbs				
Aframomum spp L	Zingiberaceae	16	11	-
Ageratum conyzoides L	Asteraceae	11	19	25
Amaranthus spp L.	Amaranthaceace	8	6	16
Andropogon spp L.	Poacea	-	61	63
Aspilia africana (Pers.) C. D. Adams	Asteraceae	-	54	60
Axonopus compressus (Sw.) P.Beauv.	Poaceae	8	11	9
Brachiaria lata (Schumach.) C.E.Hubb.	Poaceae	-	25	18
Centrosema spp (DC.) Benth.	Leguminosae	13	15	8
Chromolaena odorata (L.) R.M. King & H.	Asteraceae	-	59	73
Commelina prostate H & H	Commelinaceae	7	13	14
Costus afer L.	Zingiberaceae	13	10	11
Cyprus difformis L.	Cyperaceae	-	9	11
Eleusine indica (L.) Gaertn.	Poaceae	-	7	12
Euphorbia hirta L.	Euphorbiaceae	9	10	17
Euphorbia hypossifolia L.	Euphorbiaceae	-	9	13
Heterotis rotundifolia (Sm.) Jacq.-Fél.	Melastomatacea	11	12	14
Larportiea ovalifolia	Urticaceae	10	14	7
Mimosa pudica L.	Mimosaceae	24	13	14
Panicum maximum Jacq.	Poaceae	6	56	52
Passiflora foetida L.	Passifloraceae	11	8	12
Perperomia pellucid (L.) HBK.	Piperaceae	15	11	8
Petiveria alliacea L.	Phytolaccaceae	26	66	54
Phyllantus amarus Schum. & Thonn.	Euphorbiaceae	19	20	30
Physalis micrantha L.	Solanaceae	-	31	13
Palisota hirsute (Thunb.) K Schum.	Commelinaceae	17	13	11
Tridax procumbens L.	Asteraceae	-	56	121
Climbers				
Gnetum africanum Welw.	Gnetaceae	20	8	-
Luffa cylindrical (Linn) Mj Roem.	Cucurbitaceae	-	5	-
Momordica charantia L.	Cucurbituceae	25	20	13

NF, natural forest; DF, disturbed forest; FL, farm land.

Plant species composition in soil seed bank of Guinea Savannah along Ogun River Watershed

Seedlings emergence in Guinea Savannah revealed that *Tridax procumbens* which was not present in NF had the highest emerged seedlings of 104, *Chromolaena odorata* had 94 ssedlings and *Andropogon* sp had 76 seedlings all in FL. Trees, shrubs and climbers with highest cumulative number of emerged seedlings were found in NF and DF. They included *Anogeissus leiocarpus* (23 seedlings),

Table 7. Plant species composition in soil seed bank of Swamp forest along Ogun River Watershed

Species/growth habit	Family	Cumulative no of emerged seedlings		
		NF	DF	FL
Trees				
Anthonotha macrophylla	Caesalpiniacea	1	-	-
Avicennia africana	Achanthaceae	9	2	1
Brachystegia nigerica Hoyle &A.P.D. Jones.	Leguminosae	4	1	-
Laguncularia racemosa	Combretaceae	7	2	1
Shrubs				
Alchornea cordifolia	Euphorbiaceae	13	8	-
Cnestis ferruginea	Connaraceae	17	9	-
Mallotus oppositifolius	Euphorbiaceae	-	7	2
Microdesmis puberula	Pandaceae	5	5	-
Securrinega virosa	Euphorbiaceae	-	5	-
Herbs				
Acanthus montanus	Acanthaceae	10	13	7
Acroceras zizaniodes	Poaceae	7	9	9
Ageratum conyzoides L	Asteraceae	-	22	12
Amaranthus spp L	Amaranthaceace	-	19	14
Andropogon spp L	Poacea	-	17	12
Axonopus compressus	Poaceae	-	28	16
Brachiaria deflexa	Poaceae	13	13	-
Centrosema spp (DC.) Benth.	Leguminosae	4	24	12
Chromolaena odorata (L.) R.M. King & H.	Asteraceae	-	56	54
Commelina prostate H & H	Commelinaceae	5	11	11
Cyprus difformis	Cyperaceae	-	9	-
Euphorbia hirta L.	Euphorbiaceae	3	14	13
Euphorbia hypossifolia L.	Euphorbiaceae	7	8	7
Hyptis lanceolata	Lamiaceae	13	8	6
Heterotis rotundifolia	Melastomatacea	11	35	23
Panicum maximum Jacq.	Poaceae	-	55	41
Passiflora foetida L.	Passifloraceae	11	13	10
Perperomia pellucida (L.) HBK.	Piperaceae	-	12	9
Petiveria alliacea L.	Phytolaccaceae	6	10	8
Phyllantus amarus Schum. & Thonn.	Euphorbiaceae	10	29	38
Portulaca olerecea L.	Portulaceaea	-	38	25
Polisota hirsute (Thunb.) K Schum.	Commelinaceae	15	16	12
Tridax procumbens L	Asteraceae	-	28	29
Climbers				
Calamus deerratus	Arecaceae	-	-	-
Gnetum africanum Welw.	Gnetaceae	13	8	2
Momordica charantia L	Cucurbituceae	15	10	4

NF, natural forest; DF, disturbed forest; FL, farm land.

Securrinega virosa (11 seedlings) and *Momordica charantia* (18 seedlings) respectively (Table 5).

Plant species composition in soil seed bank of Rainforest along Ogun River Watershed

Herbs dominated the soil seed bank of NF, DF and FL in the Rain Forest. *Tridax procumbens* had the highest cumulative number of emerged seedlings of 121 while *Chromolaena odorata* had 76, *Petiveria alliacea* 66, *Andropogon* sp 63, and *Aspilia africana* 60 all in FL. Some species such as *Andropogon* sp, *Aspilia africana*, *Brachiaria lata*, *Chromolaena odorata*, *Cyprus difformis*, *Eleusine indica* and *Tridax procumbens* were found in DF and FL but not in NF (Table 6).

Plant species composition in soil seed bank of Swamp Forest along Ogun River Watershed

The tree species; *Avicennia africana* had highest cumulative number of emerged seedlings of 9, *Laguncularia racemosa* had 7 in NF of Swamp Forest of Ogun River Watershed. Shrubs emergence consisted of *Cnestis ferruginea* with highest cumulative number of emerged seedlings of 17 while *Alchornea cordifolia* had 13 in NF. *Chromolaena odorata* was absent in NF but had highest cumulative number of emerged seedlings of 56. *Panicum maximum* had 55 in DF. The climber with highest cumulative number of emerged seedlings was *Momordica charantia* (15) in NF while *Gnetum africanum* had13 in DF (Table 7).

Similarity indices for seedlings emerging from soil seed bank of various land use types along Ogun River Watershed

The similarity varied from 0.50 to 0.66 for land use types and 0.70 to 0.82 for the ecological zones. DF and FL had high similarity index of 0.66 while NF and DF had 0.54. The lowest was between NF and FL (0.50). Guinea savannah and Swamp forest ecological zones had highest similarity indices of (0.82), Guinea savannah and Rain forest (0.75) and Rain forest and Swamp forest (0.70) (Tables 8, 9).

Discussion

The process of the regeneration of a forest community is completed with the establishment of seedlings, which is usually the most important phase in terms of survival (Thompson 2000). Close relationship between the relative proportion of sprouted seedlings in the soil seed bank and the species composition of the ground flora of the watershed was observed with little relationship between tree species composition. More seedlings of herbs were observed than that of tree species most especially in the disturbed areas. This is in line with findings of Oyelowo (2014) who reported emergence of more seedlings of herbs than trees in Osun river watershed. This could be ascribed to ecosystem disturbances as closer relationships between seedlings from soil seed bank and the vegetation can be relatively found in an undisturbed plant communities (Oke et al. 2006). In all the land use types of the three ecological zones, herbs, shrubs and climbers dominated the seedling emergence. This could be ascribed to the fact that many of tree species seeds, most especially in the tropics are recalcitrant and those that are orthodox can be easily attacked by the pest and diseases in the soils seed bank and thus affect their germination. According to Thompson (2000), many species present in the vegetation may be absent from the soil seed bank even in plant communities with a long history of stable species composition.

However, the cumulative number of emerged seedlings in the NF of the study area was generally with more of tree

Table 8. Similarity indices for seedlings emerged from soil seed bank of various land use types along Ogun River Watershed

	NF	DF	FL
NF	1		
DF	0.54	1	
FL	0.50	0.66	1

NF, natural forest; DF, disturbed forest; FL, farm land.

Table 9. Similarity indices for seedlings emerged from soil seed bank of ecological zones in Ogun River Watershed

	GS	RF	SF
GS	1		
RF	0.75	1	
SF	0.82	0.70	1

GS, Guinea Savannah; RF, Rain forest; SF, Swamp forest.

species than herbs such as *Tridax procumbens*, *Chromolaena odorata* and *Andropogon* spp that were predominant in FL and DF. This could be attributed to the fact that grasses and other herbaceous plants that have potentials to produce many seeds can colonize disturbed plants community at fast rate (Thompson 2000). According to Abuelbashar et al. (2022) a disturbed plant community could reflects poor regeneration status of the forest with low natural regeneration of parent trees reflects. This also corroborates the findings of Bossuyt and Hermy (2001), that emergence of herbaceous plants from seed bank from degraded temperate forest ecosystems was triggered by forest disturbances. The disturbances effect was evident in the emerged herbaceous plants seedlings observed in the seed bank of DF and FL and is in accordance with previous studies which have shown that the size and diversity of seed banks depend not on the diversity of aboveground vegetation but on the disturbance regime to which a forest community is subjected (Leckie et al. 2000; Rogers and Hartnett 2001).

These therefore imply that for sustainable forest and watershed management, soil disturbance should be minimized to avoid invasion by herbs such as *Chromolaena odorata*, *Andropogon* spp, *Cyprus difformis*, *Eleusine indica*, *Tridax procumbens* and other secondary colonizers which are indicative of forest disturbances.

Conclusion

The Investigation on natural regeneration potential of the soil seed bank of land use types in ecosystems of Ogun river watershed has provided essential information towards its sustainable management. Seedlings emergence from soil seed bank of NF in Ogun River watershed was generally with more of tree species than herbs that were predominant in FL and DF. This reveals closer relationship between seedlings from seed bank of undisturbed plant community than disturbed community which encourages invasive life forms.

References

Abuelbashar AI, Dafa-Alla Ahmed DAM, Siddig AAH, Yagoub YE, Gibreel HH. 2022. Analysis of Composition and Diversity of Natural Regeneration of Woody Species in Jebel El Gerrie Dry Land Forest East of Blue Nile State, Sudan. J For Environ Sci 38: 90-101.

Asinwa IO, Olajuyigbe SO, Aderounmu AF, Iroko OA, Kazeem-Ibrahim F. 2021. Variation in Soil Physico-Chemical Properties in Three Land Use Types of Ogun River Watershed. Tanzan J For Nat Conserv 90: 18-29.

Asinwa IO, Olajuyigbe SO. 2019. Water quality modification by land use types in watershed ecosystems of Southwestern Nigeria. Eurasia J Biosci 13: 1343-1351.

Awoniran DR, Adewole MB, Salami AT. 2011. Wetland Conversion and Fragmentation Pattern with its Impacts on Soil in the Lower Ogun River Basin. Ife Res Publ Geogr 10: 125-134.

Berga L, Buil JM, Bofill E, De Cea JC, Garcia Perez JA, Mañueco G, Polimon J, Soriano A, Yagüe J. 2006. Dams and Reservoirs, Societies and Environment in the 21st Century: 22nd International Congress on Large Dams (ICOLD), Barcelona, Spain, 18 June 2006. CRC Press, Boca Raton, FL, 314 pp.

Bhattacharya AK, Bolaji GA. 2010. Fluid flow interactions in Ogun River, Nigeria. Int J Res Rev Appl Sci 2: 173-180.

Bossuyt B, Hermy M. 2001. Influence of land use history on seed banks in European temperate forest ecosystems: a review. Ecography 24: 225-238.

Di HJ, Cameron KC, Bidwell VJ, Morgan MJ, Hanson C. 2005. A pilot regional scale model of land use impacts on groundwater quality. Manag Environ Qual 16: 220-234.

Food and Agriculture Organization (FAO). 2012. State of the World's Forests 2012. FAO, Rome, 46 pp.

Gutman G, Janetos AC, Justice CO, Moran EF, Mustard JF, Rindfuss RR, Skole D, Turner BL, Cochrane MA. 2004. Land Change Science: Observing, Monitoring and Understanding Trajectories of Change on the Earth's Surface. Springer Science+Business Media, Dordrecht.

Huber UM, Bugmann HKM, Reasoner MA. 2005. Global Change and Mountain Regions: An Overview of Current Knowledge. Springer Science+Business Media, Dordrecht, pp 73-104.

Ikenweiwe NB, Otubusin SO, Oyatogun MOO. 2007. Fisheries of Oyan Lake, south west Nigeria and potential for ecotourism development. Eur J Sci Res 16: 183-192.

Jaji MO, Bamgbose O, Odukoya OO, Arowolo TA. 2007. Water quality assessment of Ogun River, South West Nigeria. Environ Monit Assess 133: 473-482.

Kim JH, Yang HM, Jin GZ, Lee WS, Kang SK. 2001. The Aspect of Natural Regeneration for Major Tree Species in the Natural Deciduous Forest. J For Sci Kangwon Natl Univ 17: 1-17.

Lambin E, Geist H. 2007. Causes of Land-use and Land-cover Change. http://editors.eol.org/eoearth/wiki/Causes_of_land-use_and_land-cover_change. Accessed 25 Jan 2022.

Leckie S, Vellend M, Bell G, Waterway MJ, Lechowicz MJ. 2000. The seed bank in an old-growth, temperate deciduous forest.

Can J Bot 78: 181-192.

Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-Being: Policy Responses, Volume 3. Island Press, Washington, DC, 29 pp.

Oke SO, Oladipo OT, Isichei AO. 2006. Seed Bank Dynamics and Regeneration in a Secondary Lowland Rainforest in Nigeria. Int J Bot 2: 363-371.

Oyelowo OJ. 2014. Floristic composition, soil nutrients status and regeneration potentials of selected sacred groves in rainforest zone of southwest Nigeria. thesis. Federal University of Agriculture, Abeokuta, Nigeria. (in English)

Rogers WE, Hartnett DC. 2001. Temporal vegetation dynamics and recolonization mechanisms on different-sized soil disturbances in tallgrass prairie. Am J Bot 88: 1634-1642.

Simard DG, Fyles JW, Paré D, Nguyen T. 2001. Impacts of clear-cut harvesting and wildfire on soil nutrient status in the Quebec boreal forest. Can J Soil Sci 81: 229-237.

Thompson K. 1993. Persistence in soil. In: Methods in Comparative Plant Ecology (Hendry GAF, Grime JP, eds). Chapman and Hall, London, pp 199-202.

Thompson K. 2000. The functional ecology of soil seed banks. In: Seeds: The Ecology of Regeneration in Plant Communities. (Fenner M, ed). 2nd ed. CABI Publishing, New York, pp 215-235.

Tong STY, Chen W. 2002. Modeling the relationship between land use and surface water quality. J Environ Manag 66: 377-393.

United Nations Development Programme (UNDP). United Nations Development Programme Annual Report 2009. UNDP, New York, NY, pp 27.