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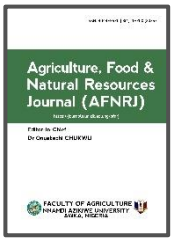

Original Article

Natural regeneration potential of the soil seed bank of different land use types in swamp forest of Ogun river watershed, Nigeria

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ABSTRACT

Unsustainable land uses are a major indicator of human activities that contribute to land degradation, a menace that inhibits the regeneration of forest estates. This study, therefore, investigated the effects of land use practices on regeneration potentials of the Swamp Forest of the Ogun River Watershed (ORW) with a view to providing baseline information towards sustainable watershed management. The swamp forest of ORW was stratified into Natural Forest (NF), Disturbed Forest (DF), and Farm Land (FL) for natural regeneration assessment of the soil seed bank. Two systematic line transects of 1000 m length were used in the laying of the sample plots. Sample plots of 25 m x 25 m were established in alternate positions along the transects. Ten plots in each land use type were randomly selected for soil core samples collection. The soil samples were placed in individual 20 cm × 30 cm × 1 cm containers in a screen house. The trays were watered regularly to induce germination, and seedlings were checked for emergence fortnightly for 18 months. Descriptive statistics were used to analyze the data. A total of 1,121 seedlings distributed among 26 families emerged from the soil of various land use types. The FL had the highest number of germinated seeds (544±42.9 seedlings), which were mostly invasive herbaceous plants, followed by DF (378±39.22 seedlings) with similar invasive species. The NF with 199±28.41 seedlings had more tree species, similar to the aboveground tree species of the study area. More invasive herbaceous plants dominated FL and DF compared to NF, which had more tree seedlings from the seed bank in relation to aboveground tree species.

KEYWORDS: *Degradation, Persistent seeds, Regeneration, Soil seed bank*

INTRODUCTION

Land comprises all physical features endowed by nature on a specific area. These components of land include the environment, fields, forests, minerals, climate, animals, and bodies/sources of water (Awomeso *et al*., 2012). Consequent on different forms of the land, the use to which a piece of land is put varies and forms Land use types. Categorically, humans as advance creatures compared to other creatures make use of land under different classes/types such as residential (housing), Institutional (Schools) commercial (businesses), industrial (manufacturing), agricultural (farming), recreational (parks), transportation (roads), and sometimes including natural areas like forests and wetlands, each with distinct characteristics based on their primary function (Enwelu *et al*., 2010; Awomeso *et al*., 2012). By and large, the upsurge in human population and the craving to meet their unlimited demands for better living led to greater impacts on the land-use management practices and the environment generally. Land-use is one of the conspicuous indicators of human activities that contribute to land

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degradation via activities such as illicit logging, irrational deforestation, overgrazing, farming, and urbanization, among others (Zhang *et al.*, 2013). The menace of deforestation emanating from the subjection of lands to different uses has led to the disruption of several ecosystems, including the inclusiveness of the Ogun River watershed (ORW) with disturbed natural regeneration potentials (Asinwa *et al*., 2018).

A watershed is an area of land that feeds all the water running under it and drains off into a larger body of water. The watershed joins with other watersheds to become a network of rivers and streams that progressively flow into larger water bodies (USEPA, 2003). It provides many ecosystem services such as enhancement of nutrient cycling, carbon storage, erosion control, wildlife movement corridors, water storage, water filtration, flood control, Food, timber, recreation, among others. These goods and services are essential to social, environmental, and economic well-being, which have attracted pressure and diminished the values of the watershed ecosystem (Esenowo & Ugwunba, 2010)

Larger percentages of Nigeria's forest landscape and watershed have been experiencing land degradation. It varies from place to place in terms of the types, duration, severity, and socio-economic impact (Asinwa *et al*., 2018). This degradation results from the interaction of physiographic features, climate, and poor land use activities. Watershed degradation, in turn, leads to accelerated ecological degeneration, reduction in economic opportunities, and increased social problems (Steffen *et al.*, 2015). There has been a global concern for the degradation of the world's environment, especially in the current century, and this has become one of the major threats to human existence, most especially as Land use changes affect watershed landscape patterns, ecosystem functions, and climate dynamics. This, therefore, necessitated the investigation of the natural regeneration potential of the soil seed bank of ORW as one of the vulnerable watersheds in Southwestern Nigeria with a view to providing essential information towards its sustainable management.

Soil seed banks, as natural storage of seeds of plants, play vital roles in the maintenance and regeneration of the watershed. It has been considered an important factor in the regeneration of most ecosystems (Asinwa, 2024). Yet, the effects of riparian forest disturbances and fragmentation on forest seed banks remain poorly understood. 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 (Steffen *et al.*, 2015). Investigation of the effects of land use practices on the regeneration potentials of the watershed is therefore pertinent for the provision of baseline data that will be useful for policy makers and stakeholders to formulate policies that will favour the protection and management of the watershed.

MATERIALS AND METHOD

The study area

The study was carried out in *Igahun*, a swamp forest portion of the Ogun River in the Southwestern part of Nigeria, between latitudes 8º 41' N and 9º 10' N and longitudes 3º 28' E and 4º 8' E. 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 southwards over a distance of about 480 km before discharging into the Lagos Lagoon. Its major tributaries are the Ofiki and Opeki rivers (Amartya & Akin-Bolaji, 2010)

There are two seasons, a dry season (from November to March) and a wet season (from April to 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 1600 and 1900 mm (Ikenweirwe *et al*., 2007). The river traversed through three major vegetation zones, which 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 at 6º 42' and 6º 38 'N to 3º 23' and 3º 20' E, where the study was carried out (Figure 1)

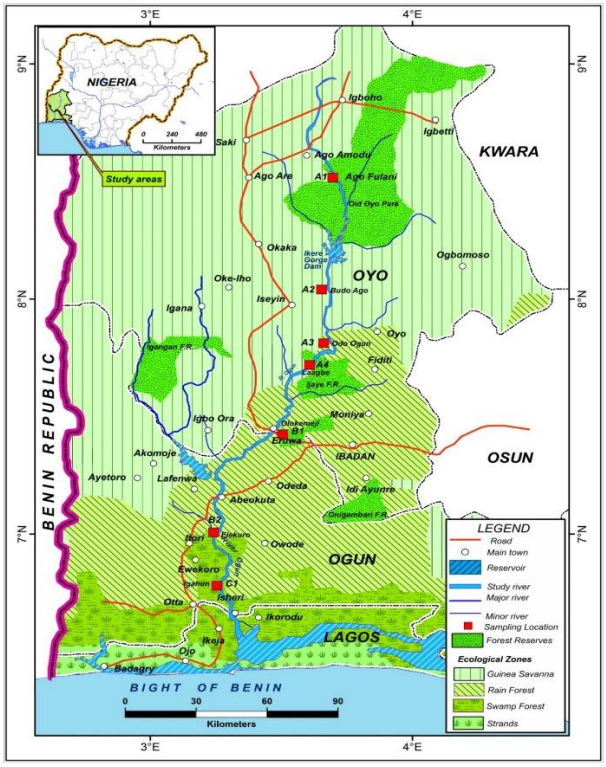

Fig. 1: Map of the study area showing study locations.

Sampling procedure

Having considered activities on the land cover, the watershed of the swamp forest was stratified into Natural Forest (NF: relatively less disturbed forest), Disturbed Forest (DF), and Farm land (FL) for assessment of natural regeneration of soil seed bank. Systematic line transects, as adopted from Olajuyigbe & Adaja (2014), were used in the laying of the sample plots along the river. A setback of 10 m from the riverbank was measured, and then two transects of 1000 m in length parallel to each other on either side of the river were laid. Then, sample plots of 25m x 25 m were established in alternate positions along the two transects at 100 m intervals (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 x 1 m quadrats were randomly laid for soil core sampling. 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 an equivalent of 0.006 kg/ha). The core samples (10) were pooled per plot in each land use type as described by Olajuyigbe & Adaja 2014).

Method of data collection

Rhizomes and roots were carefully removed from the pooled soil samples and placed in individual 20 cm × 30cm × 1 cm trays (containing 0.024 kg/ha). To prevent possible contamination of the samples, they were kept inside a screen house, which allowed free air and moisture exchange. To check for contamination, 10 trays with sterilized soil were used as a control randomly among the experimental trays. The trays were watered regularly to induce germination, and checked for seedlings emergence fortnightly for 18 months, to allow germination of persistent seeds. Seedlings were identified, and those that could not be identified were transplanted into polythene pots to encourage further growth until identification was possible. Data were analyzed using descriptive statistics, which included cross-tabulation, percentages, and frequency distribution.

RESULTS AND DISCUSSION

A total of 1,121 seedlings emerged from the soil samples collected from the various land use types (Table 1). All species were distributed among 26 families (Table 2). Farmland (FL) had the highest number of germinated seeds (544±42.9 seedlings), followed by DF (378±39.22 seedlings). The lowest seedling emergence was observed in NF (199±28.41 seedlings) (Table 1). Disturbed Forest had the highest number of species (30) distributed among 20 families, followed by FL (24) distributed among 17 families. The lowest number of species (18) distributed among 14 families was found in NF (Table 1). According to Esmailzadeh *et al* (2011), disturbed or deforested land areas are characterized by altered soil properties and increased light availability for the growth of alien plants with little or no competition from native plants. Thus, it enhances ideal conditions for invasive weeds to be established. This could be the reason why more grasses and herbs dominate the Farmland, knowing fully well that invasive plants have high seed production and an effective dispersal mechanism. On the other hand, NF had the lowest seedling emergence of mostly tree species because the growth of alien plants was inhibited due to more competition with native plants that have closed canopies. The forests have limited sunlight, peculiar soil conditions, and established indigenous species that make it difficult for invasive plants (Alberdi *et al*., 2019). This is in line with the findings of Oyelowo (2014), who reported the emergence of more seedlings of herbs than trees in the disturbed area of the Osun River watershed. According to Thompson (2000), the regeneration of a plant community in an ecosystem is incomplete without the establishment of seedlings as a very crucial phase in terms of survival. The findings from the study show that there were more similarities between sprouted seedlings in the soil seed bank and the species composition of the ground flora of the watershed in the FL and DF which depicts This conforms to the findings of Esmailzadeh *et al*. (2011) who reported that the presence of a species in the above-ground vegetation does not ensure that a seed bank will also contain the species. Esmailzadeh *et al*. (2011) also found that approximately 55 % of the taxa found in the vegetation did not occur in the persistent soil seed bank of the Sub-Mediterranean Oak Forests in Northwestern Greece. On the other hand, 43 % of the soil seed bank taxa were not found in the above-ground vegetation, which could be ascribed to forest disturbances. This confirms the assertion of Chaideftou *et al*. (2009) that there could be low similarity between above-ground vegetation and persistent soil seed bank floras in forest ecosystems and that the above-ground vegetation might not necessarily reflect the soil seed bank composition due to forest exploitation. Further to this, Thompson (2000) also affirmed that even in plant communities with a long history of stable species composition, it is well known that many species present in the vegetation may be absent from the soil seed bank.

Table 1: Characteristics Emerged Seedlings from the seed bank of various land use types at ORW after 18 months

Land Use Types	Number of Seedlings	Number of Species	Number of families
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

Seedlings' emergence revealed that *Chromolaena odorata,* which was not present in NF, had the highest density of 56, followed by *Panicum maximum* (54) and *Portulaca oleracea* (38), all in DF. Tree species: *Avicennia africana* had the highest density of (9), followed by *Laguncularia racemosa* (7) in NF. Shrubs' emergence consisted of *Cnestis ferruginea* with the highest density of (17), followed by *Alchornea cordifolia* (13) in NF. The climber with the highest density was *Momordica charantia* (15) in NF, followed by *Gnetum africanum* (13) in DF (Table 3).

Table 2: Family distribution of plant species in the Soil Seed bank of various land use types at the ORW

Family	Land Use Types		
	NF	DF	FL
Achanthaceae	2	2	2
Amaranthaceace	-	1	1
Arecaceae	1	-	-
Asteraceae	-	2	2
Caesalpiniacea	2	1	1
Combretaceae	1	1	1
Commelinaceae	2	2	2
Compositae	-	1	1
Connaraceae	1	1	-
Cucurbituceae	1	1	1
Cyperaceae	1	1	-
Euphorbiaceae	3	5	3
Gnetaceae	-	1	1
Laminaceae	1	1	1
Leguminosae	1	1	-
Melastomatacea	1	1	1
Pandaceae	1	1	-
Passifloraceae	1	1	1
Phytolaccaceae	1	1	1
Piperaceae	-	1	1
Poaceae	2	5	4
Portulaceaea	-	1	1
Solanaceae	1	-	-
Taphorbiaceae	1	1	1
Verbanaceae	1	-	-
Zingiberaceae	1	-	-

NF = Natural Forest, DF = Disturbed Forest, FL = Farm Land

The emergence of more tree species than herbs, such as *Chromolaena odorata*, *Panicum maximum*, and *Portulaca oleracea*, that were predominant in FL and DF, could be attributed to the fact that grasses and other herbaceous plants that have the potential to produce many seeds usually colonize disturbed plant communities (Thompson, 2000).

Seedlings' emergence ended in NF, DF, and FL at 62nd, 48th, and 52nd week, respectively Figure 2. The highest seedling emergence was at the 12th week in NF (54 seedlings), 4th week in DF (116 seedlings), and FL (105 seedlings) (Figure 2). This implies that the life span of the seed plays a significant role in the process of regeneration. This was evident in the emergent seedlings in the NF that lasted for 62 weeks, compared to those of DF, where emergence ended at the 48th week. Leckie *et al.* (2000) reported a relatively good representation of late successional forest species in the seed bank, which shows the potential significance of the seed bank in community regeneration. More seedlings emergence observed in the seed bank of DF and FL could be therefore be ascribed to disturbances of the two land use types and is in accordance with previous studies which have shown that the numbers of seed banks emergence depend not on the diversity of aboveground vegetation but subjective to the level of disturbances/degradation of the forest landscape (Asinwa & Olajuyigbe, 2022). Consequent upon this, degradation of the forest ecosystem through various degrees of human interference hinders the natural regeneration potential of the forest community and thus perturbs the sustainable forest and watershed management.

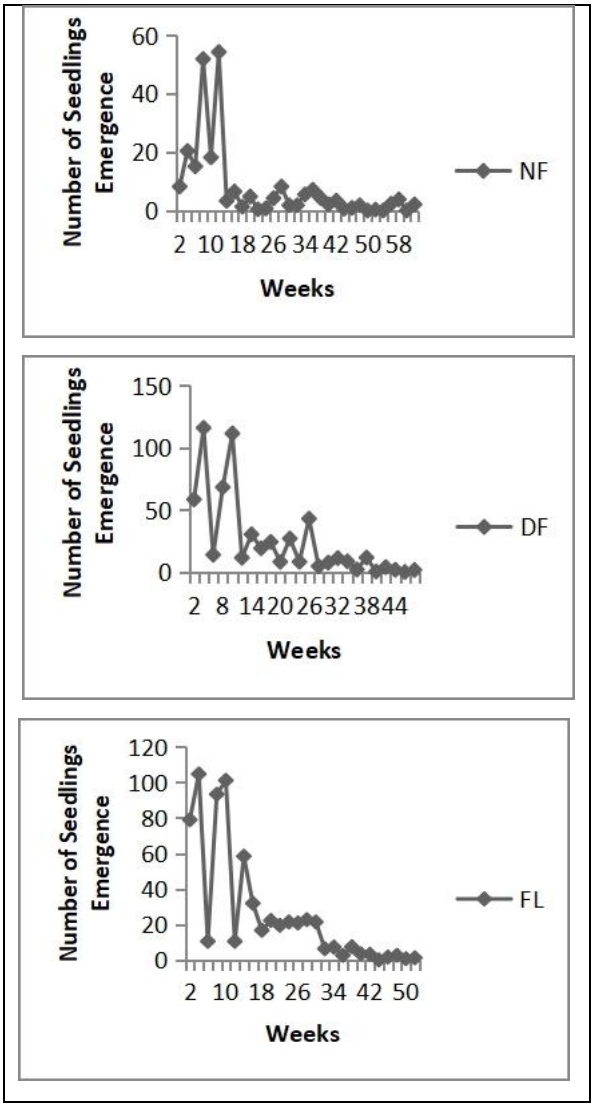

Figure 2: Fortnightly Seedlings Emergence from the Soil Seed Bank of the Swamp Forest of ORW.
(NF = Natural Forest, DF = Disturbed Forest, FL = Farmland)

Table 3: Plant species composition in the Soil Seed Bank of the Swamp Forest along the ORW

Species/ Growth Habit	Family	Cumulative Density		
		NF	DF	FL
Trees				
Anthonotha macrophylla	Caesalpiniacea	1	-	-
Avicennia africana	Achanthaceae	9	2	1
Brachystegia nigerica	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	Asteraceae	-	22	12
Amaranthus spp	Amaranthaceace	-	19	14
Andropogon spp	Poacea	-	17	12
Axonopus compressus	Poaceae	-	28	16
Brachiaria deflexa	Poaceae	13	13	-
Centrosema spp	Leguminosae	4	24	12
Chromolaena odorata	Asteraceae	-	56	54
Commelina prostrate	Commelinaceae	5	11	11
Cyprus difformis	Cyperaceae	-	9	-
Euphorbia hirta	Euphorbiaceae	3	14	13
Euphorbia hypossifolia	Euphorbiaceae	7	8	7
Hyptis lanceolata	Lamiaceae	13	8	6
Heterotis rotundifolia	Melastomatacea	11	35	23
Panicum maximum	Poaceae	-	55	41
Passiflora foetida	Passifloraceae	11	13	10
Perperomia pellucida	Piperaceae	-	12	9
Petiveria alliacea	Phytolaccaceae	6	10	8
Phyllantus amarus	Euphorbiaceae	10	29	38
Portulaca olerecea	Portulaceaea	-	38	25
Polisota hirsute	Commelinaceae	15	16	12
Tridax procumbense	Asteraceae	-	28	29
Climbers				
Calamus deerratus	Arecaceae	-	-	-
Gnetum africanum	Gnetaceae	13	8	2
Momordica charantia	Cucurbituceae	15	10	4

NF = Natural Forest, DF = Disturbed Forest, FL = Farm Land

CONCLUSION AND RECOMMENDATIONS

The study reveals that the use to which a particular land is put dictates its natural regeneration potential, as shown in the analysis of the soil seed bank of the swamp forest of the Ogun River Watershed. More invasive herbaceous plants dominated the Disturbed and Farmland compared to the undisturbed forest, which had more tree seedlings from the seed bank relating closely to aboveground tree species. It is therefore recommended that indiscriminate tree exploitation for timber, poles, and charcoal production be discouraged. There should be proper orientation for watershed dependents on the need to plant trees and adopt agroforestry practices.

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Author's Contribution
The study and write up done by IOA

Ethical Statement
Not applicable

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