Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 6, No. 4, p. 166-176, 2015
http://www.innspub.net

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RESEARCH PAPER OPEN ACCESS

Natural regeneration potential of key livelihood tree species under different land use types within Omo Biosphere Reserve, Nigeria

Chima Uzoma Darlington[1*], Adedire Moses Oladepo[2], Omokhua, Godwin Ejakhe[1]

[1]*Department of Forestry and Wildlife Management, University of Port Harcourt, Nigeria*

[2] *Department of Forestry and Wildlife Management, Federal University of Agriculture, Abeokuta, Nigeria*

Article published on April 21, 2015

Key words: Land use change, Tree species, Livelihoods, Regeneration, Omo.

Abstract

Impact of land use change on the natural regeneration potential of key livelihood tree species in Omo biosphere reserve was examined by evaluating soil seed banks under the Strict Nature Reserve (SNR); three chronosequences of arable farmland – AF_1, AF_2 and AF_3, reflecting short, medium, and long period of cultivation respectively; *Nuclea diderrichii* Plantation (NDP), *Gmelina arborea* Plantation (GAP); *Tectona grandis* Plantation (TGP); *Pinus caribaea* Plantation (PCP); and *Theobroma cacao* Plantation (CP). Similarity in key livelihood tree species from the seed banks was zero between the SNR and each of the introduced land use types except with NDP (66.67%) which is an indigenous species. Diversity of the key livelihood tree seedlings was highest in SNR (Simpson 1-D = 0.625; Shannon H = 1.04), followed by NDP (Simpson 1-D = 0.2449; Shannon H = 0.4101) and TGP (Simpson 1-D = 0.142; Shannon H = 0.2712); and zero in GAP, CP, PCP, AF_1, AF_2, and AF_3. Although the diversity of the key livelihood tree species was higher in the SNR than the introduced land use types, the low diversity indices in all the land use types including the SNR suggest that they probably regenerate through other means like seed rain, seedling bank, coppicing, and seed dispersal. The conservation of surviving stands and artificial regeneration in areas where the key livelihood tree populations have diminished was suggested.

*Corresponding Author: Chima Uzoma Darlington ✉ uzoma.chima@uniport.edu.ng

Introduction

Forests provide both tangible goods and intangible services that contribute to the wellbeing of humans both in the urban and rural areas. The use of forest ecosystems by people to support livelihoods has long been recognised (Pearson, 1937, Whitford, 1923). A reasonable percentage of the World's poor depend directly or indirectly on forests for their livelihoods. In Sub-Saharan Africa, forest goods and services are extremely important for rural livelihoods, providing food, medicine, shelter, fuel and cash income (Kaimowitz, 2003). Forest-based activities in developing countries, which are mostly in the area of Non-timber forest products, provide an equivalent of 17 million full-time jobs in the formal sector and another 30 million in the informal sector, as well as 13-35% of all rural non-farm employment (Duong, 2008).

However, the world over, forests are disappearing at alarming rates (FAO, 2010). In sub-Saharan Africa, forest degradation has been linked with poverty. As poverty and forest degradation continue to dominate global environmental policy debates, the first and seventh goals of the millennium development goals (MDGs) which are extreme poverty and environmental sustainability respectively, remain a daunting challenge especially in view of their planned achievement date.

Many primary forests in the tropical regions of the world are being converted into degraded secondary forests or intensively used agricultural areas at an alarming rate despite the apparent strong link between forest resources and rural livelihoods. Economic and demographic pressures are increasingly imposing non-sustainable development, which is driving greater proportions of tropical forests and their biodiversity to be either modified into more open and species-poor secondary forests or to be lost completely. The forest reserves are not exempted from this ugly scenario as many of them have been unprecedentedly degraded and converted to other land uses.

In Nigeria for instance, most of our forest reserves exist mainly on paper and can hardly give proper account of their original flora, fauna; and ecological processes, functions, and services. Omo Biosphere Reserve is the only Biosphere Reserve in Nigeria; and one of the 31 Biosphere Reserves in 127 countries within the Afrotropical realm (Ola-Adams, 1999). The vegetation falls within the Nigerian lowland tropical rainforest. However, the reserve has been extensively modified by anthropogenic activities; and now contains only about 0.3% of the original vegetation (Karimu, 1999). Logging, food cropping, and the establishment of monoculture plantations of exotic tree species are the major factors responsible for natural forest conversion in the reserve.

Species diversity has been identified as one of the key indices of sustainable land use practices (Shackelton, 2000). However, direct biotic change can alter diversity of forests by increasing mortality and emigrations (Bustamante and Grez, 1995). Although, several studies have been carried out to demonstrate the impact of land use change and different land use practices on different aspects of biological diversity (e.g. Castro 2008, Chazdon 2003, Chima and Uwegbulem 2012, Ihenyen *et al.* 2011, Lawrence *et al.* 2010, Zarin *et al.* 2005), no study has been carried out to ascertain the impact of introduced land use practices including monoculture plantations, on the natural regenerating potentials of key livelihood tree species in any locality. Therefore, the objective of this study was to evaluate the impact of introduced land cover types and land use practices on the natural regenerating potential of the key livelihood tree species in Omo Biosphere Reserve, Nigeria.

Materials and methods

Description of the study area and sites

Omo Biosphere Reserve is located between latitudes 6° 35' to 7° 05' N and longitudes 4° 19' to 4° 40' E in the South-west of Nigeria (Ojo, 2004); about 135 km north-east of Lagos, about 120 km east of Abeokuta and about 80 km east of Ijebu Ode (Ola-Adams, 1999). The reserve shares a common boundary with

Ago Owu, Shasha and Ife forest reserves in its northern part; Oshun forest reserve in the northwestern part and Oluwa forest reserve in the eastern part. Towards the southern part, the reserve is divided by the Benin-Ore Express Way. It covers about 130,500 hectares of land (Ola-Adams, 1999; Ojo, 2004).

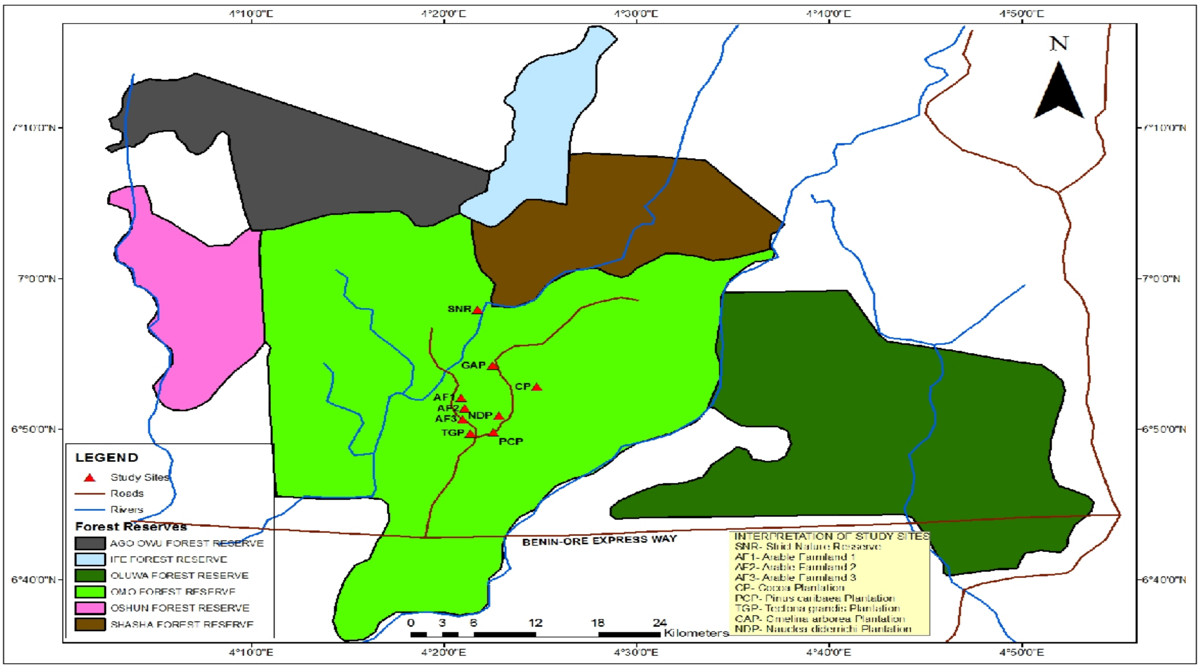

Fig. 1. Map of Omo Biosphere Reserve showing the study sites.

Nine sites - the Strict Nature Reserve (SNR), three chronosequences of arable farm land (AF_1, AF_2 and AF_3), *Theobroma Cacao* Plantation (CP), *Tectona grandis* Plantation (TGP), *Gmelina arborea* Plantation (GAP), *Pinus caribaea* Plantation (PCP), and *Nuclea diderrichii* plantation (NDP), were chosen purposively for the study. These sites represented different land use/land cover types including the natural forest and introduced land use types, and were chosen to ascertain the natural regenerating potential of the key livelihood tree species under them. Figure 1 is the map of Omo Biosphere Reserve showing the study sites.

Data collection

Five 2m x 2m plots were laid randomly in each land use type. Subsequently, three subplots - 20cm x 20cm, were marked out in a triangular shape, at the centre of each of the five plots in order to capture the spatial heterogeneity of soil seed distribution. Soil samples were removed from 0-5cm, 5-10cm and 10-15cm soil layers in each subplot and bulked for corresponding soil layers in each land use type. The bulked sample was divided into six equal parts for each land use type, and four of them randomly selected for germination trials. Soil samples were spread to a thickness of 3cm on perforated plastic trays (diameter: 30cm and depth: 3cm) that were kept moist continuously during the germination trial at the Forestry Research Institute of Nigeria (FRIN) Experimental Nursery. The seedling emergence method was used to assess the presence or otherwise of the key livelihood tree species (see Table 1) in seed banks from the different land use types. The seedling emergence method had been used by other workers (e.g. Senbeta and Taketay, 2001; Lemenih, 2004; Oke *et al*, 2007; Chima *et al.*, 2013) to evaluate species composition of seed banks in different land use types. Emerging key livelihood tree seedlings that are readily identifiable were counted, recorded and discarded on monthly basis. After identification and counting of seedlings each month, the soil samples were stirred to stimulate seed germination. This exercise continued until seed germination stopped.

Data analysis

Key livelihood tree seedling diversity

Simpson diversity index (Simpson, 1949) and Shannon-Wiener Diversity Index (Kent and Coker, 1992) was used to measure the diversity of key livelihood tree seedlings of seed bank in each land use type.

Simpson Index is expressed as:

$$D = \frac{\sum_{i=1}^{q} ni(ni-1)}{N(N-1)}$$ Eqn. 1

Where: N = total number of individuals encountered

ni = number of individuals of ith species enumerated for i=1……q

q = number of different species enumerated.

Since Simpson's index as expressed above is inversely related to diversity (i.e. the lower the index, the higher the diversity and *vice versa*), it is expressed in this study as (1 – D) to allow for a direct relationship.

Shannon-Wiener index is expressed as:

$$H = -\sum_{i=1}^{s} pi \ln pi$$ Eqn. 2

Where

pi = proportion of individuals in the ith species

s = total number of species.

Similarity in key livelihood tree seedlings between land use types

Sorensen's similarity index (SI) was used to measure the level of similarity in key livelihood tree seedlings that emerged from seed banks in different land use types. In this study, Sorensen's similarity index was computed after Ogunleye *et al.* (2004), Ojo (2004), Ihenyen *et al.* (2010), and Ihuma *et al.* (2011) using the formula below.

SI= $$SI = \frac{a}{a+b+c} X 100$$ Eqn. 3

Where

a = number of species present in both land use types under consideration.

b = number of species present in land use type 1 but absent in land use type 2.

c = number of species present in land use type 2 but absent in land use type 1.

Classification of land use types

Cluster analysis was performed using the PAleontological STatistics (PAST) software to obtain a hierarchical classification of the land use types such that those with more similar key livelihood tree species seedlings were grouped into the same cluster while those with dissimilar species were grouped into different clusters. In performing the cluster analysis, Sorensen's similarity index was used as a measure of the ecological distances between the land use types.

Results

Key livelihood tree seedlings in seed banks at different land use types

Five key livelihood tree species germinated from the examined soil seed banks (Table 2). The highest number of the key livelihood tree species was found in SNR followed by NDP/TGP, and GAP/AF1, respectively. No key livelihood tree species germinated from CP, PCP, AF_2 and AF_3 at the three soil depths, and from 5 – 10 cm and 10 – 15 cm depths in the other land use types.

Similarity in Key livelihood tree seedlings between land use types

Similarity in key livelihood tree species from the seed banks was zero between the SNR and each of the introduced land use types except with NDP where a similarity of about 67 % was recorded at the 0 -5 cm depth (Table 3). The highest similarity among the monoculture plantations was observed between GAP and TGP, while it was zero between each pair of the farmlands. Between the monoculture plantations and arable farmlands, the highest similarity was observed between GAP and AF1, followed by TGP and AF1.

Classification of land use types based on similarity of keylivelihood tree species present in their seed banks

A hierrachical classification of the land use types based on the level of similarity in key livelihood tree seedlings found in their seed banks is presented in Figure 2. GAP and TGP had the lowest ecological distance, and were grouped with only AF1. SNR and NDP were grouped together and both showed no association with the other land use types. CP, AF_2 and AF_3 were ecologically far apart and showed no form of association with one another and the other land use types.

Table 1. Checklist and ranking of key livelihood tree species in the reserve.

S/N	Species	Common or local name	Total score	Rank
1	*Khaya ivorensis*	Lagos mahogany	1295	1st
2	*Nauclea diderrichii*	Opepe	1240	2nd
3	*Terminalia ivorensis*	Black afara	850	3rd
4	*Cordia millenii*	Omo	690	4th
5	*Alstonia boonei*	Pattern wood	465	5th
6	*Terminalia superba*	White afara	375	6th
7	*Erythropleum suaveolens*	Erun-obo	330	7th
8	*Mangifera indica*	Mango	265	8th
9	*Entandrophragma utile*	Jebo	260	9th
10	*Anarcadium occidentale*	Cashew	260	9th
11	*Milicia excelsa*	Iroko	255	11th
12	*Lophira alata*	Ekki	190	12th
13	*Triplochiton schleroxylon*	Obeche	190	12th
14	*Piptadeniastrum africanum*	Agboyin	175	14th
15	*Theobroma cacao*	Cocao	145	15th
16	*Mitragyna ciliata*	African linden	140	16th
17	*Mansonia altissima*	Mansonia	140	16th
18	*Ceiba pentandra*	Kapok tree	130	18th
19	*Enantia chlorantha*	Osopupa, Yaru	130	18th
20	*Cederela odorata*	Honduras cedar	110	20th
21	*Anthonotha macrophylla*	Abara	110	20th
22	*Eleais guineensis*	Palm tree	110	20th
23	*Citrus sinensis*	Sweet orange	100	23rd
24	*Cola nitida*	Kola nut	90	24th
25	*Buchholzia coriacea*	Wonderful kola	85	25th
26	*Gmelina arborea*	Gmelina	80	26th
27	*Entandrophragma angolense*	Ijebo	75	27th
28	*Nesogordonia papaverifera*	Danta	55	28th
29	*Newbouldia laevis*	Boundary tree	55	28th
30	*Citrus aurantifolia*	Lime	55	28th
31	*Garcinia kola*	Bitter kola	40	31st
32	*Azadirachta indica*	Neem	40	31st
33	*Daniella ogea*	Ogea	35	33rd
34	*Tectona grandis*	Teak	25	34th
35	*Cleistopholis patens*	Apako	25	34th
36	*Terminalia catappa*	Indian almond	20	36th
37	*Chrysophyllum albidum*	African star apple	15	37th
38	*Parinari sp.*	Abere	15	37th

Source: Adapted from Chima et al. (2012).

Table 2. Key livelihood tree species present in seed banks under different land use types.

Species	No. of individuals								
	SNR	GAP	CP	PCP	NDP	TGP	AF_1	AF_2	AF_3
Nauclea diderrichii	1	0	0	0	6	0	0	0	0
Terminalia superba	2	0	0	0	0	0	0	0	0
Ceiba pentandra	1	0	0	0	1	0	0	0	0
Gmelina arborea	0	7	0	0	0	12	7	0	0
Tectona grandis	0	0	0	0	0	1	0	0	0
Total	4	7	0	0	7	13	7	0	0

Diversity of key livelihood tree seedlings at different land use types

The diversity of the key livelihood tree seedlings (Table 4) was highest in SNR, followed by NDP and TGP respectively; and zero in GAP, CP, PCP, AF_1, AF_2, and AF_3.

Discussion

Five key livelihood tree species (13.16% of the total number) were observed in all the examined seed banks, with three found at the SNR, one at GAP, two at NDP, two at TGP, one at AF_1, one at AF_2 and none at CP, PCP, and AF_3. The paucity of key livelihood tree species in seed banks at various land use types including the SNR may be attributed to the ephemeral nature of their seeds. Seed longevity in the soil varies among species, as a result of the characteristics of the seeds, burial depth, and climatic conditions (Milberg, 1995); and can range from nearly zero (germinating immediately when reaching the soil or even before) to several hundred years (Thompson *et al.*, 1997). Garwood (1989) and Wassie and Teketay (2006) observed that seeds of forested species are often short-lived. Dike (1992) also reported that forest species often complete their germination processes within eighty-four days after dispersal at Omo and Sapoba forest reserves in southwestern Nigeria, leading to few seeds remaining in the seed stores.

Table 3. Sorensen's similarity indices for key livelihood tree seedlings at 0 – 5 cm soil depth.

	SNR	GAP	CP	PCP	NDP	TGP	AF_1	AF_2	AF_3
SNR	*	0.00	0.00	0.00	66.67	0.00	0.00	0.00	0.00
GAP		*	0.00	0.00	0.00	50.00	100.00	0.00	0.00
CP			*	0.00	0.00	0.00	0.00	0.00	0.00
PCP				*	0.00	0.00	0.00	0.00	0.00
NDP					*	0.00	0.00	0.00	0.00
TGP						*	50.00	0.00	0.00
AF1							*	0.00	0.00
AF2								*	0.00
AF3									*

However, the complete absence of the indigenous key livelihood tree species in seed banks of the introduced land use types (except NDP which is a plantation of indigenous species), could be attributed to anthropogenic disturbances and modifications. Guevara *et al.* (2005) had observed that the disturbance of the original forest (through logging, slashing and burning, etc.) usually eliminates the seed bank of rain forest species. With the exception of NDP, the only key livelihood tree species found in the introduced land use types were *Tectona grandis* and *Gmelina arborea*; and these two species were lowly rated by the rural dwellers (Chima *et al.*, 2012).

No key livelihood tree species germinated in seed banks below 5 cm depth in all land use types. Senbeta and Teketay (2002) observed the highest number of species and densities of seeds in the upper three centimeters of soil, and a gradual decreasing number of species and densities of seeds with increasing soil depth. Degreef *et al.*, (2002) also reported that most seeds are located on the surface of the soil and that their number decline with depth. Similarly, Harper, (1982), suggested that the depth to find high abundance of seeds in soil bank is the top 2.5cm.

Table 4. Diversity indices for key livelihood tree seedlings at 0 – 5 cm soil seed bank.

	SNR	GAP	CP	PCP	NDP	TGP	AF_1	AF_2	AF_3
No. of species	3	1	0	0	2	2	1	0	0
Individuals	4	7	0	0	7	13	7	0	0
Shannon H	1.04	0	0	0	0.4101	0.2712	0	0	0
Simpson 1-D	0.625	0	0	0	0.2449	0.142	0	0	0

Similarity in key livelihood tree species composition was zero between the SNR and the introduced land use types except with NDP where a similarity of about 67% was observed. This closest ecological distance/association between the SNR and NDP underscores the restorative ability of modified/disturbed natural forest ecosystems when protected from further degradation. The NDP is the least disturbed of all the introduced land use types. It is located around the Project Management Unit and the residential quarters, and has not been logged since it was established about thirty-eight years ago. The closer association observed between AF_1 and GAP/TGP could be attributed to its lowest period of cultivation and history. The arable farmlands were established as taungya farms using mainly *Gmelina arborea* and *Tectona grandis* which are the most preferred plantation species in the reserve. Since farming in AF_1 started about thirteen years ago, trees of these species (especially those of *Gmelina arborea*) were still standing on the farm unlike in AF_2 and AF_3 where they had been logged. These remnant trees still contribute to the seed bank of AF_1 through seed rain. Moreover, fallen seeds of *Gmelina arborea* were observed on the floor of AF_1 as at the time of data collection.

Since soil seed bank contributes to the diversity and dynamics of most plant communities in the natural forest (Nathan and Casagrandi, 2004); the very low diversity of key livelihood tree species in seed banks, especially in most of the introduced land use types, underscores the need for artificial regeneration if their populations and the vital roles they play must be sustained.

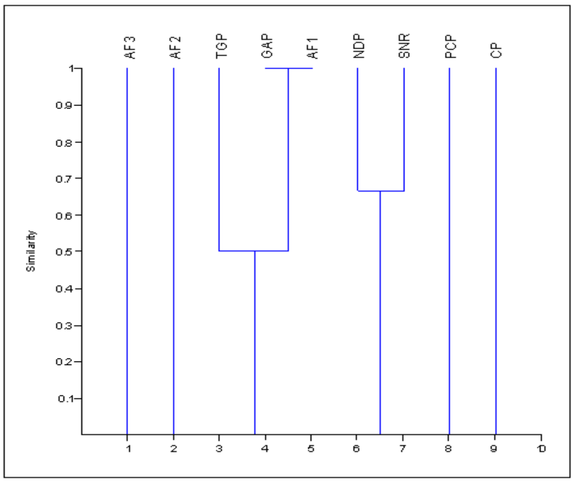

Fig. 2. Cluster dendrogram classification of land use types based on similarity of key livelihood tree seedlings from their seed banks.

Conclusion and recommendation

This study has shown that the natural regeneration of the key livelihood tree species in Omo biosphere reserve cannot be effective through the seed bank alone. The results further suggest that the key livelihood tree species most probably regenerate through other means like seed rain, seedling bank, seed dispersal, and coppicing. Hence, given the high rate of deforestation in the reserve with its negative impact on tree populations, there is need to encourage the conservation of surviving stands, and artificial regeneration, in areas where their populations have diminished due to anthropogenic activities.

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