Fuelwood Extraction Effect on Vegetation Landscapes in South West Nigeria

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Abstract

With population on the rise, efficient management of vegetation landscapes in developing countries has become increasingly challenging, owing to fuelwood usage as an affordable source of fuel for daily use. Proper understanding of fuelwood exploitation effect on varying vegetation landscapes for the purpose of effective management in Southern Nigeria, is limited. This study, therefore, examines the effect of fuelwood extraction on forest and savanna landscapes in Oyo State, South Western Nigeria. Vegetation measurements were taken from twelve (20m by 20m) quadrats respectively within the forest and savanna exploited sites and their associated control sites, totaling 48 quadrats. These quadrats were randomly selected along a 400m transect. The findings of the study reveal that mean dendrometric values were generally lower in exploited sites. The mean values for the exploited/control savanna and the exploited/control forests respectively include: Girth (cm): 25.3/48.5 and 53.0/128.8, Height (m): 4.84/6.02 and 10.04/20.74, Basal Area (msq) -0.05/0.28 and 0.32/2.32, Tree density (m/Ha): 6.08/13.25 and 11.66/12.33, Tree Diversity –0.79/0.863 and 0.85/ 0.97. *Funtumia elastica, Triplochiton scleroxylon, Albizia zygia* and *Vitellaria paradoxa, Anogeissus leiocarpus and Azadiracta indica* were dominant in the forest and savanna plots respectively. Student 't' test analysis result showed significant variation in mean dendrometric parameters and diversity values at p<0.05. Provision of affordable environmentally friendly energy alternatives for the local people is being recommended.

Keywords: Forest, fuelwood, fuelwood extraction, Nigeria and Savanna

Introduction

Tropical forests sustain important ecological functions globally while at the same time ensuring and maintaining biological diversity. The efficiency of these important functions and roles are however being challenged by several factors. These factors border majorly on ecological disturbances which alter the spatial patterning of ecosystems and the organisms found there. These disturbances shape the forest structure by making thousands of flora and fauna species go extinct every year and its full consequences on ecosystems are not totally understood (Schleuning *et al*, 2008). These disturbances range from natural disasters of insect/fire outbreaks to those influenced by human interference. Deforestation is a major disturbance plaguing forests globally. Ektveldt (2011) noted that extraction and usage of fuel wood for domestic energy by much of its urban/rural poor is a common activity on the African continent.

Fuelwood as a primary fuel has been in use for centuries in many developing economies. It consists of unprocessed woody biomass (mostly dead wood), and is often used to fuel a small fire (May-Tobin, 2012). As a significant forest product, there has been an intensification of firewood extraction activities which do not seem to be abating as local users rarely find affordable and acceptable alternatives (FAO, 2009; Arnold *et al*, 2003; Leach & Gowen, 1987; Eckholm, 1975). These users, engendered by the rise in population growth in developing countries are key to a greater encroachment on environmental resources (Hiemstra & Hovorka, 2009).

This is particularly true in Nigeria where the increase in the cost of kerosene and its attendant scarcity has forced many low-income urban dwellers to resort to the use of fuelwood/ charcoal as their major cooking energy source (Naibbi & Healey, 2013; Maconachie, 2009). Such persistent wood fuel dependence does signify important consequences for local forest resources and scarcity has been reported in some areas (Kituyi *et al*, 2001). Aabeyir *et al* (2011) noted that increased users usually translate to increased pressure on vegetal resources which may then alter the plant-soil equilibrium that exist in the tropical environment. For many of the developing countries, a strong dependence on wood fuels coupled with a slow adoption of more modern energy forms are indicators of poverty within such populations (Gumartini, 2009; IEA, 2006). Since the popularity of fuel wood amidst the poor in these countries is due to their inability to afford other fuels for cooking, the implications for the energy-forest–development scenario remain precarious.

Nigeria's heavy dependence on fuelwood has been a source of concern especially with regards to the wellbeing of its environment. Extant studies emphasizing the unabating large scale depletion of vegetal resources have further implicated the harvest and use of fuelwood as one of the driving catalysts for forest loss. Unless there is a widespread transitioning to modern fuels there is a serious threat of more irreversible changes to forests which may negatively affect the sustainability of both rural and urban livelihoods linked to fuelwood with time.

Despite the significance of this issue, there has been limited empirical studies on the link between urban fuelwood demand and environmental change, as well as the impact fuelwood extraction has on the environmental processes (Sassen *et al*, 2015; Sahoo & Davidar, 2013; Wangchuck, 2011; Zhou *et al*, 2009; Brown *et al*, 2009). Although, Aweto's (1995) review of fuelwood production in West Africa surmised that fuelwood activities generally impact unfavourably on the environment; there are few local empirical studies in West-Africa and Nigeria in particular.

Past studies on effects of fuelwood extraction such as Foley *et al* (2002) reported regression in tree numbers and diameters in a study of two Sahelian village forests while Cline-Cole (1987) also detailed impacts on tree density and specie density in Northern Nigeria. None of these studies showed differentials in how fuelwood removals affected key vegetation parameters of different exploited areas. It is probable that the removals of materials such as coarse woody debris may manifest differently in the long-term ecological condition of various extraction sites, given losses of soil, nutrient, carbon and water resources (Brown *et al*, 2009).

This study therefore examines the effect of fuelwood extraction on vegetation landscape (forest and savanna) in parts of South Western Nigeria. The set-out objectives of this study are to: characterize and compare effects of fuel wood extraction on vegetation structure (tree density, girth, basal area), species composition, diversity and richness on savanna and forest extraction sites.

Description of Study Area

This study was conducted in Oyo State South-western Nigeria, located between latitudes 6°55' to 8°45'N and longitudes 2°50' to 3°56'E. Two forest areas of extraction and control plots were chosen and the same procedure repeated for the savanna sites. The forest extraction site (A) was Alaja village in the Arulogun area in Akinyele Local Government Area (Ibadan), while the natural forest stand of the Onigambari forest reserve was chosen as the forest control site

(C) located in Oluyole Local Government Area (LGA) close to the Southern part of Ibadan in Oyo State. The savanna extraction study was carried out at Ago Serafu, Iseyin (B) while the Old Oyo National Park (D), in the Northernmost corner of Oyo Ile range served as the savanna control located in the Northern southerly fashion across Oyo. The Oyo State vegetation generally is classified under two types of vegetation: tropical forest and derived savanna. Both manifest different flora and plant communities based largely on the amount of rainfall received in the area (Ayoub, 1988). Oyo State has a sub - equatorial climate with a relatively high humidity and distinct wet- dry periods (November – March). Its daily temperature is usually about 21°C- 35 °C while its mean annual rainfall ranges between 800 mm to 1500 mm with a slightly longer dry season in the Northern parts (Ayoub, 1988). Rainfall amount varies within the state. The Southern part enjoys between 1200mm and 1800mm of rainfall. The Northern part has a lower average of 800mm and 1500mm of annual rainfall. Much of the State is underlain by soils derived mainly from pre-Cambrian rocks, especially hornblende biotite gneiss.

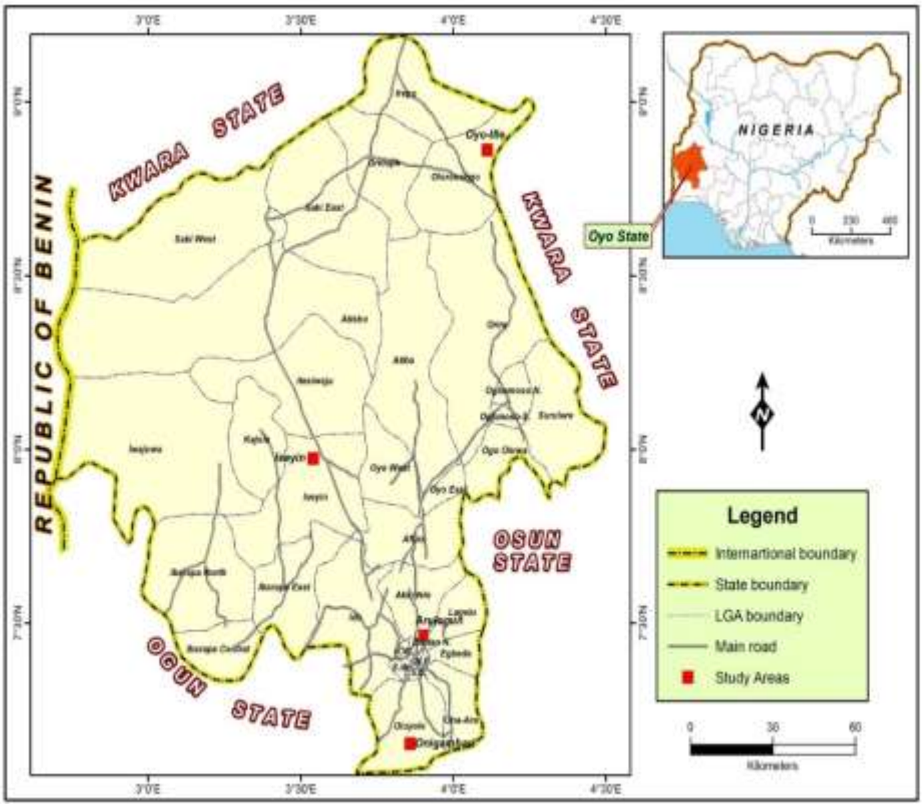

Fig. 1: Map showing forest and savanna study sites in Oyo State

Materials and Methods

The study made use of primary and secondary data. Primary data were collected from direct field survey, carried out on vegetation. For the purpose of examining the vegetation of the study area, as well as the dendrometric changes in the exploited vegetation, vegetation structural parameters comprising of tree height, basal area and Diameter at Breast height, were obtained from 20m by 20m quadrats. Only tree species with a girth $\geq$ 20cm within the quadrats were measured and enumerated, ignoring juvenile trees. Species density, diversity and Simpsons Index were calculated using the aforementioned tree measurements.

The vegetation structural parameters were obtained in the following manner:

i. Tree height was measured with a Hagar altimeter (Alan, 2012).

ii. Girth was obtained with a calibrated tape rule.

iii. Diameter at Breast Height was derived from the girth, using girth/π = dbh

iv. Basal area (m^2) was calculated from a known relationship with diameter at breast height using the Basal Area (BA) = $(girth)^2/4\pi$

v. Species composition was obtained by counting of individual trees.

vi. Species density which refers to **the** number of individual tree species per unit area was obtained thus: SpD = Total number of individuals of a specie in all quadrants / Area of the quadrants in hectares.

vii. Species diversity was obtained using the Simpson's index thus: $\mathbf{D} = \sum_{i=1}^{s} \frac{ni\,(ni-1)}{N(N-1)}$, where n is the number of individual tree species.

viii. The similarity index was obtained from the Sorenson's index

$$SI = \frac{2C}{A+B} \times 100$$

Where C = number of species in sites A and B; A = number of species at site A and not in B;

B = number of species at sites B and not in A.

The species composition was determined by counting the number of occurrences of each particular species. The Diversity and Simpsons's index were calculated using the aforementioned measurements. Plant identification was done by a taxonomist following Keay *et al* (1953) and Gbile *et al* (1988).

The quadrats from which the measurements were obtained from were randomly located along a 400m transect in the field. Measurements were obtained from exploited forest and savanna sites and their respective control sites. The exploited forest and savanna sites include Alaja forest and Serafu savanna landscapes respectively. The control sites for both the forest and savanna landscapes include Onigambari forest and the Oyo-Ile savanna reserve. Twelve quadrats of 20m by 20m were located within each of the forest and savanna exploited landscapes and their respective control sites, totaling 48 quadrats.

Result of the Findings

The various vegetation measurements obtained from the trees of the study are shown in Table 1.

Table 1: Mean dendrometric characteristics values for the study area

Environment	**Savanna**		**Forest**	
Dendrometric Characteristics (Mean Values)	Serafu (Savanna) (Exploited)	Oyoile (Savanna) (Control)	Alaja (Forest) (Exploited)	Onigambari (Forest) (Control)
Girth (cm)	25.3(0.39) *	48.5(3.78)	53.0(3.02) *	128.8(9.86)
Height (m)	4.84(0.27) *	6.02(0.17)	10.04(0.55) *	20.74(1.45)
Basal Area (msq)	0.05(0.002)*	0.28(0.04)	0.32(0.04)*	2.32(0.42)
Tree number	4.2 (0.6)	6.8(0.75)	9.2(0.78)	10.1(1.0)
Tree Density (m/Ha)	6.08 (3.0)*	13.25(4.1)	11.66(3.6)*	12.33(4.8)
Tree Diversity	0.79 (0.07)*	0.863 (0.02)	0.85(0.08)*	0.97(0.01)

*Significant at 0.1%

The dendrometric characteristics of the savanna plots revealed that the tree girths in the exploited plots were all below 30cm, having a mean girth of 25.3cm. Conversely, the control savanna plot trees showed a much larger girth dimension, with a mean girth of 48.5cm. The exploited savanna plots had a mean height of 4.84m, while those of the control area were higher at a mean height of 6m. Similarly, for the forests, the control plots were significantly higher (averaging 20.74m in height) than the exploited area trees (averaging 10.4m). The basal area mean values for both the exploited forest (0.32cm) and savanna areas (0.05cm) were noticeably lower than their control area equivalents (forest 2.32cm, savanna 0.28cm) (Table 1).

For the forests, many of the dominant species found in both sites showed a much lower density in the exploited plots compared to the control (Table 1). Similar results were obtained for the savannas, whereby lower tree densities were recorded when compared with those found in the control plots. Both the exploited and control savannas, recorded some measure of diversity such that all values were greater than zero. The exploited savanna however had a slightly lower mean diversity value of 0.79 than that of the control savanna, having a value of 0.86. A similar result was seen in the forests, with the control forest generating a much higher mean diversity value of 0.97 than the exploited site (0.85) since it was a relatively unexploited rainforest. Student 't' test analysis result showed significant variation in tree density, basal area, height and girth at $p<0.1$ significance level. Student 't' test analysis result showed significant variation in species diversity at $p<0.05$ significance level.

A notable variety of tree species were observed in the study area. The number of occurrences of each of the tree species encountered in the forest and savanna areas is shown in Table 2. The species composition of trees in the two forests sites (Exploited Alaja and Control Onigambari reserve) was higher than those of the two savannas sites (Serafu and Oyo-Ile). Furthermore, the tree population in the exploited forest plots was lower than those in the control plots (Table 2).

Table 2: Species composition and number of tree species under forest and savanna vegetation in Oyo state.

S/N	Species	Local Name	Family	Onigambari (Control-Forest)	Alaja (Exploited Forest)	Oyo-Ile (Control-Savanna)	Serafu (Exploited Savanna)
1	*Acacia hockii*	*Ede*	*Mimosaceae*	-	-	4	-
2	*Afzelia africana*	*Apa*	*Caesalpinioideae*	1	-	5	3
4	*Ajadin,ajade*	*Ayunre Weere*		-	-	-	1
5	*Albizia ferruginea*	*Banabana*	*Mimoasceae*	3	1	-	-
6	*Albizia zygia*	*Ayunre*	*Mimoasceae*	2	11	-	-
7	*Alchornea cordifolia*	*Ijan*	*Euphorbiaceae*	-	2	-	-
9	*Alophylus africana*	*Ekan ahoro*	*Sapindaceae*	-	4	-	-
10	*Alstonia boonei*	*Ahun*	*Apocynaceae*	4	-	-	-
11	*Anacardium occidentale*	*Kaju*	*Anacardiaceae*	-	-	-	4
12	*Ancistrophyllum secundiflorum*	*Okuku*	*Arecaceae*	-	-	1	-
13	*Anogeissus leiocarpus*	*Ayin*	*Combretaceae*	-	-	2	7
15	*Anthocleista djalonensis*	*saapo*	*Gentianaceae*	-	1	-	-
16	*Antiaris toxicaria var africana*	*ooro*	*Moraceae*	1	10	-	-
17	*Abo*			-	-	-	2
18	*Asa funfun*			-	1	-	-
19	*Asasa*			1	-	-	-
20	*Azadirachta indica*	*Dongoyaro*	*Meliaceae*	-	-	-	8
20	*Blighia sapida*	*Isin igbo*	*Sapindaceae*	2	2	-	-
21	*Blighia unijugata*	*Isin oko*	*Sapindaceae*	-	8	-	-
22	*Bombax buonopozense*	*eso olu kondo*	*Bombacaceae*	1	-	-	-
23	*Bosqueia angolensis (Trilepisium.)*	*lahoro*	*Moraceae*	8	5	-	-
24	*Bridelia micrantha*	*Ira*	*Euphorbiaceae*	-	2	-	-
25	*Bridellia ferruginea*	*Ira odan*	*Euphorbiaceae*	1	-	6	6
26	*Burkea africana*	*Asapa*	*Caesalpiniaceae*	-	-	6	16
27	*Buse*			-	-	-	1
28	*Cedrela odorata*		*Meliaceae*	3	-	-	-
29	*Ceiba pentandra*	*Araba*	*Bombacaceae*	3	1	-	-
30	*Celtis mildbraedii*		*Sterculiaceae*	2	-	-	-
31	*Chordea alliodora*			1	-	-	-
32	*Chrysophyllum albidum*	*agbalumo*	*Sapotaceae*	2	1	-	-
33	*Citrus medica*	*goingoin*	*Rutaceae*	-	1	-	-
34	*Cola gigantea*	*Obi agbaya*	*Sterculiaceae*	5	-	-	-
35	*Cola millenii*	*Obi edun*	*Sterculiaceae*	8	1	-	-
36	*Cola nitida*	*obi*		1	5	-	-
37	*Cordia millenii*	*Omo*	*Boragineaceae*	3	-	-	-
38	*Cussonia arborea*	*Sigo, siga*	*Araliaceae*	-	-	1	-
39	*Dalbergia lactea*	*Igi ojiji*	*Laguminosae*	-	2	-	-
40	*Dallium guinesis*	*aaran*	*Fabaceae*	1	-	-	-
41	*Daniella ojea*	*asunwole*	*Caesalpiniaceae*	2	-	-	-
42	*Daniellia oliveri*	*iya*	*Caesalpiniaceae*	-	-	13	7

43	*Deibola pinnata*	*lagbao,ogiri egba*	*Sapindaceae*	1	-	-	-
44	*Detarium microcarpum*	*Aluki, Arira*	*Ceasalpiniaceae*	1	-	-	-
45	*Dialium guineense*	*Awin*	*Meliaceae*	1	-	-	-
46	*Dichrostachys cinerea*	*Ajagboluuti*	*Mimosaceae*	-	-	1	-
48	*Disthemonantus benthamianus*	*Aayan*	*Ceasalpiniaceae*	-	-	1	-
49	*Entada abyssinica*	*gbengbe*		-	-	-	1
50	*Entandrophragma sp*	*Ako ijebu*	*Meliaceae*	8	-	-	-
51	*Ficus capensis*	*opoto*	*Moraceae*	-	-	10	4
52	*Ficus exasperata*	*ipin*	*Moraceae*	-	4	-	-
53	*Ficus mucuso*	*Obobo*	*Moraceae*	-	4	-	-
54	*Funtumia elastica*	*Ire*	*Apocynaceae*	12	8	-	-
55	*Gardenia ternifolia*	*Oruwan*	*Rubiaceae*	-	-	4	-
56	*Gliricidia sepium*	*Agunmaniye*	*Papilionaceae*	-	4	-	-
57	*Hymenocardia acida*	*Orupa*	*Hymenocardiacea e*	-	-	18	1
58	*Isoberlini doka*	*baabo*		-	-	2	-
59	*Kleptofoli*	*Igi efo*		1	-	-	-
60	*Landa osan*	*Landa osan*		1	-	-	-
61	*Lecaniodiscus cupanioides*	*Aaka*	*Sapindaceae*	-	4	-	-
62	*Lonchocarpus sericeus*	*Ipapo, Paapo*	*Papilionaceae*	-	8	1	-
63	*Lophira lanceolata*	*Pahan, Pehen*	*Ochnaceae*	-	-	3	5
64	*Malacanta eli*	ilaka ile		2	-	-	-
65	*Maranthes polyandra*	*Idofun*	*Chrysobalanacea es*	-	-	2	-
66	*Massularia acuminata*	*Pako ijebu*	*Rutaceae*	2	-	-	-
67	*Milicia excelsa*	*Iroko*	*Moraceae*	-	1	-	-
68	*Milletia thonningii*	*Ito*	*Papilionaceae*	-	5	-	-
69	*Myrianthus arboreus*	*ewe ade*	*Cecroplaceae*	-	1	-	-
70	*Monterea*	*Abo/dodo fufun*		-	1	-	-
71	*Morinda lucida*	*oruwo*	*Rubiaceae*	-	3	-	-
72	*Morus mesozygia*	*Igi aiye*	*Moraceae*	-	1	-	-
73	*Newbouldia laevis*	*Akoko*	*Bignoniaceae*	2	4	-	-
74	*Olax subscorpioidea*	*Ifon*	*Olacaceae*	1	-	-	-
75	*Parkia biglobosa*	*Igba*	*Mimosaceae*	-	1	3	2
76	*Phyllanthus discoideus*	*Awe*	*Euphorbiaceae*	-	1	-	3
77	*Piliostigma thonningii*	*Abafe*	*Caesalpiniaceae*	-	-	6	2
78	*Piptadeniastrum africanum*	*agboyin*	*Mimosaceae*	1	-	-	-
79	*Prosopis Africana*	*agboyin*	*Mimosaceae*	-	-	5	-
80	*Pseudocedrela kotschyi*	*Emigbegiri*	*Meliaceae*	5	-	2	-
81	*Pterocarpus angolensis*	*Ara*	*Papilionaceae*	-	-	1	-
82	*Pterygota macrocarpa*	*poroporo*		5	-	-	-
83	*Psidium guajava*	*guava*	*Myrtaceae*	-	1	-	-

84	*Hura reptens*	Kerebuje tyre moto		-	2	-	-
85	*Pycnanthus angolensis*	*Akomu*	*Myristicaceae*	3	3	-	-
86	*Rauvolfia vomitoria*	*Asofeyeje*	*Apocynaceae*	-	2	-	-
87	*Ricinodendron heudelotii*	*Erinmodo, epu*	*Euphorbiaceae*	7	-	-	-
88	*Securidaca longipedunculata*	*ipeta*	*Polygalaceae*	-	-	-	3
89	*Senna siamea*		*Caesalpiniaceae*	-	3	-	-
90	*Spondias audit*		*Anacardiaceae*	-	-	1	1
91	*Spondias mombin*	*Iyeye*	*Anacardiaceae*	-	4	-	-
92	*Sterculia tragacantha*	*Koko igbo, alawefon*		8	-	-	-
93	*Sasa*			1	-	-	-
94	*Strychnos spinosa*	*Orombo Igbo*	*Loganaceae*	-	-	4	-
95	*Tabernaemontanan pachysiphon*	*Dodo*	*Apocynaceae*	4	5	-	-
96	*Terminalia avicennioides*	*idin*	*Combretaceae*	-	-	20	2
97	*Terminalia superba*	*afara*	*Combretaceae*	-	2	-	-
98	*Tetracera pototoria*	*Opon*	*Dillenlaceae*	1	1	-	1
99	*Treculia monadelfia*			3	5	-	-
100	*Triplochiton scleroxylon*	*Arere*	*Sterculiaceae*	12	2	-	-
101	*Vitellaria paradoxa*	*Emi*	*Sapotaceae*	-	-	25	3
102	*Vitex doniana*	*Ori*	*Verbenaceae*	-	-	2	1
103	*Vitex ferruginea*	*Oriko, Orieta*	*Verbenaceae*	-	-	-	2
104	*Zanthoxylum xanthoxyloides*	*Ata pagara*	*Sterculiaceae*	3	-	-	-
105	*Zeltis zenkeri*	*ita*	*Ulmaceae*	9	4	-	-
	TOTAL			148	140	159	73

Key species common to both landscapes showed variation in tree count and abundance (see Fig 2 & Fig 3). In the savanna landscape, four out of the five tree species in the exploited plots had higher tree counts than the control plots. In the forest landscape, only three out of the five species had a higher tree count than their counterparts in the exploited forest plots (Fig 2 & Fig 3). Although both sites had 11 tree species in common, specie richness recorded for the exploited forest plots was lower (43 species) than for the control plots (45 species).

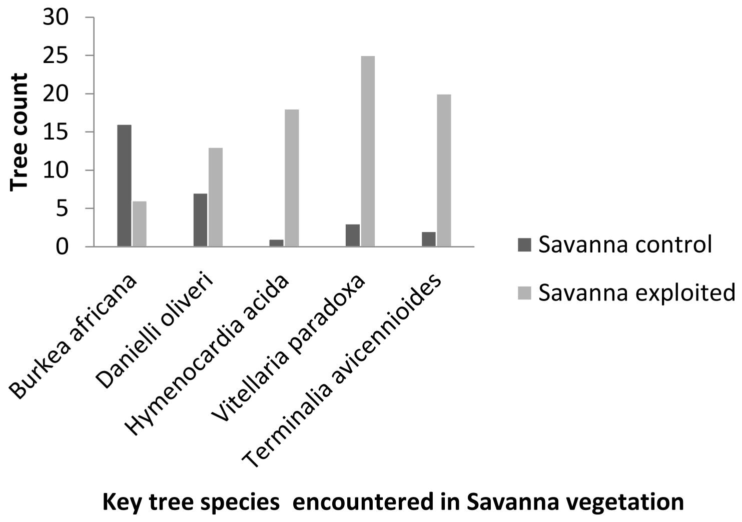

Fig.2: Chart showing variation in frequency of key tree species common to the two savanna areas.

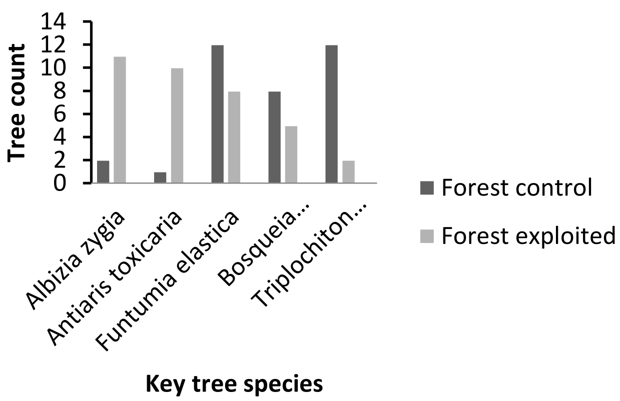

Fig. 3: Chart showing variation in frequency of key tree species common to the two forest areas

Conversely, the two savannas had higher species density (Table 1) and a higher degree of commonality in number of tree species for both exploited and control plots. Variations observed include lowered specie richness in the exploited savanna plots (23) as against that of the control plots (27); lowered mean specie value of 4.2 for the exploited plots as against 6.8 for the control vplots (see Table 2).

In the savanna plots, *Vitellaria paradoxa* had the highest number of individuals per species (28 individuals) followed by *Terminalia avicennioides* (22), *Burkea africana* (22) *Daniella oliveri* (20) and *Hymenocardia acida (19).* All except *Burkea africana* were more abundant in the exploited savanna than in the control plots but notably in juvenile sizes. Other dominant species also seen in the exploited savanna plots were *Anogeissus leiocarpus,* and *Azadiracta indica* (Table 2). By contrast, dominant species encountered in the Oyo-ile savanna control plots were *Burkea africana, Daniella oliveri, Terminallia avicennoides,* with the most abundant being *Burkea africana* (16) (Fig. 2).

The most abundant species seen in the control forest were *Funtumia elastica* (12) and *Triplochiton scleroxylon* (12). Conversely, in the exploited forest area, *Albizia zygia* (11) was the most abundant tree species. Other dominant species encountered were *Antiaris toxicaria, Blighia unijugata, Cola nitida, Gliricidia sepium, Newbouldia laevis* and *Lonchocarpus* *sericeus.* Typical species absent in the exploited forest but found at the control plots include *Sterculia tragacantha, Alstonei boonei, Ceiba pentandra, Cola millenii, Cola gigantea, Entandrophragma spp, Ricinodendron heudelotii, Pterygota macrocarpa* (Fig. 3). Significant typical/indigenous species missing in the exploited forest that were found in the control plots include *Daniellia ogea, Alstonia boonei, Entandrophragma spp, Pterygota macrocarpa, Sterculia tragacantha, Zanthoxylum xanthoxyloides, Ricindenodron heudelotii, Terminallia superba, Piptadeniastrum africanum, Massularia acuminata, Malacanta eli.* When compared, the forest control plots exhibited more richness in species (45) and higher tree population (148) than seen in the exploited plots (Table 2). The mean population for the exploited forests was generally lower than in the control sites. The data reveals that the total number of tree species in the exploited savanna was 73, and 159 under the control savanna. In the forest plots, the exploited plots had 140 and its control plots had 149 tree stands.

The Sorensen's similarity index of vegetation under the forest and savanna is presented in Table 3. The analysis reveals that the similarity index in the savanna vegetation between exploited and unexploited plots was 44%, while that of the forest was lower, being 38%.

Table 3: Sorensen's Similarity Index (SID) of forest and savanna vegetation.

Land use	Exploited Savanna		Control Savanna		Exploited Forest		Control Forest	
	SID	SID (%)	SID	SID (%)	SID	SID (%)	SID	SID (%)
Exploited Savanna	1	100						
Control Savanna	0.44	44	1	100				
Exploited Forest	-	-	-	-	1	100		
Control Forest	-	-	-	-	0.38	38	1	100

Source: Fieldwork (2015)

The similarity values give a fair indication of the overlap homogenous nature of both savanna sites as against that of the forest sites.

For the purpose of analysing the tree population structure, the tree size class distribution was determined. This was derived from the classification of tree girths into various cohorts. This is further depicted by histograms for each of the individual sites (see Figs 4 – 9). The result of the analysis indicated spatial variation across both forest and savanna plots (Figs 4 – 9).

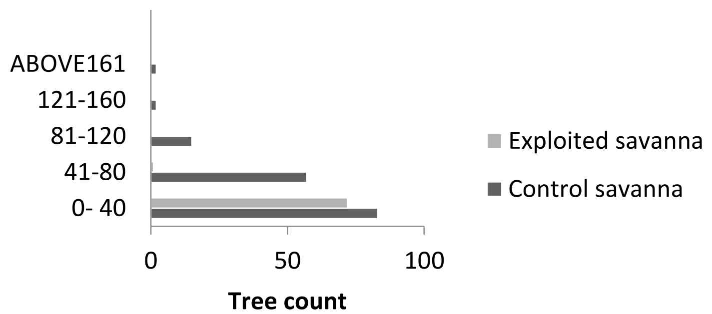

Fig. 4: Chart comparing variation in girth class distribution between the two Savanna areas (Exploited/Serafu and Control/ Oyo-Ile).

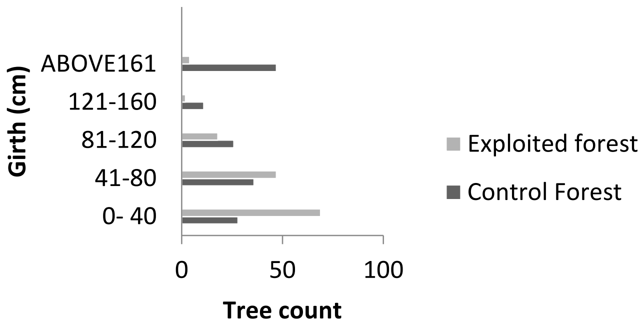

Fig. 5 Chart comparing variation in size class distribution in the two forest areas (exploited/Alaja and control Onigambari).

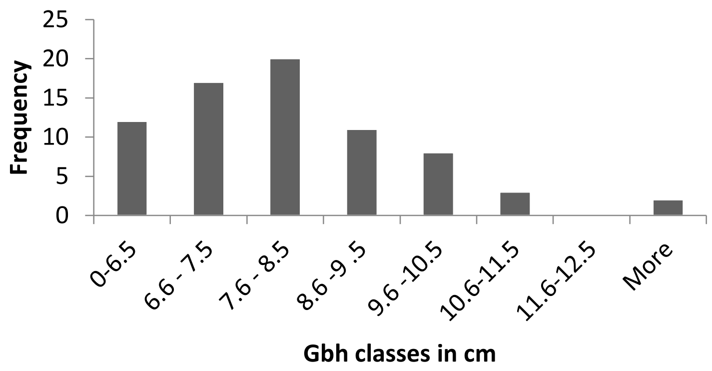

Fig. 6 Chart showing histogram of the Exploited savanna

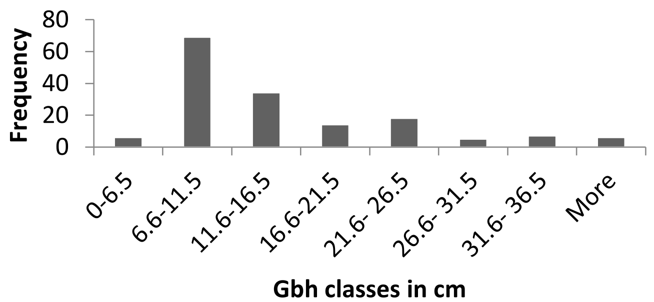

Fig. 7: Chart showing histogram of the Unexploited savanna (control)

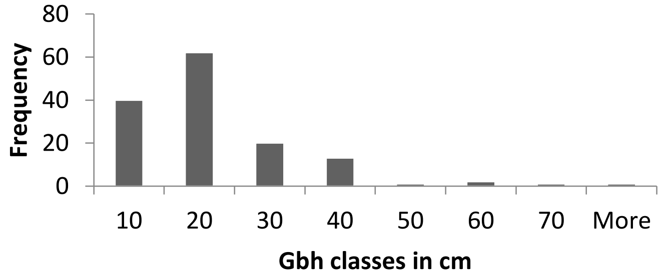

Fig.8: Chart showing histogram of the Exploited forest

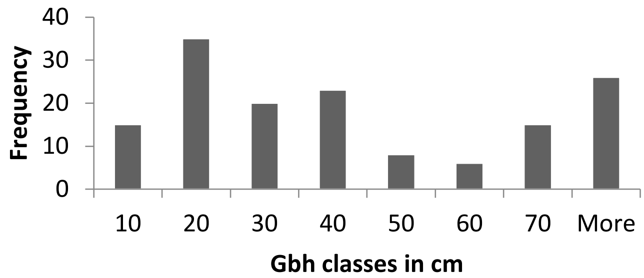

Fig. 9: Chart showing histogram of the Unexploited Forest (control)

Discussion

Tree counts in the Oyo Ile control savanna area revealed a slightly higher number of trees than that for both exploited and control forest sites. The savanna trees were however smaller in size and hence lower in maturity, as reflected by the girths and basal area values (Table 1). The situation of relatively higher tree count in the control savanna is a likely indication of sequential progression of the savanna woodland to a dry forest. The occurrence of a high number of savanna juveniles may also be attributed to the effect of suppression by wild fires (Hennenberg *et al,* 2005) leading to a more pronounced grass-tree co -existence. The observed lower tree count in the forest sites could be attributed to the restriction of growth as a result of the shielding of juveniles from insolation, by the broadened forest canopy. The foregoing is suggestive of the occurrence and subsequent impact of disturbance events on the key species abundance in the savanna plots. This confirms the findings of a number of other studies which reported disturbance as a factor influencing tree species alteration. Omoro (2012), Baroody (2013) and Egbinola (2015) noted that bush burning, farming and a number of other human disturbances were responsible for the alteration of mature forest species to savanna species.

The total tree species counts for the both forest sites were observed to be relatively higher than those for both savanna sites (Table 2). This situation agrees with the findings of Adejuwon and Adesina (1988) and Ratnam *et al* (2011). The relatively lower species richness values observed in the exploited forest supports other forest research results highlighting tropical forests as possessing lower specie densities, higher diversities while also manifesting very little degree of trees clumping (Ratnam *et al*, 2011; Keay, 1953; Emuh & Gbadegesin, 2009). The exploited and control forests exhibited slightly different patterns of specie composition. The exploited forest (Alaja) reflected the characteristics of a secondary forest, surrounded by homesteads and agricultural lands, with the occurrence of locally preferred trees such as *Baphia nitida, Albizia zygia, Alchornea cordifolia* and *Newbouldia laevis.* Many typical pioneer trees, such as *Ceiba petandra,* were missing and most of the dominants (*Antiaris toxicaria*) observed, occurred as multipurpose trees in single stands throughout the forest. The control forest (Onigambari), however, appears to be a secondary forest, displaying similar characteristics of a mature rain forest. This is reflected in the high number of seral and primary species found, of which many had large diameters, thereby corroborating the findings of Salami *et al* (2016). Summarily, a forest- savanna comparison, seen from Table 2, reflects greater species erosion in the exploited savanna plot than the forest plot. Previous findings from other climes in Asia (Sahoo & Davidar, 2013) and India (Chettri *et al*, 2002) suggest a greater extraction pressure on biomass in open canopy forests than on closed canopy forests due in part to high human interference.

Burkea africana abundance occurred more as juveniles, in the savanna area, as seen from the low structural values recorded. This could be attributed to the impact of human disturbance resulting in opening up of more of the woodland to insolation, thereby encouraging greater net primary productivity and quicker regeneration. Some uncommon species such as *Vitex* *doniana, Entada abyssinica, Tetracera potatoria* were seen occurring in the exploited savanna, in very low counts. According to Teketay *et al* (2016), Pitman *et al* (2002), this situation is evident of the effects of fuelwood extraction culminating in the stimulation of more species in the intermediate stages. The exploited savanna appears to be in the recovery stage, given the high juvenile number. The Savanna control plots, however had a number of pioneer species in moderate numbers such as *Hymenocardia acida*, *Burkea africana*, as well as, a few dominant species as *Terminallia avicennoides* and *Daniellia oliveri*. The savanna control plots seemed to be in early succession, evidenced by the occurrence of a few isolated mature successional species of *Isoberlini doka*, *Afzelia africana* and *Anogeissus leiocarpus* (GBH over 100cm). With these species approaching the middle storey in height, an early progression towards becoming a dry forest is established. The most obvious impact discernible from the comparison of both savanna sites is that there is higher intense alteration of tree size class structure and in a lesser fashion, species erosion in the exploited sites, both being testaments to the effects of tree extraction / harvesting.

In the case of the forest sites, many of the dominant species found occurring in both sites showed a much lower density in the exploited plots compared to the control (Table 2). This is suggestive of the occurrence of human induced species erosion, which agrees with the findings of Wessels *et al* (2011), Shackleton *et al* (1994) and Scholes (1987). Similar results were obtained for both the forest and savanna exploited sites. Lower tree densities were, however, recorded for the control counterparts. This finding is in consonance with other research on effect of disturbance on trees (Chettri *et al*, 2002). The student 't' test analysis result revealed a significant variation in tree species density between both savanna plots, and forest plots respectively, at 0.05 significance level.

Both the exploited and control savannas recorded some measure of diversity as all values were greater than zero. A similar result was seen in the forests, with the control forest generating a much higher mean diversity value of 0.97, than that of the exploited site of 0.85. This is confirmed by the effective number of individual tree species recorded and their significance of difference observed at $p<0.05$ (Table 2). The higher diversity values displayed by the forests further substantiate the known fact that the most distinctive feature of tropical forests is the large genetic pool from which abundant species can be found. This is especially the case, as forests generally have larger number of species in a given area than occurs in the drier savannas (Ayoub, 1987; Scholes, 1987; Barbour *et al*, 1982). Hennenberg *et al* (2005) noted that savannas are more likely to be disturbed culminating in fewer species occurrences, than that of the forest. This disagrees with Feka *et al* (2011), who noted that species were likely to increase following a disturbance (intermediate disturbance theory). Both the exploited forest and savanna, however showed a discernible drop in diversity levels when compared with the control plots. This corresponds with the findings of Emuh and Gbadegesin (2009), whereby a decrease in diversity characteristics irrespective of the vegetation landscape was observed. The slightly lowered indices further confirm the impact of moderate human pressure. The slightly higher similarity index in the savanna gives a fair indication of the overlap or homogenous nature of the species of both savanna sites. The lower similarity value of the forest further confirms the fact that tropical rainforests generally have higher gene pools, and by consequence a higher capacity to conserve biodiversity (Barbour *et al*, 1982).

The relatively lower values of structural characteristics for the exploited plots, being characterised by smaller sized trees, is indicative of significant negative impact of the activity of extraction on both the forest and the savanna landscapes. This agrees with Sassen *et al* (2015), based on the notion of disturbance being a notable factor in the reduction of tree sizes. This is often evidenced by the observed reduction in basal area of preferred species with increasing distance into the hinterland. Further confirming this, Tredennick (2014) reported the occurrence of a demographic shift to noticeably low biomass sizes, from the model analysis of savanna and forest trees, following increased tree harvest. Feka *et al* (2011), also laying credence to the aforementioned, noted that disturbance brings a trend of decreasing diversity and density with increasing girth classes.

In the exploited savanna area, the results reveal a conspicuous absence of trees of girth greater than 40cm. An exceptional occurrence of *Danieli oleivera*, having a girth of 48cm was however, observed (Fig. 4). Majority of the trees encountered were saplings and small trees (GBH < 40cm, n = 72trees) and more than 50% were under 4m in height. This is in line with findings of Mueller-Dombois (2002) and Hennenberg *et al* (2005), whereby the effect of constant removals culminates in the establishment of smaller sized trees. This situation is suggestive of the activity of selective tree harvesting demonstrated by the removal of mature tree class sizes. By consequence, juvenile species survival is encouraged owing to the reduction of the inhibiting influence of tree canopies. Figs. 6 - 9 reveal the variation in the tree distribution. Fig. 6 reflects the bell-shaped nature of tree distribution, showing the occurrence of relatively fewer saplings as against that of small trees within the exploited savanna area. The control savanna clearly reflected a reverse 'J' shape in its distribution with fewer saplings, a higher number in middle classes than the very large individuals (Fig. 7)**.** Conversely, both the exploited forest (Fig. 8) and control forest (Fig. 9) showed a richer composition of trees although the exploited plots reflected a reverse 'J' shape in distribution with most trees being small in size. Low incidences of giant-sized trees (>160cm in girth) and a missing size class of 120cm – 160cm was observed (Fig. 5). This scenario is suggestive of the occurrence of long-term wood removal process reflecting what appears to be a communal management of forest lands with moderate harvesting pressure. The control forest site had an irregular mix with both large and small sized trees represented in all size classes suggesting it was a relatively mature and stable forest, agreeing with findings of Tsheboeng and Murray-Hudson (2013). The exploited forest has a relatively lower incidence of giant-sized trees than the control forest.

Conclusion

This study has examined the effect of fuelwood extraction on vegetation landscapes in South West Nigeria. The findings of the study revealed that human disturbances in form of fuelwood extraction have impacted on tree population and specie richness of both forest and savanna regions but with different intensities. The tree population recorded for each forest was almost twice that of the exploited savanna. Similar results were obtained for the savannas such that for both the forest and savanna exploited sites, lower tree densities were recorded when compared with those found in the control plots. Comparatively, more variation was found between the exploited and control forests than was seen in the exploited and control savannas.

This study has revealed the existence of significant differences in the vegetation characteristics (Tree density, diversity, species composition, tree structure) of exploited sites and the unexploited (control) sites. It further suggests that firewood extraction, though moderate, does influence important changes on the vegetal component of an ecosystem. These changes are reflected in varying ways in both forest and savanna areas.

Recommendations

Based on the findings of the study, the following recommendations are made;

Based on the findings of the study, the following recommendations are made:

i. Given the changes that extraction of wood brings to forests and woodlands , there is a need for more research into increasing potential fuelwood supplies through the resuscitation of previous established plantations within the study area and environs.

ii. There is also the need to reframe demand interventions to ensure the use of environment-friendly energy sources as alternatives to fuelwood.

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