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IMPACT OF SHIFTING AGRICULTURE ON TREE ABUNDANCE IN AN AGRARIAN COMMUNITY WITHIN THE NIGER DELTA REGION OF NIGERIA

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ABSTRACT
Impact of land use intensification through shifting agriculture on tree abundance was examined using four sites - an uncultivated site, and three fallow plots (Chronosequences 1, 2 and 3) reflecting increasing period and intensity of cultivation. Fourteen (14) tree species belonging to nine families were encountered in the uncultivated site. Tree density was 268 trees /hectare for the entire site while the density for individual species ranged from 3 to 51 trees/ hectare. Seven (7) tree species belonging to 6 families were encountered in Chronosequence 1. Tree density was 77 trees/ hectare for the entire site while the density for the individual species ranged from 2 to18 trees/hectare. In Chronosequence 2, six (6) tree species belonging to 5 families were encountered. Tree density was 142 trees /hectare for the entire site while the density for the individual species ranged from 2 to 54 trees/ hectare. In Chronosequence 3, three (3) tree species belonging to 3 families were encountered. Tree density was 40 trees/ hectare for the entire site while the density for the individual species ranged from 2 to31 trees/hectare. Tree species richness and diversity decreased with an increase in period and intensity of cultivation, with the uncultivated site and Chronosequence 3 having the highest and least diversity, respectively. Variation in tree species composition between the uncultivated site and the fallow plots also increased with increase in period and intensity of cultivation with the highest dissimilarity observed between the uncultivated site and Chronosequence 3. Populations of *Pentaclethra macrophylla, Harungana madagascariensis,* and *Massularia acuminata* compared better in some of the fallow plots than in the uncultivated site, while species like *Ceiba pentandra, Baphia nitida, Napoleona vogelli,* and *Anthonotha macrophylla*, were completely absent in the fallow plots. Land use intensification through shifting agriculture was found to impact negatively on tree abundance. Integrated and more eco-friendly farming systems like farm forestry and agroforestry were suggested as alternatives to shifting cultivation.

Keywords: shifting cultivation, land use intensification, tree populations, change index, Niger delta.

INTRODUCTION

Shifting cultivation is a very popular agricultural practice especially in the tropics. Christanty (1986) defined it as an agricultural system which is characterized by a rotation of field rather than of crops, short period of cropping (one to three years) alternated with long fallow period (up to twenty or more years, but often as short as six to eight years); and clearing by means of slash and burn. However, land used for agriculture and non-agricultural purposes have created land scarcity, leading to shorter fallow periods. In many cases, farmers have reduced their fallow periods below the sustainable level necessary to maintain an ecological balance under shifting cultivation (Harwood, 1996; Adesina *et al.*, 2000; Brady, 1996; Essama-Nssah *et al.*, 2002), thereby making the traditional sustainable slash and burn agriculture unsustainable and environmentally degrading.

The increase in human populations and urbanization particularly in the developing countries, have put tremendous pressure on land. As human populations continue to grow, land use intensity increases, and the negative effects of deforestation are likely to worsen (Chazdon, 2003). The extension of arable cropping for increased food production has been directly responsible for the reduction in forested areas. Reports have shown that 40% of the land surface of the earth was converted into cropland and permanent pasture by early 1990s (Rajiv and Upandhyay, 1999). Due to increase in human populations, fallow periods of shifting cultivation have drastically reduced, making the farmland to be infertile or less fertile. As a result, the hunger for fertile forested lands is on the increase just to meet the demand for food security in the rural areas and to improve the economic situation of the rural dwellers.

Although, shifting cultivation is estimated to support the livelihoods of some 300-500 million people worldwide (Brady, 1996), the slash and burn tendency especially where fallow periods have drastically reduced due to increasing populations, has grave implications for trees and the majority of people that depend on them. The dependence of people on trees and forests is unlimited. More than 25 percent of the world's population - an estimated 1.5 billion people - relies on forest resources for their livelihoods, and of these almost 1.2 billion live in extreme poverty (World Bank, 2001).

Given the importance of trees to the environment and rural livelihoods, the need for empirical ecological knowledge that will aid a systematic understanding of the impact of land use intensification through shifting agriculture, on tree populations, cannot be overemphasized. The study was a step in that direction. The specific objectives are: (1) to determine and compare tree abundance between the uncultivated forestland and arable farmlands of different ages; (2) to ascertain the

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impact of land use intensification through shifting agriculture on tree diversity; (3) to determine the extent of tree species compositional variation and/or similarity between the uncultivated forestland and different chronosequences of cultivated lands; and (4) to ascertain the extent of change in individual tree populations due to varying degrees of shifting cultivation.

MATERIALS AND METHODS

Description of study area

The study was carried out in Emohua Community in Emohua Local Government Area (LGA) of Rivers State, Nigeria. The LGA lies between latitude 4°53′0″N and longitude 6°52′0″E (Wikipedia, 2011). It has an area of 831km^2 and a population of 201, 901 as at the 2006 National Census. Emohua LGA has boundaries with Ikwere, Abua/Odual, Ahoada East, Ogba/Egbema /Ndoni, Obio/Akpor, and Asari-Toru LGAs. The mean monthly temperature ranges from 25^{o}C - 28^{o}C. The mean annual temperature is 20^{o}C. Relative Humidity is high and decreases in the dry season. The average monthly rainfall in Emohua ranges from 29mm-300mm. Different vegetation types are found in Emohua. These are mainly the lowland rainforest, freshwater swamp and mangrove forests. Economic trees which abound in the area include, *Melicia excelsa*, *Cocos nucifera*, *Raffia hookeri*, *Elaeis guineensis*, *Allablanckia florinbunda*, among others.

The Emohua people are predominantly farmers. They produce food crops like yam, cassava, melon, maize, vegetable, etc. The communal lands are usually shared for the purpose of farming. At the end of each farming season, they abandon the farmland for another and later return after some years. The fallow period in the study area presently is 7 years.

Selection and description of the study sites

Four sites were purposively chosen for the study after a reconnaissance survey. The sites were chosen due to their suitability to the objectives of the study. The uncultivated site (4^o 51′ 22.5″ N and 6^{o}50′55.14″ E) which served as the control for the study is a mature secondary forest which has not been subjected to arable farming at least to the best of the knowledge of the elderly persons in the Village. However, the rural dwellers collect Non-Timber Forest Products (NTFPs) from the site. The site is characterized by trees with large girth sizes; mostly pioneer species. Also, lianas and other climbers are present. Chronosequence 1 (4^{o}51′12.02″ N and 6^{o}50′55″ E) is a fallow plot that had been cultivated only once (about 14 years ago). Chronosequence 2 (4^{o}51′17.60″ N and 6^{o}50′58.05″ E) is a fallow plot that had been cultivated 4 times since about 28 years ago. Chronosequence 3 (4^{o}51′54.86 N and 6^{o}50′35.26″ E) is also a fallow plot that has been under cultivation since over 50 years ago. The longest distance between sites was less than 120m while the shortest distance between sites was less than 20m. Figure-1 is the Map of Rivers State showing the study area and the study sites.

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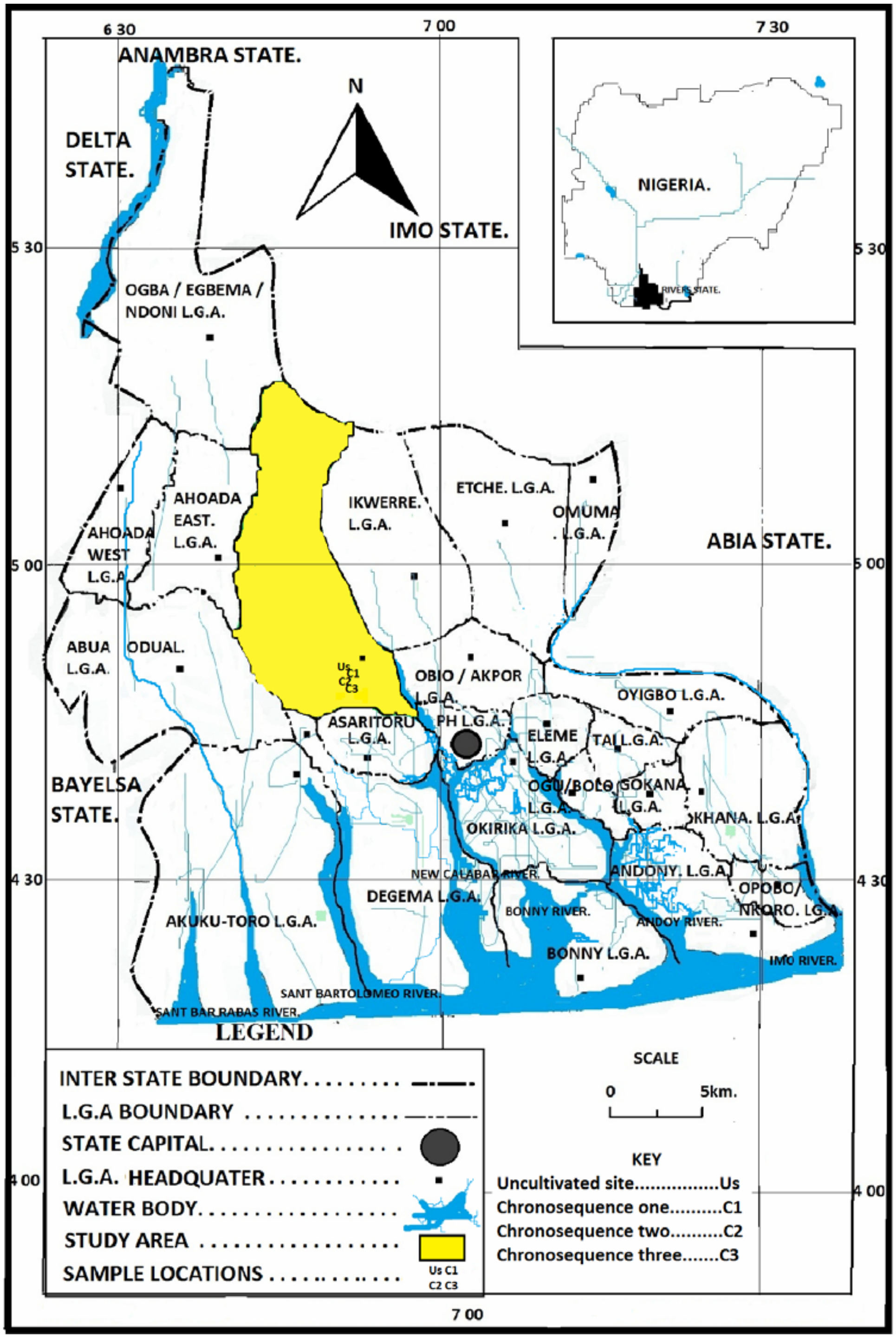

Figure-1. Map of Rivers State showing the study area and the study sites

Study approach

Both the spatial analogue and chronosequence techniques of studying ecosystem dynamics were employed in the study. The spatial analogue method involves spatial sampling on sites that are subject to different land uses but operating within a similar environment. The chronosequence method is a synchronized spatial sampling from neighbouring sites of different ages managed on similar soils, and under similar climatic conditions and management practices (Young, 1991; Hartemink, 1997). These techniques have been widely used by several authors (e.g. Salami, 1998; McDonagh *et al*., 2001; Garten, 2002; Chima *et al*., 2009), to study several aspects of ecosystem dynamics.

Tree enumeration

Five 35m × 35m quadrats were randomly distributed in each of the sites. This quadrat size falls within the range specified in the literature for ecological studies in the humid tropics (Salami, 2006). Narrow cut lines were made to demarcate the plot boundaries. Species identification was done with the aid of the keys provided by Keay (1989). All single-stem woody plants of erect posture with a minimum height of 5m and diameter at breast height (dbh) of 5cm were identified to species level and the number of individuals counted.

Assessment of alpha diversity

Two common approaches for measuring alpha diversity are species richness and evenness/heterogeneity (Ojo, 1996). Species richness simply refers to the number of species in the community while evenness/heterogeneity refers to the distribution of individuals among the species.

In this study, species richness was computed as the total number of tree species encountered in each site. In addition, both Margalef (Clifford and Stephenson, 1975) and Mehinick indices were computed for each of the sites.

- Margalef's Index (ml) = (S - 1) / lnN

Where

S = number of species
N = total number of individuals encountered

- Menhinick's Index (Mh) = S/√N

Where

S = number of species
N = total number of individuals encountered

For the measurement of evenness/heterogeneity, Simpson Index (Simpson, 1949) and Shannon-Wiener Index were computed for each of the sites.

- Simpson's Index is expressed as:

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

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.

- Shannon-Wiener Index is expressed as:

$$H = -\sum_{i=1}^{s} pi \log pi$$

Where

pi = proportion of individuals in the ith species

s = total number of species

Assessment beta diversity

Sorensen's similarity index (Pielou, 1969) was used to measure beta diversity.
Sorensen's index is expressed as:

SI = [a / a + b + c] * 100

Where
a = number of species present in both sites under consideration
b = number of species present in Site 1 but absent in Site 2
c = number of species present in Site 2 but absent in Site 1

Computation of tree density

Tree density (per hectare) was computed for individual tree species in each site by dividing a hectare ($10000m^2$) with the total area sampled ($6125\ m^2$) and multiplying by the number of individuals of that particular species enumerated in the site. The total tree density for each site was then obtained by adding the densities for all the tree species found in that site.

Computation of change index

Change Index (%) was used to measure the extent of change in the populations of the individual tree species due to varying degrees of shifting cultivation. The change index was computed according to Salami (1998); Islam and Weil (2000); Chima *et al*, (2009); and Aiyeloja and Chima (2011).The calculation of the change index was based on the assumption that the mature secondary forest is the ideal vegetation in the area. Therefore, the number of each tree species in the mature secondary forest was taken as an approximation of the optimal number. Consequently, the index of change was derived from the difference between the number of an individual tree species in the mature secondary forest and that of each of the chronosequences. The computed difference was then expressed as a percentage of the number in the mature secondary forest to obtain the Change Index (%), which was used either as a degradation index or an improvement index.

RESULTS

Tree species composition and abundance at the various sites

The various tree species encountered at the various sites and their densities are shown in Tables 1- 4 while the actual number of individuals from which the densities were extrapolated is shown in Table-5. Fourteen (14) species belonging to 9 families were enumerated in the uncultivated site; tree density was 268 trees /hectare for the entire site while the density for the individual tree species ranged from 3 to 51trees/hectare (Table-1). In Chronosequence 1, seven (7) tree species belonging to 6 families were encountered. Tree density was 77 trees / hectare for the entire site while the density for the individual tree species ranged from 2 to18 trees/hectare

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(Table-2). In Chronosequence 2, six (6) tree species belonging to 5 families were encountered. Tree density was 142 trees / hectare for the entire site while the density for the individual tree species ranged from 2 to54 trees/hectare (Table-3). In Chronosequence 3, three (3) species belonging to 3 families were encountered. Tree density was 40 trees/ hectare for the entire site while the density for the individual tree species ranged from 2 to31 trees/hectare.

Table-1. Checklist of tree species encountered in the uncultivated site

S. No.	Species	Family	Density (trees/per hectare)
1	*Elaeis guineensis*	Palmae	51
2	*Funtumia elastica*	Apocynaceae	24
3	*Harungana madagascariensis*	Guttiferae	39
4	*Baphia nitida*	Leguminosae	21
5	*Allanblackia floribunda*	Guttiferae	8
6	*Uapaca sp.*	Euphorbiaceae	15
7	*Pentaclethra macrophylla*	Leguminosae	37
8	*Musanga cecropioides*	Moraceae	15
9	*Anthonotha macrophylla*	Leguminosae	20
10	*Ficus sp.*	Moraceae	3
11	*Ficus exasperata*	Moraceae	13
12	*Ceiba pentandra*	Bombacaceae	8
13	*Napoleona vogelii*	Lecythidaceae	7
14	*Polyalthia sp.*	Annonaceae	7
		Total	268

Table-2. Checklist of tree species encountered in Chronosequence one

S. No.	Species	Family	**Density** (trees/hectare)
1	*Musanga cecropioides*	Moraceae	10
2	*Pentaclethra macrophylla*	Leguminosae	16
3	*Harungana madagascariensis*	Guttiferae	18
4	*Funtumia elastica*	Apocynaceae	3
5	*Allanblackia floribunda*	Guttiferae	10
6	*Uapaca sp.*	Euphorbiaceae	18
7	*Elaeis guineensis*	Palmae	2
		Total	**77**

Table-3. Checklist of tree species encountered in Chronosequence two

S. No.	Species	Family	**Density** (trees/hectare)
1	*Pentaclethra macrophylla*	Leguminosae	41
2	*Massularia acuminata*	Rubiaceae	37
3	*Harungana madagascariensis*	Guttiferae	54
4	*Allanblackia floribunda*	Guttiferae	3
5	*Elaeis guineensis*	Palmae	2
6	*Musanga cecropioides*	Moraceae	5
		Total	142

Table-4. Checklist of tree species encountered in Chronosequence three

S. No.	Species	Family	Density (trees/hectare)
1	*Harungana madagascariensis*	Guttiferae	31
2	*Uapaca sp.*	Euphorbiaceae	7
3	*Massularia acuminata*	Rubiaceae	2
		Total	40

Table-5. Number of individuals of different tree species encountered in all sites

S. No.	Species	Number of individuals			
		Uncultivated site	Chronosequence 1	Chronosequence 2	Chronosequence 3
1	*Elaeis guineensis*	31	1	1	0
2	*Funtumia elastica*	15	2	0	0
3	*Harungana madagascariensis*	24	11	33	19
4	*Baphia nitida*	13	0	0	0
5	*Allanblackia floribunda*	5	6	2	0
6	*Uapaca sp.*	9	11	0	4
7	*Pentaclethra macrophylla*	23	10	25	0
8	*Musanga cecropioides*	9	6	3	0
9	*Anthonotha macrophylla*	12	0	0	0
10	*Ficus sp.*	2	0	0	0
11	*Ficus exasperata*	8	0	0	0
12	*Ceiba pentandra*	5	0	0	0
13	*Napoleona vogelii*	4	0	0	0
14	*Polyalthia sp.*	4	0	0	0
15	*Massularia acuminata*	0	0	23	1
	Total	164	47	87	24

Distribution of tree species among families at various sites

The distribution of the tree species among families is shown in Figure-2. In the Uncultivated Site, the families *Leguminosae* and *Moraceae* had the highest number of species. In Chronosequences 1 and 2, the family *Guttiferae* had the highest number of species; while each of the 3 species encountered in Chronosequence 3 belongs to three different families.

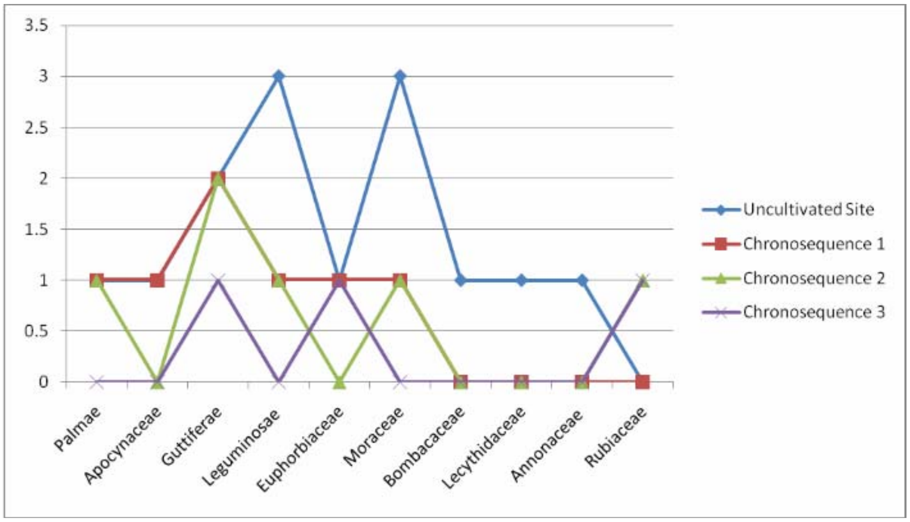

Figure-2. Distribution of tree species among families at the various sites

Tree species diversity at the various sites

The alpha diversity indices for the various sites are shown in Table-6. Tree diversity was highest in the Uncultivated Site, followed by Chronosequences 1 and 2 respectively, while Chronosequence 3 was the least diverse.

Table-6. Alpha diversity indices for the different sites.

	Uncultivated site	Chronosequence 1	Chronosequence 2	Chronosequence 3
Taxa S	14	7	6	3
Shannon H	2.3960	1.7510	1.3320	0.6160
Simpson 1-D	0.8916	0.8103	0.7018	0.3438
Menhinick	1.0930	1.0210	0.6433	0.6124
Margalef	2.5490	1.5580	1.1200	0.6293

Similarity/dissimilarity in tree species composition between sites

Sorensen's similarity indices for different sites are shown in Table-7. Chronosequence 1 is the most similar site to the uncultivated site in terms of tree species composition while Chronosequence 3 is the most dissimilar. Among the cultivated sites, Chronosequence 1 and Chronosequence 2 are the most similar while Chronosequence 1 and Chronosequence 3 are the most dissimilar.

Table-7. Sorensen's similarity indices for the different sites.

	Uncultivated site	Chronosequence 1	Chronosequence 2	Chronosequence 3
Uncultivated Site	*	50.00	33.33	13.33
Chronosequence 1		*	62.50	25.00
Chronosequence 2			*	28.57
Chronosequence 3				*

Extent of change in individual tree populations within the cultivated sites

Indices of change for different tree species are shown in Table-8. In Chronosequence 1, the degradation index ranged from 33.33% (for *Musanga cecropioides*) to 100% (for *Baphia nitida, Anthonotha macrophylla, Ficus spp., Napoleona vogelii, Polyalthia sp.* and *Ceiba pentandra*), while the populations of *Allanblackia floribunda* and *Uapaca sp.* increased by 20% and 22%, respectively.

In Chronosequence 2, the degradation index ranged from 60% (for *Allanblackia florinbunda)* to 100% (for *Funtumia elastica*, *Baphia nitida*, *Uapaca sp.*, *Anthonotha macrophylla*, *Ficus spp*., *Napoleona vogelii*, *Polyalthia sp.* and *Ceiba pentandra*), while the populations of *Pentaclethra macrophylla* and *Harungana madagascariensis* increased by 8.70% and 37.50%, respectively. In Chronosequence 3, the degradation index ranged from 20.83% *(for Harungana madagascariensis*) to 100% (for *Elaeis guineensis*, *Funtumia elastica*, *Baphia nitida*, *Allanblackia floribunda, Pentaclethra macrophylla, Musanga cecropioides*, *Anthonotha macrophylla, Ficus spp*., *Napoleona vogelii*, *Polyalthia sp.* and *Ceiba pentandra*). *Massularia acuminata* was absent in the Uncultivated Site and Chronosequence 1 while it was found in Chronosequences 2 and 3.

Table-8. Indices of change in tree species populations.

Species	**Change index** (%)			
	Uncultivated site	**Chronosequence 1**	**Chronosequence 2**	**Chronosequence 3**
Elaeis guineensis	-	96.77	96.77	100.00
Funtumia elastica	-	86.67	100.00	100.00
Harungana madagascariensis	-	54.17	-37.50*	20.83
Baphia nitida	-	100.00	100.00	100.00
Allablackia floribunda	-	-20.00*	60.00	100.00
Uapaca sp.	-	-22.22*	100.00	55.55
Pentaclethra macrophylla	-	56.52	-8.70*	100.00
Musanga cecropioides	-	33.33	66.67	100.00
Anthonotha macrophylla	-	100.00	100.00	100.00
Ficus sp.	-	100.00	100.00	100.00
Ficus exasperata	-	100.00	100.00	100.00
Ceiba pentandra	-	100.00	100.00	100.00
Napoleona vogelii	-	100.00	100.00	100.00
Polyalthia sp.	-	100.00	100.00	100.00
Massularia acuminata	-	0.00	23^{+}	1^{+}

*A negative index indicates a corresponding percentage increase in the number of the species at the cultivated site in question in relation to the number of that species at the uncultivated site.
$^{+}$ Not actually a change index but the number of individuals of the species encountered where the species is absent in the uncultivated site

DISCUSSIONS

The number of tree species and families was highest in the Uncultivated Site followed by Chronosequences 1, 2, and 3, respectively. The study has shown that the higher the land use intensification through shifting agriculture, the lesser the species richness and the number of families. The within-community (alpha diversity) was also highest in the Uncultivated Site followed by Chronosequences 1, 2 and 3, respectively. This could be attributed to varying degrees of arable farming and land use intensification. Chima *et al.* (2011) in a study carried out in Rivers State attributed low tree species richness and diversity to high human influence and several years of continuous arable cropping.

Tree density was highest in the uncultivated site, followed by chronosequence 2 and Chronosequence 1 respectively, while the least density was recorded in Chronosequence 3. The higher density in Chronosequence 2 than in Chronosequence 1 despite the longer period of cultivation in the former is as a result of higher populations of species like *Harungana madagascariensis*, *Pentaclethra macrophylla*, and *Massularia acuminata,* which are highly valued by the local people. For example, *Harungana madagascariensis* stem is used to stake yams, *Massularia acuminata* is used as chewing stick, while the edible seeds of *Pentaclethra macrophylla* contribute immensely to the livelihoods of the rural dwellers.

In respect of changes in the populations of individual tree species, the study revealed that populations of some species have dwindled to a large extent while some have been lost completely. For instance, the population of *Elaeis guineensis* has reduced by 96.77 % in both Chronosequences 1 and 2, and by 100% in Chronosequence 3. Also populations of other species like *Baphia nitida, Ficus exasperata, Ceiba pentandra, Napoleona vogelii, and Polyalthia sp*., have either been drastically reduced or completely lost. IUCN (2002) observed that habitat loss is responsible for biodiversity loss and ultimate extinction of species.

Despite the deterioration of tree species in the cultivated sites, an improvement in tree populations was observed in some of the fallow plots (especially Chronosequences 1 and 2) for species like *Pentaclethra macrophylla, Harungana madagascariensis* and *Massularia acuminata.* These species seem to have been favoured despite the destructive tendencies of shifting agriculture probably due to their importance to the owners of the farms.

CONCLUSION AND RECOMMENDATIONS

The study has shown that land use intensification through shifting cultivation, can have negative impact on tree populations by reducing tree density, tree species richness, and diversity. It was recommended that plans to reduce further pressure from shifting agriculture on the remaining forests should be put in place by all stakeholders in the community. Since it may not be possible to increase the fallow period beyond the present 7 years due to increasing human populations, efforts should be geared towards introducing and practicing a more eco-friendly system of farming like farm forestry or agroforestry, which allows for the integration of trees and arable crops on the same piece of land.

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