CONSERVATION OF TREE SPECIES DIVERSITY IN TROPICAL RAINFOREST ECOSYSTEM OF SOUTH-WEST NIGERIA

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ADEKUNLE, V. A. J. 2006. Conservation of tree species diversity in tropical rainforest ecosystem of south-west Nigeria. Three reserves, each of size 50 × 50 m, were selected in the ecological zone comprising eight sampling plots. Identification and distribution into families of all woody plants with diameter at breast height (dbh) > 10 cm were carried out. Frequency distribution per ha of each species and relative diversity were determined. A total of 54 different tree species (24 families) were identified in Ala, 41 species (21 families) in Omo and 55 species (20 families) in Shasha Forest Reserves. The most prevalent species in the ecosystem was *Strombosia pustulata*, while the family Leguminosae had the highest number of species. Eighty-four percent of the species are regarded as rare or threatened with extinction while 16% were relatively abundant. The highest species diversity indices were obtained in Shasha Forest Reserve (3.656 and 0.914, Shannon and evenness indices respectively), the lowest in Omo Forest Reserve (3.342 and 0.900 respectively). There was no significant difference in the number of individual ha^{-1} on species basis, the relative density of species and also in the distribution of species into families ($p > 0.05$). Fifty percent of the species could be regarded as habitat generalists as they occurred in the three reserves. The contribution of the ecosystem to rural livelihood in the supply of some products and in environmental conservation and the need for urgent conservation efforts are highlighted.

Keywords: Relative density, vegetation, herbs, rural livelihood, forest reserve, sampling

ADEKUNLE, V. A. J. 2006. Pemuliharaan kepelbagaian spesies pokok di ekosistem hutan hujan tropika di barat daya Nigeria. Tiga hutan simpan, setiap satunya berkeluasan 50 m × 50 m, dipilih di zon ekologi yang mengandungi lapan plot sampel. Semua tumbuhan berkayu yang berdiameter aras dada (dbh) > 10 cm dikenal pasti dan dikelaskan mengikut famili. Sebanyak 54 spesies pokok berbeza (24 famili) di kenal pasti di Hutan Simpan Ala, 41 spesies (21 famili) di Hutan Simpan Omo dan 55 spesies (20 famili) di Hutan Simpan Shasha. Spesies yang paling luas taburannya ialah *Strombosia pustulata* sementara famili Leguminosae mempunyai bilangan spesies yang tertinggi. Sebanyak 84% spesies dianggap sebagai spesies nadir atau terancam oleh kepupusan sementara 16% spesies mempunyai bilangan yang agak tinggi. Indeks kepelbagaian spesies yang paling tinggi didapati di Hutan Simpan Shasha (indeks Shannon 3.656, indeks malar 0.914) sementara yang paling rendah adalah di Hutan Simpan Omo (indeks Shannon 3.342, indeks malar 0.900). Tidak terdapat perbezaan ketara dalam jumlah individu per hektar ($p > 0.05$) dari segi spesies, ketumpatan relatif spesies dan juga taburan spesies mengikut famili. Lima puluh peratus spesies boleh dianggap sebagai juruam habitat kerana spesies-spesies tersebut wujud dalam ketiga-tiga hutan simpan. Turut dibincangkan dalam kertas kerja ini ialah sumbangan ekosistem terhadap mata pencarian penduduk luar bandar dari segi bekalan sesetengah produk dan juga dari segi pemuliharaan alam sekitar serta keperluan usaha pemuliharaan yang segera.

INTRODUCTION

Only less than 10% of land area in Nigeria is under forest reserves, although the proposed area was 25% (NEST 1991). Rapid rate of forest reduction heightens the importance of managing tropical rainforests. Principal causes of deforestation in Nigeria include clearance for agriculture, road construction and plantation establishment, uncontrolled exploitation, and poor organization and funding of the forestry subsector. As a result of the ever-increasing demand for food, tropical rainforests are encroached and clear felled for agricultural purposes by poor farmers and landless people.

A considerable part of Nigerian forest is also being destroyed through indiscriminate and reckless logging of timber, extraction of non-timber

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forest products and log transportation. There are always felling damages to residual plants and total vegetation removal during roads and gantry constructions. During these activities, wild animals are killed and their habitats are destroyed, altering their feeding and grazing pattern.

A plantation programme aimed at establishing one million hectares of rainforest in Nigeria was proposed due to the slow regeneration habit of natural forest, fear of its total disappearance and the determination of the forestry subsector to meet the increasing demand for wood. Only 224 524 ha (22.5%) of this projection have been established and about 76% of them are located in the tropical rainforest region of southern Nigeria. During plantation establishment, the natural forests are usually clear felled of their native plants. Wanton removal of plant and animal species through these activities is very inimical to biological conservation and has led to loss of biodiversity and extinction especially of many natural species with narrow range.

This study was conducted to assess tree species evenness, relative abundance (the number of individuals of a given species divided by the total number of individuals of all species found), family level richness and community diversity of tropical rainforest ecosystem in south-west Nigeria. Three forest reserves were selected from the vegetation for the study. The contribution of the ecosystem to rural livelihood was also determined. Attention was paid to species that require urgent conservation measure (rare and endemic species) and those that offer the greatest potential for sustainable use.

MATERIALS AND METHODS

The study area is part of the tropical rainforest ecosystem in south-west Nigeria. This ecological zone is located between latitudes 24° S and 24° N and longitudes 10° E and 20° W. In south-west Nigeria, tropical rainforest begins a few kilometers inland along the coast and forms a continuous strip of green belt separating the coastal vegetation from the derived and Guinea savanna vegetations. It is 300 km wide in its widest area. The mean annual temperature is between 20 and 28 °C and the mean annual rainfall, between 1200 and 2100 mm. It is an area with high relative humidity.

Three forest reserves within the tropical rainforest ecosystem were selected for data collection. The selection was done to cover the region adequately. The selected reserves were those that are properly managed by the State government. So, logging and other activities are controlled and encroachment, illegal felling and reckless exploitation of the forest resources are reduced.

The selected reserves were as follows:
(1) Shasha Forest Reserve (215 km^2). This is located in Ife South Local Government Area of Osun State. It lies between latitudes 9° 4' and 9° 50' N and longitudes 3° 54' and 4° 6' E. The altitude of the forest is 122 m with a mean annual rainfall of 1421 mm. The soil type is the ferruginous tropical soils on crystalline acid rock, the topography gently undulating plain.
(2) Omo Forest Reserve (460 km^2). This is located in area J4, Ijebu East Local Government Area of Ogun State. It is located between latitudes 60° 35' and 70° 05' N and longitudes 4° 05' and 4° 40' E. It is bounded by Benin-Lagos express road to the south and by Omo and Oni rivers to the east.
(3) Ala Forest Reserve (166 km^2) which is located in Akure North Local Government Area of Ondo State. It lies between latitude 6° 45' and 7° N and longitude 5° and 5° 10' E. It is divided into 100 annual coupes for effective management.

Data collection

Systematic cluster sampling technique was adopted for plot location in each of the three sites. The 1000 × 200 m area, referred to as cluster, was divided into two 200 × 200 m tracts. The tracts were 600 m apart. The cluster was located inside the reserve where the vegetation was relatively undisturbed and edge effect adequately overcome. Each tract was further divided into plots of 50 × 50 m. Four plots were selected for the study; these were at the end of south-west and south-east corners of each tract as shown in Figure 1. All living trees with diameter at breast height (dbh) > 10 cm on each field plot were recorded by species. All tree species were assigned to families and relative diversity (number of species in a family) was obtained for tree species diversity classification. Number of trees encountered in the sampling plots on species basis was extrapolated by multiplying it

with the number of plots ha^{-1} to obtain the abundance of the species in one hectare. Relative density was calculated according to Oduwaye *et al.* (2003):

$$RD = \frac{n_i}{N} \times 100$$

where
RD = relative density
n_i = number of individuals of species i
N = total number of individual in the entire population

Analysis of variance (ANOVA) was used to test for differences in the number of trees per hectare, species abundance, relative density and family richness. Where significant differences were discovered to exist, Fishers' least square difference was used for mean separation. Community diversity indices were calculated from a mathematical formula that takes into account both species richness and relative abundance of each species in the community. The equation for the Shannon-Weaver diversity index (Price 1997) used was:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

H' = Shannon diversity index
S = total number of species in the community
p_i = relative density

Evenness (E) was calculated as described by Magurran (1988):

$$E = \frac{H'}{\ln S}$$

For site occupancy analysis, the number of sites from which a family was sampled was determined and any family found in the three sites was referred to as a habitat generalist (Hughes *et al.* 2000).

RESULTS AND DISCUSSION

The results of this study showed the level of tree species diversity, richness and distribution in tropical rainforest ecosystem as represented by the sites selected for this study. A total of 55 species (20 families) were encountered in Shasha Forest Reserve, 54 (24 families) in Ala Forest Reserve and 41 (21 families) in Omo Forest Reserve (Tables 1–3). A total of 81 species distributed among 30 families were identified across the three sites. The species with highest number of individual ha^{-1} was *Strombosia pustulata* with a relative density of 9.4% in Shasha, 8.1% in Ala and 9.6% in Omo Forest Reserves. The number of individual trees ha^{-1} of all species was 159, 148 and 115 in Shasha, Ala and Omo Forest Reserves respectively. In Shasha, 12.7% of the species were encountered more than five times ha^{-1} and 56.4% occurred only once. In Ala, 13% of the species were encountered more than five times ha^{-1} and 46.3% occurred only once ha^{-1}. In Omo, 12.2% species occurred more than five times and 39.0% were encountered only once ha^{-1}.

The results of the Shannon index (H') indicated that the highest community diversity was discovered in Shasha Forest Reserve (3.656). This is followed by Ala Forest Reserve (3.621) while the least value was obtained for Omo Forest Reserve (3.342). The species diversity values obtained for the three sites were very close. This showed that the sites were able to conserve tree species diversity. Species evenness (E) results followed the same pattern as H'. The highest value 0.914 was obtained for Shasha Forest Reserve while 0.908 and 0.900 were obtained for Ala and Omo respectively. The Ogun State Plantation Development Project has converted a large part of the Omo Forest Reserve to plantations of fast growing exotic and indigenous species. Between 1966 and 1996, a total of 26 983 ha of the forest has been converted for this purpose. This practice does not support biodiversity conservation.

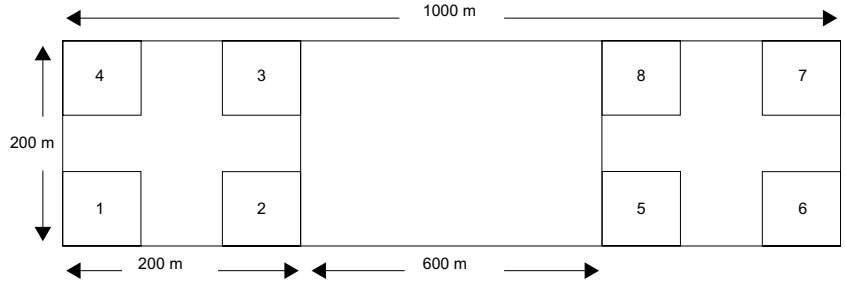

Figure 1 Systematic cluster sampling technique adopted for sample plot location (plot size = 50 × 50 m)

Table 1 Species, relative frequency and Shannon index in Shasha Forest Reserve

Species	Family	No ha^{-1}	Relative density (%)	$p_i \ln p_i$
Afzelia africana	Leguminosae	1	0.63	-0.032
Albizia ferruginea	Leguminosae	3	1.89	-0.075
Albizia zygia	Leguminosae	1	0.63	-0.032
Alstonia congensis	Apocynaceae	1	0.63	-0.032
Antiaris africana	Moraceae	1	0.63	-0.032
Baphia nitida	Papilonaceae	1	0.63	-0.032
Bombax bounopozense	Bombaceae	1	0.63	-0.032
Brachystegia nigerica	Leguminosae	1	0.63	-0.032
Carapa procera	Meliaceae	1	0.63	-0.032
Ceiba pentandra	Bombaceae	5	3.14	-0.109
Celtis zenkeri	Ulmaceae	6	3.77	-0.124
Cleistopholis patens	Annonaceae	1	0.63	-0.032
Cola gigantea	Sterculiaceae	2	1.26	-0.055
Cordia millenii	Boraginaceae	5	3.14	-0.109
Cordia platythyrsa	Boraginaceae	8	5.03	-0.15
Cylicodiscus gabunensis	Leguminosae	1	0.63	-0.032
Daniellia ogea	Leguminosae	1	0.63	-0.032
Diospyros dendo	Ebenaceae	1	0.63	-0.032
Diospyros iturensis	Ebenaceae	11	6.92	-0.185
Drypetes chevalieri	Euphobiaceae	7	4.40	-0.137
Enantia chloranta	Annonaceae	1	0.63	-0.032
Entandrophragma angolensis	Meliaceae	2	1.26	-0.055
Erythrophleum guineense	Leguminosae	1	0.63	-0.032
Ficus exasperata	Moraceae	1	0.63	-0.032
Funtumia elastica	Apocynaceae	2	1.26	-0.055
Gossweilerodendron balsamiferum	Leguminosae	1	0.63	-0.032
Guarea thompsonii	Meliaceae	1	0.63	-0.032
Harungana madagascariensis	Gultiferaceae	1	0.63	-0.032
Hildegardia barteri	Sterculiaceae	1	0.63	-0.032
Irvingia gabonensis	Irvingiaceae	1	0.63	-0.032
Khaya ivorensis	Meliaceae	1	0.63	-0.032
Lovoa trichilioides	Meliaceae	1	0.63	-0.032
Macaranga staudtii	Euphobiaceae	1	0.63	-0.032
Manilkara obovata	Sapotaceae	2	1.26	-0.055
Mansonia altissima	Sterculiaceae	9	5.66	-0.163
Milicia excelsa	Moraceae	1	0.63	-0.032
Mitragyna ciliata	Rubiaceae	1	0.63	-0.032
Morus mesozygia	Moraceae	1	0.63	-0.032
Nesogordonia papaverifera	Sterculiaceae	2	1.26	-0.055
Parinari robusta	Rosaceae	2	1.26	-0.055
Pausinystalia johimbe	Rubiaceae	1	0.63	-0.032
Pterygota macrocapa	Sterculiaceae	1	0.63	-0.032
Pycnanthus angolensis	Myristicaceae	3	1.89	-0.075
Ricinodendron heuderotii	Euphobiaceae	5	3.14	-0.109

(continued)

(Table 1 - continued)

Species	Family	No ha^{-1}	Relative density (%)	$p_i \ln p_i$
Sterculia oblonga	Sterculiaceae	11	6.92	-0.185
Sterculia rhinopetala	Sterculiaceae	5	3.14	-0.109
Sterculia tragacantha	Sterculiaceae	5	3.14	-0.109
Strombosia pustulata	Olacaceae	15	9.43	-0.223
Terminalia ivorensis	Combretaceae	5	3.14	-0.109
Terminalia superba	Combretaceae	5	3.14	-0.109
Treculia africana	Moraceae	1	0.63	-0.032
Trichilia monadelpha	Meliaceae	1	0.63	-0.032
Triplochiton scleroxylon	Sterculiaceae	5	3.14	-0.109
Xylopia aethiopica	Annonaceae	1	0.63	-0.032
Zanthoxylum zanthoxyloides	Rutaceae	3	5.08	-0.151
	Total	159		-3.656
			H'	3.656

The family with the highest number of species in the ecosystem was Leguminosae with eight species in Shasha, nine species in Ala and five in Omo Forest Reserves (Table 4). Sterculiaceae had the highest number of species (nine) in Shasha Forest Reserve. This is followed by Meliaceae with six species in Shasha. Moraceae had six species in Ala Forest Reserve. Apocynaceae, Leguminosae and Sterculiaceae each had four species each in Omo Forest Reserve. These results also confirmed that the lowland rainforest ecosystem had few species with large numbers of individuals and many species with few numbers of individuals. *Strombosia pustulata*, *Drypetes paxii*, *Cordia millenii* and *Mansonia altissima* were abundant but they made up only 15% of species encountered in the entire ecosystem. These different species were mixed in uneven proportions. Table 5 is the summary of tree species diversity and distribution in the ecological zone.

From the one-way analysis of variance (ANOVA), there were no significant differences in species abundance per hectare ($F = 0.036$, df 2: 147, $p \geq 0.05$), relative density of species ($F = 1.113$, df 2: 147, $p \geq 0.05$) and distribution of species into families ($F = 1.027$, df 2: 68, $p \geq 0.05$) (Table 6). Therefore, the numbers of species and families in tropical rainforest do not differ across the reserves as shown by the sites selected for this study. The results of the habitat occupancy and specialization revealed that 50% of the families occurred in three sites (habitat generalist), 30% in two sites and 20% in a single site (Figure 2). Species richness and distribution are the most important characteristics of tropical rainforest ecosystem.

Regardless of plot size, the number of tree species is far greater in tropical rainforest than in any other forest community. However, the number of trees and species encountered in this study was low compared with previous reports by Nwoboshi (1982), FORMECU (1999) and Akindele (2000). This is an indication that the ecosystem studied had been adversely affected and disturbed by the growing human population. As a result, some species were extinct while several others were endangered.

This forest type is the major source of economic hardwood exploited for timber. The rate of timber exploitation increased as it generates more revenue. Forestry subsector contributes significantly to the States' internally generated revenue in south-west Nigeria. Between 1996 and 2000 forestry contributed a total of ₦600 m to Ondo State's revenue (Akindele 2003). This amount was mainly from sales of wood and tariff on forest products from the reserves in the State.

The endangered species in Nigerian forests due to encroachment, logging and exploitation for food, herbs, firewood and other products have been reported. In some Nigerian States with lowland rainforest vegetation, some of the rare species have been banned from exploitation because they were on the verge of extinction. Some of the banned species found in this study include *Diospyros* spp. and *Milicia excelsa*. These species are the most valued hardwood species in Nigeria for the supply of sawn timbers and timber contractors usually harvest them before they attain the minimum girth (48 cm) for harvest as specified by the policy in Nigeria.

Table 2 Species, relative frequency and Shannon index in Ala Forest Reserve

Species	Family	No ha^{-1}	Relative density (%)	$p_i \ln p_i$
Afzelia africana	Leguminosae	6	4.05	-0.13
Albizia ferruginea	Leguminosae	4	2.70	-0.098
Albizia zygia	Leguminosae	2	1.35	-0.058
Alstonia boonei	Apocynaceae	6	4.05	-0.13
Antiaris africana	Moraceae	5	3.38	-0.114
Antiaris toxicaria	Moraceae	3	2.03	-0.079
Avicennia germinans	Avicenniaceae	1	0.68	-0.034
Berlinia grandiflora	Leguminosae	1	0.68	-0.034
Bombax buonopozense	Bombaceae	2	1.35	-0.058
Bosqueia angolensis	Moraceae	1	0.68	-0.034
Brachystegia enrycoma	Leguminosae	1	0.68	-0.034
Brachystegia nigerica	Leguminosae	1	0.68	-0.034
Canarium schweinfurthii	Burseraceae	1	0.68	-0.034
Celtis zenkeri	Ulmaceae	1	0.68	-0.034
Chrysophyllum albidum	Sapotaceae	1	0.68	-0.034
Cleistopholis patens	Annonaceae	1	0.68	-0.034
Cola gigantea	Sterculiaceae	2	1.35	-0.058
Cordia millenii	Boraginaceae	9	6.08	-0.17
Cordia platythyrsa	Boraginaceae	1	0.68	-0.034
Crossopteryx febrifuga	Rubiaceae	2	1.35	-0.058
Daniellia ogea	Leguminosae	1	0.68	-0.034
Entandrophragma angolense	Meliaceae	1	0.68	-0.034
Ficus exasperata	Moraceae	2	1.35	-0.058
Gossweilerodendron balsamiferum	Leguminosae	2	1.35	-0.058
Guarea thompsonii	Meliaceae	1	0.68	-0.034
Harungana madagascariensis	Gultiferaceae	3	2.03	-0.079
Hevea brasiliensis	Euphorbiaceae	4	2.70	-0.098
Hunteria umbellate	Apocyaceae	1	0.68	-0.034
Irvingia gabonensis	Irvingiaceae	1	0.68	-0.034
Khaya grandifoliola	Meliaceae	1	0.68	-0.034
Khaya ivorensis	Meliaceae	2	1.35	-0.058
Lannea welwitschii	Anacardaceae	2	1.35	-0.058
Lecaniodiscus cupanioides	Sapindaceae	1	0.68	-0.034
Lophira alata	Ochnaceae	1	0.68	-0.034
Lovoa trichilioides	Meliaceae	3	2.03	-0.079
Macaranga spp.	Euphorbiaceae	1	0.68	-0.034
Mansonia altissima	Sterculiaceae	10	6.76	-0.182
Milicia excelsa	Moraceae	1	0.68	-0.034
Mitragyna ciliata	Rubiaceae	2	1.35	-0.058
Nesogordonia papaverifera	Sterculiaceae	1	0.68	-0.034
Parinari congensis	Rosaceae	1	0.68	-0.034
Parinari robusta	Rosaceae	1	0.68	-0.034
Pentaclethra macrophylla	Leguminosae	2	1.35	-0.058
Pterygota macrocarpa	Sterculiaceae	4	2.70	-0.098

(continued)

(Table 2 - continued)

Species	Family	No ha^{-1}	Relative density (%)	$p_i \ln p_i$
Ricinodendron heudelotii	Euphorbiaceae	2	1.35	-0.058
Sterculia oblonga	Sterculiaceae	2	1.35	-0.058
Sterculia rhinopetala	Sterculiaceae	12	8.11	-0.204
Strombosia pustulata	Olacaceae	12	8.11	-0.204
Terminalia ivorensis	Combretaceae	2	1.35	-0.058
Terminalia superba	Combretaceae	4	2.70	-0.098
Treculia africana	Moraceae	4	2.70	-0.098
Triplochiton schleroxylon	Sterculiaceae	8	5.41	-0.158
Vitex doniana	Verbenaceae	1	0.68	-0.034
Zanthoxylum zanthoxyloides	Rutaceae	1	0.68	-0.034
	Total	148		-3.621
			H'	3.621

The socio-economic importance of the tree species encountered in tropical rainforests cannot be overemphasized. They serve as means of survival for rural dwellers by providing essential goods and services, e.g. chewing sticks, firewood, stakes, poles, nuts, honey, fruits, fodder, drugs, fibres, spices, resins and gum. The forest products are also sources of raw materials for several cottage industries very common in rural areas of Nigeria. The wild fruits found in the study areas (e.g. *Chrysophyllum albidum, Irvingia gabonensis, Treculia africana, Dialium guineense, Lecaniodiscus cupanioides, Vitex doniana* and *Cola milleni*) are sources of vitamins, proteins and income for the people.

The medicinal value of some of the tree species identified in the study areas is also worth noticing. Herbal medicine is very popular among rural dwellers and urban poor. They rely on medicinal plants such as *Antiaris africana, Alstonia boonei, Zanthoxylum zanthoxyloides, Ceiba pentandra, Xylopia aethiopica,* and *Khaya* spp. to cure various ailments including sickle cell anemia, diarrhoea, dysentery and epilepsy. The herbs are either concocted or decocted and sometimes several different plant species are combined for effectiveness. The high cost of medicine is another reason why these people cannot dispense with the use of herbs.

Chewing sticks as cheap substitute for chemical dentifrice is gaining popularity in Africa. The increase in the prices of chemical toothpaste and brushes has made them inaccessible to the masses. Species harvested as chewing sticks were *Z. zanthoxyloides* and *D. guineense*. However *Massularia acuminata*, the most popular species used in Nigeria, was not encountered in the three study sites. This species is almost extinct in part of Nigeria rainforests and is being imported from other countries (Aderounmu *et al.* 2002).

Many small-scale industries in the rural communities derive their raw materials from the tropical rainforest. These small-scale industries require little or no initial capital investment and they are sources of employment for many rural dwellers. Some of the common small-scale industries in the rural areas that depend so much on the forest species include craftworks (e.g. basket weaving), carving and production of farm tool handles. *Diospyros* spp. and *Lecaniodiscus cupanioides* are common species for carving and making farm tool handles respectively by the rural dwellers in the study areas. Timber is economically the most important forest product in Nigeria. About 52% of trees species were harvested for timber and 2% for herbs in this study (Table 7).

Reserve conservation through *in situ* and *ex situ* methods will make the ecosystem sustainable. *In situ* conservation is achieved through effective management of permanent sample plots, nature reserves, game reserves, forest reserves and sacred groves. This will allow the continued existence of species in their natural habitat and remove the difficulties in trying to conserve them outside their ecosystem. In Nigeria, all these are located within the gazetted Forest Reserves, which should ensure increased protection. Unfortunately, these plots have been tampered with through various human activities. *Ex situ* conservation methods involve conserving and maintaining the genetic resources outside its

Table 3 Species, relative frequency and Shannon index in Omo Forest Reserve

Species	Family	No ha^{-1}	Relative density (%)	$p_i \ln p_i$
Albizia zygia	Leguminosae	1	0.87	-0.041
Alstonia boonei	Apocynaceae	2	1.74	-0.07
Anthocleista vogelii	Longaniacea	1	0.87	-0.041
Ceiba pentandra	Bombaceae	1	0.87	-0.041
Chrysophyllum perpulchrum	Sapotaceae	9	7.83	-0.199
Chrysophyllum albidum	Sapotaceae	1	0.87	-0.041
Cleistopholis patens	Annonaceae	1	0.87	-0.041
Cola gigantea	Sterculiaceae	2	1.74	-0.07
Cordia millenii	Bignoniaceae	9	7.83	-0.199
Corynanthe pachyceras	Rubiaceae	2	1.74	-0.07
Dialium guineense	Leguminosae	1	0.87	-0.041
Desplatsia spp.	Tiliaceae	1	0.87	-0.041
Diospyros crassiflora	Ebenaceae	3	2.61	-0.095
Diospyros dendo	Ebenaceae	10	8.70	-0.212
Diospyros iturensis	Ebenaceae	1	0.87	-0.041
Dracaena mannii	Agavaceae	3	2.61	-0.095
Drypetes gossweileri	Euphorbiaceae	4	3.48	-0.117
Drypetes paxii	Euphorbiaceae	11	9.57	-0.225
Entandrophragma angolense	Meliaceae	2	1.74	-0.07
Ficus exasperata	Moraceae	1	0.87	-0.041
Funtumia elastica	Apocynaceae	1	0.87	-0.041
Harungana madagascariensis	Gultiferaceae	2	1.74	-0.07
Holoptelea grandis	Ulmaceae	1	0.87	-0.041
Hunteria umbellata	Apocynaceae	3	2.61	-0.095
Khaya ivorensis	Meliaceae	2	1.74	-0.07
Mitragyna ciliata	Rubiaceae	2	1.74	-0.07
Musanga cecropioides	Moraceae	2	1.74	-0.07
Parinari robusta	Rosaceae	2	1.74	-0.07
Picralima nitida	Apocynaceae	1	0.87	-0.041
Piptadeniastrum africanum	Leguminosae	2	1.74	-0.07
Pterocarpus osun	Leguminosae	2	1.74	-0.07
Pterygota macrocarpa	Sterculiaceae	1	0.87	-0.041
Pycnanthus angolensis	Myristicaceae	3	2.61	-0.095
Ricinodendron heudelotii	Euphorbiaceae	2	1.74	-0.07
Sterculia rhinopetala	Sterculiaceae	2	1.74	-0.07
Strombosia pustulata	Olacaceae	11	9.57	-0.225
Terminalia ivorensis	Combretaceae	1	0.87	-0.041
Terminalia superba	Combretaceae	5	4.35	-0.136
Trichilia tessmannii	Meliaceae	1	0.87	-0.041
Triplochiton scheroxylum	Sterculiaceae	2	1.74	-0.07
Xylopia aethiopica	Annonaceae	1	0.87	-0.041
	Total	115		-3.342
			H’	3.342

Table 4 Family distribution of species in the forest reserves studied

Family	No. of species		
	Shasha	Ala	Omo
Agavaceae	-	-	1
Anacardaceae	-	1	-
Annonaceae	3	1	2
Apocynaceae	2	2	4
Avicenniaceae	-	1	-
Bignonaceae	-	-	1
Bombaceae	2	1	1
Boraginaceae	2	2	-
Burseraceae	-	1	-
Combretaceae	2	2	2
Ebenaceae	2	-	3
Euphorbiaceae	4	3	3
Gultiferaceae	1	1	1
Irvingiaceae	1	1	-
Leguminosae	8	9	4
Longaniaceae	-	-	1
Meliaceae	6	5	3
Moraceae	5	6	2
Myristicaceae	1	-	1
Ochnaceae	-	1	-
Olacaceae	1	1	1
Rosaceae	1	2	1
Rubiaceae	2	2	2
Rutaceae	1	1	-
Sapindaceae	-	1	-
Sapotaceae	1	1	2
Sterculiaceae	9	7	4
Tiliaceae	-	-	1
Ulmaceae	1	1	1
Verbenaceae	-	1	-
Total	55	54	41

area of origin. This aids in the introduction of new species as well as breeding and multiplication of difficult species and those that are heavily exploited.

CONCLUSIONS

The information obtained in this study clearly indicated the diversity of tree species in tropical rainforest ecosystem of south-west Nigeria. The reduction in the number of trees ha^{-1} and species richness when compared with previous reports revealed that the ecosystem has been disturbed by various activities of man. The small percentage of industrial timber species in these forest reserves is also an indication that the lowland rainforest ecosystem of south-west Nigeria is under threat.

Forest policy makers should, therefore, intensify the management of tropical natural forest using *in situ* and *ex situ* conservation methods. Controlling the intensity of tree harvesting, improving logging practice and stopping illegal felling can reduce the damage to rainforest structure and biodiversity. Reduction in wood waste generated in the wood industries through adequate maintenance of machines and establishment of integrated wood industries will go a long way in reducing the pressure on the forest.

Officers patrolling the forest (forest and game guards) should enforce the existing forest laws and edicts, and arrest and prosecute illegal exploiters of natural resources to serve as deterrent to others. These laws include the 'endangered

Table 5 Summary of tree species diversity and distribution in the study area

Site	No. of Species	No. of individual trees	No. of families	H'	E
Shasha FR	55	159	20	3.656	0.914
Ala FR	54	148	24	3.621	0.908
Omo FR	41	115	21	3.342	0.900

H' = Shannon diversity index; E = Evenness

Table 6 Significant differences in number ha^{-1}, species distribution among the families and relative density

Study site	Abundance of species ha^{-1}	Relative density	Species distribution among families
Shasha FR	2.89 ± 0.418	1.876 ± 0.269	2.50 ± 0.28
Ala FR	2.74 ± 0.378	1.854 ± 0.255	2.08 ±0.25
Omo FR	2.80 ± 0.449	2.440 ± 0.160	1.78 ± 0.16

Table 7 Selected economic uses of tree species and their relative abundance in the study area

Uses	No of individuals ha^{-1}	No. of species	% total of species found in the study area
Timber	105	42	51.85
Medicinal	79	21	25.92
Edible fruits, nuts and condiment	54	15	18.52
Chewing sticks	5	4	4.94
Leaves for wrapping	4	2	2.47
Rubber, resin and gum	28	19	23.46

Note: The total number of species across the three sites is 81 but some species have more than one uses.

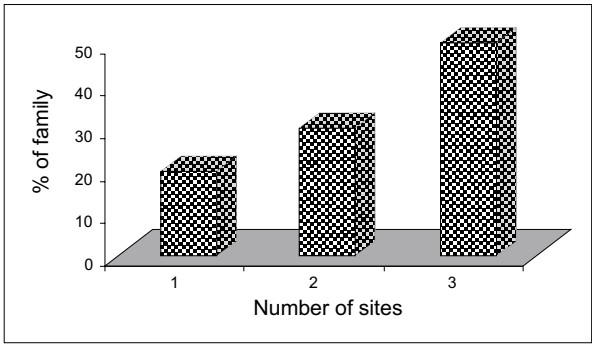

Figure 2 Habitat occupancy of families

species' law (Control of International Traffic) Decree No. 11 of 1985, the National Resources Conservation Council Decree 1989 and the Forestry Amendment Edict of Western State, 1973.

Exploitation of trees below the merchantable size should be prevented in totality. Even when trees are removed, it should be done in a way to preserve the residual trees and the forest ecosystem. The lesser-utilized species should be researched on to improve their durability so as to reduce pressure on the most economic species being threatened with extinction. The conversion of natural forest into plantations of fast growing exotic species should be discouraged. This is because monocultures do not give room for biodiversity conservation. Free areas, as well as marginal and degraded land should be devoted for plantation development.

REFERENCES

Aderounmu, A. F., Ladipo, D. O. & Adebisi, A. A. 2002. Nigerian chewingstick species: diminishing non-timber forest resources with immense commercial potential. Pp. 119–126 in Abu, J. E. *et al.* (Eds.) *Forestry and Challenges of Sustainable Livelihood. Proceedings of the Annual Conference of the Forestry Association of Nigeria.* 4–8 November 2002. Akure.

Akindele, S. O. 2000. An overview of the national forest resources study of Nigeria. In Jand, R. *et al.* (Eds.) XXI IUFRO Kuala Lumpur World Congress. *Poster Abstract* 3(4): 145.

AKINDELE, S. O. 2003. Protection of our Forest: The Challenges. Invited paper presented at the workshop organized by Ondo State Ministry Agriculture, Fisheries and Forest Resources on 4 November 2003. Akure.

FORMECU 1999. *Forest Resources Study of Nigeria.* Overview Revised National Report prepared for Forest Management, Evaluation and Coordinating Unit of the Federal Department of Forestry Abuja. *Geomatics International Inc.* (1): 108.

HUGHES, J. B., DAILY, G. C. & EHRLICH, P. R 2000. Conservation of insect diversity, a habitat approach. *Conservation Biology* 14(6): 1788–1797.

MAGURRAN, A. E. 1988. *Ecological Diversity and Its Measurement.* Princeton University Press, Princeton.

NEST. 1991. *Nigeria Threatened Environment.* Nigeria Environment Study/Action Team, Ibadan.

NWOBOSHI, L. C. 1982. *Tropical Silviculture, Principles and Techniques.* Ibadan University Press, Ibadan.

ODUWAIYE, E. A., OYELEYE, B. & OGUNTALA, A. B. 2003. Species diversity and potentiality for forest regeneration in Okomu permanent sample plot. Pp. 264–271 in Abu, J. E. *et al.* (Eds.) *Forestry and Challenges of Sustainable Livelihood. Proceedings of the Annual Conference of the Forestry Association of Nigeria.* 4–8 November 2002. Akure.

PRICE, P. W. 1997. *Insect Ecology.* Third Edition. Wiley, New York.