ROLE OF SACRED GROVE IN IN-SITU BIODIVERSITY CONSERVATION IN RAINFOREST ZONE OF SOUTH-WESTERN NIGERIA

JC Onyekwelu* & JA Olusola

Department of Forestry and Wood Technology Federal University of Technology, PMB 704, Akure, Nigeria

Received July 2012

ONYEKWELU JC & OLUSOLA JA. 2014. Role of sacred grove in in-situ biodiversity conservation in rainforest zone of south-western Nigeria. Though sacred groves were established for spiritual purposes, they are contributing to in-situ biodiversity conservation. The role of groves in biodiversity conservation in south-western Nigeria was investigated in Osun-Osogbo and Igbo-Olodumare sacred groves and compared with degraded and primary forests. All trees (diameter at breast height (dbh) ≥ 10 cm) were identified and their dbh values measured in each of the 48 temporary sample plots of 20 m × 40 m. Tree seedlings were assessed within 5 m × 10 m quadrat. Osun-Osogbo grove had the highest species abundance (61), diversity index (3.54), number of seedlings (66 species), species evenness (0.66) and percentage of endangered tree species (32.6%) which indicated its importance in in-situ biodiversity conservation. The lower diversity indices of Igbo-Olodumare grove is attributed to its rockiness and low-sacredness, which has led to encroachment. Sacred groves were preserved by fear of deity, cultural importance and place of worship. Benefits derived from groves by the community included healing, protection, tourism and employment. Tree felling within groves was regarded as abomination and sacrifices must be offered before any tree was felled. The rules and taboos used to preserve/protect the groves are crumbling, which must be addressed if they are to continue playing important role in in-situ biodiversity conservation.

Keywords: Primary forest, degraded forest, tree seedlings, Osun-Osogbo, Igbo-Olodumare, deity taboos

ONYEKWELU JC & OLUSOLA JA. 2014. Peranan kelompok pokok suci dalam pemuliharaan biodiversiti *in situ* di zon hutan hujan barat daya Nigeria. Walaupun kelompok pokok suci ditubuhkan bagi tujuan kerohanian, ia turut menyumbang dalam pemuliharaan *in situ*. Peranan kelompok pokok dalam pemuliharaan biodiversiti di barat daya Nigeria diselidik di Osun-Osogbo dan Igbo-Olodumare dan keputusan dibandingkan dengan hutan usang serta hutan primer. Semua pokok (diameter aras dada (dbh) ≥ 10 cm) dicam dan dbh diukur di setiap satu daripada 48 plot sementara berukuran 20 m × 40 m. Anak biji benih pokok dinilai dalam kuadrat 5 m × 10 m. Kelompok pokok di Osun-Osogbo mempunyai kelimpahan tertinggi (61), begitu juga indeks diversiti (3.54), bilangan anak benih (66 spesies), kesamaan spesies (0.66) dan peratusan spesies terancam (32.6%). Ini menunjukkan kepentingan kelompok pokok ini dalam pemuliharaan *in situ*. Indeks diversiti yang lebih rendah di kelompok pokok Igbo-Olodumare disebabkan oleh kawasannya yang berbatu serta dianggap kurang suci, lantas menyebabkan kawasan ini diceroboh. Kelompok pokok suci dipelihara kerana rasa takut terhadap dewa, kepentingan kebudayaan serta dijadikan tempat pemujaan. Faedah yang diperoleh komuniti daripada kelompok pokok ini termasuklah pemulihan, perlindungan, pelancongan serta pekerjaan. Penebangan pokok di kawasan kelompok pokok dianggap satu perbuatan keji dan korban mesti diberi sebelum pokok ditebang. Peraturan serta pantang larang yang digunakan untuk memulihara serta melindungi kelompok pokok semakin rapuh. Masalah ini mesti ditangani jika kelompok pokok perlu terus memainkan peranan penting dalam pemuliharaan *in situ* biodiversiti.

INTRODUCTION

One of the greatest assets of tropical rainforest ecosystems is their rich flora and fauna diversity. Though accounting for only 7% of the earth dry surface area, about 70% of the plant and animal species of the world inhabit rainforests (Lovejoy 1997). Rainforests harbour a great diversity of tree species, housing between 100 and 300 tree species per ha (Sollins 1998, Pitman et al. 2005). This rich biodiversity of rainforests is partly responsible for the pressure under which they have been subjected to for decades. Globally, about 10 million ha of rainforests are degraded each year, with encroachment, timber exploitation and shifting cultivation being the main causes.

**onyekwelujc@yahoo.co.uk*

Global forest resources assessment between 2000 and 2010 revealed that Nigeria lost about 410,000 ha (3.7%) of its natural forests to deforestation (FRA 2010, FAO 2011). Deforestation and forest degradation are usually accompanied by species extinction, reduction in biodiversity and decrease in forest productivity, which underscore the need for forest conservation or careful sustainable close-to-nature forest management.

Successful biodiversity conservation requires an understanding of species distribution. Biodiversity conservation and/or restoration in degraded forests is a challenge to forest managers and conservationists. Most conventional forest conservation methods are institutional based and do not integrate the knowledge of local communities that have interacted with the forests for centuries. Among the various forms of local community participation in biodiversity conservation, sacred groves are the most widely practised. A sacred grove is a stand of trees of religious, social and cultural importance to a particular culture. They feature in various cultures and occur in various forms including remnants of old forests, sites for religious and cultural festivals, burial grounds for chiefs and sites of ancestral worship. Sacred groves are found in all continents but their methods of conservation vary according to their intrinsic nature, distribution and local beliefs. They vary greatly in size from as low as 0.001 ha to as high as 26,326 ha (Mgumia & Oba 2003, Khan et al. 2008). Though sacred groves were originally established for spiritual, cultural and worship purposes, they have greatly contributed to in-situ biodiversity conservation such that today they are noted to represent biodiversity hotspots (Myers et al. 2000) and are considered as refuge for endangered species. The importance of sacred groves as a tool for biodiversity conservation is hinged on their widespread distribution and their important roles as reservoirs of local biodiversity of threatened species (Laird 1999).

The tropical rainforest zone of Nigeria is relatively small, accounting for only 9.7% of the country's land area of 983,213 km^2 and 14.3% of the forest area of 234,004 km^2. However, despite its small size, this zone is source of the bulk of the country's timber resources. Rainforests in Nigeria are under pressure and have showed signs of human activity even before colonial times. Though many trace the beginning of forest conservation in Nigeria to the creation of forest reserves during the early 20th century, a lot of indigenous communities have age-long traditional systems (sacred groves) for protection of plant and animal species before the advent of conventional forest reservation (Okali 1997). Usually, species protection is secured using taboos, religious beliefs or by dedicating the species to one or more deities. This way, patches of primary forests remain today in many areas as scattered island on farmlands near towns and villages. To date, there are few empirical studies that compare biodiversity conservation among different forest ecosystems.

This study investigated the role of sacred groves in in-situ biodiversity conservation in the rainforest zone of south-western Nigeria. It tested whether traditional forest conservation method (sacred grove) contributed significantly to in-situ biodiversity conservation in natural tropical forest ecosystem. To accomplish this, biodiversity indices of sacred groves were compared with those of primary and degraded natural forest ecosystems.

METHODOLOGY

Study sites

Two sacred groves (Osun-Osogbo and Igbo-Olodumare), two primary forests (Queen's forest, Akure and Oluwa forests (primary portion)) and two degraded forests (Akure/Ofosu and the degraded portion of Oluwa forest) were selected from the rainforest zone of south-western Nigeria. The climate and site conditions of the study area have been described by Onyekwelu et al. (2008).

Osun-Osogbo sacred grove is located outside Osogbo town in Osun State and dedicated to Osun goddess. It is dotted with 40 sanctuaries and shrines, two palaces and several sculptures and artworks in honour of Osun goddess and other deities. The sacred grove is a Nigerian national monument and a UNESCO World Heritage site since 2005. It covers an area of 75 ha and is encircled by a buffer zone of 47 ha (IUCN 2005). Igbo-Olodumare sacred grove is located in Igbo-Olodumare town in Okeigbo/Ile-Oluji local government area of Ondo state. It covers an area of 7 ha and is known for its spiritual significance. Queen's forest, Akure is one of the strict nature reserves in Nigeria, with no record of human activities. It was constituted in 1936 and covers an area of 600 ha. Akure/Ofosu forest reserve is located in Akure south local government area of Ondo State and occupies an area of 6993 ha. It has been heavily exploited and thus has become highly degraded. Oluwa forest reserve is located in Odigbo local government area of Ondo State and occupies 87,816 ha of land. It has experienced heavy and repeated timber exploitation such that by the early 1970s, most parts have experienced serious degradation and were designated for forest plantation establishment. However, about 11,000 ha are accounted for by primary forest, rock outcrops and water bodies (Onyekwelu et al. 2010).

Data collection

Two line transects of 1000 m each and separated from each other by at least 1000 m were laid approximately at the middle of each site. Temporary sample plots of 20 m × 40 m were laid every 250 m along each transect, giving 4 plots per transect, 8 per site and 48 for the study. Within each plot, all living trees with diameter at breast height (dbh) ≥ 10 cm were identified and their dbh measured. For tree seedling enumeration, a 5 m × 10 m quadrant was laid at the middle of each plot. All seedlings with dbh < 10 cm were identified and their frequencies recorded. Factors contributing to preservation/conservation and socioeconomic importance of the sacred groves were investigated through direct discussion with chief priests of each sacred grove as well as through structured questionnaire distributed to 20 respondents selected randomly from the community closest to each sacred grove. All 40 questionnaires (i.e. 20 per sacred grove) were retrieved.

Data analysis

Diversity indices computed were species relative density, species richness, Shannon–Wiener diversity index, species evenness, species similarity and important value index (IVI). Species relative density (RD) and species relative dominance (RDo) of each site were computed using equations 1 and 2.

$$RD = \frac{n_i}{N} \times 100 \qquad (1)$$

where RD = relative density, n_i = number of individuals per species and N = total number of individuals in the entire population.

$$RDo = \frac{\sum Ba_i \times 100}{\sum Ba_n} \qquad (2)$$

where RDo = relative dominance, Ba_i = basal area of individual tree belonging to the i^{th} species and Ba_n = stand basal area.

Species diversity index was calculated using Shannon–Wiener diversity index (equation 3), while Shannon's equitability index (E_H) (equation 4) was adopted for estimating species evenness. Before applying any statistical tool in comparing Shannon–Wiener diversity indices of the ecosystems under investigation, their exponentials (exp H') were computed based on Jost (2007).

$$H' = \sum_{i=1}^{s} p_i \ln(p_i) \qquad (3)$$

where H' = Shannon diversity index, S = total number of species in the habitat, p_i = proportion of S made up of the i^{th} species and ln = natural logarithm.

$$E_H = \frac{\sum_{i=1}^{s} p_i \ln(p_i)}{\ln(S)} \qquad (4)$$

IVI was computed as the sum of the values of species relative density, relative frequency and relative dominance. Sorensen's species similarity index (SI) between two sites, A and B, was calculated using equation 5.

$$SI = \left(\frac{2\,ab}{a+b}\right) \times 100 \qquad (5)$$

where a and b = number of species at sites A and B respectively.

One-way analysis of variance (ANOVA) was used to test for significant differences between diversity indices and other parameters of the various sites using SPSS 16.0. Means found to differ significantly were separated using Fisher's least square difference. Upon retrieval, the questionnaires were coded and analysed using descriptive statistics.

RESULTS

Maximum dbh of trees in all sites varied from 90.4 to 154.4 cm, with Osun-Osogbo grove and Queen's forest having the highest value and Igbo-Olodumare grove and degraded forest at Oluwa, the lowest. Mean dbh (range 21.7 to 33.3 cm) was highest in Queen's plot and lowest in degraded forest in Oluwa. Except for degraded forest in Oluwa, mean dbh values in all other sites were not significantly different (Table 1). Basal area ranged from 65 to 18.8 $m^2 ha^{-1}$ and was significantly different between the sites. Diameter distribution of trees (Figure 1) in all sites followed inverse J-shape, typical of natural tropical forests. The largest individual trees were encountered in Osun-Osogbo grove, followed by Queen's forest and Akure/Ofosu degraded forest.

Members of Sterculiaceae, Moraceae, Euphorbiaceae, Apocynaceae and Mimosoidaceae families were dominant in all sites while members of Burseraceae, Irvingiaceae, Agavaceae, Tiliaceae, Lecythidaceae were the least dominant (Table 2). Based on species relative dominance and IVI, tree species that dominated the four sites were *Ricinodendron heudelotii, Celtis zenkeri* and *Cola* spp. Species with high relative density included *Holarrhena floribunda* (11.31), *Cola millenii* (9.95) and *Celtis zenkeri* (8.14) in Osun-Osogbo grove, *Hildegardia barteri* (38.46), *Ricinodendron heudolotii* (11.31) and *Sterculia rhinopetala* (9.05) in Igbo-Olodumare, *Cola gigantea* (11.83), *Cordia millenii* (8.06) and *Ricinodendron heudolotii* (7.53) in Akure/Ofosu forest, *Celtis zenkeri* (14.85), *Ricinodendron heudelotii* (9.90) and *Pterygota macrocarpa* (7.92) in degraded forest in Oluwa, *Mansonia altissima* (13.88), *Celtis zenkeri* (9.61) and *Triplochiton scleroxylon* (9.25) in Queen's forest, as well as *Diospyros* spp. (17.28), *Strombosia pustulata* (7.41) and *Celtis zenkeri* (6.79) in primary forest in Oluwa (Table 3).

Number of tree species encountered in all sites varied from 29 to 61, with Osun-Osogbo grove having the highest species abundance and Igbo-Olodumare having the least abundance (Table 1). Apart from Queen's forest, species abundance in Osun-Osogbo grove was significantly higher than those of other sites. Tree species abundance in Igbo-Olodumare was significantly lower than those of Osun-Osogbo grove, Queen's forest and Akure/Ofosu degraded forest but statistically comparable with those of primary and degraded forests in Oluwa (Table 1). Between 21.6 and 33.3% of tree species in the four sites were classified as endangered species in Nigerian forests by FORMECU (1999). Except for the lower percentage of endangered tree species present in primary forest at Oluwa, the conservation of endangered species is fairly similar in the rest of the sites (Table 1). Shannon–Wiener diversity index ranged from 2.35 to 3.54 in all sites, with Osun-Osogbo and Igbo-Olodumare groves having the highest and lowest values respectively (Table 1). Except for the significantly lower value in Igbo-Olodumare,

Table 1 Summary of ANOVA results for tree parameters and biodiversity indices of the study sites

Biodiversity index/tree characteristic	Sacred grove		Degraded forest		Primary forest	
	Osun-Osogbo	Igbo-Olodumare	Akure/Ofosu	Oluwa	Queen's	Oluwa
No. of tree families	18 ab	16 b	21 ab	18 ab	23 a	20 a
No. of tree species (richness)	61 a	29 c	45 b	31 c	51 ab	37 bc
No. of seedling species	66	28	36	31	49	29
No. of endangered species	20 (32.8)	8 (32.0)	13 (28.9)	9 (29.0)	17 (33.3)	8 (21.6)
Diversity index (H')	3.54 a	2.35 b	3.41 a	3.10 a	3.30 a	3.16 a
Species evenness (E_H)	0.66 a	0.44 a	0.65 a	0.67 a	0.59 a	0.62 a
Mean basal area ($m^2 ha^{-1}$)	42.5 b	25.0 c	31.3 bc	18.8 d	65.0 a	33.8 bc
Mean dbh (cm)	31.2 ab	26.2 ab	29.5 ab	21.7 b	33.3 a	25.2 ab
Maximum dbh (cm)	154.4	105.0	130.4	90.4	140.0	110.2

Values in parentheses are percentages of the number of endangered species to total species; values followed by the same letter within the same row are not significantly different ($p < 0.05$)

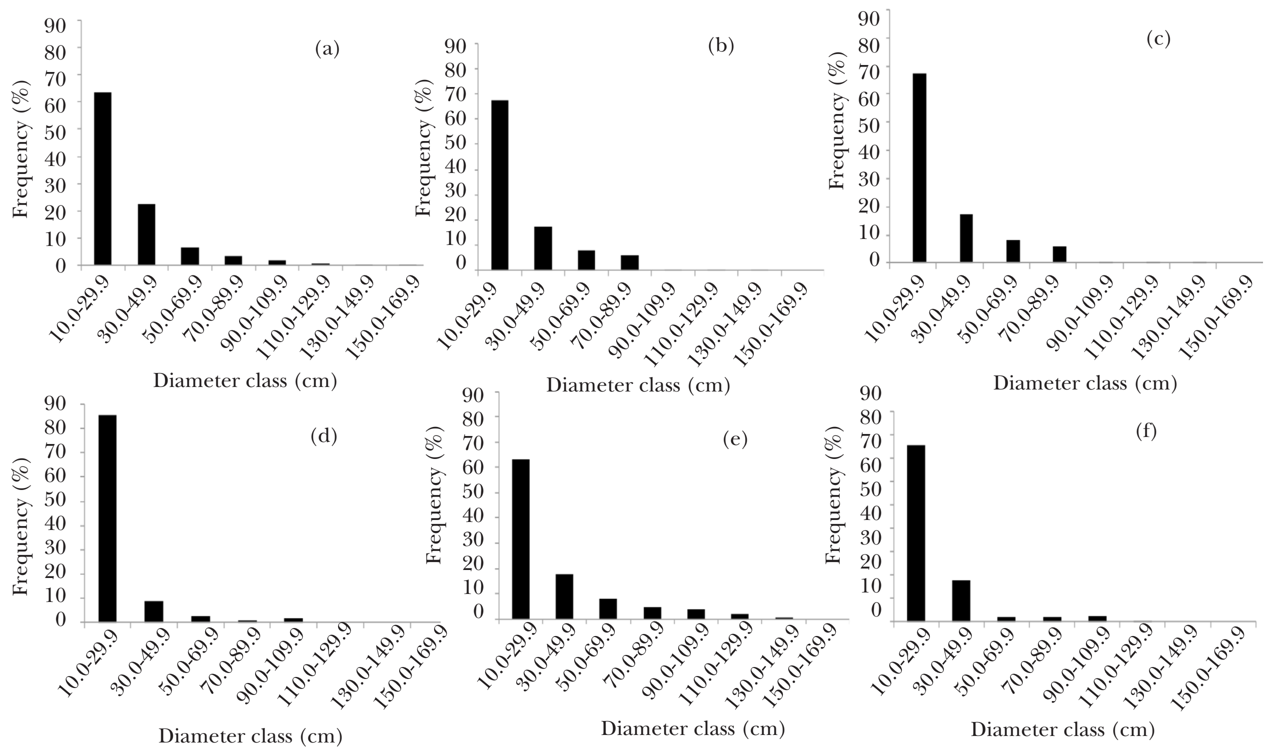

Figure 1 Diameter distribution of trees in (a) Osun-Osogbo sacred grove, (b) Igbo-Olodumare sacred grove, (c) Akure/ Ofosu forest reserve, (d) Oluwa forest (degraded forest portion), (e) Queen's forest, Akure and (f) Oluwa forest (primary forest portion)

diversity index was statistically similar in all study sites. Species evenness ranged from 0.44 to 0.67 and was statistically similar in all sites (Table 1).

There was a total of 124 seedling species in all sites. With 66 seedling species, regeneration was highest in Osun-Osogbo, followed by Queen's forest with 49 seedling species. Akure/ Ofosu degraded forest, degraded forest at Oluwa, primary forest at Oluwa and Igbo-Olodumare had 36, 31, 29 and 28 seedling species respectively. Regeneration (number of seedlings) of *Diospyros* spp., *Cola* spp., *Sterculia rhinopetala* and *Carpolobia lutea* was high in all sites. Species with high numbers of seedlings in specific sites were *Alchornea cordifolia, Cola millenii, Brachystegia eurycoma* in Osun-Osogbo, *Holarrhenea floribunda, Hunteria umbellata, Diospyros* spp. in Igbo-Olodumare, *Bliphia sapida, S. pustulata, M. altissima* in Akure/Ofosu, *Diospyros* spp., *Baphia nitida, C. lutea* in Oluwa degraded forest, *Dracaena mannii, Diospyros* spp., *C. lutea* in Oluwa primary forest, and *Diospyros* spp., *S. pustulata* and *Cola* spp. in Queen's forest.

Several reasons were given by respondents for preservation of sacred groves (Table 4a). For Igbo-Olodumare, historical/cultural importance (50%) and education and research (25%) were the dominant factors while for Osun-Osogbo, home of deity/place of worship (45%) and historical/cultural importance (25%) were the main factors. Place of worship, healings and miracles were the most important belief systems that positively contributed to preservation of Osun-Osogbo, while in Igbo-Olodumare, fear of deity was most important (Table 4b). Reasons for not felling trees and collecting non-timber forest products (NTFPs) indiscriminately at the groves were belief that tree felling was an abomination, need to offer sacrifice before felling trees, taboos/superstitions and need to preserve the natural outlook of the groves (Table 5a). About 25 and 30% of respondents in Igbo-Olodumare and Osun-Oogbo respectively considered tree felling within the groves as abomination and opined (15 and 30% respectively) that sacrifices must be offered to the gods before any tree was felled. The communities benefited in several ways from sacred groves with promotion of art and culture being the most prominent (50 and 40% of respondents in Igbo-Olodumare and Osun-Oogbo respectively) (Table 5b). Other benefits from the groves included healing, provision of

Table 2 Summary of family and tree species richness in the study sites

Family	Sacred grove		Degraded forest		Primary forest	
	Osun-Osogbo	Igbo-Olodumare	Akure/Ofosu	Oluwa	Queen's forest	Oluwa
Agavaceae	1	-	1	-	-	-
Anacardiaceae	2	1	-	-	-	-
Annonaceae	-	2	1	1	2	1
Apocynaceae	4	3	3	4	2	2
Bignoniaceae	1	2	1	2	1	-
Bombacaceae	2	2	1	-	2	1
Burseraceae	-	-	-	-	1	1
Caesalpinioideae	4	1	-	-	2	-
Chrysobalanaceae	-	-	-	-	-	-
Combretaceae	-	-	1	1	1	-
Ebenaceae	-	2	1	1	2	1
Erythroxylaceae	-	-	-	-	1	-
Euphorbiaceae	6	2	4	3	6	5
Irvingiaceae	-	-	-	2	-	-
Lecythidaceae	-	-	-	-	-	1
Meliaceae	3	-	2	1	1	1
Mimosoidaceae	8	1	1	2	2	1
Moraceae	8	1	7	2	4	4
Myristicaceae	-	1	-	1	1	1
Olacaceae	1	-	1	1	2	1
Papilioniodeae	4	1	1	1	1	1
Rhizophoraceae	-	-	-	-	1	-
Rubiaceae	1	-	1	-	2	1
Rutaceae	2	-	-	1	-	2
Sapindaceae	3	-	-	-	-	1
Sapotaceae	3	-	1	1	2	2
Simaroubaceae	-	-	-	-	1	-
Sterculiaceae	6	6	9	6	12	7
Tiliaceae	-	-	1	-	-	-
Ulmaceae	2	-	1	1	2	2
Violaceae	-	-	1	-	-	1
	61	25	45	31	51	37

social amenities, protection, revenue generation, tourism and employment.

DISCUSSION

Trees species richness in the study sites was lower than the range (100 to 300 ha^{-1}) given by Sollins (1998) and Pitman et al. (2005) but was within the range reported for some rainforest sites in Nigeria (Adekunle 2006, Onyekwelu et al. 2008) and higher than some sites in India (Chandrashekara & Sankar 1998). Higher number of tree species has been reported in some sacred groves in Sierra Leone and Kerala, India than in Igbo-Olodumare and Osun-Osogbo (Lebbie & Guries 1995, Rajendraprasad et al. 1998). Lower tree species richness in Osun-Osogbo and Igbo-Olodumare groves could be site specific rather than indication of their poor biodiversity conservation status. Tropical rainforests of south-western Nigeria are inherently poor in tree species, with number of tree species rarely more than 70 ha^{-1} (Adekunle & Olagoke 2008, Onyekwelu et al. 2008).

Members of Meliaceae, Sterculiaceae, Ulmaceae, Euphorbiaceae and Apocynaceae dominate Nigerian rainforests (Adekunle & Olagoke 2008, Onyekwelu et al. 2008),

Table 3 List of five most dominant tree species in each study ecosystem

Family		Species	Frequency	Conservation status	Mean dbh (cm)	RDo (%)	RD (%)	IVI
Osun-Osogbo sacred grove								
1	Apocynaceae	*Holarrhena floribunda*	25	-	23.9	5.04	11.31	8.18
2	Sterculiceae	*Cola millenii*	22	-	17.3	2.31	9.95	6.13
3	Ulmaceae	*Celtis zenkeri*	18	-	27.7	6.05	8.14	7.1
4	Euphorbiaceae	*Ricinodendron heudolotii*	11	Endangered	25.4	2.83	4.98	3.9
5	Mimosoidaceae	*Albizia zygia*	10	-	40.2	5.81	4.52	5.17
Igbo-Olodumare sacred grove								
1	Sterculiaceae	*Hildegardia barteri*	85	-	29.1	44.6	34.46	41.6
2	Euphorbiaceae	*Ricinodendron heudolotii*	25	Endangered	31.0	17.2	11.31	14.3
3	Sterculiaceae	*Sterculia rhinopetala*	20	Endangered	20.3	5.54	9.05	7.3
4	Sterculiaceae	*Cola hipsida*	16	-	21.2	3.39	7.24	5.31
5	Euphorbiaceae	*Bridelia micrantha*	10	-	22.6	2.25	4.52	3.39
				-				
Akure/Ofosu degraded forest				-				
1	Sterculiaceae	*Cola gigantea*	22	-	58.4	39.76	11.83	25.8
2	Bignonaceae	*Cordia millenii*	15	-	22.0	3.25	8.06	5.66
3	Euphorbiaceae	*Ricinodendron heudolotii*	14	Endangered	43.7	13.38	7.53	10.5
4	Sterculiaceae	*Pterygota macrocarpa*	13	-	30.6	6.79	6.99	6.89
5	Comretaceae	*Terminalia superba*	8	Endangered	20.1	1.57	4.30	2.94
Oluwa degraded forest								
1	Ulmaceae	*Celtis zenkeri*	15	-	15.0	5.08	14.85	9.97
2	Euphorbiaceae	*Ricinodendron heudolotii*	10	Endangered	35.8	25.37	9.9	17.6
3	Sterculiaceae	*Pterygota macrocarpa*	8	-	23.0	10.0	7.92	8.96
4	Ebenaceae	*Diospyros* spp.	8	-	15.3	2.67	7.92	5.29
5	Moraceae	*Myrianthus arboreus*	7	-	16.4	2.71	6.93	4.82
				-				
Queen's forest, Akure (primary forest)								
1	Sterculiaceae	*Mansonia altissima*	39	Endangered	25.9	5.94	13.88	9.91
2	Ulmaceae	*Celtis zenkeri*	27	-	20.4	3.63	9.61	6.62
3	Sterculiaceae	*Triplochiton scleronxylon*	26	Endangered	65.8	29.19	9.25	19.2
4	Sterculiaceae	*Sterculia rhinopetala*	17	Endangered	62.6	5.31	6.05	5.68
5	Olacaceae	*Srombosia pustulata*	15	-	23.0	2.01	5.34	3.67
				-				
Oluwa primary forest				-				
1	Ebenaceae	*Diospyros* spp.	28	-	16.4	5.53	17.28	11.4
2	Olacaceae	*Strombosia pustulata*	12	-	20.5	3.91	7.41	5.66
3	Ulmaceae	*Celtis zenkeri*	11	-	28.6	7.2	6.79	6.99
4	Sterculiaceae	*Cola acauminata*	11	-	22.1	3.92	6.79	5.35
5	Euphorbiaceae	*Ricinodendron heudolotii*	7	Endangered	49.4	15.94	4.32	10.1

Dbh = diameter at breast height, RDo = species relative dominance, RD = species relative density, IVI = importance value index

which agrees with results of our current study. In addition, members of Mimosoidaceae, Annonaceae, Sapotaceae and Bombacaceae are also important floristic composition of some of the sites. Diversity index in this study was within the range reported by Adekunle (2006) and Onyekwelu et al. (2008) but higher than the values of Nath et al. (2005). Diversity index for Osun-Osogbo (3.54) and Igbo-Olodumare (2.35) were higher than values (1.2–1.4) reported for sacred groves in Tanzania (Mgumia & Oba 2003). The non-significant species evenness values for all sites suggested that trees species distribution was similar in all the sites.

Table 4(a) Reasons for sacred grove preservation

Reason	Sacred grove			
	Osun-Osogbo		Igbo-Olodumare	
	Frequency	%	Frequency	%
Tourism	2	10	2	10
Home of deity/place of worship	9	45	2	10
Historical/dultural importance	5	25	10	50
Nature preservation	1	5	1	5
Education and research	3	15	5	25
Total	20	100	20	100

Table 4(b) Traditional belief that contributed to sacred grove preservation

Belief system	Sacred grove			
	Osun-Osogbo		Igbo-Olodumare	
	Frequency	%	Frequency	%
Place of important community festival	3	15	1	5
Fear of deity	2	10	10	50
Place of worship, healing and miraculous site	15	75	5	25
No idea	-	-	4	20
Total	20	100	20	100

Table 5(a) Factors preventing tree felling and NTFPs collection in sacred groves

Factor	Sacred grove			
	Osun-Osogbo		Igbo-Olodumare	
	Frequency	%	Frequency	%
Abomination	5	25	6	30
Offer sacrifice before felling tree	6	30	3	15
Taboo/superstition	3	15	2	10
Nature preservation	6	30	6	30
No response	-	-	3	15
Total	20	100	20	100

Table 5(b) Socio-cultural benefits derived from sacred groves by community

Type of benefit	Sacred grove			
	Osun-Osogbo		Igbo-Olodumare	
	Frequency	%	Frequency	%
Employment	2	10	-	-
Social amenity	-	-	2	10
Promotion of art and culture	8	40	10	50
Protection	2	10	1	5
Healing (solution to barrenness)	4	20	-	-
Revenue generation	2	10	2	10
Tourism	2	10	5	25
Total	20	100	20	100

Osun-Osogbo grove demonstrated higher biodiversity indices than primary and degraded forests (Table 1), which agreed with some published results. In Tanzania, species richness in sacred groves was greater than in state forest reserves (Mgumia & Oba 2003). Species richness of Osun-Osogbo grove was similar to that of Guako sacred grove in Ghana (Adomako et al. 1997) but higher than that of some sacred groves in Kerala (Chandrashekara & Sankar 1998). Similar and higher diversity indices of Osun-Osogbo grove compared with primary and degraded forests respectively are an indication that the sacred grove is comparable or even better than natural forests in terms of species richness, species diversity index and seedling regeneration potential. Thus, although the sacred grove was established for religious and spiritual purposes, its preservation plays an important role in in-situ biodiversity conservation. Higher species diversity of Osun-Osogbo is attributed to its mature, fairly undisturbed forest canopy, which supports a rich and diverse flora and fauna (IUCN 2005). About 70% of Osun-Osogbo grove is primary forest (IUCN 2005). There are indications that sacred groves can harbour higher species diversity than that reported in this study. For example, 121 plant species were found in sacred groves in Nigeria, 318 in India and 82 in Sierra Leone (Lebbie & Guries 1995, Rajendraprasad et al. 1998). The evidence that sacred groves contain high species diversity and richness may support the consideration of conservationists for promoting sacred groves for in-situ biodiversity conservation.

High concentration of endangered tree species in sacred groves in this study (Table 1) is another indication of their important role in in-situ biodiversity conservation, which is in agreement with some published results (Colding & Folke 1997, Mgumia & Oba 2003). Given the prevalence of endangered species in sacred groves, they could be used to promote in-situ conservation of endangered species. Sacred groves are repositories of rare and endemic species. Under the sacred grove system, forest preservation is secured using taboos, cultural and religious beliefs or by dedicating the forest to deities. Through respect and fear of the taboos and deity, people keep away from the sacred grove. The role of sacred groves in biodiversity conservation is attracting increasing attention of international organisations such as UNESCO and World Wide Fund for Nature (WWF). Sacred grove is important for the implementation of article 8(j) of the Conservation of Biological Diversity, which stresses the use of traditional wisdom and practices for conservation and sustainable use of biodiversity (Chandrashekara & Sankar 1998).

The good conservation status of Osun-Osogbo grove can be attributed to the way people interact with it. People see the grove as home of deity (Osun goddess), place of worship, historical and cultural site, which suggest that they hold the grove in high regard and committed to its preservation. In Tanzania, sacred groves are preserved for worship purpose and protected from exploitation, while removal of plant parts requires ritual performance (Mgumia & Oba 2003). Tree felling within Osun-Osogbo groves is regarded as an abomination and where trees must be felled, sacrifices must be offered to Osun goddess. Thus, due to the fear of Osun goddess, the people refrain from felling trees within the groves. In Sierra Leone and India, sacred groves are protected against overexploitation by sanctions and taboos associated with some deities and only certain groups of people are allowed access (Lebbie & Guries 1995, Rajendraprasad et al. 1998). In addition, the good conservation status of Osun-Osogbo can be attributed to the social, cultural, spiritual and economic benefits derived by the people. Such benefits include promotion of art and culture, healing, protection, revenue generation, tourism, employment and provision of social amenities.

Though the biodiversity indices of Igbo-Olodumare were poorer than those of Osun-Osogbo, they were comparable with those of degraded and primary forests. The poorer biodiversity conservation status of Igbo-Olodumare in comparison with Osun-Osogbo can be attributed to the rockiness of the site. Rock outcrops is scattered all over the grove. In addition, Igbo-Olodumare grove assumes a low-sacredness status as only 5% of the community dwellers see the grove as the home of deity and place of worship (Table 3a). On the other hand, 50% of community dwellers see Igbo-Olodumare as a historical and cultural site and this has led to significant conservation. Since people are no longer afraid of the deity and taboos associated with this grove, there have been encroachments, which may have led to erosion of some tree species. Due to the changing socioeconomic conditions and landuse systems, many sacred groves in India are now threatened and facing altered size, vegetation structure and species composition (Chandrashekara & Sankar 1998).

Considerations for management of sacred groves for in-situ biodiversity conservation

Results of the present study as well as reports in available literature indicate that sacred groves are playing important roles in in-situ biodiversity conservation, which is attributed to the spiritual significance, fear of deity, taboos and sanctions attached to them. However, our results and some research reports showed that the belief systems and taboos on which sacred groves were established are crumbling as many people no longer believe the taboos nor fear the deities. For example, by the 1950s, political and religious changes were already having a marked detrimental effect on Osun-Osogbo grove. Customary responsibilities and sanctions were weakening, shrines were becoming neglected and traditional priests began to disappear (IUCN 2005). Traditional rules, laws, taboo and beliefs have, over time, been substantially erased from the minds and culture of the people, resulting in the encroachment and degradation of sacred groves (Godson 1998). There are concerns that the elaborate socio-ritual systems that operate in sacred groves are culturally specific and difficult to replicate and operate in formal forest conservation systems (Laird 1999). State forestry staffs do not have requisite knowledge to manage sacred grove since they lack baseline knowledge of the functioning of sacred groves and understanding of their rules and taboos. Consequently, the management of sacred groves must remain in the hands of indigenous people.

Given the fast changing cultures, it is doubtful if the belief systems governing sacred groves can be sustained. The weakening of traditional institutions for managing sacred groves will have to be addressed if they are to continue their important role in the conservation of in-situ biodiversity as is the case in Osun-Osogbo grove. With encouragement and support from local people, the traditional institutions in Osun-Osogbo sacred grove were strengthened and a new sacred art movement formed to challenge land speculators, repel poachers and protect shrines, which brought the grove back to life and significance (IUCN 2005). Since one of the most important functions of sacred groves is cultural and historical preservation, promotion and development of cultural heritage of the people will inevitably lead to their preservation and, by implication, their biodiversity conservation potentials. The growing interests by conservation agencies such as WWF and International Union for Conservation of Nature could have beneficial influence on protection of sacred groves (Posey 1999). This paper identifies some emerging factors that will be important in future preservation of sacred groves and their biodiversity conservation potentials, which include employment generation, tourism and revenue. Every year, thousands of tourists visit Osun-Osogbo and Igbo-Olodumare groves. The economic gains from tourism by community dwellers will increase their commitment to protection and preservation of the groves. Since becoming a Nigerian national monument, Osun-Osogbo employs 75 staff members (IUCN 2005), most of whom are indigenous people. The promotion of these emerging factors will increase the biodiversity conservation potentials of the groves.

CONCLUSIONS

Although sacred groves were initially established to meet religious and spiritual needs of indigenous people, they are playing important roles in in-situ biodiversity conservation. However, the belief systems, taboos and sanctions on which sacred groves were established are crumbling. Given the fast changing cultures, it is doubtful if these belief systems can be sustained. The weakening of traditional institutions for managing sacred groves must be addressed if they are to continue playing important roles in in-situ biodiversity conservation. Since state forestry staff members do not have requisite knowledge and experience to manage sacred groves, future management must remain in the hands of indigenous people. Factors such as tourism, revenue and employment generation will play important roles in the future preservation of sacred groves and their biodiversity conservation potentials. Thus, the promotion of cultural heritage of indigenous people as well as the emerging factors will inevitably lead to preservation of sacred groves and biodiversity conservation.

REFERENCES

Adekunle VAJ. 2006. Conservation of tree species diversity in tropical rainforest ecosystem of southwest Nigeria. *Journal of Tropical Forest Science* 18: 91–101.

Adekunle VAJ & Olagoke AO. 2008. Diversity and biovolume of tree species in natural forest ecosystem in the bitumen-producing area of Ondo state, Nigeria: a baseline study. *Biodiversity and Conservation* 17: 2735–2755.

Adomako EE, Adomako JK & Baylis-Smith TP. 1997. Conservation by tradition: the case study of the Guako sacred grove. Pp 7–15 in Amlalo DS, Atisatorme LD & Fiati C (eds) *Biodiversity Conservation: Traditional Knowledge and Modern Concepts. Proceedings of the Third UNESCO MAB Regional Seminar*. 9–12 March 1997, Cape Coast.

Chandrashekara UM & Sankar S. 1998. Ecology and management of sacred groves in Kerala, India. *Forest Ecology and Management* 112: 165–177.

Colding J & Folke C. 1997. The relations among threatened species, their protection, and taboos. *Conservation Ecology* 1. Http://www.consecol.org/vol1/iss1/art6/.

FAO (Food and Agricultural Organization of the United Nations). 2011. *State of the World's Forests, 2011*. FAO, Rome.

FRA (Global Forest Resources Assessment). 2010. *Global Forest Resources Assessment 2010, Main Report*. FAO Forestry Paper 163. FAO, Rome.

FORMECU (Forestry Management Evaluation and Coordinating Unit). 1999. *Forest Resources Study, Nigeria*. Revised National Report Volume 2 prepared for FORMECU by Beak and Geomatics International.

Godson CV. 1998. Some perspectives of traditional African knowledge in biodiversity conservation. Pp 43–54 Amlalo DS, Atisatorme LD & Fiati C (eds) *Biodiversity Conservation: Traditional Knowledge and Modern Concepts. Proceedings of the Third UNESCO MAB Regional Seminar*. 9–12 March 1997, Cape Coast.

IUCN. (International Union for Conservation of Nature) 2005. Osun-Osogbo sacred grove (Nigeria), ID no. 1118. Pp 31–38 in *Evaluations of Cultural Properties. UNESCO World Heritage Convention*. Http://unesdoc.unesco.org/images/0014/001488/148831e.pdf.

Khan ML, Khumbongmayum DV & Tripathi RS. 2008. The sacred groves and their significance in conserving biodiversity—an overview. *International Journal of Ecology and Environmental Sciences* 34: 277–291.

Jost L. 2007. Partitioning diversity into independent alpha and beta components. *Ecology* 88: 2427–2439.

Laird SA. 1999. Forests, culture and conservation. Pp 347–396 in Posey DA (ed) *Cultural and Spiritual Values of Biodiversity. A Complementary Contribution to the Global Biodiversity Assessment*. United Nations Environment Programme, Nairobi.

Lebbie AR & Guries RP. 1995. Ethnobotanical value and conservation of sacred groves of the Kpaa Mende in Sierra Leone. *Economic Botany* 49: 297–308.

Lovejoy TE. 1997. Biodiversity: what is it? Pp 7–14 in Reaka-Kudla et al. (eds.) *Biodiversity II: Understanding and Protecting our Natural Resources*. Joseph Henry, Washington DC.

Myers N, Mittermeier RA, Mittermeier CG, Da Fonseca GAB & Kent J. 2000. Biodiversity hotspots for conservation priorities. *Nature* 203: 853–858.

Millar D, Aniah R & Atoyure P. 1999. Shrines and groves. Compass newsletter. Pp 34–36 in Posey DA (ed) *Cultural and Spiritual Values of Biodiversity. A Complementary Contribution to the Global Biodiversity Assessment*. United Nations Environment Programme, Nairobi.

Mgumia FH & Oba G. 2003. Potential role of sacred groves in biodiversity conservation in Tanzania. *Environment and Conservation* 30: 259–265.

Nath PC, Arunachalam A, Khan ML, Arunachalam K & Barbhuiya AR. 2005. Vegetation analysis and tree population structure of tropical wet evergreen forests in and around Namdapha National Park, northeast India. *Biodiversity and Conservation* 14: 2109–2136.

Okali DUU. 1997. Environmental and resources development: towards sustainable forestry development in Nigeria. Pp 1–12 in Oduwaiye et al. (eds) *Environment and Resource Development. Proceedings of the 1997 Annual Conference of the Forestry Association of Nigeria*. 22–26 September 1997, Ibadan.

Onyekwelu JC, Mosandl R & Stimm B. 2008. Tree species diversity and soil status of primary and degraded tropical rainforest ecosystems in south-western Nigeria. *Journal of Tropical Forest Science* 20: 193–204.

Onyekwelu JC, Mosandl R & Stimm B. 2010. Effect of land-use systems and seasonal variation on microbial biomass and population in tropical rainforest soils. *Nigerian Journal of Forestry* 40: 60–68.

Pitman NCA, Cerón CE, Reyes CI, Thurber M & Arellano J. 2005. Catastrophic natural origin of a species-poor tree community in the world's richest forest. *Journal of Tropical Ecology* 21: 559–568.

Posey DA. 1999. Introduction: culture and nature—the inextricable link. Pp 1–19 in Posey DA (ed) *Cultural and Spiritual Values of Biodiversity. A complementary Contribution to the Global Biodiversity Assessment*. United Nations Environment Programme, Nairobi.

Rajendraprasad M, Krishnan PN & Pushpangadan P. 1998. The life form spectrum of sacred groves—a functional tool to analyse the vegetation. *Tropical Ecology* 39: 211–217.

Sollins P. 1998. Factors influencing species composition in tropical lowland rain forest: does soil matter? *Ecology* 79: 23–30.