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Ecological and Environmental Implications of National Development: A Case Study of Obanla Natural Forest, Federal University of Technology, Akure, Nigeria

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Abstract: Tree species diversity and microbial population in Obanla Natural Forest located at the Federal University of Technology, Akure were assessed to examine the implication of national development on biological diversity and environmental conservation. Obanla Forest is a small portion of natural forest (9.34 ha) left behind during land clearing for infrastructural development and it is presently serving as a field laboratory for students and staff of Forestry and Wood Technology Department, Federal University of Technology, Akure, Nigeria. Data were collected with a systematic sampling technique involving two parallel line transects located 200 m apart at the centre of the forest. Four sample plots were laid alternatively on both side of each transects. The plots were of equal size (25×25 m) and they were 50 m apart. All trees in each plot whose dbh is 10 cm and above were enumerated. Composite soil samples were collected from each of the plots for microbial analysis. The result revealed that the forest is very rich in tree species, which are very valuable for rural livelihood, environmental conservation, teaching and research purposes. Also, there are different species of microbes especially fungi and bacteria in relative abundance in the forest soil. From the whole land area occupied by FUTA, only this small portion has not witnessed any form of human interference and disturbance. Forty-eight tree species distributed among 25 families were encountered in the forest. Highest percentage (26%) of tree species enumerated per hectare was in utility class 1. These are tree species that are utilized presently as decorative veneer, sawn timber and plywood. For diameter distribution, an inversed J-shaped curve was obtained and 32% of the total trees per hectare are in lowest diameter class (10-20 cm) while the least (13%) are in the diameter class of 40-49 cm. The basal area/ha and volume/ha obtained for this forest are 27.25 m^2 and 301.09 m^3, respectively. Greater proportion of the volume and basal area are in utility class 1. Highest percentage (57%) of the trees/ha was also of good quality and form with straight, cylindrical boles, without defects or knots. These are trees in grade 1 category. Twelve species of bacterial and ten species of fungi were isolated from the soil samples. Their population (Most Probable Number-MPN g^{-1} dry soil) varied between 4.2×10^6 and 7.0×10^6 for bacteria and that of fungi varied between 2.0×10^5 and 9.0×10^5. It was concluded that this forest should be protected to be able to conserve biodiversity in perpetuity and for environmental conservation, teaching and research purposes.

Key words: Microbes, illegal logging, encroachment, ecological zones, *in situ* conservation

INTRODUCTION

The development of forest resources management in Nigeria could be divided into three phases. These phases are the reservation phase which was between 1899 and 1930, the exploitation phase between 1930 and 1960 and the development phase from 1960 to date. The first phase was pioneered by the colonial authorities. It involved the demarcation and establishment of tracts of forest land as reserves, provision for their protection and controlling of exploitation. This began in 1899 by one Mr Thompson, a serving British Forest Officer transferred from India to Nigeria (Enabor, 1981; Adekunle, 2005; Oyebo, 2006). At reservation phase, a target of 25% of the country's land area was proposed for reservation but little was achieved due to stiff resistance by the local communities who saw this process as a way of taking over their land by the government. As a result, only about 10% of the target was actualized and constituted and published in government official gazette. During the second phase, there was an increase in forest exploitation because many Nigerian timber species were accepted in international market after extensive testing of their samples. The third phase witnessed a large scale afforestation projects and plantation establishment through Taungya system to argument wood supply from the natural forest. Today more than one million hectares of plantation has been established in the country (Onyekwelu, 2002).

Ogunlade (1993) reported that one third of Nigeria land area (983, 213 km^2) could be classified as forest from where just 10% was successfully put under reservation. Forest reserves are portion of forest estate constituted by law and gazette by the State or Local Government. Entrance and activities such as logging, hunting, farming and collection of minor forest products in forest reserves are controlled by the government. All other woodlands apart from the 10% under reservation are regarded as free areas. Also available records in the Federal Department of Forestry, Abuja show that Nigeria has a total of 1160 constituted forest reserves covering a land area of about 1075 km^2. Aybaomi (2006) reported that most of these reserves only exist today on paper. Rural development, encroachment, logging, massive conversion to agriculture and large scale afforestation projects are some of the problems responsible for the disappearance of the tropical natural forest ecosystem in developing countries of the world. It was reported that the natural forest is disappearing today at an alarming rate of 3.5% (about 350,000-400, 000 ha) per annum (Oyebo, 2006).

Nigeria ecological zone can broadly be divided into two namely savanna and rainforest. The savanna region covers an area of 75, 297 km^2 and is made up of Sudan, Sahel, Guinea and Derived savanna. The rainforest which accounts for only 2% of the country's forest area is located in the southern part of the country and it comprises the humid lowland forest, fresh water swamp and the mangrove forest. Each of these ecological zones has their own peculiarities and supports a wide range of plant and animal species. But the tropical rainforest has been adjudged the richest.

The Federal University of Technology, Akure is one of the seven Universities of Technology established by the Federal Government of Nigeria between 1981 and 1983. FUTA formerly came to existence in 1981 and was to use as its temporary campus, the site of the Federal Polytechnic at Akure while the Polytechnic was to relocate to Ado Ekiti then in the old Ondo State but now in Ekiti State. The university occupied a total land area of 640 ha divided into two sections popularly referred to as Obakekere and Obanla. Academic activities began in the first half of the land (Obakekere) occupied by the Polytechnic while gradual development into academic core of the second half (Obanla) began in 1986. Obanla land occupied the students' hostel, the students' centre, the Senate Building, Lecture theatres, library complex, sport complex, Schools' building etc. The natural vegetations of the area were totally removed during the construction of these infrastructures and roads. The only portion of the natural forest left behind is the Obanla natural forest, the study site.

Impacts of vegetation removal during infrastructural development on biological diversity and environmental conservation cannot be overestimated. Vegetations rich in indigenous plant and animal species indispensable and essential for rural livelihood are normally destroyed to pave way for the establishment of structures. It is common today to see vast hectare of land area destroyed for the establishment of schools, roads, petrol stations, large scale afforestation project and industries.

Management of tropical forests for economic production, biological and environmental conservation should not be handled with levity by any nation lucky to be endowed with these natural resources. Presently, the existing tropical rain forests are not properly managed in a real sense of the term in Nigeria. Continuous exploitation without adequate regeneration strategies has led to structurally and genetically degraded forest, which are extremely difficult and expensive to rehabilitate. While a lot of useful tropical hardwood species have gone into extinction, many are vulnerable, rare or endangered. The need to assess the impacts of forest removal for national development on biological diversity and the environment using Obanla forest whose highest proportion has been clear felled for infrastructural development becomes very obvious. The volume of wood in this forest, tree and animal species diversity and microbial population were estimated to confirm the level of destruction and the suitability of the forest for teaching and research purposes. The objectives of this study therefore are to assess tree and microbial species diversity in the forest, identify species going into extinction and those that could be referred to as been relatively abundance, obtain the yield of the forest in terms of volume/ha and basal area/ha, recommend appropriate management strategies for the forest to make it appropriate for biodiversity and environmental conservation, research purpose and students' practical field.

MATERIALS AND METHODS

The Study Area

This study was carried out at Obanla natural forest, which is a portion of forest left behind during land clearing for the establishment of the Federal University of Technology, Akure, Ondo State, Nigeria. As a result, the forest is very rich in tree and animal species diversity. It is used presently as botanical garden and practical field for dendrology courses by students and staff of the Department of Forestry and Wood Technology, FUTA. This forest was formerly part of Akure forest reserve located between four towns namely Akure, Idanre, Ondo and Ilesa. Specifically, Obanla natural forest is located along Akure-Ilesa road in the North Western part of FUTA on Longitude 05^0 18'E and Latitude 07°17'N. The forest is about 9.34 ha in size. Generally, the vegetation zone is the tropical humid lowland forest ecosystem. This ecological zone has been described in detail by Nwoboshi (1982), Okojie (1996) and Adekunle (2002). FUTA occupies a total land area of 640 ha. As a result of physical development, the original native vegetation has been removed leaving behind this small portion (9.4 ha translating into 1.5% of total FUTA land mass).

Method of Data Collection

Sample Plots Demarcation

Eight plots of 25×25 m were located using systematic sampling technique. Sample plots were laid in two parallel line transects of 200 m apart. Four plots of 50 m interval were laid alternately on both sides of each transect (Fig. 1). Tree enumeration and soil sample collection were done in each of the sample plots.

Measurement of Tree Growth Variables in the Selected Sites

Measurement and identification were limited to all woody plants of 10 cm diameter at breast height and above encounter in each plot (Okali and Ola-Adams, 1987). With this minimum diameter at breast height, most of the classes of woody plants were captured during identification and measurement. The following tree data were collected in each sample plot for further analysis:

- Diameter at breast height (dbh): This is the stem diameter at a position of 1.3 m above the ground level.
- Diameters over bark at the base, middle and merchantable top of all trees in the plots
- Total height of all trees in each plot using Spiegel relaskop.

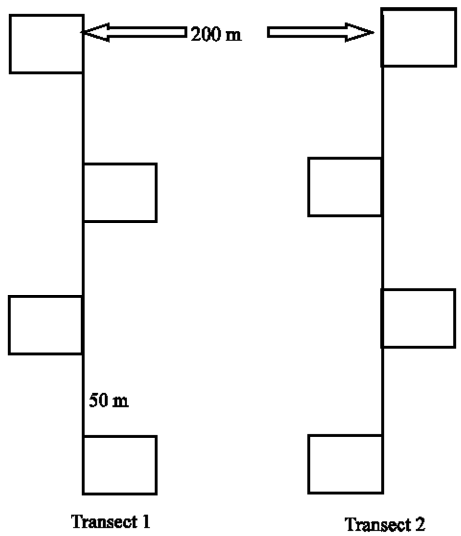

Fig. 1: Sample plot layout

For trees growing on a slope, the dbh was measured from the uphill side. Buttresses are considered to be non-commercial. So, when buttresses extending above 1.30 m above ground surface were encountered, the equivalent of diameter at breast height was measured at a height of 20 cm above the upper limit of the buttresses and this height was noted in the field data-recording sheet. All trees measured were first cleaned of vines, thorns and superficial plants when present at breast height point to ensure accurate diameter measurement. Trees forked below the breast-height point were treated as two. When knots or localized deformations occurred at breast height point, a more representative dbh point either above or below the breast height point was chosen for dbh measurement for that particular tree.

Tree Species Identification

The botanical name of every living tree whose diameter at breast height is ≥ 10 cm encountered in each field plot was recorded. In cases where a tree's botanical name was not known immediately, such a tree was identified by its common/local name. Trees that could not be identified were referred to as unknown. Specimens of such trees (e.g., leaves, bark and fruits) were collected for identification in plant herbarium. Each tree was recorded individually in the field forms, palms and vines were not measured and possible effort was made not to omit any eligible stem in a plot. This is because any tree species omitted will deny the existence of that species in the forest.

Soil Sample Collection for Microbial Characterizations

Soil samples were collected at the surface (0-20 cm depth) from three different equidistance points located diagonally in the selected sample plots. Soil samples from each of the plots were mixed to obtained composite soil samples. The samples were properly labeled and preserved for microbial analysis in the laboratory. The analyses were carried out in the Department of Food and Industrial Microbiology laboratory, FUTA.

Enumeration of Bacteria and Fungi

The standard procedures for the determination of the total number of soil bacteria (most probable number-MPN) was adopted for bacteria culturing (Alexander, 1982). Suspension of the soil samples were prepared with sterile water and a serial dilution of five factors were made for accurate counting. Then 1mL of the appropriate dilution was carefully transferred to sterilized Petri dishes containing sterile molten nutrient agar at about 37°C. This was mixed and allowed to solidify. It was incubated for 24 h. The bacteria that grew into colonies were sub-cultured to obtain pure culture for easy identification. Identification was done according to Bergeys manual of determinative bacteriology.

For fungi culturing, serial dilution of the suspension were also transferred into Petri dishes containing sterile, molten malt extract agar. This was kept in an incubator at 30°C for five days. Fungi that grow were sub-cultured to obtain pure culture for easy identification. Morphological and biochemical characterization was done for identification (Cowan and Steel, 1977).

Data Analysis

Basal Area Calculation

The basal area of all trees in the sample plots were calculated using the formula:

$$BA = (\pi\ D^2)/4$$

where BA = Basal area (m^2), D = Diameter at breast height (cm) and π = pie (3.142). The total BA for each plot was obtained by adding all trees BA in the plot. Mean BA for the plot was calculated with the formula:

$$\bar{BA}_p = \frac{\sum BA}{n}$$

where $\bar{BA}_p$ = mean Basal area per plot, n = number of plots or sampling unit.

Basal area per hectare was obtained by multiplying mean basal area per plot with number of plots in a hectare (16 plots):

$$BA_{ha} = \bar{BA}_p \times 16$$

Volume Calculation

The volume of each tree was calculated in every plot using the Newton's formula of Husch *et al.* (2003):

$$V = (h/6)\ (A_b + 4A_m + A_t).$$

where: V = Tree volume (in m^3), A_b, A_m and A_t = tree cross-sectional area at the base, middle and top of merchantable height, respectively (in m^2) and h = total height (in meters). The plot volumes were obtained by adding the volumes of all the trees in the plot (Vp) while mean plot volume was estimated by dividing the total plot volume by number of sample plots. Mean volume for the sample plots was calculated:

$$\bar{V}_p = \frac{\sum Vp}{8}$$

$\bar{V}_p$ = mean plots volume

The volume of trees per hectare (V_h) was therefore estimated by multiplying this mean by the number of sampling units in a hectare (16).

Tree Species Identification and Biodiversity Indices

All tree species were assigned to families and number of species in each of the families was obtained for tree species diversity classification. Number of occurrence of individual species and relative density for tree species were also obtained.

Relative density was calculated according to Oduwaye *et al.* (2003):

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

Where
RD = The relative density
nii = No. of individuals of species I (i.e., the abundance of ith tree species)
N = Total number of individual in the entire population (i.e.,∑ ni-total abundance in a vegetation type).

The 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-Weiner diversity index (Price, 1997) used is:

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

H' = Shannon-Weiner diversity index
S = Total number of species in the community
pi = The proportional abundance of ith tree species (ni/N).

Species evenness (E_H) in the forest was determined using Shannon's Equitability of Kent and Coker (1992):

$$E_H = \frac{H'}{H_{max}} = \frac{\sum_{i=1}^{s} P_i \ln(p_i)}{\ln(S)}$$

Tree Species Classification According To Utility Classes

The eight utility classes recognized by Sutter (1979) and updated by Formecu (1999) were adopted. These authors divided all utility into two categories. Category A is made up of the first six classes and contained tree species that are very useful at present. Category B has the last two classes which comprised tree species that are not utilized at present (i.e., lesser utilized species). The classifications and the respective utilization potentials are as follows:

- Category A: Species utilized at present
- Peelers and slicers for decorative veneers
- Peelers and slicers for utility plywood
- Sawnwood for furniture and joinery
- Sawnwood for heavy construction
- Wood for handcraft and specialized uses
- Category B: Species not utilized at present
- Capable of reaching 40 cm diameter at breast height or diameter above buttress (dab)
- Rarely reaching 40 cm diameter at breast height or dab.

RESULT AND DISCUSSION

As typical of tropical rainforest ecosystem, a wide range of tree species was discovered to be present in this small natural forest left behind during site preparation for FUTA infrastructural development. Table 1 gives an indication of tree species diversity and abundance. The table contains the list of tree species encountered in the stand using acceptable botanical names and their respective families. On the whole, a total of 221 stems were enumerated in the sample plots. This value was extrapolated to a total of 296 individual trees per hectare and 2, 664 individual stems in the entire stand. The trees belong to 48 species distributed among 26 families. The species with the highest number of occurrence and relative density (most abundance species) is ***Futumia elastica*** with 20 stems ha^{-1} and a relative density of 6.76. This is followed by ***Bernilia spp*, *Ceiba petandra and*, *Sterculia rhinopetala*** with 16 stems ha^{-1} each and a relative density of 5.41. The number of species (48) present in this forest is more than what was obtained for Oluwa forest reserve (45) and a little bit less than 51, the number obtained for Queen's forest by Onyekwelu ***et al.*** (2005). So, species richness in Obanla Natural Forest is within the range of 45 and 56 reported for other rainforests in Nigeria by Lowe (1997) and Adekunle (2006). From Table 2, it was discovered that the family Sterculiaceae has the highest number of species (6 species). Euphobiaceae follows this with 5 species. Of all the species encountered, 21 (44%) have their frequency to be equal or greater than 5 while the remaining (56%)

Table 1: Tree species, families, number encountered and species diversity index in the study area

Tree No.	Species	Family	N ha^{-1}	N/9.4 ha	Relative density ha^{-1}	Pi = (ni/N)	pi Ln	H' = (piLnpi)
1	*Albizia ferruginea*	Mimosaceae	1	9	0.337838	0.003378	-5.69036	-0.01922
2	*Albizia zygia*	Mimosaceae	8	72	2.702703	0.027027	-3.61092	-0.09759
3	*Alstonia congensis*	Apocynaceae	7	63	2.364865	0.023649	-3.74445	-0.08855
4	*Anthocleista* sp.	Loganiaceae	1	9	0.337838	0.003378	-5.69036	-0.01922
5	*Berlinia auriculata*	Caesalpiniaceae	16	144	5.405405	0.054054	-2.91777	-0.15772
6	*Blighia sapida*	Sapindaceae	1	9	0.337838	0.003378	-5.69036	-0.01922
7	*Bombas buonopozense*	Bombacaceae	3	27	1.013514	0.010135	-4.59175	-0.04654
8	*Bosquea angolensis*	Moraceae	7	63	2.364865	0.023649	-3.74445	-0.08855
9	*Brachystegia enrycoma*	Caesalpiniaceae	12	108	4.054054	0.040541	-3.20545	-0.12995
10	*Bridelia grandis*	Euphorbiaceae	4	36	1.351351	0.013514	-4.30407	-0.05816
11	*Canarium schweinfurthii*	Burseraceae	4	36	1.351351	0.013514	-4.30407	-0.05816
12	*Ceiba petandra*	Bombacaceae	16	144	5.405405	0.054054	-2.91777	-0.15772
13	*Celtis zenkerii*	Ebenaceae	12	108	4.054054	0.040541	-3.20545	-0.12995
14	*Chrysophyllum albidum*	Sapotaceae	3	27	1.013514	0.010135	-4.59175	-0.04654
15	*Chrysophyllum* sp.	Sapoteceae	1	9	0.337838	0.003378	-5.69036	-0.01922
16	*Cleistopholis patens*	Annonaceae	3	27	1.013514	0.010135	-4.59175	-0.04654
17	*Cola gigantea*	Sterculaceae	12	108	4.054054	0.040541	-3.20545	-0.12995
18	*Cola nitida*	Sterculaceae	8	72	2.702703	0.027027	-3.61092	-0.09759
19	*Daniellia ogea*	Caesalpiniaceae	7	63	2.364865	0.023649	-3.74445	-0.08855
20	*Desplatsia* sp.	Tiliaceae	1	9	0.337838	0.003378	-5.69036	-0.01922
21	*Drypetes gosweilleri*	Euphorbiaceae	5	45	1.689189	0.016892	-4.08092	-0.06893
22	*Entadrophyragma candollei*	Meliaceae	7	63	2.364865	0.023649	-3.74445	-0.08855
23	*Ficus exasperata*	Moraceae	11	99	3.716216	0.037162	-3.29246	-0.12236
24	*Funtumia elastica*	Apocynaceae	20	180	6.756757	0.067568	-2.69463	-0.18207
25	*Guarea thompsonii*	Meliaceae	1	9	0.337838	0.003378	-5.69036	-0.01922
26	*Harungana madagascariensis*	Hyperricaceae	4	36	1.351351	0.013514	-4.30407	-0.05816
27	*Holoptelia grandis*	Ulmaceae	4	36	1.351351	0.013514	-4.30407	-0.05816
28	*Lannea welwitschii*	Anacardiaceae	1	9	0.337838	0.003378	-5.60036	-0.01922
29	*Macaranga* sp.	Euphorbiaceae	4	36	1.351351	0.013514	-4.30407	-0.05816
30	*Milicia excelsa*	Moraceae	3	27	1.013514	0.010135	-4.59175	-0.04654
31	*Mitragyna ciliata*	Rubiaceae	11	99	3.716216	0.037162	-3.29246	-0.12236
32	*Parinari robusta*	Rosaceae	7	63	2.364865	0.023649	-3.74445	-0.08855
33	*Pentaclethra macrophylla*	Mimosaceae	5	45	1.689189	0.016892	-4.08092	-0.06893
34	*Phyllanthus discoideus*	Euphorbiaceae	8	72	2.702703	0.027027	-3.61092	-0.09759
35	*Picralima nitida*	Apocynaceae	4	36	1.351351	0.013514	-4.30407	-0.05816
36	*Pitptadeniastrum africanum*	Mimosaceae	4	36	1.351351	0.013514	-4.30407	-0.05816
37	*Pterocarpus santalinoides*	Palpilionaceae	4	36	1.351351	0.013514	-4.30407	-0.05816
38	*Pterygota macrocarpa*	Sterculiaceae	1	9	0.337838	0.003378	-5.69036	-0.01922
39	*pycnanthus angolensis*	Mysristicaceae	5	45	1.689189	0.016892	-4.08092	-0.06893
40	*Ricinodendron heudelotti*	Euphorbiaceae	4	36	1.351351	0.013514	-4.30407	-0.05816
41	*Spathoiea campanulata*	Bignoniaceae	5	45	1.689189	0.016892	-4.08092	-0.06893
42	*Sterculia oblonga*	Sterculaceae	12	108	4.054054	0.040541	-3.20545	-0.12995
43	*Sterculia rhinopetala*	Sterculaceae	16	144	5.405405	0.054054	-2.91777	-0.15772
44	*Strombosia pustulata*	Olacaceae	9	81	3.040541	0.030405	-3.49313	-0.10621
45	*Trichilia welwitschii*	Meliaceae	7	63	2.364865	0.023649	-3.74445	-0.08855
46	*Triplochiton seleroxylon*	Sterculiaceae	3	27	1.013514	0.010135	-4.59175	-0.04654
47	*Xylopia aethiopica*	Annonaceae	1	9	0.337838	0.003378	-5.69036	-0.01922
48	*Zanthoxylum zanthoxyloides*	Rutaceae	3	27	1.013514	0.010135	-4.59175	-0.04654
		Total	296	2664				-3.60148

N/ha = No. trees/ha, N/9.34 ha = number of trees in the entire Obanla natural forest, H' =-∑ pilnpi = 3.60

Table 2: Families encountered in Obanla Natural Forest, FUTA and number of species

S/N	Family	No. of sp.	S/No.	Family	No. of sp.
1	Anacardiaceae	1	14	Moraceae	3
2	Annonaceae	2	15	Mysristicaceae	1
3	Apocynaceae	3	16	Olacaceae	1
4	Bignoniaceae	1	17	Palpilionaceae	1
5	Bombacaceae	2	18	Rosaceae	1
6	Burseraceae	1	19	Rubiaceae	1
7	Caesalpiniaceae	3	20	Rutaceae	1
8	Ebenaceae	1	21	Sapindaceae	1
9	Euphorbiaceae	5	22	Sapotaceae	2
10	Hyperricaceae	1	23	Sterculaceae	6
11	Longaniaceae	1	24	Tiliaceae	1
12	Meliaceae	3	25	Ulmaceae	1
13	Mimosaceae	4		Total	48

have theirs to be less than 5. Tree families available in this study site are characteristic of the tropical humid lowland forest ecosystem of Nigeria. The fact that Sterculiaceae family is the most dominant family in this forest is in conformity with the study of Sarumi *et al*. (1996), Were (2001) and Adekunle (2006). They all reported that the Nigerian lowland rainforest ecosystem is dominated by members of the Sterculiaceae, Moraceae, Ulmaceae and Euphobiaceae.

The Relative Density (RD) varied between 0.33 and 6.76. The Shannon Weiner value is 3.60 and species evenness (E_H) is 0.93. RD is an index for assessing species relative distribution according to Brashear *et al*. (2004) while Shannon-Weiner index (H') was adopted in this study because it takes both species richness and evenness in a community into account and also because species abundances are standardized to proportions (Guo *et al*., 2003). The Shannon-Weiner diversity index obtained for this site is within the general limit of 1.5 and 3.5 for Shannon-Weiner diversity index (Kent and Coker, 1992). The index obtained in this study is similar to what was obtained by Onyekwelu *et al*. (2005) and Adekunle (2006) for some selected forest reserves in southwest Nigeria. The values obtained for two different forest reserves by Onyekwelu *et al*. (2005) are 3.31 for Omo Biosphere Reserve (popularly refer to as Queen's forest) and 3.31 for Oluwa forest reserve. Their respective E_H are 0.66 and 0.60. Adekunle (2006) obtained values that ranged between 3.34 and 3.66 for Ala, Omo and Shasha Forest Reserves and relative density that ranged between 1.85 and 2.44. Ala, Omo and Shasha are forest reserves where logging and other activities are controlled and monitored. While Queen's forest is a primary, undegraded forest, Oluwa forest reserves is a forest that has not been exploited since the commencement of large scale afforestation project in the place in the early 1970s. All these sites were located in the same ecological zone, the tropical humid lowland zone.

The closeness of H' for all these sites revealed that tree species diversity in the sites is similar. A comparison of species evenness (E_H) shows that tree species are slightly more evenly distributed in Obanla (since it has the highest E_H) than the other forest reserves. The fact that this small forest was able to compare favourable with other primary undegraded forest reserves (especially in terms of species diversity and evenness) revealed that Obanla forest has not witnessed any form of human interference. As a result, it is very rich in tree species that are of immense value to man in the supply of so many indispensable goods and services. It is pertinent to note therefore that this small left over forest has gone a long way in conservation of biological diversity for research purpose and posterity.

UTILITY CLASS DISTRIBUTION

The tree species encountered in this study fell into seven out of the eight utility classes recognized by Formecu (1999). The utility classes and the respective species encountered under them are as follows:

Utility Class 1

Berlinia species, *Daniella ogea*, *Desplatsia species*, *Entadrophragama angolensis*, *Guarea thompsonii*, *Milicia excelsa*, *Sterculia rhinopetala* and *Triplochiton scleroxylon*

Utility Class 2

Alstonia cogensis, *Chysophyllum albidun*, *Cleistopholis patens*, *Harungana madagascariensis*, *Holoptelia grandis*, *Lannea welwitschii*, *Mitragyna ciliata*, *Pterocarpus osun*, *Pycnanthus angolensis* and *Lovoa trichilioides*

Utility Class 3

Cola gigantea,*Pentachlethra macrophylla*,*Picralima nitida*,*Ricinodendron heudelotii*, *Spathodea campanulata*

Utility Class 4

Albizia ferruginea, *Albizia zygia*, *Bosquea angolensis*, *Celtis zenkerii*, *Drypetes gosweileri*, *Zanthozylum zantoxylioides*, *Phyllanthus discoideus*, *Parinari robusta and Strombosia pustulata*

Utility Class 5

Bombax buonopozense, *Ceiba pentandra*, *Piptadeniastrum africanum*

Utility Class 6

-No tree

Utility Class 7

Anthocleista species, *Blighia sapida*, *Canarium schweifurthii*, *Funtumia elastica*, *Pterygotha macrocarpa*

Utility Class 8

Bridelia grandis, *Chrysophyllum species*, *Ficus exasperata*, *Macaranga species*, *Musanga cecropioides*, *Xylopia aethipica*

Utility class 6 has no tree. This suggests that the tree species classified into utility class 6 by Sutter (1979) and modified by Formecu (1999) are not available in Obanla natural forest. They might be present in the large portion already cleared for infrastructural development. They were probably removed during clearing of the forest for construction of school buildings, roads, staff quarters etc, plantation development or farming. So, tree species expected in this class have gone into extinction in this forest. Utility class 1 has the highest distribution of tree in the reserve. It accounted for 26.24% of the total number of trees per hectare enumerated during the inventory. This is followed by those in utility class 8 that accounted for 18% (Table 3). Apart from these utilization potentials, tree species in this forest are valuable for the supply of edible fruits (*Chrysophyllum albidum*), herbs that cure different sicknesses (*Zanthoxyllum zanthoxylioides*), poles, wrapping leaves, spices and sawn timbers.

On the whole, trees species utilizable for timber (utility class 1-5) accounted for about 74.16%, while the remaining 25.39% consisted of the tree species with no potential utility for timber at present (i.e., utility classes 7 and 8). So, this small forest is very rich in tree species that are valuable for the supply of timber, veneer, herbs, fruits, poles etc. These products could be obtained at the same time from this forest. The environmental conservation roles, social, ecological and academic benefits of this forest cannot be overestimated too. The forest is serving as a covering (watershed) for a small spring

Table 3: Frequency distributions of trees into the eight various utility classes

Utility class	Sample distribution	Distribution per hectare	Distribution for the entire forest area	Percgent Distribution ha^{-1}
1	58	77	719	26.24
2	35	47	439	15.84
3	23	31	290	10.41
4	27	37	226	12.23
5	17	23	215	7.69
6	0	0	000	0.00
7	21	28	262	9.50
8	40	53	495	18.09
Total	221	296	2.646	100.00

Table 4: Frequency distributions of trees into diameter classes according to the eight utility classes

	Diameter class (cm)					
Utility class	10-20 cm	21-30 cm	31-39 cm	40-49 cm	>50 cm	Utility class total
1	19	12	9	7	11	58
2	12	8	7	5	3	35
3	10	3	5	4	1	23
4	6	9	5	5	2	27
5	7	1	3	4	2	17
6	0	0	0	0	0	0
7	9	5	7	0	0	21
8	8	8	8	3	13	40
Sample plot total	71	46	44	28	32	221
Total ha^{-1}	94	62	59	38	43	296
% ha^{-1}	32	21	20	13	15	100

flowing across the forest. This spring is relied upon for the supply of water for activities in the school nursery. It is also serving as shelter belt and modifies the weather condition for those residing in the staff quarters opposite the forest.

Table 4 shows the diameter distribution of sample trees according to utility classes in Obanla natural forest. Highest proportion (32%) of total number of trees per hectare is in the least diameter class (10-20 cm) across all the seven utility classes adopted. This is followed by those whose diameter class is 21-30 cm (20%). The least is in the diameter class of 40-49 cm (13%). It has been widely reported for diameter distribution in natural forest that diameter sizes of trees are inversely proportional to frequency (Nwoboshi, 1982, Adekunle, 2002). The diameter distribution curve assumed the inverse J-shaped pattern also reported to be common with any tropical natural forest ecosystem by these authors. According to the diameter distribution table (Table 4), about 28% of the total tree enumerated is of merchantable size (diameter at breast height = 48 cm) as specified by logging policy. These are the trees that could be available for exploitation but logging is not adviceable in the forest for it to continue to meet the objective of reservation. Lahde *et al.* (1994) noted that in an all sized (uneven aged) forest, it is common to find most of the trees having small diameter and few of the trees in higher diameter classes.

Volume distribution according to utility classes is presented in Table 5. A total volume of 301.09 m^3 was obtained per hectare while the volume for the entire forest is estimated as 2,812.20 m^3.

Highest volume was recorded for trees in utility class 1 while the least was for trees in utility class 7. The result of basal area estimation (m^2) is similar to what was obtained for volume. Highest basal area was obtained for trees in class 1 while the least was obtained for class 7 (Table 6). The basal area per hectare and for the entire forest estate is estimated as 27.25 and 254.51 m^3, respectively. The high basal area and volume obtained further confirmed that the forest is very mature and has not experinced serious human disturbance. This makes it very adequate for biodiversity and environment conservation, research and for other academic purposes.

From Table 7, about 57% of trees per hectare (across the seven available utility classes) belong to trees that could be regarded as grade 1. These are trees with straight bole, without defect or knots

Table 5: Volume distribution among utility classes in Obanla natural forest

Utility class	Volume for the sample plots (m^3)	Volume per hectare (m^3 ha^{-1})	Volume for the entire forest area (m^3)
1	59.08	78.77	735.71
2	25.98	34.64	323.54
3	24.65	32.87	307.01
4	41.79	55.72	520.43
5	16.40	21.87	204.27
6	0.00	0.00	0.00
7	9.73	12.97	121.14
8	48.19	64.25	600.10
Total	225.82	301.09	2,812.20

Table 6: Basal area distribution among utility classes in Obanla natural forest

Utility class	Basal area for the sample plots (m^2)	Basal area per hectare (m^2 ha^{-1})	Basal area for the forest area (m^2)
1	65.1	8.68	81.07
2	2.89	3.83	35.77
3	1.79	2.39	22.32
4	4.41	5.88	54.92
5	1.90	2.53	23.63
6	0.00	0.00	0.00
7	0.97	1.29	12.05
8	1.99	2.65	24.75
Total	20.4	27.25	254.51

Table 7: Stem grade for the natural forest sample trees according to utility classes

	Quality grade class				
Utility class	1	2	3	Utility class total (sample plots)	Utility class total (ha)
1	38	8	12	58	78
2	21	7	7	35	47
3	12	5	3	20	27
4	15	5	8	28	38
5	13	2	2	17	23
6	0	0	0	0	0
7	12	1	8	21	29
8	17	3	20	40	54
Stem quality grade class total (sample plots)	128	33	60	221	296
Stem quality grade class total (ha)	170	45		81	296
% Stem grade distribution ha^{-1}	57	15	27	100	

and of very good quality. For height distribution of trees, 66% of total trees encountered per hectare have their height to be less than 30 m while 32% have their height between 31-40 m. Those that could be referred to as emergent (height above 40 m) are just 2% of the total trees per hectare (Table 8).

The results of bacteria and fungi diversity and abundance (Most Probable Number-MPN g^{-1} dry soil) were presented in Table 9 and 10, respectively. Twelve species of bacteria and ten species of fungi were isolated from the soil samples, but the abundance of the microbes ranged between 4.2 $x10^6$ and 7.0 $\times10^6$ for bacteria and between 2.0×10^5 and 9.0×10^6 for fungi. The results obtained for microbial population and diversity in this present study are very similar to the findings of Adekunle *et al*. (2005) in a similar ecosystem. For microbial diversity, thirteen and eleven species of bacteria and fungi, respectively were obtained by Adekunle *et al*. (2005) from Akure forest reserve while twelve and ten were obtained in this study. The species' name and abundance are also very similar. The abundance and diversity of microbes in the soil samples showed that the soil is likely to be very rich in organic matter and humus. The roles of microbes in organic matter decomposition, humus formation and nitrogen fixation cannot be overestimated. The abundance and diversity of micro-organisms has direct impact on soil nutrient under favourable environmental conditions (high air temperature and soil moisture content). The most important nutrient supply to the forest soil is derived from litter

Table 8: Height distribution frequency among utility classes in Obanla natural forest

Utility class	Height class < 30 m	31-39 m	>40	Utility class total (sampling plots)	Utility class total (ha)
1	37	20	2	59	78
2	23	11	0	34	46
3	14	9	0	23	31
4	17	10	0	27	36
5	14	3	0	17	23
6	0	0	0	0	0
7	18	3	0	21	29
8	23	15	2	40	53
Class total (Sample plots)	146	71	4	221	296
Class total (ha)	195	95	6	296	
% class total ha^{-1}	66	32	2	100	

Table 9: Bacteria abundance and diversity in the soil samples from the study area

Plot	MPN g^{-1} dry soil	Bacteria present
1	5.4×10^6	*Bacillus cereus*
2	4.8×10^6	*Citrobacter freundii*
3	5.9×10^6	*Sarcina flava*
4	4.2×10^6	*Streptomyces iriscens*
5	6.7×10^6	*Shigella dysenteriate*
6	7.0×10^6	*Clostridium sporogenes*
7	4.3×10^6	*Bacillus polymyxa*
8	6.1×10^6	*Sarcina maxima*
9	4.5×10^6	*Aerobacter aerogenes*
10	4.3×10^6	*Bacillus subtilis*
11	6.5×10^6	*Escherichia coli*
12	5.9×10^6	*Streptococcus faecalis*

Table 10: Fungi abundance and diversity in the soil sample from the study area

Plot	MPN g^{-1} dry soil	Fungi present
1	4.0×10^5	*Penicillium* sp.
2	4.0×10^5	*Aspergillum raperis*
3	8.0×10^5	*Trichoderma species*
4	5.0×10^5	*Candida* sp.
5	6.0×10^5	*Neurospora crassa*
6	5.0×10^5	*Fusarium* sp.
7	9.0×10^5	*Aspergillum niger*
8	5.0×10^5	*Rhizopus* sp.
9	8.0×10^5	*Aspergillum fumigatus*
10	5.0×10^5	*Gonatobotrys simplex*

decomposition by actions of these organisms. They mobilized the chemical elements in the litters and make them reabsorbable by plant roots. This is responsible for the availability of fertile land under natural forest which predisposes forest areas to encroachment by landless farmers. Also the presence and abundance of microorganisms in the soil are governed by the amount of organic matter, the activities of plant roots, soil temperature and moisture and nutrient availability.

CONCLUSION AND RECOMMENDATION

Tree yield (Diameter distribution, height distribution, basal area and volume), tree species and microbial diversity of Obanla natural forest, a small relic of natural forest left behind during the construction of the Federal University of Technology, Akure has been studied. It was discovered that tree species diversity and abundance in this small forest compared favourable with other forest reserves and undegraded forest in the same ecosystem. Infrastructural development has serious negative impacts on tree species and microbial diversity and the environment.

The ecological, social, economic and environmental roles of the forest were of great importance. These roles are been lost as more forests are destroyed for any reason what so ever. Very high percentage of trees is of good grade and belongs to species that are in Category A. These are trees with great potential for utilization at present. The soils are rich in soil micro-organism (bacteria and fungi). This forest was discovered to be a very useful instrument for teaching and research and for biological diversity and environmental conservation. It has gone a long way to conserved tree species and microbial diversity. It should therefore be surveyed and the boundaries marked with life fence to prevent illegal loggers and encroachers. Its further removal for construction of infrastructures should be avoided. This small natural forest, which is left over during site preparation for the construction of buildings and roads should be constituted as forest reserve and published in the country's official gazette.

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