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IMPACT OF FOREST COVER ON PLANT SPECIES DIVERSITY, SOIL PROPERTIES AND MICROBIAL POPULATION IN A LOWLAND FOREST, ILE-IFE, NIGERIA

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ABSTRACT

Studies of influence of forest cover on understorey species diversity, nutrient availability, soil moisture and microbial population abound in literature. However, little work has been done in lowland secondary forest in Ile-Ife, Nigeria. This study therefore examined the impact of forest cover on plant species diversity, soil nutrients and microbial population in Ile-Ife. Plants species encountered within 2m by 2m plot under forest cover and adjacent open area were counted and identified to species level. Floristic compositions, species distribution, species diversity indices (Shannon-Wiener index, Simpson's Index and species evenness) were calculated. Composite soil samples were collected at the depth of 0-15cm, air-dried, sieved and analysed for soil pH, total N, C, cations (Na, K, Ca and Mg), available and total P. Microbial population was also considered. Results revealed that there were 49 species distributed into 28 families (293 individuals) under the tree cover, while there were 53 species distributed into 33 families (451 individuals) in the open vegetation. Soil physico-chemical properties such as pH, moisture, total N, C, P, available P, exchangeable cations (Mg, Na, Ca, and K), exchangeable acidity and soil moisture were also significantly higher ($p < 0.001$) in the area under the cover. The count of bacteria (colony form) 6.12×10^5 - 4.09×10^6 and fungi (spores form) 7.07×10^5 - 5.31×10^6were also found to be significantly higher under the forest cover compared with the values for bacteria and fungi respectively (2.52×10^4 - $2.19\times10^5$and 8.57×10^2 - 4.32×10^3) in the open area. The Jaccard index of similarity (79.49%) was high between the study sites. The result of this study showed that forest cover has a beneficial effect on soil properties and nutrient pool. Plants species richness and microbes population were also higher under the forest cover than in the open area. Species diversity and richness, soil nutrient, and microbial population were greatly influenced by forest cover.

Keywords: lowland forest; microbial population; population; species diversity; forest cover.

INTRODUCTION

The forest canopy is defined as "the top layer of a forest or wooded ecosystem consisting of overlapping leaves and branches of trees, shrubs, or both (Margaret *et al.*, 1996). Forest canopy is also frequently explained as the percentage area occupied by the vertical projection of tree crowns; a proportion of the forest floor covered by the vertical projection of the tree crowns (Rautiainen *et*

al., 2005). The tree canopy is very important in that it modulates the availability and variability of some key resources for the organisms living in the understorey, thus affecting its own regeneration (Washburn and Arthur, 2003).

Generally, canopy opening has been regarded by most authors (Jose *et al.,* 2008) as influencing available light to the understorey, or as having an effect on rainfall interception. In which case the forest canopy reduces the intensity of light reaching the under canopy which is the opposite of what happen in the open area. Canopy also alters water flow and content as it changes precipitation pathways (Prescott, 2002). Trees modify microenvironment in terms of reduced soil and air temperatures, wind speed and irradiation, resulting into reduced soil water evaporation and increased relative humidity (Jose *et al.,* 2008). The indirect effects such as those mediated by soil and litter have also been proven to be important for plant growth in the understorey (Puerta-Pinẽro *et al.,* 2006).

Plant species can influence the composition of underlying soil microbial communities (Garbeva *et al.*, 2006). These influences can be due to differences in forest cover, rooting depth, and litter quality and quantity (Gregory, 2006) or to secondary effects on soil pH, moisture, and nutrient levels. Microbes (bacteria, archaea, fungi, and protozoan) are very important in all processes related to soil function (Adekunle and Dafiwhare, 2008). The microbial constituents of soil are entirely responsible for the breakdown of organic matter and the degradation of toxic molecules (Forsyth, 2009). Overall, denser forest cover implies higher rate of respiration (Hibbard *et al.,* 2005). Soil bacterial diversity is influenced by several biotic and abiotic factors (Schimidt, 2006), which could be determined by the presence of cover or its absence. Nannipieri *et al*. (2003) and Zak *et al*. (2003) reported that plant diversity usually affects microbial process, which controls the rate of ecosystem N cycling, in which case the habitation of the microbes is dependent on temperature, moisture content and other factors which are predetermined by the percentage of forest cover.

Forest canopies contain a major portion of the diversity of organisms on earth and constitute the bulk of photosynthetic active foliage and biomass in forest ecosystems (Margaret *et al.,* 1996). Studies on the effect of tree canopy on herbaceous diversity in tropical forests have yielded equivocal results. The studies on tree canopy on herbaceous tree species and understorey abound in other parts of the world (Joshi *et al.,* 2001; Rodriquez-Echeverria and Perez-Fernandez, 2003). Isichei and Muoghalu (1992) have also looked at the effect of tree canopy on soil fertility in savannah vegetation in Nigeria. However, generally, little work has been reported in the secondary lowland rainforest in Nigeria. Therefore, this study was carried out in order to provide information on the impact of tree canopy on species diversity, soil properties, and microbial population. The specific objectives of this study are to determine to what extent forest canopy affect plant species composition and richness, soil properties and microbial population.

MATERIALS AND METHODS

Study area

This study was conducted at the Obafemi Awolowo University, Ile-Ife in Osun State, Southwestern Nigeria. Ile-Ife lies on latitude 7° 32′ N and longitude 4° 31′ E. The elevation of the Ife ranges from 215m to 457m above sea level (Hall, 1969). The details of the longitude and latitude and the elevation of the study sites are shown in Table 1.

The climate of the area is tropical with two prominent seasons, the rainy and dry seasons. The dry season is short, usually lasting 4 months from November to March and the longer rainy season prevails during the remaining months. The annual rainfall averages 1413 mm yr^{-1} in a 5-year survey (Duncan, 1974). The relative humidity in the early morning is generally high, usually over 90% throughout the year. At mid-day, it is rather lower, around 80% in the wet season as low as 50-60% in the dry season (Hall, 1969). The soils are moderately to strongly leached and have low to medium humus content, weakly acid to neutral surface layers and moderately to strongly acid sub-soils (Smyth and Montgomery, 1962). The original vegetation of Ile-Ife is lowland rainforest as climax vegetation (Keay, 1959). The forest sub-type is dry deciduous forest (Onochie, 1979). White (1983) classifies the vegetation as Guinea-Congolian rainforest-drier type.

Sampling procedures

The study was conducted in the secondary lowland rainforest at Obafemi Awolowo University, Ile-Ife. Ten tree cover were selected within the forest 2m by 2m plot was marked out within each of the ten tree cover using a measuring tape. Ten other points (open area) were selected adjacent to each of the trees cover at a distance of 4m away from the tree canopy (open area), where 2m by 2m plot was also

marked out. This study was carried out between September and October, 2012, the peak of the raining season because it is expected that the plant growth will be at its peak. The species that forms the forest cover used in this study were *Baphia nitida, Chrysophylum cainito, Margaritaria discoides, Dracaena mannii, Blighia sapida, Trilepsium madagascariensis, Napoleona imperialis* and *Microdesmis puberula*.

Identification and enumeration of plant species

All the plants species encountered within the study plots (open and cover) were counted and identified to species level. The unidentified plant species were taken to the IFE Herbarium for proper identification using the Flora of West Tropical Africa (Hutchinson and Dalziel, 1954, 1972). Floristic composition, habit, diversity and distribution of the species were determined. Species richness, diversity indices; Shannon-wiener index and Simpson's Index and species evenness (E) (Pieolou index) were calculated.

Soil sample collection and analysis

Composite soil samples were collected with a soil auger at the depth of 0 - 15cm from each plot. The collected soil samples were taken to the laboratory, air dried, passed through a 2mm sieve and analysed for pH, exchangeable cations (Ca, Mg, K, and Na), total N, C, available and total P and exchangeable acidity. The soil pH was determined electrochemically in both distilled water and 0.01M $CaCl_2$ (1:2 soil to solution ratio) and reading the measurement on a pH meter. The exchangeable cations (Ca, Mg, K, and Na), total nitrogen, carbon, available phosphorus, total phosphorus and exchangeable acidity were analysed according to the methods described by Tel and Rao (1982). The soil moisture was determined from the soil samples collected from the plots (forest cover and the open area) and a known mass (5g) of soil sample was weighed out of the freshly collected soil sample at a depth of 0-15cm and was kept in the aluminium foil and kept in the oven at 105°C for 24hours. The percentage soil moisture was done according to the method described by (Anderson and Ingram, 1993) and was calculated using this formula:

$$Soil\ moisture = \frac{Initial\ weight - weight\ after\ drying}{initial\ weight} \times 100$$

$$Weight\ after\ drying = weight\ after\ drying\ with\ foil - weight\ of\ foil$$

Determination of the microbial population

The assessment of the soil sample for fungi and bacteria count was determined by standard pour plate method as described by Nwachukwu and Akpata (2003). Ten grammes of soil samples was weighed and mixed with one hundred millilitres of sterile distilled water as stock from which a ten-fold serial dilution was prepared. One milliliter of the appropriate dilution was carefully transferred to sterile Petri dishes followed by sterile molten nutrient agar of 40-42 °C, mixed, allowed to solidified and incubated for 24 hours at 37 °C for bacteria while for fungi culturing, inoculum from serial dilution of the same soil suspension was transferred into sterile Petri dishes followed by sterile molten Sabouraud Dextrose agar of 40-42 °C, mixed, allowed to solidified and incubated in an incubator at 25°C for 5 days. Growth of microorganism was observed after incubation period and the population determined by standard microbiological method putting into consideration the dilution factor (Olutiola *et al*., 1992).

Data and statistical analysis

For each plot, number of trees species (i.e. species richness), genera and families were established. The Simpson index of diversity (1-D) was also calculated

$$D = \frac{\Sigma n(n-1)}{N(N-1)}$$

where N is the total number of individual species present at the study sites.

n is the number of species present at the study sites.

Plant species diversity index *H'* of each sample plot was calculated using the method prescribed by (Shannon and Wiener, 1963):

$$H' = -\Sigma Pi \ln Pi$$

where $Pi = ni/N$ is the relative abundance proportion of i species and ln = Natural logarithm

N is the total number of individuals present at the study sites.

ni is the number of species present at the study sites.

The degree of similarity in species composition between open and cover area was compared using Jaccard's Index of similarity (J):

$$J = {}^{j}/_{r} \times 100$$

where j is the number of species found in both cover and open plots

r is the number of species found in each of the plots added together except common species in the two sites (i.e. number of species found in only one or the other).

The evenness index (Pieolou, 1966) was calculated thus:

$$E = \frac{H'}{LnS}$$

where S is the total species number in each site

H' is the diversity index and

Ln = natural logarithm.

Statistical analysis was carried out using T-test to test for significant difference in soil properties (soil moisture, pH, total N, C, Mg, K, Na, Ca, available P and total P) and other parameters (microbial count and plant species diversity) between the forest cover and open area. The significant probability was set at $p < 0.05$ and the statistical procedures were performed using SPSS 2010 version.

RESULTS

Floristic composition and richness

The details of the differences in the number of individual plant species present in both the area underneath and outside the forest cover are presented in Table 2. The study revealed that there were 49 species distributed into 28 families (293 individuals) under the tree cover, while 53 species distributed into 33 families (451 individuals) were encountered in the open adjacent vegetation. The number of herbaceous species (156) recorded in the open was higher than those found under the tree cover (71); the number of shrubs (182) was also higher in the open than under the forest cover (72). Total number of 8 Creepers/twiners were found in the open compared with only one found under the tree cover. However, higher number of tree saplings (100) and climbers (27) were recorded under the forest cover compared to (61) tree samplings and (17) climbers that were recorded in the open. Eight grasses and one non-vascular plant species were recorded in the open and cover sites respectively (Table 2, Fig. 1).

The following species *Phaulopsis falcisepala*, *Asystasia gangetica*, *Petiveria alliacea* were dominant in the adjacent open area, while *Albizia zygia*, *Asystasia gangetica* and *Geophila* species are the dominant plant species in the area underneath the forest cover (Table 2). The following dominant species *Petiveria alliance* (Shrub) *Asystasia gangetica* got reduced from 102 in the open area to 27 under the forest cover and from 65 to 19 respectively. The number of *Phaulopsis falcisepala* species was also higher in the open (49) compared to 15 that was recorded under the forest cover (Table 2). The families most abundantly represented in the area underneath the forest cover are Acanthaceae, Apocynaceae, Papilionaceae, Rubiaceae while the families most abundantly represented in the open areas are Ceasalpiniaceae, Acanthaceae, Sapindaceae, Rubiaceae, and Papilionaceae.

The result of diversity measurements in the species related to Shannon Wiener, Simpson's index and the evenness measures in the area underneath the forest cover and those outside the cover are shown in Fig. 2. The Jaccard index of similarity (79.49%) indicates high similarity in richness, composition and relative abundance between the two study area considered (area underneath and outside cover).

Soil properties

Results showed that the soil properties were generally lower in the open area compared with the closed tree canopy area. Total N, C, P, available P, exchangeable cations (Mg, Na, Ca, and K), exchangeable acidity and soil moisture were found to be significantly higher ($p < 0.001$) in the area under the cover than in the adjacent open area (Table 3). Soil pH was slightly acidic (5.01-6.08) and was significantly ($p < 0.01$) higher in the area underneath the cover than area in the open (Table 3). The bacteria count of 6.12×10^5 to $4.09\times10^6$and fungal count of 7.07×10^5 to 5.31×10^6 was higher in area under the canopy than 2.52×10^4 to $2.19\times10^5$and 8.57×10^2 to 4.32×10^3 for bacteria and fungi respectively in the open area (Table 3).

Table 1: Location and elevation in metres (m) of the study area

Study point	Longitude and Latitude		Elevation (m)	
	Cover	Open	Cover	Open
1	N07° 31.046′ E004°063′	N07° 31.316′ E004° 31.489′	261	275
2	N07° 31.319′ E004° 31.490′	N07° 31.317′ E004° 31. 490′	269	287
3	N07° 31.315′ E004° 31.501′	N07° 31.311′ E004°31. 493′	282	293
4	N07° 31. 348′ E004° 31.492′	N07° 31.345′ E004° 31. 495′	299	300
5	N07° 31.345′ E004° 31.492′	N07° 31.349′ E004° 31.491′	286	299
6	N07° 31.334′ E004°31.491′	N07° 31.338′ E004° 31.496′	306	292
7	N07° 31.337′ E004°31.491′	N07° 31.331′ E004°31.482′	301	292
8	N07° 31.347′ E004°31.471′	N07° 31.358′ E004°31.462′	286	254
9	N07° 31.350′ E004°31.462′	N07° 31.346′ E004°31.462′	263	302
10	N07° 31.353′ E004°31.466′	N07° 31.351′ E004°31.474′	293	300

Table 2: Comparison of species composition, distribution and families encountered across the study sites.

Species composition	Family	Covered area	Opened area
Herb			
Aegylia oblique	Connaraceae	-	5
Asystasia gangetica	Acanthaceae	19	65
Carteria andasonia	Caparidaceae	-	2
Crossandra flavahook	Acanthaceae	1	4
Dioscoreophyllum cumminsii	Menispermaceae	5	-
Geophila spp.	Rubiaceae	28	14
Phaulopsis falcisepala	Acanthaceae	15	49
Pouzolzia guineensis	Urticaceae	-	12
Talinum triangulare	Portulacaceae	3	-
Thassali spp.	Rubiaceae	-	2
Unknown	Caparidaceae	-	1
Vigna gracilis	Papilionaceae	-	2
		71	**156**
Shrubs			
Alchornea laxiflora	Euphorbiaceae	2	10
Allophylus africanus	Sapindaceae	3	-
Caladium bicolour	Areceae	-	1
Combretum spp.	Combretaceae	5	7
Cnestis ferruginea	Connaraceae	3	-
Dalbergia spp.	Papilionaceae	2	3
Diospyrosmon buttensis	Ebenaceae	1	-
Fluggea virosa	Euphorbiaceae	-	4
Lecaniodiscus cupanoides	Sapindaceae	15	4
Malacanthaolnifolia	Sapotaceae	-	2
Mallotus oppositifolius	Euphorbiaceae	-	1
Microdermis puberula	Pandaceae	9	-
Pauridiantha hirtella	Rubiaceae	-	1
Petiveria alliacea	Phytolacaceae	27	102
Pregularia daemia	Asclepiadacea	3	6
Piperum bellulata	Piperaceae	-	2
Rothmannia hirsipda	Rubiaceae	1	18
Rytigynia spp.	Rubiaceae	-	18
Senna hirsute	Ceasalpiniaceae	-	3

Sphenocentrum jollyanum	Menispermaceae	1	-
	Sub-total	**72**	**182**
Tree samplings			
Albizia adianthifolia	Mimosaceae	3	6
Albizia zygia	Mimosaceae	23	11
Antiaris Africana	Moraceae	6	3
Baphia nitida	Papilionaceae	15	1
Blighia sapida	Sapindaceae	-	2
Bauhinia monandra	Caesalpiniaceae	-	1
Bauhinia tomentosa	Caesalpiniaceae	2	4
Celtis zenkeri	Celastreaceae	2	3
Delonix regia	Caesalpiniaceae	1	-
Dracinea manii	Agavaceae	2	-
Funtumia elastic	Apocynaceae	12	14
Holarrhena floribunda	Apocynaceae	4	2
Milletia thonningi	Papilioniaceae	-	5
Napoleona imperialis	Nytaginaceae	1	-
Newbouldia laevis	Bignoniaceae	11	2
Pterocarpous spp.	Papilioniaceae	1	2
Thassali kolly	Rubiaceae	2	-
Treculia welwittia	Meliaceae	1	-
Trema orientalis	Ulmaceae	5	-
Trichilia prieureana	Meliaceae	5	1
Triplesium madagascariensis	Moraceae	4	4
	Sub-total	**100**	**61**
Non woody Climbers			
Aristolo chiaringens	Aristolochiaceae	-	1
Baissea subsessillis	Apocynaceae	8	-
Cissus spp.	Ampelidaceae	1	-
Dioscorea spp.	Dioscoreaceae	3	1
Dioscorea spp.	Dioscoreaceae	-	2
Momordica charantia	Cucurbitaceae	3	4
Momordica cissoides	Cucurbitaceae	11	9
Paulina pinnata	Sapindaceae	1	-
	Sub-total	**27**	**17**
Creeper/Twiner			
Cissampelo sowariensis	Menispermaceae	-	1
Commelina erecta	Commelinaceae	-	4
Thunbergia grandiflora	Acanthaceae	1	1
Unknown	Unknown	-	2
	Sub-total	**1**	**8**
Grass			
Bambusa vulgaris	Gramineae	-	7
Sansceveria liberica	Liliaceae	-	1
	Sub-total	**0**	**8**
Scrambler			

Panicum brevifolium	Graminae	21	19
		21	**19**
Non Vascular Plant (Fern)			
Pteris spp.	adianthaceae	1	-
	Sub-total	**1**	
Grand Total		**293**	**451**

Table 3: Soil properties and microbial population determined across the study sites.

Soil properties	Covered areas	Open areas
Total P (ppm)	93.51±0.85	84.68±1.10 ***
Available P (ppm)	35.89±0.55	27.89±0.91 ***
Exchangeable acidity	0.07±0.003	0.05±0.002 ***
Total N (%)	0.41±0.01	0.36±0.01 ***
Total C (%)	2.45±0.24	2.06±0.12***
C:N ratio	5.98	5.72
Exchangeable cations		
Ca (mol/kg)	5.39±0.11	4.96±0.05 ***
Mg (mol/kg)	2.32±0.14	1.57±0.12 ***
K (mol/kg)	0.90±0.01	0.67±0.04 ***
Na (mol/kg)	0.17±0.03	0.14±0.01 *
pH		
Distilled water	6.08±0.11	5.32±0.17 ***
0.01M $CaCl_2$	5.63±0.12	5.01±0.17 **
Soil moisture (%)	19.36±0.88	16.30±0.39 ***
Microbial population		
Bacteria (cfu/ml)	6.12×10^5 - 4.09×10^6	2.52×10^4 - 2.19×10^5 **
Fungi (sfu/ml)	7.07×10^5 - 5.31×10^6	8.57×10^2 - 4.32×10^3 ***

*, **, *** represent significantly levels at 0.05, 0.01 and 0.001
cfu means colony forming unit
sfu means spore forming unit
Results are presented as mean, where n=10.

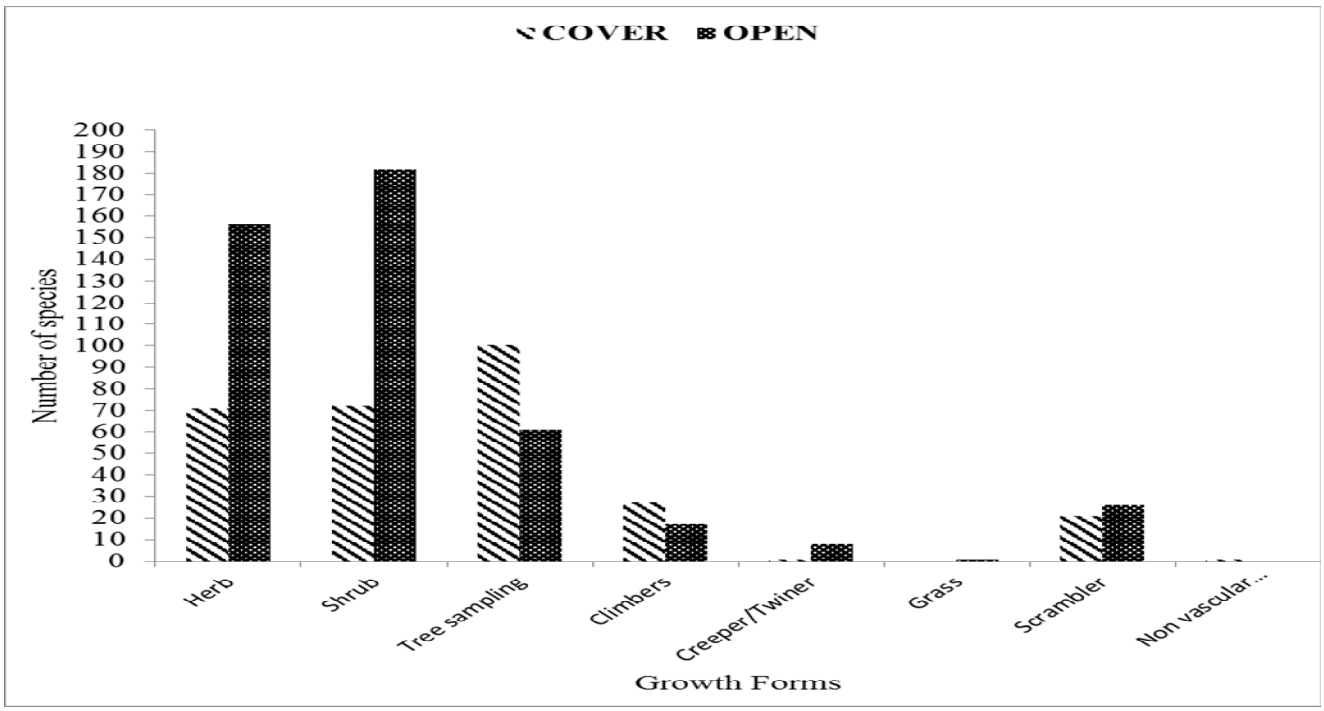
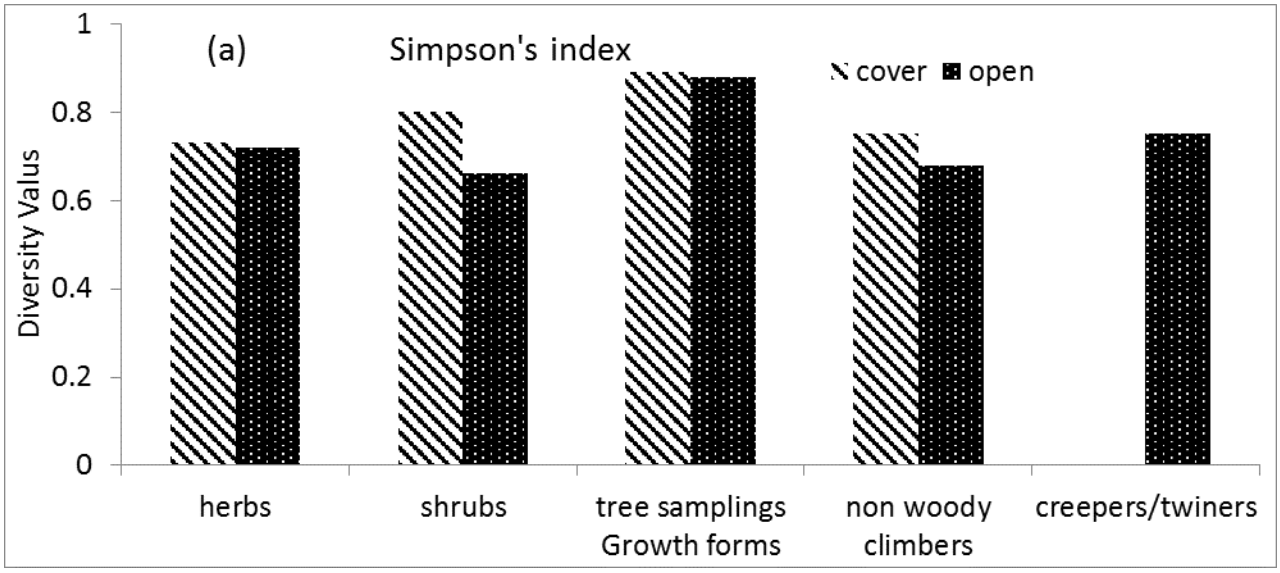


Figure 1: Distribution of species composition in different growth form of species encountered across the study sites.



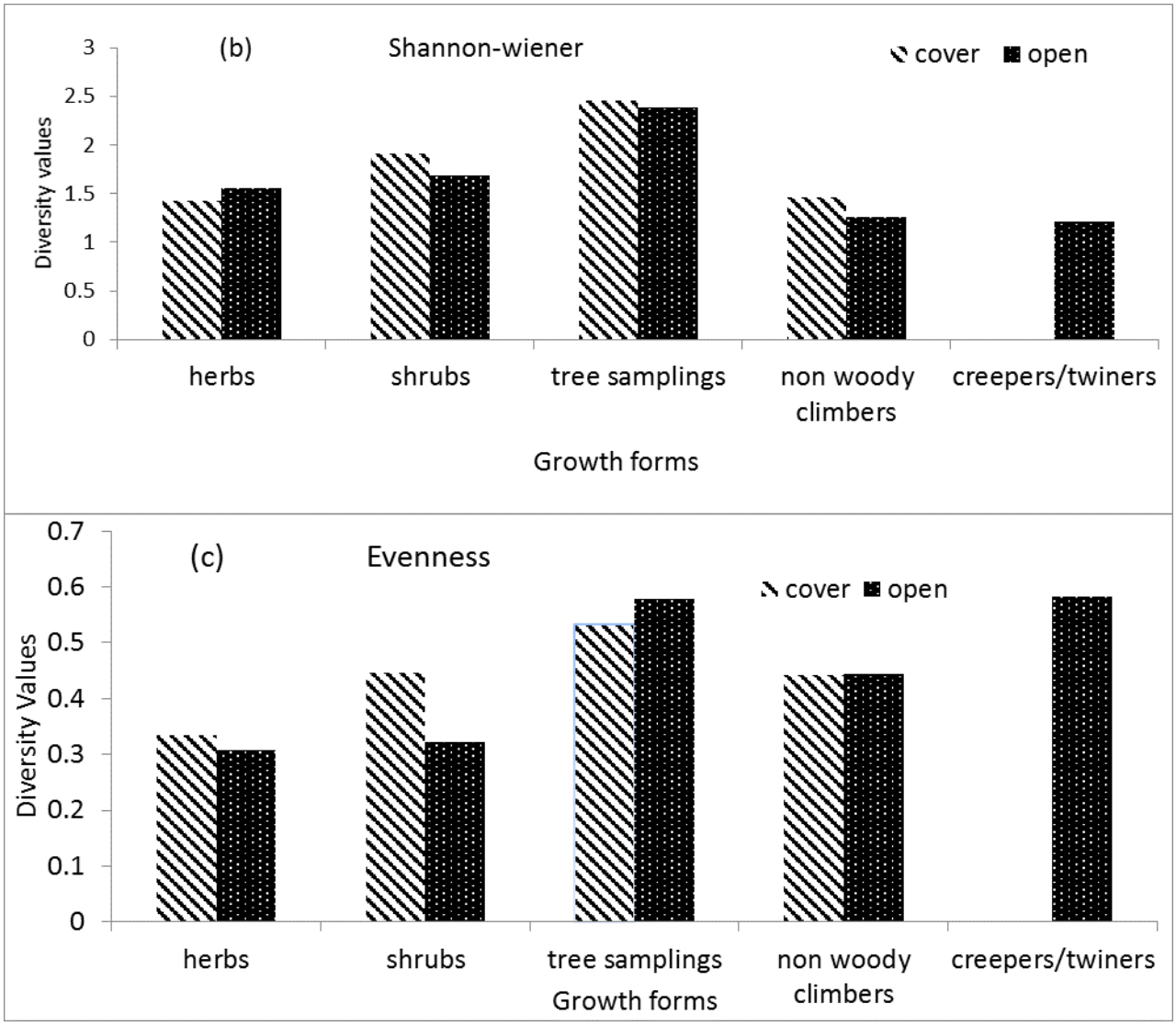


Figure 2. Comparison of species diversity indices measured in both the forest cover and open area.

DISCUSSION

Species composition and richness

The lower number of species (herbs and shrubs) encountered underneath the forest cover might be related to the level of disturbance caused by human activities and the amount of light that penetrates through the cover. The level of shade in area underneath the cover is high and this might not be favourable for growth of understorey species (herb, shrub and non-woody climbers) because of low light availability that can inhibit seedlings emergence. This is consistent with a number of other studies which have reported that the overall cover and biomass of forest understorey vegetation often drastically decrease with cover (Gillet *et al.,* 1999). Stone and Wolfe (1996) have also reported more understorey species with canopy openings.

The result of higher number of shrubs recorded in the open area in this study is similar to the findings of Lü *et al.* (2011) who reported that shrub layer, was the most species-rich in all the various growth forms. The higher presence of the following dominant species *Petiveria alliance* (Shrub), *Asystasia gangetica* and *Phaulopsis falcisepala* in the open area of the secondary forest might indicate that the species are not shade tolerant species. The higher species diversity index (the herb layer, creeper/twiner) found in the open area is expected, except for the shrub layers. The absence of sheltering effect could be a possible mechanism for higher species diversity of the herb layer, creeper/twiner in the

open area, since the presence of trees and cover hindered species survival, thereby influencing the species diversity (Sanchez-Jordan, 2010). Theoretically it has been explained that species diversity is a function of species richness and evenness, therefore, the high degree of species diversity in the community underneath cover (trees, shrubs and herbs) recorded values in this study might indicate that the species in the community under cover interact with the individuals of different species than that of community in the open area. The evenness index revealed that the plant species in open areas had more consistency in species distribution, that is the range of occurrence of individual species was not relatively different) as compared to the areas underneath the cover. The high similarity index encountered in this study indicated that plant that emerges from the study sites might have their regeneration source from plants from the same source. The presence of certain common species (31) and high value of similarity (79.49%) in the areas underneath forest cover and the open area may be due to similarity of the stands (in terms of resource availability, similar environmental condition and similar mode of propagation and dispersal), thereby making it possible for the species to invade and survive (Lalfakawma *et al.*, 2009).

Soil Properties

The result of higher exchangeable cations, acidity and other soil properties in the area outside forest cover is similar to the result reported by Kieft *et al.* (1998). Data on soil nutrients in area underneath and outside tree cover suggests that plants living relatively close to each other may be exposed to different rates of nutrients supply. Several other workers (Isichei and Muoghalu, 1992) have reported higher values in soil properties (Nitrogen, Sodium, Calcium, Magnesium, pH) underneath tree cover than area outside tree cover as found in this study, though their work was carried out in the savannah grassland. Also, similar result (trend) was reported in the study carried out by Gutiérrez *et al.* (1993). This may be partly as a result of organic matter accumulation underneath tree cover and reduced leaching. Tree roots from rooting zones to tree canopies may also be sources of nutrients under tree canopies (Isichei and Muoghalu, 1992). Leachates from tree canopies which might not be present in the open vegetation have been reported to be part of nutrient contributor to the soil (Isichei and Muoghalu, 1992). The higher cations present underneath tree canopy may be as a result of higher organic matter which leads to greater absorptive capacity of cations (Kadeba and Benjaminsen, 1976). The tree cover reduces the force of rain drops striking the surface, the soil underneath tree cover is likely to be more resistant to rain splash, water and wind erosion. Joshi *et al.* (2001) have also reported more soil moisture in covered area than in the open and this had been attributed to the drying effect of solar radiation in the open area.

The possible mechanism through which trees facilitate the below canopy environment for ground vegetation is interception of direct solar heat, which could reduce soil temperature and evaporation, thus increasing the below canopy soil moisture (Vetaas, 1992). Pausas and Austin (2001) advocated that a decrease in radiation is often associated with an increase in water availability, therefore, it is expected that tree canopies will improve soil nutrients, soil organic matter (Escudero *et al.*, 2001) and mineralizable nitrogen (Weltzin and Coughenour, 1990). Other, studies have shown that soils developing underneath the tree cover have greater water-holding capacity and macro-porosity favourable to infiltration and redistribution of soil water (Joffre and Rambal, 1993).

Microbial population

Soil microbial communities are an integral component of many ecosystem processes (Jackson *et al*., 2007). The microbial population of the area underneath the tree cover was found twice those of the area outside tree cover. Woody plant canopies alter the microenvironment and physical and fertility conditions of soil (Weltzin and Coughenour, 1990). Trees modify microenvironment in terms of reduced soil and air temperatures, wind speed and irradiation, resulting into reduced soil water evaporation and increased relative humidity (Jose *et al.*, 2008). It has also been pointed out that trees also acquire nutrients from deeper soil layers and redistribute them at the surface through litter fall which enhances soil carbon and nutrients. All these may create a favourable condition that benefits microbial activity. Gallardo and Schlesinger (1995) have also reported that soil water and temperature were influenced by tree cover litter

accumulated and this creates a favourable condition that enhances microbial activity. Most microorganisms (bacteria and fungi) thrives best in a narrow pH range near neutrality, between pH 6.5 and 7.5; very few thrives below pH 4.0. Many bacteria such as the acidophiles responsible for acid fermentation are remarkably tolerant of acidity.

The relative abundance of the microbes encountered in the areas underneath cover are indication that soils underneath forest cover are rich in biodegradable organic matters and these are very important in humus formation. This might have accounted for the usual fertile land underneath tree cover. In addition, excretions from soil microorganisms affect water and air movement within the soil. In the course of this study, it was observed that worm casts are more common in the areas underneath tree cover compared to the open area. This is an indication of the higher breaking down of organic matter underneath the tree cover. Ford *et al.* (2004) reported that some fungi function largely in the breakdown of complex organic molecules like lignin (a compound that is resistant to bacteria degradation). Sundareshwar *et al.* (2003) have also pointed out that bacteria are very beneficial to trees by regulating inputs and outputs of nitrogen.

CONCLUSION

The study revealed that the numbers of herbaceous species, shrubs, tree samplings and climbers recorded under the tree cover were higher than those found in the open area. The number of creepers/twiners and grasses found in the open was higher compared with under the tree cover. The families most abundantly represented in the area underneath the forest cover are Acanthaceae, Apocynaceae, Papilionaceae, Rubiaceae while the families most abundantly represented in the open areas are Ceasalpiniaceae, Acanthaceae, Sapindaceae, Rubiaceae, and Papilionaceae. The Jaccard index of similarity (79.49%) indicated high similarity in richness, composition and relative abundance between the two study areas. Results also showed that the soil properties; total N, C, P, available P, exchangeable cations (Mg, Na, Ca, and K), exchangeable acidity and soil moisture were significantly higher in the area under the cover than in the adjacent open area. Soil pH was slightly acidic (5.01-6.08) and was significantly ($p < 0.01$) higher in the area underneath the cover than area in the open. It is therefore, suggested that strong regulatory measures should be put in place and also effort to re-establish the depleted tree species populations should be encouraged. Disturbance especially through human activities should be discouraged or completely avoided because of their negative impacts on plant species diversity, nutrients availability and microbial population. This study did not only align with the reported trend of higher nutrients under tree cover and lower species diversity especially twinners and grasses, but also provided concrete values to back up the known trend.

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REFERENCES

Adekunle, V.A.J. and Dafiwhare, H.B. (2008). Diversity and abundance of microbes, pH and organic matter in soils of different forest types in tropical humid lowland forest ecosystem Nigeria. Journal of Biodiversity and Ecology 1(4): 333-342.

Anderson, J.M. and Ingram, J.S.I. (1993). *Tropical soil biology and fertility:* A Handbook of Methods, 2nd ed. CAB International Wallingford UK. 57.

Duncan, E.R. (1974). Weather information from the University of Ife, Ile-Ife, Faculty of Agric Research Bullettin 2, University of Ife Press, Ile-Ife, Nigeria. 14.

Ford, P.L., Potter, D.U., Pendleton, B., Ribbie, W.A. and Gottfried, G.J. (2004). Southwestern grassland ecology. In: Assessment of Grassland Ecosystem Conditions in SW United States (Finch, D.M. Ed.), Forest. Ser. Gen. Tech. Rep., RMRS-GTR-135, 1:18-48.

Forsyth, M.H. (2009). Microbial diversity in Virginia old hardwood forest soil week #1 Bio 203 laboratory module, Virginia state University, USA. 14p.

Gallardo, A. and Schlesinger, W.H. (1995). Factors determining soil microbial biomass and nutrient immobilization in desert soils. Biogeochemistry 28: 55-68.

Garbeva, P.J., Postma, J., Van Veen, A. and Van Elsas, J.D. (2006). Effect of above-ground plant species on soil microbial community structure & its impact on suppression of *Rhizoctonia solani* AG3. Environmental Microbiology 8: 233-246.

Gillet, F., Murisier, B., Buttler, A., Gallandat, J. and Gobat, J. (1999). Influence of tree cover on the diversity of herbaceous communities in subalpine wooded pastures. Applied Vegetation Science 2: 47-54.

Gregory, P.J. (2006). Roots rhizophere and soil: the route to a better understanding of soil science. European Journal of Soil Science 57: 2-12.

Gutiérrez, J.R., Meserve, P.L., Contreras, L.C., Vásquez, H. and Jaksic, F.M. (1993). Spatial distribution of soil nutrients and ephemeral plants underneath and outside the canopy of *Porlieria chilensis* shrubs (Zigophyllaceae) in arid coastal Chile. Oecologia 95: 347-352.

Hall, J.B. (1969). The vegetation of Ile-Ife, University of Ife, herbarium bulletin1.

Hibbard, K.A., Law, B.E., Reichstein, M. and Sulzman, J. (2005). An analysis of soil respiration across northern hemisphere temperate ecosystems. Biogeochemistry 73: 29-70.

Hutchinson, J. and Dalziel, J.M. (1954-72). Flora of West Tropical Africa (2nd eds) by RWJ Keay and FN Hepper, Crown Agents, London.

Isichei, A.O. and Muoghalu, J.I. (1992). The effect of tree canopy cover on soil fertility in a Nigerian savanna. Journal of Tropical Ecology 8(3): 329-338.

Jackson, R.B., Fierer, N. and Schimel, J.P. (2007). New directions in microbial ecology. Ecology 88: 1343-1344.

Joffre, R. and Rambal, S. (1993). How tree cover influences the water balance of Mediterranean rangelands. Ecology 74: 570-582.

Jose, S., Allen, S.C. and Nair, P.K.R. (2008). Tree crop interactions lessons from temperate alley-cropping systems, In: Batish DR, kohli RK, Jose S, Singh HP (eds) Ecological Basis of Agroforestry. CRC press, Boca Raton, Fl.

Joshi, B., Singh, B.P., Rawat, Y.S. and Geol, D. (2001). Facilitative effect of *Corianiana palensis* on species diversity and growth of herbs in severely eroded hill slopes. Current Science 80: 678-682.

Kadeba, O. and Benjaminsen, J.N. (1976). Contribution of organic matter and clay to the cation exchange capacity of soils in the savanna zone of Nigeria. Communication in Soil Science and Plant Analysis 7: 129-144.

Keay, R.W.J. (1959). An outline of Nigeria Vegetation. (3rd edition). Federal ministry of information printing division, Lagos, Nigeria.

Kieft, T.L., White, C.S., Loftin, R.S., Aguilar, R., Craig, J.A. and Skaar, D.A. (1998). Temporal dynamics in soil carbon and nitrogen resources at a grassland-shrubland ecotone. Ecology 79: 671-683.

Lalfakawma, S.U.K., Roy, S., Vanlalhriatpuia, K. and Vanalalhluna, P.C. (2009). Community composition and tree population structure in undisturbed and disturbed tropical semi-evergreen forest stands of North-East India. Applied Ecology and Environmental Research 7(4): 303-318.

Lü, X., Yin, J. and Tang, J. (2011). Diversity and composition of understory vegetation in the tropical seasonal rain forest of Xishuangbanna, SW China. Revista Biologia Tropical 59(1): 455-463.

Margaret, D., Loman, P.K. and Wittman, K. (1996). Forest canopies: Methods, hypotheses and future directions. Annual Review of Ecology, Evolution and Systematics 27: 55-81.

Nannipieri, P.J., Ascher, M.T., Ceccherini, L., Landing, G., Pietramellara and Renella, G. (2003). Ecological significance of biological activity in soil biochemistry. European Journal of Science 54: 655-670.

Nwachukwu, S.C.U. and Akpata, T.V.I. (2003). Principles of quantitative microbiology. University of Lagos Press, Lagos, Nigeria. 77pp.

Onochie, C.F.A. (1979). The Nigeria Rainforest ecosystem: An overview In: *Okali DUU. (Editor).* The Nigeria Ecosystem. Proceedings of the Man and Biosphere on the Nigeria Rain Forest Ecosystem, University of Ibadan, Conference Centre, 24-26 January Nigerian MAB Committee, Ibadan.

Pausas, J.G. and Austin, M.P. (2001). Patterns of plant species richness in relation to different environments: an appraisal. Journal of Vegetation Science 12: 153-166.

Pieolou, E.C. (1966). Species diversity and pattern diversity in the study of ecological succession. Theoretical Biology 10: 370-383.

Prescott, C.E. (2002). The influence of the forest canopy on nutrient cycling. Tree Physiology 27: 1193-1200.

Puerta-Pinẽro, C., Gomez, J.M. and Zamora, R. (2006). Species specific effects on top soil development affect Quercus ilex seedling performance. Acta Oecological 29: 65-71.

Rautiainen, M., Stenberg, P. and Nilsson, T. (2005). Estimating canopy cover in scots pine stands. Silva Fennica 39(1): 137-142.

Rodriquez-Echeverria, S. and Perez-Fernandez, M.A. (2003). Soil fertility and herb facilitation by Retamasphaerocarpa. Journal of Vegetation Science 14: 507-814.

Sanchez-Jardon, L., Acosta, B., Pozo, A., Del-Casado, M.A., Ovalle, C. and Elizalde, H.F. (2010). Grassland productivity and diversity on a tree cover gradient in Nothofaguspumilio in NW Patagonia. Agriculture, Ecosystems and Environment 137: 213-218.

Shannon, C.E. and Wiener, W. (1963). The Mathematical Theory of communication, University of lllinois press. Urbana. 117.

Schimidt, T.M. (2006). The maturing of microbial ecology. International Journal of Food Microbiology 9: 217-223.

Smyth, A.J. and Montgomery, F.R. (1962). Soil and land use in central western Nigeria. The government of western Nigeria, Ibadan.

SPSS (2010). Statistical Package for Social Sciences version model 17.0 SPSS Inc, Chicago.

Stone, W.E. and Wolfe, M.L. (1996). Response of understory vegetation to variable mortality following a mountain pine beetle epidemic in lodge pole pine stands in northern Utah. Vegetatio 122: 1-12.

Sundareshwar, P.V., Morris, J. and Koepfler, E. (2003). Phosphorus limitation of coastal ecosystem processes. Science 299: 563-565.

Tel, D.A. and Rao, P.V. (1982). Automated and semi-automated methods for soil and plant analysis. Manual series No.7 International Institute of Tropical Agriculture, Ibadan, Nigeria. 33pp.

Vetaas, O.R. (1992). Micro-site effects of tree and shrubs in a dry savanna. Journal of Vegetation Science 3: 337-344.

Washburn, C.S.M. and Arthur, M.A. (2003). Spatial variability in soil nutrient availability in an oak-pine forest: potential effects of tree species. Canadian Journal of Forest Research 33: 2321-2330.

Weltzin, J.F. and Coughenour, M.B. (1990). Savanna tree influence on understory vegetation and soil nutrients in Northwestern Kenya. Journal of Vegetation Science 1: 325-334.

White, F. (1983). The vegetation of Africa. UNESCO/AETFAT/UNSO, Paris.

Zak, D.R., Holmes, W.E., White, D.C., Peacock, A.D. and Tilman, D. (2003). Plant diversity, soil microbial communities and Ecosystem function: Are there any links? Ecology 84(8): 2042-2050.