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Full Length Research Paper

Assessment of tree species distribution and diversity in the major urban green spaces of Nairobi city, Kenya

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Plant composition of urban green spaces is an important component of urban ecosystem as it influences the provision of many environmental and social services that contribute to the quality life. In Nairobi, a few remnants of continuous highland forest exist but they are under increasing pressure from the rapidly changing surrounding landscape. The plant composition is being altered by human encroachment and other related activities. The status of the current plant composition in relation to location and disturbance level is unknown. This study was therefore carried out to determine the variation in tree composition and distribution in three major green spaces within Nairobi city namely City Park, Karura and Ngong' forests. Transects were laid out along environmental gradients, and the type, size, abundance and diameter at breast height (DBH) of tree species recorded within 20*15 m quadrats. The following aspects were calculated; abundance, species richness and distribution of tree diameters at breast height (DBH) and importance value (IVI). Indigenous species contributed 82% whilst exotic species accounted for 18% of the total species recorded. A mean quadrat species richness of 6.3, 4.7 and 4.1 was recorded in City Park, Karura and Ngong' forests, respectively. It was observed that few tree species dominate and this reduces the diversity. At forest edges, exotic species were abundant, but this changed as one moves to the center, where the composition was mainly indigenous due to minimal disturbance. It can be concluded from this study that for conservation of the green urban spaces, there should be proper planning in place to minimize the human encroachment and to enhance plant diversity especially indigenous species. Further, it is necessary to encourage all stakeholders to participate in the conservation of these important sites.

Key words: Urban vegetation, remnant habitat, anthropogenic effects, phytosociology, species richness, importance value.

INTRODUCTION

Urbanization in developing countries has accelerated in the past twenty years and nearly half of world's population are urbanized and projected to increase (K'Akumu et al., 2007). As urban areas expand existing

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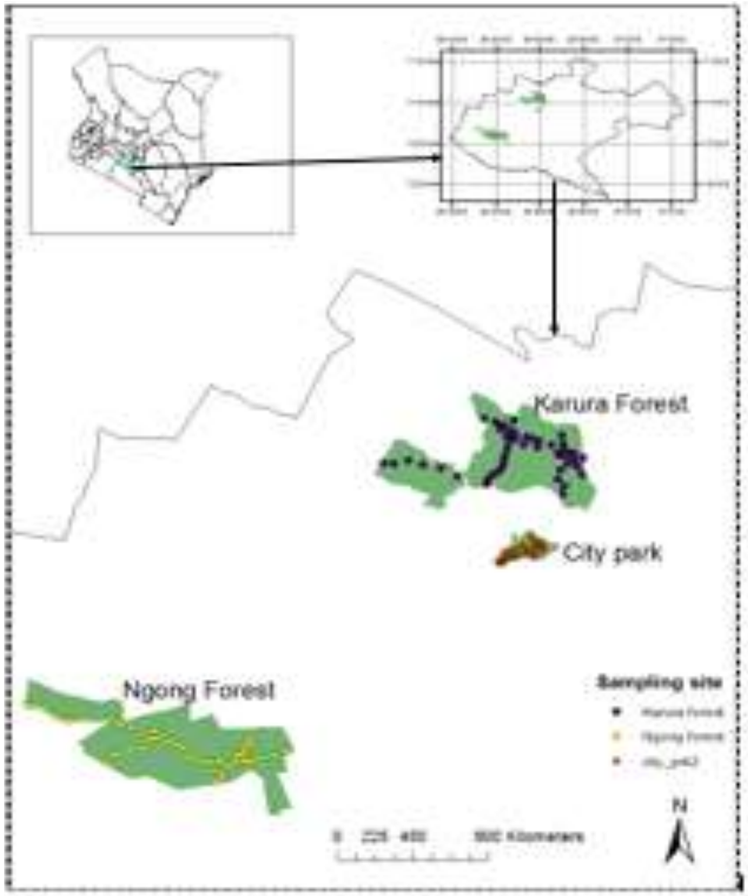

Figure 1. Section of Nairobi showing study sites.

forests may be destroyed, fragmented, or included as part of urban landscapes, exposing them to a number of threats including destruction of native species, invasion by exotic species, fires caused by human activities, pest and pathogen outbreaks, and unmanaged outdoor recreation activities (Chavez, 2005). Additionally, the process of urbanization leads to destruction and removal of vast area of the forests with serious impacts on the indigenous tree species (Ouinsavi and Sokpon, 2010). The replacement of indigenous species with exotic results in biotic homogenization and reduction in the biological uniqueness of local ecosystems (Blair, 1999). Nairobi's large and growing population is one of the main forces driving the city's overwhelming environmental challenges. Ongoing rural to urban migration, high natural birth rates, and poor or inappropriate city planning conspire to continue degrading the city's water and air quality. In turn, environmental degradation has impacts on human health and the economy (Tibaijuka, 2007).

The physical expansion of Nairobi has come at the expense of the natural environment. The urban sprawl, construction of roads and other city infrastructure has led to the loss of forests and other natural areas, such as mixed rangeland and bush lands (Tibaijuka, 2007). As a result, the forest cover receded and was replaced by coffee plantations. Later, the demand for food for the growing population led to the transformation of the city's outskirts to other agricultural uses, which in turn were threatened by further urban growth. The rise of unplanned settlements poses a threat to the protected areas in terms of depletion, pollution, plant diversity and destruction of habitats.

From the aforementioned challenges, this study aimed to determine the tree variation and distribution in the major green spaces in Nairobi city, Kenya.

MATERIALS AND METHODS

Description of study area

The city is located at the South-eastern end of Kenya's agricultural heartland, between approximately longitude 1° 9'S, 1° 28'S and latitude 36° 4'E, 37° 10'E (Figure 1). It occupies an area of about 696 km^2 and the altitude varies between 1,500 and 1,850 m above sea level (Tibaijuka, 2007).

City Park is located between Limuru road and forest road. It was curved from Karura forest and maintained as a recreation facility.

Table 1. Geographical characteristics of the study sites.

Study site	City Park	Karura forest	Ngong' forest
Date gazette	2009	1932	1932
Distance from CBD (Km)	4.6	7.8	12.5
Current area (Ha)	60	1041	1224.4
Location	Central eastern part of Nairobi	North central part of Nairobi	Western part of Nairobi

Part of it was landscaped, and the rest of the land is a remnant forest acting as habitat for plants and animals. It is one of the only few remaining intact portions of the rich indigenous forest that once extended over much of greater Nairobi.

Karura Forest Reserve is located in the north central part of Nairobi city. It is a dry upland forest and a water catchment for Thigiri, Karura, Ruaraka and Gitathura river systems. The forest supports plantation trees, indigenous trees and grasslands. It has a unique indigenous trees species composition that provides shelter to various fauna and below ground biodiversity. The forest has plantations that cover 632 ha while 260 ha are covered by indigenous plants.

Ngong forest is a dry land forest located within the confines of Nairobi city in the western part. It supports planted trees, indigenous trees and grasslands. The forest has had several excisions since its gazettement, most of them occurring between 1963 and 1994 (Sousa et. al., 2007).

Geographical characteristics of the study sites

The geographical characteristic of the study sites is given in Table 1.

Sampling and sampling plots layout

Quadrat plot's area 300 m² (20 m × 15 m) were used to collect data on trees, shrubs, saplings and herbaceous species for City Park. Grids of 20 m × 15 m were laid on a map, then a starting point was set at the starting edge of the park on the lower end and extended upslope to make a belt transect. Sampling quadrats were set at every 50 m interval. Subsequent transects were set in parallel manner with a separating distance of 150 m. In Karura and Ngong' forests transect belts were laid from one edge of the forest section to the other, and quadrats of 20 m × 15 m set along the transects at an interval of 100m between the quadrats. Transects were selected to represent the main environmental gradients in the study areas. The environmental gradients considered included, slope, riverine conditions and site exterior boundary to interior of the green space. The total numbers of quadrats sampled were 36, 51 and 41 for City Park, Karura and Ngong' forests, respectively.

Data collection

Within the quadrats all trees of height 8 m and above were identified up to species level and classified according to Beentje (1994). Diameter at breast height (DBH) was measured at a height of 1.3 m from the ground for all trees within the quadrat. For trees with multi-stems, each stem was measured separately and reported as a single index by taking the square root of the sum of all squared stem DBHs (Height et al., 2006). The geographical position of the studied quadrants were recorded by the use of global positioning system (GPS).

Data analysis

In order to understand the population structure and distribution pattern of tree vegetation in these semi-natural forest sites the data collected was used to derive several ecological variables. For each species, the number of individual trees recorded in all the quadrats and transects was summed to give the value of tree species abundance for the whole study site. The number of quadrats where a given species occurred was counted to give incidence. Species richness was derived from the total count of different types of tree species observed in all transects for each study site. Tree size was assessed using average DBH of all trees in the quadrats(Nagendra and Gopal, 2011). For each transect the average and standard deviations in diameters at breast height (DBH) of all trees were calculated. Trees were assigned to six different DBH size classes: 0-15, 15-30, 30-45, 45-60, 65-75 and >75 cm. The distribution of trees amongst different size classes was calculated using a measure similar to shannon diversity to give size class diversity (Nagendra and Gopal, 2011). The other variables such as species diversity, density, basal area and frequency were calculated or derived using standard formulas (Kigomo et al., 2015) as follows:

1. Shannon index of diversity (*H*); obtained using the following equation:

$$H' = -\sum_{i=1}^{N} Pi * lnPi$$

Where: H', Shannon diversity index; Pi, proportion (n/N) of individuals of one particular species found (n) divided by total number of individuals found (N); ln, is natural log and Σ is the sum calculations.
2. Basal area (BA): The cross sectional area of each stem measured at 1.3 m above the ground; obtained using the equation:

$$BA = \pi * (DBH/2)^2 \quad \pi = 3.14$$

3. Relative basal area (RBA): Basal area of a given species divided by the total basal areas of all the species *100:

i. Absolute frequency: The number of quadrats in which a given species was found divided by the total number of quadrats sampled.
ii. Relative frequency: Frequency of a given species divided by the total frequencies of all the sampled species*100
iii. Absolute density: The total number of individuals tallied for a given species divided by the total area of the measured plots (plants per hectare).
iv. Relative density: Density of a given species divided by the sum of the densities of all of the species* 100.
v. Importance value index (IVI): Relative frequency + Relative density + Relative basal area for each species.

All the computed phytosociological parameters in the three sites were tabulated for all the recorded tree species to show species

Table 2. Families with more than one tree species.

Species per family	Family (Number of species in brackets where applicable)
5 and Above	Myrtaceae (7), Euphorbiaceae (6), Mimosoideae (5),Oleaceae (5), Rubiaceae (5), Rutaceae (5).
4	Bignoniaceae, Celastraseae
3	Flacourtiaceae, Loganiaceae, Moraceae, Sapotaceae, Ulmaceae
2	Ebenaceae, Ochnaceae, Papilionoideae

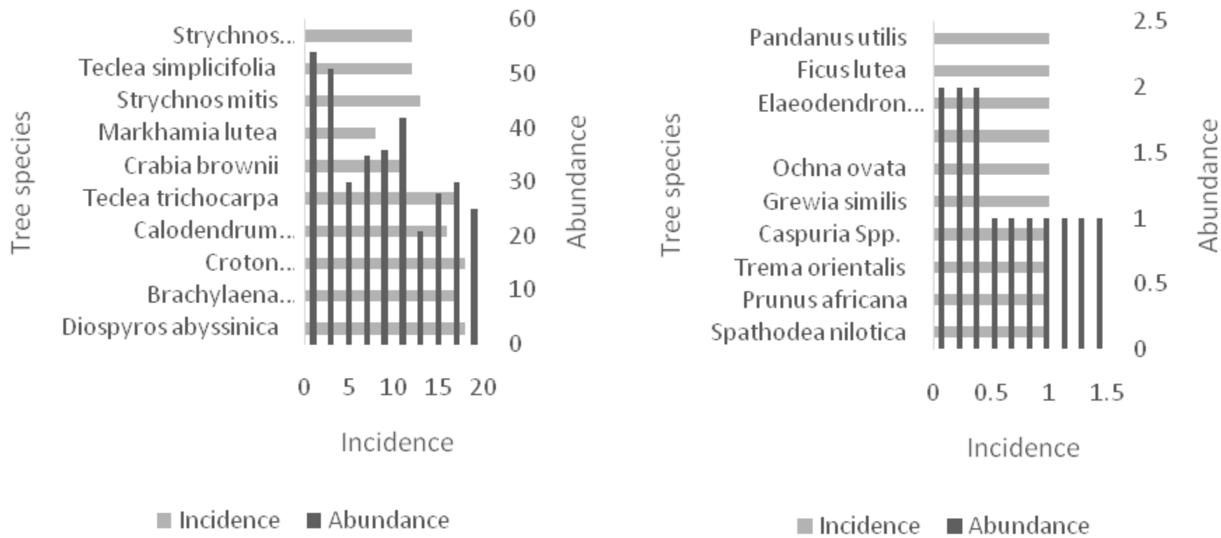

Figure 2a. Tree species abundance and incidence in City park for top and bottom ten trees. N/B: The order of tree species from bottom to top on the Y-axis also refer to order of tree species from left to right on the X-axis.

variations according to method of Lenza et al. (2015).

RESULTS AND DISCUSSION

Type of tree species and distribution

A total of 1,850 trees were sampled in 128 quadrats. Of these, 69.3% of the trees were native species, while the rest were exotic species. A total of 84 tree species were encountered which were distributed across 37 families; 69 out of 84 were native while 15 species were exotic. Plants in the Mrytaceae and Euphorbiaceae families were most common each with seven and six species, respectively. Four families had 5 species, two families had 4 species, five families had 3, and three families had 2 species each (Table 2). Overall, Karura forest recorded the highest abundance with 916 trees followed by City Park and Ngong' forest which had 491 and 445 trees, respectively. Overall, the most dominant species was *Eucalyptus paniculata* followed by *Drypetes gerrardii* and *Teclea trichocarpa.* Among the ten dominant species, eight were indigenous and only two were exotic.

Karura forest contributed seven of the top ten most abundant tree species, followed by City Park with two and Ngong' forest with one. In City Park, *D. abysinnica* was the most abundant tree species with a count of 54 while the least abundant trees were *Ficus lutea, Elaeodendron buchananii, Pandanus utilis* and *Mystroxylon ethiopicum* with a count of 1. At Karura forest, *E. paniculata* was the most abundant tree species with a count of 214 with trees like *Croton aleinus*, *Combretum mole*, *Grewia similis* and *Vangueria madagascariensis* having a count of 1. In Ngong' forest, *E. paniculata* was the most abundant tree species with a count of 118 and with trees like *Acocanthera oppositifolia, Cordia africana*, and *Maytenus undata* having a count of 1 (Figure 2a to c).

The abundance of the identified species when compared with incidence indicates that at city park *D. abysinnica* was more evenly distributed, occurring in 18 of the 36 sampled quadrats; unlike *E. paniculata* which was unevenly distributed as it appeared only in 12 and 8 out of the sampled 51 and 41 quadrats in Karura and Ngong' forests respectively. In Karura and Ngong' forests, the plantations done at specific areas were the

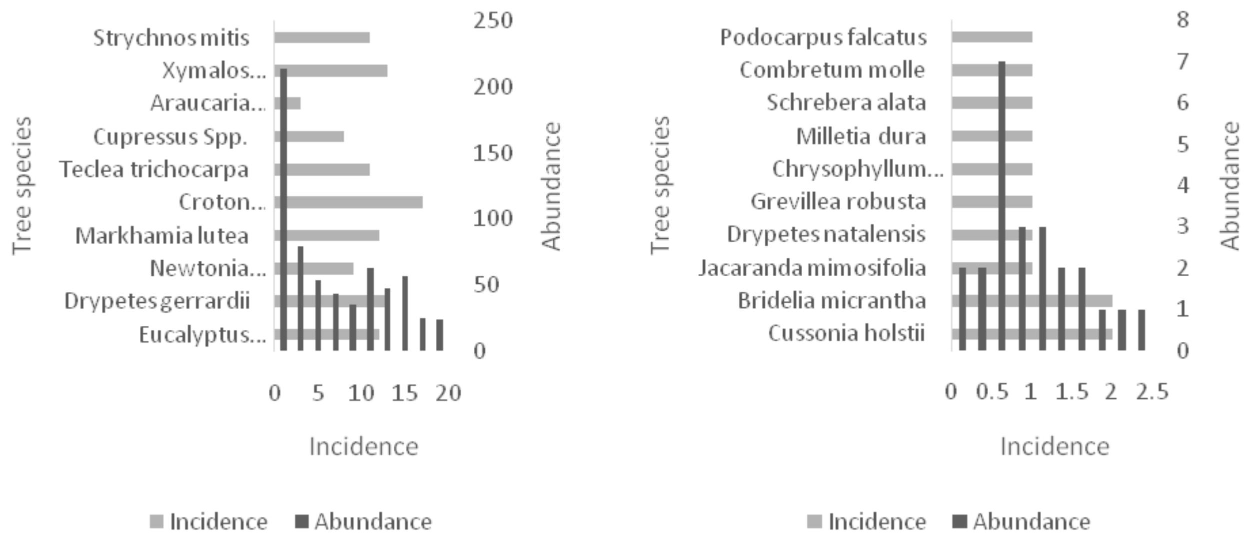

Figure 2b. Karura forest tree species abundance (count) and incidence (%) for top and bottom ten. The order of tree species from bottom to top on the Y-axis also refer to order of tree species from left to right on the X-axis.

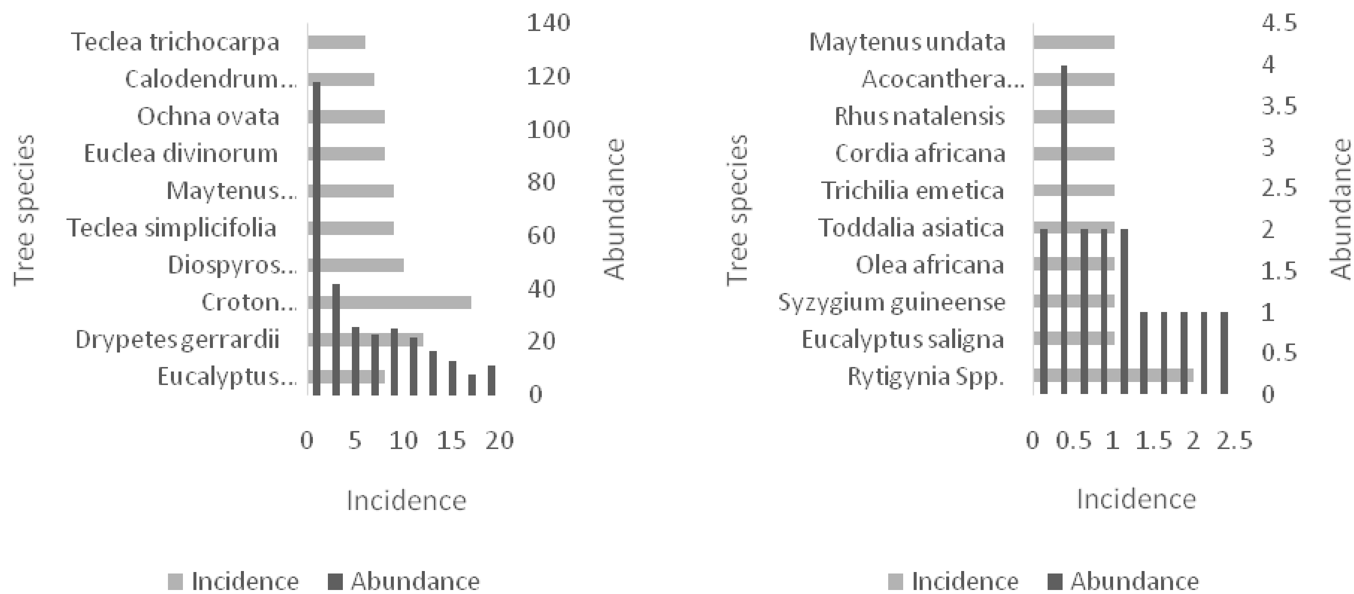

Figure 2c. Ngong' forest tree species abundance (count) and incidence(%) for top and bottom ten. The order of tree species from bottom to top on the Yaxis also refer to order of tree species from left to right on the X axis.

contributing factor of the unevenness of *E. paniculata* (Figure 2a to c).

The computed mean tree species richness per quadrat was 6.3, 4.7 and 4.1 for City Park, Karura and Ngong' forests, respectively (Table 3). Tree species frequency curves indicated that at City Park *D. abysinnica* and *C. megalocarpus* were the most common occurring in 18 out of the 36 sampled quadrats followed by *Teclea trichocarpa* and *Brachylaena huillensis* (17/38); while *Pandanus utilis, Trema orientalis, Ochna ovata* and *Ficus lutea* were the least common occurring only in 1 out of the 36 sampled quadrats. In Karura forest *Croton megalocarpus* was the most common occurring in 17 out of the 51 sampled quadrats, followed by *D. gerrardii* and *Xymalos monospora* (13/51). *Grewia similis, Milletia dura* and *Trema orientalis* were the least common occurring in 1 out of the 51 sampled quadrats. In Ngong' forest *C. megalocarpus* was the most common occurring in 17 out

Table 3. Attributes of the study sites - quadrats, species richness and diversity - summarized for the three study sites of Nairobi Kenya.

Site tree attributes	City Park	Karura Forest	Ngong' Forest
Number of quadrats	36	51	41
Percentage of indigenous trees	85.70	85	82.10
Average DBH (cm) per quadrat - mean and standard deviation	34.8 ± 22.7	21.5 ± 14.1	19.7 ± 8.8
Species richness per quadrat - mean and standard deviation	6.3 ± 3.1	4.7 ± 1.5	4.1 ± 0.3
Species Shannon diversity per quadrat - mean and standard deviation	2.3 ± 0.6	2.3 ± 0.5	2.5 ± 0.7
Size class diversity per quadrat - mean and standard deviation	1.7 ± 0.2	1.3 ± 0.4	0.6 ± 0.5

Species richness refers to the number of species. Shanon diversity is an index of diversity, calculated as H'=-$\sum_{i=1}^{N} Pi * lnPi$ where N is the total number of species and P*i* is the proportional abundance of the *i*th species. Size class diversity is calculated similarly based on the distribution of trees in different DBH categories as described further in the "Methods".

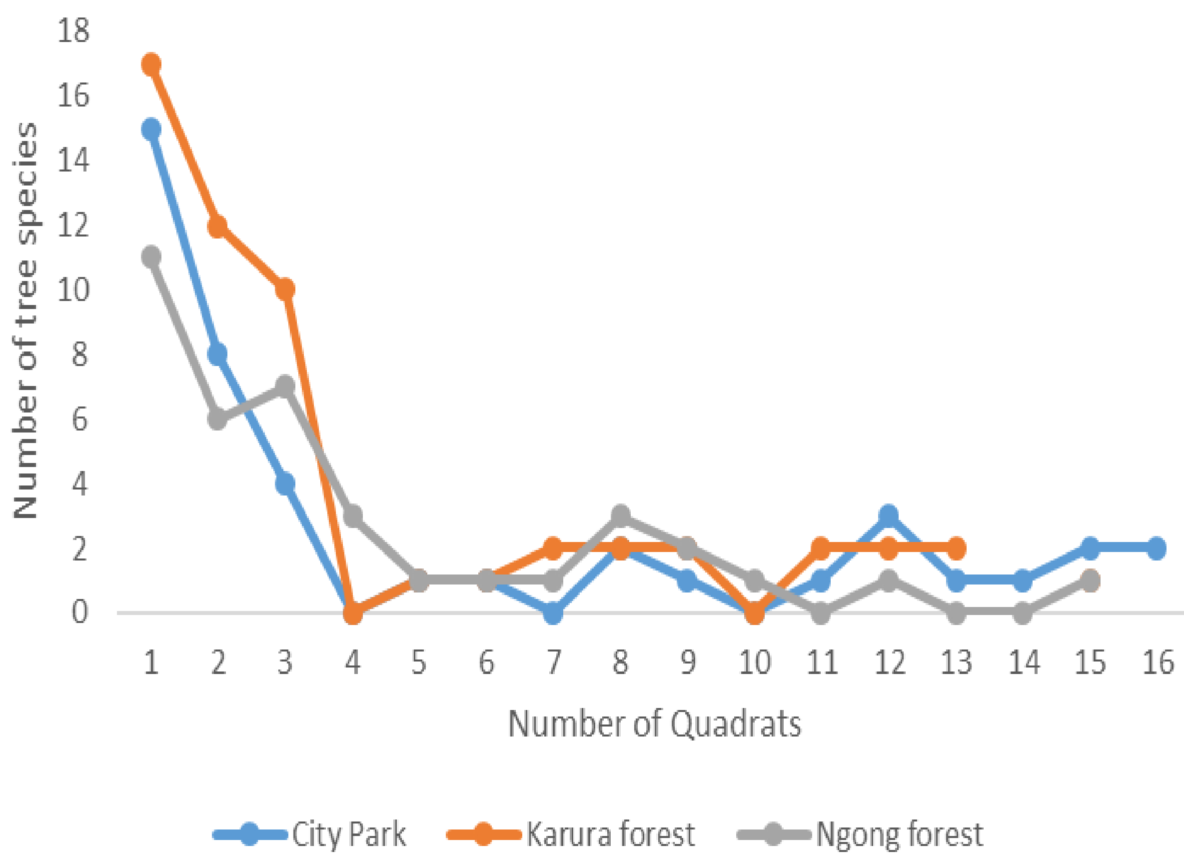

Figure 3. Tree species frequency curve at the study sites..The X-axis shows the number of quadrats in which the given tree species in the Y- axis were encountered out of the studied quadrats in the three sites for example in City Park only two species were repeatedly ecountered in 18 quadrats, while 15 species were each encountered only once in a quadrat).

of the 41 sampled quadrats, followed by *D. gerrardii* (12/41); while *Rhus natalensis, Cordia africana, Markhamia lutea. Toddalia asiatica, Trichilia emetica, Olea Africana and Syzygium guineense* were the least common occurring in 1 out of the 41 sampled quadrats (Figure 3).

Relative tree sizes and density

Majority of the trees encountered were in the DBH class 15-30 cm, followed by 0-15 cm and lastly the 60-75 cm class (Figure 4). Table 5a to c shows the tree species distribution among the DBH classes. *E. paniculata, T.*

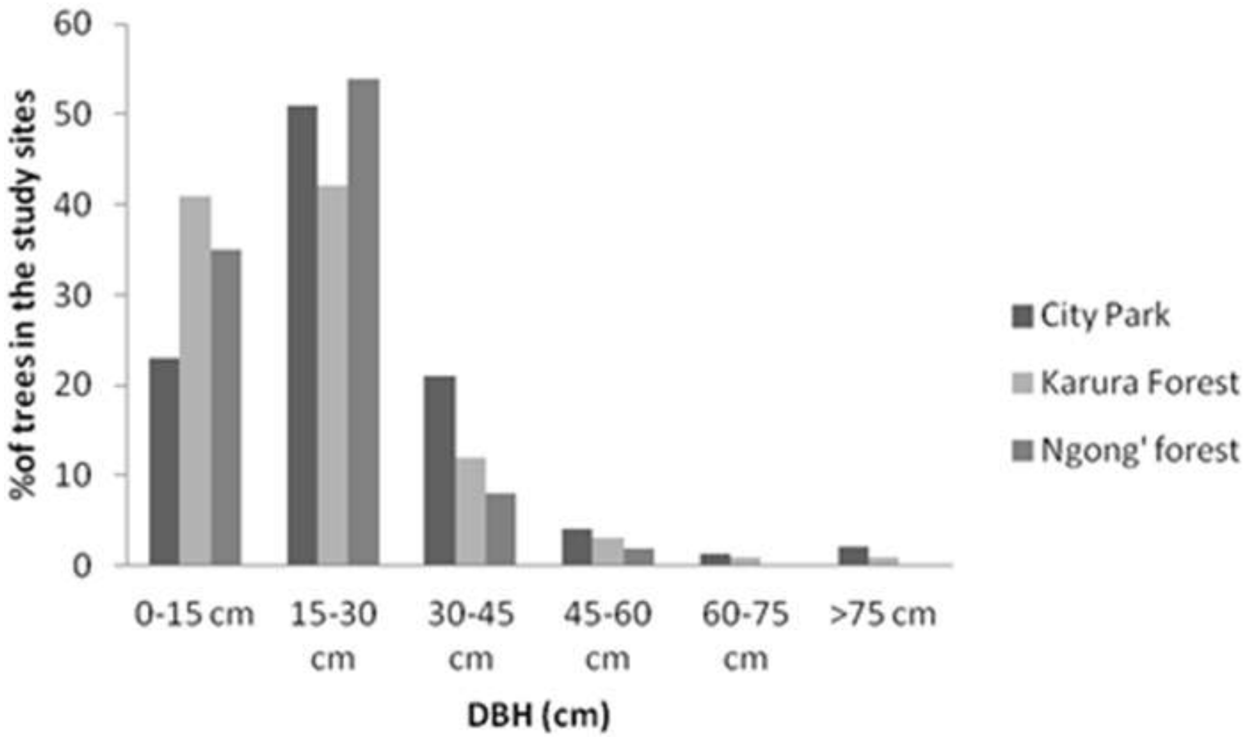

Figure 4. Propotional distribution of tree DBH across the three green spaces.

trichocarpa, and *Crabia brownii* were dominated by individuals in the two lower classes <15 cm and 15-30 cm DBH and do not have individuals in the size categories of 60-75 and >75 cm DBH. *Newtonia buchananii* and *Markhamia lutea* were fairly represented in all size categories.

Tree species important value index (IVI) has been used in other studies before to show the ecological importance of a given ecosystem (Aerts et al., 2011; Kacholi, 2014). At City Park *D. abyssinica* had the highest relative density and importance value followed by *B. huillensis* and *C. megalocarpus*. At Karura and Ngong' forests; *E. paniculata* had the highest IVI followed by *D.gerrardii*, *Newtonia buchananii* and *C. megalocarpus* respectively (Table 4). Table 6 shows a complete table of the phytosociological parameters of the species identified in the study sites.

Conclusion

Disturbance of the green spaces leads to increased unused resources which gives way to the invasive species that takes over the gaps created due to the disturbance (Davies et al., 2008). The boundaries of unprotected green space especially City Park, therefore had more invasive species dominating unlike the interior parts which were less disturbed. The study showed that Nairobi green spaces had high tree species richness; with 84 species recorded from128 quadrats sampled containing a total of 1850 trees. The tree distribution was however dominated by a few species with the top five species accounting for almost 50% of all tree species. There was a clear variation in species richness between City Park, Karura forest and Ngong forest. City Park leads in mean species richness followed by Karura forest and Ngong' forest respectively. This could be due to higher disturbance which opens space for other species to develop as the space regenerates. City Park is more open to visitation and the bushes regularly cleared by the management thus creating some level of disturbance that allows other plant species to establish. Karura and Ngong forests though enclosed, they have experienced various levels of uncontrolled disturbance and encroachment from the surrounding communities in informal settlements. In order to protect the many indigenous plant species that create these invaluable habitats, efforts are needed to continually manage them in sustainable manner by engaging the key stakeholders. Recent initiatives such as by the 'Friends of Karura Forest' to fence the forest, conduct tree plantings, and initiate guided nature walks for visitors, through the Kenya Forest Service and by involving the neighboring residents of Huruma community will contribute greatly in the conservation of Karura forest. In City Park, Nature Kenya, through 'The Friends of City' contributes in gathering

Table 4. Top then tree species based on the Importance Value Index (IVI) across the sites (RA: Relative Abundance, FR: Relative Frequency, Rden: Relative density).

Tree species/site	Family	Derived ecological Variables			
		RA	RF	Rden	IVI
City Park					
Diospyros abyssinica	Ebenaceae	11.00	8.00	16.41	44.73
Brachylaena huillensis	Compositae	10.39	7.56	14.63	36.60
Croton megalocarpus	Euphorbaceae	6.11	8.00	9.11	26.77
Calodendrum campense	Rutaceae	7.13	7.11	9.45	23.34
Teclea trichocarpa	Rutaceae	7.33	7.56	10.33	22.47
Crabia brownii	Papilionoideae	8.55	4.89	7.80	20.44
Markhamia lutea	Bignoniaceae	4.28	3.56	2.84	18.54
Strychnos mitis	Loganiaceae	5.70	5.78	6.14	16.37
Teclea simplicifolia	Rutaceae	6.11	5.33	6.08	15.84
Strychnos usambarensis	Loganiaceae	5.09	5.33	5.06	12.77
Karura					
Eucalyptus paniculata	Myrtaceae	23.36	4.88	31.50	91.32
Drypetes gerrardii	Putranjivaceae	8.62	5.28	12.60	24.35
Newtonia buchananii	Mimosoideae	5.90	3.66	5.96	19.02
Markhamia lutea	Bignoniaceae	4.69	4.88	6.33	16.77
Croton megalocarpus	Euphobiaceae	3.82	6.91	7.30	16.05
Teclea trichocarpa	Rutaceae	6.88	4.47	8.50	15.94
Cupressus Spp.	Cupressaceae	5.13	3.25	4.61	14.56
Araucaria heterophylla	Aruacariaceae	6.22	1.22	2.10	11.28
Xymalos monospora	Monimiaceae	2.73	5.28	3.99	9.59
Strychno smitis	Loganiaceae	2.62	4.47	3.24	8.28
Ngong'					
Eucalyptus paniculata	Myrtaceae	26.64	5.16	29.38	96.65
Drypetes gerrardii	putranjivaceae	9.48	7.74	15.69	36.56
Croton megalocarpus	Euphorbaceae	5.87	10.97	13.76	28.72
Diospyros abyssinica	Ebenaceae	5.19	6.45	7.16	16.68
Teclea simplicifolia	Rutaceae	5.64	5.81	7.00	14.44
Maytenus senegalensis	Celastraceae	4.97	5.81	6.16	14.43
Euclea divinorum	Ebenaceae	3.84	5.16	4.23	10.77
Ochna ovata	Ochnaceae	2.93	5.16	3.24	8.97
Calodendrum campense	Rutaceae	1.81	4.52	1.74	6.84
Teclea trichocarpa	Rutaceae	2.48	3.87	2.05	6.31

Table 5a. DBH size class distribution of the ten most dominant tree species, based on sample of the population of City Park.

Species	Species percentage of DBH Class (cm)						Number of trees sampled
	0-15	15-30	30-45	45-60	60-75	>75	
D. abyssinica	18.5	46.3	33.3	1.85	0	0	54
B. huillensis	15.7	62.7	19.6	0	1.96	0	51
C. brownii	21.4	64.3	14.3	0	0	0	42
T. trichocarpa	22.2	72.2	5.56	0	0	0	36
C. campense	11.4	71.4	11.4	2.86	2.86	0	35
C. megalocarpus	10	40	26.7	20	3.33	0	30
T. simplicifolia	23.3	56.7	16.7	3.33	0	0	30
S. mitis	25	53.6	17.9	0	0	3.57	28
S. usambarensis	44	48	4	4	0	0	25
R. lucida	13	73.9	13	0	0	0	23

Table 5b. DBH size class distribution of the ten most dominant tree species, based on sample of the population of Karura forest.

Species	Species percentage of DBH Class (cm)						Number of trees sampled
	0-15	15-30	30-45	45-60	60-75	>75	
E. paniculata	37.4	54.2	6.54	1.4	0.47	0	214
D. gerrardii	43.9	48.8	4.88	1.22	1.22	0	82
T. trichocarpa	50	46.7	3.33	0	0	0	60
A. heterophylla	19.3	42.1	29.8	8.77	0	0	57
N. buchananii	25.9	37	18.5	5.56	7.41	5.56	54
C. spp.	8.51	34	51.1	6.38	0	0	47
M. lutea	23.3	39.5	16.3	11.6	6.98	2.33	43
C. megalocarpus	22.9	57.1	17.1	2.86	0	0	35
E. ficifolia	75	25	0	0	0	0	28
X. monospora	76	24	0	0	0	0	25

Table 5c. DBH size class distribution of the ten most dominant tree species, based on sample of the population of Ngong' forest.

Species	Species percentage of DBH Class (cm)						Number of trees sampled
	0-15	15-30	30-45	45-60	60-75	>75	
E. paniculata	41.8	54.9	3.28	0	0	0	122
D. gerrardii	19	57.1	19	4.76	0	0	42
J. mimosifolia	14.8	85.2	0	0	0	0	27
C. megalocarpus	36	48	16	0	0	0	25
D. abyssinica	13	82.6	4.35	0	0	0	23
T. simplicifolia	59.1	36.4	4.55	0	0	0	22
M. senegalensis	36.4	59.1	0	4.55	0	0	22
E. divinorum	47.1	41.2	11.8	0	0	0	17
E. maculata	13.3	53.3	26.7	6.67	0	0	15
M. lutea	28.6	71.4	0	0	0	0	14

Table 6. Phytosociological parameters of the species and families sampled in City Park (CP), Karura forest (KF) and Ngong'forest (NF) arranged in a decreasing order of the maximum IVI values recorded for a given species in the three green spaces in Nairobi.

S/N	Species	Family	N			BA			IVI		
			CP	KF	NF	CP	KF	NF	CP	KF	NF
1	*E. paniculata*	Myrtaceae	-	214	118	-	1314.2	340.2	-	91.32	96.65
2	*D. abyssinica*	Ebenaceae	54	13	23	166.1	5.5	16.84	44.73	4.76	16.68
3	*Brachylaena huillensis*	Compositae	51	14	6	117.8	5.34	0.37	36.6	5.43	2.56
4	*D. gerrardii*	Euphorbiaceae	17	79	42	19.72	154.61	71.92	11.19	24.35	36.56
5	*C. megalocarpus*	Euphorbiaceae	30	35	26	78.97	43.94	21.89	26.77	16.05	28.72
6	*Calodendrum campense*	Rutaceae	35	5	8	55.38	0.52	3.17	23.34	1.43	6.84
7	*T. trichocarpa*	Rutaceae	36	63	11	37.48	70.91	2.13	22.47	15.94	6.31
8	*Crabia brownie*	Papilionoideae	42	11	3	63.4	2.71	0.27	20.44	2.28	2.27
9	*Newtonia buchananii*	Mimosoideae	-	54	-	-	224.87	-	-	19.02	-
10	*M. lutea*	Bignoniaceae	21	43	-	99.35	132.97	-	18.54	16.77	-
11	*Strychnos mitis*	Loganiaceae	28	24	9	36.41	13.7	3.99	16.37	8.28	5.35
12	*T. simplicifolia*	Rutaceae	30	18	25	36.19	8.98	8.94	15.84	4.77	14.44
13	*Cupressus* spp.	Cupressaceae	-	47	-	-	160.14	-	-	14.56	-
14	*M. senegalensis*	Celastraceae	-	_	22	-	-	13.46	-	-	14.43
15	*Strychnos usambarensis*	Loganiaceae	25	12	-	19.39	3.18	-	12.77	3.46	-

Table 6. Cont'd.

16	*Araucaria heterophylla*	Araucariaceae	-	57	-	-	190.52	-	-	11.28	-
17	*E. divinorum*	Ebenaceae	3	7	17	0.2	0.34	7.56	0.52	1.98	10.77
18	*Rawsonia lucida*	Flacourtiaceae	23	-	-	21.8	-	-	10.16	-	-
19	*Xymalos monospora*	Monimiaceae	-	25	7	-	7.73	0.71	-	9.59	3.58
20	*Ochna ovata*	Ochnaceae	1	5	13	0.01	0.35	3.11	0.46	1.42	8.97
21	*Strychnos mitis*	Loganiaceae	-	24	9	-	13.7	3.99	-	8.28	5.35
22	*Ficus thonningii*	Moraceae	7	-	4	33.76	-	0.51	7.51	-	1.63
23	*Calodendrum campense*	Rutaceae	-	5	8	-	0.52	3.17	-	1.43	6.84
24	*J. mimosifolia*	Bignoniaceae	9	7	27	9.89	2.68	24.93	3	0.61	6.04
25	*Chaetacme aristata*	Ulmaceae	12	12	-	6.46	3.15	-	5.97	4.01	-
26	*E. maculate*	Myrtaceae	-	-	15	-	-	12.84	-	-	4.57
27	*Warbugia ugandensis*	Canellaceae	-	16	5	-	4.71	1.4	-	4.42	2.66
28	*Strychnos usambarensis*	Loganiaceae	-	12	-	-	3.18	-	-	3.46	-
29	*Olea europea*	Oleaceae	-	10	4	-	2.6	0.52	-	1.7	3.17
30	*Acacia mearnsii*	Mimosoideae	-	6	4	-	0.56	0.45	-	0.98	3.16
31	*Celtis Africana*	Ulmaceae	7	4	-	2.52	0.4	-	3.1	1.38	-
32	*Eucalyptus ficifolia*	Myrtaceae	-	28	-	-	9.31	-	-	2.64	-
33	*Teclea nobilis*	Rutaceae	-	-	5	-	-	0.78	-	_	2.54
34	*Sapium ellipticum*	Euphorbiaceae	-	6	-	-	1.42	-	-	2.46	-
35	*Elaeodendron buchananii*	Celastraceae	-	3	4	-	0.16	0.69	-	1.34	2.43
36	*Mimusops kummel*	Sapotaceae	2	-	4	0.138	-	0.41	0.97	-	2.38
37	*Schrebera alata*	Oleaceae	3	1	4	1.33	0.09	0.37	1.15	0.422	2.38
38	*Allophylus rubifolius*	Sapindaceae	-	6	-	-	0.53	-	-	1.94	-
39	*Rothmannia urcelliformis*	Rubiaceae	3	6	-	0.17	0.5	-	1.01	1.94	-
40	*Pterelobium stellatum*	Fabaceae	-	5	-	-	0.19	-	-	1.88	-
41	*Manilkara discolor*	Sapotaceae	3	3	-	0.73	7.16	-	1.57	1.63	-
42	*Grevillea robusta*	Proteaceae	4	-	2	1.49	-	0.95	1.21	-	1.59
43	*Ochna insculpta*	Ochnaceae	4	-	-	0.37	-	-	1.58	-	-
44	*Ficus natalensis*	Moraceae	3	6	-	0.29	3.23	-	0.29	1.58	-
45	*Olea hochstetteri*	Oleaceae	3	-	-	0.15	-	-	1.5	-	-
46	*Eucalyptus grandis*	Myrtaceae	2	-	-	4	-	-	1.45	-	-
47	*Cussonia holstii*	Araliaceae	-	2	2	-	0.22	0.15	-	0.87	1.44
48	*Dovyalis abyssinica*	Flacourtiaceae	-	1	2	-	0.01	0.04	-	0.42	1.42
49	*Ochna ovata*	Ochnaceae	1	5	-	0.01	0.35	0.46	-	1.42	-
50	*Rytigynia Spp.*	Rubiaceae	-	-	2	-	-	0.01	-	-	1.42
51	*Vangueria infausta*	Rubiaceae	6	4		0.2	0.13	-	1.12	1.372	
52	*Eucalyptus saligna*	Myrtaceae	-	9	4	-	6.61	3.14	-	1.31	1.34
53	*Syzygium cordatum*	Myrtaceae	-	7	-	-	2.43	-	-	1.09	-
54	*Albizia gummifera*	Mimosoideae	2	2	-	0.72	1.69	-	1.05	0.93	-
55	*Dracaena*	Liliaceae	-	6	-	-	1.04	-	-	1	-
56	*Syzygium guineense*	Myrtaceae	-	6	2	-	0.63	0.66	-	0.99	0.83
57	*Oxyanthus Spp.*	Rubiaceae	-	4	-	-	0.45	-	-	0.93	-
58	*Adenia gummifera*	Passifloraceae	4	3	-	0.25	0.06	-	0.54	0.89	-
59	*Acacia pentagona*	Mimosoideae	-	3	-	_	0.05	-	_	0.89	-
60	*Prunus Africana*	Rosaceae	2	2	-	0.1	0.56	-	0.49	0.89	-
61	*Bridelia micrantha*	Euphorbiaceae	-	2	-	-	0.04	_	-	0.86	-
62	*Olea Africana*	Oleaceae	-	-	2	-	-	0.1	-	-	0.73
63	*Toddalia asiatica*	Rutaceae	-	-	2	-	-	0.04	-	-	0.71
64	*Trichilia emetic*	Meliaceae	-	-	1	-	-	0.17	-	-	0.71
65	*Cordia Africana*	Boraginaceae	-	-	1	-	-	0.07	-	-	0.69
66	*Rhus natalensis*	Anacardiaceae	-	-	1	-	-	0.03	-	-	0.68

Table 6. Cont'd.

67	*Acocanthera oppositifolia*	Apocynaceae	-	-	1	-	-	0.03	-	-	0.68
68	*Maytenus undata*	Celastraceae	-	-	1	-	-	0.02	-	-	0.68
69	*Nuxia congesta*	Loganiaceae	3	-	-	0.68	-	-	0.58	-	-
70	*Euphorbia Spp.*	Euphorbiaceae	4	-	-	0.45	-	-	0.57	-	-
71	*Spathodea nilotica*	Bignoniaceae	2	-	-	0.26	-	-	0.51	-	-
72	*Trema orientalis*	Ulmaceae	2	-	-	0.04	-	-	0.48	-	-
73	*Grewia similis*	Tiliaceae	1	1	-	0.01	0.02	-	0.46	0.42	-
74	*Mystroxylon ethiopicum*	Celastraceae	1	-	-	0.01	-	-	0.46	_	-
75	*Ficus lutea*	Moraceae	1	-	-	0.003	-	-	0.46	_	-
76	*Drypetes natalensis*	putranjivaceae	-	3	-	-	0.33	-	-	0.46	-
77	*Chrysophyllum viridifolium*	Sapotaceae	-	2	-	-	0.27	-	-	0.44	-
78	*Milletia dura*	Papilionoideae	-	2	-	-	0.05	-	-	0.43	-
79	*Combretum molle*	Combretaceae	-	1	-	-	0.05	-	-	0.42	-
80	*Podocarpus falcatus*	Podocarpaceae	-	1	-	-	0.05	-	-	0.42	-
81	*Commiphora Spp.*	Burseraceae	-	1	-	-	0.04	-	-	0.42	-
82	*Obetia Spp.*	Urticaceae	-	1	-	-	0.03	-	-	0.42	-
83	*Croton aleinus*	Euphorbiaceae	-	1	-	-	0.01	-	-	0.42	-
84	*Pandanus utilis*	Pandanaceae	1	-	-	0.07	-	-	0.03	-	-

N = number of individuals; BA = basal area; IVI = importance value index.

useful ecological information and on many occasions has helped to protect the habitat from encroachment and elevate its value as conservation and natural recreation site for City residents. Similar efforts at Ngong Forest will broaden the understanding about green spaces to a wider population, change perception and help to inform on best management practices to sustain their value. Stakeholders such as the Kenya Forest Services (KFS), the Department of Environment of Nairobi County, researchers, planners and the civil society should continue engaging the surrounding communities in the protection of urban green spaces through training and initiating environmentally friendly alternative sources of income rather than those deemed destructive. As indicated by the Shannon's index of diversity in the various transects for the three sites the value is low mainly due to over dominance of few species, some exotic. These green spaces must be continually managed to protect and enhance species composition and distribution as they are essential habitats for biodiversity and serve other key ecological functions.

Conflict of Interests

The authors have not declared any conflict of interests.

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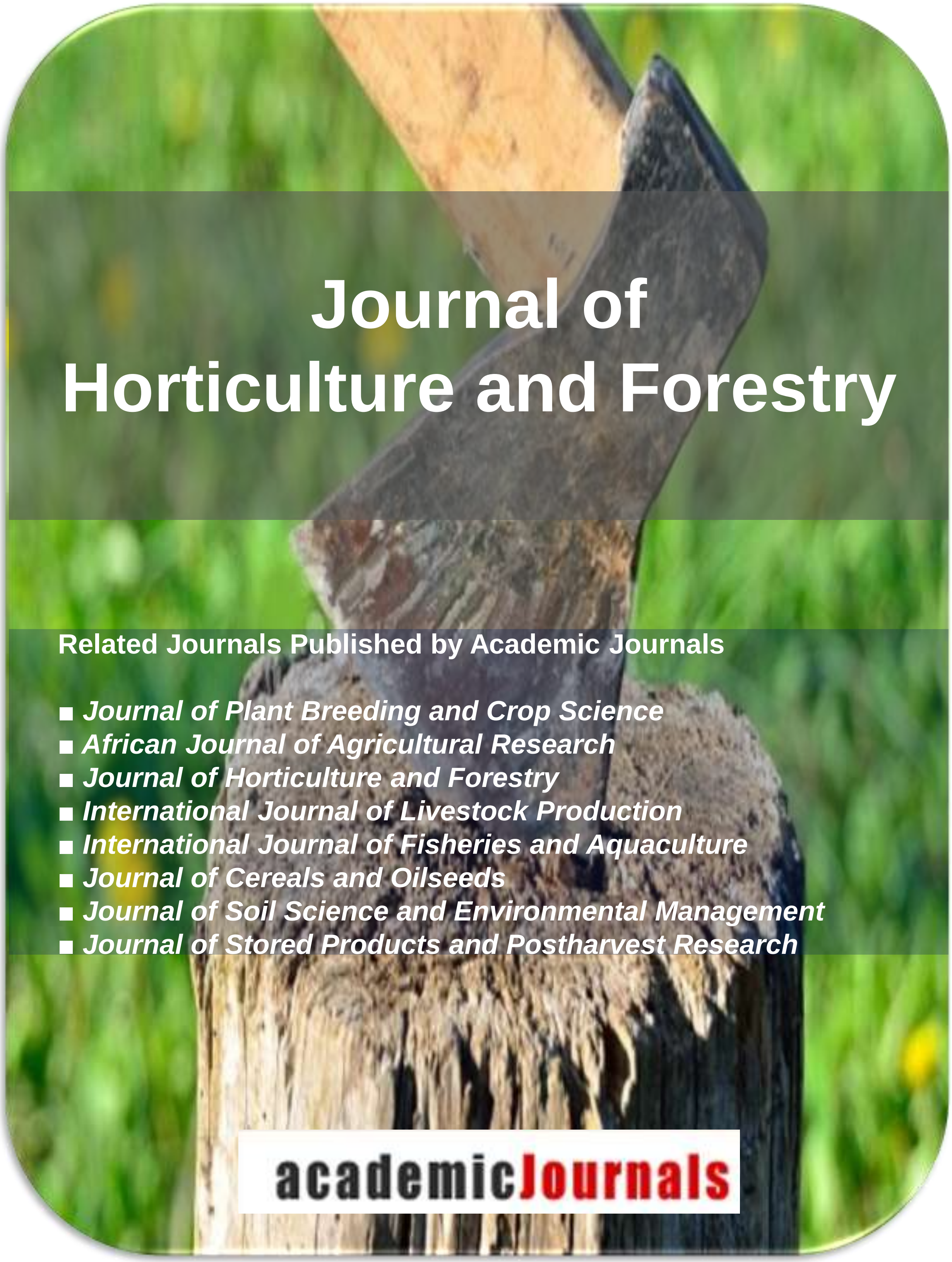

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