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Research Article

Variation in Woody Species Abundance and Distribution in and around Kibale National Park, Uganda

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Several protected areas in Uganda are increasingly facing encroachment making farmlands indispensable hubs for biodiversity conservation. A comparative study was conducted comprising a protected area in Kibale National Park and surrounding farmlands to establish how farmlands mimic the forest floristic structure. Study results show very low similarity between the forest and farmland ecosystems ($CC_j = 0.11$). A total of 50 and 29 species were identified in the forest and, farmland, respectively; 8 were shared. Importance value indices of woody species in the forest ranged from 0.3 to 29.9 with *Celtis durandii* being the most important while those in the farmland were 1.9–79.2, *Eucalyptus grandis*, having the highest index. Woody species diversity and evenness were higher in the forest ecosystem ($H' = 3.46$, $J' = 0.85$) compared to the farmland ($H' = 2.72$, $J' = 0.79$). The 10–<20 cm diameter class was the lowest in both ecosystems. Communities adjacent to the park should be educated about the value of the park and conservation in general. Since adjacent farmlands provide important ecotones to the park, on-farm indigenous tree retention and planting are required. Further research on threatened species is needed to enhance conservation in and around KNP.

1. Introduction

Kibale National Park received the protected status as a national park in 1993 [1, 2]. It was initially Kibale forest and a hunting ground for the Omukama of Tooro [3]. It underwent a series of transformations from being a gazetted Crown Forest in 1932 to Central Forest Reserve in 1948 and was gazetted as Kibale Forest Game Corridor in 1964 [4]. However, just like in other developing countries, Uganda's protected areas such as Kibale National Park (KNP) experience extensive human disturbances due to hunting, grazing, settlement, cultivation, fuel wood extraction, and collection of nonwood forest products which contribute to the livelihood of communities adjacent to protected forests [5]. In turn, these negatively affect tree growth and forest cover [6].

Hamilton [7] reported that changes in the patterns of woody species diversity and distribution in forests and farmland ecosystems can also be attributed to environmental factors such as canopy density, slope, soil, and altitude. Woody species composition usually varies with altitude whereby species numbers generally decline with elevation. There are also indirect effects of regional and global human industrial activities that influence the Earth's atmosphere and climate. Such environmental and human activities can lead to loss of woody species diversity, reduced species composition, and sparse distribution in protected areas where they are permitted or tolerated [6]. Environmental factors that can however positively influence woody species diversity include rainfall and proximity to the Pleistocene refugia [8]. Although some woody species may survive owing to their ability to coppice, mature quickly, and adapt to the stress and plantation forestry, they usually remain with a poor population structure [9].

Uganda is currently experiencing a rapid human population growth rate estimated at 3.4% per annum which has a strong correlation with expansion of agricultural land and overexploitation of natural resources within and outside protected areas [10, 11]. This coupled with the high levels of poverty implies that overexploitation of woody products is likely to continue [12]. Relatedly, overexploitation is being aggravated by the rising demand for wood products for both domestic and commercial purposes. Currently, 90% of Ugandans can only afford wood fuel for energy needs. It is one in ten (10%) of the population that has access to electricity [13].

In order to guide the decision-making processes [14] of the Kibale National Park managers and other stakeholders regarding conservation, there is need for information on the abundance and distribution of woody species inside and outside Kibale Park. Despite of this need, most studies and publications in KNP have focused on property rights and community participation [3] and pathology [15], mating behaviour [16], male social relationships [17], and feeding ecology [18] of chimpanzees. Information on the floristic structure of woody species within and outside Kibale National Park is scanty, scarce, and unpublished. Even the findings of a comparative study in 2010 on tree species diversity and distribution in the logged and unlogged compartments of KNP have remained largely less publicized. A study was therefore carried out to determine the variation of woody species abundance and distribution in and around Kibale National Park (KNP). The findings in this study do not only show how much of the woody species diversity in the protected area needs to be conserved and/or introduced on farms but also provide an important baseline for monitoring the impact of farming on biodiversity.

2. Study Area and Methods

2.1. Study Area. Kibale National Park (KNP) is located in western Uganda and covers approximately 795 km^2 [19]. It is located approximately 320 kilometers by road, west of Kampala, Uganda's capital and largest city (Figure 1). The park lies between 0°13′–0°41′N and 30°19′–30°32′E. It is a moist, evergreen, and semideciduous forest and falls within the Albertine rift zone [20]. The study was conducted in compartment K-14, one of the three forest compartments, around the Makerere University Biological Field Station (MUBFS) and in the farmlands in Rushenyi A and B villages in Kanyawara, Kabarole district. The 405 ha forest compartment K-14 experienced low intensity selective felling from May through December 1969 [19]. In this study, a farmland refers to a piece of land owned under customary, leasehold, freehold, or mailo tenure system but used or suitable for crop cultivation and/or livestock rearing. Kanyawara is situated at an elevation of 1,500 masl. Mean annual rainfall is 1,700 mm (1990–1996), mean daily minimum temperature is 15.5°C, and mean daily maximum temperature is 23.7°C as per the years 1990–1996 [21].

Rushenyi is mainly occupied by the Batooro [11]. Other ethnic groups include the Banyarwanda, Banyankole, Banyoro, Bakiga, and Baganda and some migrants from the Democratic Republic of Congo. The majority of the community is engaged in subsistence farming—cultivating coffee, maize beans, cassava, millet, and groundnuts. Livestock is also reared as an emergency source of income. A report by NEMA [12] indicates the length of fallow periods to be declining. This is probably due to the population growth and increasing expansion of agricultural land. There is high dependence on wood for domestic fuelwood supply and house construction [3].

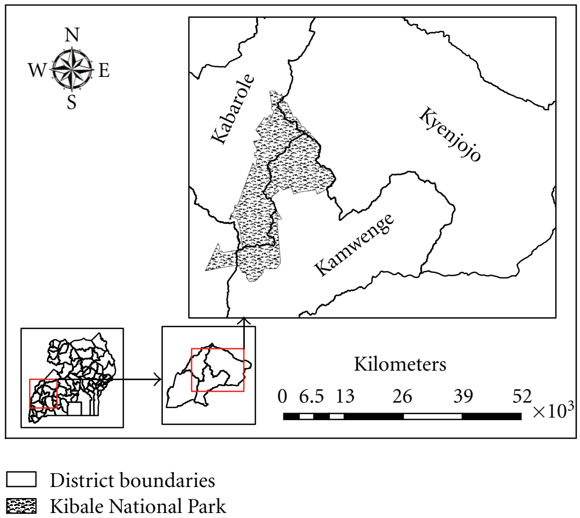

Figure 1: Map of Uganda showing location of the study area.

Sampling sites in the forest compartment had well-drained loam soils and waterlogged clay soils. Some plots were steep, gently sloping and others flat. The compartment had dense undergrowth that was not easy to penetrate, and the canopy was varying; in some plots it was closed, half closed and in others open. There was evidence of animal trampling and tree felling by elephants. The sites in the farmland had well-drained loam soils. The undergrowth was mainly open, and the slope was steep, and in some plots it was gently sloping. There was evidence of human activities such as crop growing, animal grazing, and charcoal burning.

2.2. Field Methods. Field work was conducted in January-February 2011. Plot sampling and point quarter methods were used to collect data. A total of five (5) transects were established during the inventory. The ratio of transects on farmland and forest ecosystem was 2 : 3. This was because the area of the forest ecosystem studied was larger than the farmland. Each transect in forestry compartment was 1 kilometre long. Ten plots were alternately laid on each transect. The distance between two consecutive plots was 100 m. The first plot on each transect in the forest compartment was oriented in the N-S direction following the compass direction. To avoid the edge effect, plots were laid 5 m from the trail. Each study plot of 20 × 10 m was nested (Figure 2) as done by Eilu and Obua [9].

Within the largest plot of 20 × 10 m, large woody species (≥20 cm dbh) were sampled. In 10 × 10 m subplot, woody species of size class (10 < 20 cm dbh) were assessed, in a 5 × 10 m subplot woody species of size class (5 cm < 10 cm dbh) were identified, and in a 5 × 5 m subplot the size class (1 < 5 cm dbh) was sampled. The woody species sampled were identified, counted, and their dbh recorded. Following Tabuti [22] and Agea et al., [23], the woody species that were not identified immediately were tagged and taken to Makerere University Herbarium for identification.

In the farmland, the point-centred quarter method (PCQM) was used. According to Mitchell [24], PCQM is suitable for determining the relative importance of various sparsely distributed woody species in a community such as farmland. Measuring importance can aid understanding the successional stages of a habitat. Two (2) transects were therefore randomly laid 100 m away from the home gardens in the N-S direction. Twenty (20) points of 50 m apart were laid on each transect, in an alternating way, giving a total of 40 sample points. Each point was divided into four (4) quadrants. Two (2) woody species of size classes (1 < 5 cm dbh), (5 < 10 cm dbh), (10 < 20 cm dbh), and (>20 cm dbh) in each quarter closer to the centre and within a maximum distance of 20 m from the central point were sampled, identified, and dbh measured and recorded. The Geographical Positioning System (GPS) coordinates of each sample point and other point characteristics (topography, soil type, drainage, human activity, land use, canopy cover, and undergrowth) were also recorded.

2.3. Data Analysis. The raw data on woody species from both ecosystems was entered in MS Excel. Data was analysed at forest compartment, farmland, and species level. The forest and the farmland ecosystems were compared. The species area curves were generated. To compare the successional stages of woody species, a combined graph of population structure for the farmland and forest ecosystem was drawn. The tree species richness, composition, and distribution were determined and presented in tables.

The woody species diversity and evenness in the forest compartments and in the farmland were calculated as done by [25] using Shannon-Weaver diversity index; $H' = -(\sum(\rho_i \ln \rho_i))$, where ρ_i is the proportion of individuals or the abundance of the ith species expressed as a proportion of total number of individuals encountered during the inventory. The product of $\rho_i \ln \rho_i$ for each species in the sites was summed up and multiplied by −1 to give H' [26]. The values of Shannon's diversity index, H', typically lie between 1.5 and 3.5, although in exceptional cases, they can exceed 4.5 [27]. The relative abundance with which each species is represented in an area was calculated using Shannon's species evenness index (J'), expressed as $J' = H'/\ln S$, where S is the total number of species.

The importance value index (IVI) was calculated by summing up relative density, relative dominance, and relative distribution for the forest compartment and the farmland;

$$\text{IVI} = \sum(\text{relative density} + \text{relative coverage} + \text{relative distribution}). \quad (1)$$

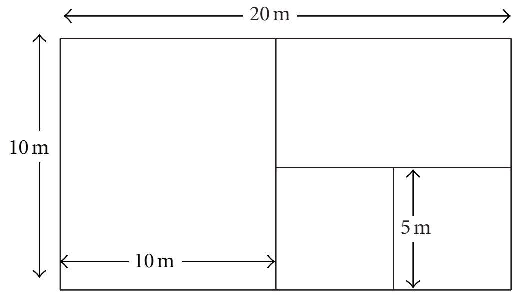

Figure 2: Plot layout.

The Jaccard coefficient was used to determine the similarity of woody species in the farmland and forest ecosystem. Jaccard coefficient was computed from

$$CC_j = \frac{C}{((S_1 + S_2) - C)}, \quad (2)$$

where S_1 = number of species in community 1, S_2 = number of species in community 2, and C = number of species common to both communities [28].

3. Results

3.1. Woody Species Composition, Similarity, Importance, Density, and Diversity. A total of 71 woody species were encountered in both ecosystems (Table 1). Of these, 29 and 50 species were encountered on the farmland and forest ecosystem, respectively. The Jaccard coefficient of ecosystems similarity of 0.113 shows a low similarity in species composition inthe two ecosystems. Only 8 species were encountered in both ecosystems. Some of the shared species included *Vernonia auliculifera*, *Hallea ciliate,* and *Croton macrostachyus*.

The importance value indices (IVI) of woody species in the farmland ranged from 79.19 to 1.92. Woody species with the highest IVI values of 79.19, 41.03, and 25.30 included *Eucalyptus grandis*, *Ficus saussurean,* and *Dracaena draco,* respectively. They constituted 27.6% of the total IVI on farm. *Albizia gummifera* had the least IVI value of 1.92 on farm. In the forest ecosystem, the IVI of woody species were between 29.91 and 0.25. Species with the highest IVI values of 29.91, 14.10, and 11.15 were *Celtis durandii*, *Diospyros mespiliformis,* and *Olea welwitschii,* respectively. These three woody species contributed 32.2% of the total IVI in the forest ecosystem. *Citropsis articulata* had the least IVI value of 0.25 in the forest ecosystem (Table 1).

The woody species with high IVI values in both ecosystems generally had high absolute densities and distribution. In the farmland *Ficus saussureana*, *Eucalyptus grandis,* and *Dracaena draco*, had absolute densities of 20.65, 14.66, and 7.43 cm^2/m^2, respectively. Similarly, *Celtis durandii*, *Olea welwitschii,* and *Newtonia buchananii* were the densest in the forest ecosystem. They had respective absolute densities of 219.94, 94.31, and 89.24 cm^2/m^2 (Table 1). Woody species diversity and evenness were higher in the forest ecosystem

Table 1: Woody species composition and importance value index in the farmland and forest ecosystems.

Species	Farmland				Forest ecosystem			
	Rel. density	Rel. coverage	Rel. distribution	IVI	Rel. density	Rel. coverage	Rel. distribution	IVI
Celtis durandii Engl.					5.52	24.32	0.08	29.91
Diospyros mespiliformis Hochst. Ex A. DC.					6.00	8.05	0.06	14.10
Olea welwitschii (Knobl.) Gilg and Schellenb.					0.72	10.43	0.00	11.15
Newtonia buchananii (Baker) G.C.C. Gilbert and Boutique					0.72	9.87	0.01	10.60
Funtumia latifolia (Benth.) Stapf.					2.88	5.42	0.04	8.33
Acanthophoenix crinita H. Wendl.					7.19	0.85	0.01	8.06
Markhamia lutea K. Schum.					2.64	3.63	0.03	6.30
Teclea nobilis Hook. f. ex Oliver					4.32	1.31	0.05	5.67
Linoceara johnsonii					2.40	2.58	0.03	5.01
Hallea ciliate Leroy	0.67	0.91	1.25	2.83	0.96	3.91	0.01	4.88
Millettia dura Dunn.	0.67	0.00	1.25	1.93	1.68	2.68	0.01	4.37
Neoboutonia macrocalyx Pax.					0.96	3.18	0.02	4.15
Diospyros abyssinica (Hiern) F. White					0.96	2.36	0.01	3.33
Mimusops bagshawei S. Moore					0.24	2.78	0.01	3.03
Rothmannia urcelliformis					2.40	0.50	0.04	2.94
Cassipourea ruwenzoriensis					2.16	0.65	0.02	2.84
Tarcelipas sp.					2.40	0.42	0.00	2.82
Psychotria capensis (Eckl.) Vatke					2.40	0.35	0.02	2.77
Melianthus arboreus					0.96	1.78	0.00	2.75
Vernonia auliculifera	0.67	0.01	2.50	3.18	2.16	0.52	0.02	2.70
Kigelia moosa Sprague.					1.92	0.74	0.02	2.69
Strombosia scheffleri					1.68	0.66	0.03	2.37
Xymalos monospora Baill.					1.44	0.83	0.02	2.30
Blighia unijugata Bak					1.92	0.25	0.03	2.20
Dovyalis macrocalyx (Oliv.) Warb					1.68	0.27	0.02	1.98
Tabernaemontana paucifolia Muell. Arg.					1.20	0.71	0.02	1.93
Celtis africana N. L. Burm					1.20	0.69	0.02	1.90
Acanthus pubescens Engl.	7.38	0.03	1.25	8.66	1.68	0.18	0.01	1.88
Croton macrostachys Hochst. Ex A. Rich	1.34	0.02	1.25	2.61	0.72	1.00	0.01	1.73
Pleiocarpa micrantha					1.20	0.43	0.01	1.64
Euadenia eminens Hook. f.					0.72	0.67	0.01	1.41
Premna angolensis Gürke					0.48	0.88	0.00	1.36
Uvariopsis congensis					1.20	0.13	0.02	1.35
Ehretia cymosa Thonn.					0.48	0.77	0.01	1.26
Alangium chinense (Lour.) Harms.					0.24	0.77	0.00	1.01
Trichilia splendida A.Chev.					0.72	0.20	0.01	0.94
Psychotria capensis (Eckl.) Vatke					0.72	0.16	0.01	0.89
Clausena anisata (Willd) Hook					0.72	0.11	0.00	0.83
Bersama abyssinica Fresen.	0.67	0.00	1.25	1.92	0.72	0.06	0.01	0.80
Aningeria altissima (A. Cheval.)					0.48	0.23	0.01	0.72
Chaetacme aristata Planch.					0.48	0.18	0.01	0.68

Table 1: Continued.

Species	Farmland				Forest ecosystem			
	Rel. density	Rel. coverage	Rel. distribution	IVI	Rel. density	Rel. coverage	Rel. distribution	IVI
Parinarium excelsum Sabine					0.48	0.12	0.01	0.61
Hoslundia opposita Vahl.	0.67	0.01	1.25	1.93	0.48	0.10	0.01	0.59
Tarena angolensis Benth.					0.48	0.04	0.01	0.52
Aphania senegalensis (Juss. Ex Poir.)					0.24	0.15	0.00	0.40
Bridelia micrantha (Hochst.)	1.34	0.02	1.25	2.61	0.24	0.10	0.00	0.34
Bosqueia phoberos Baill					0.24	0.09	0.00	0.33
Chrysophyllum albidum G. Don					0.24	0.03	0.00	0.27
Dovyalis macrocarpa Bamps					0.24	0.03	0.00	0.27
Citropsis articulata (Willd. Ex Spreng.) Swingle and M. Kellerm.					0.24	0.01	0.00	0.25
Albizia gummifera C. A. Smith	0.67	0.00	1.25	1.92				
Albizia grandibracteata Taub.	1.34	0.27	1.25	2.86				
Coffea robusta Emil Laurent	5.37	0.46	5.00	10.83				
Cyphomandra betacea Miers.	0.67	0.01	1.25	1.93				
Discopodium penninervium Most.	2.01	0.01	2.50	4.52				
Dracaena draco Linn.	4.70	14.35	6.25	25.30				
Erythrina abyssinica Lam. ex DC.	4.70	4.86	6.25	15.81				
Eucalyptus grandis Hill ex Maiden	30.87	28.32	20.00	79.19				
Euphorbia sp.	4.03	0.30	5.00	9.33				
Ficus brachypoda (Miq.) Miq	2.01	4.64	2.50	9.15				
Ficus brachylepis Warb.	0.67	0.04	1.25	1.96				
Ficus saussureana DC.	0.67	39.11	1.25	41.03				
Grevillea robusta A. Cunn. ex R.Br.	5.37	1.75	5.00	12.12				
Psidium guajava L.	0.67	0.50	1.25	2.42				
Indigofera arrecta Benth. ex. Harv. and Sond.	0.67	0.01	1.25	1.93				
Maesa lanceolata Forsk.	4.70	1.30	7.50	13.50				
Persea americana Mill.	2.68	1.52	5.00	9.20				
Pinus caribaea Morelet	0.67	0.06	1.25	1.98				
Ricinus communis Linn.	2.01	0.06	1.25	3.32				
Vernonia amygdalina Delile	4.03	1.31	5.00	10.34				
Vernonia sp.	6.71	0.10	5.00	11.81				

($H' = 3.46, J' = 0.85$) compared to the farmland ($H' = 2.72$, $J' = 0.79$).

3.2. Population Structure of Woody Species. In both ecosystems, the population of woody species generally follows an inverse *J*. The 10–<20 cm diameter class was however the lowest in both sites (Figure 3).

3.3. Species Accumulation Curves. Figures 4 and 5 show that the sampling effort in the farmland was adequate while that in the forest ecosystem was inadequate. The farmland ecosystem exhibited an initial exponential increase in the number of woody species. As the sampled area increases, the curve levels off, rises and tends towards an asymptote. The sampling effort in the forest was however inadequate as it did not exhaust all the species in the forest ecosystem. This is shown by Figure 5 that did not approach an asymptote.

4. Discussion of Results

4.1. Woody Species Composition, Richness, and Diversity. Some of the 50 woody species recorded in Kibale National Park (KNP) during this study are also found in other national parks. According to Korbee [29], the nationally threatened *Newtonia buchananii* and *Strombosia scheffleri* and the dominant *Parinarium excelsum* are also found in Bwindi Impenetrable National Park (BINP). *P. excelsum* is reported as dominant in both KNP and BINP [20, 29]

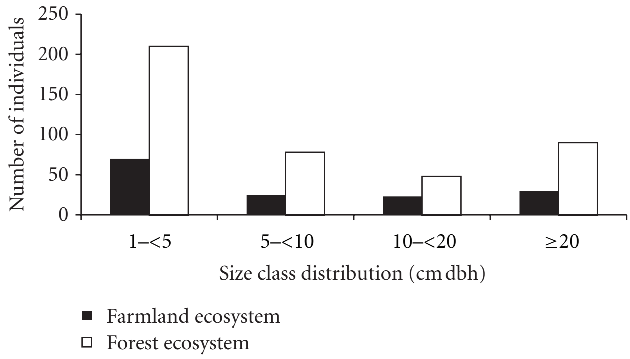

Figure 3: Population structure of woody species in the farmland and forest ecosystem.

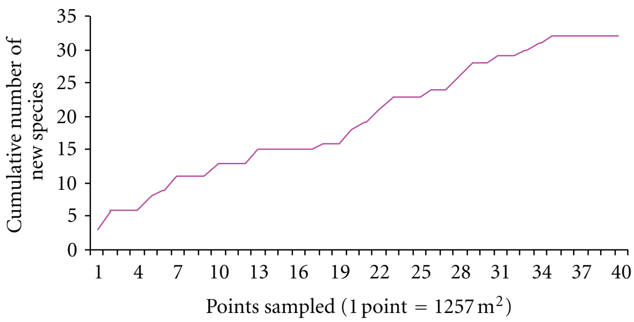

Figure 4: Farmland ecosystem.

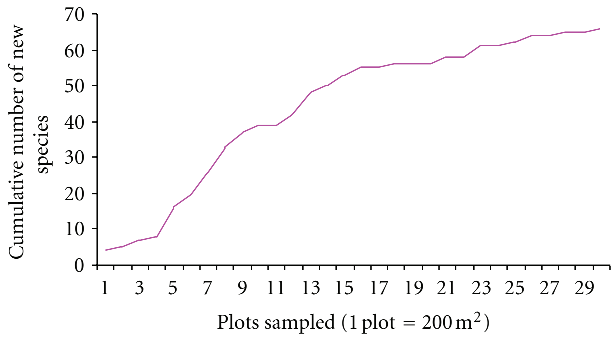

Figure 5: Forest ecosystem.

probably because the two parks have undulating terrains with low-lying areas and highlands that favour the species. *P. excelsum* is a climax community which tends to single-species dominance, at 1,500 m above sea level.

The woody species recorded in KNP are slightly less than the 72 species reported by Eilu and Obua [9] in BINP. The slight difference in species richness could be because both parks share in the high levels of endemism of the Albertine Rift in the Eastern Afromontane hotspot [8]. Additionally, the flora of the Eastern Afromontane hotspot shows much uniformity and continuity, its composition changing with increasing altitude. Even then, Turner [30] considers Kibale National Park as being lower in species richness than most tropical forests. More still, BINP is an older, more complex, and biologically richer ecosystem than KNP. Among the East African forests, Bwindi has some of the richest populations of trees, small mammals, birds, butterflies, reptiles, and moths. Korbee [29] reported BINP to be having more than 220 tree species (more than 50% of Uganda's tree species). The park's diverse species are partly a result of the large variations of altitude and habitat types and may also be because the forest was a refuge for species during glaciations in the Pleistocene epoch [29].

This study also shows that the number of woody species in the forest is almost twice those in the adjacent farmlands. Other comparative studies in tropical forests such as Kakamega, Mabira, and Budongo [31] and Bwindi [9] show that woody species richness is usually higher in less degraded than degraded sites. In Bwindi Impenetrable Forest, woody species richness in intact sites was about three times higher than in the completely degraded forest. Numerous factors such as interspecific interactions, habitat modification, seedling bank, availability of resources, disturbance levels together with stochastic factors like random climatic variability, fluctuations of resources, and dispersal limitation may influence the vegetation composition in a particular habitat [32, 33].

The greater woody species diversity in the forest ecosystem than farmland is comparable with many studies, which suggest that diversity is always higher in the less disturbed areas such as forests than more degraded sites like farmlands [9, 31, 34]. Farmers usually uproot most of the woody plants on their farms to ease heaping of soil during potato planting while slash-and-burn farming that is associated with growing coffee, groundnuts, and potato removes a substantial amount of woody plants to varying extents. It is probably a result of canopy opening during logging authorized about 30 years ago [20] which could have enhanced seed germination and growth in the forest ecosystem [35]. There could also be interdependence and coevolution in that other species in the forest may increase the reproductive success of all their members by attracting pollinators while others may produce a noxious chemical that protects all of them from herbivores [36].

This study emphasizes the importance of human and environmental factors in influencing disjunctions of woody species' distributions and diversity. The big difference in species composition in the forest ecosystem compared to a farmland may be attributed to anthropogenic activities carried out on the farmland. These activities include clearing of land for crop cultivation and burning which causes the disappearance of woody species [10, 23].

4.2. Woody Species Density. The absolute density of woody species was generally higher in the forest than in the farmlands. Elsewhere in Guinea, woody species such as *Vitellaria paradoxa* have been reported to have lower absolute densities in the continuous fields than in fallows because farmers retain only well-established trees close to reproductive size [37]. This probably accounts for higher densities of the ≥20 DBH size class in the forest than farmland ecosystem (Figure 2). Several studies on tree regeneration have documented a decrease in sapling density further from edges and have suggested that this may represent a regeneration response to disturbance, where many younger individuals are recruited into the locations left vacant by the death of older trees [9, 38].

4.3. Importance Value Index (IVI) of Woody Species. The importance value index (IVI) is an aggregate index that summarises the density, abundance, and distribution of a species. It measures the overall importance of a species and gives an indication of the ecological success of a species in a particular area [39]. The IVI of a species is a function of (a) the number of plants within the quadrats (abundance), (b) its influence on the other species through its shading, competition, or aggressiveness (dominance), and (c) its contribution to the community through its distribution (frequency). In the farmland ecosystem, the floristic structure of woody species showed a wider variation (Table 1) with IVI values ranging from 79.2 to 1.9. *Eucalyptus grandis* and *Ficus saussureana* were the first and second most important species. Although there is inadequate baseline information, the high IVI values of *E. grandis* and *F. saussureana* could be due to their high relative density, distribution, and cover on farm. This could be because local communities always select plants that can be used for fruits, firewood, medicine, shade, construction materials, and hedge for retention [40]. Furthermore, the planting of *E. grandis* is particularly being promoted by community-based organisations around KNP for fuelwood, poles, and timber [3].

The IVI values for woody species in the forest ecosystem in this study are lower than those reported the previous years. Whereas this study presents *Celtis durandii* and *Diospyros mespiliformis* as the first and second most important species in the forest, a previous assessment placed these species in the 7th and 33rd positions, respectively. There could also be some differences of in species composition, distribution, abundance, and densities in the line transects assessed in this study and the previous. In this study, *C. durandii* and *D. mespiliformis* were the first and fourth dominant species, respectively.

4.4. Population Structure of Woody Species. In both ecosystems, the population of woody species generally followed an inverse "*J*" (Figure 1). As noted by Lykke [41], for a population to maintain itself, it needs to have abundant juveniles which will recruit into adult size classes. However, the absence of adults in a population negatively affects recruitment into population by seed [42]. In other tropics, Muthuramkumar and Parthasarathy [39] found an inverse "*J*" among the tropical lianas in India. Additionally, Eilu and Obua [9] reported a similar trend for the diameter size classes of woody species in Bwindi Impenetrable Forest. The inverse "*J*" shows that a small fraction of the seedling and sapling classes usually survives to the larger tree classes. This could be so because there are usually two phases of mortality comprising initial mortality which is high, caused by microsite effects or small terrestrial animals, and for the larger dbh classes, competition with other plants that become important continued as the plants grew larger [35]. Mortality tends to increase due to reduced gap size and light availability, physical damage, soil dryness, and herbivore attack [43].

The 10–<20 cm diameter class was however the lowest (Figure 3). Perhaps this is caused by the harvesting. According to Tabuti et al. [10], exploitation of woody species continues because Uganda is experiencing a rising demand in wood products for both domestic and commercial purposes. Bikaako-Kajura [3] reported that communities around Kibale National Park exploit woody plants for poles and wood fuel. In the forest ecosystem, this diameter class may be low due to elephant trampling and herbivory [43].

4.5. Species Accumulation Curves. The species area curve approaches an asymptote only in the farmland ecosystem (Figures 4 and 5).The variation in species area curves may be attributed to the more random distribution of woody species in the forest than in the farmland ecosystem [39]. Hoekstra and Djinide [44] reported that several trees found on traditional farming systems are not deliberately grown with agricultural crops but are retained for other useful factors. These factors may include poles, medicine, timber, fuelwood, shade, and fruits [40, 45–47]. Although more species were recorded in the forest than farmland, there was need to assess more transects in order to exhaust all the species in the forest ecosystem.

5. Conclusion and Recommendations

This study shows that the floristic structure in Kibale National Park (KNP) is different from that of the adjacent farmland ecosystem. Adjacent communities were selectively tending a few indigenous woody species that provide desired products such as fruits, timber, poles, and medicine. Although some farmers have established *Eucalyptus* sp., *Pinus* sp. and *Grivellea* sp. woodlots, other interventions such as on-farm retention of both indigenous and exotic woody species should be properly implemented and/or enhanced by rural communities in collaboration with the Tooro Kingdom, Civil Society, and Local Governments [48]. There is need for further research most especially in the forest since the sampling effort in this study did not exhaust all the woody species. The adjacent communities should be sensitized on the value and techniques of natural resource conservation. Further research is required in both ecosystems to identify species that are threatened by extinction. In addition, propagation trials are needed in order to shorten the juvenile phases of preferred indigenous woody species so that more farmers can get involved in their conservation.

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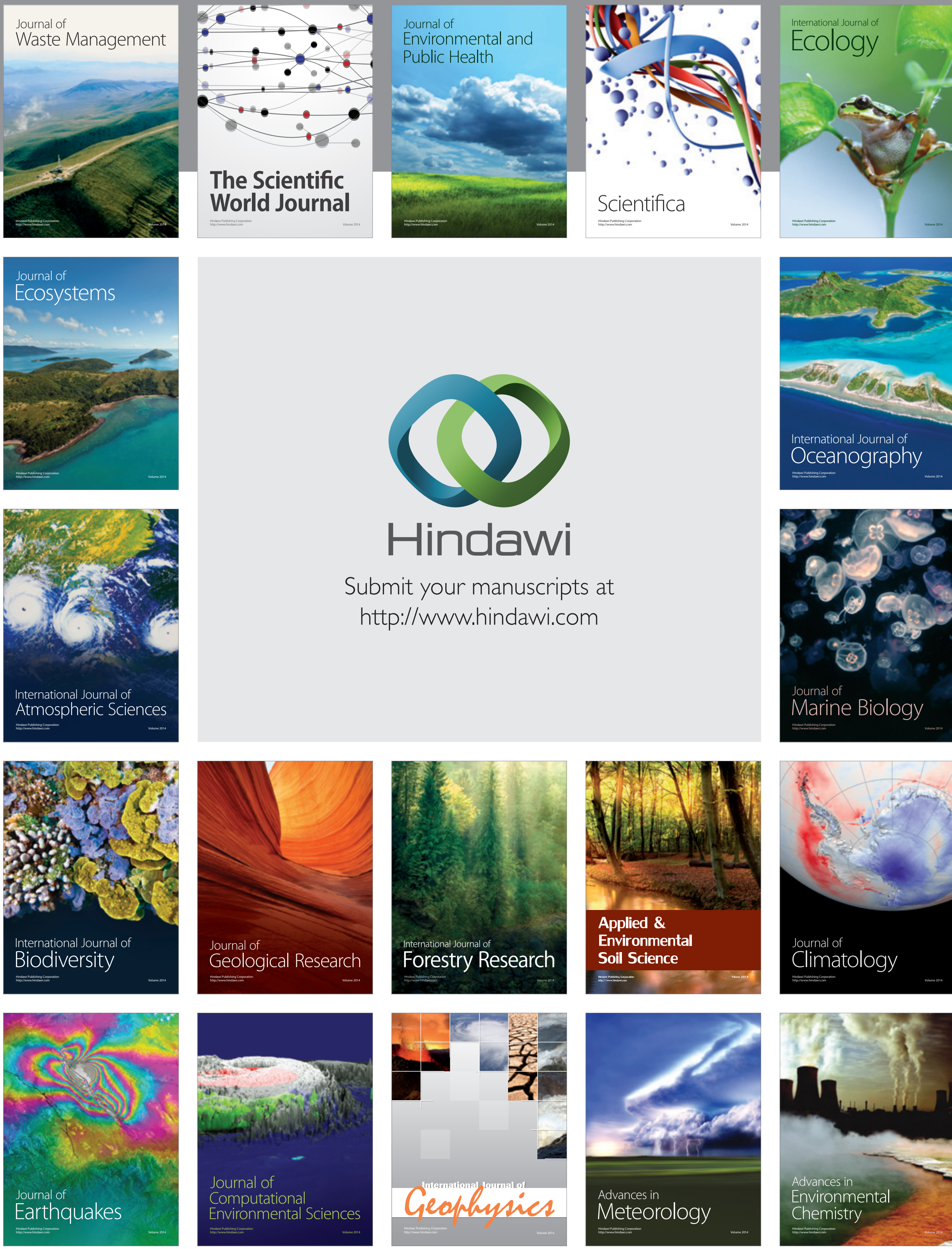
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