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Tree Species Structure, Composition, and Diversity in Sierra Leone Forest Ecosystem: An Evaluation of Two Protected Forests

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Abstract Biodiversity assessment and forest ecosystem are critical for species conservation. However, limited research had been done in Sierra Leone's tropical forests. This research explores the feasibility between two different protected areas of forest. This was accomplished by comparing the forest status in terms of tree species composition, diameter at breast height of each tree (to assess basal area), tree species density, and species abundance. Systematic sampling design, with a total of 15 sampling plots each, were districted in both forest ecosystems. All tree species (dbh ≥ 10 cm) in every plot were classified and their height, diameter at breast height (dbh) and diameters at the top, middle and base were evaluated for Otamba Kilimi National Park (strictly protected) and Kangari Hills Forest Reserve. There were 180 individual trees belonging to 24 species in the National Park, and 155 individual trees belonging to 58 species in the Forest Reserve. The most abundant species in the Forest Reserve was *Xylopia aethiopica* with 25 species compared to the National Park, which was dominated by *Spondias mombin* with 35 individual species. The Forest Reserve had a higher Shannon-Wiener index (3.63) and evenness (0.89) than the National Park with Shannon-Wiener index (2.76) and evenness (0.87). The Forest Reserve had a higher basal area (33 m^2 ha^{-1}) and volume (741.32 m^3 h^{-1}) compared to the National Park with a basal area (12.42 m^3 ha^{-1}) and volume (184.42 m^3 h^{-1}). Results indicate that the Forest Reserve is a potential biodiversity hotspot compared to the National Park. We conclude that the National Park is of lower tree diversity than the Forest Reserve by a degree that probably varies depending on improved management strategies, reforestation measures such as seed regeneration and/or enrichment planting, which will facilitate the gradual return of complex forests. The information on tree species structure and composition can provide baseline information for biodiversity conservation of protected forests in the country.

Keywords: *national park, forest reserve, species diversity, species richness, diameter at breast height, Sierra Leone*

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1. Introduction

Biodiversity assessment and forest ecosystem are critical for species conservation. Biodiversity is characterized as the parts of the living world to be conserved through conservation management and conservation biology [1]. The tropical rainforests like those in Sierra Leone have been identified as the most biologically diverse terrestrial ecosystems on earth [2,3,4,5,6,7]. However, the diversity of tree species in tropical rainforests varies with geography, habitat parameters, and levels of disturbance [8]. The accumulation of carbon dioxide from the atmosphere which serves as essential C-pools is one of the most significant roles of forest ecosystems [9,10]. Tropical forests play an essential role in combating local and global climate, in addition to providing raw materials for plant enhancement products and advanced pharmaceutical industries [11]. They are crucial for the environment in minimizing soil erosion, preserving soil moisture and regulating the flow of streams, as well as controlling the temperature of the area and providing shelter for a diverse range of flora and fauna [12]. Protected areas were enacted by restricting direct anthropogenic impacts to preserve natural forest environments and biodiversity. Consequently, understanding the structure and composition of protected forests can, therefore, be regarded as a guideline in the scope of the strategies to reduce emissions from deforestation and forest degradation (REDD) [13]. It also contributes to the development of techniques for the selection of taxa in reforestation, especially in the conservation of tree species

diversity [14,15]. Comprehensive information on plant species structure, composition and abundance is the critical element for effective management approaches in the various forest ecosystems [16]. However, in order to evaluate the function of current protected areas and forests in REDD, a detailed and accurate evaluation of their potential resources is required [17].

In Sierra Leone, information about protected areas is very scanty. In addition, the floristic compositions, types of plant communities, forest diversity, and population structure of tree species are not well researched and documented [18]. The current guiding principle in the forestry and wildlife sector has been ineffective in addressing emerging forest governance and management challenges [19]. The forestry act of 1988 remains the principal legal framework guiding the administration and regulation of forestry and protected areas in Sierra Leone [20]. The environmental management practices by the Environment Protection Agency (EPA) and other related environmental protection organizations are faced with several challenges due to the lack of effective and updated forest management regulations [21]. Thus, as the human population and per-capital spending are growing in the country, there is an increasing pressure on forests for timber, minerals, food, and biofuels such as firewood and charcoal that increases pressure on the natural forest [22,23]. A report by U.S Aid indicated that between 1975 and 2013, an average of 30% of Sierra Leone forest or around 1,100km^2 had been degraded [24]. Deforestation enthused by commercial logging is particularly important for biodiversity conservation, as it reflects forest invasion and economic growth with crucial negative impacts on biodiversity and wildlife protection [25]. Forest cover removal can have a negative impact on the environment; the most dramatic impact is a loss of habitat for millions of species, and drastically promotes climate change [26]. Other factors contributing to the dramatic decline in floristic composition in Sierra Leone are illegal forest operations, inadequate human resource, and capacity in the Forestry Division, ineffective forest patrol, stoppage of annual royalty payments to communities, obsolete forestry legislation and regulations. Evaluation of forest structure and composition is beneficial in understanding the status of the tree structure, and diversity for conservation purposes [27]. Knowledge of the composition of species and the diversity of tree species is significant not only for understanding the structure of a forest community but also for planning and implementing community conservation approaches [28,29,30,31].

There is increasing international consensus on the need for successful prioritization, preparation, restoration and evaluation of the world's forests and the species diversity to address the challenges these ecosystems are facing. However, conservation measures must be accompanied by reliable data on the different components of forest biodiversity and also to understand how to restore, protect, and manage these habitats. Consequently, floristic studies are required to produce baseline data that are critical in formulating such management strategies. Given the existence of inadequate species checklists in the country's forest ecosystems, however, no comprehensive and accurate research on the floristic diversity of protected forests is recorded. The current study was undertaken to evaluate the species composition, abundance, and diversity of two protected forests in Sierra Leone; the Outamba-kilimi National Park (strictly protected) and Kangarial hills non-hunting Forest Reserve. Data from this comprehensive inventory will provide the necessary information and enhance our understanding by documenting ecologically beneficial species and species of specific concern, hence establishing management strategies for forest biodiversity conservation. The main objective of this study was to evaluate the species composition, abundance, and diversity of two protected forests in Sierra Leone; the Outamba-kilimi National Park (strictly protected) and Kangarial hills non-hunting Forest Reserve.

2. Materials and Methods

2.1 Study Areas

The Outamba Kilimi National Park is currently the only National Park in the far north of Sierra Leone on the border with the Republic of Guinea (9°46′10″N 12°01′34″W). The vegetation is primarily southern Guinea savanna woodland with isolated patches of forest with an area of 110,900 ha (1,109 km^2) and an altitude of 200-480m. The reserve has small regions of raphia palm swamp-forest and riverine grassland terrain, which is mostly flat with few hills. The Mongo and Little Scarcies rivers flow southwest through the park. The area receives approximately 1000 mm of rainfall annually. Most of the park's roughly 2,200 mm of precipitation from June to September followed by a dry season lasting from about November to April.

The Kangari Hills Forest Reserve is a non-hunting forest reserve in the center of Sierra Leone (8°23′54″N 11°36′58″W). Lying between 200 and 500 meters above sea level, the reserve has an area of 8,573 hectares (85.73 km²). The hills are drained by a network of rivers and the valleys through which they flow support swamps which, once adopted, are suitable for agriculture, which is the main occupation of the inhabitants in the villages around them. At higher altitudes, at an altitude of 300–600 m, the vegetation is primarily closed moist forest, while at lower elevations, secondary forest, interrupted by bush fallow. The rainfall is bimodal with a mean annual rainfall of 3,500 mm with the rainy season ranging from May to October and the dry season from November to April. The soil in the study areas is the weathered and leached lateritic type, mainly acidic, yellow-brown and contain oxids of aluminum and iron. Its Kaolin clay is readily workable and free draining. Other clay minerals in progressively smaller amounts are gibbsite, chlorite, illite, quartz, and goethite. There is also a unique suite of interstratified minerals composed of illite with chlorite or vermiculite in various combinations.

2.2. Sampling Procedures

Systematic sampling techniques were used for the selection of sampling plots in both forest ecosystems guided by existing maps and information from the forest workers. At each interval of 50m, the sampling plots were

surveyed with a square shape to the baseline. The sampling plots with a radius size (10 × 10 m) were identified along the transect lines using Geographic Positioning System (elevation, latitude, and longitude) as recommended by Mueller-Dombois and Ellenberg [32] and Chytry et al. [33]. A total of 30 sampling plots for trees (≥ 10 cm) diameter at breast height, i.e., dbh and 1.3m above ground level, were demarcated. All plots were placed at least 100 m away from trekking trails to prevent anthropogenic impacts on the forest. The names of the tree types, height and dbh were recorded in each sampling plot and the Sunnto Clinometer [34] was used to measure tree heights. Pressed samples were taken to the Njala University National Herbarium for identification and confirmation for some species that could not be identified directly on the field.

2.3. Data Analysis

2.3.1. Tree Species Diversity

The Shannon diversity index (H^1) was used to measure the species abundance and richness and quantify the diversity of the woody species. This index takes both species abundance and species richness into account:

$$\text{Shannon Weiner Diversity Index}(H) = -\sum_{i=1}^{s} piInpi$$

where H' is the Shannon-Wiener diversity index; S is the total number of species in the community; pi is the proportion of S made up of the i species; Ln is the natural logarithm.

To determine the Evenness Index (E), the Pielou Evenness Index [35] formula was used:

$$Evenness\ Index\ (E) = \sum H / In(S),$$

where E is the Pielou Evenness Index, ln is the normal logarithm, S number of species.

The Dominance Index (C) was determined using the formula:

$$Dominance\ Index\ (C) = \sum (ni / N)^2,$$

where C is the Dominance Index, ni is the number of individuals of a particular species, N is the total number of individuals of all species.

The Importance Value Index (IVI) was calculated using the quadrate method [32]. The (IVI) of species is defined as the sum of its relative density (RD), relative dominance (RD) and relative frequency (RF).

$$Importance\ Value\ index\ (IVI) = RD + RF + RD,$$

which are calculated using the following equations:

$$\text{Density}(\text{D}) = \frac{\text{Number of individuals of a species}}{\text{Area of all sample units}}$$

$$\text{Relative Density}(\text{RD}) = \frac{\text{Number of individual species}}{\text{Density for all species}} \times 100$$

$$\text{Frequency}(\text{F}) = \frac{\text{Number of quadrats containing certain species}}{\text{Total number of quadrats}}$$

$$\text{Relative Frequency}(\text{RF}) = \frac{\text{Frequency of a certain species}}{\text{Total number of species}} \times 100$$

$$\text{Dominance}(\text{D}) = \frac{\text{Basal area of a species}}{\text{Area of all sample units}}$$

$$\text{Relative Dominance}(\text{RD}) = \frac{\text{Dominance of one species}}{\text{Dominance of all species}} \times 100$$

2.3.2. Tree Basal Area

The basal area (BA m^2) of all trees in the sample plots was calculated using the formula:

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

where BA = Basal Area, and D = Diameter at breast height (m)

The total basal area of trees in each sample plot was obtained and used to determine the per hectare equivalents.

2.3.3. Volume

The volume of each tree was calculated using the Newton's formula [36],

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

where V = Tree volume (m^3), A_b, A_m and A_t = tree cross-sectional area at the base, middle and top of merchantable height, respectively (m^2) and h = tree height (m). Plot volumes were also obtained by adding the volumes of all the trees in the plot. The mean volume for sample plots was calculated by dividing the total plot volume by the number of sample plots (15 plots). Volume per hectare was calculated by multiplying the average volume per plot with the number of plots 10×10m per hectare (30 plots).

3. Results

3.1. Tree Species Diversity and Abundance

A total of 335 individual tree species were recorded at both study sites where180 individual trees belonging to 24 species were enumerated in the National Park, and 155 individual trees belonging to 59 species were identified in the Forest Reserve (Apendix 1). However, a total of 73 tree species and 45 families were recorded at both sites, and 10 species were common between the two management systems. The Forest Reserve was dominated by *Xylopia aethiopica* and *Albizia zygia* with 25 and 10 individual species respectively, while the National Park was dominated by *Spondias mombin* and *Margaritaria discioides* with 35 and 32 individual species respectively. The Forest Reserve was dominated by the family Annonaceae (17.4%) and Mimosaceae (14.1%) of the total tree stand while the National Park was dominated by

Anacardiaceae (19.4%) and Caesalpiniaceae (18.8%) of the total tree stand. During the survey, four tree species that are endemic to the National Park were recorded: *Anisophyllea laurina*, *Diospyros thomasii*, *Diospyros heudelotii* and *Dialium guineense*. Biodiversity assessment usually focuses on the species level and diversity and is one of the most relevant measures used to evaluate ecosystem at various scales. In the present study, the Forest Reserve had a higher Shannon-Wiener index (3.63) and evenness (0.89) than the National Perk with Shannon-Wiener index (2.76) and evenness (0.87) (Table 1). However, this study reveals that seven of the tree species recorded were of importance to the International Union of Conservation of Nature (IUCN) conservation with one Endangered (*Placodiscus pseudostipularis*) and six Vulnerable (*Nauclea diderrichii*, *Milicia regia*, *Lophira alata*, *Heritiera utilis*, *Drypetes afzelii*, *Cryptosepallum tetraphyllum*). There were 25 species recorded in the small size class (10-30cm dbh), while 18 species were recorded in the size class of ≥30cm dbh.

Table 1. Summary of the tree species variables obtained from both protected areas.

Variables	Protected Areas	
	Forest Reserve	National Park
Number of trees/ha	155	180
Number of stems/ha	367	382
Basal area/ha (m^2)	33	13
Volume/ha (m^3)	741.3	184.4
Number of families	30	15
Number of species	58	24
Average height (cm)	38.4	20.1
Mean Dbh (cm)	29	19
Species evenness	0.89	0.87
Shannon diversity index	(3.63506)	2.76399

3.2. Forest Structure

At the National Park, 144 trees belonging to the small diameter class of 10 – 30 cm and 36 trees belonging to the large diameter class ≥30cm were enumerated, while 105 trees belonging to the small diameter class of 10 – 30 cm, and 50 trees belonging to the large diameter class ≥30cm were identified in the Forest Reserve. There was a decrease in the number of stems as the diameter increases. The number of stems was inversely proportional to the diameter sizes, which is typical of mature natural forest with a reverse J pattern of the dbh class frequency which indicates a healthy recruitment of the individuals in both protected areas. The lowest diameter class (10 - 20 cm) had the highest number of stems in both protected areas. This class had 233 stems ha^{-1}, about 61% of the total stems ha^{-1} in the National park. Similarly, there were 140 stems ha^{-1}, about 38% of the total stems ha^{-1} in the Forest Reserve. The overall mean wood volume recorded in the Forest Reserve was higher (741.32 m^3 h^{-1}) than the overall mean wood volume recorded in the National Park (184.42 m^3 h^{-1}) (Table 1). The overall basal area recorded in the Forest Reserve was higher (33 m^2 ha^{-1}) than the overall basal area recorded in the National Park (13 m^2 ha^{-1}). An estimate of all parameters of the natural forests was done on individual trees and by plots. The linear function for estimating the height of trees measured for height in the field and the linear relationship between basal area and wood volume in the National Park was recorded as R^2 = 0.9067 and R^2= 0.7554 respectively (Figure 1) while the linear function for estimating the height of trees measured for height in the field and the linear relationship between basal area and wood volume in the Forest Reserve was recorded as R^2 = 0.0083 and R^2 = 0.9988 respectively (Figure 2). However, *Spondias mombin* had the highest species importance with an IVI of 20.7 followed by *Pterocarpus erinaceus* with IVI of 18.1 at the National Park, while Xylopia aethiopica had the highest species importance with an IVI of 14.5 followed by *Albizia zygia* with IVI of 5.2 at the Forest Reserve. Also, higher stem density was observed in the National Park (382 stems per ha), than the stem density recorded in the Forest Reserve (367 stems per ha), while the average DBH (29cm) and height (38.4m) recorded in the Forest Reserve was higher than the average DBH (19.8cm) and height (20.1cm) recorded in the National Park.

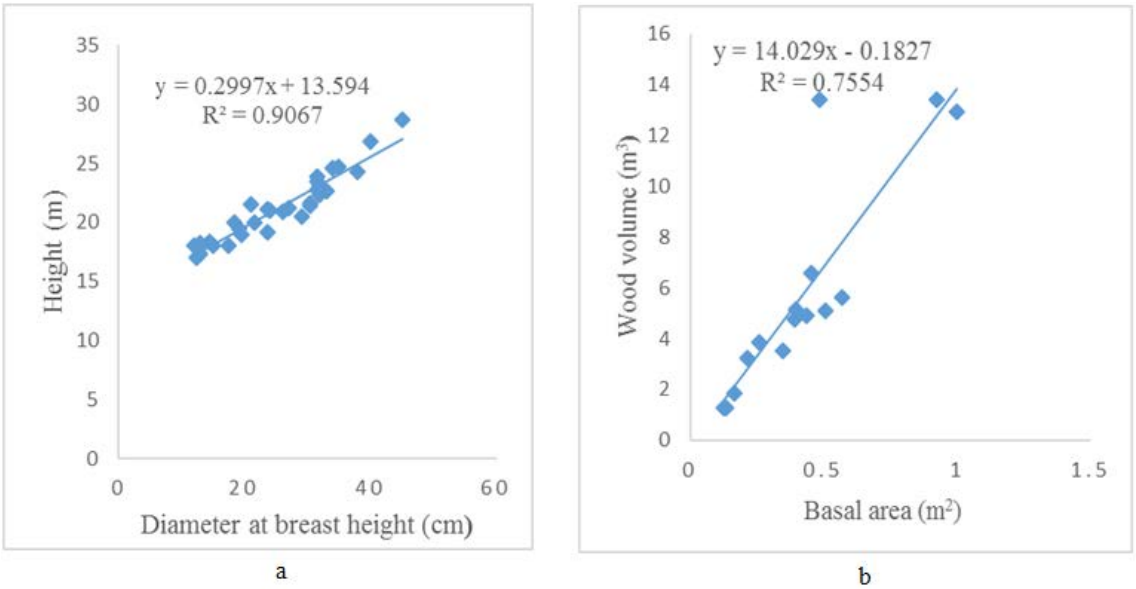

Figure 1. a) Linear function for the National Park and b) Regression of the volume and basal area of the National Park (NOTE: y → tree height (m), x → DBH (cm))

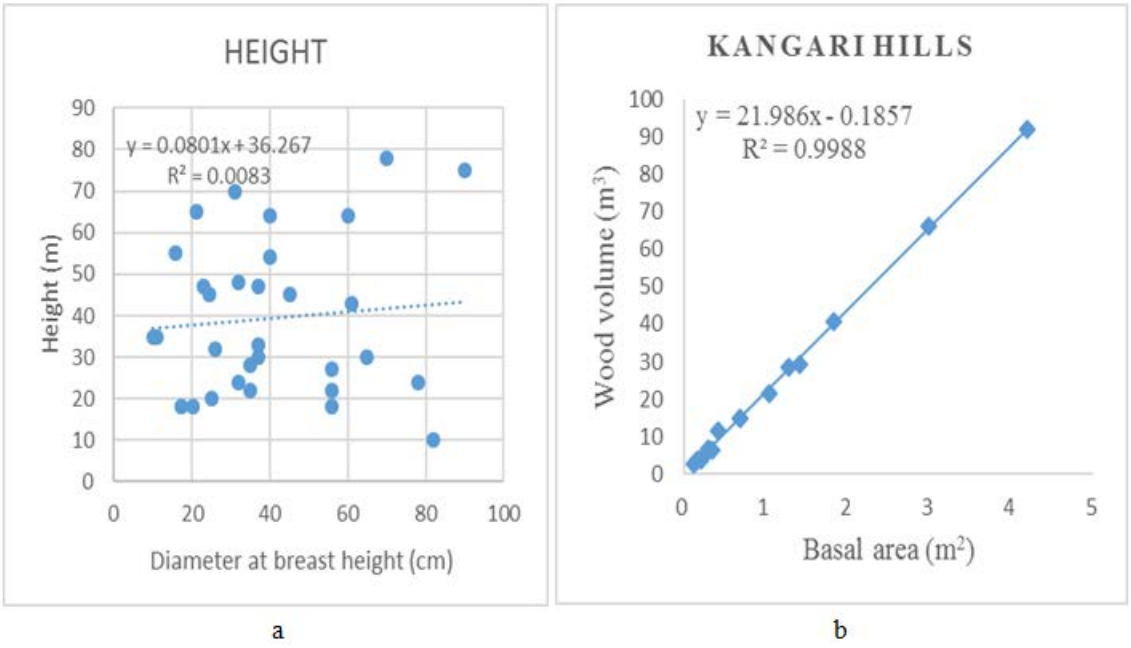

Figure 2: a) Linear function for the Forest Reserve and b) Regression of the volume and basal area of the Forest Reserve

4. Discussion

The composition and diversity of plant species vary among regions with different conservation management systems. A total of 73 species with 72 genera and 45 families were enumerated in this study. Similarly, a total of 73 species distributed into 30 families and 65 genera were identified in the study conducted in Oban Forest Reserve in Nigeria [37]. In a survey conducted in the northern forest-savanna ecotone of Ghana, a total of 88 species belonging to 78 genera and 30 families were identified [38]. In contrast, Olajuyigbe and Jeminiwa [39] recorded 60 tree species from 22 families in the Eda forest reserve ecosystems. Also, Sanwo et al. [40] documented 63 species representing 65 genera and 25 families in a tropical forest reserve in southern Nigeria. A total of 108 species belonging to 99 genera and 57 families were identified in the Wof-Washa forest in Ethiopia [41]. The two protected areas were dominated by the families Annonaceae, Mimosaceae, Anacardiaceae, and Caesalpiniaceae of the total tree stand. Other dominant families were Moraceae, Euphorbiaceae, and Papilionaceae. This result is similar to the findings of Adekunle and Olagok [42] that this set of tree species dominated the tropical rainforest ecosystem of southwest Nigeria. On the contrary, Meliaceae, Sterculiaceae, and Mimosoideae were reported as the families that dominated the tropical rainforest of Southwest Nigeria [43], and in Southwest Ghana [38]. This variability in the floristic composition of the different forests studied could be attributed to the nature of the geological substrates and climatic variability.

The stableness of any habitat/population depends directly on diversity. In this study, the Shannon – Wiener diversity index for the Forest Reserve was comparatively higher (3.63) than that in the National Park. This finding is similar to other tropical rainforest reserves. For instance, Aigbe and Omokhua [37] reported a Shannon's Diversity Index (H^I) = 3.795 for a tropical forest reserve in Southeast Nigeria. In addition, Adekunle et al. [43] recorded a H^I = 3.75 and Parthasarathy [44] reported H^I = 3.89 for Forest Reserves in Nigeria and in India, respectively. This observation is contrary to Olajuyigbe and Jeminiwa, [39] who recorded a lower H^I = 3.22 for Eda forest reserve ecosystems in the Southwest region of Nigeria while Adekunle and Olagok [42] reported a higher H^I = 4.02, in Southwest rainforests in Nigeria. The Forest Reserve ecosystem is within the average of stability. When compared to some rainforests around the world, particularly in Africa, the Forest Reserve could be considered to be species-rich. Hence, care is required because any activity requiring the removal of timber, poles, and fuelwood trees can result in this index being altered. Such alterations can cause loss and flora changes [45], and increasing exploitation over the period will contribute to the depletion of the forest, contributing to decreasing the quality and availability of many forest products. On the other hand, Shannon – Wiener diversity index recorded in the National Park (2.76399) indicates normal species diversity. This is because the results recorded are within the good diversity range of 1.5 and 3.5 suggested by Kent and Coker [46]. Similarly, Maguzu et al. [47] reported a lower Shannon – Wiener diversity index of 2.2717 for a Forest Reserve studied in the Muheza District–Tanga Region of Tanzania. However, if protection can be strengthened, natural regeneration would turn the National Park into a denser one. Such variability in the abundance and diversity of biodiversity may be attributed to the pattern of disruption obtained over decades through conservation management, and ecological adaptation and site factors.

Consequently, the interactions among the environmental, geographic, and edaphic factors influence the vegetation types and composition. The topography and environmental condition of an area could be related to the varying species composition and diversity in different ecosystems [48]. Higher rates of diversity in protected areas are mostly attributed to the level of conservation, level of disturbances in addition to fertile soil conditions, and relative humidity. Also, the difference in tree species composition between the Forest Reserve and the National

Park may be attributed to the various vegetation types with the National Park being dominated by woodland savanna, grassland savanna and gallery forest. The higher tree species diversity in the Forest Reserve indicates that it is significant to place economic importance on the forest vegetation and other biodiversity.

Despite the frequent disturbances from illegal human activities on the Reserve Forest such as logging of firewood, the Forest Reserve recorded a higher basal area (33 m^2) than the National Park. This is similar to the basal area reported by Aigbe and Omokhua [37] who recorded a basal area/ha of 34.67 m^2 in a tropical rainforest in Nigeria. On the contrary, Adekunle et al. [49] and Kumar et al, [50] reported a relatively lower basal area/ha for other tropical Forest Reserves of the world. The higher tree basal area recorded in the Forest Reserve could be attributed to the relatively regulated management with limited human utilization pressure. Also, the high annual precipitation rate and balanced tropical environment of the study area could have led to high tree growth. This may indicate that the Kangari Hills Forest Reserve is potentially one of the richest reserves left in Sierra Leone.

Also, higher stem density was observed in the National Park (382 stems ha^{-1}), than the stem density recorded in the Forest Reserve (367 stems ha^{-1}). This observation is similar to Duran et al. [51] who recorded 347 stems ha^{-1} in 148 species distributed among 42 families in a tropical deciduous forest in Mexico. Also, the value is similar to the density recorded by Wilder [52] while examining the vegetation composition and structure of the Taita Hills Forests (297 stems - 578 stems ha^{-1} at Chawia and Mbololo forests respectively). He also recorded that there were 301 stems ha^{-1}, 380 stems ha^{-1} and 386 stems ha^{-1} of other forests Ronge, Ngangao and Sagalla respectively. The current results suggested that the forest is still good, but some interventions are needed to maintain and improve it.

The overall mean wood volume (741.32 m^3 h^{-1}) recorded in the Forest Reserve is higher than 45.22 m^3 ha^{-1} recorded by Adekunle et al. [43] for Akure Forest Reserve in Southwest Nigeria, the 391 m^3 ha^{-1} reported by Wittmann et al. [53] for a riparian forest in southeastern Brazil, and the 406 - 416 m^3 ha^{-1} reported by Tonolli et al. [54] for multilayer forest areas in Italy. The difference in such values may also be due to the different methods used for volume calculation, sampling capacity, differences in geographical location, soil parameters, and different environmental and climatic conditions. It is, however, evident that the management of protected areas has clear implications for the conservation of tree diversity in forest ecosystems. Management practices, for instance, might affect the potential longer-term role of the two protected areas in forest conservation.

5. Conclusions

This study gives an insight into the structure, composition, and diversity of tree species in two protected areas in Sierra Leone. Species richness, Shannon Diversity Index, evenness were higher in the Forest Reserve than the National Parks. At the same time, the stem density in the National Park was higher than that in the Forest Reserve. Results indicate that the Forest Reserve is a potential biodiversity hotspot compared to the National Park. In summary, the findings of our research suggest that improved conservation management strategies are appropriate mechanisms to enhance tree species diversity in the National Park. Management interventions (such as enrichment planting with indigenous species) can further assist in the restoration of the National Park ecosystem to ensure sustainable biodiversity conservation. In addition, the higher biodiversity indices in the Forest Reserve suggests that the forest will continue to grow and become more diverse and stable if these conservation management strategies are maintained. Tree species with a low overall score for rarity should be regarded as rare, and hence, conservation interventions are needed to prevent them from going into extinction. This research provides baseline information on tree species structure and composition for biodiversity conservation of protected forests in Sierra Leone. However, further research on tree structure and composition of various ecosystems is needed in Sierra Leone.

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Conflicts of Interest

The authors declare no conflict of interest.

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Appendix 1.

Number of individual species and families encountered in the Forest Reserve and the National Park

Species	Families	Forest Reserve	National Park
Albizia adianthifolia	Mimosaceae	3	0
Albizia zygia	Mimosaceae	10	2
Allanblackia parviflora	**Vegetable tallow tree**	1	0
Allophyllus africanus	Sapindaceae	0	5
Amphimas pterocarpoides	Papilionaceae	1	0
Anisophyllea laurina	Rhizophoraceae	1	3
Anisophyllea meniaudi	Rhizophoraceae	1	0
Anthocleista nobilis	Loganiaceae	1	0
Anthocleista procera	Loganiaceae	1	0
Anthonotha macrophylla	Caesalpiniaceae	3	0
Antiaris Africana	Moraceae	2	2
Blighia unijugata	Sapindaceae	2	0
Bombax buonopozens	Bombacaceae	2	0
Borrasus aethiopica	**African palmyra palm**	0	2
Canarium schweinfurthii	Burseraceae	3	0
Cathormion altissimum	Mimosaceae	2	0
Carapa procera	Meliaceae	3	0
Cassia seiberina	Caesalpiniaceae	0	2
Ceiba pentandra	Bombacaceae	0	4
Cleistopholis patens	Annonaceae	1	0
Cleistanthus polystachyus	Papilionaceae	1	0
Cola chlamydantha	Sterculiaceae	0	3
Cola latieritia	Sterculiaceae	0	1
Cryptosepallum tetraphyllum	Caesalpiniaceae	1	0
Cynometra leonensis	Caesalpiniaceae	1	0
Dialium guineense	Caesalpiniaceae	1	24
Daniellia thurifera	Caesalpiniaceae	1	0
Daniellia ogea	Caesalpiniaceae	1	3
Diospyros heudelotii	Ebenaceae	1	**1**
Diospyros thomasii	Ebenaceae	2	1
Drypetes Africana	Euphorbiaceae	1	0
Drypetes afzelii	Euphorbiaceae	3	0
Erythrophleum ivorense	Caesalpiniaceae	0	4
Fagara macrophylla	Rutaceae	1	0
Ficus mucuso	Moraceae	2	3
Funtumia Africana	Apocynaceae	6	5
Garcinia smeathmannia	**Garcinia polyantha Oliv**	1	0
Hannoa klaineana	Simaroubaceae	1	0
Heritiera utilis	*Sterculiaceae*	2	0
Hibiscus sterculifolius	Malvaceae	0	5
Homalium Africana	Flacourtiaceae	1	0
Holarrhena floribunda	Apocynaceae	1	0
Hymenocardia lyrata	Euphorbiaceae	1	0
Lophira alata	Ochnaceae	2	0
Macaranga barteri	Euphorbiaceae	5	0
Macaranga heudelotii	Euphorbiaceae	1	0
Margaritaria discioides	Euphorbiaceae	0	32
Milicia regia	Moraceae	3	3
Musanga cecropioides	Moraceae	5	0

Species	Families	Forest Reserve	National Park
Myrianthus serratus	Cecropiaceae	5	0
Nauclea diderrichii	Rubiaceae	2	0
Octoknema borealis	Oktoknemataceae	1	0
Parkia bicolor	Mimosaceae	3	0
Parkia biglobosa	Mimosaceae	0	4
Parinari excels	Chrysobalanaceae	6	0
Pentaclethra macrophylla	Mimosaceae	1	0
Phyllocosmus africanus	Ixonanthaceae	8	0
Placodiscus pseudostipularis	Sapindaceae	1	0
Piptadeniastrum africanum	Caesalpiniaceae	3	0
Pterocarpus erinaceus	Papilionaceae	0	28
Pterocarpus santalimioides	Papilionaceae	0	4
Pycnanthus angolensis	Myristicaceae	1	0
Samanea dinklagei	Mimosaceae	2	0
Scottellia leonensis	Flacourtiaceae	1	0
Spondias mombin	Anacardiaceae	0	35
Strombosia grandiflora	Olacaceae	3	0
Terminalia ivorensis	Combretaceae	4	0
Terminalia superba	Combretaceae	0	4
Vitex micrantha	Verbenaceae	2	0
Warneckea farcicularis	Melastomataceae	3	0
Warneckea guineensis	Melastomataceae	1	0
Xylopia acutiflora	Annonaceae	1	0
Xylopia aethiopica	Annonaceae	25	0
TOTAL = 73		**155**	**180**