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ORIGINAL PAPER

Diversity, abundance, and structure of tree communities in the Uluguru forests in the Morogoro region, Tanzania

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Abstract Uluguru forests are globally recognized as important biodiversity hotspots, but anthropogenic pressure threatens their value. This study examined species diversity, abundance, and structure of trees in the Uluguru forests. All trees of diameter at breast height (DBH) $\geq$ 10 cm were inventoried in seven forests ranging from 3 to 995 ha in area. A total of 900 stems, 101 species and 34 families were inventoried. Fabaceae was the most speciose family. *Ehretia amoena* Klotzsch was the most abundant species with relative abundance of 9.22 %. The forests differed significantly in species richness (26–93 species ha^{-1}), tree density (85–390 stems ha^{-1}), basal area (3–24 m^2 ha^{-1}) and Shannon-Wiener diversity (2.50–4.02). Forest area was significantly and positively correlated with species richness ($r = 0.92$) and species diversity ($r = 0.95$). Tree density showed significant positive correlation with species richness ($r = 0.80$) and basal area ($r = 0.85$). Milawilila and Nemele forests had highest floristic similarity (0.55) followed by Kimboza and Kilengwe (0.54) while the rest had similarity coefficients of less than 0.50. Despite legislative protection, many forests remain at risk and therefore the possibility to conserve highly valuable tree species via enhanced protection or cultivation must be considered.

Keywords Eastern arc · Biodiversity · Disturbance · Hotspots · Similarity

Introduction

Tree species distribution differs greatly from one place to the other in most tropical forests, mainly due to variations in biogeography, habitat and disturbances (Whitmore 1989). The variety of tree species richness has been reported in the neo-tropical forests, tropical forests, and Southeast Asia forests (Gentry 1988; Whitmore 1989; Valencia et al. 1994). In African forests, a maximum of 60 species ha^{-1} was reported, with a number of other studies (Hill and Curran 2001; Mwavu 2007; Kacholi 2013) reporting much higher species richness than this figure for trees of DBH $\geq$ 10 cm. Though tropical forests are known to be speciose, they are vulnerable to deforestation and degradation (Madoffe et al. 2006), which ultimately leads to fragmentation and loss of habitats. In order to guide nature conservation efforts worldwide, Myers et al. (2000) focused on the concept of biodiversity hotspots, which considers regions with exceptional concentrations of endemic species and which experience high rates of habitat loss due to natural and anthropogenic degradation. The authors proposed that protection and conservation activities should be focused on these hotspots. The Eastern Arc and

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other coastal forests (Uluguru forests inclusive) of Tanzania are one of the identified 25 global hotspots and are estimated to host 4000 plant species of which 38 % are endemic.

Uluguru forests are facing the threat of losing species due to increased anthropogenic activities and fragmentation (Newmark 1998). Increased forest fragmentation has been described as the greatest threat to much of tropical forest biodiversity (Hill and Curran 2001). A rapid human population increase in proximity to many tropical forests is putting more pressure on these ecosystems via the demand for timber for building purposes, firewood/charcoaling, the provision of food and medicine or increased demand for farmland. Increased wildfire risk from accidental and non-accidental lightings is a further threat (Burgess et al. 2002). Such threats, which should not be underrated, are also occurring in other biodiversity hotspots within the country (Madoffe et al. 2006). More attention is needed for research and conservation in these ecosystems. Studies of floristic composition and structure in forests have become an essential instrument in assessing the sustainability of the forests and the role they play in the conservation of species and management of forest ecosystems (Malimbwi et al. 2005). The present study aimed to: (1) provide information on the status of floristic diversity, abundance, and structure of trees of DBH ≥ 10 cm in the selected Uluguru forests; (2) compare the present findings with other forest inventories done in Tanzania and elsewhere, and (3) determine the relationship between forest area and numbers of tree species, tree density, basal area, and several common measures of diversity. We aimed to improve knowledge of the status of tropical rainforests and contribute to biodiversity management and conservation.

Materials and methods

Description of the study area

Uluguru Mountains are located about 200 km west of Dar es Salaam City, and south of Morogoro town. The range is one components of the Eastern Arc Mountains, stretching from the Taita Hills in southern Kenya to Udzungwa Mountain in south-central Tanzania. The range covers an area of 1500 km^2 and elevation ranges from 150 m on the southeastern margin to a peak of 2630 m above mean sea level. The climate is oceanic due to proximity to the Indian Ocean with a bimodal rainfall regime, the long rainy season lasts from March to May, peaking in April and the short rainy season lasts from October to December. Mean annual rainfall and temperature are 740 mm and 25.1 °C, respectively. Agriculture is the main socioeconomic activity for most people living in villages surrounding the studied forests. Seven forests were selected to represent lowland forest (i.e. <800 m above mean sea level) with minimum anthropological disturbance, and to represent a range of forest areas (Fig. 1).

Data collection

All trees with a diameter at breast height (DBH) ≥ 10 cm measured at 1.3 m above the ground were sampled from a total of 114 plots of 20 × 20 m (0.04 ha) each. Eighteen plots were sampled in each forest at Kimboza, Kisego, Kilengwe, Milawilila and Nemele while 12 plots of the same size were sampled at Ngambaula and Gunauye. The plots were placed in the forests from the edge towards the interior. Trees were counted, identified and DBH were measured. Trees with multiple stems at 1.3 m height were treated as a single individual whereby the diameters of all stems were taken and averaged. If a tree had buttress and abnormality at 1.3 m height, the diameter was measured just above the buttress where the stem assumed near cylindrical shape. These data were collected from June 2010 to February 2011.

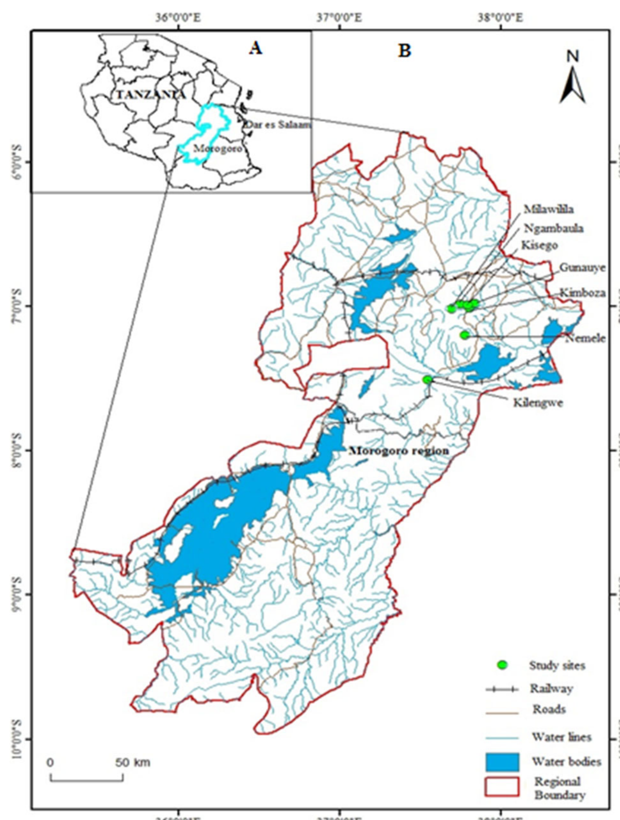

Fig. 1 The figure shows two maps, the map of Tanzania (map A, to the *top left corner*) showing the setting of Morogoro region in the country and the map of Morogoro region (map B) that shows the location of the seven studied forests within the region

Data analysis

Species diversity was calculated using the Shannon-Wiener diversity index while the structure of the forests was described by stem density (stems ha^{-1}), basal area (m^2 ha^{-1}) and size class distributions (SCDs). A total of 7 size class distributions arranged in 10 cm intervals was formed based on recorded trees diameters in all forests. Differences of the structural characteristics (*i.e.* stand density and basal area) between forests were tested using one-way analysis of variance (ANOVA) followed by the post hoc Tukey's HSD multiple comparison test. The number of recorded species in each forest and the first order jackknife richness estimator were used as measure of species richness (Magurran 2004). Species richness was calculated and species accumulation curves were constructed using Species Richness and Diversity IV (SDR IV) Software (Seaby and Henderson 2006a). Sørensen coefficients of similarities were calculated between the studied forest pairs and Pearson correlation coefficients were calculated to determine the relationship between floristic similarity, forest area, species diversity, tree density and basal area. The coefficients were calculated using the Community Analysis Package version 4 software (CAP IV) (Seaby and Henderson 2006b).

Results

Floristic description

A total of 900 trees (1335 stems ha^{-1}) with DBH $\geq$ 10 cm representing 101 species, 73 genera and 34 families were recorded in the seven forests (Table 3 in Appendix). The most speciose family was Fabaceae (with 33 species), followed by Moraceae (6 species) and Sterculiaceae (5 species). Of the 34 recorded families, 38 % were represented by one species only while out of the 101 recorded species, 17 % were represented by one individual only. *Ehretia amoena* was the most abundant species representing 9.2 % of the total stems, followed by *Sorindeia madagascariensis* (6.1 %) and *Khaya anthotheca* (4.7 %). *E. amoena* and *Diospyros squarrosa* were the most frequent species occurring in six of the surveyed forests. About 41.6 % of the total species occurred in one forest while 15.0 % of species occurred in one plot out of 114 surveyed plots. Observed species richness (Table 1) varied widely from 17 species (at Ngambaula) to 67 species (at Kilengwe). Of all recorded species in all forests, 13 are considered threatened on the 2014 IUCN plant redlist, of which one is Endangered (*Cynometra uluguruensis*), five are Vulnerable (*K. anthotheca, Ophrypetalum odoratum, Millettia sacleuxii, Allanblackia uluguruensis, Allanblackia stuhlmannii*), five are Near Threatened/Lower Risk (*Milicia excelsa, Pterocarpus angolensis, Pandanus rabaiensis, D. melanoxylon, Pouteria altissima*), and two are Least Concern (*Cussonia zimmermannii and Holarrhena pubescens*). Among the threatened species, two were endemic (*A. uluguruensis, C. uluguruensis*) and three were near endemic (*Scorodophloeus fischeri, A. stuhlmannii,* and *O. odoratum*).

In Kilengwe, a total of 199 trees (276 stems ha^{-1}) belonging to 67 species (93 species ha^{-1}), 26 families, and 54 genera were recorded. *Brachystegia speciformis* was most abundant with 8 individuals while 28.4 % of the species in the studied forest area were rare, being represented by only one individual. In Kimboza, a total of 281 trees (390 stems ha^{-1}) belonging to 52 species (72 species ha^{-1}), 22 families, and 39 genera were recorded. *K. anthotheca* was most abundant (37 individuals) followed by *S. madagascariensis* (27) and *E. amoena* (25). Of the Kimboza species, 23.1 % were rare, being represented by only one individual. In Milawilila, a total of 124 trees (172 stems ha^{-1}) of 20 species (28 species ha^{-1}), 15 families, and 18 genera were recorded. *Xylopia parviflora* was dominant with 26 individuals, followed by *E. amoena* with 21 individuals. Only one species was represented by a single individual in Milawilila forest.

In Kisego, 101 trees (140 stems ha^{-1}) representing 21 species (29 species ha^{-1}), 12 families, and 19 genera were recorded. The most abundant species were *E. amoena* (23 individuals) and *Albizia versicolor* (14 individuals), while 33.3 % of the species were represented by only one individual. In Nemele, 70 trees (97 stems ha^{-1}) of 19 species (26 species ha^{-1}), 13 families, and 16 genera were recorded. The most abundant species were *E. amoena* (8 individual) followed by *Voacanga Africana* (7 individuals), and 31.6 % of the species were represented by one individual. In Ngambaula, a total of 41 trees (86 stems ha^{-1}) of 17 species (35 species ha^{-1}), 9 families, and 15 genera were recorded. In Gunauye, a total of 84 trees (175 stems ha^{-1}) of 22 species (46 species ha^{-1}), 14 families, and 19 genera were recorded. *Brachystegia boehmii* and *D. squarrosa* were the most dominant species at Ngambaula while *S. madagascariensis* was most abundant at Gunauye. Of the recorded species, 41.7 and 22.7 % were represented by one individual at Ngambaula and Gunauye, respectively.

Species diversity and species accumulation curves

Kilengwe and Kimboza were the most diverse forests, having highest diversity indices of 4.02 and 3.40, respectively (Table 1). The least diverse forest was Kisego with 2.50 diversity value. When all data are pooled, an overall Shannon-Wiener diversity index of 4.03 was obtained. The species accumulation curves for Kimboza and Kilengwe

Table 1 Forest size, tree species richness, diversity, density and basal areas in the studied forests

Forests	Forest area (ha)	Observed species	Species richness (Species ha^{-1})	Jackknife 1 (±SD)	Shannon Wiener (±SE)	Tree density (stems ha^{-1}) (±SE)	Basal area (m^2 ha^{-1}) (±SE)
Kilengwe	995	67	93	86 ± 4	4.02 ± 0.07	276 ± 35	8 ± 1
Kimboza	405	52	72	64 ± 3	3.40 ± 0.14	390 ± 52	24 ± 5
Kisego	119	21	29	28 ± 2	2.50 ± 0.13	140 ± 14	3 ± 0
Milawilila	13	20	28	21 ± 1	2.62 ± 0.09	172 ± 14	13 ± 3
Nemele	8	19	26	26 ± 2	2.76 ± 0.11	97 ± 10	5 ± 3
Ngambaula	3	17	35	27 ± 3	2.60 ± 0.19	85 ± 15	3 ± 1
Gunauye	3	22	46	27 ± 2	2.80 ± 0.07	175 ± 27	5 ± 1

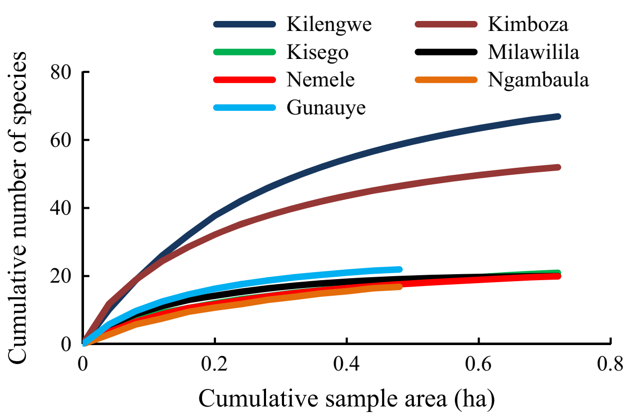

Fig. 2 Species accumulation curves of tree species based on the cumulative plot samples in each of the seven studied forest areas

(Fig. 2) showed an increasing trend as the number of plots increased while the curves for Milawilila, Kisego, Ngambaula, Nemele and Gunauye rapidly approached an asymptote. The first order jackknife species richness estimator calculated higher species richness than was recorded in the field (Table 1).

Correlation between forest area, structure, species richness and diversity

Forest area was significantly positively correlated with species richness and species diversity (Table 2). Tree density was positively and significantly correlated with species richness and basal area density. Although tree density and basal area were positively correlated with forest area, the association was not statistically significant.

Species composition similarity

Species composition similarity between the studied forests revealed higher similarity coefficient between Nemele and Milawilila (0.55), followed by Kimboza and Kilengwe (0.54). The remaining forest pairs had similarity coefficients of less than 0.50. The lowest similarity coefficient was 0.20 between Nemele and Kisego (Fig. 3).

Structural composition of the forests

Tree density varied significantly between forests ($F_{(6,107)} = 14.37$, $p < 0.001$), ranging from 85 to 390 stems ha^{-1} (Table 1). Kimboza supported considerably greater density than the other forests with the exception of Kilengwe, which did not differ considerably. Tree density at Kilengwe was considerably higher than at Nemele, Ngambaula and Kisego but did not differ significantly from density at Milawilila and Gunauye. Other forest pairs did not differ appreciably in terms of tree density. Basal area density differed greatly between forests ($F_{(6,107)} = 9.92, p < 0.0001$), ranging from 3 to 24 m^2 ha^{-1} (Table 1). Kimboza had significantly higher basal area followed by Milawilila and Kilengwe while Kisego had the lowest basal area density.

The size class distribution of trees (Fig. 4) in the forests exhibited the “negative exponential” or “inverse J-shape”. About 69.1 and 18.2 % of recorded trees in all forests were represented in 10–19.9 and 20–29.9 cm DBH size classes, respectively. Kisego and Gunauye had no individual in the size classes’ ≥50 cm DBH. Though Nemele and Ngambaula possessed individuals in size class >70 cm DBH, the forests had no individuals in size classes between 40 and <70 cm DBH. The maximum DBH value in the present study was 126 cm recorded for *K. anthotheca* at Kimboza forest, followed by *Brachystegia bussei* (Nemele) and *Synsepalum cerasiferum* (Milawilila) at 122 and 106 cm, respectively.

Discussion

Floristic composition, species richness and diversity

The dominant family in our research area is Fabaceae with 33.7 % of the individual trees. This result concurs with the

Table 2 Correlations between forest size, species richness, diversity, density and basal area

Parameters	Forest size (ha)	Species richness	Shannon-Wiener	Tree density (stems ha^{-1})	Basal area (m^2 ha^{-1})
Forest size	1.00				
Species richness	0.92*	1.00			
Shannon-Wiener	0.95*	0.96*	1.00		
Tree density	0.66	0.80*	0.74	1.00	
Basal area	0.28	0.44	0.42	0.85*	1.00

* Indicate significant correlation between the two parameters ($p < 0.05$)

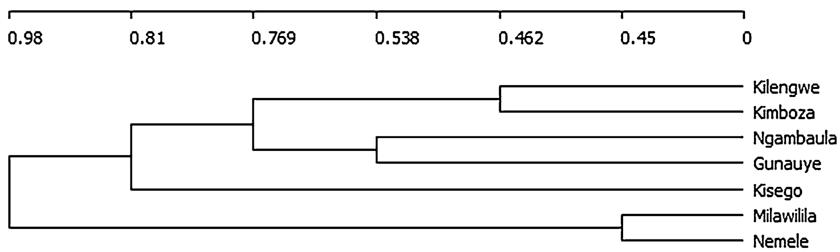

Fig. 3 The dendrogram constructed using Ward group linkage and Sørensen coefficients of similarity shows dissimilarity coefficients among the seven studied forest pairs in Uluguru. The dissimilarity coefficients increase as the scale increases while similarity increases in an opposite direction of the dendogram scale

findings of Burgess and Muir (1994) and Burgess and Clarke (2000) who reported the same family to dominate the coastal forests of Tanzania by 25 %–50 % of trees. Mrema (2006) and Rwamugira (2008) reported the family Fabaceae to be dominant in Dindili and Ruvu forests in Tanzania, respectively. Moreover, the finding confirms the verdict of different authors (e.g. Gentry 1988; Valencia et al. 1994; Mwavu 2007; Addo-Fordjour et al. 2009) that the Fabaceae family is the most speciose tree family in many tropical lowland forests.

The range of species richness (26–93 species ha^{-1}) in this study overlaps that reported by Malimbwi et al. (2005) of 8–66 species ha^{-1} in different lowland forests of Mvomero district in Morogoro region. However, the range is within the range reported by Mwavu (2007) of 24–112 species ha^{-1} in Budongo forests in Uganda. In contrast, the recorded species richness appears to be lower when compared to Amazonian forests where species richness of 275–283 species ha^{-1} was reported for upper Amazonia (Gentry 1988). The comparisons involving different studies are complicated due to fact that different plot sizes, sampling protocols, total used sampled area and sometimes subjectivity used to arrive at a range of values in other studies is unclear. The occurrence of *D. squarrosa* and *E. amoena* in the six forests and *S. madagascariensis, S. fischeri, Oxyanthus goetzei*, and *A. versicolor* in five forests indicate that they thrive across a wide range of habitats.

According to Kent and Coker (1992), a forest community is said to be rich if it has a Shannon-Wiener diversity index value of ≥3.5. With the exception of Kilengwe forest, the rest had Shannon-Wiener diversity values below 3.5 making them relatively poor in diversity. The overall diversity index of 4.03 for all seven forests signifies that Uluguru forests as a whole support high diversity. The high diversity in Kilengwe and Kimboza could be due to fact that these forests are relatively undisturbed as compared to other studied forests where illegal logging, encroachment, hunting, removal of tree bark for medicinal use, fire, and collection of forest products were observed to be the main activities of the local population. A small scale gold mining was seen near Kimboza forest and this could account for the low recorded tree diversity.

The presence of threatened species in the studied forests could be because this area is within the Eastern Arc of coastal forests of Tanzania, which are known to be biodiversity hotspots and centers of endemism for both flora and fauna (Myers et al. 2000). Temu and Andrew (2008) also found that the Uluguru forests contain several endemic plant species while the study area is among the recognized important ecoregions and an endemic bird area in Tanzania (Mittermeier et al. 1998; Stattersfield et al. 1998; Burgess et al. 2007). The floristic composition, overall diversity and threatened species listed in the IUCN categories show that the Uluguru forests are qualitatively diverse. Additionally, among the threatened species, *P. angolensis, D. melanoxylon, K. anthotheca, and M. excelsa* have also been reported by several authors (e.g. Ahrends 2005; Modest et al. 2010) to be severely exploited for timber in the coastal forests of Tanzania and some logged below the minimum harvestable diameter. This could be the reason why some of these species occurred at very low frequencies in the sampled forests.

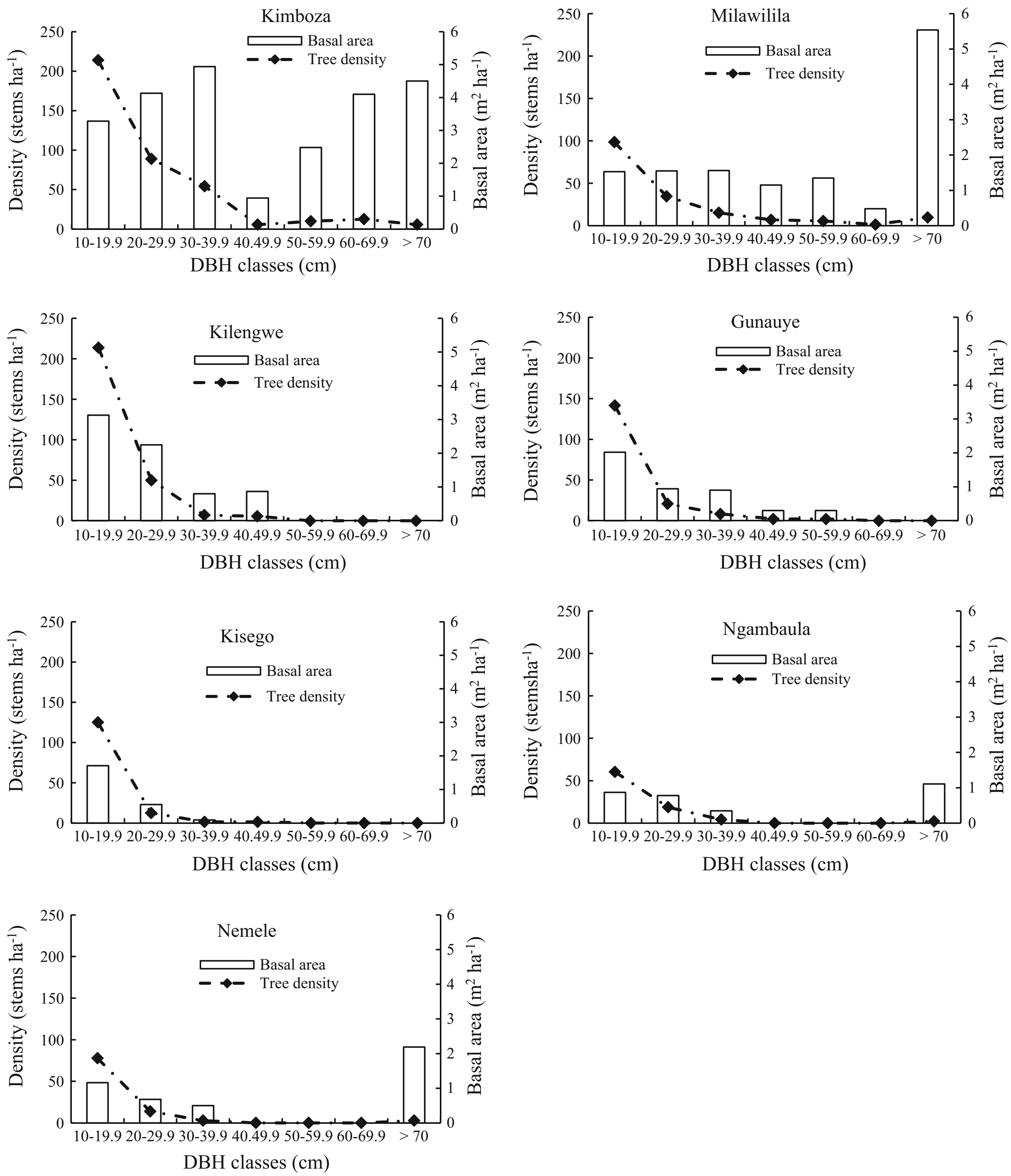

Fig. 4 Size class distributions (SDC's) of the trees in the studied Uluguru forests

Species accumulation curves

The species accumulation curves for Kilengwe and Kimboza forests (Fig. 2) illustrated an escalating trend as the number of plots increased. This observation concurs with the results shown in Table 1 where the species richness estimator predicted more species in the forests than were recorded. The species accumulation curves for Milawilila, Nemele, Ngambaula and Gunauye approached an asymptote signifying that most of the species in these forests were recorded (Magurran 2004). This is also supported by the species richness estimator, which provides estimates that did not differ markedly from the recorded species richness. On the contrary, the curves for Kilengwe and Kimboza did not show asymptotic behavior due to the presence of many rare species and species with narrow habitat ranges (Gotelli and Colwell 2011). The high species richness in Kilengwe and Kimboza could also be attributed to their large areas and high environmental heterogeneity (Tuomisto and Ruokolainen 2005). The increasing trend in the number of species with increasing forest size implies that a reduction in forest size will lead to species loss as supported by the correlation coefficients between forest size and species richness in Table 2.

Association between forest size, structure, species richness, and diversity

The significant associations between forest area and species richness/diversity (Table 2), support the hypothesis that large forests contain greater numbers of tree species. Also, it suggests that increased forest fragmentation which normally results in area reduction would cause the loss of tree species. The smaller the population, the more vulnerable it is to extinction when fluctuations in microclimate, resources and other factors occur (Hill and Curran 2001). Thus, large forests are needed by many species in order to maintain viable populations, though it is important also to recognize the complementary value of small forest fragments. Forest size and stand were positively correlated, suggesting that the density of trees is greater in larger forest fragments than smaller ones. Thus, in case of forest fragmentation, stand density is expected to decline too. The significant correlation between basal area density and tree density signifies that a decline in stand density would lead to decreased basal area density. Species richness, diversity, stand density and basal area density are reported to decline in response to increased intensity of anthropogenic disturbance in tropical forests (Top et al. 2009; Kacholi 2013).

Similarity among the studied forests

The species composition similarity coefficients among the studied forests ranged from 0.20 to 0.55 (Fig. 3). The highest similarity between Milawilila and Nemele, and that of Kimboza and Kilengwe could be attributed to similar environmental conditions among the pairs as compared to Kisego and Nemele which had least similarity value. With exception of the two forest pairs that showed high floristic similarity, the remaining pairs had similarity coefficients below 0.50, signifying that each forest has its own unique species composition. Thus, all the forests are important in terms of the floristic diversity and sensitive from a conservation point of view.

Structural composition of the forests

The observed basal area densities of the studied forests are within the range (1.7–32 m^2 ha^{-1}) reported by Malimbwi et al. (2005) in their inventories of the forests of Morogoro region in Tanzania. The considerably higher basal area density in Kimboza and Milawilila was contributed by high stem density in the higher DBH classes as compared to other forests. Kimboza revealed a 54 % increase in basal area density from the value (15.8 m^2 ha^{-1}) observed by Malimbwi et al. (2005), which signifies that the forest has not been greatly affected by human disturbance during the interval from 2005 to 2010. In contrast, the observed basal area density at Kilengwe was lower by 29 % than the value (11.2 m^2 ha^{-1}) observed by Malimbwi et al. (2005), implying that the forest was impacted by anthropogenic disturbances. The significantly lower basal areas at Kilengwe, Kisego, Nemele, Ngambaula and Gunauye suggest that these forests are overexploited and in reality no big trees were recorded in these forests (Fig. 4). Rwamugira (2008) reported average basal area of 4.7 m^2 ha^{-1} (for trees with DBH $\geq$ 10 cm) at a disturbed stand in the Ruvu forest in the Morogoro region, while Malimbwi et al. (2005) recorded very low basal area of 1.7 m^2 ha^{-1} at Mindu forest in the same region, and concluded that the forest was disturbed. Illegal logging is the main cause for low basal areas in many forests in Morogoro (Malimbwi et al. 2005) and it is reported to be done by well coordinated syndicates involving traders, irresponsible local government leaders and unfaithful villagers (Kacholi 2013).

The size class distributions of Kilengwe, Kisego, Nemele, Ngambaula and Gunauye indicate that the tree species are recruiting and there are signs of recovery from the effects of previous and on-going disturbances. Illegal logging was also observed in these forests, indicating that the forests are still under anthropogenic pressure. The anthropogenic pressure could have resulted to the absence of individuals in the higher size classes in the forests (Fig. 4) because big trees are illegally logged by locals for various purposes. The significant differences in the observed structural features between the studied forests are mainly due to anthropogenic exploitation, which targets trees of high size classes for timber and building poles. Other factors such as soils, habitat preferences/adaptation ability between species, and presence of favorable conditions for regeneration have been reported to affect forest structure (Richards 1952; Zegeye et al. 2006). Our results show that forests of smaller area had lower stand density and basal area (Table 2). The reason could be that the small fragments are highly vulnerable to human disturbances because they are easily accessible for logging and clearance activities that affect the forest structure as reported by Echeverria et al. (2007). In Madagascar, the spatial pattern analysis of forest structure revealed that levels of basal area were associated with accessibility to the fragments (Ingram et al. 2005).

Conclusion and recommendations

Understanding forest tree diversity, abundance, and diversity are very important in management of the ecosystem for environmental and conservation value. This study has revealed that family Fabaceae was the most speciose family in the forests while *D. squarrosa* and *E. amoena* were the most common species occurring in six forests. Species richness, diversity and tree density were positively correlated with forest size. Though the smaller forests had lower species richness, they must be given priority in conservation to avoid loss of species especially endemic and near endemic species. The structural parameters differed significantly between the studied stands. The floristic similarity revealed low similarity coefficients among many forest pairs. Despite legislative protection, many forest fragments in Uluguru remain at risk and therefore the possibility to conserve highly valuable tree species via enhanced protection or cultivation must be considered. The study recommends the following; (1) more conservation and management efforts should be put to rare and threatened species, (2) research is needed to investigate major causes, types and level of anthropogenic disturbances to forests, (3) study of soils in Uluguru forest fragments is needed to understand their influence on tree composition and distribution, (4) research on the effects of climate change and land use/cover change is needed to understand changes over time within and around the forests, and (5) protection of forests should be emphasized so that future generation can enjoy nature and meet their needs.

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Appendix

See Table 3.

Table 3 Tree species abundance in the surveyed forests

Species	Family	Kilengwe	Kimboza	Milawilila	Nemele	Kisego	Ngambaula	Gunauye	Total	Relative Abundance
Ehretia amoena Klotzsch.	Boragnaceae	5	25	21	8	23	1	–	83	9.22
Sorindeia madagascariensis DC.	Anacardiaceae	–	27	6	6	–	4	12	55	6.11
Khaya anthotheca (Welw.) C. DC.	Meliaceae	3	37	–	–	–	2	–	42	4.67
Albizia versicolor Welw. ex Oliv.	Fabaceae	4	–	2	3	14	–	12	35	3.89
Diospyros squarrosa Klotzsch	Ebenaceae	5	3	10	5	–	6	4	33	3.67
Scorodophleous fischeri (Taub) J. Leon	Fabaceae	1	12	9	–	–	3	6	31	3.44
Albizia glaberrima (Schum & Thonn.) Benth.	Fabaceae	5	6	3	3	9	–	–	26	2.89
Xyalopia parviflora (A. Rich.) Benth.	Annonaceae	–	–	26	–	–	–	–	26	2.89
Annona senegalensis Pers.	Annonaceae	1	7	3	–	13	–	–	24	2.67
Antiaris toxicaria (Pers.) Lesch.	Moraceae	2	19	–	–	2	1	–	24	2.67
Synsepalum cerasiferum (Welw.) T.D. Penn.	Sapotaceae	7	–	8	6	–	–	–	21	2.33

Table 3 continued

Species	Family	Kilengwe	Kimboza	Milawilila	Nemele	Kisego	Ngambaula	Gunauye	Total	Relative Abundance
Strychnos spinosa Lam.	Loganiaceae	4	7	–	7	–	–	2	20	2.22
Grewia similis K. Schum.	Tiliaceae	2	14	–	–	–	1	1	18	2.00
Milicia excelsa (Welw.) C. Berg	Moraceae	1	8	–	–	2	3	3	17	1.89
Albizia gumminifera (J.F. Gmel.) C.A.Sm	Fabaceae	–	3	–	–	11	2	–	16	1.78
Bridelia micrantha (Hochst.) Baill.	Euphorbiaceae	2	2	4	–	3	–	5	16	1.78
Dombeya natalensis Sond.	Sterculiaceae	6	1	3	1	–	5	–	16	1.78
Brachystegia boehmii Taub.	Fabaceae	–	4	–	–	4	6	–	14	1.56
Oxyanthus goetzei K. Schum.	Rubiaceae	1	6	3	2	–	–	2	14	1.56
Bombax rhodognaphalon K. Schum.	Bombacaceae	–	1	3	3	–	–	6	13	1.44
Brachystegia spiciformis Benth.	Fabaceae	8	3	–	2	–	–	–	13	1.44
Vitex doniana Sweet	Verbenaceae	5	7	–	–	1	–	–	13	1.44
Voacanga Africana Stapf.	Apocynaceae	–	–	6	7	–	–	–	13	1.44
Deinbollia borbonica Sheff.	Sapindaceae	4	–	–	1	1	–	6	12	1.33
Acacia polyacantha Wild.	Fabaceae	3	7	–	–	–	–	–	10	1.11
Albizia petersiana (Bolle) Oliv.	Fabaceae	3	–	–	–	–	1	6	10	1.11
Combretum molle R. Br. ex G. Don.	Combretaceae	3	6	–	–	–	–	–	9	1.00
Dalbergia boehmii Taub.	Fabaceae	5	4	–	–	–	–	–	9	1.00
Dombeya rotundefalia (Hochst.) Planch.	Sterculiaceae	2	7	–	–	–	–	–	9	1.00
Ficus lutea Vahl.	Moraceae	2	1	–	–	–	2	4	9	1.00
Julbernardia globiflora (Benth.) Troupin.	Fabaceae	7	1	–	–	–	1	–	9	1.00
Markhamia zanzibarica Bojer ex DC.	Bignoniaceae	1	–	6	–	–	–	2	9	1.00
Acacia nigrescens Oliv.	Fabaceae	5	2	–	1	–	–	–	8	0.89
Ophrypetalum odoratum Diels.	Annonaceae	6	2	–	–	–	–	–	8	0.89
Terminalia sambesiaca Engl. & Diels.	Combretaceae	4	1	–	3	–	–	–	8	0.89
Burkea africana Hook.f.	Fabaceae	7	–	–	–	–	–	–	7	0.78

Table 3 continued

Species	Family	Kilengwe	Kimboza	Milawilila	Nemele	Kisego	Ngambaula	Gunauye	Total	Relative Abundance
Delonix elata (L.) Gamble	Fabaceae	–	–	–	7	–	–	–	7	0.78
Millettia usamarensis Taub.	Fabaceae	–	5	–	–	–	1	1	7	0.78
Trema orientalis (L.) Blume	Ulmaceae	4	–	3	–	–	–	–	7	0.78
Bauhinia petersiana Bolle	Fabaceae	6	–	–	–	–	–	–	6	0.67
Cussonia spicata Thunb.	Araliaceae	3	–	–	–	–	–	3	6	0.67
Oncoba spinosa Forssk.	Saliacaceae	4	2	–	–	–	–	–	6	0.67
Pandanus rabaiensis Rendle	Pandanaceae	–	6	–	–	–	–	–	6	0.67
Premna chrisoclada	Lamiaceae	–	6	–	–	–	–	–	6	0.67
Sterculia quinqueloba (Garcke) K. Schum.	Sterculiaceae	3	3	–	–	–	–	–	6	0.67
Stereospermum kunthianum Cham.	Bignoniaceae	5	1	–	–	–	–	–	6	0.67
Allanblackia uluguruensis Engl.	Clusiaceae	2	–	2	1	–	–	–	5	0.56
Commiphora africana (A. Rich.) Engl.	Burseraceae	3	2	–	–	–	–	–	5	0.56
Commiphora eminii Engl.	Burseraceae	1	2	–	–	–	–	2	5	0.56
Cynometra uluguruensis Harms.	Fabaceae	4	1	–	–	–	–	–	5	0.56
Ficus exasperate Vahl.	Moraceae	2	1	–	–	–	–	2	5	0.56
Myrianthus holstii Engl.	Moraceae	4	–	–	–	1	–	–	5	0.56
Sclerocarya birrea (A. Rich.) Hochst.	Anacardiaceae	5	–	–	–	–	–	–	5	0.56
Cassipourea mallosana Alston.	Rhizophoraceae	2	–	2	–	–	–	–	4	0.44
Cyphostemma adenocaula	Orchidaceae	–	–	–	–	4	–	–	4	0.44
Diospyros mespiliformis Hiern.	Ebenaceae	–	3	–	–	–	–	1	4	0.44
Diplorhynchus condylocarpon (Muell. Arg.) Pichon	Apocynaceae	1	–	–	–	3	–	–	4	0.44
Ficus sycomorus L.	Moraceae	–	2	–	–	–	1	1	4	0.44
Markhamia obtusifolia (Baker) Spraque	Bignoniaceae	4	–	–	–	–	–	–	4	0.44
Acacia seyal Del.	Fabaceae	3	–	–	–	–	–	–	3	0.33
Allanblackia stuhlmannii Engl.	Clusiaceae	–	–	3	–	–	–	–	3	0.33
Cassia abbreviate Oliv.	Fabaceae	1	–	–	–	1	–	–	3	0.33
Dalbergia melanoxylon Guill. & Perr.	Fabaceae	3	–	–	–	–	–	–	3	0.33

Table 3 continued

Species	Family	Kilengwe	Kimboza	Milawilila	Nemele	Kisego	Ngambaula	Gunauye	Total	Relative Abundance
Garcinia bifasciculata N. Robson	Clusiaceae	–	3	–	–	–	–	–	3	0.33
Grewia goetzeana K. Schum	Malvaceae	–	3	–	–	–	–	–	3	0.33
Holarrhena pubescens (Buch. Ham.) Wall. ex Don.	Apocyanceae	–	3	–	–	–	–	–	3	0.33
Lecaniodiscus flaxinifolius Baker	Sapindaceae	–	–	–	–	2	1	–	3	0.33
Senna siamea (Lam.) Irwin et Barneby	Fabaceae	–	3	–	–	–	–	–	3	0.33
Acacia caffra (Thunb.) Wild	Fabaceae	2	–	–	–	–	–	–	2	0.22
Albizia amara Boivin.	Fabaceae	–	–	–	2	–	–	–	2	0.22
Anthocleista grandiflora L.	Loganiaceae	2	–	–	–	–	–	–	2	0.22
Brachystegia temarindoides Benth.	Fabaceae	2	–	–	–	–	–	–	2	0.22
Breonadia salicina (Vahl) Happer & J.R.I Wood	Rubiaceae	2	–	–	–	–	–	–	2	0.22
Combretum zeyheri Sond.	Combretaceae	–	2	–	–	–	–	–	2	0.22
Cussonia arborea Hochst. Ex A.Rich	Araliaceae	–	–	–	–	2	–	–	2	0.22
Drypetes gerradii Hutch.	Euphorbiaceae	–	2	–	–	–	–	–	2	0.22
Englerophytum natalense (Sond.) T.D. Penn.	Sapotaceae	2	–	–	–	–	–	–	2	0.22
Erythrophleum suaveolens (Guill. & Perr.) Brennan	Fabaceae	1	–	–	–	1	–	–	2	0.22
Harungana madagascariensis Lam. ex Poir	Clusiaceae	1	–	1	–	–	–	–	2	0.22
Mangifera indica L.	Anacardiaceae	–	2	–	–	–	–	–	2	0.22
Margaritaria discoidea (Baill.) G. L. Webster	Euphorbiaceae	2	–	–	–	–	–	–	2	0.22
Millettia sacleuxii Dunn.	Fabaceae	–	2	–	–	–	–	–	2	0.22
Parkia filicoidea Welw. ex Oliv.	Fabaceae	2	–	–	–	–	–	–	2	0.22
Steganotaenia araliaceae Hochest.	Apiaceae	–	–	–	–	–	–	–	2	0.22
Sterculia appendiculata K. Schum.	Sterculiaceae	1	1	–	–	–	–	–	2	0.22
Trichilia emetic Vahl.	Meliaceae	–	–	–	–	2	–	–	2	0.22
Brachystegia bussei Harms.	Fabaceae	–	–	–	1	–	–	–	1	0.11

Table 3 continued

Species	Family	Kilengwe	Kimboza	Milawilila	Nemele	Kisego	Ngambaula	Gunauye	Total	Relative Abundance
Combretum adenogonium Stued. ex Rich.	Combretaceae	1	–	–	–	–	–	–	1	0.11
Cussonia Zimmermannii Harms.	Araliaceae	1	–	–	–	–	–	–	1	0.11
Dichrostachs cinerea Wight et Arn	Fabaceae	–	–	–	–	1	–	–	1	0.11
Harrisonia abyssinica Oliv.	Simaroubaceae	1	–	–	–	–	–	–	1	0.11
Lonchocarpus bussei Harms.	Fabaceae	1	–	–	–	–	–	–	1	0.11
Newtonia buchananii (Baker) G.C.C. Gilbert& Boutique	Fabaceae	–	–	–	1	–	–	–	1	0.11
Pouteria altissima Baehni	Sapotaceae	1	–	–	–	–	–	–	1	0.11
Pseudolachnostylis maprouneifolia Pax.	Phyllanthaceae	1	–	–	–	–	–	–	1	0.11
Pterocarpus angolensis DC.	Fabaceae	–	1	–	–	–	–	–	1	0.11
Pterocarpus rotundifolia (Sond.) Druce	Fabaceae	–	1	–	–	–	–	–	1	0.11
Pterocarpus tinctorius Welw.	Fabaceae	1	–	–	–	–	–	–	1	0.11
Sterculia Africana (Lour.) Fiori	Sterculiaceae	–	–	–	–	1	–	–	1	0.11
Tabernaemontana pachysiphon Stapf.	Apocynaceae	1	–	–	–	–	–	–	1	0.11
Zanthoxylum deremense (Engl.)	Rutaceae	–	1	–	–	–	–	–	1	0.11
Total		199	281	124	70	101	41	84	900	100

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