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Original article

Tree diversity, stand structure, and community composition of tropical forests in Eastern Ghats of Andhra Pradesh, India

Maradana Tarakeswara Naidu*, Owk Aniel Kumar

Department of Botany, Andhra University, Visakhapatnam, India

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A B S T R A C T

Species diversity and density of trees were assessed in four 1-ha plots (at 457–925 m in elevation) in the Eastern Ghats of the Andhra Pradesh region comprising mostly of tropical deciduous forests based on a census of all trees with girth at breast height ≥ 15cm. We compared tree community characteristics like stem density, basal area, diversity, and species composition of four plots using a tree dataset of eight belt transects (5 m × 1000 m) in the study area. A total of 2,227 individuals of 44 families, 98 genera, and 129 species were recorded. Combretaceae, Euphorbiaceae, and Anacardiaceae, showed the greatest importance value index. It was noticed that the most species were contributed by Euphorbiaceae and the tree density varied from 435 ha^{-1} to 767 ha^{-1} with an average basal area of 25.82 m^2/ha. Shannon–Weiner index (H') ranged from 3.76 to 3.96, the Simpson index ranged from 0.96 to 0.97, evenness index ranged from 0.60 to 0.78, and species richness index ranged from 10.04 to 11.24. At present the biodiversity of these forests are under threat due to the anthropogenic and upcoming mining activities. The present study will help us to understand the patterns of tree species composition and diversity in the Eastern Ghats of India.

Introduction

Tropical forests are the richest biological communities on earth and these forests have been recognized to harbor a significant proportion of global biodiversity (Myers et al 2000; Baraloto et al 2013). These forests provide many ecosystem services such as species conservation, prevention of soil erosion, and preservation of habitat for plants and animals (Armenteras et al 2009). Biotic factors such as seed quality, seedling survivorship, and recruitment are important in maintaining the tree composition of tropical forests (Connell 1971). Overexploitation has resulted in the rapid loss of forests and is recognized to be one of the biggest environmental and economic problems around the world (Mani and Parthasarathy 2006). Tropical forests are disappearing at alarming rates worldwide, reducing annually by 1–4% of their current area (Laurance 1999). Relatively increased anthropogenic pressures have led to agricultural expansion and overgrazing of livestock (Anitha et al 2010).

Trees, an important component of vegetation, must therefore be constantly monitored and managed in order to direct successional processes towards maintaining species and habitat diversity (Turner 1987; Attua and Pabi 2013). Tree species diversity is an important aspect of forest ecosystem diversity (Rennolls and Laumonier 2000; Tchouto et al 2006) and is also fundamental to tropical forest biodiversity (Evariste et al 2010). Tree census plots have been established in forest types through tropical regions to monitor forest dynamics over time and to assess the effects of disturbance and climate change on plant demography (Condit et al 1996; Laurance et al 2004; Mohandass and Davidar 2009). Tree species diversity that influences the forests are climate, stand structure, species composition, and geomorphology. Forest stand structure is a key element in understanding forest ecosystems and also an important element of stand biodiversity (Ozcelik 2009). The rapid inventory of tree species that provides information on diversity will represent an important tool to enhance our ability to maximize biodiversity conservation that results from deforestation and degradation

* Corresponding author.
E-mail address: tarakeswaranaidu@gmail.com (M.T. Naidu).
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(Baraloto et al 2013). Information from this quantitative inventory will provide a valuable reference forest assessment and improve our knowledge by the identification of ecologically, useful species as well as species of special concern, thus identifying conservation efforts for sustainability of forest biodiversity.

The Eastern Ghats (EG) is a discontinuous range of mountains situated along the eastern coast of India. EG contributes significantly to both species richness and endemicity of the Indian region (Reddy et al 2011). Due to overexploitation of medicinal plants, fuel wood collection, habitat destruction, and grazing, the plant diversity of EG hill ranges is declining at an alarming rate (Padal et al 2009; Premavani et al 2014). This may lead to the extinction of many valuable species. Irrespective of rich floral diversity, the hills are under severe threat of deforestation and degradation due to several anthropogenic activities (Naidu et al 2014a,b). Due to population pressures the forest cover has drastically shrunk and is now limited to a few relic patches in hill tracts. The present study is significant in generating useful baseline data in order to conserve and manage the native flora and fauna of this tropical forest ecosystem in the region and elsewhere in the tropical forests in India. Information from this quantitative inventory will provide valuable documentation of forest assessment and improve our knowledge in identification of ecologically useful species. The objective of this paper is to study the community composition, species diversity, and tree population structure in four stands of tropical forests of EG of Andhra Pradesh, India.

Materials and methods

Study area

The study sites are located in the Visakhaptnam district of Andhra Pradesh, India, which are part of the EG of northern Andhra Pradesh. The district lies between 17°15' and 18°32' Northern latitude and 83°54' and 83°30' in Eastern longitude with an altitude varying between 355 m and 1200 m mean sea level. The data were collected from four sites, namely Madimanulu (MM), Tyada (TD), Kokkiripalli (KP), and Sndhiputtu (SP), in the years 2012–2014 (Figure 1). The temperature of the Visakhapatnam district is characterized by permanent high temperatures ranging from 15°C to 38°C. Rainfall (1000–2000 mm) is considerably more in the high areas. Geologically, rocks are the oldest, belonging to the Archean system, with gnesis being the most common rock in the hills. The soils are ferruginous loams mixed with quartzite in the hill slopes (Subrahmanyam 1982). The natural vegetation of the district has a broad sense of tropical deciduous types (Champion and Seth 1968) with most of the species characteristic to the deciduous forest of the EG. The district is undergoing rapid changes in vegetation and is facing large scale anthropogenic forcing in the form of mining, thermal power generation, hydro-power project, etc. Besides sporadic tree felling, widespread lopping and extraction of nontimber resources has been noticed. The forest cover is continuously decreasing and the remnant forest cover exists in the form of fragments of varying sizes.

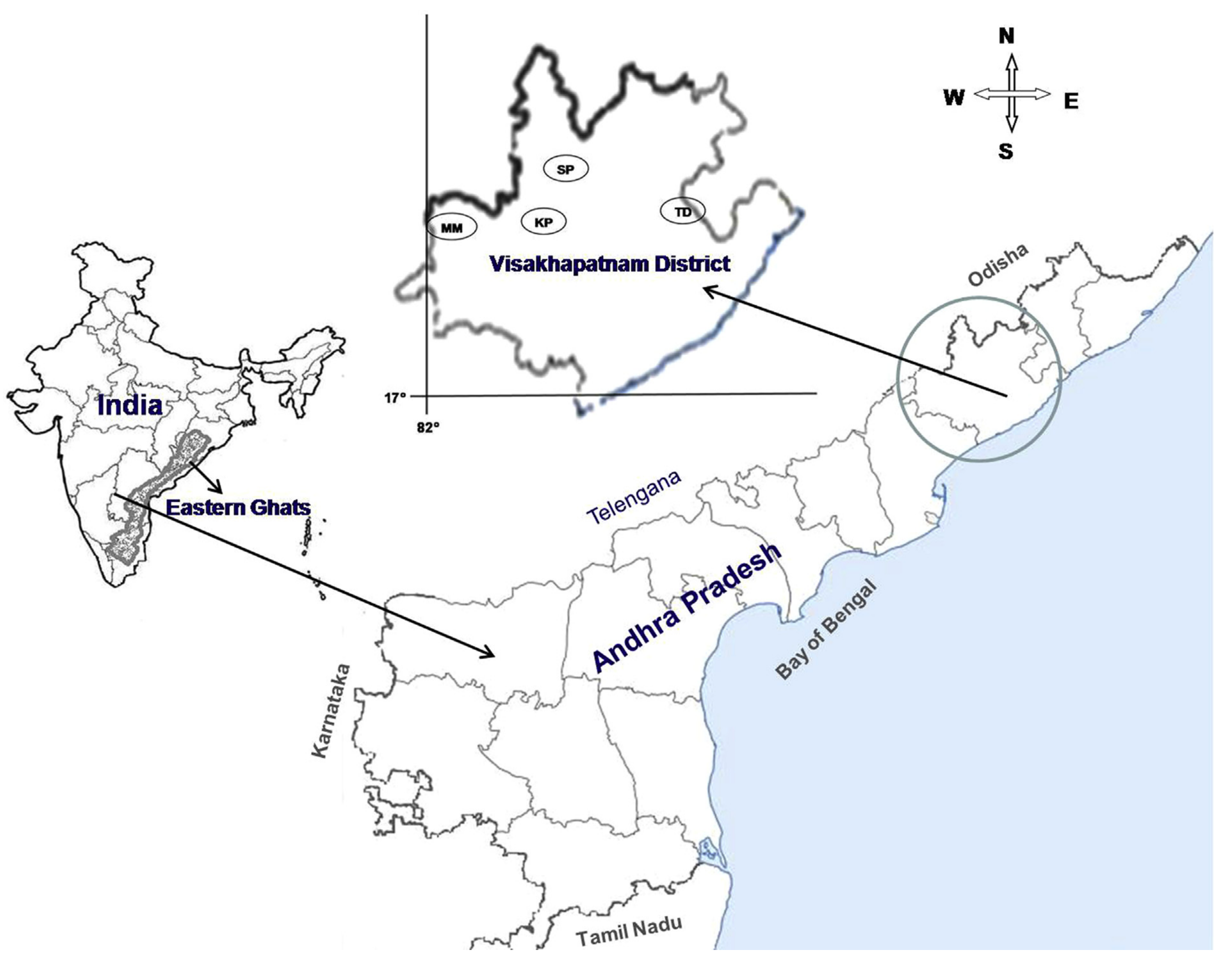

Figure 1. Map showing the sampled localities in the Visakhapatnam district: KP = Kokkiripalli; MM = Madimanulu; SP = Sndhiputtu; TD = Tyada.

Methods

For the determination of biodiversity, methodology prescribed by the National Bioresource Development Board, Department of Biotechnology, Government of India to quantify plant resources of India was followed. In all the six study sites, two belt transects of size 5 m × 1000 m (totaling 1 ha) were laid in each site during the calendar years 2010–2012 and all live trees with ≥ 15 cm girth at breast height were enumerated. The representative taxa were collected and identified with the help of regional floras (Gamble and Fischer 1915–1935; Rao and Kumari 2002–2008) and made into herbarium. The voucher specimens were housed in the Botany Department Herbarium, Department of Botany, Andhra University, Visakhapatnam, India.

Data analysis

Based on the individuals recorded in the discrete plot samples, vegetation data were quantitatively analyzed for basal area, relative density, relative frequency, and relative dominance. The importance value index (IVI) of tree species was determined as the sum of relative frequency, relative density, and relative dominance (Curtis and McIntosh 1950). Structural composition was analyzed by comparing the distribution of tree diameter classes. The data were also used to compute community indices like species diversity (H') of different tree species and was calculated using the Shannon–Weiner Index (Shannon and Weiner 1963):

$$H' = -\sum(\mathrm{ni}/n)/\mathrm{n}(\mathrm{ni}/n) \tag{1}$$

where, ni/*n* denotes the importance probability of each species in a population, ni is the importance of value of species, and *n* is the total number of individuals of all species in that vegetation type.

Species dominance (Cd) was calculated following the index by Simpson (1949):

$$\mathrm{Cd} = \sum(\mathrm{ni}/n) \tag{2}$$

where, ni and *n* are the same as those for Shannon–Weiner information function.

Equitability of evenness refers to the degree of relative dominance of each species in that area. It was calculated according to Pielou (1966) as:

$$\mathrm{Evenness(e)} = H'/\log S \tag{3}$$

where, H'= Shannon index, S = number of species.

Species richness was determined by Margalef index (1968) as:

$$d = S_1/\log N \tag{4}$$

where, S is the number of species and *N* is the number of individuals.

Results

A total of 2,227 individuals belonging to 129 species (≥ 15 cm) among 98 genera and 44 families from four 1-ha plots were enumerated (Table A1) in tropical forests of EG in northern Andhra Pradesh. Out of these, 32 families comprising 64 genera, 72 species, and 554 individuals were recorded in plot TD; 31 families representing 61 genera, 71 species, and 767 individuals were recorded in plot MM; 62 species belonging 53 genera, 30 families, and 435 individuals were recorded in plot SP; and plot KP contributed 471 individuals belonging to 70 species among 56 genera and 30 families (Table 1). Diversity of tree species in the study plots calculated using the Shannon–Weiner index (H') showed that the highest diversity was in plot MM (3.96) and the lowest diversity was in TD (3.76), with dominance of Simpson's value ranging from 0.96 to 0.97. Evenness index was the lowest at plot TD (0.6) and maximum at plot SP (0.78), and Margalef index was the highest in plot TD with 11.24.

The number of plant families in the study area was 44 taxonomically well-represented families. Euphorbiaceae had the maximum number of species (10 species) followed by Rubiaceae and Moraceae (9 species each); Caesalpiniaceae (7 species); Combretaceae, Rutaceae, and Meliaceae (6 species each); Fabaceae, Verbenaceae, and Sterculiaceae (5 species each); Anacardiaceae, Mimosaceae, and Annonaceae (4 species each); Apocynaceae, Ebenaceae, Bignoniaceae, Flacourtiaceae, and Sapotaceae (3 species each). Seven families, Burseraceae, Tiliaceae, Loganiaceae, Dilleniaceae, Ulmaceae, Elaeocarpaceae, and Rhamnaceae, had two species each and 18 families had only a single species in the study area. Based on density, Euphorbiaceae contributed 11% of the stand density followed by Combretaceae (10%), Anacardiaceae (8%), Mimosaceae (5.9%), and Rubiaceae 5.8% (Table 2). Combretaceae contributed 111.7 IVI followed by Euphorbiaceae (111.5), Anacardiaceae (102.6), Rubiaceae (72.26), and Fabaceae (70.5).

The mean stand density was 556 individuals/ha. The highest stand density was observed in MM (767 individuals/ha), whereas the lowest stand density was observed in SP (435 individual/ha), and the other two plots showed moderate densities. The density of different tree species is along the study area. The basal area in all the study plots ranged from 12.98 m^2/ha (SP) to 33.63 m^2/ha (MM) and the mean basal area for the four plots was 25.82 m^2/ha (Table 1). Tree species richness as well as diversity decreased with increasing girth classes (15–30 class). A comparison was made for the relative distribution of the total number of individuals. Tree girth class-wise density was more for the 31–60 class interval with 845 individuals and Shannon index (4.3) followed by 61–90 girth class (814 and 4.03), 15–30 girth class (223 and 3.99), 91–120 class (141 and 3.36), 12–150 class (117 and 3.56), and > 150 girth class represented 87 individuals and 3.14. Species occurrence rate was highest in both 15–30 girth class and > 150 girth class and lowest in 61–90 girth class with 0.12 (Table 3). Tree girth class-wise density in TD was more for the 31–60 girth class and represented 203 individuals and 3.72 m^2/ha basal area and the highest basal area contributed in the > 150 girth class as 9.18 m^2/ha; the highest contributed in the 61–90 girth class as 13.24 m^2/ha and the 31–60

Table 1. Floristic richness, number of individuals, and diversity indices for the four 1-ha plots in the Eastern Ghats of northern Andhra Pradesh.

Variable	TD	MM	SP	KP
No. of species	72	71	62	70
No. of genera	64	61	53	56
No. of families	32	31	30	30
Density	554	767	435	471
Basal area (m^2/ha)	32.53	33.63	12.98	24.17
Shannon	3.76	3.96	3.88	3.91
Simpson	0.96	0.97	0.97	0.97
Evenness	0.6	0.74	0.78	0.71
Margalef	11.24	10.54	10.04	11.21
Elevation	595	457	648	925
Latitude	18° 12' 735" N	17° 57' 408" N	18° 21' 087" N	17° 59' 516" N
Longitude	83° 02' 566" E	82° 03' 548" E	82° 29' 139" E	82° 28' 269" E

E = east; KP = Kokkiripalli; MM = Madimanulu; N = north; SP = Sndhiputtu; TD = Tyada.

Table 2. Dominant families based on importance value index (IVI) and number of species, genera, and individuals.

S. no.	Family	No. of species	No. of genera	No of individuals	IVI
1	Combretaceae	6	2	225	111.7
2	Euphorbiaceae	10	6	251	111.5
3	Anacardiaceae	4	4	176	102.6
4	Rubiaceae	9	9	130	72.26
5	Fabaceae	5	5	116	70.5
6	Mimosaceae	4	3	132	66.14
7	Burseraceae	2	2	117	54.99
8	Caesalpiniaceae	7	4	90	53.08
9	Sterculiaceae	5	4	84	41.96
10	Ebenaceae	3	1	81	40.8
11	Moraceae	9	2	50	38.12
12	Verbenaceae	5	4	63	37.96
13	Sapindaceae	1	1	63	30.78
14	Tiliaceae	2	1	56	29.73
15	Rutaceae	6	6	38	27.69
16	Myrtaceae	1	1	52	27.43
17	Apocynaceae	3	2	51	24.49
18	Meliaceae	6	6	52	24.08
19	Malvaceae	1	1	51	23.77
20	Annonaceae	4	3	28	21.39
21	Bignoniaceae	3	2	29	16.7
22	Flacourtiaceae	3	3	40	16.53
23	Flindersiaceae	1	1	35	16.36
24	Loganiaceae	2	1	24	15.85
25	Magnoliaceae	1	1	22	14.59
26	Oleaceae	2	2	30	13.24
27	Dilleniaceae	2	1	26	12.8
28	Sapotaceae	3	2	13	10.59
29	Ulmaceae	2	2	14	10.17
30	Arecaceae	1	1	11	9.88
31	Lythraceae	1	1	15	9.61
32	Elaeocarpaceae	2	2	8	6.06
33	Lauraceae	1	1	12	5.71
34	Alangiaceae	1	1	7	5.67
35	Rhamnaceae	2	1	8	5.54
36	Bischofiaceae	1	1	6	3.5
37	Cochlospermaceae	1	1	6	3.19
38	Bombacaceae	1	1	2	3.17
39	Hernandiaceae	1	1	3	2.09
40	Stilaginaceae	1	1	3	1.83
41	Leeaceae	1	1	4	1.62
42	Simaroubaceae	1	1	1	1.47
43	Lecythidaceae	1	1	1	1.34
44	Ochnaceae	1	1	1	1.34
	Total	129	98	2227	1200

S. no. = species number.

class had the highest number individuals in plot MM; in plot SP, the 31–60 class had the highest number of individuals with 188, and the 61–90 girth class showed 5.34 m^2/ha basal area, where as in plot KP, the 61–90 girth class contributed 221 individuals and basal area with 9.64 m^2/ha (Figure 2).

The IVI of the tree species (Figure 2) in the TD plot suggested that *Anogeissus latifolia* (IVI = 20.87), *Lannea coromendelica* (14.94), and *Tamarindus indica* (14.11) were the dominant species. These species were followed by *Xylia xylocarpa*, *Haldinia cordifolia*, and *Mallotus philippensis*. However, among the plot MM, *Pterocarpus marsupium* (13.57), *Michelia champaca* (12.53), and *Mangifera indica* (11.71) were the dominant species, followed by *Anogeissus latifolia*, *Terminalia alata*, and *Syzygium cumini*. In the plot SP, *Xylia xylocarpa* (12.98), *Terminalia alata* (12.68), and *Mangifera indica* (11.67) were the dominant species with the highest IVI values, followed by *Pongamia pinnata*, *Anogeissus latifolia*, and *Caryota urens*, where as in plot KP, *Garuga pinnata* (12.97), *Bridelia retusa* (11.51), and *Terminalia bellerica* (11.42) were the dominant species followed by *Mallotus philippensis*, *Albizia procera*, and *Schleichera oleosa* were the codominant species (Table 4).

Table 3. Species richness, stand density, and diversity index for different stem size classes for the four 1-ha plots in the Eastern Ghats of northern Andhra Pradesh.

Girth class (cm)	Species richness	Stem density	Species occurrence rate species richness/stem density	Shannon index
15–30	75	223	0.33	3.99
31–60	112	845	0.13	4.3
61–90	98	814	0.12	4.03
91–120	47	141	0.33	3.36
121–150	49	117	0.41	3.56
>150	29	87	0.33	3.14

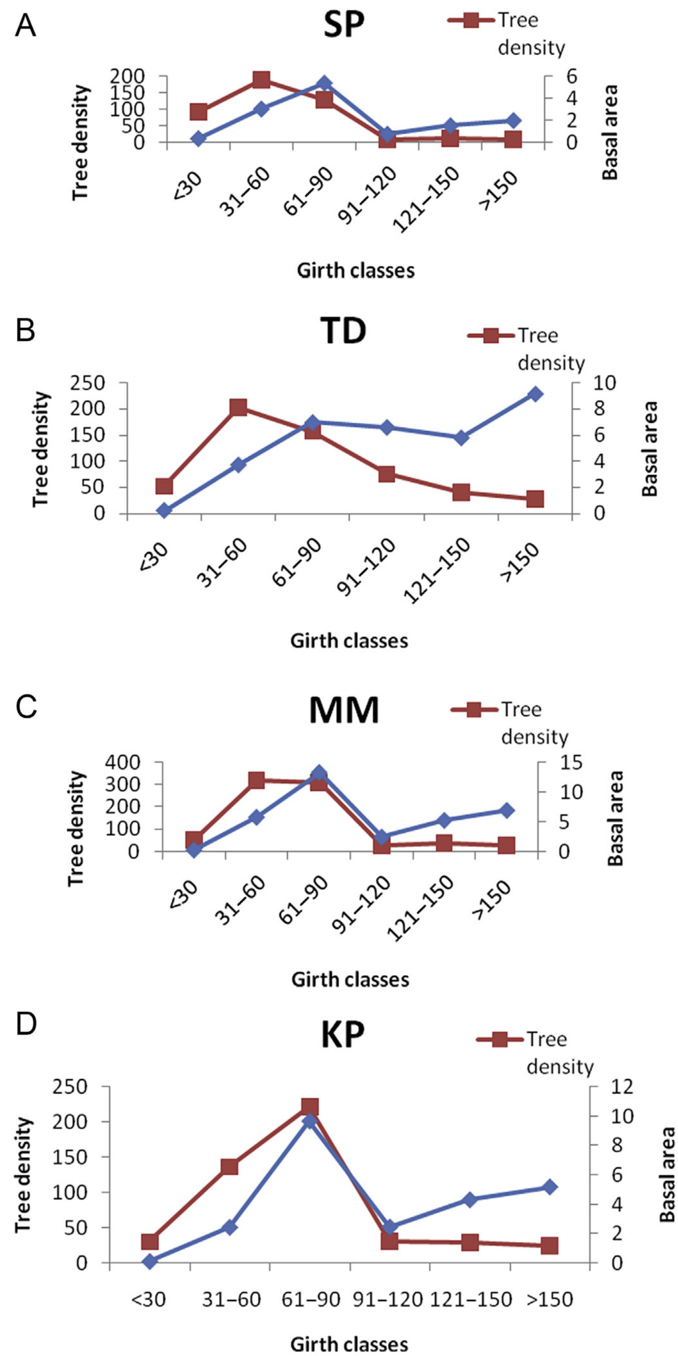

Figure 2. Contribution of tree stands density and basal area based on girth class distribution: A, Sndhiputtu (SP); B, Tyada (TD); C, Madimanulu (MM); D, Kokkiripalli (KP).

Table 4. Density, importance value index (IVI), and basal area of the 10 most important species in four study sites.

Species	TD			Species	MM			Species	SP			Species	KP		
	IVI	D	BA		IVI	D	BA		IVI	D	BA		IVI	D	BA
Anogeissus latifolia	21	46	3.44	*Anogeissus latifolia*	12	33	1.73	*Diospyros sylvatica*	8.2	16	0.2	*Scleichera oleosa*	10	18	1
Lannea coromandelica	15	31	2.39	*Garuga pinnata*	9	28	1.1	*Semecarpus anacardium*	8.2	13	0.3	*Terminalia bellirica*	11	15	0.5
Tamarindus indica	14	11	3.3	*Haldinia cordifolia*	9.4	26	1.31	*Pongamia pinnata*	11	7	1.1	*Grewia tiliifolia*	9.4	14	1
Xylia xylocarpa	14	31	2	*Mangifera indica*	12	28	2.01	*Chloroxylon swietenia*	8.2	18	0.2	*Pterocrpus marsupium*	10	25	0.9
Haldinia cordifolia	13	20	2.45	*Michelia champaca*	13	19	2.68	*Caryota urens*	9.9	11	0.6	*Mallotus philippensis*	11	24	0.8
Mallotus philippensis	12	39	1.01	*Protium serratum*	7.6	24	0.79	*Terminalia alata*	13	20	0.7	*Bridelia retusa*	12	13	1.6
Garuga pinnata	9.8	21	1.32	*Pterocarpus marsupium*	14	32	2.46	*Anogeissus latifolia*	10	15	0.7	*Kydia calycina*	10	15	1.4
Pterospermum xylocarpum	8.5	22	0.82	*Syzygium cumini*	9.7	24	1.49	*Mangifera indica*	12	10	1	*Garuga pinnata*	13	19	1.6
Mangifera indica	8.2	3	2.18	*Terminalia alata*	11	36	1.41	*Lannea coromandelica*	9.7	14	0.5	*Mangifera indica*	8.6	8	1.3
Schleichera oleosa	8	16	1.01	*Xylia xylocarpa*	7.5	25	0.73	*Xylia xylocarpa*	13	20	0.9	*Albizia procera*	10	13	1.6

BA = Basal area; D = Density; KP = Kokkiripalli; MM = Madimanulu; SP = Sndhiputtu; TD = Tyada.

Discussion

Knowing **s**pecies diversity is a useful tool in plant ecology and forestry to compare the composition of different species. Tree species diversity in tropical forests differ greatly from location to location mainly due to variation in biogeography, habitat, and disturbance (Neumann and Starlinger 2001; Padalia et al 2004). Plant diversity changes are compared in conjunction with human impacts. Certain changes are easy to predict, at least qualitatively. Population sizes when reduced may have deleterious consequences (Sukumar et al 1992). Hence, the present investigation was aimed at assessing the tree diversity changes in the EG of India.

The stand density of northern EG represented maximum tree species diversity on plot TD (72 species), followed by plot MM (71), plot KP (70), and plot SP (62). The number of tree species recorded in the present study was found to be lower than the number of species reported by several workers in other tropical forests (Fox et al 1997, 94 species; Kadavul and Parthasarathy 1999a, 89 species; Khera et al 2001, 92 species; Attua and Pabi 2013, 88 species). The tree species richness in the tropics showed a wide variation, ranging from a low value of 20 species/ha in Ngovayang's lowland forests, Cameroon (Gonmadje et al 2011), 137–168 species/ha in terra-frime forest, Amazonia (Ferreira and Prance 1998), to a very high 307 species/ha in Amazonia Ecuadar (Valencia et al 1994). Species diversity was significantly influenced by forest structure and species composition (Huang et al 2003)—high species diversity is often connected to more complex vertical structure.

The absolute stand density of the four plots ranged from 435 trees/ha to 767 trees/ha with 556 trees/ha mean stand density being lower compared with densities reported from the Kalarayan hills (640–986 trees/ha, Kadavul and Parthasarathy 1999b), EG of northern Andhra Pradesh (639–836 trees/ha, Reddy et al 2011). However, the tree density is comparable with other tropical forests of Kalakkad, Western Ghats (575–855 trees/ha, Parthasarathy 1999), Anamalais (270–673 tree/ha, Ayyappan and Parthasarathy 1999), Gandhmaran hills, EG (565–671 trees/ha, Sahu et al 2010), Brazil (420–777 trees/ha, Campbell et al 1992), Sulawesi (408 trees/ha, Whitmore and Sidiyasa 1986). Tree density can be affected by natural calamities, anthropogenic activities, and soil properties.

The basal area of trees in northern EG forests (mean 25.82 m^2/ha, range 12.98–33.63) is much higher than the range (1.31–13.78 m^2/ha, Sagar and Singh 2006). The reported basal areas from other studies include 7–23 m^2/ha from certain dry forest communities in India (Jha and Singh 1990), 10.79–20.44 m^2/ha for tropical dry evergreen forests of southern India (Parthasarathy and Sethi 1997) and 3.9–16.7 m^2/ha for Miombo woodlands, Tanzania (Backeus et al 2006). The values are less comparable with those reported from New Caledonia (47–49.5 m^2/ha, Jaffre and Veillon 1990) and fan-palm dominated forests of east coast peninsular Malaysia (25.3–48.6 m^2/ha, Nizam et al 2013). The differences in the basal area of tree layers among the study plots may be due to differences in altitude, species composition, age of trees, and extent of disturbances and successional strategies of the stands. Girth class frequency showed that the population structure of trees exhibited in the study plots are in harmony with other forest stands (Bhadra et al 2010; Sahu et al 2010). Tree distribution across different girth classes revealed how well the growing forest is utilizing functional and structural resources. The diameter distribution of trees has been often used to represent the population structure of forests (Rao et al 1990).

Biodiversity indices are generated to bring the diversity and abundance of species in different habitats to a similar scale for comparison and the higher the value, the greater the species richness. The higher values of the diversity indices revealed a forest with high tree species diversity and abundance (Adekunle et al 2013). Shannon–Weiner values for tree species diversity in the present study (3.76–3.96) ranged between 0. 81 and 4.1 (Visalakshi 1995; Sahu et al 2012; Sundarapandian and Swamy 2000). The extent of dominance (Simpson's index) in the present study is within a range of 0.21–1.34 in other forests (Knight 1975; Visalakshi 1995; Lalfakwma et al 2009). The Margalef index within the range of 4.54–23.41 for tropical forests reported by earlier workers (Mishra et al 2005; Kumar et al 2010; Sathish et al 2013). Biodiversity is necessary to assess ecosystem health because it affects key ecological processes. Woody plant species are key components of the forest ecosystem and are responsible for forest architecture and influences the overall composition of forest communities. Documenting the patterns of tree diversity and their distribution provides a good database, useful for management measures in these forests. A comprehensive approach to forest management is needed for the conservation of dominant tree species that are necessary for the canopy formation as well as maintaining the ecological balance of the forests. Tree species density, distribution, and population structure analyzed in this study should be useful to the conservation researchers and scientists and also to the forest managers for effective management of the forest conservation. The preservation of these forests is crucial not only for conservation of their rich biodiversity, but also for meeting the basic needs of the local population. Therefore, this paper calls for an urgent conservation plan to conserve biological diversity.

Appendix 1. List of all tree species encountered in four study sites in order of decreasing importance value index (IVI) values.

S. no.	Species name	Family	Abundance	IVI
1	*Anogeissus latifolia*	Combretaceae	98	44.99
2	*Mangifera indica*	Anacardiaceae	49	40.25
3	*Xylia xylocarpa*	Mimosaceae	86	39.03
4	*Lannea coromandelica*	Anacardiaceae	81	38.98
5	*Garuga pinnata*	Burseraceae	74	35
6	*Mallotus philippensis*	Euphorbiaceae	92	34.47
7	*Terminalia alata*	Combretaceae	73	31.78
8	*Schleichera oleosa*	Sapindaceae	63	30.78
9	*Pterocarpus marsupium*	Fabaceae	67	29.73
10	*Syzygium cumini*	Myrtaceae	52	27.43
11	*Haldinia cordifolia*	Rubiaceae	50	26.65
12	*Grewia tiliifolia*	Tiliaceae	48	26.03
13	*Kydia calycina*	Malvaceae	51	23.77
14	*Pterospermum xylocarpum*	Sterculiaceae	42	20.77
15	*Protium serratum*	Burseraceae	43	19.99
16	*Tamarindus indica*	Caesalpiniaceae	22	18.98
17	*Diospyros sylvatica*	Ebenaceae	36	18.6
18	*Wrightia tinctoria*	Apocynaceae	43	18.23
19	*Terminalia bellirica*	Combretaceae	26	16.88
20	*Bridelia airy-shawii*	Euphorbiaceae	19	16.77
21	*Chloroxylon swietenia*	Flindersiaceae	35	16.36
22	*Diospyros montana*	Ebenaceae	37	16
23	*Albizia odoratissima*	Mimosaceae	31	15.38
24	*Michelia champaca*	Magnoliaceae	22	14.59
25	*Cleistanthus collinus*	Euphorbiaceae	48	14.43
26	*Ougeinia oojeinensis*	Fabaceae	22	13.94
27	*Macaranga peltata*	Euphorbiaceae	27	13.78
28	*Callicarpa arborea*	Verbenaceae	28	13.59
29	*Semecarpus anacardium*	Anacardiaceae	22	13.5
30	*Canthium dicoccum*	Rubiaceae	29	13.36
31	*Miliusa tomentosa*	Annonaceae	17	13.28
32	*Pongamia pinnata*	Fabaceae	9	13.26
33	*Strychnos nuxvomica*	Loganiaceae	17	11.43
34	*Terminalia chebula*	Combretaceae	20	11.35
35	*Dalbergia paniculata*	Fabaceae	16	11.13
36	*Mitragyna parvifolia*	Rubiaceae	18	11.13
37	*Sterculia urens*	Sterculiaceae	20	10.95
38	*Schrebera swietenoides*	Oleaceae	22	10.54
39	*Albizia procera*	Mimosaceae	13	10.29
40	*Buchanania lanzan*	Anacardiaceae	24	9.907
41	*Bauhinia racemosa*	Caesalpiniaceae	17	9.899
42	*Caryota urens*	Arecaceae	11	9.882
43	*Lagerstroemia parviflora*	Lythraceae	15	9.617
44	*Ficus semicordata*	Moraceae	10	9.463
45	*Phyllanthus emblica*	Euphorbiaceae	15	9.329
46	*Artocarpus heterophyllus*	Moraceae	17	9.153
47	*Homalium nepaulense*	Flacourtiaceae	22	8.561
48	*Glochidion velutinum*	Euphorbiaceae	13	8.31
49	*Dillenia pentagyna*	Dilleniaceae	15	8.146
50	*Gmelina arborea*	Verbenaceae	8	8.03
51	*Gardenia latifolia*	Rubiaceae	11	7.532
52	*Madhuca indica*	Sapotaceae	8	7.495
53	*Premna tomentosa*	Verbenaceae	10	7.053
54	*Aegle marmelos*	Rutaceae	11	6.926
55	*Firmiana colorata*	Sterculiaceae	16	6.618
56	*Naringi crenulata*	Rutaceae	8	6.569
57	*Stereospermum colais*	Bignoniaceae	16	6.339
58	*Bauhinia malabarica*	Caesalpiniaceae	10	6.233
59	*Toona ciliata*	Meliaceae	11	6.23
60	*Diospyros melanoxylon*	Ebenaceae	8	6.198
61	*Cassia fistula*	Caesalpiniaceae	13	6.188
62	*Stereospemum personatum*	Bignoniaceae	7	6.114
63	*Bauhinia semla*	Caesalpiniaceae	16	5.746
64	*Litsea glutinosa*	Lauraceae	12	5.714
65	*Callicarpa tomentosa*	Verbenaceae	8	5.681
66	*Alangium salvifolium*	Alangiaceae	7	5.677
67	*Casearia tomentosa*	Flacourtiaceae	10	5.596
68	*Trema orientalis*	Ulmaceae	10	5.462
69	*Cipadessa baccifera*	Meliaceae	14	5.295
70	*Murraya paniculata*	Rutaceae	8	5.29
71	*Bridelia montana*	Euphorbiaceae	12	5.263
72	*Wrightia arborea*	Apocynaceae	7	4.93
73	*Polyalthia cerasoides*	Annonaceae	8	4.801

Appendix 1. (*continued*)

S. no.	Species name	Family	Abundance	IVI
74	*Walsura trifoliata*	Meliaceae	10	4.785
75	*Holoptelea integrifolia*	Ulmaceae	4	4.711
76	*Dillenia indica*	Dilleniaceae	11	4.649
77	*Hymenodictyon orixense*	Rubiaceae	6	4.632
78	*Sloanea sterculiacea*	Elaeocarpaceae	5	4.499
79	*Strychnos potatorum*	Loganiaceae	7	4.42
80	*Terminalia arjuna*	Combretaceae	5	4.368
81	*Bauhinia variegate*	Caesalpiniaceae	9	4.362
82	*Ficus tomentosa*	Moraceae	5	4.323
83	*Oroxylum indicum*	Bignoniaceae	6	4.247
84	*Ziziphus xylopyrus*	Rhamnaceae	7	4.14
85	*Atalantia monophylla*	Rutaceae	4	3.978
86	*Ficus microcarpa*	Moraceae	4	3.956
87	*Glochidion zeylanicum*	Euphorbiaceae	7	3.862
88	*Grewia damine*	Tiliaceae	8	3.698
89	*Vitex leucoxylon*	Verbenaceae	9	3.607
90	*Bischofia javanica*	Bischofiaceae	6	3.502
91	*Trichilia connaroides*	Meliaceae	11	3.485
92	*Zanthoxylum armatum*	Rutaceae	5	3.23
93	*Cochlospermum religiosum*	Cochlospermaceae	6	3.197
94	*Bombax ceiba*	Bombacaceae	2	3.178
95	*Soymida febrifuga*	Meliaceae	5	3.022
96	*Glochidion ellipticum*	Euphorbiaceae	9	2.828
97	*Ficus palmata*	Moraceae	4	2.814
98	*Nyctanthes arbortristis*	Oleaceae	8	2.704
99	*Ficus exasperata*	Moraceae	4	2.702
100	*Wendlandia gamblei*	Rubiaceae	9	2.548
101	*Ixora pavetta*	Rubiaceae	2	2.524
102	*Morinda pubescens*	Rubiaceae	3	2.51
103	*Cleistanthus patulus*	Euphorbiaceae	9	2.489
104	*Erythrina suberosa*	Fabaceae	2	2.436
105	*Flacourtia jangomas*	Flacourtiaceae	8	2.378
106	*Anogeissus acuminata*	Combretaceae	3	2.365
107	*Ficus auriculata*	Moraceae	2	2.216
108	*Gyrocarpus americanus*	Hernandiaceae	3	2.096
109	*Ficus racemosa*	Moraceae	3	2.094
110	*Annona reticulate*	Annonaceae	2	1.955
111	*Eriolaena hookeriana*	Sterculiaceae	5	1.844
112	*Antidesma acidum*	Stilaginaceae	3	1.831
113	*Sterculia villosa*	Sterculiaceae	1	1.772
114	*Limonia acidissima*	Rutaceae	2	1.696
115	*Saraca asoca*	Caesalpiniaceae	3	1.673
116	*Leea indica*	Leeaceae	4	1.626
117	*Xantolis tomentosa*	Sapotaceae	3	1.576
118	*Elaeocarpus tectorius*	Elaeocarpaceae	3	1.569
119	*Madhuca longifolia*	Sapotaceae	2	1.519
120	*Ailanthus excelsa*	Simaroubaceae	1	1.475
121	*Acacia catechu*	Mimosaceae	2	1.437
122	*Ziziphus mauritiana*	Rhamnaceae	1	1.402
123	*Ficus tinctoria*	Moraceae	1	1.399
124	*Meyna spinosa*	Rubiaceae	2	1.374
125	*Annona squamosa*	Annonaceae	1	1.349
126	*Careya arborea*	Lecythidaceae	1	1.347
127	*Ochna obtusata*	Ochnaceae	1	1.341
128	*Alstonia venenata*	Apocynaceae	1	1.338
129	*Aglaia elegnoidea*	Meliaceae	1	1.268
Total			2227	1200

S. no. = species number.

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