Article

A contemporary assessment of tree species in Sathyamangalam Tiger Reserve, Southern India

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Abstract
Tree species inventory was carried out in five forest types of Sathyamangalam Tiger Reserve (STR). The forest type was divided into homogenous vegetation strata (HVS) based on the altitude, temperature, precipitation and forest types. A total of 8 ha area was sampled using 0.1 ha (20m × 50m) plot and all tree species ≥ 1cm girth at breast height (gbh) within the plot were enumerated. In all, 4614 individuals were recorded that belonged to 122 species representing 90 genera and 39 families. Fabaceae, Euphorbiaceae, Rubiaceae, and Combretaceae were the species-rich families. The mean stand density of STR was 577 ha^{-1}, but it varied from 180 ha^{-1} to 779 ha^{-1}. Similarly, the mean basal area of the STR was 14.51 m^2ha^{-1} which ranged between 8.41 m^2 ha^{-1} and 26.96 m^2 ha^{-1}. The stem count was low at the lowest girth class (1-10 cm gbh) and high at 20-30 cm gbh in all the forest types. *Anogeissus latifolia* was the dominant species in the semi-evergreen and deciduous forest types while *Chloroxylon swietenia* was dominant in the thorn forest. The Shannon-Weiner and Simpson's indices ranged from 2.13 to 3.61 and from 0.75 to 0.96 respectively. The Sorenson's similarity index ranged from 0.12 to 0.85. As this study is a pioneer study that provides a baseline information about the tree species present in the STR.

Keywords dry deciduous forest; forest type map; remote sensing data; Sathyamangalam Tiger Reserve; species richness; tree diversity.

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1 Introduction

Tropical forests represent the biologically richest ecosystems on earth (Podong and Poolsiri, 2013), covering less than 10% of the land area but harbor the largest reservoir of terrestrial biodiversity. They spread over about 47% of total forest area around the world, of which ca. 18% are distributed in Asia (FAO, 2001). More than 50% of known plant species growing in tropical forests and they provide ecologically and economically valued products (Mayaux et al., 2005). About 86% of the forests in India are tropical, of which 53% are dry deciduous, 37% moist deciduous and rest is wet evergreen and semi-evergreen (Sagar et al., 2007). Globally, tropical forest inventories were started with the assessment of trees (Slik et al., 2015) not only due to its dominant life form, provisioning of resources and habitats for all other species, indicator of ecological process and changes but also useful for effective conservation and management (Koushik and Datta, 2015; Koellner et al.,2004).

In the Eastern Ghats, Gandhi and Sundarapandian (2014), Reddy et al. (2011), and Sahu et al. (2012) carried out tree diversity. In the Western Ghats, Dharmatma et al. (2016), Anitha et al. (2009), and Sukumar et al. (1992) studied the tree diversity. The Sathyamangalam Tiger Reserve (STR) was devoid of such tree inventory and diversity studies. Remote sensing data have been used in forest inventories for a long time (Jensen, 1986; Schneider, 2001). In fact, forestry was the first after military sector to use this data to a large extent in order to support the inventory tasks (Dees and Koch, 1997; Koch et al., 2008). It can generate information about tropical forest ecology that is not practically possible from ground-based studies like the area of forest cover and its relationship between climate, temperature, phenology and large tree mortality (Clark et al., 2003; Jeffrey et al., 2007; Lillesand et al., 2013). Understanding the distribution of different forest types and its aerial extent is necessary for an effective floristic inventory and diversity study in a region (Jayakumar et al., 2009; Jayakumar et al., 2011). Balaguru et al. (2006), Jayakumar et al. (2000), Nagendra and Gadgil (1999), and Padalia et al. (2004) successfully carried out the floristic diversity studies after mapping the vegetation types using remote sensing data. For conducting an efficient inventory study, the use of satellite data is imperative.

The method of sampling decides the success and failure of floristic inventory and diversity studies. For a proper tree inventory and diversity assessment in a forest region, it is important to consider all the forest types occurring in that region, their areal extent, distribution of each forest type in different elevations, and the trend in precipitation (Jayakumar et al., 2009). Because, occurrence of a tree species or forest type in a region is not merely by chance, but it is based on a specific predilection in the altitudinal range that corresponds to a specific temperature and rainfall pattern (Grytnes and McCain, 2007; Kluge et al., 2006; Pokhriyal et al., 2012; Stage and Salas, 2007). Thus, for an accurate inventory, the study area needs to be divided into homogenous vegetation strata (HVS), which is nothing but forest areas having a unique combination of altitude, temperature, and rainfall.

2 Study Area and Methodology

2.1 Study site

Sathyamangalam Tiger Reserve (STR), the largest Tiger reserve of Tamil Nadu, located between 10°29'15" to 11°43'11" N latitude and 76°50'46" to 77°27'22" E longitude covers 1400 km^2 (Fig. 1). This reserve was established in 2013. The soil types include red soil, black cotton soil, and alluvial soil. The rock types of STR mainly belong to the great gneissic series of pre-Cambrian age. The common metamorphic derivatives found in the reserve are metamorphosed sedimentary rocks such as quartzite, hornblende, amphibolites, pyroxenites, pyroxene and minerals found in the reserve are feldspar, quartzite, magnetite, garnet and kyanite (Anuradha et al., 2012; FMP, 2010). The topography of the reserve is highly variable with plains, slopes, hills, streams and rivers. The elevation ranges between 250m and 1450m above sea level (asl). It receives a mean annual rainfall of 850 mm, and the mean minimum and mean maximum temperatures were 21°C and 28°C, respectively (Nishanth et al., 2012). Bhavani and Moyar are the two perennial rivers that run through the reserve area. The sanctuary is rich in flora and fauna, known for sandal wood (*Santalum album)* and Asian elephants (*Elephas maximus)*. It is predominantly a tropical dry forest, which includes dry thorn, dry deciduous, semi evergreen and savanna forest types. There are a number of tribal settlements inside the sanctuary that depend on forests and forest products for their livelihoods. They also practice agriculture alongside the streams, rivers and plains (Balasubramanian et al., 2011). The current study is limited within the core zone area (650 sq. km) of the Tiger reserve, which includes semi evergreen (SE), deciduous (D), thorn (T), savanna (S) and riparian (R) forest types (Fig. 1).

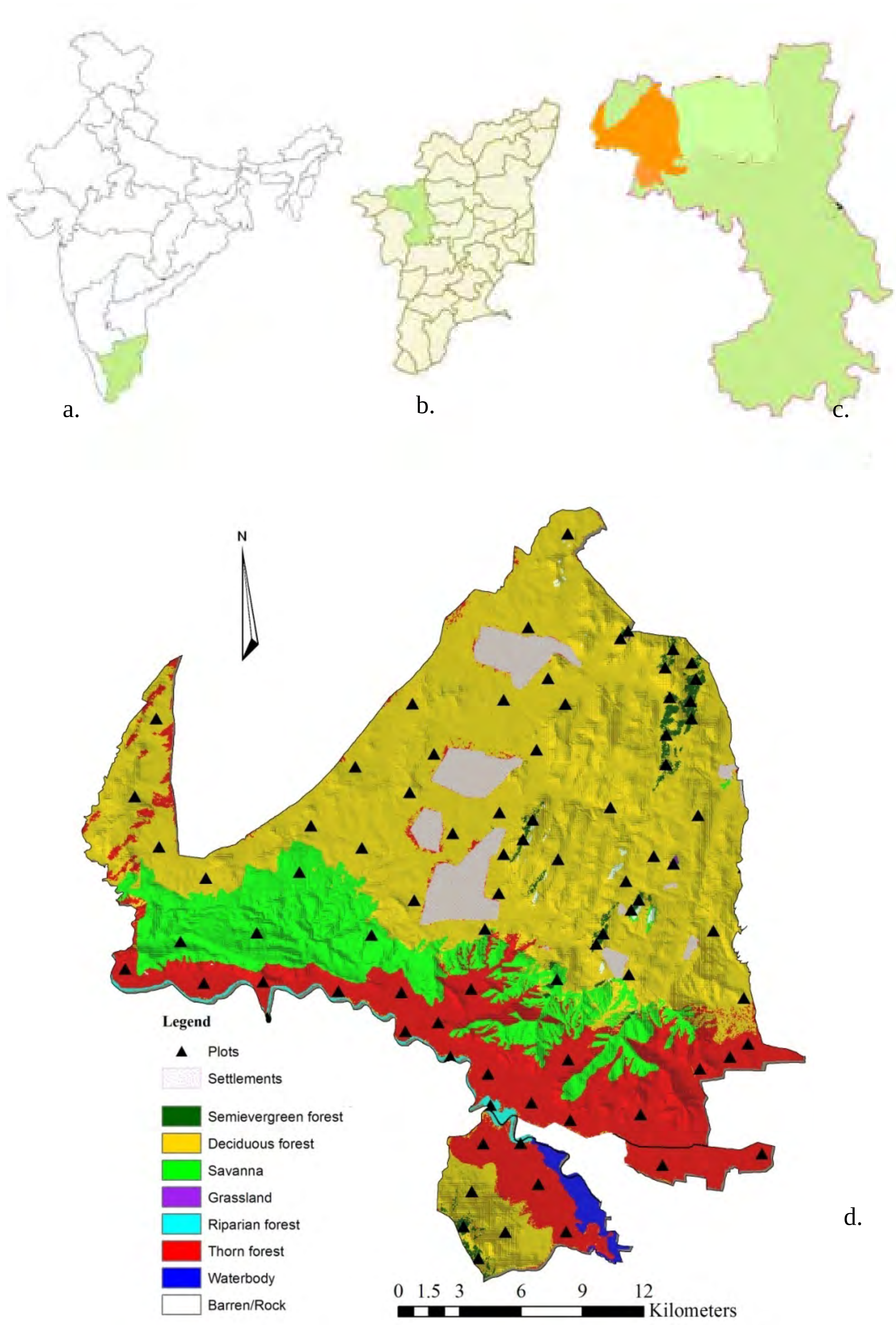


Fig. 1 a. India map b. Tamil Nadu map c. Erode district map showing study area d. Core zone area of Sathyamangalam Tiger Reserve showing forest types and distributed plots.

2.2 Materials used

Survey of India toposheets No. 58A/14 and A/15, 58E/1-3 on 1:50000 scale were procured from the Survey of India, Chennai. Indian Remote Sensing Satellite (IRS) P6 Linear Imaging and Self-Scanning (LISS) III data of 26thFebruary 2012 was also procured from the National Remote Sensing Centre, Hyderabad. ASTER Global Digital Elevation Model (GDEM) data was downloaded from the United States Geological Survey (USGS) (www.usgs.gov) website. We also downloaded the temperature and precipitation data from the global climate database (www.worldclim.org.). A Trimble JUNO 3B global positioning system (GPS) and ERDAS Imagine Version 11 software were also used.

2.3 Data processing

2.3.1 Forest type map preparation

Detailed reconnaissance field visit was carried out in March 2012. Locations of various forest types were collected using GPS. In the lab, spectral signatures were collected from the IRS P6 LISS III satellite data for each forest typebased on the field knowledge. Preliminary forest type map of STR (Fig. 1) was prepared following supervised classification technique using the maximum likelihood algorithm in the ERDAS Imagine software. Corrections were made on the preliminary forest type map after thorough field verification, and final forest type map was prepared. Accuracy assessment was carried out in 250 locations to verify the overall and individual class accuracies.

2.3.2 Preparation of homogenous vegetation stratum (HVS)

To accomplish the HVS, spatial data such as forest types, elevation, temperature, and rainfall are required.

The ASTER Global Digital Elevation Model (GDEM) spatial data downloaded from (www.usgs.gov), provides the global elevation data in 30m x 30m pixel resolution. The temperature and precipitation data downloaded from the global climate database (www.worldclim.org) provide the trend of temperature in Celsius and precipitation in millimeter in 1km pixel size. The pixels correspond to the study area were extracted from the global elevation, temperature and precipitation data using the reserve boundary.

Based on the ASTER data, the elevation of the study area ranged from 234 to 1450. It was reclassified into four classes with 200 m interval. Based on the global climate data, the minimum and maximum temperature and rainfall ranged from 20.3ºC to 27º.5C and 737mm to 1027mm respectively. We reclassified the temperature and precipitation data into four classes with 2^0C and 100mm intervals respectively.

The forest type map and the reclassified elevation, temperature, and rainfall data were re-sampled to 30m cell size. The four data layers were subjected to matrix analysis to prepare the homogenous vegetation strata (HVS) having polygons with a unique combination of values from all four layers. All the above processes were done using ERDAS imagine 11 software.

2.4 Sample distribution

Tree inventory sample locations were plotted on the HVS map using stratified random sampling technique with the help of ERDAS imagine software. The geographical co-ordinates of each sample location were noted.

The vegetation sampling was conducted during 2013 to 2014. Each inventory plot was located on the field with the help of Trimble Juno 3B series GPS and a 0.1 ha plot (50 × 20m) was established at 80 sites (8 ha). The size of the plot was determined based on Phillips et al. (2003). Inside the plot, all the living tree species of ≥ 1 cm gbh were measured at 1.3m from the ground level. Voucher specimens were collected for all species recorded and identified using the Flora of Nilgiri and Pulney Hill-tops (Fyson, 1915), Flora of Tamil Nadu, India (Nair and Henry, 1983), the Flora of the Tamil Nadu Carnatic (Matthew, 1983), and The Flora of the Palni hills (Matthew, 1999). Finally, the taxonomic names of each species were verified using Angiosperm Phylogeny Group (APG) III Classification (Bremer et al., 2009).

2.5 Data analysis

Frequency, density, basal area, important value index (IVI), Shannon-Wiener index and Simpson dominant indices were calculated based on Magurran (2004). Similarity index of different forest types was calculated by taking the number of species presents (Janson and Vegelius, 1981). Population structure of trees wasanalysed after converting the values to per hectare by grouping the tree individuals into 10 girth classes with a 10 cm interval. Species dominance and rank abundance curves were also prepared after normalization of data to per hectare.

3 Results and Discussion

3.1 Forest type mapping

There were five forest types recorded in the reserve namely semi evergreen, deciduous, thorn, savanna and riparian. The deciduous forest type, which predominately covered a major area in the reserve, occupied a maximum area of 296.5 sq. km (48.56%) (Table 1) followed by thorn forest 160.7 sq. km (26.31%) and the minimum area by savanna 24.3 sq. km (3.98%).

3.1.1 Homogenous Vegetation Strata (HVS)

There were eleven HVS classes recorded in the semi evergreen type, which spreads between 800 and 1451 m elevations, 700-1027 mm rainfall and 20-23 ^{0}C temperature (Table 1). Maximum areas were confined to 1000-1200 m elevation with 800-1000 mm rainfall and 20-23^{0}C. The deciduous type also comprised of 11 HVS between 800 and 1200 m elevations, 700-1000 mm rainfall and 20-25 ^{0}C with the maximum area at 800-1000 m elevation. The thorn forest type had eight HVS, distributed between 400 and 1000 m elevation, 700-800 mm rainfall and 22-27 ^{0}C. The savanna and riparian forests fell in single elevation class each respectively above 1200 m and below 400 m (Table 1).

Table 1 Detailed list of Homogenous vegetation strata (HVS) showing forest types with distributed plots in various altitude, rainfall and temperature.

Forest Type	Altitude in meter	Rainfall in mm	Temperature in ^{0}C	Area in hectares	Plots distributed
Semi evergreen	800-1000	900-1000	20-21	160.01	1
			22-23	98.43	1
	1000-1200	700-800	20-21	825.89	2
			22-23	961.93	2
		800-900	20-21	2398.14	5
			22-23	392.5	1
		900-1000	20-21	1320.06	2
	1200-1451	700-800	20-21	179.78	1
		800-900	20-21	1809.07	3
		900-1000	20-21	993.4	1
		1000-1027	20-21	40.79	1
			Total	**9780**	**20**

Deciduous	400-800	800-900	22-23		1281.01	2
			24-25		4650.45	4
	800-1000	700-800	20-21		3431.05	3
			22-23		2064.96	2
			24-25		2113.1	2
		800-900	20-21		3157.37	3
			22-23		5024.15	5
		900-1000	20-21		2551.83	2
	1000-1200	700-800	20-21		1028.85	2
			22-23		2022.37	2
		800-900	20-21		2325.86	3
				Total	**29651**	**30**
Thorn	200-400	700-800	24-25		2859.26	3
			26-27		3101.01	4
	400-800	700-800	22-23		513.8	1
			24-25		2704.84	3
			26-27		1632.68	2
		800-900	24-25		155.56	1
	800-1000	700-800	22-23		1734.39	3
			24-25		1368.46	3
				Total	**16070**	**20**
Savanna	1200-1451	800-900	20-21		2902.14	2
			22-23		4528.86	3
				Total	**7431**	**5**
Riparian	200-400	700-800	24-25		116.18	1
			26-27		456.22	3
		800-900	26-27		168.6	1
				Total	**741**	**5**

3.2 Richness

In the STR, a total of 4614 individuals were recorded, which belonged to 122 tree species of 90 genera and 39 families (Table 2). The tree species richness of STR (122) is higher compared with other tropical dry forests in Puerto Rico (50) (Murphy and Lugo, 1986), Mudumalai Wildlife Sanctuary (71) (Sukumar et al., 1992), Savanadurga state forest (53) (Murali et al., 2003), Bhadra wildlife sanctuary (46) (Krishnamurthy et al., 2010) and Rajasthan tropical dry forest (14-36) (Sultana et al., 2014).

Of all the families, Fabaceae was the species-rich family with 24 species similar to Mudumalai wildlife sanctuary (Sukumar et al., 1992) but different from the other tropical forests of India where Combretaceae and Mimosaceae are the species-rich families reported by Sultana et al. (2014) in the Rajasthan, Kumar et al., (2010) in the Western Ghats and Krishnamurthy et al. (2010) in the Bhadra wildlife sanctuary followed by Euphorbiaceae and Rubiaceae with 10 species each. While the Combretaceae was a dominant family in terms of abundance (1015) followed by Rubiaceae (650) and Fabaceae (612).

Table 2 Consolidated details of richness and diversity status of tree species in different forest types of STR.

Variables	**Semi evergreen**	**Deciduous**	**Thorn**	**Savanna**	**Riparian**	**STR**
Number of Plots Surveyed	20	30	20	5	5	80
Area Surveyed (ha)	2	3	2	0.5	0.5	8
Number of Species	90	90	66	22	28	122
Number of Genus	74	72	54	20	25	90
Number of Family	37	33	29	15	18	39
Number of Individuals	1558	1704	723	359	270	4614
Density (No. ha^{-1})	779	568	361.5	179.5	540	576.75
Basal Area (m^2)	43.2	36.96	16.82	5.64	13.48	116.1
Basal Area(m^2 ha^{-1})	21.6	12.32	8.41	11.28	26.96	14.51
Simpson_1-D	0.94	0.9	0.96	0.85	0.75	0.95
Shannon_H	3.48	3.26	3.61	2.28	2.13	3.71

Anogeissus latifolia dominated in STR with 866 individuals (18.76%) and 39.8 as IVI value (Table 3), followed by *Catunaregam spinosa* with 241 individuals (5.22%) and 9.7 as IVI and *Prosopis juliflora,* an exotic species, with 207 individuals (4.48%) and 8.7 as IVI. *A. latifolia* is found to be the dominant species not only in the STR but also in the dry forest of Western Ghats (Joseph et al., 2008; Reddy and Ugle, 2008; Reddy et al., 2008). Orwa et al. (2009) substantiated that the *A. latifolia* is able to survive in a harsh climate.

In the semi evergreen and deciduous forest types, *A. latifolia*was the dominant species with 147 individuals and 166 individuals per hectare respectively. In the case of thorn forest, *Chloroxylon swietenia* was the dominant tree species with 40 individuals per hectare. *Viburnum punctatum* and *P. juliflora* dominated the savanna and riparian forest types respectively with 188 individuals and 296 individuals per hectare. In the STR, except *A. latifolia,* all other tree species have IVI less than 15. Although *Canthium dicoccum* was the fourth dominant species in the STR, it stood second in the IVI value (11.4). The IVI contributions of top ten species among five forest types of the reserve were given in fig 2. It is also important to note that the exotic species, *P. juliflora,* is dominant in riparian forest. This may be due to the spread of its seeds across this forest type by different animals (Kumar and Mathur, 2014; Orr et al., 2005).

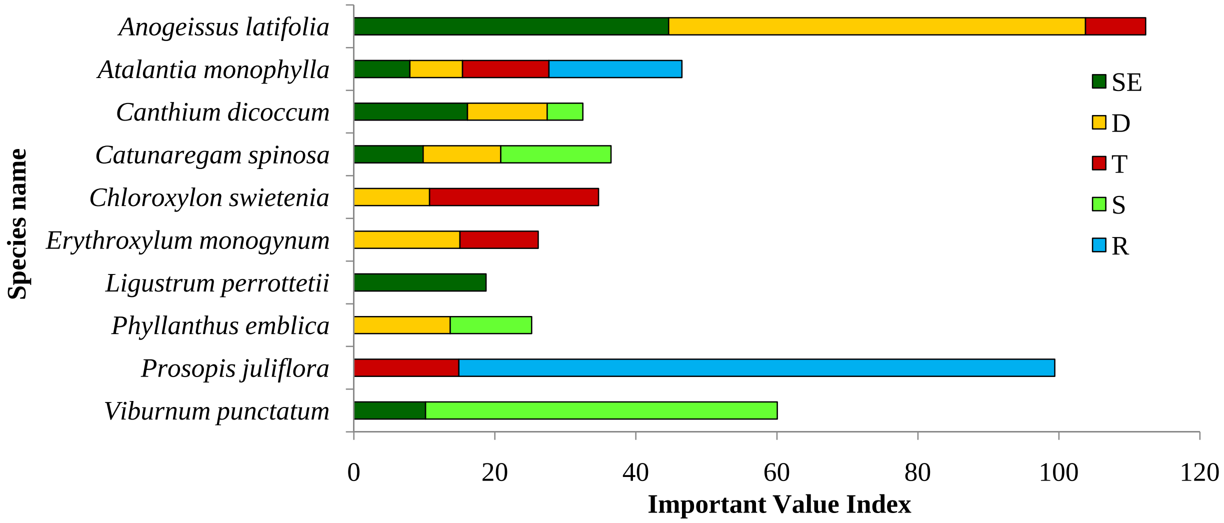


Fig. 2 Important Value Index (IVI) of the top ten species of STR distributed in five forest types.

3.3 Stand density and basal area

The mean stand density of trees per hectare was 577. The maximum density of trees was recorded in the semi evergreen type (779 ha^{-1}) and the minimum of 180 ha^{-1} was recorded in the Savanna (Table 2). The total basal area was 116.1 m^2/8 ha. Among the five forest types, riparian contributed the highest basal area of 26.96 m^2ha^{-1}, while thorn forest had the lowest basal area (8.41 m^2ha^{-1}) (Table 2). The forest stand of STR (577 ha^{-1}) is lesser than Rajasthan dry forest (917-1716 ha^{-1}) (Sultana et al., 2014), Bhadra wildlife sanctuary (980 ha^{-1}) (Krishnamurthy et al., 2010), Tropical dry forest of Odisha (591 ha^{-1}) (Sahu et al., 2007) and Garo hills forest (570-846 ha^{-1}) (Upadhaya et al., 2015) but higher than Mudumalai Tiger reserve (540 ha^{-1}) (Sukumar et al., 1992). The lower stand density of STR results in the lower basal area (14.51m^2 ha^{-1}), which is lower compared with the above mentioned tropical dry forests. The contribution of the stand from five forest types to STR varies noticeably from 5.85% to 36.94%.

3.4 Diversity indices

The overall Shannon diversity and Simpson dominance indices were 3.71 and 0.95 respectively. With regard to various forest types, these diversity indices varied between 2.13 to 3.61 and 0.75 to 0.96 respectively. Sorensen's similarity coefficient values revealed a marked difference in the distribution of plant species among all the forest types. The similarity values varied between 0.12 and 0.85 (Table 3).

Table 3 Similarity (Sorensen's coefficient) in species composition SI/density (Ss) in different vegetation types of STR.

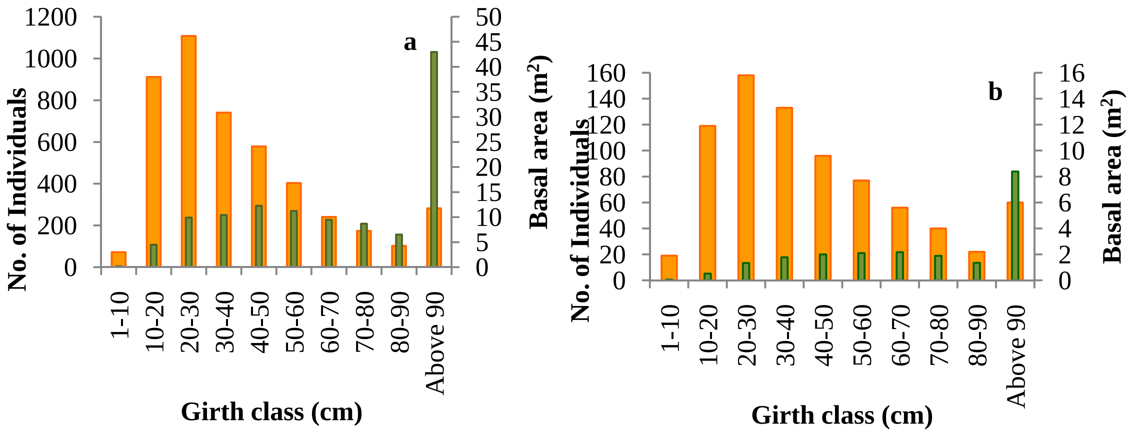
Type	STR	Semi evergreen	Deciduous	Thorn	Savanna	Riparian
STR	1	0.85	0.85	0.7	0.3	0.37
Semi evergreen		1	0.77	0.61	0.35	0.35
Deciduous			1	0.66	0.37	0.33
Thorn				1	0.27	0.44
Savanna					1	0.12
Riparian						1

Sorensen's similarity index reveals that the tree species common to the semi evergreen and deciduous forest types is 77%, and between semi evergreen and the thorn is 66%. This similarity may be attributed to the location of these forests in similar altitudinal ranges; for example, the thorn forest is present in the STR from the foothill to 800m asl. The deciduous forest occupies 400m to 1000m asl. The semi evergreen forest type is located between 800 and 1200 asl. These three forest types share common altitudinal ranges between 30 to 60%.

Fire is one of the prevalent factors governing the savanna forest types (Andersen et al., 2005; Gashaw et al., 2002; Hoffmann et al., 2012; Werf et al., 2010). The species such as *Pterocarpus marsupium*, *Phyllanthus emblica*, *Buchananialatifolia* are able to survive in this region, which is also present in the thorn, deciduous and semi evergreen forest types with few fire incidences. Savanna shares less than 40% of tree species with other forest types. The riparian forest type also shares 40% of tree species with other forest types.

3.5 Girth class

The interesting feature observed in the STR is the total number of tree individuals recorded in different girth classes. The stand density of STR was maximum at 20-30 cm gbh and minimum at 1-10 cm gbh class and basal area was highest at above 90cm class and lowest at 1-10cm class (Fig. 3a). The size class above 90cm has 42.97m^2 basal area in the STR and in the individual forest type; it varies from 8.39 m^2 to 14.98m^2 (Fig.3b-f). In general, the lowest girth class (1-20cm) has recorded with more individuals (Krishnamurthy et al., 2010; Singh and Singh, 1991) but in the STR, it has lesser individuals. This may be due to the occurrence of more fire incidences (The mean area burnt per annum from 1997 to 2012 was 18km^2 with a minimum of 1km^2 and maximum 74km^2 per annum throughout STR (Kodandapani, 2013). STR has the highest stem density in 20-30 cm gbh class, and it gradually decreases with the increase in size classes until 80-90cm gbh. This pattern is also seen in Odisha forest (Sahu et al., 2007).



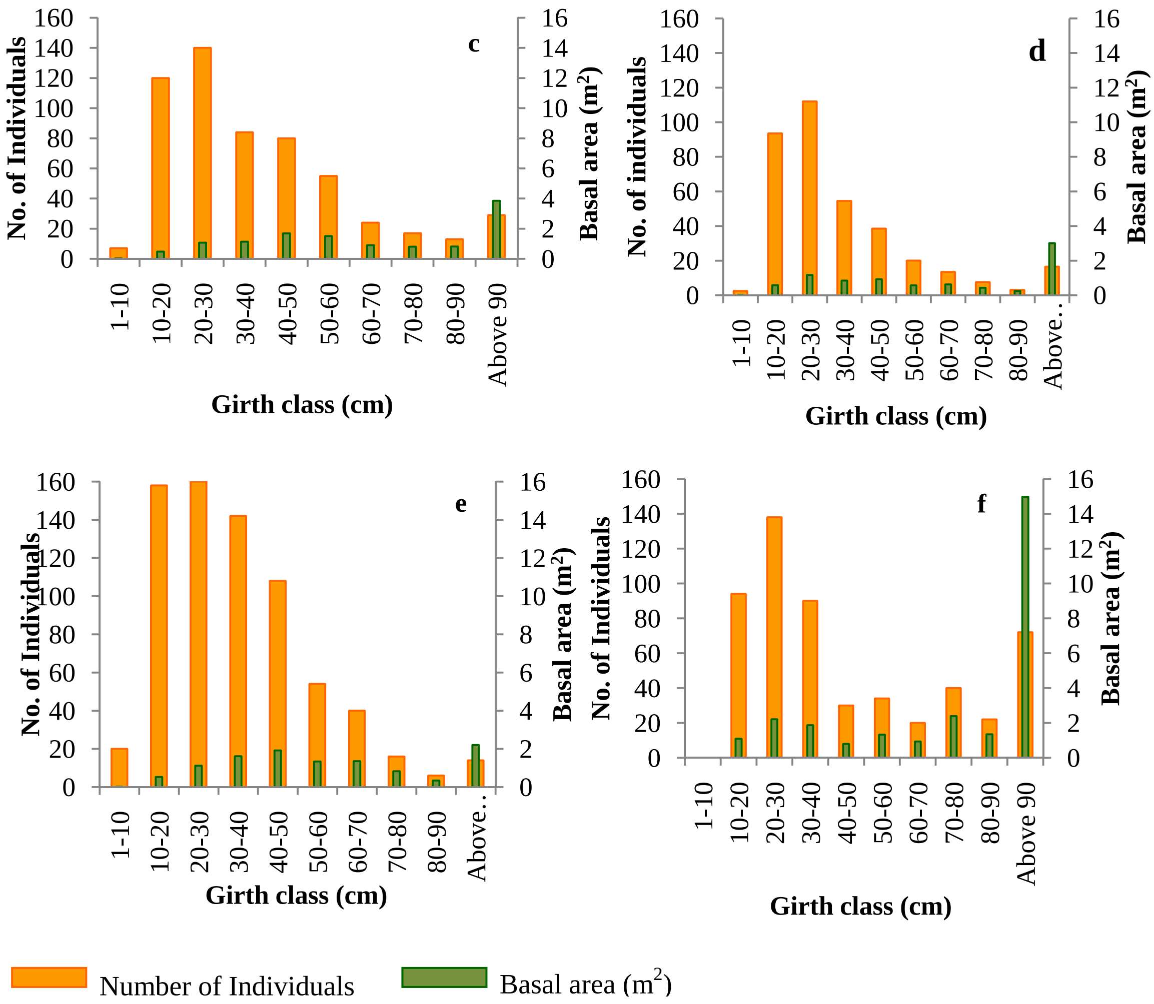


Fig. 3 Girth class wise stem density and basal area distribution patterns of five forest types in STR. the x-axis represents Girth class, they-axisrepresents a number of individuals, z-axisrepresents thebasal area in m^2. a. STR, b. Semi evergreen, c. Deciduous, d. Thorn, e. Savanna and f. Riparian.

3.6 Rank abundance

Rank abundance curve for all forest types (Fig. 4) depicts the species ranking based on relative abundance, ranked from the most to the least abundant (x-axis), relative abundance (y-axis) is expressed on a logarithmic scale. The semi evergreen and deciduous forest types were species-rich when compared to other forest types. Savanna has fewer numbers of species (Table 2). The even slope line of deciduous forest type shows that it has more evenly distributed species when compared to semi evergreen. The rank abundance curves of different forest types reveal that the distribution of species is more or less even in deciduous compared to semi evergreen although having similar species richness.

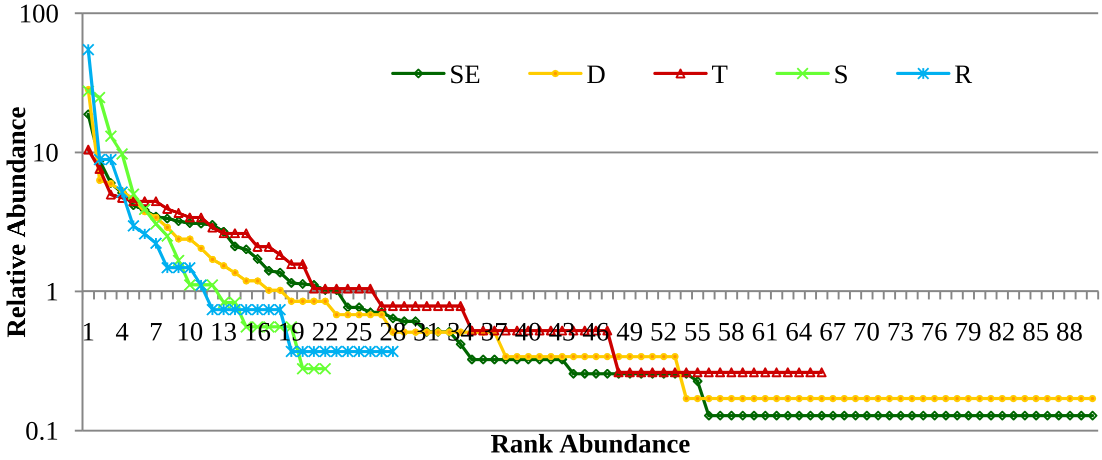


Fig. 4 Rank abundance curves for the five forest types. SE-Semi evergreen, D-Deciduous, T-Thorn, S-Savanna, R-Riparian.

4 Conclusion

The preparation of HVS helped us to cover 650 sq. km forest areas within 80 plots and to proportionately distribute the plots in each forest type according to its areal extent. The results show that STR is a species rich than other dry deciduous forests of India, which calls for improved conservation and management efforts and also intense biodiversity research. The lesser number of individuals recorded in the lowergirth classes of different forest types may be attributed to the occurrence of fire in this reserve. However, further study is required to ascertain the impact of fire on seedlings and saplings. Conservation efforts should step up to increase the regeneration ratio. Species with fewer occurrences should be considered rare and prevent them from extinction. The occurrence of more individuals of *P. juliflora*, an invasive weed, in the riparian forest requires immediate removal with the help of forest department to safeguard the flora and fauna of this region. This pioneer inventory study provides a baseline data on tree species richness and diversity of different forest types in the STR.

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Appendix Table Species abundance in each forest types of STR and total abundance with basal area (BA) and important value index (IVI).

Species Name	SE	D	T	S	R	STR	BA	IVI
Acacia nilotica (L.) P.J.H.Hurter & Mabb.	-	1	-	-	-	1	0.01	0.14
Acacia planifrons Wight & Arn.	-	10	34	-	-	44	1.07	2.53
Aegle marmelos (L.) Correa	-	7	-	-	-	7	0.27	0.60
Aglaia elaeagnoidea (A. Juss.) Benth.	1	-	-	-	-	1	0.02	0.15
Albizia amara (Roxb.) B.Boivin	3	1	36	-	-	40	1.18	2.87
Albizia lebbeck (L.) Benth.	1	2	-	-	-	3	0.73	1.02
Albizia odoratissima (L.f.) Benth.	4	1	-	-	-	5	0.40	0.89
Anogeissus latifolia (Roxb. ex DC.) Wall. ex Guill. & Perr.	293	499	27	47	-	866	19.08	39.79
Atalantia monophylla (Roxb.) DC.	53	50	44	-	24	171	3.58	8.98
Azadirachta indica A.Juss.	9	9	6	-	1	25	2.28	3.38
Bauhinia racemosa Lam	16	12	9	-	-	37	0.99	3.14
Bridelia ferruginea Benth	5	20	-	2	-	27	0.61	1.98
Buchanania axillaris (Desr.) Ramam.	1	4	-	-	-	5	0.13	0.66
Buchanania latifolia Roxb.	5	12	2	2	-	21	0.72	2.39
Butea monosperma (Lam.) Taub.	-	-	4	-	-	4	0.12	2.00
Callicarpa tomentosa (L.) Murr.	5	-	-	-	-	5	0.18	0.49
Canthium dicoccum (Gaertn.) Teys. & Binn.	93	67	25	4	-	189	4.20	11.43
Canthium parviflorum Lam.	-	-	3	-	-	3	0.03	0.42
Capparis divaricata Lam.	2	4	1	-	-	7	0.28	0.83
Carissa carandas L.	9	1	19	-	-	29	0.46	2.01
Carissa spinarum L.	-	-	4	-	-	4	0.07	0.58
Cassia fistula L.	34	14	5	4	-	57	1.03	4.53
Cassine glauca (Rottb.) O. Kuntze	1	19	6	-	1	27	0.88	2.55
Cassine paniculata (Wight & Arn.) Lobr.-Callen	3	9	-	1	-	13	0.26	1.49
Catunaregam spinosa (Thunb.) Tirveng.	80	105	31	35	-	251	2.56	9.72
Celtis philippensis Bl. Var. *wightii* (Planch.) Soep.	50	3	1	89	1	144	3.10	7.32
Chionanthus mala-elengi (Dennst.) P.S. Green	4	10	6	-	-	20	0.37	1.84
Chionanthus ramiflorus Roxb.	10	-	-	-	-	10	0.52	0.99
Chionanthus zeylanica L.	4	21	8	-	-	33	0.47	2.10
Chloroxylon swietenia DC.	13	80	79	-	1	173	3.10	9.81
Clausena anisata (Willd.) J.Hk. ex Benth.	-	4	-	3	-	7	0.09	0.56
Commiphora berryi (Arn.) Engl.	-	-	6	-	-	6	0.68	0.93
Commiphora caudata Engl.	4	1	3	-	-	8	0.36	1.25
Cordia monoica Roxb.	17	3	37	-	7	64	1.68	4.15
Crateva adansonii DC.	-	-	-	-	4	4	0.31	0.57
Dalbergia lanceolaria L.f.	-	4	-	-	-	4	0.29	0.56
Dalbergia sissoo Roxb. Ex DC.	5	5	-	-	-	10	0.69	1.25
Deccania pubescens Var. *candolleana* (Wight & Arn.) Tirveng.	5	1	-	-	-	6	0.12	0.45
Dichrostachys cinerea Wight et Arn.	1	1	3	-	-	5	0.05	0.59
Diospyros ebenum J.Koenig	22	-	2	-	8	32	1.90	2.88
Diospyros ferrea (Willd.) Bakh.	11	11	2	-	2	26	0.43	2.14
Diospyrous montana Roxb.	7	7	8	-	2	24	0.67	2.74

Drypetes roxburghii (Wall.) Hurusawa	3	-	-	-	-	3	0.14	0.30
Drypetes sepiaria (Wight & Arn.) Pax & K.Hoffm.	1	2	3	-	-	6	0.04	0.49
Erythrina indica L.	2	-	-	-	-	2	0.02	0.17
Erythroxylum monogynum Roxb.	18	112	34	-	-	164	2.35	8.97
Euphorbia antiquorum L.	3	5	15	-	-	23	0.53	1.72
Ficus bengalensis L.	2	1	3	-	-	6	1.68	2.02
Ficus microcarpa L.f.	-	6	-	-	-	6	0.03	0.48
Ficus religiosa L.	1	-	-	-	-	1	0.66	0.70
Ficus virens L.	1	2	-	-	-	3	0.91	1.17
Filicium decipiens (Wt. & Arn.) Thw.	5	-	-	-	-	5	0.34	0.62
Flacourtia indica (Burm.f.) Merr.	3	-	-	-	-	3	0.01	0.18
Flueggea leucopyrus Willd.	2	1	13	-	-	16	0.13	1.33
Gardenia latifolia Ait.	1	1	1	-	-	3	0.02	0.41
Gardenia resinifera Roxb	1	18	2	-	-	21	0.11	1.54
Givotia rottleriformis Griffith	1	2	-	-	-	3	0.10	0.48
Gmelina arborea Roxb.	2	3	1	-	-	6	0.27	1.02
Gmelina asiatica L.	-	-	26	-	2	28	0.40	1.94
Grewia orbiculata Rottl.	-	5	7	-	-	12	0.08	0.76
Grewia tilifilia Vahl	2	4	-	2	-	8	0.36	1.14
Gyrocarpus americanus Jacq.	4	1	1	-	1	7	0.58	1.20
Haldina cordifolia (Roxb.) Risd.	1	1	1	-	-	3	0.16	0.53
Hardwickia binata Roxb.	1	8	6	-	1	16	0.77	1.88
Ixora pavetta Andrews	28	37	20	-	1	86	1.20	5.08
Ligustrum perrottetii A. DC.	135	10	1	2	-	148	2.83	7.29
Limonia acidissima L.	-	2	-	-	-	2	0.01	0.27
Macaranga peltata (Roxb.) Muell. Arg.	2	-	-	-	-	2	0.20	0.33
Madhuca longifolia L.	-	1	-	-	-	1	0.11	0.23
Mallotus philippensis (Lam.) Muell.Arg.	16	-	-	-	-	16	0.77	1.23
Mallotus tetracoccus (Roxb.) Kurz	-	2	-	-	-	2	0.24	0.47
Manilkara hexandra (Roxb.) Dubard	4	13	-	-	-	17	0.35	1.21
Maytenus emarginata (Willd.) Ding Hou	5	12	5	-	1	23	0.37	1.91
Memycylon edule Roxb.	5	-	4	1	-	10	0.11	0.75
Memycylon umbellatum Burm.f.	41	27	2	1	-	71	0.71	3.03
Miliusa eriocarpa Dunn	60	-	-	-	2	62	0.97	2.40
Millettia pinnata (L.) Panigrahi	-	-	-	-	6	6	0.64	0.79
Moringa concanensis Nimmo ex Dalz. & Gibson	2	9	3	-	4	18	2.14	3.00
Mundulea sericea (Willd.) A. Chev.	-	-	19	-	1	20	0.12	1.08
Naringi crenulata (Roxb.) Nicols.	1	2	-	-	-	3	0.04	0.43
Neolitsea scrobiculata (Meisner) Gamble	1	-	-	-	-	1	0.01	0.14
Ochna obtusa DC.	1	1	-	-	-	2	0.04	0.29
Olea dioica Roxb.	48	2	-	14	-	64	1.16	3.15
Persea macrantha (Nees) Kosterm.	1	-	-	-	-	1	0.00	0.13
Phoeba lanceolata (Nees) Nees	25	-	-	-	-	25	1.18	2.10
Phyllanthus emblica L.	48	94	1	18	-	161	2.63	8.93
Premna latifolia Roxb.	1	-	16	-	-	17	0.25	1.24
Premna tomentosa Willd.	1	1	-	-	-	2	0.06	0.32
Prosopis juliflora (Sw.) DC.	-	1	58	-	148	207	3.35	8.68
Prosopis spicigera L.	-	-	1	-	-	1	0.02	0.15
Pterocarpus marsupium Roxb.	11	42	7	3	-	63	4.04	7.80
Radermachera xylocarpus (Roxb.) Schumann	2	-	7	-	-	9	0.08	1.03
Salvadora persica L.	-	-	2	-	-	2	0.03	0.18
Santalum album L.	-	1	1	-	-	2	0.00	0.26
Sapindus emarginatus Vahl	13	15	12	-	3	43	1.45	4.37
Schleichera oleosa (Lour.) Oken	1	-	1	-	24	26	1.18	1.91
Semicarpus anacardium L. f.	1	5	-	-	-	6	0.13	0.68
Senegalia catechu (L.f.) P.J.H.Hurter & Mabb.	-	30	7	-	-	37	0.32	2.28
Senegalia polyacantha (Willd.) Seigler & Ebinger	-	5	3	-	-	8	0.22	0.80
Shorea roxburghii G. Don	8	23	-	-	-	31	3.24	3.90
Soymida febrifuga (Roxb.) Adr. Juss	-	6	6	-	-	12	0.34	1.10
Strychnos nux-vomica L.	-	8	3	-	-	11	0.42	0.93
Strychnos potatorum L.f.	1	3	-	-	-	4	0.21	0.59
Syzygium cumini (L.) Skeels.	30	8	-	11	4	53	3.18	5.31
Tamarindus indica L.	2	1	-	-	1	4	1.40	1.62
Tarenna asiatica (L.) Kuntze ex K. Schum.	51	5	-	-	-	56	0.19	2.69

Tectona grandis L.f.	3	16	-	-	-	19	1.66	2.61
Terminalia arjuna (DC.) Wight & Arn.	-	16	-	4	-	20	0.69	1.35
Terminalia bellirica (Gaertn.) Roxb.	-	2	3	-	2	7	0.68	1.07
Terminalia chebula Retz.	-	1	-	-	-	1	0.03	0.15
Terminalia crenulata Roth.	50	61	1	9	-	121	4.00	9.13
Toona ciliata M. Roem.	-	3	-	-	-	3	0.05	0.21
Trewia polycarpa Benth.	-	-	-	-	14	14	2.53	2.59
Vachellia horrida (L.) Kyal. & Boatwr.	-	-	11	-	-	11	0.05	0.39
Vachellia leucpohloea (Roxb.) Maslin, Seigler & Ebinger	1	5	-	-	-	6	0.39	1.02
Vachellia nilotica (L.) P.J.H.Hurter & Mabb.	1	-	-	-	-	1	0.02	0.15
Viburnum punctatum Ham. Ex G.Don	76	3	-	99	-	178	1.69	6.74
Vitex altissima L.f.	5	9	1	-	-	15	0.29	1.67
Wendlandia thyrsoidea (Schult.) Steud.	31	5	-	6	-	42	0.40	1.91
Wrightia tinctoria (Roxb.) R.Br.	12	3	-	-	-	15	0.45	0.94
Ziziphus jujuba Mill.	1	3	4	-	2	10	0.32	1.26
Zizipus rugosa Lam.	8	41	-	2	2	53	1.25	4.41