Indian Forester, **149** (4) : 403-417, 2023
DOI: 10.36808/if/2023/v149i4/168130

ISSN: 0019-4816
eISSN: 2321-094X

Diversity and Distribution Pattern of Woody Species

in Bugarikallu Permanent Preservation Plot, Bannerghatta National Park, Bengaluru

A one-hectare permanent forest vegetation plot was established in Bannerghatta National Park (BNP) to understand the influence of climate variability on dry forests of peninsular India. All woody individuals >1 cm dbh (diameter at breast height) were enumerated for species, given unique number, measured for size, and mapped for spatial location. The plot had 2165 individuals >1 cm dbh belonging to 76 species. Most abundant species was Ixora arborea, a shrub (333 individuals, 15.38% of abundance) followed by Anogeissus latifolia, a tree species (249 individuals, 11.50% of abundance). The top ten species accounted for 75.69% of the total abundance, 69.4% of individuals occurs in the 1-5 cm size class while 3 individuals >30 cm dbh occupy 10% of the total basal area. Tree species Anogeissus latifolia had the highest basal area in the plot; Anogeissus latifolia, Ixora arborea and Acacia chundra contribute to 42.4% of the total basal area of the plot. There were 35 angiosperm families with Fabaceae being the most speciose. There were 18 families with one species each. Decalepis hamiltonii, an endangered species occurred in the plot.

Key words: Seasonally dry tropical forests, Diversity, Climate change, Peninsular India

Woody species are the most efficient carbon sinks of a dry forest ecosystem; higher the diversity, healthier is the forest and its surrounding environment.

BALASUBRAMANYA SHARMA, MANJUNATHA M., POORVASHREE P., BOYA SARITHA, KIRANRADDI MORAB, NAGESH C., O.K. REMADEVI, H.S. DATTARAJA[1], H.S. SURESH[1], K.H. VINAYA KUMAR AND RITU KAKKAR
Environmental Management and Policy Research Institute (EMPRI)
"Hasiru Bhavana", Doresanipalya Forest Campus, Vinayaka Nagara Circle, J.P Nagar 5th Phase, Bengaluru-560078, India
Email : sharmabalasubramanya@gmail.com

Received July, 2022
Accepted February, 2023

Introduction

The seasonally dry tropical forest (SDTF) is characterized by moisture stress and distinct seasonality of wet period and megafauna (Murphy and Lugo, 1986). SDTF is the most extensive and largest biome among the different forest types of the globe (Miles *et al*., 2006). In India SDTF or tropical dry forests accounts for more than 90% of the natural forests (Singh and Kushwaha, 2005). SDTF is an extensive biome, but our understanding of ecology and dynamics of the forests is rather poor (Miles *et al*., 2006; Murphy and Lugo, 1986). The primary focus in tropics is on the rain forests while SDTF which occupy more than half of global vegetation is largely neglected (Pennington *et al*., 2018). SDTF is an interesting biome as it supports plant species which bunch out traits that are required to adapt to dry and stressful environment. They are the ecosystems that are modified to a large extent for human necessities. There are several attempts to understand the diversity, structure and dynamics of SDTF both at international (Lott and Atkinson, 2006; Pennington *et al*., 2004) and national level (Dattaraja *et al*., 2018; Kakkar *et al*., 2018; Sukumar *et al*., 1992). Hoffmann (Hoffmann *et al*., 2012) attributes the existence and distribution of SDTF to fire, climate, soil and finally to people.

Tropical dry forests are the most threatened with a decline in diversity. Diversity estimates are necessary and an important component of forest conservation and management activities. The diversity assessments could be undertaken either via plot based methods, transects or random surveys (Tewari *et al*., 2014). Most of the plots are established to assess the plant diversity and measure tree girth over a longer period in order to understand the basal area and biomass

[1]Centre for Ecological Sciences and Divecha Centre for Climate Change, Indian Institute of Science, Bengaluru-560012, India

accumulation (Rai, 1996). Permanent Preservation Plots (PPPs) are established to not only estimate species richness and species succession (Bakker *et al*., 1996) but also to take up studies on the spatial distribution, understand the stand structure, soil nutrition, and carbon dynamics. The advantages in setting up a PPP is the reduction in imprecision of estimates of change and the possibility of breaking down the global estimates of change into their components (growth, mortality, recruitment) (Houllier *et al*., 1998).

Bannerghatta National Park (BNP) a dry tropical forest region in the vicinity of Bengaluru city is irregularly shaped with an area of 260.51 km^2. The vegetation of BNP can be broadly classified into scrub type (dry deciduous scrub), southern tropical dry deciduous and southern tropical moist mixed forests. The park is home to many nomadic elephants (Gopalakrishna *et al*., 2010), native tree species (Gopalakrishna *et al*., 2015), birds and mammals (Kumara *et al*., 2011) but it is also prone to habitat loss (Ramachandra *et al*., 2016). The protected area of BNP is under tremendous pressure from the burgeoning city of Bengaluru and is the only natural forest in the vicinity of the city that acts as an indispensable lung space to the urban concrete jungle. Ecologically sensitive zones are earmarked around BNP (Ramachandra *et al*., 2016) and these act as shock absorbers to the protected area. Illegal quarrying in eco-sensitive zones, urbanization, fragmentation, and habitat degradation are the major threats affecting BNP. Studies on floral diversity of BNP have been addressed in most of the studies but detailed accounts based on standard methodologies are lacking.

The present study is our effort to provide quantitative information on floristic diversity of one of the permanent plots in the core region of BNP. The project "Establishment of permanent preservation plots (PPPs) at Bannerghatta National Park (BNP) and Doresanipalya Reserve Forest (DRF) to assess the impact of climate change" undertaken by Environmental Management and Policy Research Institute (EMPRI) has established 3 PPPs, 2 in BNP (Thalewood House and Bugarikallu) and 1 in DRF (Doresanipalya) based on the type of vegetation and using standard methodology.

The objectives of the study are :

1) To establish a 1-hectare (100 m x 100 m) PPP in dry deciduous Bugarikallu forest of BNP.
2) To identify, tag, and measure the dbh of all woody species present in 1-hectare plot.
3) To map the spatial locations of all the tagged individuals and understand the aggregation patterns.
4) To monitor the long-term changes in the 1-hectare plot by periodic girth measurements of the tagged individuals and by undertaking mortality & recruitment studies.

The current paper describes the native plant diversity and spatial pattern based on the first census data obtained after the establishment of the 1-hectare PPP in the undisturbed area of BNP.

Material and Methods

Study area

Permanent Preservation Plot (PPP) of size 1-hectare (100 m x 100 m) was established in Bugarikallu locality ($12^0$42'47" N, $77^0$32'25" E) of Harohalli range in BNP. The study area is located at a distance of 25 km from Bengaluru city and has a gently undulating topography. The plot was established in this terrain. Geologically the rocks are made of crypto crystalline to course granites and complex gneiss (Raju, 2014). The climate of BNP is monsoonal type. Vegetation of BNP is mainly tropical dry type having tropical dry thorn forest, southern tropical dry deciduous forest and moist mixed forest (Gopalakrishna *et al*., 2015). The vegetation of the Bugarikallu study area is typically dry deciduous with predominantly trees that shed their leaves during the dryer months. A detailed account on the study area can also be found in Kakkar *et al*. (2018).

Establishment of PPP

The location for the PPP was identified after a reconnaissance survey (Kakkar *et al*., 2018). The Bugarikallu PPP is located in a region having dry deciduous vegetation. The plot was established as per the Centre for Tropical Forest Science (CTFS) protocol (Condit, 1998); the 1-hectare plot was gridded into 25 subplots of size 20 m x 20 m with the help of a Theodolite for slope corrections.

Woody species comprising of Trees, Shrubs and Climbers (Lianas) >1 cm dbh were identified to species level. The identified individuals were tagged using numbered aluminium tags. Each tagged individual was measured using a dial caliper in cases where the dbh was 1-5 cm and using a measuring tape for dbh > 5 cm, for accurate estimations. An ocular estimate of height was made for each individual.

The spatial mapping of each tagged individual was noted by measuring the local x and y coordinates using a measuring tape. The local x and y coordinates were converted into global x and y coordinates for spatial mapping.

Data analysis

Data were analysed to characterize the plot both at community level and species level. The Important Value Index (IVI) which characterizes the species' contribution to the community was calculated as the sum of Relative Frequency (RF), Relative Density (RD), and Relative Dominance (R Dom) (Curtis and McIntosh, 1951).

The Family Importance Value (FIV) index was calculated as sum of relative occurrence of species (number of species in each family), relative abundance (number of individuals in each family to total number of individuals), and relative dominance (basal area of each family to the total basal area) (Mori *et al*., 1983).

Species accumulation curves or Species richness curves were drawn using EstimateS (Colwell, 2013).

Diversity indices were obtained using the PAleontological STatistics software (PAST) (Hammer *et al*., 2001).

Diversity estimates of different groups based on life forms were compared. The groups were group 1 - all individuals including climbers, group 2 - climbers excluded, group 3 - all individuals >10 cm dbh (trees) performing diversity t-test using PAST.

The rank abundance model was also estimated using PAST. The observed abundance and estimated abundance were plotted against the rank. The estimated abundances were obtained from PAST and a log series model was applied to the estimates.

The spatial distribution of individuals in the plot was analysed using BioDiversity Pro (McAleece *et al*., 1997).

Results

The Bugarikallu forest dynamics plot had 2165 individuals >1 cm dbh belonging to 76 different flowering plant species during the first census (identification, tagging and measurement). The most abundant species were *Ixora arborea* (333 individuals, 15.38% of total abundance) followed by canopy tree *Anogeissus latifolia* (249 individuals, 11.50% of total abundance). There were 48 species with <10 individuals and 20 species with one individual in the plot. They include species such as *Ficus benghalensis, Memecylon umbellatum, Phyllanthus indofischeri* and *Scolopia crenata*. The top ten species accounts for 75.72% of abundance (Table 1).

Species accumulation curve

The sampling methodology followed and the quadrats sampled are crucial for a proper assessment of species in a plot. A Species Accumulation Curve (SAC) or the Species richness curve will inform us whether the sampling is adequate (Zhao *et al*., 2010) and can be a useful way to judge our efforts. The SAC was estimated for the Bugarikallu PPP using the software EstimateS. A tendency towards an asymptote (Fig. 1) is seen in the Bugarikallu plot implying that there is less probability of obtaining more species with additional sampling efforts.

Rank-abundance plot

The Rank-Abundance curve or Whittaker plot provides a visual observation on the species richness as well as the species evenness. The shape of the curve is used to infer which model best fits the data (Magurran, 2004). The log series model of the Bugarikallu plot shows an R^2 value of 0.883 and nearly fits the estimated abundance values. The slope of the model is moderately steep (Fig. 2) implying the dominance of some of the species in the plot.

Diversity pattern

The diversity pattern with three different combinations - diversity estimates including climbers, diversity estimates without climbers and diversity estimates for trees above 10 cm dbh has been given in the Table 2.

The species richness is reduced once the size class cut-off is introduced. There is considerable reduction in number of species with individuals >10 cm and above. However, the dominance of a species increases. *Acacia chundra* dominates with 54 individuals (34.2% of abundance) followed by *Anogeissus latifolia* (22.1% of abundance) and *Diospyros melanoxylon* (7.38% of

Table 1 : Abundance and Cumulative Abundance of top ten species in the Bugarikallu plot, BNP

SN	Species (Family, Life form)	Abundance	Relative abundance (%)	Cumulative abundance (%)
1.	*Ixora arborea* (Rubiaceae, Shrub)	333	15.38	15.38
2.	*Anogeissus latifolia* (Combretaceae, Tree)	249	11.50	26.88
3.	*Erythroxylum monogynum* (Erythroxylaceae, Tree)	238	10.99	37.87
4.	*Pterolobium hexapetalum* (Fabaceae, Climber)	169	7.81	45.68
5.	*Maytenus emarginata* (Celastraceae, Shrub)	130	6.00	51.68
6.	*Ochna obtusata* (Ochnaceae, Tree)	125	5.77	57.45
7.	*Tarenna asiatica* (Rubiaceae, Shrub)	116	5.36	62.81
8.	*Acacia chundra* (Fabaceae, Tree)	96	4.43	67.24
9.	*Canthium dicoccum* (Rubiaceae, Tree)	95	4.39	71.63
10.	*Jasminum angustifolium* (Oleaceae, Climber)	88	4.06	75.69

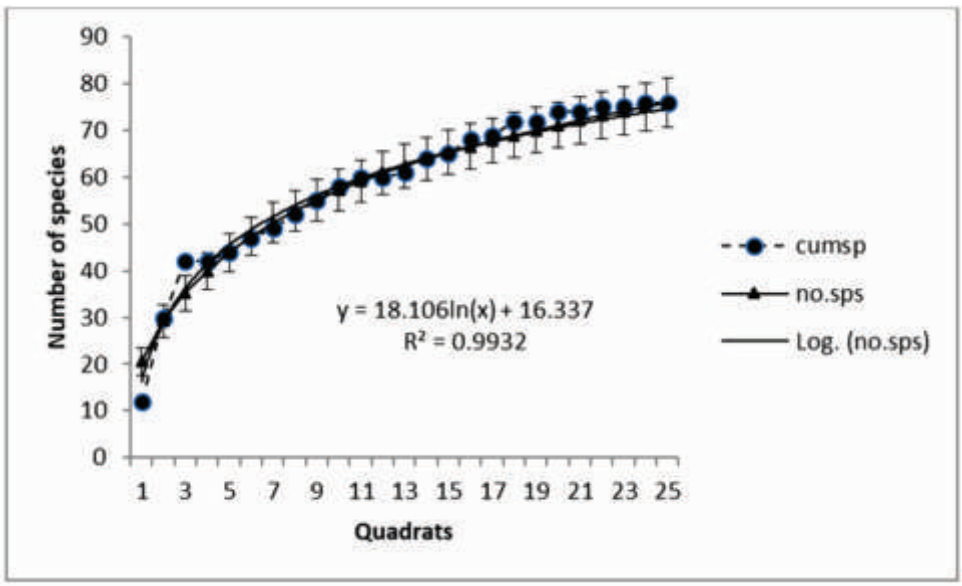

Fig. 1 : Species Accumulation Curve of Bugarikallu plot, BNP

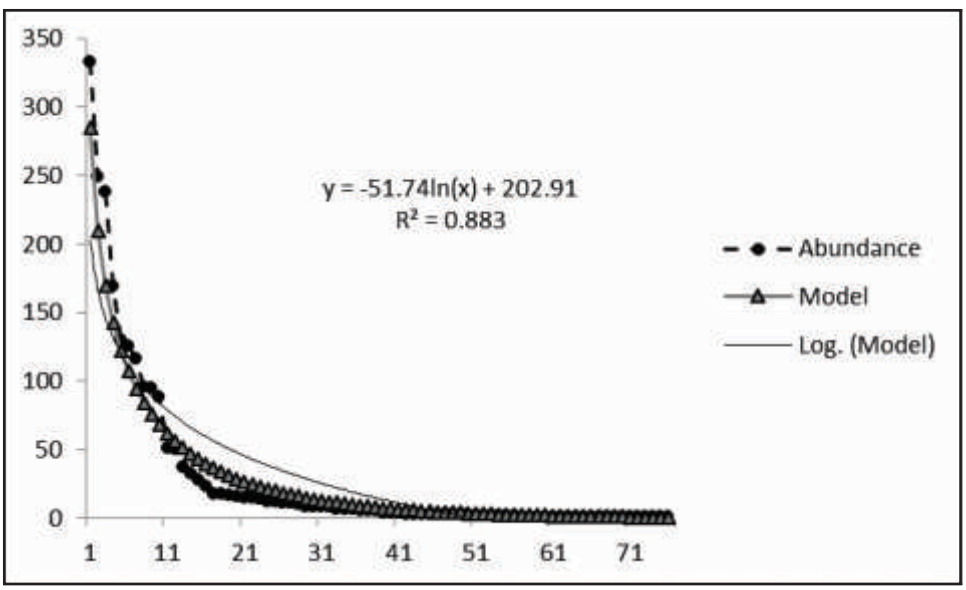

Fig. 2 : Rank-Abundance model of Bugarikallu data, BNP

Table 2 : Diversity estimates for different combinations in Bugarikallu plot, BNP

Parameters	Diversity all life forms included	Diversity excluding climbers	Diversity, woody stems >10 cm dbh
Number of species	76	61	30
Dominance	0.072	0.092	0.181
Simpson's Index	0.927	0.907	0.819
Shannon's Index	3.078	2.842	2.344
Evenness	0.285	0.281	0.347
Fisher's Alpha	15.33	12.17	11.32

abundance). These three species accounts for 63.7% of the total abundance.

The diversity estimates of different groups based on life forms are significantly different from each other (diversity t test, PAST, significant all cases).

The mean number of species decreased across quadrats with each group. There were few species per quadrat among trees >10 cm dbh (Table 3). Each parameter of diversity measure except for dominance decreased with each group while dominance was high among trees above 10 cm dbh (Table 3).

Spatial dispersion

The species dispersion was tested based on the mean-to-variance ratio. The dispersion was classified into two categories such as aggregated (clumped) and random dispersion. The significance of dispersion was determined using the chi-square test.

Twenty-eight species in the plot showed significant clumped (aggregated) dispersion while forty-eight species showed random dispersion at the scale of a hectare. Species such as *Ixora arborea, Erythroxylum monogynum, Anogeissus latifolia, Semecarpus anacardium* and *Randia dumetorum* showed significant clumped dispersion at a scale of a hectare. None of the random dispersion was significant except for *Vitex altissima* (p=0.029) (Annexure 1).

However, species such as *Pterocarpus marsupium, Bauhinia racemosa, Diospyros montana, Dalbergia lanceolaria* and *Cassia montana* have shown significant random dispersion at a 10% level. The dispersion pattern of each species with significance level is given in the Annexure 1.

The spatial distribution of all the individuals in the 1-hectare plot is depicted in Fig. 3. The number of individuals in the plot is highest in three subplots having individuals of 152, 146, and 143. *Ixora arborea, Erythroxylum monogynum, Anogeissus latifolia, Semecarpus anacardium* and *Pterolobium hexapetalum* with clumped dispersion are shown in Fig. 4; *Diospyros melanoxylon, Lagerstroemia parviflora, Flacourtia indica,* and *Strychnos potatorum* with random dispersion is shown in Fig. 5.

Structure

There were 2165 stems >1 cm dbh in the plot when all life-forms were considered and 2015 stems when only woody stems between 1-10 cm dbh were considered while there were 150 stems >10 cm and above. The total basal area of the plot including all life-forms was 10.24 m^2 a hectare. However, the basal area contributed by woody individuals >30 cm dbh was 1.06 m^2 a hectare. There is a considerable contribution of individuals >10 cm dbh to both basal area and biomass. A total of 57.5% of the basal area is contributed by the individuals >10 cm dbh and shrubs and trees contribute over 95% of the basal area in this category. Over 90% of the total biomass of the plot is concentrated among the individuals between 1-30 cm dbh size classes. Trees and shrubs contribute to 87.6% of the biomass in this size class and 12.4% is contributed by climbers.

There were three large trees >30 cm dbh in the plot. The largest among them was *Ficus microcarpa* (91.9 cm dbh) followed by *Ficus benghalensis* (41.7 cm dbh) and *Cassia siamea* (exotic, 40.4 cm dbh).

Floristics

According to Importance Value Index (IVI) *Anogeissus latifolia* was the dominant species (33.63) followed by *Ixora arborea* (30.20), *Erythroxylum monogynum* (25.27) and *Acacia chundra* (24.04). IVI values for the top ten species is given in the Table 4. The complete list of species with Importance Value Index is as in Annexure 2.

Trees account for 61.8% of the total species complement with 47 species while climbers account for 19.7% with 15 species and shrubs with 14 species account for 18.4% of the species complement. Trees (52.6%) and shrubs (31.1%) account for 83.8% of the total density in the plot. In terms of basal area, trees (83.7%) and shrubs (13.3%) constitute 97.1% of the total basal area of the plot.

There were 35 families of angiosperms in the plot. Fabaceae (Leguminosae) with 12 species (15.79% of total species complement) was the most speciose family

Table 3 : Mean diversity estimates for different combinations in Bugarikallu plot, BNP

Parameters	Diversity all life forms included (mean±sd)	Diversity excluding climbers (mean±sd)	Diversity, woody stems >10 cm dbh (mean±sd)
Number of species	20.6±5.06	16.8±3.86	3.76±1.39
Dominance	0.10±0.02	0.125±0.01	0.377±0.200
Simpson's Index	0.89±0.02	0.874±0.01	0.622±0.200
Shannon's Index	2.551±0.204	2.363±0.152	1.15±0.446
Evenness	0.645±0.07	0.655±0.08	0.914±0.066
Fisher's Alpha	8.854±2.144	7.026±1.64	3.628±2.90

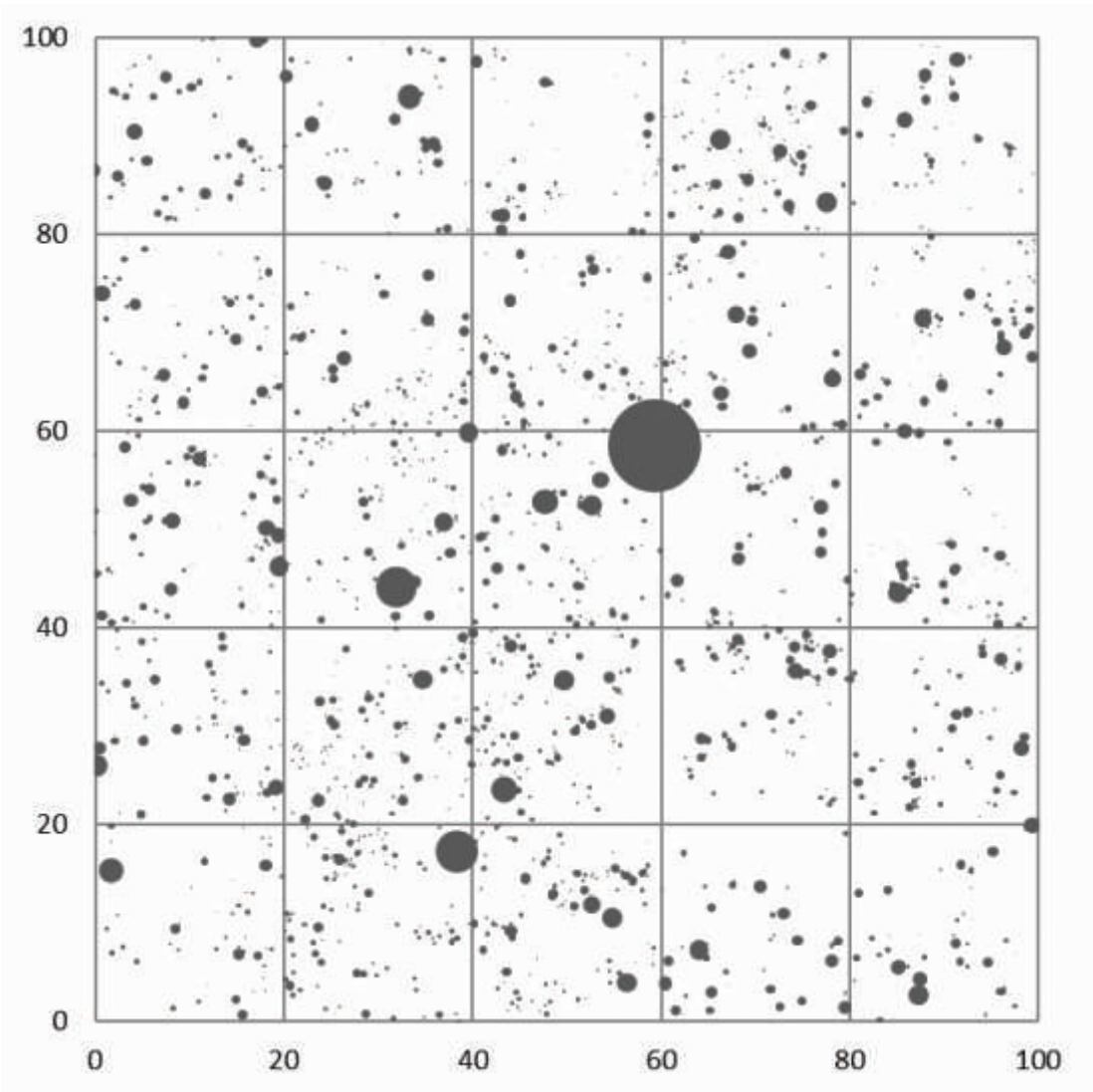

Fig. 3: Spatial distribution of all the individuals in the 1-hectare PPP

followed by Rubiaceae (6 species, 7.89%) and Rhamnaceae (5 species, 6.58%). There were 18 families with one species. The most abundant family was Rubiaceae (575 individuals) followed by families such as Fabaceae (344 individuals) and Combretaceae (259 individuals). According to FIV index, family Fabaceae had highest FIV index (55.86) followed by Rubiaceae (49.59) and Combretaceae (34.57). The top ten families in order of FIV index are given in the Table 5. The complete list of families with FIV index is as in Annexure 3.

Discussion

Bannerghatta National Park is characterized by tropical dry forests. The one-hectare plot in Bugarikallu is representative of large tracts of dry forests in BNP. The plot has 76 species among 2165 individuals >1 cm dbh, while the plot in Thalewood House close to Bugarikallu had 68 species among 1586 individuals (Kakkar *et al*., 2021). The diversity patterns of the two plots in BNP were not statistically different (PAST, Diversity t test, NS). There were 110 species including climbers between these two plots, but they had 39.74% of species shared while 60.26% species were unique to Bugarikallu. This pattern suggests that there is a significant compositional change between these two plots. Diversity studies by laying transects (Gopalakrishna *et al*., 2015) revealed 128 species across BNP. In terms of species composition, the larger landscape of BNP had *Anogeissus latifolia* and *Acacia chundra* as the dominant species while the Bugarikallu plot also had a similar trend. *Anogeissus latifolia* was the second most dominant in Bugarikallu with *Acacia chundra* also contributing to the stand whereas the one-

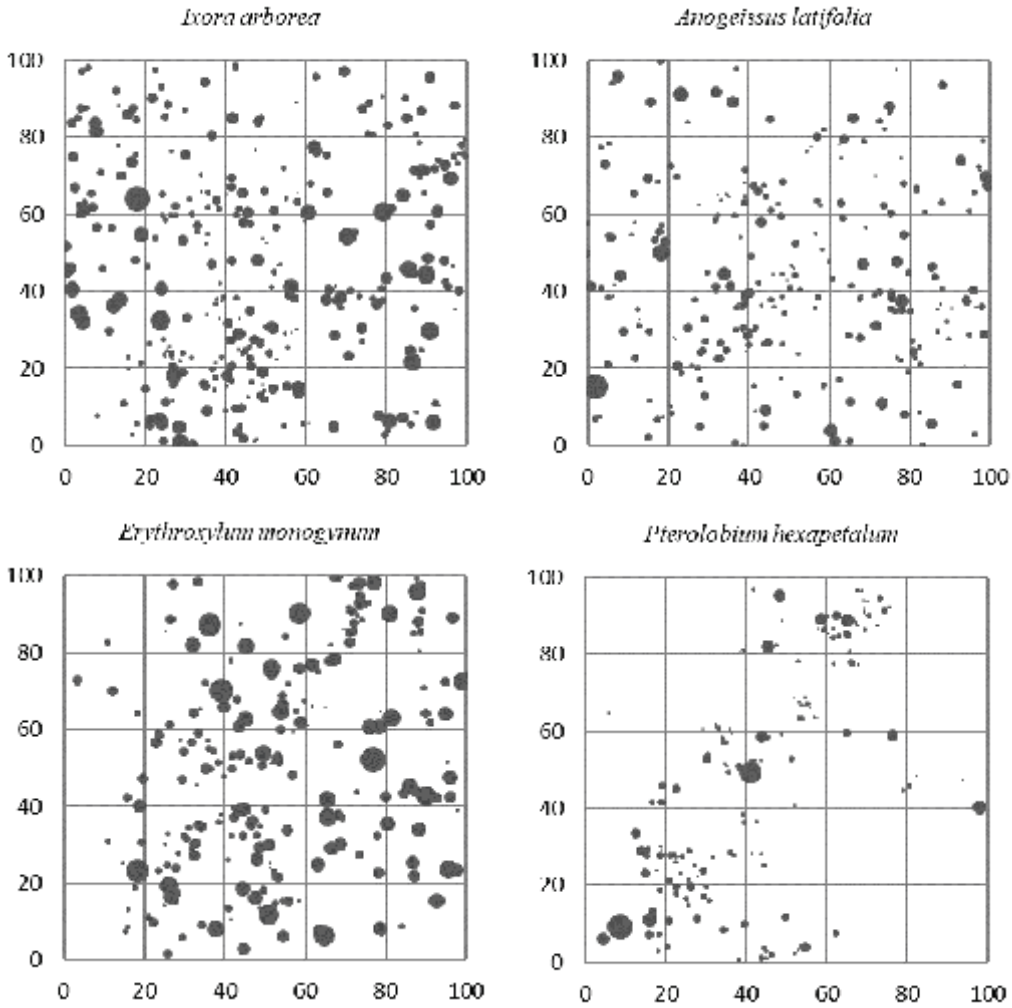

Fig. 4: Clumped dispersion of individuals of 4 species

Table 4: Importance Value Index of top ten species in Bugarikallu forest dynamics plot, BNP

Species (Family)	Relative frequency (%)	Relative density (%)	Relative dominance (%)	Important Value Index (IVI)
Anogeissus latifolia (Combretaceae)	4.85	11.50	17.28	33.63
Ixora arborea (Rubiaceae)	4.85	15.38	9.97	30.20
Erythroxylum monogynum (Erythroxylaceae)	4.85	10.99	9.43	25.27
Acacia chundra (Fabaceae)	4.47	4.43	15.14	24.04
Pterolobium hexapetalum (Fabaceae)	3.69	7.81	1.63	13.13
Ochna obtusata (Ochnaceae)	4.08	5.77	2.68	12.53
Canthium dicoccum (Rubiaceae)	4.08	4.39	3.92	12.39
Maytenus emarginata (Celastraceae)	4.47	6.00	1.48	11.95
Tarenna asiatica (Rubiaceae)	3.69	5.36	0.85	9.90
Diospyros melanoxylon (Ebenaceae)	4.27	2.36	2.92	9.55

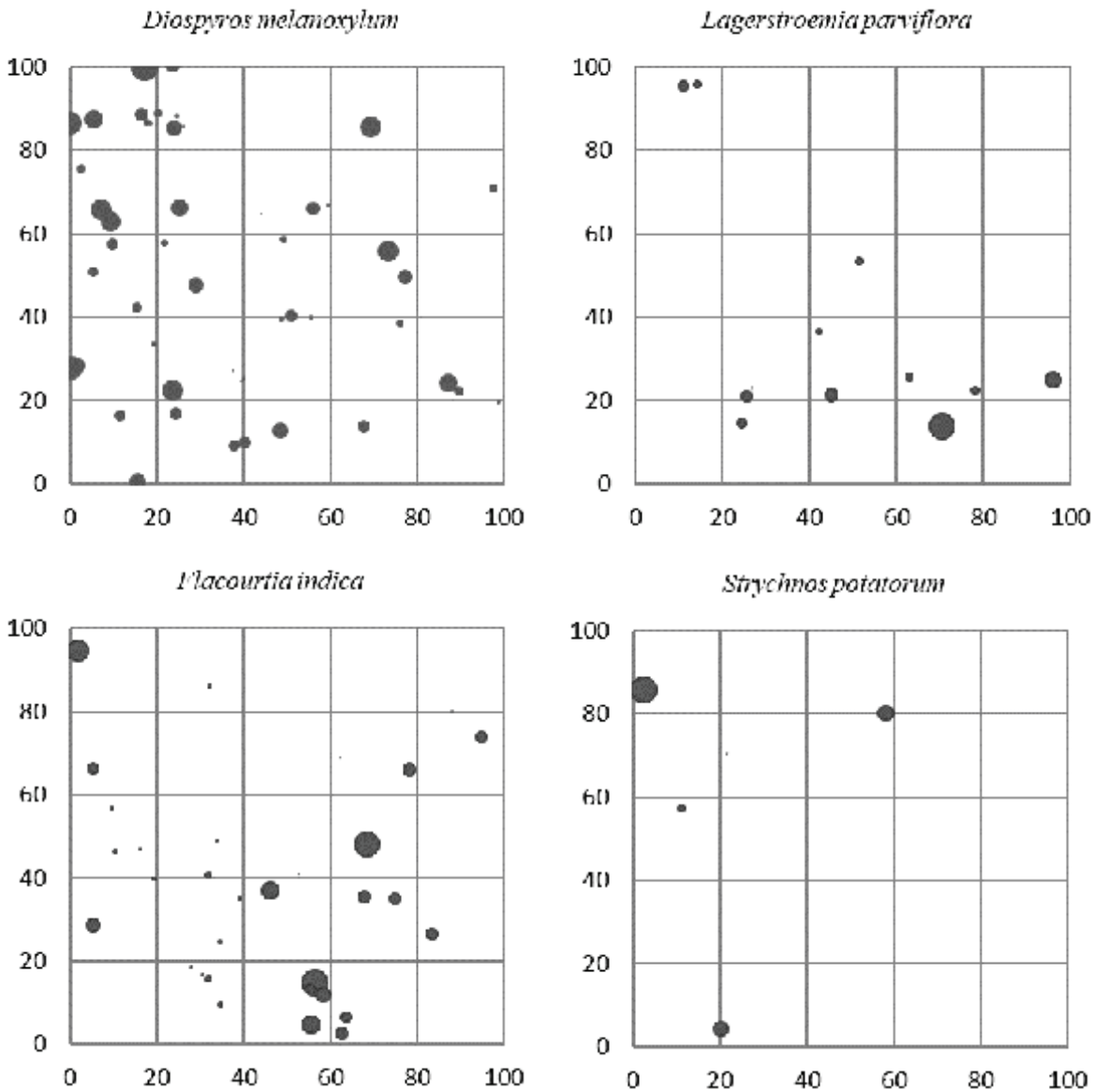

Fig. 5: Random dispersion of individuals of 4 species

hectare plot at Thalewood House had *Olea dioica* and *Cipadessa baccifera* as the most abundant species (Kakkar *et al*., 2021). The differences in the species composition could be attributed to the spatial heterogeneity in the landscape. The Thalewood House plot is an exceptional habitat compared to Bugarikallu plot. Bugarikallu plot in general goes with the landscape of BNP. The life-form composition of the plot is 61.8% tree species followed by 19.7% of the species belonging to climbers and 18.4% of them being shrubs. A similar pattern is reported in Similipal Tiger Reserve (Reddy *et al*., 2007), Kafta Sheraro National Park dry forest, Ethiopia (Temesgen and Warkineh, 2020), and deciduous forests of Sagar district, Madhya Pradesh (Thakur, 2015).

The species richness of Bugarikallu plot is in the range of species numbers reported from different locations. However, there are sites with a smaller number of species (Narayan *et al*., 2017). There are several studies in dry forests of India and elsewhere in the tropics with various dimensions and species richness. Each study has a different plot size and size cut-off. For example, the Bugarikallu plot had 31 species for stems >=10 cm dbh. The species richness of a plot also depends on the inclusion of different life forms.

Table 5: Top ten families in the order of Family Importance Value (FIV) index in Bugarikallu plot

Family	Relative no. species (%)	Relative abundance (%)	Relative dominance (%)	Family importance value (FIV) index
Leguminosae (Fabaceae)	15.79	15.89	24.18	55.86
Rubiaceae	7.89	26.56	15.14	49.59
Combretaceae	3.95	11.96	18.66	34.57
Erythroxylaceae	1.32	10.99	9.43	21.74
Moraceae	2.63	0.09	13.49	16.21
Celastraceae	3.95	6.33	2.07	12.35
Rhamnaceae	6.58	2.73	0.54	9.85
Ochnaceae	1.32	5.77	2.68	9.77
Ebenaceae	2.63	2.63	3.23	8.49
Tiliaceae	3.95	2.4	0.86	7.21

Hence direct comparison would be difficult. However, the mean species richness in Mudumalai dry thorn forests was 32.4±9.4 while in dry deciduous forests it was 29.0±12.7 (Dattaraja *et al*., 2018). Mean species richness in each hectare of 50 ha forest dynamics plot at Mudumalai was 71 (Sukumar *et al*., 1992). Species richness varied from 39 to 49 (individuals >3 cm dbh) per hectare in Javadi hills, Eastern Ghats (Naveenkumar *et al*., 2017), 64 to 143 species ha^{-1} in dry forests of Africa (Temesgen and Warkineh, 2020), 16 to 67 species ha^{-1} for stems above 5 cm dbh from Espinhaco mountains in Brazil (Coelho *et al*., 2012). The species richness of a plot can be explained by both abiotic (climate and habitat heterogeneity) and biotic factors (soils, herbivores).

The density of stems over 1 cm dbh in the Bugarikallu plot is on the higher side in comparison with other deciduous plots while the basal area is 10.24 m^2. The range of basal area values reported for dry forests in India is between 12.44 m^2ha^{-1} and 75.9 m^2ha^{-1} (Verma *et al*., 2013). The basal area of Bugarikallu plot is on the lower side when compared to other deciduous forests in India. Basal area varied from 13.05 m^2ha^{-1} to 28.42 m^2ha^{-1} in the dry forests of Eastern Ghats (Naidu *et al*., 2018), 6.58 to 23.21 m^2ha^{-1} in Vindhya ranges of Uttar Pradesh (Jha and Singh, 1990), 8.25 m^2ha^{-1} to 79.3 m^2ha^{-1} in African dry forests (Temesgen and Warkineh, 2020), 9.9 to 46.6 m^2ha^{-1} (for stems >5 cm) in dry forests of Brazil (Coelho *et al*., 2012). Lower values of basal area in the plot could be attributed to the distribution of individuals in different size classes. There are a large proportion of individuals in the smaller size class that do not contribute much to the basal area.

Floristics

Bugarikallu plot is characterized by domination of Fabaceae. Dry forests in peninsular India are dominated by either Combretaceae (Sukumar *et al*., 1992; Naidu *et al*., 2018) or Fabaceae (Naveenkumar *et al*., 2017; Pilania *et al*., 2015; Thakur, 2015; Yadav *et al*., 2019) with some exceptions (Sudhakar *et al*., 2007; Naidu *et al*., 2018). Combretaceae was the third family in Bugarikallu that had high FIV index. Though Combretaceae had only four species, basal area of hardwood species such as *Terminalia* and *Anogeissus* substantially contributed to FIV index. The dry forest of other regions is also largely dominated by Fabaceae along with other families (Ancona *et al*., 2019; Arriaga and Leon, 1989; Coelho *et al*., 2012; Gentry, 1995; Gillespie *et al*., 2000; Linares-Palomino, 2006; Temesgen and Warkineh, 2020). But the dry forest in New Caledonia has a completely different familial assemblage compared to the rest of tropics. The dry forests are dominated by families such as Sapindaceae, Euphorbiaceae, Rutaceae and Myrtaceae (Gillespie and Jaffre, 2003).

Conclusion

One of the important questions with respect to conservation and protection of biodiversity of south Asian forests is to understand how rich a community is (Coleman *et al*., 2019). Enumeration of the forest provides baseline information on the biodiversity aspects that is required for conservation of the ecosystem. Tropical dry forest is the most extensive biome in India. Considering the species richness of the Bugarikallu plot, the plot deserves the protection accorded by the forest department. The parameters such as species richness, the density of individuals, basal area and floristics of the plot are in the range of values reported from other forests elsewhere in the tropics. A long-term study would be beneficial as this forest plot is close to the vicinity of a metro (Bengaluru city) which inputs large amount of carbon through various activities.

बुगारीकल्लु स्थायी संरक्षण भूखंड, बन्नेरघट्टा राष्ट्रीय उद्यान, बेंगलुरु में काष्ठीय प्रजातियों की विविधता और वितरण आकृति

बालासुब्रमण्य शर्मा, एम. मंजूनाथ, पी. पूर्वश्री, बोयासरिता, किरनराढी मोराब, सी. नागेश, ओ.के. रेमादेवी, एच.एस. दत्तराज, एच.एस.सुरेश, के.एच.विनय कुमार और रितु कक्कड़

सारांश

प्रायद्वीपीय भारत के शुष्क वनों पर जलवायु परिवर्तन के प्रभाव को समझने के लिए बन्नेरघट्टा राष्ट्रीय उद्यान (बीएनपी) में एक हेक्टेयर स्थायी वन वनस्पति भूखंड स्थापित किया गया। सभी लकड़ी वाले पेड़ों को >1 सेमी डीबीएच (स्तन की ऊंचाई पर व्यास) प्रजातियों के लिए सूचीबद्ध किया गया, अद्वितीय संख्या दी गई, आकार के लिए मापा गया, एवं स्थानिक स्थान के लिए मैप किया गया। इस भूखंड में 76 प्रजातियों के 2165 पेड़ एवं झाड़ी >1 सेमी डीबीएच थे। सबसे प्रचुर प्रजाति *इक्सोरा आर्बोरिया* थी, एक झाड़ी (333 व्यक्ति, प्रचुरता का 15.38%) इसके बाद *एनोजिसस लैटिफोलिया,* एक पेड़ की प्रजाति (249 व्यक्ति, प्रचुरता का 11.50%) थी। शीर्ष दस प्रजातियों में कुल प्रचुरता का 75.69% था, 69.4% पेड 1–5 सेमी आकार वर्ग में होते हैं जबकि 3 पेड >30 सेमी डीबीएच कुल आधार क्षेत्र का 10% पर फैलाव करते हैं। पेड़ की प्रजाति *एनोजिसस लैटिफोलिया* का भूखंड में सबसे अधिक बेसल क्षेत्र थाय *एनोजिसस लैटिफोलिया, इक्सोरा आर्बोरिया* और *अकैसिया* चंद्रा भूखंड के कुल बेसल क्षेत्र का 42.4% योगदान करते हैं। फैबेसी के सबसे विशिष्ट होने के साथ आवृतबीजी के 35 परिवार थे जिसमें 18 परिवार में केवल एक प्रजाति पायी गयी। इस भूखंड में एक लुप्तप्राय प्रजाति *डेकालेपिस हैमिल्टोनी* भी पाई गई।

References

Ancona J.J., Ruenes-Morales R., Huchim-Herrera J., Montañez-Escalante P.I. and González-Iturbe J.A. (2019). Woody Species Structure, Diversity, and Floristic Affinities in Seasonaly Dry Forest in the Uxmal Archaeological Zone. *Tropical and Subtropical Agroecosystems*, **22**: 13.

Arriaga L. and Leon J.L. (1989). The Mexican tropical deciduous forest of Baja California Sur: A floristic and structural approach. *Vegetation*, **84**(1): 45–52. https://doi.org/10.1007/BF00054664

Bakker J.P., Olff H., Willems J.H. and Zobel M. (1996). Why do we need permanent plots in the study of long-term vegetation dynamics? *Journal of Vegetation Science*, **7**(2): 147–156. https://doi.org/10.2307/3236314

Coelho M.S., Almada E.D., Quintino A.V., Fernandes G.W., Santos R.M. and SÁnchez-Azofeifa G.A. (2012). Floristic composition and structure of a tropical dry forest at different successional stages in the Espinhaço Mountains, southeastern Brazil. *Interciencia*, **37**: 8.

Coleman J.L., Ascher J.S., Bickford D., Buchori D., Cabanban A., Chisholm R.A., Chong K. Y., Christie P., Clements G.R., dela Cruz T.E.E., Dressler W., Edwards D.P., Francis C.M., Friess D.A., Giam X., Gibson L., Huang D., Hughes A.C., Jaafar Z. and Carrasco L.R. (2019). Top 100 research questions for biodiversity conservation in Southeast Asia. *Biological Conservation*, **234**: 211–220. https://doi.org/10.1016/ j.biocon.2019.03.028

Colwell R K. (2013). Estimates: Statistical Estimation of Species Richness and Shared Species from Samples. Version 9. User's Guide and Application

Condit R. (1998). *Tropical Forest Census Plots*. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-03664-8

Curtis J.T. and McIntosh R.P. (1951). An Upland Forest Continuum in the Prairie-Forest Border Region of Wisconsin. *Ecology*, **32**(3): 476–496. https://doi.org/10.2307/1931725

Dattaraja H.S., Pulla S., Suresh H.S., Nagaraja M.S., Srinivasa Murthy C.A. and Sukumar R. (2018). Woody plant diversity in relation to environmental factors in a seasonally dry tropical forest landscape. *Journal of Vegetation Science*, **29**(4): 704–714. https://doi.org/10.1111/jvs.12652

Gentry A.H. (1995). Diversity and floristic composition of neotropical dry forests. In S. H. Bullock, H. A. Mooney, & E. Medina (Eds.), *Seasonally Dry Tropical Forests* (1st ed., pp. 146–194). Cambridge University Press. https://doi.org/10.1017/CBO9780511753398.007

Gillespie T.W., Grijalva A. and Farris C.N. (2000). Diversity, composition, and structure of tropical dry forests in Central America. *Plant Ecology*, **147**(1): 11. https://doi.org/10.1023/A:1009848525399

Gillespie T.W. and Jaffre T. (2003). Tropical dry forests in New Caledonia. *Biodiversity and Conservation*, **12**(8): 12. https://doi.org/10.1023/A:1023649831355

Gopalakrishna S.P., Kaonga M.L., Somashekar R.K., Suresh H.S. and Suresh R. (2015). Tree diversity in the tropical dry forest of Bannerghatta National Park in Eastern Ghats, Southern India. *European Journal of Ecology*, **1**(2): 12–27. https://doi.org/10.1515/eje-2015-0013

Gopalakrishna S P, R.K. Somashekar, Vijay D Anand and Surendra Varma (2010). Asian Elephant and Bannerghatta National Park in Eastern Ghats, Southern India. *Gajah*, **33**: 47–52.

Hammer O., Harper D.A.T. and Ryan P.D. (2001). PAST: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontologia Electronica*, **4**(1): 9.

Hoffmann W.A., Geiger E.L., Gotsch S.G., Rossatto D.R., Silva L.C.R., Lau O. L., Haridasan M. and Franco A. C. (2012). Ecological thresholds at the savanna-forest boundary: How plant traits, resources and fire govern the distribution of tropical biomes. *Ecology Letters*, **15**(7): 759–768. https://doi.org/10.1111/j.1461-0248.2012.01789.x

Houllier F., Krishnan R.M. and Elouard C. (1998). *Assessment of forest biological diversity. A FAO training course. 1- Lecture notes*. Institut Français de Pondichéry. https://hal.archives-ouvertes.fr/hal-00373545

Jha C.S. and Singh J.S. (1990). Composition and Dynamics of Dry Tropical Forest in Relation to Soil Texture. *Journal of Vegetation Science*, **1**(5): 609–614.

Kakkar R., Kumar K.H.V., Remadevi O.K., Manjunatha M., Saritha B., Sharma B., Kiranraddi M., Dattaraja H.S. and Suresh H.S. (2021). Patterns of woody species diversity and structure in Thalewood House permanent preservation plot in Bannerghatta National Park, Bangalore, India. *Tropical Ecology*, **62**(4): 626–643. https://doi.org/10.1007/s42965-021-00169-y

Kakkar R., Kumar K.H.V., Remadevi O.K., Manjunatha M., Saritha B., Sharma B., Kiranraddi M., H.S. Dattaraja and H.S. Suresh. (2018). Establishing Permanent Preservation Plots in Bannerghatta National Park for long-term ecological studies to monitor climate change. *My Forest*, **54**(2): 19–34.

Kumara H.N., Girish M.K.S. and Murugesan M. (2011). *Assessment of occurrence and abundance of large mammals, birds and woody plants in Bannerghatta National Park, Karnataka* (SACON Technical Report No. 99; p. 98). Salim Ali Centre for Ornithology and Natural History.

Linares-Palomino R. (2006). Phytogeography and Floristics of Seasonally Dry Tropical Forests in Peru. In R. T. Pennington, G. P. Lewis, and J. A. Ratter (Eds.), *Neotropical Savannas and Seasonally Dry Forests* (1st ed., pp. 257–279). CRC Press. https://doi.org/10.1201/9781420004496-11

Lott E. and Atkinson T. (2006). Mexican and Central American Seasonally Dry Tropical Forests: Chamela-Cuixmala, Jalisco, as a Focal Point for Comparison. In R. Toby Pennington, G. Lewis, and J. Ratter (Eds.), *Neotropical Savannas and Seasonally Dry Forests* (Vol. 20060637, pp. 315–342). CRC Press. https://doi.org/10.1201/9781420004496.ch13

Magurran A.E. (2004). *Measuring biological diversity*. Blackwell Pub.

McAleece N., Gage J.D.G., Lambshead P.J.D. and Paterson G.L.J. (1997). *BioDiversity Professional statistics analysis software*. Jointly developed by the Scottish Association for Marine Science and the Natural History Museum London.

Miles L., Newton A.C., DeFries R.S., Ravilious C., May I., Blyth S., Kapos V. and Gordon J.E. (2006). A global overview of the conservation status of tropical dry forests. *Journal of Biogeography*, **33**(3): 491–505. https://doi.org/10.1111/j.1365-2699.2005.01424.x.

Mori S.A., Boom B.M., de Carvalino A.M. and dos Santos T.S. (1983). Ecological Importance of Myrtaceae in an Eastern Brazilian Wet Forest. *Biotropica*, **15**(1): 68. https://doi.org/10.2307/2388002

Murphy P.G. and Lugo A.E. (1986). Ecology of Tropical Dry Forest. *Annual Review of Ecology and Systematics*, **17**(1): 67–88. https://doi.org/10.1146/annurev.es.17.110186.000435

Narayan C., Kumar A., Ghritlahre M.K. and Anshumali (2017). Structure and Floristic Composition of Tropical Deciduous Forests Around Bokaro District, Jharkhand, India. *International Journal of Ecology and Environmental Sciences*, **43**: 263–273.

Naveenkumar J., Arunkumar K.S. and Sundarapandian Sm. (2017). Biomass and carbon stocks of a tropical dry forest of the Javadi Hills, Eastern Ghats, India. *Carbon Management*, **8**(5–6): 351–361. https://doi.org/10.1080/17583004.2017.1362946

Pennington R.T., Lavin M., Prado D.E., Pendry C.A., Pell S.K. and Butterworth C.A. (2004). Historical climate change and speciation: Neotropical seasonally dry forest plants show patterns of both Tertiary and Quaternary diversifications. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, **359**(1443): 515–538. https://doi.org/10.1098/rstb.2003.1435

Pennington R.T., Lehmann C.E.R. and Rowland L.M. (2018). Tropical savannas and dry forests. *Current Biology*, **28**(9): R541–R545. https://doi.org/10.1016/j.cub.2018.03.014

Pilania P.K., Gujar R.V., Joshi P.M., Shrivastav S.C. and Panchal N.S. (2015). Phytosociological and Ethanobotanical Study of Trees in a Tropical Dry Deciduous Forest in Panchmahal district of Gujarat, Western India. *Indian Forester*, **141**(4): 422–427.

Rai S.N. (1996). Long term research sites in tropical forests of India. *UNESCO*, 146.

Raju R. (2014). *Master Plan of Bannerghatta Biological Park, Bangalore* [Master Plan 2014-15 to 2033-34]. Karnataka Forest Department.

Ramachandra T.V., Setturu Bharath, Subash Chandran M.D., Harish R. Bhat, Rao G.R., Akhil C.A., Vishnu D. Mukri, Vrijulal M.V., Chaturved Shet, Gouri Kulkarni and Bharath H. Aithal. (2016). Sustainable Management of Bannerghatta National Park (BNP): Need and Challenges. *ENVIS Technical Report*, *109*.

Reddy C.S., Pattanaik C., Mohapatra A. and Biswal A.K. (2007). Phytosociological Observations on Tree Diversity of Tropical Forest of Similipal Biosphere Reserve, Orissa, India. *Taiwania*, **52**(4): 352–359.

Singh K.P. and Kushwaha C.P. (2005). Emerging Paradigms of tree phenology in dry tropics. *Current Science*, **89**(6): 964–975.

Sudhakar R.C., Babar S., Giriraj A., Reddy K.N. and Thulsi Rao K. (2007). Structure and Floristic Composition of Tree Diversity in Tropical Dry Deciduous Forest of Eastern Ghats, Southern Andhra Pradesh, India. *Asian Journal of Scientific Research*, **1**(1): 57–64. https://doi.org/10.3923/ajsr.2008.57.64

Sukumar, Dattaraja H.S., Suresh H.S., Radhakrishnan J., Vasudeva R., Nirmala S. and Joshi N.V. (1992). Long-term monitoring of vegetation in a tropical deciduous forest in Mudumalai, southern India. *Current Science*, **62**(9): 608–616.

Tarakeswara Naidu M., Premavani D., Suthari S. and Venkaiah M. (2018). Assessment of tree diversity in tropical deciduous forests of Northcentral Eastern Ghats, India. *Geology, Ecology, and Landscapes*, **2**(3): 216–227. https://doi.org/10.1080/24749508.2018.1452479

Temesgen F. and Warkineh B. (2020). Woody Species Structure and Regeneration Status in Kafta Sheraro National Park Dry Forest, Tigray Region, Ethiopia. *International Journal of Forestry Research*, 2020, 1–22. https://doi.org/10.1155/2020/4597456

Tewari V.P., Sukumar R., Kumar R. and Gadow K.V. (2014). Forest observational studies in India: Past developments and considerations for the future. *Forest Ecology and Management*, **316**: 32–46. https://doi.org/10.1016/j.foreco.2013.06.050

Thakur A.S. (2015). Floristic composition, life-forms and biological spectrum of tropical dry deciduous forest in Sagar District, Madhya Pradesh, India. *Tropical Plant Research*, **2**(2): 112–119.

Verma P., Verma P. and Sagar R. (2013). Variations in N mineralization and herbaceous species diversity due to sites, seasons, and N treatments in a seasonally dry tropical environment of India. *Forest Ecology and Management*, **297**: 15–26. https://doi.org/10.1016/j.foreco.2013.02.006

Yadav D.K., Ghosh L. and Jhariya M.K. (2019). Floristic Composition and Diversity in the Forest Fragments of Dry and Moist Tropical Forest. *Journal of Plant Development Sciences*, **11**(4): 201–212.

Zhao J., Ouyang Z., Xu W., Zheng H. and Meng X. (2010). Sampling adequacy estimation for plant species composition by accumulation curves—A case study of urban vegetation in Beijing, China. *Landscape and Urban Planning*, **95**(3): 113–121. https://doi.org/10.1016/j.landurbplan.2009.12.008.

Annexure 1: Aggregated or Random Dispersion of individuals in the Bugarikallu plot

Species	Variance	Mean	Chi-sq	d.f.	P value	Dispersion
Clumped dispersion						
Acacia chundra	8.89	3.84	55.5625	24	0.0003	Aggregated
Acacia concinna	0.9167	0.4	55	24	0.0003	Aggregated
Anogeissus latifolia	33.1233	9.96	79.8153	24	0	Aggregated
Albizia chinensis	0.3333	0.2	40	24	0.0214	Aggregated
Breynia vitis-idaea	4.41	0.92	115.0435	24	0	Aggregated
Canthium dicoccum	20.0833	3.8	126.8421	24	0	Aggregated
Canthium parviflorum	1.3233	0.64	49.625	24	0.0016	Aggregated
Cassia fistula	1.5433	0.72	51.4444	24	0.001	Aggregated
Dendrocalamus strictus	2.75	0.6	110	24	0	Aggregated
Dodonaea viscosa	2.21	0.72	73.6667	24	0	Aggregated
Erythroxylum monogynum	37.8433	9.52	95.4034	24	0	Aggregated
Grewia orbiculata	3.3333	2	40	24	0.0214	Aggregated
Holarrhena antidysenterica	5.0267	1.12	107.7143	24	0	Aggregated
Ixora arborea	66.8933	13.32	120.5285	24	0	Aggregated
Jasminum angustifolium	20.1767	3.52	137.5682	24	0	Aggregated
Madhuca indica	0.6433	0.32	48.25	24	0.0024	Aggregated
Maytenus emarginata	12.6667	5.2	58.4615	24	0.0001	Aggregated
Ochna obtusata	20.3333	5	97.6	24	0	Aggregated
Polyalthia coffeoides	0.36	0.12	72	24	0	Aggregated
Premna tomentosa	0.44	0.24	44	24	0.0077	Aggregated
Pterolobium hexapetalum	48.69	6.76	172.8639	24	0	Aggregated
Randia dumetorum	1.59	0.56	68.1429	24	0	Aggregated
Scutia myrtina	2.56	0.68	90.3529	24	0	Aggregated
Semecarpus anacardium	0.36	0.12	72	24	0	Aggregated
Tarenna asiatica	21.6567	4.64	112.0172	24	0	Aggregated
Terminalia chebula	0.6433	0.32	48.25	24	0.0024	Aggregated
Terminalia paniculata	0.16	0.08	48	24	0.0026	Aggregated
Ziziphus oenopolia	2.6767	1.48	43.4054	24	0.009	Aggregated
Species	Variance	Mean	Chi-sq	d.f.	P value	Dispersion
Random dispersion						
Acacia leucophloea	0.04	0.04	24	24	0.4617	Random
Albizia amara	0.14	0.16	21	24	0.6392	Random
Argyreia cuneata	0.0767	0.08	23	24	0.52	Random
Atalantia monophylla	0.04	0.04	24	24	0.4617	Random
Bauhinia racemosa	0.3567	0.24	35.6667	24	0.059	Random
Bridelia retusa	0.0767	0.08	23	24	0.52	Random
Buchanania axillaris	0.5067	0.44	27.6364	24	0.2754	Random
Cansjera rheedei	0.11	0.12	22	24	0.5796	Random
Capparis sepiaria	0.11	0.12	22	24	0.5796	Random
Carmona retusa	0.04	0.04	24	24	0.4617	Random
Cassia montana	0.2233	0.16	33.5	24	0.0937	Random
Cassia siamea	0.5067	0.44	27.6364	24	0.2754	Random
Cassine glauca	0.0767	0.08	23	24	0.52	Random
Celastrus paniculatus	0.25	0.2	30	24	0.1844	Random
Cipadessa baccifera	0.04	0.04	24	24	0.4617	Random
Dalbergia lanceolaria	0.6767	0.48	33.8333	24	0.0875	Random
Decalepis hamiltonii	0.04	0.04	24	24	0.4617	Random
Diospyros melanoxylon	2.3733	2.04	27.9216	24	0.2631	Random
Diospyros montana	0.3567	0.24	35.6667	24	0.059	Random
Eucalyptus globulus	0.04	0.04	24	24	0.4617	Random
Ficus benghalensis	0.04	0.04	24	24	0.4617	Random
Ficus microcarpa	0.04	0.04	24	24	0.4617	Random
Flacourtia indica	1.3767	1.28	25.8125	24	0.3626	Random

Species	Variance	Mean	Chi-sq	d.f.	P value	Dispersion
Flueggea leucopyrus	0.04	0.04	24	24	0.4617	Random
Gardenia turgida	0.04	0.04	24	24	0.4617	Random
Grewia asiatica	0.04	0.04	24	24	0.4617	Random
Grewia hirsuta	0.04	0.04	24	24	0.4617	Random
Gymnema sylvestre	0.2233	0.16	33.5	24	0.0937	Random
Lagerstroemia parviflora	0.5933	0.48	29.6667	24	0.1957	Random
Memecylon umbellatum	0.04	0.04	24	24	0.4617	Random
Naringi crenulata	0.11	0.12	22	24	0.5796	Random
Phyllanthus indofischeri	0.04	0.04	24	24	0.4617	Random
Polyalthia cerasoides	0.75	0.6	30	24	0.1844	Random
Pterocarpus marsupium	0.4767	0.32	35.75	24	0.0579	Random
Rapanea wightiana	0.04	0.04	24	24	0.4617	Random
Santalum album	0.11	0.12	22	24	0.5796	Random
Scolopia crenata	0.04	0.04	24	24	0.4617	Random
Secamone emetica	0.04	0.04	24	24	0.4617	Random
Shorea roxburghii	0.0767	0.08	23	24	0.52	Random
Soymida febrifuga	0.0767	0.08	23	24	0.52	Random
Stereospermum suaveolens	0.11	0.12	22	24	0.5796	Random
Strychnos potatorum	0.1667	0.2	20	24	0.6973	Random
Toddalia asiatica	0.31	0.32	23.25	24	0.5053	Random
Ventilago maderaspatana	0.04	0.04	24	24	0.4617	Random
Vitex altissima	0.1933	0.12	38.6667	24	0.0296	Random
Wrightia tinctoria	0.04	0.04	24	24	0.4617	Random
Ziziphus rugosa	0.04	0.04	24	24	0.4617	Random
Ziziphus xylopyrus	0.11	0.12	22	24	0.5796	Random

Annexure 2: Importance Value Index (IVI) of all the species in the plot

Species	Total individuals	Basal area (m^2)	Importance Value Index (IVI)
Anogeissus latifolia	249	1.769731	33.63
Ixora arborea	333	1.021452	30.20
Erythroxylum monogynum	238	0.965725	25.27
Acacia chundra	96	1.550662	24.04
Pterolobium hexapetalum	169	0.167438	13.13
Ochna obtusata	125	0.274464	12.53
Canthium dicoccum	95	0.401754	12.39
Maytenus emarginata	130	0.151897	11.95
Tarenna asiatica	116	0.086865	9.90
Diospyros melanoxylon	51	0.299017	9.55
Jasminum angustifolium	88	0.036880	8.50
Ficus benghalensis	1	0.717176	7.24
Grewia orbiculata	50	0.080413	6.79
Ficus microcarpa	1	0.664617	6.73
Cassia siamea	11	0.385221	5.82
Ziziphus oenopolia	37	0.031336	5.71
Flacourtia indica	32	0.057759	5.54
Holarrhena antidysenterica	28	0.049329	3.71
Buchanania axillaris	11	0.149452	3.52
Dalbergia lanceolaria	12	0.094368	3.02
Polyalthia cerasoides	15	0.033566	2.96
Breynia vitis-idaea	23	0.013094	2.94
Lagerstroemia parviflora	12	0.080184	2.88
Cassia fistula	18	0.034051	2.71
Canthium parviflorum	16	0.023459	2.52
Madhuca indica	8	0.139357	2.51
Bauhinia racemosa	6	0.141898	2.45

Species	Total individuals	Basal area (m^2)	Importance Value Index (IVI)
Randia dumetorum	14	0.016781	2.36
Terminalia chebula	8	0.114643	2.27
Dendrocalamus strictus	15	0.040271	2.25
Pterocarpus marsupium	8	0.072749	2.25
Scutia myrtina	17	0.016044	2.12
Dodonaea viscosa	18	0.006011	2.06
Toddalia asiatica	8	0.002211	1.75
Strychnos potatorum	5	0.037469	1.57
Diospyros montana	6	0.032035	1.37
Acacia concinna	10	0.010888	1.35
Premna tomentosa	6	0.021907	1.27
Semecarpus anacardium	3	0.090217	1.21
Celastrus paniculatus	5	0.008110	1.09
Albizia amara	4	0.010455	1.06
Stereospermum suaveolens	3	0.028316	1.00
Cassine glauca	2	0.052368	0.99
Capparis sepiaria	3	0.014032	0.86
Naringi crenulata	3	0.012099	0.84
Vitex altissima	3	0.030505	0.83
Albizia chinensis	5	0.000911	0.82
Shorea roxburghii	2	0.030449	0.78
Cassia montana	4	0.000558	0.77
Gymnema sylvestre	4	0.001051	0.77
Cansjera rheedei	3	0.001583	0.74
Santalum album	3	0.002121	0.74
Ziziphus xylopyrus	3	0.002050	0.74
Wrightia tinctoria	1	0.046810	0.70
Soymida febrifuga	2	0.011782	0.60
Bridelia retusa	2	0.009632	0.57
Terminalia paniculata	2	0.026532	0.54
Argyreia cuneata	2	0.000485	0.48
Eucalyptus globulus	1	0.016586	0.40
Polyalthia coffeoides	3	0.002485	0.35
Phyllanthus indofischeri	1	0.010605	0.34
Rapanea wightiana	1	0.008481	0.32
Acacia leucophloea	1	0.006691	0.31
Grewia asiatica	1	0.007180	0.31
Memecylon umbellatum	1	0.006404	0.30
Ventilago maderaspatana	1	0.005439	0.29
Scolopia crenata	1	0.002035	0.26
Flueggea leucopyrus	1	0.001134	0.25
Ziziphus rugosa	1	0.000661	0.25
Atalantia monophylla	1	0.000133	0.24
Carmona retusa	1	0.000177	0.24
Cipadessa baccifera	1	0.000177	0.24
Decalepis hamiltonii	1	0.000227	0.24
Gardenia turgida	1	0.000095	0.24
Grewia hirsuta	1	0.000095	0.24
Secamone emetica	1	0.000177	0.24

Annexure 3: Complete list of Families with Family Importance Value (FIV) Index

Family	Number of species occurring in Family	Family Importance Value (FIV) index
Leguminosae (Fabaceae)	12	55.86
Rubiaceae	6	49.59
Combretaceae	3	34.57
Erythroxylaceae	1	21.74
Moraceae	2	16.21
Celastraceae	3	12.35
Rhamnaceae	5	9.85
Ochnaceae	1	9.77
Ebenaceae	2	8.49
Tiliaceae	3	7.21
Euphorbiaceae	4	6.85
Oleaceae	1	5.74
Anacardiaceae	2	5.62
Apocynaceae	2	4.91
Flacourtiaceae	2	4.73
Rutaceae	3	4.64
Asclepiadaceae	3	4.24
Annonaceae	2	3.81
Verbenaceae	2	3.56
Sapotaceae	1	3.05
Meliaceae	2	2.89
Lythraceae	1	2.65
Poaceae	1	2.4
Sapindaceae	1	2.21
Loganiaceae	1	1.92
Bignoniaceae	1	1.74
Dipterocarpaceae	1	1.71
Capparaceae	1	1.6
Myrtaceae	1	1.53
Opiliaceae	1	1.48
Santalaceae	1	1.48
Myrsinaceae	1	1.45
Melastomataceae	1	1.43
Convolvulaceae	1	1.41
Boraginaceae	1	1.37

Acknowledgement

Environmental Management and Policy Research Institute (EMPRI) would like to thank the Department of Science and Technology (DST) for funding the research under the Strategic Programmes, Large Initiatives and Coordinated Action Enabler (SPLICE) project. Authors also thank the Karnataka Forest Department (KFD) for research permits and support extended during the field visits. The help provided by the forest staff during the field work in BNP is gratefully acknowledged. Authors are indebted to the Director General and staff of EMPRI for their support and constant encouragement.