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Changes in structural attributes of plant communities along disturbance gradients in a dry deciduous forest of Western Ghats, India

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Abstract Changes in tree and understory plant diversity and community composition in two sites at different disturbance levels were studied on the Anaikatty hills, Western Ghats. Systematic sampling using small scale permanent quadrates (50 × 20 m for trees, 5 × 5 m for shrubs/saplings, 1 × 1 m for herbs/seedlings) enumerated 3,376 individuals of trees (106 species), 8,599 of individuals shrubs (122 species) and 16,659 individuals of herbs (145 species). Among the two sites, species richness and diversity were highest for low disturbed stand (98 and 3.9, respectively) compared to high disturbed site (45 and 2.71, respectively). Result of cluster analysis showed that two distinct clusters were formed on the basis of disturbance of the area in concordance with our field observation. A total of 37 species were common to both sites, sixty one species exclusively found in low disturbed site and eight species were pertained to highly disturbed site. Mann–Whitney test based on Monte Carlo approximation at 95% confidence levels indicated that both populations were not entirely different. The clear difference was only observed for average basal area of trees, density of seedlings, number of species, density and diversity for shrubs and number of species and diversity for herb. The species composition were different in two stand i.e., *Nothopegia racemosa–Albizia amara–Maba neilghrrensis* in low disturbed stand and *Albizia amara–Pleiospermium alatum–Bauhinia racemosa* in high disturbed stand. The major disturbance factors identification using spearman rank correlation indicated that the disturbance in low disturbed habitats were mostly from past logging followed by cutting and illicit felling and grazing, while in high disturbed habitats, it was human presence, past logging and lopping and fuel wood collection.

Keywords Cluster analysis · Disturbance · Small scale permanent plots · Structural attributes · Western Ghats

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Introduction

Disturbance plays a central role in shaping the species composition in forests (Pickett and White 1985). They directly influence community and population dynamics by altering resource availability (Denslow et al. 1998) by causing mortality and providing opportunities for recruitment (Canham and Marks 1985), and by influencing the relative competitive status of individuals (Sousa 1984). The hypothesis that intermediate disturbance enhance ecological diversity as proposed by Connell (1978), but roots back to Watt (1947), Hutchinson (1953), and Grime (1973), has been a point of interest and debate for the last few decades (Wilson 1994). The lower limit of the hypothesis says that if disturbances are too rare, the competitive dominants eliminate other species and reduce diversity as equilibrium conditions develop. The upper limit is a caution that if disturbances are too frequent, most species go locally extinct, which lowers diversity, because they can not tolerate repeated disturbances.

Disturbances associated with anthropogenic activities have overruled natural disturbances in many tropical landscapes. If the human induced disturbance starts in a system, the degradation will continue until and unless some protective measures will be introduced. In other words, anthropogenic disturbance oriented degradation is irreversible in nature and it may reach the upper limit of the intermediate disturbance hypothesis, where most species may go locally extinct. Despite a wide range of studies on the effect of disturbances on experimental (Armesto and Pickett 1985; McCabe and Gotelli 2000; Hooper et al. 2004), theoretical (Huston 1979; Wilkinson 1999) and observational conditions (Abugov 1982; Huston 1994; Townsend et al. 1997; Slik et al. 2002; Hooper et al. 2004), we still lack comprehensive understanding of the vulnerability and sensitivity of ecosystems to change in disturbance regime (Death and Winterbourn 1995; McCabe and Gotelli 2000).

Tropical or subtropical dry forests account for 42% of the total global forest cover (Murphy and Lugo 1986). These forests have undergone severe large-scale changes such as timber extraction, creation of pastures, accidental or intentional fires (Gerhardt and Hytteborn 1992) and as a source of fuel wood (Murphy and Lugo 1986). Despite their over-exploitation there have been relatively few studies of tropical dry forest and even fewer studies done on their recovery following man made disturbance (McLaren and McDonald 2003).

In India dry deciduous forests contribute 46% of the forests, but the systematic studies were limited (except Sukumar et al. 1992; Sagar and Singh 2005) and major studies were concentrated on tropical evergreen forests (Pascal and Pelissier 1996; Ayyappan and Parthasarathy 1999; Parthasarathy 2001; Muthuramkumar et al. 2006). So there is lack of information from the dry forests of Western Ghats. Also, it is worthwhile to note that most of these studies were conducted in an ideal condition where the human presence was nil or minimum and it was not representing the actual condition where a predominant human presence is overwhelming the natural conditions. So it is important to characterize the communities in human dominated landscape in terms of its richness, diversity and assemblages for knowing the stability and viability of the system for long term existence. It is not only helpful to formulate conservation practices but also lead to several ecological insights like coexistence, competitive exclusion, speciation, dominance, exploitation of local resources, etc.

The mountains along the west coast of peninsular India, the Western Ghats, is recognized as one of the eight ‘hottest hot spots’ of biological diversity in the world (Myers et al. 2000) and among the 200 globally most important ecoregions (Olson and Dinerstien 1998). This unique land faces severe threats from human disturbance due to deforestation, developmental activities, conversion to plantations, and habitat fragmentation (Nair 1991). Menon and Bawa (1997) estimated that between 1920 and 1990 forest cover in the Western Ghats declined by 40%, resulting in a four fold increase in the number of fragments, and an 83% reduction in size of forest patches. This is not surprising given that this region is having the highest human population density among the biodiversity hotspots (Cincotta et al. 2000) and one among four hotspots with high human population pressure (Shi et al. 2005). Nilgiri Biosphere Reserve (NBR) within Western Ghats is the first established Biosphere Reserve in India with rich repository of biological diversity (3,203 km^2). Dry forests cover major portion of the NBR and are one of the most threatened habitats due to continuous human disturbances (Gadgil and Meher-Homji 1986). Of the total forested area of 5,520 km^2, the tropical dry deciduous and tropical dry thorn forests are predominant, accounting for 29.7% and 38% of the area, respectively (Narendran et al. 2001).

Anaikatty hills or reserve forest, situated at the foothills of the Nilgiri Biosphere Reserve, falls under southern dry mixed deciduous forest according to Champion and Seth's (1968) classification of Indian forests. This area, belonged to different royalties upto the eighteenth century, had dense forests although the economically backward practiced shifting cultivation and the well to do indulged in hunting. Timber extraction (selective logging) began on a commercial scale in some parts of the hills in late nineteenth century and the extraction of non-timber forest products (NTFP) too increased. Even though, selective logging has been prohibited in early 1970s, the other disturbances by the surrounding socio-economically backward population continued in the area (as per the 2001 census, the average per capita income of respondents was less than one third of the state; Purushothaman 2004). The disturbance from the surrounding population in the form of cutting and illicit felling, lopping and fuel wood collections, NTFP collection, grazing etc are a matter of concern in the long term existence of the hills (Purushothaman 2004; Anitha et al. 2007). In this context, Salim Ali Centre for Ornithology and Natural History established small scale permanent plots in Anaikatty Hills to reveal the various ecological processes in human dominated landscape. We discuss below the changes in structural attributes along the disturbance gradients.

Materials and methods

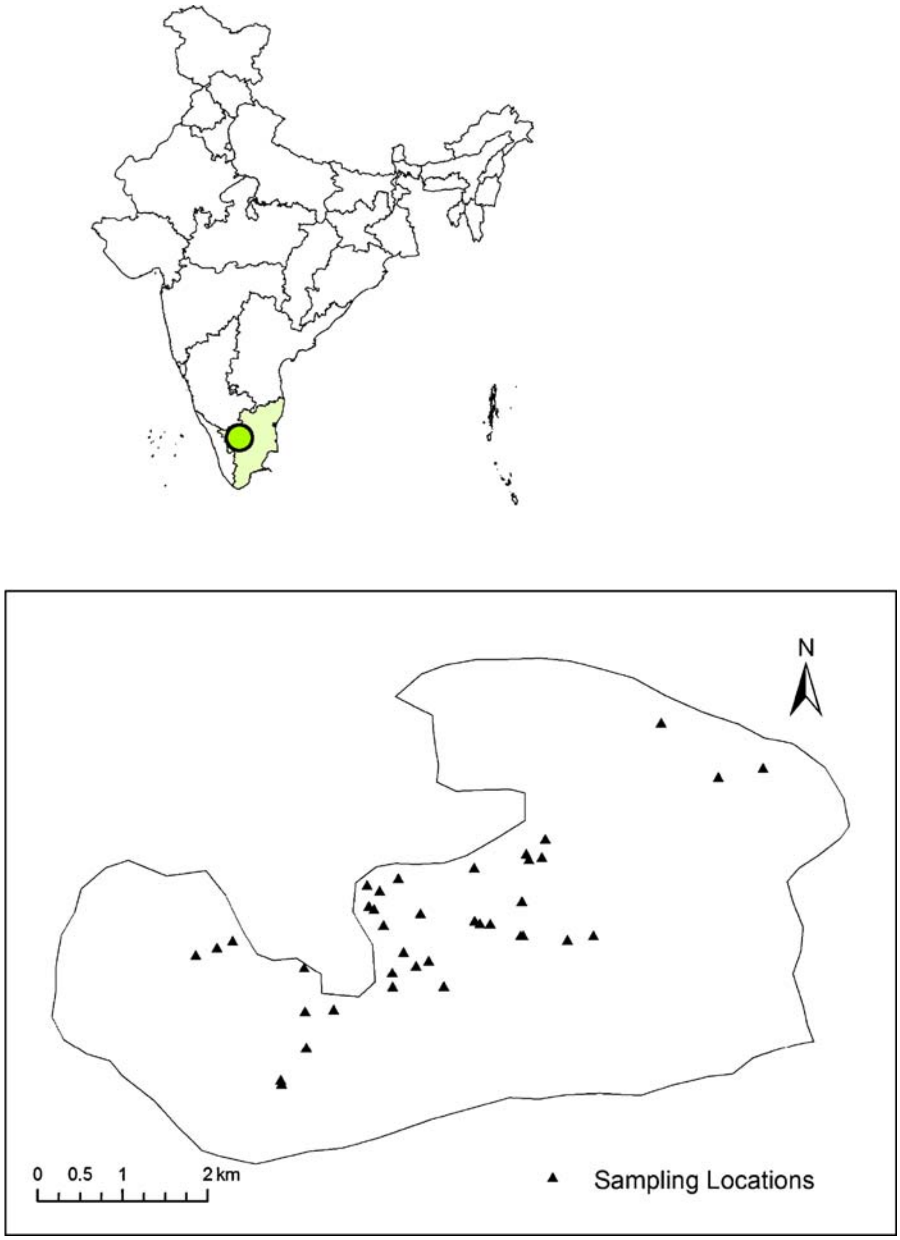
Location

Anaikatty Reserve Forest (76°39′ to 76°50′ E and 11°0′ to 11°31′ N), is an area of about 140 km^2, administratively situated in the Coimbatore forest division of Tamil Nadu (Fig. 1). The area is boarded by Palghat Forest division of Kerala State on the west, agricultural planes in the east, Palghat gap (35 km wide gap in the Western Ghats) in the south and Sathyamangalam and Nilgiri Forest Divisions in the north. The terrain is undulating with seasonal waterfalls and is watershed of the River Bhavani. The hills on the north and south rise from an elevation of 560–1,600 m a.s.l. Rock formation in the study area is gneiss of Archaean age group, comprising a variety of rock types. Soil type of this forest is generally hard gravel in major portions and red loamy in some patches. The climate of the area is semi-arid as it is located in the rain shadow part of the Western Ghats. The average rainfall was 668 mm per year for the past 10 years, and it receives majority of the rainfall from the northeast monsoon. Maximum temperature varied from 29°C to 37°C. Monthly mean relative humidity fluctuated between 32% and 92%.

Data collection

The data has been collected from forty quadrates of 50 × 20 m size laid on different disturbances level. In each of the plot (0.1 ha), number of individuals of trees, GBH and height were noted. Woody plants with more than 20 cm GBH were measured. Four quadrates of 5 × 5 m and nine quadrates of 1 × 1 m were laid within the 50 × 20 m quadrate in a zig-zag manner (Fig. 2) for recording shrubs including saplings and herbs (seedlings), respectively. Plant species were identified with the help of Flora of Presidency of Madras (Gamble and Fischer 1915–1935) and the collections deposited in the herbarium of SACON. The specimens were taken into Botanical Survey of India to confirm the identity. The data collected were analyzed to obtain quantitative structure and composition of plant communities. In addition, disturbance factors like grazing, cutting and illicit felling, lopping and fuel wood collections, past logging, NTFP collection, other human presences, proximity of fire and existence of weeds were also noted in the field.

Fig. 1 Location of sample points in Anaikatty reserve forest



Data analysis

We employed cluster analysis to ordinate the sample plots into high and low disturbed categories on the basis of species composition. Before clustering, the whole datasets were log transformed as the assumptions of cluster analysis include homoscedasticity (equal variance) and normal distribution of the variables (Alther 1979). Ward's minimum variance linkage (minimization of within group dispersion) method has been used for group linkage since it uses an analysis of variance (ANOVA) approach to evaluate the distances between clusters (Judd 1980). The Distance measure used was Relative Euclidian as it incorporates species abundance totals within each sample units so that the final distance measure is standardized relative to differences in total sample units abundance (Ludwig and Reynolds 1988). The structural attributes like species rich-

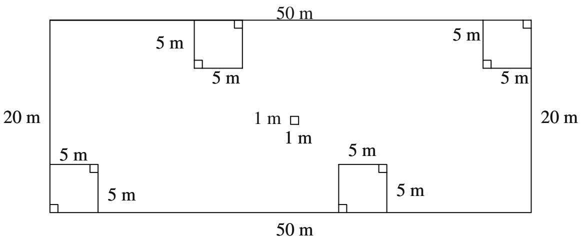


Fig. 2 Sampling method adopted for trees (50 × 20 m), shrubs (5 × 5 m) and herbs (1× 1 m)

ness, diversity index (Shannon–Wiener diversity index) and number of individuals per plot were calculated for high and low disturbed habitats. For shrubs/saplings and herbs/seedlings, the individuals counted in sub plots added together for each main plot for valid comparison. Non-parametric Mann–Whitney *U* test has been conducted to check whether both populations were derived from the single population. Monte Carlo approximation with confidence level of 95% has used to test the significant difference between the mean values in two populations. The dominant species in both habitats, were characterized by Important Value Index (IVI) of the species after Curtis (1959). IVI for each species computed by summing up Relative density, Relative dominance and Relative frequency of the individual. The qualitative information on disturbance factors were given appropriate weightages by scaling it in a 1–10 scale. Spearman rank correlation has been conducted between Shannon diversity index and disturbance factors to identify most influential disturbance factors in affecting the community in both low and high disturbed habitats. All the analysis were assisted by computer programs such as EstimateS (Colwell 2005), Species Diversity and Richness (Henderson and Seaby 2001) and PC-ORD (McCunne and Mefford 1999) and SPSS (SPSS, Inc. Chicago, IL, USA).

Results

Species number

We have recorded 128 species of woody plants belonging to 30 families (77 genera) from forty small-scale permanent plots. The samples enumerated 3,376 individuals of trees (106 species), 8,599 of individuals of shrubs (122 species) and 16,659 individuals of herbs (145 species). In trees, maximum number of individuals were encountered by *Albizia amara* ($n = 438$, 12.97%) followed by *Pleiospermum alatum* ($n = 387$, 12.55%) and *Nothopegia racemosa* ($n = 130$, 3.85%) and *Cordia monoica* ($n = 130$, 3.85%). In the shrub layer *Lantana camara* (11.82%) and *Sida acuta* (11.02%) were abundant species whereas in herb layer *Aristida depressa* (30.94%) and *Digitaria* sp. (18.59%) formed the abundant species. The Fabaceae with 21 species (22%), constitute dominant family followed by Rutaceae (seven species, 7.29%), Euphorbiaceae (six species, 6.25%) and Verbenaceae (six species, 6.25%).

Cluster analysis

Classification of plots according to the species composition could be analysed from the cluster analysis. Two distinct groups were formed in the cluster analysis on the basis of disturbance of the area in concordance with our field data (Fig. 3). First group consisted of 17 plots and the second with 23 plots. The ordination analysis satisfactorily classified the plots into high and low disturbed categories except for plots P10, P11 and P12. Altogether 37 species were common to both sites, 61 species exclusively found in low disturbed site and 8 species were pertained to highly disturbed site. The majority of species consisted of common species in the above mentioned plots i.e., in P10 (common species were 70%), P11 (53%), P12 (64%). This could be the reason for inclusion of these plots into the clusters of high disturbed sites. But the site location and other disturbance parameters noted in the field favored these plots to be included in the low disturbed category.

Species accumulation curves

Species-area curves were generated by plotting cumulative number of tree species against number of quadrate sampled using 50 × 20 m plots. Species area curves for both low and high disturbed stands approached asymptotes, conforming that almost all species present in these two

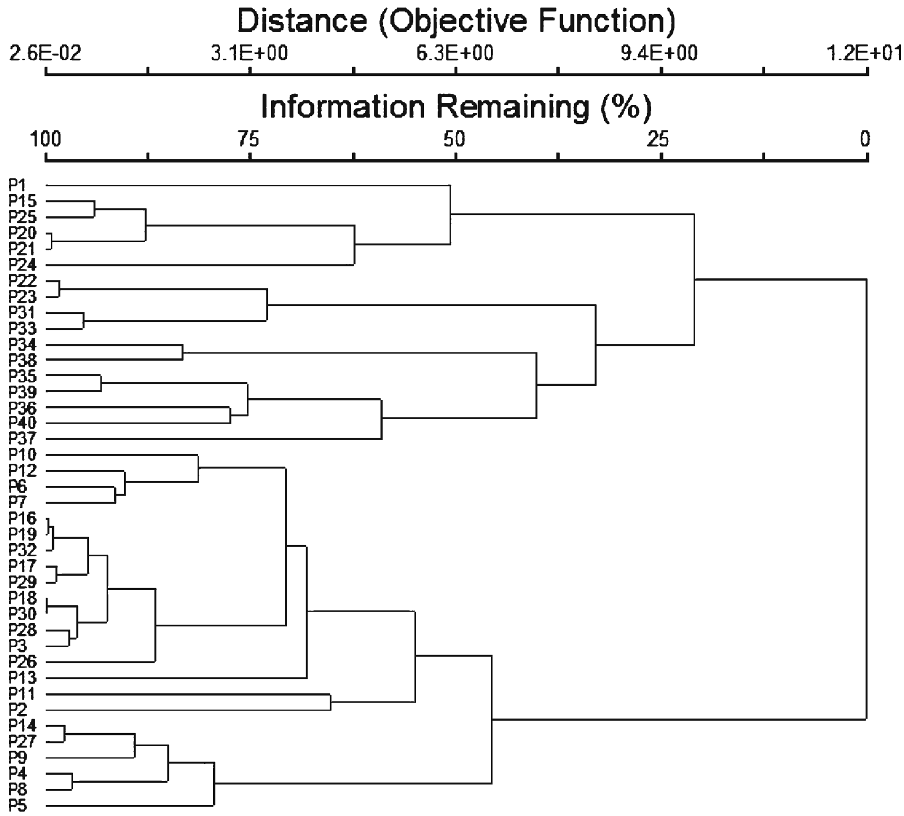


Fig. 3 Grouping of plots using cluster analysis based on relative Euclidian distance

areas were being sampled (Fig. 4). Number of species recorded were different between sites. A total of 98 species were recorded at low disturbed site, whereas, 45 species detected in high disturbed site. The trajectories of the two species accumulation curves clearly showed the significant difference between species richness in two sites.

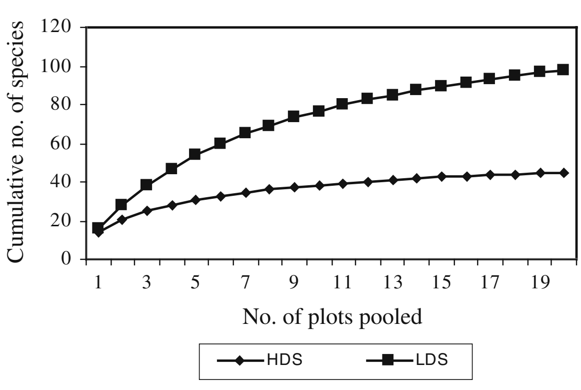


Fig. 4 Species accumulation curve of both sites

Structural attributes comparison

Richness, density and diversity

The species richness, stand density, diversity of trees, saplings, seedlings, shrubs and herbs in both habitats are given in Table 1. On an average, 16 species were found in one plot of 0.1 ha in low disturbed sites, whereas, it was 14 in high disturbed sites and significant value was slightly above than 0.05 (0.09). Eventhough, the number of individuals per plots were different for both sites (95 and 74 individuals in low and high disturbed sites respectively), Mann Whitney test based on Monte Carlo approximation of confidence levels indicated that mean number of individuals per plot were not significantly different ($p > 0.05$) at 95% confidence intervals. Shannon–Weiner diversity index also followed a similar fashion in both habitats. The parameters which have showed significant difference ($p < 0.05$) were average basal area of trees, density of seedlings, number of

Table 1 Structural attribute changes in low and high disturbed habitats of Anaikatty Hills

Habit	Parameters	Undisturbed (mean ± SD)	Disturbed (mean ± SD)	Mann–Whitney *U* test	
				z value	*p* value[a]
Tree	Total species richness	98	45	–	–
	Number of species/ plot	15.75 ± 4.76	13.75 ± 3.54	−1.3714	0.087
	(Number of individuals/plot)	94.55 ± 44.92	74.25 ± 34.05	−1.3801	0.085
	Shannon Index (/plot)	2.22 ± 0.34	2.06 ± 0.38	−1.2984	0.102
	Avg. basal area/plot (m^2)	2.11 ± 1.25	1.06 ± 0.88	−2.7591	0.002*
Sapling	Species richness	70	35	–	–
	Number of species/plot	9.65 ± 4.43	8.6 ± 4.63	−0.8141	0.219
	Density (number of individuals/plot)	9.30 ± 4.47	8.25 ± 4.04	−1.0456	0.153
	Shannon index (/plot)	1.71 ± 0.65	1.62 ± 0.68	−0.2705	0.397
Seedling	Species richness	70	43	–	
	Number of species/plot	10.80 ± 4.58	10.00 ± 4.70	−0.5833	0.287
	Density (number of individuals/plot)	34.05 ± 12.32	10.20 ± 5.40	−5.1722	0.000*
	Shannon index (/plot)	1.85 ± 0.42	1.79 ± 0.49	−0.4869	0.318
Shrubs	Species richness	106	69	–	
	Number of species/plot	14.9 ± 6.89	17.65 ± 5.31	−4.0919	0.000*
	Density (number of /plot)	132.15 ± 76.12	297.05 ± 255.69	−2.4618	0.005*
	Shannon index (/plot)	1.93 ± .75	2.29 ± .38	−1.7854	0.038*
Herbs	Species richness	121	95	–	
	Number of species/plot	20.05 ± 9.64	27.65 ± 8.23	−2.7211	0.004*
	Density (number of individuals/plot)	426.45 ± 319.63	440.2 ± 258.01	−0.2705	0.395
	Shannon index (/plot)	1.74 ± 0.71	3.06 ± .33	−5.0043	0.000*

[a]Monte Carlo significance at 95% confidence interval (one-tailed)

*$p < 0.05$

species, density and diversity for shrubs and number of species and diversity for herbs. The species richness, density and diversity of trees, saplings and seedlings were higher in low disturbed habitats, whereas, shrubs and herbs showed higher diversity and density in high disturbed habitats. Though, the density of shrubs and herbs were lesser, the total species richness was higher (106 and 121) in low disturbed habitats compared to high disturbed habitats (69 and 95, respectively).

Community structure

1. Low disturbed habitat – A total of 1891 trees belonging to 98 species of trees were recorded in the low disturbed site. Most dominant tree species represented in this area in terms of IVI are *N. racemosa* (19.34), *A. amara* (17.88), *Maba neilghrrensis* (11.77). On the basis of IVI value, it can be concluded that the area is dominated by *N. racemosa–A. amara-M. neilghrrensis* association.
2. High disturbed forest – A total of 1485 trees belonging to 45 species of trees were recorded in the high disturbed site. The area is dominated by *A. amara* (IVI = 63.82), *Pleiospermium alatum* (IVI = 46.11), *Bauhinia racemosa* (IVI = 18) association.

GBH size class

Stems were classified into various size classes and higher number of individuals were found in the lowest classes indicating a regenerating population. The size class distributions exhibited the roughly negative exponential or 'inverse J', curves typical of natural forests (Fig. 5).

Population status

1. Low disturbed site – In total 98 tree species, 70 saplings, and 70 seedlings were enumerated from this site. Of these *Clausena heptaphylla* with 290 individuals, *N. racemosa* (288), *Pavetta indica* (273) *Acacia canescens* (200)

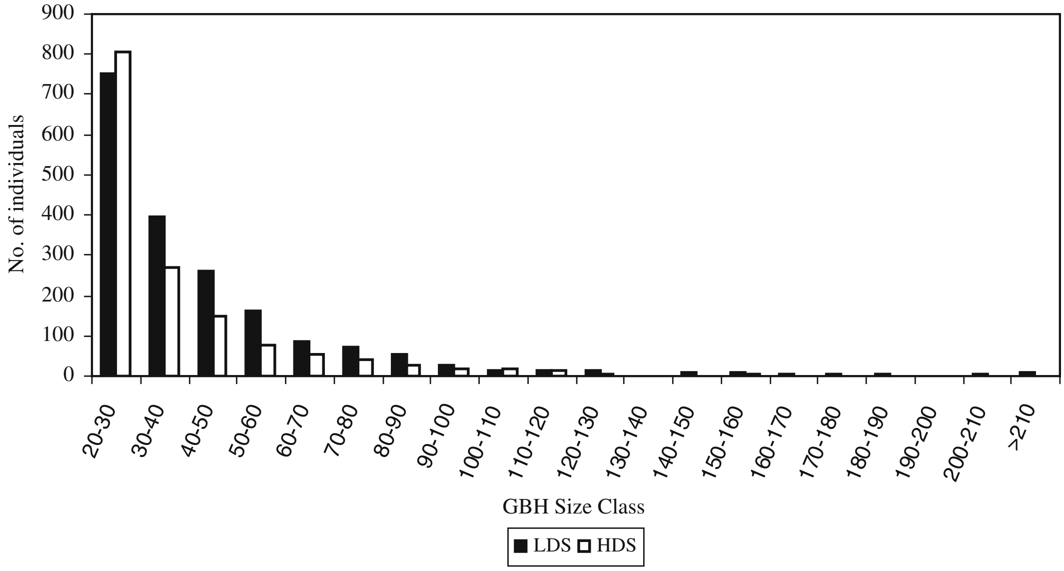


Fig. 5 GBH size class distribution of two sites

and *A. amara* (184) showed maximum distribution. *A. amara* represented maximum number of trees i.e., 158 followed by *N. racemosa* (130), *Maba neilghrrensis* (117) and *Anogeissus latifolia* (88). *C. heptaphylla* had higher number of sapling i.e., 133, followed by *P. indica* (123), *A. canescens* (71), *Stereospermum personatum* (58). Seedling density was highest for *A. canescens* (124), followed by *N. racemosa* (108) and *C. heptaphylla* (104). In total 73 species were found in adult and recruiting class whereas 11 species were found only in recruiting class (which lack adult individuals) and 25 species were found only in adult class (which neither had seedling nor sapling).

2. High disturbed site – In total 45 tree species, 35 saplings, and 43 seedlings were reported from this site. Of these *A. canescens* with 658 individuals, *P. alatum* (651), *A. amara* (324) *Phyllanthus polyphyllus* (286) and *Maba buxifolia* (229) showed maximum distribution. *P. alatum* represented maximum number of trees i.e., 387 followed by *A. amara* (280), *M. buxifolia* (111) and *B. racemosa* (83). *A. canescens* had higher number of sapling i.e., 311, followed by *P. polyphyllus* (135), *P. indica* (128). Seedling density was highest for *A. canescens* (315), followed by *P. alatum* (162) and *P. polyphyllus* (81). In total 80 species were found in adult and recruiting class, in which 14 species were found only in recruiting class (which lack adult individuals) and 10 species were found only in adult class (which neither had seedling nor sapling).

Disturbance factor analysis

The analysis using correlation matrix indicated that the disturbance factors has a negative correlation with tree species diversity (Table 2). The major disturbance parameters in low disturbed habitats were past logging (–0.43) followed by cutting and illicit felling (–0.38) and grazing (–0.33). While major threats to high disturbed habitats came

Table 2 Correlation between Shannon diversity in low and high disturbed plots of Anaikatty Hills

Habit	Grazing	Cutting/illicit felling	Lopping of fuelwood	Past logging	Human presence	NTFP collection	Fire proximity
Low disturbed	−0.33	−0.38	−0.13	−0.43	−0.10	−0.33	−0.19
High disturbed	−0.38	−0.46	−0.46	−0.48	−0.53	−0.18	−0.22

from human presence (–0.53), past logging (– 0.48) and lopping and fuel wood collection (–0.46).

Discussion

Structural attributes changes

We performed Non-parametric Mann–Whitney *U* test to prove whether both communities were derived from the single parent community. Results proved that both populations were derived from a single population excluding average basal area of trees, density of seedlings, number of species, density and diversity for shrubs and number of species and diversity for herb. The lower density of seedlings in high disturbed habitats is an indication of frequent disturbances in the form of trampling and grazing. The high disturbed habitat is dominated by the invasive species such as *L. camara*, *Chromolaena odorata* which would be reflected in the high density of shrubs and herb cover. In the both stands, maximum number of individuals were observed in 20–30 cm GBH for tree species i.e., 753 individuals were occurred in least disturbed site and 806 in high disturbed site. GBH size class showed a pattern of substantial reduction of density in higher classes. Least disturbed stand represented up to the class of >210 (363 cm for *Stereospermum alatum*) and highly disturbed stand represented up to the class of 170–180 (177 cm for *Commiphora caudata*). Many studies observed a decrease in density with an increase of girth class (e.g. Chittibabu and Parthasarathy 2000; Kadavul and Parthasarathy 1999; Hara et al. 1997; Newbery et al. 1992). Mean basal area/ plot for low disturbed site found to be higher compared to high disturbed site (2.11 ± 1.25 and 1.06 ± 0.88, respectively) showed significant variation ($z = -2.759$, $p < 0.05$). The main reason for the reduced basal area of highly disturbed stand is high level of cutting of the trees for various purposes. The frequent cutting was evident from the cutting sign and the multiple branching of stems at ground level. Chittibabu and Parthasarathy (2000) observed low mean stand basal area of the disturbed site due to selective felling of larger girth class trees and increased stand basal area in undisturbed area as a result of unchopped larger stems in Kolli hills, Eastern Ghats.

Changes in floristic composition

Major changes in structural attributes were qualitative in nature i.e., disturbance induced shift in floristic compositions in Anaikatty hills. Community structure of low disturbed stand characterized by the floristic structure of *N. racemosa*-*A. amara*–*M. neilghrrensis* where as high disturbed stand showed *A. amara*–*P. alatum*–*B. racemosa* as their vegetation community.Changes in species composition related to environmental parameters and disturbances factors are reported in several instances (e.g. Sagar and Singh 2005; Sharma and Raghubanshi 2006).

N. racemosa and *M. neilghrrensis* were found exclusively in the low disturbed habitat and they are shade tolerant primary forest species which can't tolerate any disturbance activities. The germination and growth of these species require closed canopy and high humidity. The representation of these species as seedlings and saplings shows certain pockets of low disturbed habitat are safe from the disturbance activities.

Intermediate disturbance hypothesis states if the frequent disturbance factors continues residing primary forest species will be wiped out from the system and disturbance adapted generalist (pioneers) replace them. We assume the primary forest species were shrunken or eliminated from the high disturbed habitat due to the recurrent disturbances. For instance, we recorded primary species such as *Cassine glauca*, *Alphonsea sclerocarpa* as mature trees (GBH $\geq$ 20 cm) from both habitats which shows the high disturbed areas were dense primary forest long back. The recurrent disturbance helped for the intrusion of *P. alatum*, a light demanding pioneer (heliophilic) species in the highly disturbed habitat. When the anthropogenic disturbance is more intense than the natural disturbance regime, the forest shows a lager seed bank mostly composed of pioneer species or secondary species (Eilu and Obua 2005). The presence of many pioneer species or secondary species in the high disturbed areas proves the habitat had undergone serious anthropogenic disturbance events which are discussed in the following paragraphs.

Disturbance factors

Correlation analysis between tree diversity and disturbance factors pointed that both the habitats were under threat from different sources of disturbances at varying intensity. This can be linked to the land-uses and livelihood patterns of forest depended communities of the area. The area had a dense forest although shifting cultivation and hunting were practiced in the area during eighteenth century. Tribal population was involved in the shifting cultivation and it was in full harmony with nature. Hunting was mainly for elephants and it was restricted to particular families and too once or twice in a year. So these activities didn't damage the intact forest cover. During 1909 – 10 illicit felling were reported from the accessible lower altitude area for timber extraction. The area was under different royalties during this period. Timber extraction (selective logging) began on a commercial scale when East-India Company gained control over major part of the area which was major beginning of degradation. During the period of 1950–1970 timber extraction, shifting and *kumri* cultivation (a system of agro-forestry where leaseholders inside forests take care of planted or regenerated saplings while cultivating the land in between) were main disturbance factors of the area. Later these activities were banned in the area, when the area came under Reserve Forest category. But the threats from the surrounding population have increased primarily due to their lower economic status. Local people depend on fuel wood as primary source of energy. Majority of the tribal are heavily depends on firewood for cooking purposes. Apart from that, the small-scale hotels available in the small township Anaikatty also depends firewood as their primary cooking fuel. Scrub jungles were heavily utilized for firewood. Species such as *A. amara*, *A. latifolia*, *C. monoica*, *Mundulea sericea* are the preferred species of firewood. Das and Sarkar (2005) observed that fuelwood demand is inversely related with the socio-economic status of the people. In addition, we have observed signs of illicit felling of timber trees. The increased construction activities outside the reserve forest points out the extraction of timber from the area. Also, direct sighting of cutting of sandal trees (*Santalum album*) were noted three times. Besides, tribal peoples used to cut small timbers (*C. monoica*, *Anogessus latifolia*, *Manilkara roxburghiana*, *Pterocarpus marsupium*, *Diospyros ovalifolia*) and Bamboo poles for building implements from the area. The area is a centre of brick industries and casual labors at brick industries form the major non-farm income for local people. The brick industries and associated infrastructure such as transportation, township (even though small) pose a critical threat to the area. The area is also surrounded by plantations and estates of coconut, banana, sugarcane. The mass worshipping places inside the forest form another disturbance as the associated treck paths, massive cutting of wood for food preparation, plucking of flowers for worship etc cumulatively upset the forest and wildlife.

Grazing was another major source of disturbance as people has taken it as occupation. In earlier periods onwards the *Irulas* settlers were granted a concession to graze their cattle free of charge. High disturbed site experiences grazing from cattle, goat and sheep. Grazing pressure in low disturbed area is low and observes only from cattle mainly nomadic mode of grazing in dry season. Browsing and trampling by livestock especially of goat might be deleteriously affected recruitment of seedling and also promoted soil erosion in the area. Cattle favor palatable species (removal of native species as they are palatable) and leaving the non-palatable weed species and thus promotes invasion of weedy species. The area has been invaded by weeds such as *L. camara*, *C. odorata*, *Parthenium hysterophorous*, *Opuntia dileii*, *Ageratum coenozoides. Prosopis juliflora* started invading in the forest boarders and high disturbed areas. Even though *L. camara* is the abundant and common weed in the area, some pockets of low disturbed habitat escaped the invasion of the species. The NTFP collection forms 12% of income in the local community (Purushothaman 2004). NTFP mainly includes species such as *Acacia sinuata*, *Phyllanthus emblica*, *Sapindus emarginatus*, *Solanum anguvii*, *Terminalia chebula*, *Phoenix sylvestre*, *Tribulus terrestris*, *Curculigo orchioides* and honey. Tubers of *Dicoscoria* spp., *Gloriosa suberba* were extensively taken by the people by digging out the forest floor. People used to fire the area in dry seasons to encourage the sprouting of the leaves of *P. sylvestre* which is a NTFP. Small scale of fire by local hunters and tuber collectors of *Dicoscoria* spp., *G. suberba* also observed in the area.

Conclusion

The study highlights that two habitats differed in floristic composition in Anaikatty hills due to various disturbance factors. The low disturbed habitat harbors a 'specialist' community where as high disturbed stand holds a 'generalist' community. The low disturbed stand provided habitat for 61 primary forest species. We assume if the disturbance factors are increased these species would be wiped out from the system which results into local extinction of this species from Anaikatty hills. For such species an urgent species recovery programme have to be implemented to prevent the local-extinction. Further researches have to be carried out to understand the reproductive ecology of these primary forest species.

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