# COMMUNITY COMPOSITION AND TREE POPULATION STRUCTURE IN UNDISTURBED AND DISTURBED TROPICAL SEMI-EVERGREEN FOREST STANDS OF NORTH-EAST INDIA

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**Abstract** Species composition, density, importance value index, diversity, dominance and tree population structure were studied in disturbed and undisturbed stands of tropical semi-evergreen forest in Lunglei District of Mizoram, North-East India. Total number of species in the undisturbed stand was 67 while in the disturbed stand 63 species were recorded. Number of tree and shrub species in the undisturbed stand were higher (32 and 18) than the disturbed stand (17 and 16). However, the number of herbaceous species remained higher in the disturbed stand (30) compared to the undisturbed stand (17). *Castanopsis tribuloides* (Smith) was common in both stands, and showed dominance in the undisturbed stand with a density of 90 individuals' $ha^{-1}$. However *Schima wallichii* (DC.) Korth Choicy was dominant in the disturbed stand with a density of 125 individuals' $ha^{-1}$. In both stands higher dbh classes showed lower density than that of the lower and intermediate girth classes. In general, the undisturbed forest stand showed more density of trees in each dbh classes and the intermediate girth class in particular. The study reveals that the anthropogenic disturbance causes disruption of forest structure and changes community composition which ultimately leads to disruption of tree population structure.
**Key words:** *Dominance, Species diversity, Floristic composition, Forest structure, Girth class*

## Introduction

The structure of plant as well as animal communities in many natural ecosystems is largely influenced by the disturbances, frequently occurring in the system naturally or due to anthropogenic activities [2, 6, 16, 33]. In many of these systems, disturbances change overall community structure [54, 60] which in turn can ultimately affect community and population dynamics. The importance of disturbance for maintaining community composition [15, 21, 43] and determining population dynamics [37, 49, 50, 58] has been well recognized in the tropical and extra-tropical systems. Disturbances also have profound effect on the regeneration of non-pioneer under storey trees [33]. [10] viewed disturbance as a negative force that destroys climax assemblages and brings instability in the system, while [28, 36, 42] considered it as a positive force that might increase species diversity in the community by preventing competitive exclusion by dominant species. Species richness has been related to the occurrence of natural disturbance by several authors [22, 28, 45].

Apart from disturbances, climate, especially precipitation also play significant role in species composition and structure [4, 11, 19]. The diameter distribution of trees has been often used to represent the population structure of forests [31, 40, 51].

Configuration of curves has also been correlated with successional status of forests [20, 51] and degree of tolerance to shade [63]. In this study, we assessed the overall species composition and tree population structure in an undisturbed and disturbed tropical forest stands of Mizoram, North-East India.

## Materials and methods

### *Study Site*

The study was carried out in two forest stands, one disturbed and the other relatively undisturbed stands of tropical semi-evergreen forest [9], located in Lunglei District, Mizoram, North-East India. The disturbed stand is located at Hminlokawn (latitude 22°51´30´´N and longitude 92° 47´0´´ E) *ca*. 9 km north of the undisturbed stand located at Zobawk (latitude 22$^{o}$ 47´30´´ N and longitude 92° 47´50´´ E) and the sites are *ca.* 230 km south of Aizawl, the capital city of Mizoram. The undisturbed stand is about 25 years old natural forest stand (local source) which is preserved by the village community of Zobawk (*ca.* 16 km from the Lunglei town) from any type of anthropogenic interruption in the natural forest growth except negligible non timber forest products collection by the local community for their sustenance. While the disturbed stand is situated in the outskirt of Lunglei (*ca.* 8 km from the town), which is experiencing high degree of disturbance in terms of various anthropogenic activities such as fire wood collection, timber logging and grazing etc. Each of the selected forest stands covers an area of more than about 25 ha of land.

The climate is monsoonic under the direct influence of the south-west monsoon, with marked seasonal variation in temperature and rainfall. Depending on the variation in temperature and other climatic conditions, three seasons *viz.* winter (November-February), spring (March-May), rainy/summer season (Jun-October) are observed in the area as is in other parts of the state. The cold or winter season starts from November and lasts till February with comparatively lower temperature (11-23 °C) and very less rainfall. The rainy season or summer, the longest season (nearly 6 months) starts in the second part of May with interrupted showers, and incessant rain begins in June and continues till September and ends in the last part of October. During this season temperature remains high (temperature ranged between 22-34 °C). Normally July and August are the most precipitated months, receiving about 40% of the annual rainfall; while December and January are the driest months. During 2004 and 2005 the area received 4,076 mm and 2,773 mm of rainfall respectively [1]. The mean minimum and maximum temperature were 15.5 and 26.5 °C, respectively, and relative humidity varied between 41 and 89%.

## Methodology

To study the community composition and other phytosociological characteristics of the vegetation at the selected sites, thorough field surveys were conducted during June 2002- May 2003 for site selection and quadrat study. Phytosociological attributes of each species were studied by randomly laying 50 quadrats of 10 x 10 $m^2$ sizes, for trees (≥10 cm dbh.) and 5 x 5 $m^2$ quadrats for shrubs, 20 quadrates of 1 x 1 $m^2$ for herbaceous species at each of the selected forest stands. Total 240 quadrats were laid (120 quadrates at each sites) covering entire study area to minimize sampling error. The size and the number of quadrats were determined following [30, 38]. Floristic composition, density, diversity, dominance, distribution and tree population structure were studied according to [38, 39, 56]. From the relative values the importance value index (IVI) was calculated according to [12]. All the plants encountered in the quadrates were identified with the help of herbaria and different flora viz. Flora of Assam, Flora of British India and Flora of Arunachal Pradesh etc. The data collected were also used to compute community indices such as Sorensen's similarity index [59], Shannon-Wiener's diversity index [55], and Pielou's evenness index [46].

## Results

Both stands showed high floristic composition (*Tables 1-2*). IVI distribution curve (*Figure 1*) showed that the disturbed stand had higher dominance or low evenness while the undisturbed stand had lower dominance or higher evenness among trees and shrubs. Total number of species in the undisturbed stand was 67 while in the disturbed stand 63 species were recorded. Total density of plants was 2,84,510 individuals $ha^{-1}$ and 1,04,030 individuals $ha^{-1}$ in the disturbed and undisturbed stands respectively. Higher density in the disturbed stand is due to the predominance of herbaceous species with high densities. Number of tree species in the undisturbed stand was 32 while in the disturbed stand it was 17. Number of shrub species was higher in the undisturbed stand (18) than in the disturbed stand (16). Nonetheless, the number of herbaceous species remained higher in the disturbed stand (30) than in the undisturbed stand (17). *Castanopsis tribuloides* was common in both stands, and showed dominance in the undisturbed stand with a density of 90 individuals' $ha^{-1}$. *Schima wallichii* was dominant in the disturbed stand with a density of 125 individuals' $ha^{-1}$. The canopy of the forest is composed of both evergreen and deciduous broad-leaved trees, whose height reached not more than 25 m. The species were distributed in four strata, *viz.*, canopy layer, sub-canopy layer, shrub layer and herbaceous layer.

The canopy layer (height>10 m) was dominated by *Castanopsis tribuloides* in the undisturbed stand and *Schima wallichii* in the disturbed stand. *Castanopsis tribuloides* is also present in large numbers in the disturbed stand. In the undisturbed stand *Engelhardtia spicata, Cinnamomum obtusifolium*, *Macaranga indica*, *Elaeocarpus robusta* and *Sapium baccatum* were more in number after *Castanopsis tribuloides*. In the disturbed stand this layer consists of *Schima wallichii, Castanopsis tribuloides* and *Macaranga indica*. The sub-canopy layer (3-10 m height) was composed mainly of *Cinnamomum glaucescens, Alseodaphne petiolaris*, and *Helicia robusta* besides few other species in the undisturbed stand whereas in the disturbed stand *Wendlandia grandis*, *Cinnamomum glaucescens,* and *Eurya symplocina* were the main component species. The canopy and sub-canopy trees together forms a continuous dense cover in the undisturbed stand, except for few gaps formed here and there due to natural disturbances like tree falls etc. In the disturbed stand, the continuity was interrupted by different sizes of gaps created by tree falls mostly due to anthropogenic activities.

The shrub layer was dominated by *Derris wallichii* in the disturbed stand, and by *Pinanga gracilis* in the undisturbed stand. *Rubus birmanicus, Rhynchotechum ellipticum, Morinda angustifolia, Maesa montana* and *Milletia pachycarpa* were also present in large number in the disturbed stand. *Areca triandra, Acacia pinnata, Smilax ovalifolia, Derris wallichii, Calamus guruba* and *Lonicera macaranda* are the main component species besides *Pinanga gracilis* in the shrub layer of the undisturbed stand. Lianas and other woody climbers and twiners were quite common in both forest stands.

***Table 1.*** *Density (plants ha$^{-1}$) and importance value index (IVI) of component species in the two tropical semi-evergreen forest stands. (Species rating based on IVI shown in parenthesis)*

| Species | Undisturbed | | | Disturbed | | |
|---|---|---|---|---|---|---|
| | Density | TBC | IVI | Density | TBC | IVI |
| **Trees** | | | | | | |
| *Actinodaphne obovata* (Nees) Bl. | 15 | 52.65 | 3.72 (32) | - | - | - |
| *Alseodaphne petiolaris* (Mwiaan.) Hook. f. | 40 | 232.46 | 10.99 (6) | - | - | - |
| *Callicarpa arborea* Roxb. | 10 | 26.39 | 2.28 (37) | - | - | - |
| *Castanopsis indica* Roxb. ex Lindley | 10 | 149.63 | 5.08 (24) | - | - | - |
| *Castanopsis tribuloides* Smith | 90 | 688.60 | 27.70 (1) | 60 | 583.19 | 35.13 (20) |
| *Celtis australis* L. | 15 | 61.90 | 3.91 (29) | 25 | 71.96 | 9.21 (9) |
| *Cinnamomum glaucescens* (Nees) Meissn | 70 | 358.04 | 16.83 (3) | - | - | - |
| *Cinnamomum obtusifoluim* (Roxb.) Nees. | 45 | 170.33 | 10.42 (8) | - | - | - |
| *Cinnamomum zeylanicum* Bl. | 30 | 114.73 | 6.63 (19) | - | - | - |
| *Diospyros toposia* Buch-Ham. | 5 | 46.43 | 1.90 (40) | - | - | - |
| *Drimycarpus racemosus* Hook. | 5 | 6.06 | 0.98 (49) | 10 | 33.39 | 3.87 (23) |
| *Dysoxylum macrocarpum* Roxb. | 30 | 86.12 | 7.01 (16) | - | - | - |
| *Dysoxylum procera* Hiem. | 10 | 25.88 | 2.27 (39) | - | - | - |
| *Elaeocarpus robusta* var.*grandis F. Muell* | 40 | 205.2 | 10.88 (7) | 5 | 14.33 | 1.84 (29) |
| *Engelhardtia spicata* Bl. | 15 | 109.99 | 5.02 (25) | 25 | 137.33 | 12.73 (6) |
| *Eriobotrya bengalensis* (Roxb.) Hook. f. | 10 | 116.42 | 4.33 (26) | - | - | - |
| *Eugenia cumini* (L.) Druce | 5 | 22.99 | 1.36 (44) | - | - | - |
| *Eurya symplocina* Bl. | - | - | - | 35 | 123.81 | 13.03 (5) |
| *Ficus prostrata* Wall. ex. Miquel | - | - | - | 10 | 84.67 | 5.90 (16) |
| *Garcinia morella* (Gaertn.) Desr. | 5 | 21.80 | 1.34 (45) | - | - | - |
| *Glycosmis pentaphylla* (Retz.) Correa | - | - | - | 10 | 38.71 | 4.08 (21) |
| *Helicia robusta* Roxb. | 25 | 66.56 | 5.21 (22) | - | - | - |
| *Ilex godajam* (Colebr.) Wall. Ex. Hook. f. | 20 | 164.02 | 7.09 (15) | - | - | - |
| *Leea indica* (Burm. f.) Merr. | 5 | 4.08 | 0.93 (50) | - | - | - |
| *Litsea polyantha* Juss. | 10 | 15.99 | 1.72 (42) | 15 | 40.15 | 5.41 (18) |
| *Litsea semecarpifolia* (Wall.) Hook. f. | 15 | 50.04 | 3.15 (34) | - | - | - |
| *Macaranga indica* Wight. | 35 | 141.22 | 8.07 (13) | 45 | 206.93 | 18.88 (3) |
| *Mitragyna diversifolia* (Hook. f.) | - | - | - | 10 | 33.54 | 3.87 (22) |
| *Myristica linifolia* (Roxb.) Warburg. | 20 | 82.29 | 5.40 (21) | - | - | - |
| *Olea dioca* Roxb. | - | - | - | 5 | 7.36 | 1.56 (30) |
| *Phoebe attenuata* (Nees.) Nees. | 10 | 92.06 | 3.78 (30) | - | - | - |
| *Quercus xylocarpa* Kurz. | 40 | 316.26 | 12.37 (4) | - | - | - |
| *Randia wallichii* Hook. f. | - | - | - | 10 | 39.08 | 4.09 (20) |
| *Rhus sucedánea* L. | - | - | - | 10 | 28.37 | 3.66 (25) |
| *Sapium baccatum* Roxb. | 55 | 494.47 | 18.43 (2) | - | - | - |
| *Schima wallichii* (DC.) Korth. Choicy | 35 | 220.91 | 9.88 (10) | 125 | 933.45 | 60.31 (1) |
| *Styrax polysperma* Clarke in Hook. f. | 30 | 173.49 | 8.48 (12) | - | - | - |
| *Styrax serrulatum* Roxb. | 15 | 16.26 | 2.90 (36) | 10 | 25.29 | 3.55 (26) |
| *Syzygium sp.* | - | - | - | 25 | 68.54 | 9.07 (11) |
| *Wendlandia grandis* (Hook. f.) Cowan. | 10 | 25.98 | 2.27 (38) | - | - | - |
| **Shrubs** | | | | | | |
| *Acacia caesia* L. | 10 | 0.25 | 1.17 (46) | 45 | 0.94 | 9.14 (10) |
| *Acacia pinnata* L. | 55 | 0.09 | 5.14 (23) | - | - | - |
| *Acmenosperma claviflorum* Roxb. Kausal. | - | - | - | 5 | 2.21 | 1.36 (31) |
| *Anodendron paniculatum* A. DC. | 20 | 0.26 | 3.38 (33) | - | - | - |
| *Areca triandra* Roxb. Wx Buch. Ham. | 70 | 1.49 | 7.19 (14) | - | - | - |
| *Arenga pinnata* (Wurmb) Merr | 20 | 4.34 | 2.95 (35) | - | - | - |
| *Bauhinia anguina* (Roxb.)H. Ohadhi | 25 | 2.33 | 3.75 (31) | 35 | 1.62 | 5.56 (27) |
| *Bauhinia tenuiflora* G. Watt ex C. B. Clarke (basionym) | - | - | - | 20 | 0.07 | 4.31 (19) |
| *Calamus guruba* Ham. | 80 | 1.70 | 9.39 (11) | - | - | - |


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| | | | | | | |
|---|---|---|---|---|---|---|
| *Caryota urens* L. | 15 | 0.20 | 1.50 (43) | - | - | - |
| *Derris wallichii* Prain | 85 | 13.77 | 9.99 (9) | 15 | 10.26 | 17.00 (4) |
| *Entada pursaetha* DC. | - | - | - | 30 | 2.02 | 6.93 (15) |
| *Litsea angustifolia* Wall. Ex. Hook. F. | 45 | 1.72 | 5.56 (20) | 15 | 0.15 | 3.82 (24) |
| *Lonicera sp.* | 50 | 5.09 | 6.99 (17) | - | - | - |
| *Maesa montana* A. DC. | - | - | - | 50 | 1.23 | 8.88 (12) |
| *Melastoma nepalensis* Lodd. | - | - | - | 5 | 0.09 | 1.27 (32) |
| *Millitia sp.* | 10 | 0.18 | 1.17 (47) | 40 | 0.52 | 7.86 (13) |
| *Morinda angustifolia* Roxb. | - | - | - | 40 | 0.64 | 7.09 (14) |
| *Phlogacanthus tubiflorum* Nees | 10 | 0.01 | 1.17 (48) | - | - | - |
| *Pinanga gracilis* (Rox.) Bl. | 105 | 2.86 | 11.05 (5) | - | - | - |
| *Rhynchotechum ellipticum* (Wall. ex. D. Dietr) A. DC. | 40 | 0.22 | 4.17 (27) | 65 | 0.18 | 10.32 (8) |
| *Rubus birmanicus* Hook. f. | - | - | - | 85 | 0.42 | 12.31 (7) |
| *Sauraria sp.* | 10 | 3.45 | 1.76 (41) | - | - | - |
| *Schefflera venulosa* (Wight & Arn.) Harms. | - | - | - | 5 | 0.09 | 1.27 (33) |
| *Smilax ovalifolia* Roxb. | 65 | 0.16 | 6.83 (18) | - | - | - |
| *Spatholobus roxburghii* Benth. | 40 | 0.19 | 4.17 (28) | - | - | - |
| *Tabernaemontana divaricota* (L.) R.Br.ex.Roem &Schdult | - | - | - | 15 | 0.29 | 3.05 (28) |

- indicates species absence

The number of herbaceous species differed between the two stands. The undisturbed stand harbors lesser number of herb species as compared to the disturbed stand. *Hedychium coccineum* is common in both stands, but it is out-numbered by *Selaginella sp*. and *Digitaria adscendens* in the disturbed stand. The ground vegetation is very less and sparse under canopy whereas it is dense in the forest floor of gaps.

The density of tree seedlings and saplings also varied between the two stands (*Table 3*). The saplings of *Castanopsis tribuloides* were abundant in the undisturbed stand followed by saplings of *Cinnamomum glaucescens*. In the disturbed stand, saplings of *Schima wallichii* were abundant, followed by saplings of *Wendlandia grandis* and *Castanopsis tribuloides*.

Shannon's Species Diversity Index shows that the undisturbed stand have higher diversity (H′=3.1461) as compared to that of the disturbed stand (H′ =2.2881). Pielou's Evenness Index also reveals that the undisturbed stand has more consistency in species distribution. Undisturbed stand had higher evenness index (E=0.7565) while the disturbed stand had lower evenness (E= 0.6488) (*Table 4*). Sorensen's similarity indices between the two stands revealed that these stands have similarities to some extent in species composition which is more prominent in shrub component than the trees (*Table 4*).

In both stands higher dbh classes showed lower density (*Table 7 and Figure 2*) than that of the lower and intermediate girth classes. A similar trend of straight line relationship between density and diameter (negative exponential curve) was observed in the undisturbed and disturbed forest stands. However, intermediate girth class (21-20cm) showed more density than that of lower dbh (10-20 cm) in the two stands (Figure 2). In both forest stands, trees with intermediate dbh class (21-20 cm) showed highest density per ha than all other dbh classes. Individuals of the lowest dbh class (10-20 cm) showed higher tree density per hectare after intermediate dbh class in both undisturbed and disturbed forest stands followed by other dbh classes in the order of 31-40 cm > 41-50 cm > 51-60 cm in the two stands. In the disturbed stand high dbh (51-60 cm) individuals were found to be as much as those of the undisturbed stand. In general, the undisturbed forest stand showed more density of trees in each dbh classes, particularly


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the intermediate girth class, except the individuals with highest girth class (61-70 cm) was absent in this stand which were found in the disturbed stand only.

***Table 2.*** *Density (plants $ha^{-1}$ x $10^3$) and importance value index (IVI) of herbs component species in the two (Undisturbed and disturbed) tropical semi-evergreen forest stands.*

| Species | Undisturbed | | Disturbed | |
|---|---|---|---|---|
| | Density | IVI | Density | IVI |
| *Ageratum conyzoides* L. | - | - | 1.70 | 3.23 |
| *Bidens pilosa* L. | - | - | 1.50 | 18.48 |
| *Blumea lanceolaria* (Roxb.) Druce | - | - | 0.35 | 7.32 |
| *Cissampelos pareira* L. | 0.05 | 2.50 | 0.15 | 1.97 |
| *Commelina benghalensis* L. | 0.40 | 10.29 | - | - |
| *Curculigo capitulate* (Lour) Kuntze | 0.60 | 29.78 | 0.10 | 2.80 |
| *Cynodon dactylon* (syn) *Panicum dactylon* (L) pers. | - | - | 0.75 | 8.37 |
| *Cyperus rotundus* L. | - | - | 0.75 | 12.97 |
| *Dalbergia tamariscifolia* Cav. | 0.55 | 19.35 | - | - |
| *Dioscoria alata* L. | - | - | 0.85 | 9.16 |
| *Digitaria adscendens* (HBK) Henr. | - | - | 2.95 | 12.67 |
| *Diplazium esculentum* (Retz) Sw. | 0.30 | 5.13 | - | - |
| *Dryopteris sp.* | - | - | 0.20 | 1.99 |
| *Eupatorium adenophorum* Spreng | - | - | 0.30 | 4.27 |
| *Eupatorium riparium* Regel | - | - | 1.10 | 10.68 |
| *Eupatorium odoratum* L. | - | - | 0.85 | 17.56 |
| *Gleichenia sp.* | 0.90 | 15.39 | - | - |
| *Hedychium coccineum* Buch.-Ham.ex.Sm. | 2.40 | 99.93 | 1.05 | 23.82 |
| *Hedyotis scandens* Roxb. | 0.15 | 5.66 | 0.20 | 3.63 |
| *Imperata cylindrical* (L.) Beauv. | - | - | 2.00 | 10.85 |
| *Ipomea sp.* | - | - | 0.30 | 3.85 |
| *Lygodium flexosum* (L.) Sw. | - | - | 0.10 | 2.20 |
| *Mikania micrantha* HBK | - | - | 0.50 | 6.94 |
| *Oxalis corniculata* L. | - | - | 0.10 | 1.24 |
| *Panicum sp.* | 0.55 | 11.21 | 0.70 | 5.66 |
| *Paspalum sp.* | - | - | 2.35 | 15.64 |
| *Passiflora nepalensis* Wall. | - | - | 0.10 | 2.95 |
| *Phrynium capitatum* Willd. | 1.55 | 29.43 | - | - |
| *Piper longum* L. | 0.35 | 10.25 | 0.65 | 14.95 |
| *Polygonum sp.* | - | - | 0.45 | 7.06 |
| *Pteridium sp.* | 0.40 | 16.83 | - | - |
| *Pueraria subspicata* (Benth.) Maesen | 0.30 | 9.46 | 0.05 | 1.26 |
| *Scoparia dulcis* L. | - | - | 1.70 | 12.29 |
| *Selaginella sp.* | 0.30 | 6.79 | 4.40 | 27.27 |
| *Themeda arundinacea* Roxb. | 0.10 | 2.94 | - | - |
| *Thysanolaena maxima* O.ktze | 1.25 | 21.76 | 1.45 | 16.80 |
| *Urena lobota* L. | - | - | 0.70 | 13.41 |

- indicates species absence


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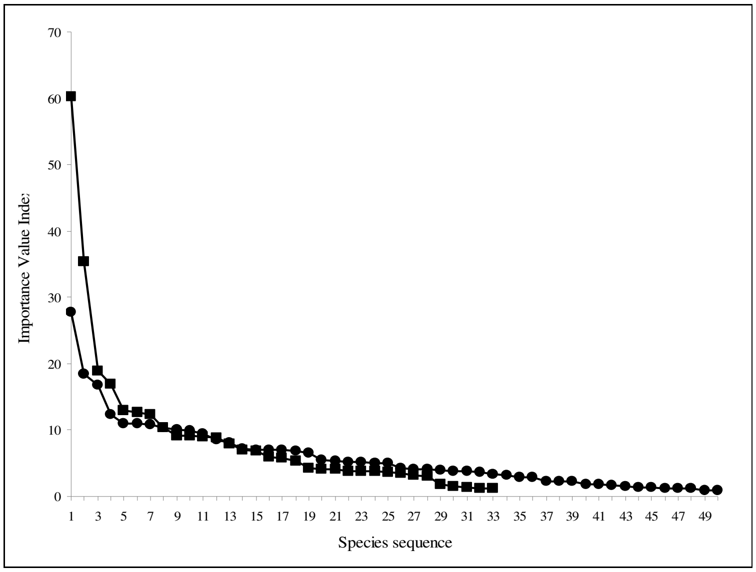


***Figure 1.*** *IVI distribution among tress and shrubs in the disturbed (■) and undisturbed (●) forest stands*

***Table 3.*** *Density of tree seedlings (plants ha$^{-1}$ x 10$^{3}$) and saplings (plants ha-1) during peak growth period (August- September, 2005) in the undisturbed and disturbed forest stands*

| **Species** | **Undisturbed** | | **Disturbed** | |
|---|---|---|---|---|
| | **Seedlings** | **Sapling** | **Seedlings** | **Sapling** |
| *A. petilorais* | - | 30 | - | - |
| *C. tribuloides* | 1.85 | 35 | 1.60 | 35 |
| *C. australis* | 0.10 | 10 | 0.40 | 30 |
| *C. glaucescens* | 0.25 | 30 | 0.85 | 25 |
| *C. obtusifoluim* | 0.45 | 15 | - | 15 |
| *C. zeylanicum* | 1.65 | 20 | 0.70 | - |
| *D. racemosus* | - | - | 0.10 | - |
| *D. macrocarpum* | 0.40 | 10 | - | - |
| *E. robusta* | 0.35 | 5 | - | 10 |
| *E. spicata* | 0.25 | 5 | 0.30 | 30 |
| *E. cumini* | 1.10 | 25 | 1.05 | 40 |
| *E. symplocina* | - | - | 0.15 | 10 |
| *L. indica* | 0.05 | - | - | 5 |
| *L. polyantha* | - | 5 | - | - |
| *M. indica* | - | - | 1.20 | 15 |
| *M. linifolia* | 0.75 | 20 | - | - |
| *O. peniculata* | - | - | - | 5 |
| *P. attenuata* | - | - | - | 5 |
| *R. wallichii* | - | - | - | 30 |
| *R. sucedánea* | - | - | - | 5 |
| *S. baccatum* | - | 15 | - | - |
| *S. wallichii* | 1.60 | 10 | 7.90 | 95 |
| *S. polysperma* | 0.15 | - | - | - |
| *S. serrulatum* | - | - | - | 10 |
| *S. saligna* | - | - | 0.20 | - |
| *W. grandis* | - | 5 | 0.80 | 50 |

- indicates species absence

***Table 4.*** *Community indices of trees and shrubs in the two forest stands*

| Community indices | Source of variation | Index value |
|---|---|---|
| Sorensen's similarity index | Trees | 36.73 |
| | Shrubs | 41.18 |
| Shannon's diversity index | Undisturbed | 3.1461 |
| | Disturbed | 2.2881 |
| Pielou's evenness index | Undisturbed | 0.7565 |
| | Disturbed | 0.6488 |

***Table 5***. *DBH distribution of tree species in the undisturbed stand*

| Species | Family | Dbh class | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | 10-20 | 21-30 | 31-40 | 41-50 | 51-60 | 61-70 | |
| *A. obovata* | Lauraceae | 1 | 2 | - | - | - | - | 3 |
| *A. petiolaris* | Lauraceae | 3 | 3 | - | 2 | - | - | 8 |
| *C. arborea* | Verbenaceae | 1 | 2 | - | - | - | - | 3 |
| *C. indica* | Fagaceae | - | - | - | 2 | - | - | 2 |
| *C. tribuloides* | Fagaceae | 3 | 6 | 5 | 3 | 1 | - | 18 |
| *C. australis* | Ulmaceae | 1 | 2 | - | - | - | - | 3 |
| *C. glaucescens* | Lauraceae | 7 | 2 | 4 | - | - | - | 13 |
| *C. obtusifoluim* | Lauraceae | 3 | 5 | 1 | - | - | - | 9 |
| *C. zeylanicum* | Lauraceae | 3 | 2 | 1 | - | - | - | 6 |
| *D. toposia* | Ebenaceae | - | - | 1 | - | - | - | 1 |
| *D. racemosus* | Anacardiaceae | 1 | - | - | - | - | - | 1 |
| *D. macrocarpum* | Meliaceae | 4 | 2 | - | - | - | - | 6 |
| *D. procera* | Meliaceae | 1 | 1 | - | - | - | - | 2 |
| *E. robusta* | Tiliaceae | 1 | 5 | 2 | - | - | - | 8 |
| *E. spicata* | Juglandaceae | - | 1 | 2 | - | - | - | 3 |
| *E. bengalensis* | Rosaceae | - | - | 1 | 1 | - | - | 2 |
| *E. cumini* | Myrtaceae | - | 1 | - | - | - | - | 1 |
| *G. morella* | Guttiferae | - | 1 | - | - | - | - | 1 |
| *H. robusta* | Proteaceae | 3 | 2 | - | - | - | - | 5 |
| *I. godajam* | Ilicineae | - | 2 | 1 | 1 | - | - | 4 |
| *L. indica* | Ampelidaceae | 1 | - | - | - | - | - | 1 |
| *L. polyantha* | Lauraceae | 2 | - | - | - | - | - | 2 |
| *L. semecarpifolia* | Lauraceae | 1 | 2 | - | - | - | - | 3 |
| *M. indica* | Euphorbiaceae | 2 | 4 | 1 | - | - | - | 7 |
| *M. linifolia* | Myristicaceae | 1 | 2 | 1 | - | - | - | 4 |
| *P. attenuata* | Lauraceae | - | 1 | - | 1 | - | - | 2 |
| *Q. xylocarpa* | Fagaceae | 3 | - | 3 | 2 | - | - | 8 |
| *S.. baccatum* | Euphorbiaceae | 3 | 3 | 2 | 1 | 2 | - | 11 |
| *S. wallichii* | Theaceae | 2 | 3 | - | 2 | - | - | 7 |
| *S. polysperma* | Styraceae | 2 | 2 | 1 | 1 | - | - | 6 |
| *S. serrulatum* | Styraceae | 3 | - | - | - | - | - | 3 |
| *W. grandis* | Rubiaceae | 1 | 1 | - | - | - | - | 2 |
| Total number of trees | | **53** | **57** | **26** | **16** | **3** | **-** | **155** |


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***Table 6.*** *DBH distribution of tree species in the disturbed stand*

| **Species** | **Family** | **Dbh class** | | | | | | **Total** |
|---|---|---|---|---|---|---|---|---|
| | | **10-20** | **21-30** | **31-40** | **41-50** | **51-60** | **61-70** | |
| *C. tribuloides* | Fagaceae | 4 | 3 | 1 | 2 | 1 | 1 | 12 |
| *C. australis* | Ulmaceae | 3 | 2 | - | - | - | - | 5 |
| *D. racemosus* | Anacardiaceae | 1 | 1 | - | - | - | - | 2 |
| *E. robusta* | Tiliaceae | 1 | - | - | - | - | - | 1 |
| *E. spicata* | Juglandaceae | 1 | 2 | 2 | - | - | - | 5 |
| *E. symplocina* | Theaceae | 3 | 4 | - | - | - | - | 7 |
| *F. prostrata* | Moraceae | - | - | 2 | - | - | - | 2 |
| *G. pentaphylla* | Rubiaceae | 1 | 1 | - | - | - | - | 2 |
| *L. polyantha* | Lauraceae | 2 | 1 | - | - | - | - | 3 |
| *M. indica* | Euphorbiaceae | 2 | 5 | 2 | - | - | - | 9 |
| *M. diversifolia* | Rubiaceae | 1 | 1 | - | - | - | - | 2 |
| *O. dioca* | Oleaceae | 1 | - | - | - | - | - | 1 |
| *R. wallichi* | Rubiaceae | - | 2 | - | - | - | - | 2 |
| *R. sucedanea* | Anacardiaceae | 1 | 1 | - | - | - | - | 2 |
| *S. wallichii* | Theaceae | 6 | 11 | 4 | 2 | 2 | - | 25 |
| *S. serrulatum* | Styraceae | 1 | 1 | - | - | - | - | 2 |
| *S. saligna* | Myrtaceae | 3 | 2 | - | - | - | - | 5 |
| Total number of species | | **31** | **37** | **11** | **4** | **3** | **1** | **87** |

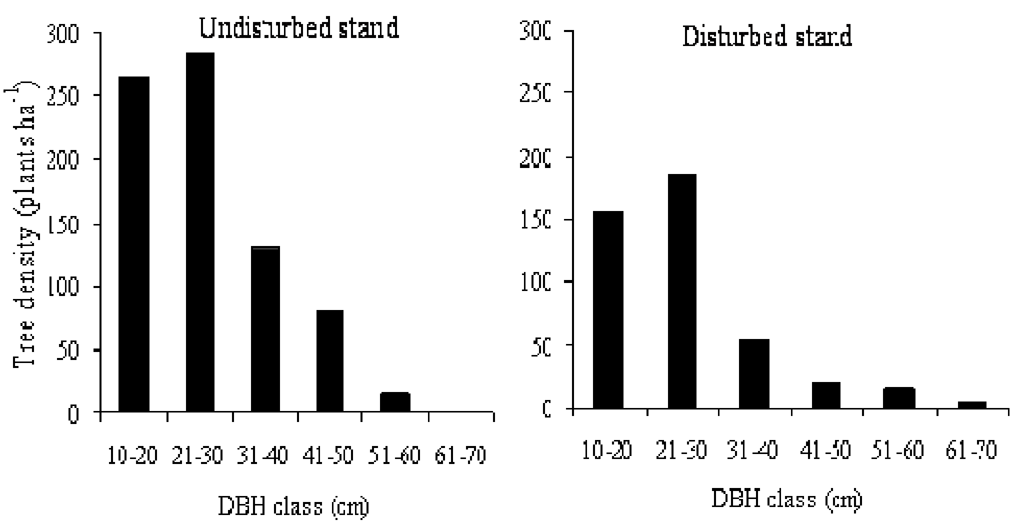


***Figure 2****. Density-diameter distribution of trees in the two forest stands.*


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***Table 7**. Species wise density diameter distribution of tree species in the two stands*

| **Species** | **Undisturbed** | | | | | **Disturbed** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Dbh (cm)** | | | | | **Dbh (cm)** | | | | | |
| | **15** | **25** | **35** | **45** | **55** | **15** | **25** | **35** | **45** | **55** | **65** |
| *A. obovata* | 5 | 10 | - | - | - | - | - | - | - | - | - |
| *A. petiolaris* | 15 | 15 | - | 10 | - | - | - | - | - | - | - |
| *C. arborea* | 5 | 10 | - | - | - | - | - | - | - | - | - |
| *C. indica* | - | - | - | 10 | - | - | - | - | - | - | - |
| *C. tribuloides* | 10 | 30 | 25 | 15 | 5 | 20 | 15 | 5 | 10 | 5 | 5 |
| *C. australis* | 5 | 10 | - | - | - | 15 | 10 | - | - | - | - |
| *C. glaucescens* | 35 | 10 | - | 20 | - | - | - | - | - | - | - |
| *C.obtusifoluim* | 15 | 25 | 5 | - | - | - | - | - | - | - | - |
| *C. zeylanicum* | 15 | 10 | 5 | - | - | - | - | - | - | - | - |
| *D. toposia* | - | - | 5 | - | - | - | - | - | - | - | - |
| *D. racemosus* | 5 | - | - | - | - | 5 | 5 | - | - | - | - |
| *D.macrocarpum* | 20 | 10 | - | - | - | - | - | - | - | - | - |
| *D. procera* | 5 | 5 | | - | - | - | - | - | - | - | - |
| *E. robusta* | 5 | 25 | 10 | - | - | 5 | - | - | - | - | - |
| *E. spicata* | - | 5 | 10 | - | - | 5 | 10 | 10 | - | - | - |
| *E. bengalensis* | - | - | 5 | 5 | - | - | - | - | - | - | - |
| *E. cumini* | - | 5 | - | - | - | - | - | - | - | - | - |
| *E. symplocina* | - | - | - | - | - | 15 | 20 | - | - | - | - |
| *F. prostrata* | - | - | - | - | - | - | - | 10 | - | - | - |
| *G. morella* | - | 5 | - | - | - | - | - | - | - | - | - |
| *G. pentaphylla* | - | - | - | - | - | 5 | 5 | - | - | - | - |
| *H. robusta* | 15 | 10 | - | - | - | - | - | - | - | - | - |
| *I. godajam* | - | 10 | 5 | 5 | - | - | - | - | - | - | - |
| *L. indica* | 5 | - | - | - | - | - | - | - | - | - | - |
| *L. polyantha* | 10 | - | - | - | - | 10 | 5 | - | - | - | - |
| *L. semecarpifolia* | 5 | 10 | - | - | - | - | - | - | - | - | - |
| *M. indica* | 10 | 20 | 5 | - | - | 10 | 15 | 10 | - | - | - |
| *M. diversifolia* | - | - | - | - | - | 5 | 5 | - | - | - | - |
| *M. linifolia* | 5 | 10 | 5 | - | - | - | - | - | - | - | - |
| *O. dioica* | - | - | - | - | - | 5 | - | - | - | - | - |
| *P. attenuata* | - | 5 | - | 5 | - | - | - | - | - | - | - |
| *Q. xylocarpa* | 15 | - | 15 | 10 | - | - | - | - | - | - | - |
| *R. wallichii* | - | - | - | - | - | - | 10 | - | - | - | - |
| *R. sucedanea* | - | - | - | - | - | 5 | 5 | - | - | - | - |
| *S. baccatum* | 15 | 15 | 10 | 5 | 10 | - | - | 10 | - | - | - |
| *S. wallichii* | 10 | 15 | - | 10 | - | 30 | 55 | 20 | - | 10 | - |
| *S. polysperma* | 10 | 10 | 5 | 5 | - | - | - | - | - | - | - |
| *S. serrulatum* | 15 | - | - | - | - | 5 | 5 | - | - | - | - |
| *S. saligna* | - | - | - | - | - | 15 | 10 | - | - | - | - |
| *W. grandis* | 5 | 5 | - | - | - | - | - | - | - | - | - |

- indicates species absence

## Discussion

Disturbance whether of natural or anthropogenic activities, leads to creation of different niches for the establishment and onward growth of tree seedlings. The results of the present study are in conformity with the findings of [48], in general, that community composition changes with disturbance. The importance of disturbance for maintaining community composition has been studied in a variety of ecosystems [15, 26, 41]. In many of these systems either increasing or decreasing disturbance changes overall community structure [54, 60]. In both stands species diversity and richness is very high as compared to other tropical forests [47].

Treefall gaps, created due to lopping and felling of trees for fuel wood, fodder forage and grazing [32], offer specialized regeneration conditions to prevailing spatial and microenvironmental heterogeneity [3]. Canopy-gaps, created by disturbances, and resulting spatial variability in under-storey light conditions have played a prominent role in expansion of forest diversity [7, 53, 57]. Such heterogeneities have been considered by many workers to be of fundamental importance in the maintenance and promotion of high tree diversity in tropical forest communities [2, 14, 28]. Our study, however, doesn't have conformity with these views. The undisturbed stand showed higher species richness and diversity as compared to that of the stand undergoing disturbance, as far as tree populations are concerned. Density and frequency are also higher in the undisturbed stand. The findings are, rather, in conformity with the view held by [10], who viewed disturbance as a negative force that destroys climax assemblages and brings instability in the system. The results also conforms the findings of [48], who found that species diversity and abundance markedly declined from undisturbed to the disturbed stands, in their study on the community composition and tree population structure of three forest stands of different degree of disturbance in the sub-tropical broad-leaved forest of Meghalaya, India.

Theoretical analyses often predict a peak in species diversity at intermediate disturbance intensity or frequency [28], although characteristic of the disturbance and the system may influence this response [44]. Thus, the disturbed stand of the present study can be considered as of high disturbance intensity as it contains lower species diversity and tree density particularly of intermediate girth class. It may be argued that the characteristics of the system and type of disturbance might be responsible for this trend [48].

Variation in the density of forest understories across sites is important for the maintenance of tree diversity as they can compete with the seedlings of trees [25, 65, 67] and could lead to ambiguous evidence for the importance of canopy gaps in maintaining tree diversity [5, 23]. [2], in their study on changes in species richness and abundance with experimental disturbance in old field plant communities, observed that the impact of disturbance on species richness depends largely on the nature of the dominance and rates of successional or seasonal change of the community. They also concluded that disturbances have positive impact in maintaining species richness in herbaceous systems.

Herbaceous species increased in number in the disturbed stand, and outnumbered the tree and shrub species in the disturbed stand supporting the view of [2]. [62] found that space created by small canopy gaps and environmental historical factors were of comparable importance for controlling herb species composition and distribution while space was of somewhat greater importance for woody plants, and that the past human land use hand a strong impact on species composition on the Barro Colorado Island of

Panama. [17] also described that the allocation and growth of herbaceous plants can be altered by previous land use, in their experiment with 12 herbaceous plant species in southern Appalachian forest stands of USA. Thus, the higher total species diversity and lower tree species composition in the disturbed stand may be attributed to the stand characteristic allowing the light-demanding herbaceous species to increase, and in turn suppressing the tree seedlings due to competition with the herbaceous species.

The presence of certain pioneer tree species, which are expected to be abundant only in the disturbed or degraded sites (e.g., *Schima wallichii*), in the undisturbed stand may be due to similarity of the stand with the disturbed stand, enhancing the species to invade and establish in it, in the past though no such record has been found. According to [24], exotic species tended to invade the biodiversity '*hot spots'* rich in native species, at a higher degree due to similarity of two sites in resource availability [61], propagule supply [34], disturbance in the past [8], or internal heterogeneity [13]. The presence of pioneer species in undisturbed stand may also be explained by the abundance-occupancy relationship of [18], who described that species increasing in abundance tend to increase in occupancy. *Schima wallichii* have high abundance in the vicinity of the undisturbed stand, and thus have high chance of occupying the undisturbed stand. The undisturbed stand shows high trees and shrubs diversity, where as herbaceous communities are lesser in number as compared to the disturbed stand. The predominance of herbaceous species in the disturbed stand could be attributed to the higher penetration of sun light in the forest floor. The diameter distribution of trees has often been used to represent population structure of forests [31, 40, 51].

Straight line relationship between density and diameter (negative exponential curve) in both stands is in conformity with that of [48, 52]. However, the lower density of lower diameter class (10-20 cm dbh) as compared to intermediate girth class (21-30 dbh) give the appearance of a positively skewed distribution curve, in both stands and can be explained as the result of selective felling of lower as well as higher girth classes in the disturbed stand, while in the undisturbed stand it can be interpreted as due to low tree mortality and lower removal rate across the intermediate diameter classes [51, 66] and lower recruitment of component tree species. The lower density of the higher dbh classes of trees in the undisturbed stand, as compared to intermediate or lower dbh classes, can be attributed to the relatively high mortality of large canopy trees [20, 35]. The above characteristics of girth classes also suggests that the forest is still growing and yet to reach to its climax stage as it is only of about 25 years old forest. The argument is further supported by the presence of highest girth class trees in the disturbed forest stand which might have been a climax forest prior to disturbance.

The present study reveals that the anthropogenic disturbance causes disruption of forest structure and changes species composition which ultimately leads to reduction of tree species, density and frequency which is a major forest component. The increase in species number, density and frequency of herbaceous community due to disturbances causes reduction of tree seed ling establishment growth which ultimately leads to reduction of trees with lower girth class. Thus, it can be suggested that proper management strategies can be adopted for judicious utilization of forest resources including controlled selective felling may reduce the forest degeneration process and enhance sustainable forest production.

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