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Vegetation Characteristics along Disturbance Gradient of Jeypore Reserve Forest of North East India

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Abstract
Forest inventory data were collected in 2012-2015 from Jeypore Reserve Forest of North East India along with disturbance gradient. All trees greater than or equal to 10cm dbh at breast height (1.37 m), shrubs and herbs and climbers were recorded. The total and relative value of each species for density, diversity, dominance and importance value index (IVI) were calculated. A total of 271 species belonging to 194 genera under 112 families have been documented among which 101 trees, 60 shrubs, 62 herbs and 48 climbers' species. The mean density was highest (836 number of individuals ha^{-1}, and 503 number of individuals ha^{-1} for trees and climbers respectively) at the pristine stand (PS) and lowest (253 number of individuals ha^{-1} and 205 number of individuals ha^{-1} for trees and climbers respectively) in degraded stand (DS). Shrubs and herbs shows a reverse trend with lowest value(4700 stems ha^{-1}, 82503 stems $ha^{-1}$for shrubs, herbs respectively) in pristine stand (PS) and highest value (7356 stems ha^{-1}, and 124530 stems ha^{-1} for shrubs and herbs respectively) in degraded stand (DS). For basal area the highest value (77.37 m^2 ha^{-1}) in PS followed by SDS with a value of 63.84 andlowest value (16.35 m^2 ha^{-1}) in DS. For shrubs it shows reverse trend.The total number of individuals/stems, evenness, species richness, diversity *etc.* decreases with the increase of disturbance gradient of the area. Correlation matrix shows diversity index is simply negatively correlated with dominance index.

Keywords: Forest inventory, Jeypore Reserve Forest, Pristine stand, Species richness, Evenness**.**

1. Introduction
Biodiversity is most essential for human survival and economic well-being and for the ecosystem function and stability (Singh, 2002).Political and scientific concerns have been raised as we are experiencing an increase in species extinction rates caused by anthropogenic activities (Ehrlich and Wilson, 1991). Tropical forests are the richest biological communities on earth and this forest have been recognized to harbour a significant population of global biodiversity (Myers et al 2000; Baraloto *et al.,* 2013). This forest provides many ecosystem services such as species conservation, prevention of soil erosion, and preservation of habitat for plants and animals (Armenteras *et al.,* 2009).
In India, habitat destruction, over exploitation, pollution and species introduction are identified as major causes of biodiversity loss (UNEP, 2001). The disturbances created by these factors determine forest dynamics and tree diversity at the local and regional scales (Burslem and Whitmore, 1999; Hubbell *et al.,* 1999); these disturbance has been considered as an important factor structuring communities (Sumina, 1994). According to Sheil (1999) the disturbance of a suitable intensity will increase species richness in old-growth communities in consonance with moderate disturbance hypothesis of Connell (1978), however, Phillips *et al.,* (1997) opined that disturbance cannot increase diversity in genuine old-growth forest. Many literatures reveal necessity of more work for diversity disturbance relationship especially in tropical wet evergreen forest.
In Northeast India, tropical wet evergreen forests are restricted to the far eastern part of the region, particularly Tirap and Changlang districts of Arunachal Pradesh, and Tinisukia and Dibrugarh districts of Assam. It is one of the 25 mega-biodiversity hotspots of the world

(Myers *et al*., 2000). It is characterized by rich vegetation, both in number as well as species density and diversity (Rao and Murti 1990). The forest of this region suffered a lot for its existence due to anthropogenic pressure, indiscriminate timber and fuel wood extraction and clear felling for shifting cultivation or construction (Ramakrishnan *et al*., 1981; Arunachalam *et al*., 2002).If such trends continue and effective conservation measures are not taken, most of the remnant native vegetation will be destroyed or replaced by successional communities (Beniwal and Haridasan, 1992; Menon *et al*., 2001). Therefore a detailed study of impacts of the disturbance on this forest patches was overdue. Quantitative inventories provide information on the diversity and structure of forest ecosystem which helps in conservation and management of the forest. Further an understanding of the forest processes is also necessary on the management of natural and disturbed vegetation (Cogdon and Herbohn 1993) particularly in Jeypore Reserve Forest since it is co-existing with many industries and coal mines, human settlement etc. all around Hence the objective of the present study is to understand the impact of different degree of disturbance on species composition and changes occurring on plant diversity along a disturbance gradient.

2. Material and Methods

The Jeypore reserve forest is the last patch of biodiversity-rich rainforest of Assam (27^0 05'N To 27^0 28'N and 95^0 20'E to 95^0 38'E), spread on both sides of the river Buridihing in the district of Dibrugarh and Tinsukia. It is continuing to the Lohit, Changlang and Tirap districts of Arunachal Pradesh and to the easternmost part of Nagaland.It was once spread over both north and south banks of Brahmaputra towards the foothills of Himalaya. The altitude ranging from 122 m to 475 m above mean sea level. The climate is tropical monsoonal which is characterized by high humidity and a rainfall of 2,226–2,372 mm. The monsoon period last from June to September, where month July is with heaviest rain fall. There is a relatively dry period from November to Feb-ruary. Average temperature ranges from 8°C to 39°C.

In the present study extensive field study has been made in the study area in different seasons (rainy, winter and summer) to access the diversity of plants. The present study is undertaken following grid pattern method. After preliminary survey of the forest, six forest areas viz., Nagfan, Hapjan, Nahorjan, DillighatAkashiganga and Baliasutiand divided into three categories, based on disturbance gradient as degraded stand (DS), semi degraded stand (SDS) and pristine stand (PS).

Vegetation data was collected from all selected sample plots (3 quadrate in each representing forest areas) with a total of 18 plots. Each plot area was gridded into 100 sub plots each (10 m x 10 m) of workable units. These 100 square metresrepresented possible sampling positions, out of which 10 quadratesof 10m x 10m for trees (>10 cm dbh) and climbers, 20 quadrates of 5m x 5m for shrubs, 40 quadrates of 1m x 1m, for herbs were randomly selected. Girth at breast height (above 1.37 m height) of all trees and shrubs were measured. A total of 180, (10x10) quadrats, 360 (5x5) quadrates and 720 (1x1) quadrates were laid for determining the dominance and basal area of species of the study area.All trees were grouped into eight girth classes viz., 30-60, 61-90, 91-120,121-150,151-180,181-210,211-240 and >241 cm.

Relative density, relative basal area and relative frequency as per Phillips (1959).The dominant and co-dominant species of each site were identified on the basis of IVI which is the sum of these three values. The species having highest IVI was defined as dominant and the species having second highest IVI (Curtis, 1959) was defined as co-dominant species. The species diversity were calculated using equations described by Shannon and weaver (1963), index of dominanceas per Simpson (1949).The evenness index was computed as per Pielou (1975)and Species Richness Index was calculated as per Margalef (1958).

3. Results

Overall, 271 species belonging to 198 genera under 112 families have been documented from the study, of which 101 tree species, 60shrub species, 62 herb species (including terrestrial 19 pteridophytes) and 48 climber species (including woody climber and epiphytic climbers).Three most dominant families are Lauraceae (19 sp) followed by Rubiaceae (17 sp) and Euphorbiaceous (13 sp) while thirty four families were represented by single species of the area (Table 1).

A total of 101 tree species (GBH >30 cm) distributed in 63genera and 33 families, out ofwhich 8% species are found common in all three stands viz., *Artocarpus chaplasha, Canarium bengalense, Dipterocarpus retusus, Magnolia hodgsonii, Mesua ferrea, Vatica lanceifolia,Shorea assamica*. In pristine stand (PS) maximum numbers oftree species (71) were recorded which are distributed in 46 genera and 27 families followed by 39 tree species in semi degraded stand (SDS) with a representation of 32 genera and 22 families and in degraded stand (DS) only 22 species were recorded with representation from 21 genera and 19 families. The mean density (Tree h^{-1}) and mean basal area(BA m^2 h^{-1}) varied with disturbance gradient showing a declining trend from Pristine stand to semi degraded stand to degraded stand (Table 1).

Shrubs are found abundantly with 60 species under 51 genera represented from 27 families. Very few species like *Blastus cochinchinensis, Ardisia depressa* are found common in all stands. During the study 32 shrubs species were found in pristine stand followed by 33 species in semi degraded stand and 43 species were found in degraded stand. *Pinanga gracilis* found dominant with a higher IVI (9.53) value in pristine stand whereas *Blastus cochinchinensis* found dominant in both semi degraded and degraded stand with an IVI value 86.20 and 130.75 respectively. Highest density and found in degraded stand (7356 No h^{-1}) followed by semi degraded stand (5647 No h^{-1}) and least density found in (4700 No h^{-1}). In above two parameters shows an increasing trend from pristine stand to semi degraded stand to degraded stand. In terms of basal area it shows maximum value in semi degraded stand (3.68 m^2 h^{-1}) followed by pristine stand (2.86 m^2 h^{-1}) and least basal area coverage (2.54 m^2 h^{-1}) in degraded stand (Table 1).

Altogether 48 species of climbers and lianas species from 32 genus and 23 families were recorded of which 20 species in pristine stand 18 species in degraded stand and 16 species were found in semi degraded stand. In terms of density pristine stand shows highest (503 No h^{-1}) followed by semi degraded stand (304 No h^{-1}) and least value found in (205 No h^{-1}) in degraded stand (Table 1.)The family

Vitaceae and Oleaceae were found among dominant families from the study stands. Sixty two herbaceous species were also recorded from three study stands representing from 52 genus and 32 families. Family Poaceae was found dominant, with maximum number of species and *Pallia subumbellata* of Commelinaceae found dominant species with maximum IVI value (42.93) in all three stands. The density shows increasing trends with the increase of disturbance intensity *i.e.*, it shows lowest value in Pristine stand and highest value in Degraded stand (Table. 1)

Table 1: comparativestand structure of Jeypore Reserve Forest along a disturbance gradient

Stand Types	**Pristine stand (PS)**				**Semi degraded stand (SDS)**				**Degraded stand (DS)**			
Plant forms	Tree	Shrub	Herb	Climber	Tree	Shrub	Herb	Climber	Tree	Shrub	Herb	Climber
No of Species	71 ± 6.55	32 ± 2.64	22 ± 2.0	20 ± 1.8	39 ± 4.68	38 ± 4.12	22 ± 1.96	16 ± 1.24	22 ± 3.12	43 ± 5.32	25 ± 2.18	18 ± 1.24
Density(No h-1)	836.53 ± 11.78	4700 ± 545.02	82503 ± 9000.26	503 ± 24.20	478.5 ± 26.85	5647 ± 834.26	102564 ± 19250.56	304 ± 17.55	253.52 ± 18.30	7356 ± 724.55	124530 ± 20544.28	205 ± 12.56
Basal area (m^2 h^{-1})	77.37 ±1.09	2.86 ± 0.28	-	-	63.84 ± 2.79	3.68 ± 1.42	-	-	16.35 ± 1.50	2.542 ± 0.46	-	-

Table 2:Ecological dominance of top ten tree species (based on IVI) for jeypore Reserve Forest

S.No	**Plant species**	**Family**	**BA (m^2 h^{-1})**	**Density (Tree h^{-1})**	**IVI**	**A/F**
1	*Dipterocarpus retusus* Bl	Dipterocarpaceae	16.00	210.00	51.92	2.10
2	*Vatica lanceifolia* Blume.	Dipterocarpaceae	15.27	128.33	26.71	1.28
3	*Mesua ferrea* L.	Clusiaceae	4.42	66.67	18.85	0.67
4	*Shorea assamica* Dyer.	Dipterocarpaceae	9.56	41.67	15.58	0.60
5	*Crypteronia paniculata* Bl	Lythraceae	7.05	3.33	7.64	1.20
6	*Dillenia indica* L.	Dilleneaceae	0.45	7.50	7.24	0.52
7	*Canarium bengalense* Roxb	Burseraceae	1.51	13.33	7.07	0.30
8	*Myristica longifolia*.Wall	Myristicaceae	0.47	13.33	7.00	1.20
9	*Artocarpus chaplasha* Roxb.	Moraceae	2.14	10.00	6.13	0.90
10	*Sapium baccatum* Roxb.	Euphorbiaceae	3.32	1.67	6.09	0.60

Girth class distribution of tree species among three stands shows a sharp declining trend from lower girth class to higher girth classes in all stands. The trees under girth class (GBH 30-60 cm) range found predominant with 54.46% in Pristine stand (PS) followed by 42.81% in Semi degraded stand (SDS) and 66.32% in Degraded stand (DS). Maximum GBH (645 cm) found in Crypteronia paniculata followed by 630 cm (GBH) in Focus sp in pristine stand. Distribution of different girth classes in three stands are depicted in in Fig. 1

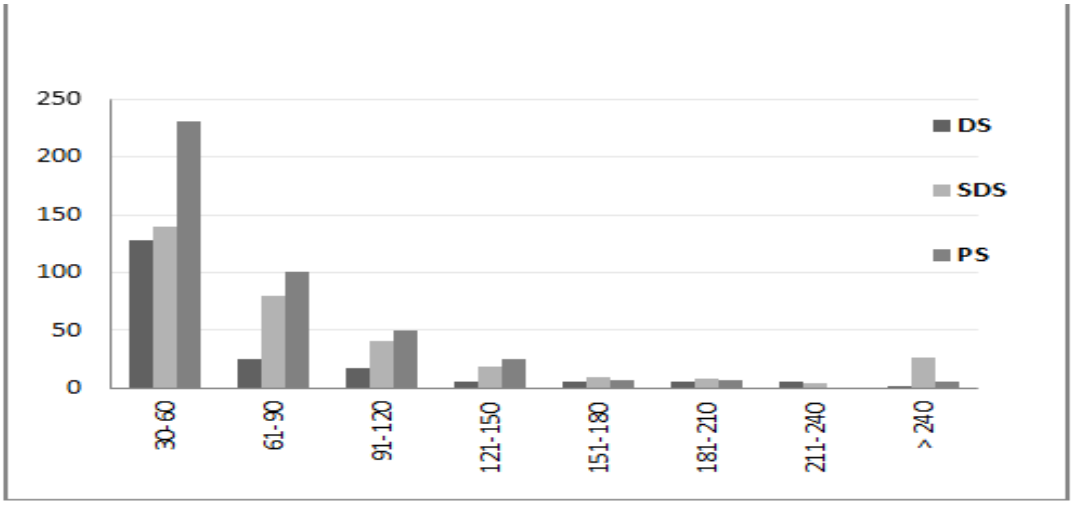

Fig.1: Population density of tree species across girth class intervals (>30 cm GBH) in among stands.

Correlation among plant forms in three stands

In pristine stand, tree was significantly positive correlation with shrub (r=1.000), herb (r=1.000) at the 0.01 level and climber (r=0.999) at the 0.05 level. Shrub was significantly positive correlated with herb (r= 1.000) at the 0.01 level and with Climber (r= 0.999) at the 0.05 level while herb was significantly positive with climber (r= 0.999) at the 0.05 level.In semi degraded stand, tree was significantly positive correlation with shrub (r=1.000), herb (r=1.000) and climber (r=0.998) at the 0.05 and 0.01 level respectively. Shrub was significantly positive correlated with herb (r= 1.000) at the 0.01 level and climber (r= 0.999) at the 0.05 level while herb was significantly positive correlated with climber (r= 0.999) at the 0.05 level.In degraded stand, tree was significantly positive correlation with shrub (r=0.999), herb (r=0.999) and climber (r=1.000) at the 0.05 level. Shrub was significantly positive correlated with herb (r= 1.000) at the 0.01 level and

Climber (r= 0.997) at the 0.05 level while herb was insignificant positive correlated with climber (r= 0.997).

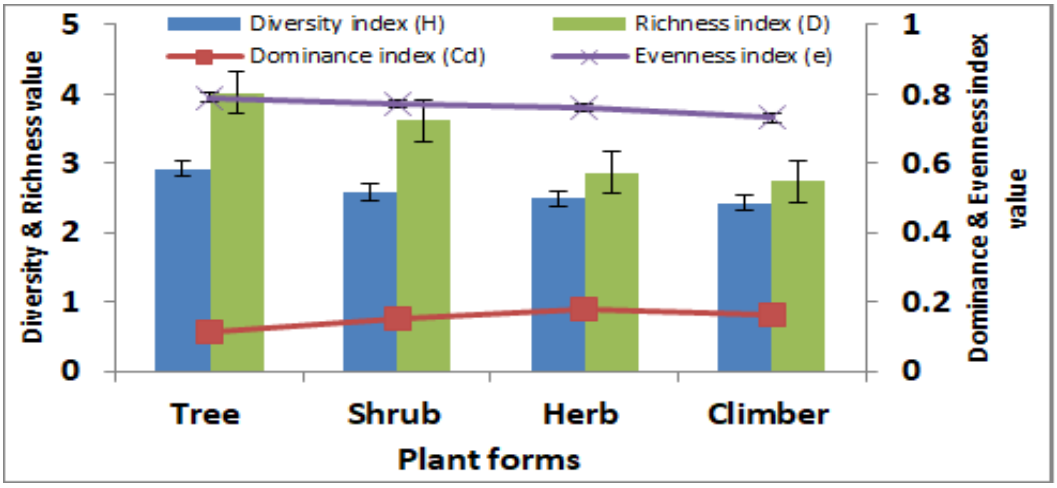

Fig.2: (a). Diversity indices of different plant forms in Pristine stand

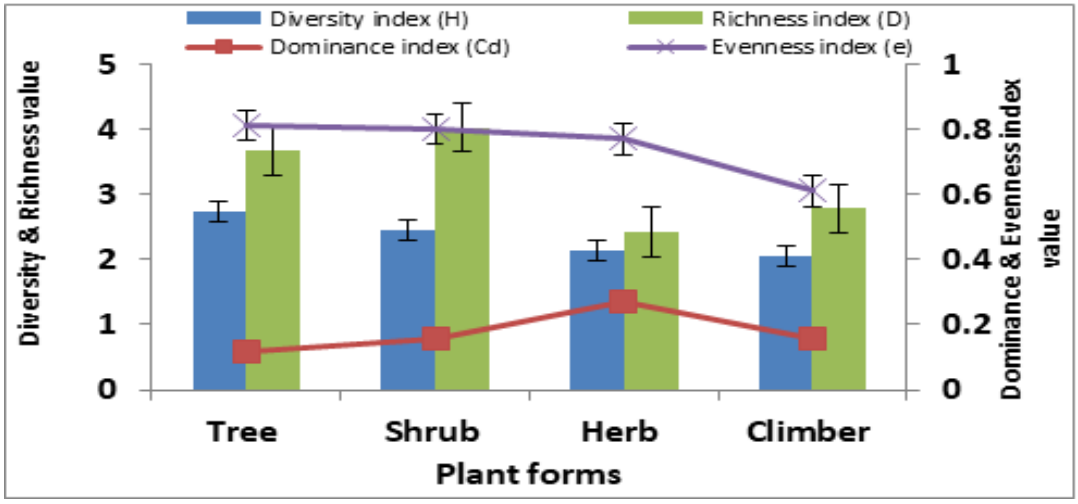

Fig.2 (b): Diversity indices of different plant forms in semi degraded stand

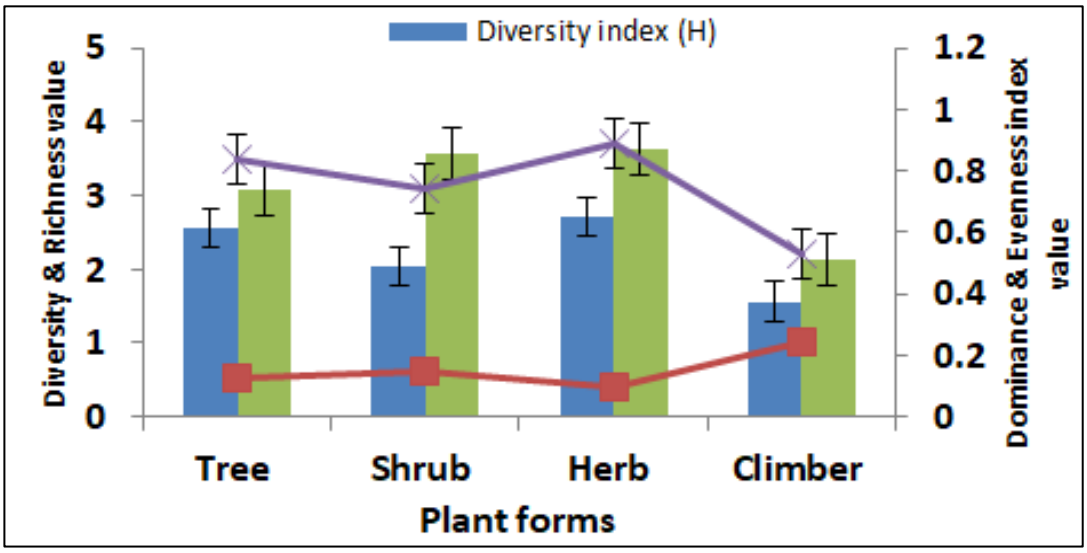

Fig.2 (c): Diversity indices of different plant forms in degraded stand

Table: Average plant species, density (No ha^{-1}), Basal area (m^2 ha^{-1}) and diversity indices of different plant forms in different disturbance stand.

Correlation among different indices in three stands

In pristine stand, diversity index was simply negatively correlated with dominance index (r=-0.504), while, positively correlated with richness index (r=0.917) and evenness index (r=0.889).Dominance index was negatively correlated with richness index (r=-0.427) and Evenness index (r=-0.084) while, richness index was also positively correlated with Evenness index (r=.0.903). There was no any significant correlation among the diversity indices.

Table 3: Correlation matrix of diversity indices for different plant form in pristine stand

	Diversity index (H)	Dominance index (Cd)	Richness index(D)	Evenness index (e)
Diversity index (H)	1			
Dominance index (Cd)	-0.504	1		
Richness index (D)	0.917	-0.427	1	
Evenness index (e)	0.889	-0.084	0.903	1

**Correlation is significant at the 0.01 level (2-tailed).*Correlation is significant at the 0.05 level (2-tailed).

Table 4: Correlation matrix of diversity indices for different plant form in semi degraded stand

	Diversity index (H)	Dominance index (Cd)	Richness index(D)	Evenness index (e)
Diversity index (H)	1			
Dominance index (Cd)	-0.603	1		
Richness index (D)	0.797	-0.713	1	
Evenness index (e)	0.756	0.036	0.539	1

** Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed)

In semi degraded stand, diversity index was simply negatively correlated with dominance index (r=-0.603) while, positively correlated with richness index (r=0.797) and evenness index (r=0.756).Dominance index was negatively correlated with richness index (r=-0.713) and positively correlated with evenness index (r=0.036). Richness index was positively correlated with evenness index (r=0.539). There was no any significant correlation among the diversity indices

Table 5: Correlation matrix of diversity indices for different plant form in degraded stand

	Diversity index (H)	Dominance index (Cd)	Richness index(D)	Evenness index (e)
Diversity index (H)	1			
Dominance index (Cd)	-0.952(*)	1		
Richness index (D)	0.742	-0.909	1	
Evenness index (e)	0.981(*)	-0.992(**)	0.851	1

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

In degraded stand, diversity index was significantly negatively correlated with dominance index (r=-0.952), significantly positive with evenness index (r=0.981) and insignificant with richness index (r=0.742).Dominance index was negatively correlated with richness index (r=--0.909) and significantly negatively correlated with evenness index (r=-0.992). Richness index was also positively correlated with evenness index (r=0.851).

4. Discussion and Conclusion:

The findings of the present study reveals that all three stand had a highly heterogeneous distribution of trees, shrubs, herbs and climbers. Such forest can be considered as highly diverse forests in the Eastern Himalaya (Singh and Singh 1987). It has been confirmed that the level of disturbance due to anthropogenic interference in the forest changes species diversity, density and basal area (Rao *et al.*, 1990; Mishra *et al.*, 2003).The tropical rainforest are rich in species density (Paijamans, 1970; Hubbell, 1979) and its diversity is affected by many factors (Connell, 1971; Hubbell, 1979; Parthasarathy, 1999). High density and basal areas were observed in pristine stand as it is experience with very minimal or zero anthropogenic interference. Lowest density and basal area found in degraded stand as maximum human interference taken place in those areas.

Total 101 tree species recorded in the study which is within the range of 20-223 species per hacter in a tropical rainforest (Whitmore. 1984). The number (101 Species) of tree species is greater than (54 species) Bhuyan *et al*,. (2003), (94 species) Nath *et al.*, (2005) tropical wet evergreen forest of Arunachal Pradeshwhereas lesser than tropical wet evergreen forest (144 species) ofWestern Ghats (Parthasarathy 1999). Tree density of pristine stand (836 h^{-1}) is much higher than that of (496 ha^{-1}, Chanderashekara and Ramakreishnan. 1994; 482 ha^{-1}, Parthasarathy and karthikeyan, 1997a; 586 ha^{-1}, Okuda *et al.*, 2003) Southern India and slightly higher (720 $ha^{-1;}$ Parthasarathy 1999) than Western Ghats.

Presence of small number of unique species in degraded forest stands and decrease in total numbers of species across disturbance gradient may reflect high utilization pressure (Bhat *et al.*, 2000). Common occurrence of *Artocarpus chaplasha, Canarium bengalense, Dipterocarpus retusus, Magnolia hodgsonii, Mesua ferrea, Vatica lanceifolia, Shorea assamica, Blastus cochinchinensis,Ardisia depressa* in all stands denotes their tolerance to biotic pressure and wide ecological amplitude. In semi degraded stand trees with low girth class are predominant because of theircontinuous anthropogenic pressure.

The density of shrubs observed lowest in pristine stand and highest in degraded stand because of non-availability of sufficient sunlight. Lowest density observed in case of herbaceous species as sunlight rarely reach to the ground layer because of closed canopy and highest in degraded stand because of sufficiently open canopy. Climbers were observed more or less equal numbers in all three stands with higher lianas species in pristine stand.

Except pristine stand all stands are facing tremendous biotic pressure due to timber and firewood collection. Although the forest areas come under reserve forest, indiscriminate tree cutting for timber and firewood is still continuing by local people for their livelihood as well as for business purposes. Moreover many people establishing tea gardens after cleaning forest areas unauthorisely leads to rapid decrease of actual forest area. Earlier days it was a treasure of many species of rattans but in my study rattans were rarely observed in core part of the forest only as a result of continuous collection by vendors for business purposes.

Jeypore Reserve Forest gaining immense importance in recent times as it is one of the important Forest, of North East India, comes under of Tropical wet evergreen Forest bearing all characters of rain forest. Inventorization and analysis of above all parameters may help in understanding the ecological significance of the species of the forest. The attention on people's participation is very much essential for effective monitoring and sustaining the plants diversity of Jeypore Reserve Forest of Assam.

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