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RESEARCH ARTICLE

PLANT DIVERSITY AND COMMUNITY CHARACTERISTICS IN DIFFERENT DISTURBANCE REGIME IN SINGPHAN WILDLIFE SANCTUARY, NAGALAND, INDIA

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ABSTRACT

Species diversity and community structure of tropical wet evergreen forest of Singphan Wildlife Sanctuary was studied in three disturbance regime i.e., highly disturbed (HD), moderately disturbed (MD) and undisturbed (UD). A total of 185 species representing 159 genera belonging to 86 families were recorded. The species richness (trees, herbs and shrubs) was found to be highest (59 species) in UD followed by MD and HD. The total basal area was recorded highest (131.5 m^2 ha^{-1}) in UD followed by HD and MD. The stand density of the woody species was found highest (408 individuals ha^{-1}) in HD followed by UD and MD. Tree density was recorded highest (1,726 individual ha^{-1}) in UD followed by HD and MD. The basal area contribution of the forest was maximum (131.5 m^2ha^{-1}) in UD stand followed by HD (119.6 m^2ha^{-1}) and lowest in MD (67.9 m^2ha^{-1}).The Shanon Weiner diversity Index of trees was found highest (3.24) in MD followed by UD and HD. Thus the study revealed that the species diversity (trees, saplings and seedlings) in the wildlife Sanctuary decreases with increased in the intensity of disturbances.

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INTRODUCTION

The vegetation in hilly area is subjected to both natural and manmade disturbances. The natural disturbances have long term influenced on the structure and stability of forest (Stephens, 1956; Wright, 1974; Sprugel, 1976; Oliver, 1981). The manmade disturbance affect the forest ecosystem drastically and also changes the species diversity, tree density and total basal area of forest (Mishra *et al.,* 2003, Singh 1998, Rao *et al.,* 1990). Nowadays, the anthropogenic pressure has tremendously increased due to population growth and other related factor to a greater extent in India. It not only affects the conventional forest area but also the protected area (PA) in many parts of northeastern region of India (Chatterjee *et al*., 2006). The Singphan wildlife Sanctuary, located in Nagaland, is rich in floral and faunal diversity, which is also considered as a home to elephants and other wild animals. Unfortunately, the PA was under constant anthropogenic pressure since its inception (Anon 2011a). Though the PA was initially notified as a reserve forest (Anon 2011a), however various anthropogenic pressure were reported viz., coal mining, diversion of forest land to non-forest activity, etc.

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In 2009, some part of the reserve forest was further notified as a wildlife Sanctuary (Anon, 2009). Unfortunately, the wildlife Sanctuary was under constant anthropogenic pressure due to the presence of network of roads within the PA, which was used frequently by the villagers of the fringe villages. Besides, the PA also sharing interstate boundary with Aboypur Reserve Forest of Assam (Anon, 2011b). The illicit felling and free grazing practice were some of the detrimental human activities that may have affected the structure and crop composition of forest. In Singphan wildlife Sanctuary, till date no ecological studies were conducted. The present study aims to investigate the plant diversity and community characteristics with regard to anthropogenic disturbance viz. high disturbed forest (HD), moderately disturbed forest (MD) and undisturbed forest (UD) of Singphan wildlife Sanctuary. The study was undertaken during October 2013 to May 2014.

MATERIALS AND METHODS

In Singphan wildlife Sanctuary, three disturbance site were selected based on anthropogenic pressure i.e., highly disturbed forest (HD), moderately disturbed forest (MD) and undisturbed forest (UD). The disturbance index was calculated as DI = Total number cut stumps ÷ Total number of individuals of all species including cut stumps x 100 (Rao *et al*., 1990).

Each disturbance regime in wildlife Sanctuary was studied by random sampling technique. In HD, 27 quadrats were laid, UD (23 quadrats) and MD (15 quadrats). The woody species were studied through 10m x 10m quadrat; shrubs (5m x 5m); and herbs or seedling (1m x 1m). The diameter at breast height (DBH) or girth at breast height (GBH) was measured at 1.37m height. All plant individuals having >30 cm GBH were considered as wood species; individuals having 10 – 30 cm GBH were considered as saplings; and individuals having less than 1m height were taken as seedlings. The associated plant species were collected and photographed for identification.

forest i.e., Whitford's index by Whitford (1948); the species richness of the vascular plants i.e., Menhinicks index (d) by Magurran (1988); Shannon and Wiener index by Shannon and Wiener (1963); Soren's similarity Index and Simpson dominance index by Simpson (1949).

RESULTS AND DISCUSSION

In Singphan wildlife Sanctuary, 185 species of 159 genera belonging to 86 families were recorded from the three disturbance categories (HD, MD and UD), which is lesser than

Table 1. Species richness index, Density (individuals ha^{-1}), Shanon Weiner Diversity index and Simpson Index for trees in SWL, Nagaland

	UD	MD	HD
Tree			
Species richness (S)	37	36	46
No of Genera	30	32	25
No of Families	25	23	22
Menhinick's Species richness index (d)	1.91	2.53	2.23
Shannon Weiner Diversity Index (D)	3.22	3.24	2.87
Simpson Dominance index	0.05	0.05	0.14
Density (individuals ha^{-1})	1726	1280	1511
Basal area (m^{2}ha^{-1})	131.5	67.9	119.6
Shrub (including sapling of trees)			
Species richness (S)	59	49	33
No of Genera	53	47	30
No of Families	33	31	24
Menhinick's Species richness index (d)	0.74	1.09	0.59
Shannon Weiner Diversity Index (D)	3.82	3.72	3.75
Simpson Dominance index	0.027	0.028	0.03
Density (individuals ha^{-1})	27326	13913	11604
Herbs (including seedling of trees)			
Species richness (S)	80	75	65
No of Genera	78	72	63
No of Family	53	52	42
Menhinick's Species richness index (d)	1.47	1.84	1.29
Shannon Weiner Diversity Index (D)	4.07	3.92	3.75
Simpson Dominance index	0.023	0.028	0.035
Density (individuals ha^{-1})	13165	11107	9174

Table 2. Similarity Index (%) of trees, shrub and herb species between different study stands

Study stands		Highly disturbed				Moderately disturbed				Undisturbed			
		A	T	S	H	A	T	S	H	A	T	S	H
HD	A	1.00	-	-	-	0.43	-	-	-	0.32	-	-	-
	T	-	1.00	-	-	-	0.22	-	-	-	0.31	-	-
	S	-	-	1.00	-	-	-	0.65	-	-	-	0.7	-
	H	-	-	-	1.00	-	-	-	0.69	-	-	-	0.68
MD	A	0.43	-	-	-	1.00	-	-	-	0.42	-	-	-
	T	-	0.22	-	-	-	1.00	-	-	-	0.51	-	-
	S	-	-	0.65	-	-	-	1.00	-	-	-	0.79	-
	H	-	-	-	0.69	-	-	-	1.00	-	-	-	0.67
UD	A	0.32	-	-	-	0.42	-	-	-	1.00	-	-	-
	T	-	0.31	-	-	-	0.52	-	-	-	1.00	-	-
	S	-	-	0.7	-	-	-	0.79	-	-	-	1.00	-
	H	-	-	-	0.68	-	-	-	0.67	-	-	-	1.00

A – All species, T – Trees, S – Shrubs and H – Herbs

Herbariums were prepared as per Jain and Rao (1977). Identification of the plants was done through published literatures and Flora of Assam (Kanjilal *et al*., 1934-40). Important community parameters such as frequency, density, abundance, basal area and important value index (IVI) of all the plant species were calculated by following the methodology of Misra (1968) and Muller–Dombios and Ellenberg (1974). Similarly, species abundance model was calculated by Magurran (1988); the distribution patterns of the species in the

(200 species) tropical wet evergreen forest of Namdapha National Park, Arunachal Pradesh (Nath *et al*., 2005). However, the plant species richness in the present study was higher than (157 species) Katarniaghat Wildlife Sanctuary (Tripathi *et al*., 2009); (144 species) tropical wet evergreen forest of Kalakad National Park in Western Ghats which (Parthasarathy 1999); (129 species) Terai – Bhabar forest in Katarniaghat Wildlife Sanctuary, located in Nanpara Tehsil of district Bahraich, U.P (Chauhan *et al*., 2008); and (54 species)

tropical wet evergreen forest of Arunachal Pradesh (Bhuyan *et al*., 2003). Of these, 71 were tree species (≥ 30cm GBH) representing 59 genera belonging to 34 families; 37 species were shrubs (22 families and 34 genera); and 37 species were herbs representing 44 families. The highest number of species were recorded (144) including tree, shrub and herbs representing 129 genera under 75 families in UD as compare to MD (122 species with 114 genera belonging to 72 families) and HD (121 species with 121 genera under 66 families). However, highest (46) tree species were recorded in HD followed by (37) tree species in UD and (36) tree species in MD. The species diversity of shrubs and sapling of trees was found highest in UD (59), followed by MD (49) and UD (33). Similar trend was found in herbs and seedling of trees category. The species diversity in this category was found highest in UD (80), followed by MD (75) and HD (65) (Table no. 1). However, Nath *et al*. (2005) reported 94 tree species, 45 shrubs and 61 herbs belonging to 73 families from tropical wet evergreen forest of Namdapha National Park, Arunachal Pradesh.

The tree density was found highest (1,726 individual ha^{-1}) in UD followed by HD (1,511 individual ha^{-1}) and MD (1,280 individual ha^{-1}) (Table no. 1). In HD, the tree species consists of *Adina sp., Dipterocarpus macrocarpus, Castanopsis indica, Schima wallichii, Phoebe cooperiana,* etc. Similarly, in UD tree species consists of *Castanopsis indica, Canarium resiniferum, Phoebe goalparensis*, *Sapium baccatum, Ficus lepidosa,* etc. and in MD, *Adina sp., Artocarpus chaplasha, Gmelina arborea, Syzygium cumini, Sapium baccatum* etc. were the trees species composition. The tree density in the present study was higher than (34 – 610 individuals ha^{-1}) the tropical wet evergreen forest of Namdapha National Park, Arunachal Pradesh (Nath *et al*., 2005); (852 - 965 individuals ha^{-1}) tropical evergreen forest of Sengaltheri, Western Ghats (Parthasarathy, 2001); and (860 – 1370 individuals ha^{-1}) tropical wet evergreen forest of the Agasthyamalai Region of Kerala, Western Ghats (Varghese, 1999). However some workers have reported much higher density (860 – 1950 individuals ha^{-1}) from tropical wet evergreen forest of Kalakad National Park in Western Ghats (Parthasarathy, 1999).

In shrubs category, the maximum density of individuals per hectare was found in UD i.e., 27,326 individual ha^{-1} followed by MD (13,913 individual ha^{-1}) and lowest in HD (1604 individual ha^{-1})**.** The density of shrub in the present study range from 11,604–27,326 individuals ha^{-1} which is much higher than (4,540 - 13,280 individuals ha^{-1}) from tropical wet evergreen forest of Namdapha National Park, Arunachal (Nath *et al*., 2005) and (5500 – 1645 individuals ha^{-1}) from tropical wet evergreen forest of the Agasthyamalai Region of Kerala, Western Ghats (Varghese and Manon, 1999). Herbs also show similar trend, maximum density (13,165 individual ha^{-1}) in UD stand followed by MD (11,107 individual ha^{-1}) and lowest in HD (91,74 individual ha^{-1}) (Table no. 1). The density of herb species in the present study ranges from 9,174 – 13,165 individuals ha^{-1} which is much lower than (69,600 – 254,334 individuals ha^{-1}) Namdapha National Park, Arunachal Pradesh (Nath *et al*., 2005). The total basal area was found highest in UD (131.5 m^2 ha^{-1}) followed by HD (119.5 m^2 ha^{-1}) and MD (67.8 m^2 ha^{-1}) (Table no.1). It was due to the presence of high density of large size trees like *Artocarpus lakoocha*, *Castanopsis indica, Phoebe goalparensis, Sapium baccatum* etc. in UD. Similarly, *Castanopsis indica, Dipterocarpus macrocarpus, Mesua ferrea, Shorea robusta, Schima wallichii* etc. in HD stand and *Artocarpus chaplasha, Castanopsis indica, Gmelina arborea, Mimosa elata, Ficus lepidosa,* etc. in MD. The basal area in the present study is much higher than basal area of stands between 7.8–98.6 m^2 ha^{-1} reported from tropical evergreen forest of Namdapha National Park, Arunachal Pradesh (Nath *et al*., 2005); 29.34 – 93.47 m^2 ha^{-1} reported from Agasthyamalai Region of Kerala, Western Ghats (Varghese *et al*., 1999); 55.34 – 67.2 m^2 ha^{-1} reported from the tropical evergreen forest of Sengaltheri, Western Ghats (Parthasarathy, 2001).

In HD stand, 100% of the total species recorded exhibits clumped distribution and in UD, 76% shows clumped distribution, random distribution (18%) and regular distribution (2%). In MD stand, 62% shows clumped distribution and 37% exhibits random distribution (Table no. 2). Dominance of the species was assigned based on the calculated IVI values. In HD, *Dipterocarpus macrocarpus* was the dominant species with highest IVI (105.39) followed by species *Schima wallichii* (20.12), *Shorea robusta* (17.68), *Adina sp.* (16.97), *Castanopsis indica* (10.52), etc. The shrub layer and herb layer was dominated by *Achyranthes aspera* (16.30) and *Cyperus rotundus* (19.9), respectively. In UD, *Castanopsis indica* (38.81) was dominant tree species followed by *Schima wallichii* (24.95), *Ficus lepidosa* (20.81), *Sapium baccatum* (18.51), etc. while in the shrub and herb layer, the dominant species were *Clerodendron viscosum* (13.91) and *Cyperus rotundus* (15.28), respectively. The *Gmelina arborea* was the dominant tree species in MD stand with highest IVI (30.82) followed by *Syzygium cumini* (25.32), *Phoebe cooperiana* (22.88), *Stereospermum personatum* (20.07), *Ficus lepidosa* (18.87) etc. while *Elshtonia fruticosa* was the dominant shrub (12.30*)* and *Cyperus rotundus* dominates the ground vegetation (15.42).

The girth class distribution of woody species has been grouped into six categories i.e. 15 – 50 cm, 51 – 85 cm, 86 – 120 cm, 121 – 155 cm, 156 – 200 cm and > 200 cm. The density girth - class distribution of woody species result shows that about 22 % of the total density of HD was constituted by the lower girth class i.e. 15 – 50 cm and it has increased to 58% and 55% in UD and MD respectively. While HD shows 25% density distribution in 51 – 85 cm girth class, UD and MD increase to 27% and 30% respectively. However HD shows highest maximum density in girth class 86 – 120 cm, by 26% it decreases in MD and UD by 9% and 10% respectively. In girth class 121 – 155 cm, HD show maximum density distribution by 15% while it decreases on MD and UD by 3% each. Surprisingly in girth class 156 – 200 cm, HD show 35% of the density distribution while in UD, it is only 1% and MD it is recorded only 2%. In the high girth class i.e. >200cm, 4% of the total density of UD shows maximum density distribution as compared to MD with only 1% and nil in HD. In the present study, the species richness of the vegetation followed the trend as herb layer > shrub layer > tree layer, which is similar to Nath *et al*. (2005) have reported from tropical wet evergreen forest of Namdapha National Park. Fabaceae and Lauraceae is the most dominant family in the study site followed by

Apocynaceae, Asteraceae, Moraceae and Zingiberaceae. Nath *et al*. (2005) have also reported similar dominant families (Asteraceae and Lauraceae) from tropical wet evergreen forest of Namdapha National Park, Arunachal Pradesh. Thus the trend of diversity (trees, saplings and seedlings) in the present study decreases with increased in the intensity of disturbances.

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