International Journal of Multidisciplinary Approach and Studies ISSN NO:: 2348 – 537X

Comparison of Tree Vegetational Parameters Within and Outside a Protected Area of Kumaun

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ABSTRACT:

Increasing anthropogenic pressure and dependence on plant products have has let to widespread exploitation of natural forest in Uttarakhand Himalaya. The study area is located between 29^{0} 24' and 29^{0} 26' N latitude and 78^{0} 53' and 78^{0} 59' E longitude between 280 and 370 m elevation in Uttarakhand Himalaya. A total of 17 tree species were present in different forest, out of which 8 species existed in disturbed site and 11species in least disturbed site. Total tree density ranged from 250.3-340 trees/100 m^{2} and total basal area from 18.1-76.15 m^{2}/ha across the disturbance, which was higher for least disturbed forest and lower for highly disturbed forest. Vegetational parameters showed that protected forest areas are important for maintaining the species richness, regeneration and the ecosystem as a whole.

Keywords**: Disturbance, Protected areas, Vegetation, Himalaya.**

INTRODUCTION

The term phytosociology is frequently used for the study of plant community structure. Phytosociological study incorporates mainly the description of the vegetation, of the terrain and it provides detailed information about composition of tree, shrubs, herb and climbers communities and also the functional aspects. The study of plant communities or vegetation for which Mueller- Dombais and Ellenberg (1974) have coined the term "vegetation ecology" has been the major component of ecology. A biotic community is any assemblage of population living in a prescribed area or physical habitat i.e, an aggregation of organisms separated in space and time which forms a distinct ecological unit (Odum 1971). Collier et al. (1973) stated that total number of species in any aspect reflects the adaptations strength of any Vegetational unit (community) in which transformation, accumulation and flow of energy are involved. The functioning of this system is closely related to the component of the community. The increase in the diversity of species in a community shows that the adoption potential is greater to changing condition of environment. Frequency as introduced by Raunkiaer (1934) indicates the distribution and dispersion of a species in a community. The density and frequency together has basic importance in determining the structure of a community. Analytic characters are directly observed in the field and are of quantitative (measure quantitatively) and qualitative (usually described) types. Qualitative characters are physiognomy, life form, phenology, stratification, sociability and vitality where as quantitative characters are frequency, density, abundance, cover and basal area. Synthetic characters are based upon the data recorded for the analytic characters. These are dominance and diversity.

The vegetational diversity of forest ecosystem of Himalaya is influenced by topography, soil, climate and geographical location of the region. There is a great diversity in the floristic pattern due to attitudinal variation, coupled with rainfall (Arora 1993). The elements vary in quality and quantity and build a structure to the community. Here is a complex relation between the structure and function within one community. Its specific species composition and structure distinguished the community, understanding of the relationship of plant community, their distribution and interaction with the environment is a pre-requisite in ecological studies. Protected areas have a mixed history of management in the Himalaya. The establishment of PAs in recent years in Himalaya as well as other parts of the country (Rodgers and Sawarkar 1988) raises hopes for the conservation of representative ecosystems and biota. The relationship between local residents and PAs often entails depriving people of access to resources upon which they depend for their daily needs (Western and Pearl, 1989; West and Brechin, 1991). The unprecedented increase in human and animal population has resulted in over exploitation of forest resources. The high dependency on forest areas extraction for grazing, fuel-wood collection and timber are some other factors which are responsible for the degradation of the forests (Bisht, 2012).

Regeneration of a species is one of the most important phenomena for maintaining the forest cover. It sustains actual and potential bio resource in consequent year for the forth-coming generation. However, large scale deforestation and degradation has deteriorated the temperate and tropical forest worldwide to the large extent (Tewari, 2008). Several studies have highlighted that disturbances play a major role in the regeneration and may cause low and high regeneration of some species in particular areas and also determine the changes that occur in successional forest, (Crowley, 1977). However, Shugart (1984) reported that establishment of communities generally resist to competitive displacement but are susceptible during regeneration i.e., gap-phase process. Knowledge of plant community structure, dynamics and succession must include information about plant reproduction (regeneration and germination), dispersal and seedling establishment and survival performance of species in a disturbance in which seed characteristics are central (Vazquez Yanes and Orozco-Segovia 1996). Light is also a major limiting factor for natural regeneration potential of species in the higher altitudinal region. Study on the effect of light has been conducted by Veblen (1989). They suggest that the successful regeneration of light loving species is directly related to increasing level of light. The interpretation of population structure of tree species was based on the assumption that size classes correspond with the age of individuals. Though, the size class distribution often differs from the age class distribution, the former in case analysed properly can also be useful for interpretation of patterns of population changes.

In this study an attempt was made to study the effect of disturbance on the regeneration potential of the forests. Sites were selected within the protected area and outside it to assess the importance of affording protection to forests.

MATERIALS AND METHODS

Site Description: The study area is located between 29^0 24’ and 29^0 26’ N latitude and 78^0 53’ and 78^0 59’ E longitude between 280 and 370 m elevation in Uttarakhand Himalaya. Monsoon pattern of rainfall influences the climate of the area. The sites were categorized as disturbed and undisturbed on the basis of the following parameters i.e. cutting of tree branches, cattle dung, pellet of wild ungulates and forest fire. (Table 1). The study sites were located within 10-15 km distance from one-another. Variation in canopy cover, intensity and frequency of anthropogenic disturbances were measured at each site.

Table 1. *Disturbance parameters recorded at the studied sites for categorization into disturbed and less disturbed sites*:

Site	**Canopy Cover (%)**	**Lopping Intensity(%)**	**Cattle dung(*d/ha)**	**Pellet of wild ungulates(d/ha)**	**Fire scars on trees (d/ha)**
Disturbed forest area (Dhela)	40	60	80	60	80
	30	70	100	80	60
	40	70	60	90	40
	30	60	90	100	30
	30	50	80	120	60
Protected forest area (Jhirna)	70	20	10	300	4
	60	10	20	250	6
	50	10	10	200	8
	80	20	20	180	4
	70	10	10	350	0

*D= dung piles per ha.

After a thorough reconnaissance of the southern site of Corbett National Park (protected area) a total of two forests selected for detailed Vegetational parameters of tree layer, one is within the protected area (Jhirna) and other is outside the protected area (Dhela) where human interference is high.

Methods:

The size and number of the samples were determined according to Saxena and Singh (1982). The trees were sampled as above 30 cm cbh (circumference at breast height). Thirty quadrats of 10 x10m were randomly placed for analysis in each site. Circumference at breast height (1.37m) was taken for tree to determine basal area which is calculated as:

$C^2/ 4\pi$ Where 'C' is the circumference at breast height.

The vegetational parameters were quantitatively analyzed for density, abundance and frequency (Curtis and Mc Intosh 1950). The ratio of abundance and frequency was used to interpret the distribution pattern of the species (Whitford 1949). The ratio <0.025 indicated regular distribution, 0.025-0.05 random distribution, and >0.05 contagious distribution (Curtis and Cottan 1956). Relative frequency, relative density and relative dominance were determined following Phillips (1959). The importance value index (IVI) was analyzed as the sum of relative frequency, relative density and relative dominance (Phillips 1959).

Species diversity was measured using Shannon-wiener information index (Shannon and Weaver, 1963):

$$H=-\sum (ni/n) \log 2 (ni/n),$$

Where, ni = the number of individual of a species

n= total number of individual of all species in that stand

Concentration of Dominance (CD) was calculated by Simpson's index (Simpson 1949),

$$CD = \sum (\frac{ni}{n})^2$$

Where, ni and n were the same as for Shannon-wiener index.

In order to develop population structure and to understand regeneration of tree species individuals were measured for height and circumference at breast height (cbh) with a girthing tape. At each site all individuals were counted for each tree species for regeneration studies in above said quadrats. In addition to seedling and sapling classes (Good and Good 1972), six more classes based on cbh were arbitrarily established as following:

A	Seedling	-	Less than 10 cm circumference
B	Sapling	-	10-30 cm circumference
C	Trees	-	Above 30 cm cbh, 30-60 cm
D		-	60-90 cm cbh
E		-	90-120 cm cbh
F		-	120-150 cm cbh
G		-	150-180 cm cbh
H		-	>180 cm cbh

From this information the total number of individuals belonging to above mentioned size classes was calculated for important species on each location. The density of each girth class for each species was divided by total density of that species on a location. The resulting value was multiplied by 100 to yield relative density for each size class and species, the relative density was plotted against the corresponding girth class.

Data were analyzed using SPSS ver 12.0 program (SPSS 2003). Least significant difference (LSD) was also determined to differentiate density and basal area among disturbance.

RESULTS

Effect of disturbance on Vegetational parameters:

The vegetation parameters for important species are given in Table 1 for both sites. Total tree density ranged from 250.3-340 trees/100 m^2 and total basal area from 18.1-76.15 m^2/ha in the two sites, which was higher for least disturbed forest and lower for highly disturbed forest.

Highly disturbed forest area:

In highly disturbed forest Dhela, individual density ranged from 10-100 trees/100 m^2, it was maximum for Mallotus *philippinensis* and minimum *Dalbergia sissoo, Aegle marmelos* and *Butea monosperma*.. Individual abundance varied from 1.00-3.00 trees/100 m2, it was maximum for *Cordia dichotoma* and minimum for *Lagerstroemia parviflora, Dalbergia sissoo, Aegle marmelos* and *Butea monosperma*. Individual A/F ratio ranged from 0.02-0.30, *Mallotus philippinensis showed regular distribution pattern, Lagerstroemia parviflora* and *Diospyros tomentosa* are randomely distributed while *Shorea robusta, Cordia dichotoma Dalbergia sissoo, Aegle marmelos and Butea monosperma* showed contagious distribution pattern. Individual basal area ranged from 0.10-12.2 m^2/ha, it was maximum for *Shorea robusta* and minimum for *Butea monosperma*. *Mallotus philippinensis* (IVI=94.8) was the dominant species followed by *Shorea robusta* (IVI=90.4), *Diospyros melonoxylon* (IVI=35.5) and *Lagerstroemia parviflora* (IVI=26.0) (Table 2).

Protected forest area:

In Protected forest Jhirna , individual density ranged from 10-100 trees/ha, it was maximum for *Diospyros melonoxylon* and minimum *Schleichera oleosa* , *Lannea coromandelica, Hymenodictyon excelsum* , *Acacia catechu* and *Garuga pinnata*. Individual abundance varied from 1.00-1.67 trees/100 m2, it was minimum for *Adina cordifolia, Cassia fistula,* *Holarrhena Antidysenterica, Schleichera oleosa, Lannea coromandelica, Hymenodictyon excelsum, Acacia catechu* and *Garuga pinnata* and maximum for *Anogeissus latifolia*. Individual A/F ratio ranged from 0.02-0.10, more than 75% species in least disturbed site showed contagious distribution pattern.

Individual basal area ranged from 0.30-19.78 m^2/ha, it was maximum for *Diospyros melonoxylon* and minimum for *Holarrhena Antidysenterica*. *Diospyros melonoxylon* (IVI=80.39) was the dominant species followed by *Anogeissus latifolia Adina cordifolia*,and *Cassia fistula*. (Table 2). Eight tree species were found in Dhela whereas 11 species were at Jhirna site. Species diversity ranged between 2.53-3.02, it was higher for least disturbed site and lower for highly disturbed site. Concentration of dominance showed reverse pattern. (Table 3). ANOVA indicated that tree richness, Density and Basal area was significantly different among sites (Table 4).

Table 2: *Vegetational data for trees in highly and least disturbed sites:*

Name of area	Species (Botanical name)	Species (Local name)	Density (D)/ha	Frequency (F)	Abundance (A) (Ind/ 100 m^2)	A / F	TBA sq.m/ha	IVI
Disturbed forest	*Mallotus philippinensis*	Rohni	100	70	1.43	0.02	2.9	94.8
	Shorea robusta	Sal	30	20	1.50	0.08	12.2	90.4
	Lagerstroemia parviflora	Dhouri	20	20	1.00	0.05	1.2	26.0
	Diospyros tomentosa	Tendu	40	30	1.33	0.04	0.5	35.5
	Cordia dichotoma	Lisaura	30	10	3.00	0.30	0.4	19.9
	Dalbergia sissoo	Shisham	10	10	1.00	0.10	0.6	12.7
	Aegle marmelos	Bel	10	10	1.00	0.10	0.2	10.7
	Butea monosperma	Dhank	10	10	1.00	0.10	0.1	10.1
			250	**180**	**11.26**	**0.79**	**18.1**	**300.0**
Protected	*Diospyros tomentosa*	Tendu	100	70	1.43	0.02	19.78	80.39

forest	*Anogeissus latifolia*	Bakuli	50	30	1.67	0.06	13.26	42.83
	Adina cordifolia	Haldu	20	20	1.00	0.05	19.21	38.25
	Cassia fistula	Amaltas	50	50	1.00	0.02	3.66	37.38
	Aegle marmelos	Bail	40	30	1.33	0.04	2.57	25.86
	Holarrhena Antidysenterica	Kuda	20	20	1.00	0.05	0.30	13.42
	Schleichera oleosa	Kusum	10	10	1.00	0.10	4.97	13.04
	Hymenodictyon excelsum	Borang	20	20	1.00	0.05	5.51	20.26
	Lannea coromandelica	Jhinngan	10	10	1.00	0.10	4.39	12.28
	Acacia catechu	Khair	10	10	1.00	0.10	1.34	8.28
	Garuga pinnata	Kharpat	10	10	1.00	0.10	1.15	8.02
			340	**280**	**12.43**	**0.69**	**76.15**	**300.00**

Table 3. *Spcies Diversity and concentration of Dominance in the studied forest area:*

	Richness	**Diversity**	**CD**
Highly disturbed site	08	2.53	0.23
Protected site	11	3.02	0.16

Table 4. *ANOVA table showing different Vegetational parameters:*

Source	**Dependent Variable**	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Disturbance	Richness	5.000	1	5.000	8.036	.011**
	Density	4.050	1	4.050	4.893	.040**
	Basal area	160.178	1	160.178	14.253	.001*

** Significant at 0.05 level

* Significant at .01 level

Regeneration pattern in Disturbed and Undisturbed forest

The regeneration of trees generally depends upon the ability of trees to provide sufficient seeds, their ability to germinate and grow as seedlings and saplings, and survive in the under canopy environment, where soil moisture and light may often be limiting (Kozlowski 1971, Good and Good 1972). Seedlings and saplings are used in most regeneration studies because seedlings are easier to manipulate and use in experiments, they show faster response to environmental conditions than large sized trees and their responses can be quantified more easily and more precisely (Zagt and Werger 1998). Sapling on the other hand shows an established phase which has significant implications as far as any species establishment is concerned, thus, vital for assessing future composition of a forest stand (Sundriyal and Sharma 1996).

The regeneration was poor at disturbed site compared to protected site. This could be attributed to frequent grazing, lopping and trampling in the area. In disturbed site *Mallotus philippinensis*, *Lagerstromeia parviflora*, *Diospyros tomentosa*, *Dalbergia sissoo* and *Aegle marmelos* (Fig 1) showed better seedling growth whereas at protected site *Diospyros tomentosa*, *Adina cardifolia*, *Cassia fistula*, *Aegle marmelos*, *Holarrhena antidysenterica*, *Schleichera oleosa*, *Ehratia laevis* and *Azardirachta latifolia* had better regeneration (Fig 2).

Fig1. Regeneration pattern of trees at disturbed site:

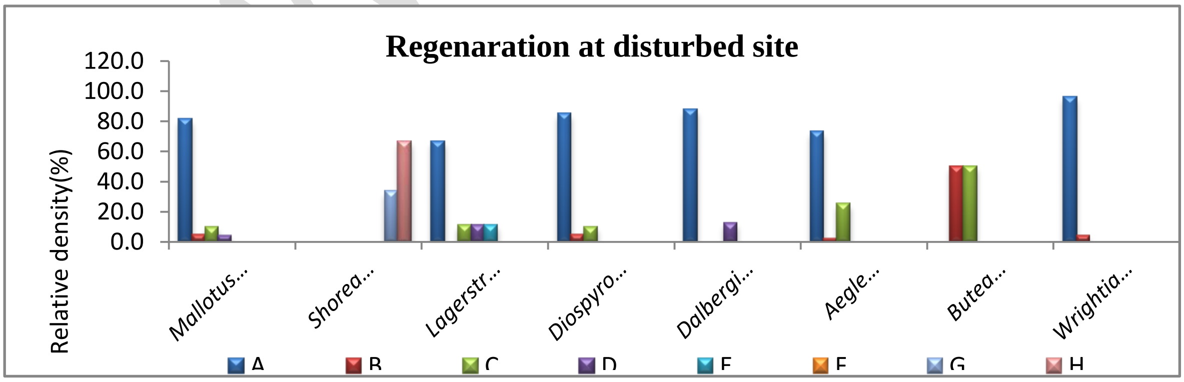
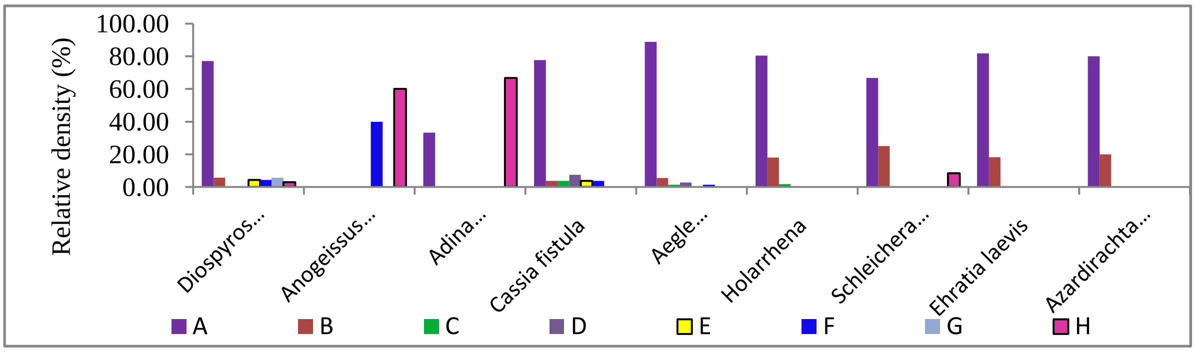


Fig 2. Regeneration pattern of trees at undisturbed site:



DISCUSSION:

The Himalaya embodies a diverse and characteristic vegetation distribution over a wide range of topographical variations (Dhaulkhandi et al. 2008). The vegetation characteristics showed dominance of one or more species in the area. Disturbance promotes undergrowth species diversity possibly by allowing several species to maintain their populations in open condition (Tewari, 2008). More penetration of light in open canopy forest may enable each species to develop large population, and large population may be less vulnerable to local extinction. However, a wide variation in species richness across sites with similar tree crown cover may indicate that several other factors, such as history of disturbance, leaf chemistry of canopy species and spatial arrangement of individuals can verify diversity (Kumar 2000). Vetaas (1997) reported that disturbance affects every level of biological organization and spans a broad range of spatial and temporal scales and is a key component of all ecosystems in forests of Nepal Himalaya. The ecological effectiveness of protected areas has previously been rather poorly explored, particularly at the level of protected area systems (rather than given individual protected areas), using genuinely temporal data (rather than space-for-time swaps), and using measures of ecosystem functioning (rather than just biodiversity features) Gaston et al. 2008. Protected areas indicating the rich biodiversity that occurs along the altitudinal gradient.

Our study indicated that tree density was high in least disturbed forest, it may be due to low disturbance which provide opportunity for formation of seeds, seed germination and seedling growth. However, establishment and survival of all the seedlings also depends upon several other climatic factors (Samant et al. 2002, Joshi 2002). Anthropogenic disturbances are prevalent in almost all the forests world wide. Species richness increased with disturbance incidence indicated that the opening of canopy promote regeneration of many species as well as understory growth. Kumar (2000) stated that generally the species richness (for all the vegetation layers) was higher in high disturbed sites. Singh (1998) reported that chronic form of disturbance in these forests involving removal of a small amount of biomass at any given time, but persisting all the year, without any respite for recovery ultimately effects regenerations. The total basal area was high in close canopy and indicated that most of the environmental factors support radial growth of the tree. The high disturbed forests were characterized by sparse canopy because the trees were lopped for fodder and fuelwood whereas dense spreading canopy was found in least disturbed high elevation forests (Kumar 2000). This would suggest that the designation and implementation of protected areas often acts to reduce levels of land use change and resource extraction (Joppa et al. 2008, Andam et al. 2008 and Bruner et al. 2001). That is, protected areas have a positive effect on the representation of plant production. This could occur for a variety of reasons, including the establishment of protected areas in regions in which plant production initially differed from that elsewhere, and changes in plant production as a consequence of management within protected areas. Present study indicated that tree diversity was higher in least disturbed forest, greater diversity in a closed canopy has also been observed by Moral, 1972 and Zobel et al. 1976. Whittaker (1972) stated that the dominance of one stratum may affect the diversity of another stratum.

Degradation of unprotected forest fragments is expected to result in low species diversity. Nevertheless, expected tree species density in riverine patches in Bulindi (53 species ha – 1) was similar to densities reported from 1-ha plots in main forests elsewhere in Uganda (Eilu et al. 2004). Concentration of dominance for tree raged from 0.16-0.23, Concentration of dominance reported by Risser and Rice (1971) for tree layer ranges from 0.10 to 0.9 for temperate forests. Adhikari (1992) and Srivastava (2002) reported the value ranging from 0.20 to 0.89 for trees layer in the central Himalayan forests. CD ranging from 0.56 to 3.36 for tree layer reported by Kharakwal et al. (2007).

The regeneration was poor at disturbed site compared to undisturbed site. This could be attributed to poor soil depth, frequent grazing and trampling of the area. In disturbed site *Mallotus philippinensis,*was the dominant species followed by *Lagerstromeia parviflora,* *Diospyros tomentosa*, *Dalbergia sissoo* and *Aegle marmelos* whereas at undisturbed site *Diospyros tomentosa* was the dominant species followed by *Adina cardifolia*, *Cassia fistula*, *Aegle marmelos*, *Holarrhena antidysenterica*, *Schleichera oleosa*, *Ehratia laevis and Azardirachta latifolia* . The light demanding species germinate faster, grow rapidly and can rarely be found growing in the forest understory (Hubbell and Foster 1978), while shade tolerant species are indifferent to gaps and can grow both in a high and low light environment. The behaviour of tree seedlings in tree fall gaps and understory partly depends on species niche specialization. Species having different regeneration strategies colonize different microsites in the forest understory and gaps; the small gaps are occupied primarily by the shade tolerant mature phase species (Srivastava 2002).

To conclude least disturbed forest would be important for maintaining the species richness, conservation of soil and the ecosystem as a whole. In sum, these results suggest that over a quarter of a century protected areas have proven effective in the protection and regeneration of tree species.

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