ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 5.2
IJAR 2015; 1(12): 520-523
www.allresearchjournal.com
Received: 04-09-2015
Accepted: 06-10-2015

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Influence of canopy cover on plant diversity in pine dominated and mixed broadleaf forest of Kumaun Central Himalaya

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Abstract
In the present study total two forest stand on different canopy cover (open canopy, moderate canopy and close canopy) were studied to assess the importance of these two parameters in supporting species regeneration and biodiversity in a pine dominated and mixed broadleaf forest between 1300 and 2000 m elevations in the Uttarakhand Himalaya. A total of 32 tree species were recorded in the forest. In all canopy cover the tree species richness was higher at mixed broadleaf forest in comparison to pine dominated forest. The maximum tree species richness (average across all forest) was 4.3, herb species richness 17.3. Higher richness at open canopy may be attributes to the presence of favourable environmental condition especially the availability of light, soil nutrient and moisture may be responsible for this herb species richness. From the present study it become evident that the base of the close canopy can support higher biodiversity and are instrumental in supporting regeneration of several tree and herb species in pine dominated and mixed broadleaf forest.

Keywords: Forest, Cover and Richness.

Introduction
The Himalayan moist temperate forests are characterized by extensive *Quercus leucotrichophora* A. Camus and conifer forest mainly *Pinus roxburghii* Sarg. Broadleaf oak forest is usually considered to be best for water and soil conservation, so much so that traditionally these forests are associated both with better quality as well as abundance of spring water (Singh and Singh 1986) [15]. Forest resources of the Himalaya are shrinking in size due to over exploitation and there is increased interest to protect, manage and make them more productive. This requires essentially the knowledge of their population status, production behavior and rate of utilization on unit area basis. Growing stock assessment is an important parameter required for sound forest management and planning. General information about the stock available per unit area is the key information desired for forest inventories, where the empirical diameter distribution of sites is not measured (Arya 2008) [2].

Himalaya one of the richest hot spot of biodiversity in the world, offers immense opportunities in various fields of biological dominos and associated pattern of sustainable life support system (Gaur 2004) [8]. Variation in species richness has been known for over a century (Brown and Davidson 1977 [4], Lomolino 2001 [10] and Bhattarai and Vetass 2003) [3]. Lomolino (2001) [10] pointed out that many components of climate and local environment (temperature, precipitation, seasonality and disturbance regime) vary with the elevation gradients and ultimately create the variation in species richness.

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 altitudinal variation, coupled with rain fall (Arora 1993) [1]. Collier *et al*. (1973) stated that total number of species in any aspect reflects the adaptation 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 adaptation potential is greater to changing condition of environment.

Material and Methods

The study area is located between 29° 20' and 29° 30'N latitude and 79° 23' and 79° 42'E longitude at an elevation of about 1300-2000 m in Uttarakhand Himalaya. The study site was dominated by *Pinus roxburghii* Sarg and *Quercus leucotrichophora* A. Camus forests. Monsoon pattern rainfall influences the climate of the area. The total rainfall was 1486.8 to 2213.4 mm (2003-2006). The mean monthly rainfall (average of three year) was 2.25 mm (November) and 498.5 mm (July). The mean maximum temperature 12.5 °C (January) to 24.9°c (June) and mean minimum temperature from 5.0°c (January) to 17.4 °C (June). Rocks of the study area are mainly sandstones, conglomerates, limestone, quartzite, schist's, granites and gneisses (Valdiya 1980) [18]. A total of 2 forests were selected in three different canopy treatment (open canopy <30%, moderate canopy 30-60% and close canopy >60%) were identified and selected for the detailed study of vegetation analysis.

Table 1: Characteristics of study sites

Forest types	Altitude	Canopy
Pine dominated forest	1350-1500	Open canopy
		Moderate canopy
		Close canopy
Mixed broadleaf forest	1400-1500	Open canopy
		Moderate canopy
		Close canopy

Phytosociological analysis is the area was done following Curtis and McIntosh (1950) [5], Curtis (1959) [6] by placing 20, 100m^2 quadrats. The density was expressed as number of individuals per 100 m^2 and total basal area cm^2 per 100/m^2. Important value index (IVI) of all tree species was the sum of relative frequency, relative density and relative basal area (Curtis 1959) [6].

For calculating the diversity and concentration of dominance IVI was used. Diversity (or total diversity) was calculated by using Shannon-weiner information (Shannon and Weaver 1963) [13] formula:

$$H = -\sum_{I=1}^{s} (Ni/N) \log 10 (Ni/N)$$

Where, Ni is the number of individual of a species and N is the total number of individual of all species in that stand.
Concentration of dominance was measured by Simpson's index (Simpson 1949) [14],

$$CD = -\sum_{I=1}^{s} (Ni/N)^2$$

Where, Ni is the number of individual of a species and N is the total number of individuals of all species.

Results

In the forest altitudinal belt between 1350-1500mm elevation. Total 32 tree species were present. The tree species richness ranged from 8 at close canopy of pine dominated forest and 26 at moderate canopy of mixed broadleaf forest. In all canopy tree species richness was higher at mixed broadleaf forest in comparison to pine dominated forest (fig1). Across all canopy cover the diversity for tree layer (1.34), shrub layer (3.16) and herb layer (4.29) the tree diversity was maximum in moderate canopy, shrub in close canopy and herb in open canopy (Table 3).

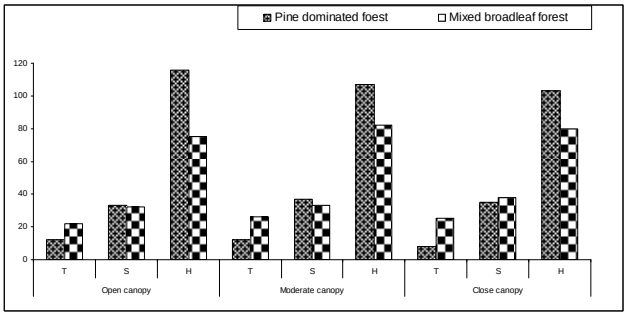

Fig 1: Species richness across different canopy cover and position of forest types

T= Trees, S= Shrubs and H= Herbs

Between forest and canopy tree density was maximum in the stand located at close canopy. The maximum tree density 347.0 trees/ha at close canopy of mixed broadleaf forest whereas minimum density was 274.0 trees/ha at open canopy of pine dominated forest. The total basal area was maximum 47.2 m²/ha at close canopy of pine dominated forest and minimum was 28.2 m²/ha at close canopy of mixed broadleaf forest. The tree cover percent was maximum at close canopy of pine dominated forest (82.0%) and minimum at open canopy of pine dominated forest (27.6%) (Table 2).

Between forest and canopy cover the shrub density was maximum at open canopy of pine dominated forest (31526.7 shrubs/ha) and minimum at moderate canopy of mixed broadleaf forest (20333.3 shrub/ha). The shrub cover percent was maximum at moderate canopy and minimum at open canopy of pine dominated forest (Table 2).

Between forest and canopy cover the herb density ranged between 10.1x10^5 herbs/ha (open canopy at pine dominated forest) and 6.8 x10^5 herbs/ha (moderate canopy at mixed broadleaf forest) (Table 2). For tree layer the Simpson index ranged between 0.52 at open canopy and 0.54 at moderate. For shrub it ranged between 0.16 at close canopy and 0.18 at open canopy and herb it ranged between 0.07 at open and close canopy and 0.08 at moderate canopy (Table 3). Herb cover percent was maximum at close canopy of mixed broadleaf forest and minimum at close canopy of pine dominated forest (Table 2).

Table 2: Vegetation parameters in different studies located on varying forest and located on the canopy cover

Forest	Canopy	Density			Total tree basal area (m²/ha)	Tree cover (%)	Shrub cover (%)	Herb cover (%)
		Tree (trees/ha)	Shrub (shrubs/ha)	Herb (x10^{5}herbs/ha)				
Pine dominated forest	Open canopy	274.0	31526.7	10.1	31.8	27.6	40.4	69.1
	Moderate canopy	277.0	29813.3	7.7	35.7	57.2	52.8	64.2
	Close canopy	308.0	25366.8	7.5	47.2	82.0	46.7	57.9
Mixed	Open canopy	306.0	30146.4	8.1	31.8	27.8	51.3	83.9

broadleaf forest	Moderate canopy	342.0	20333.3	6.8	37.4	56.3	48.7	78.2
	Close canopy	347.0	24040.0	7.6	28.2	70.5	48.9	84.4
t- test								
Between O & M		1.93	NS	NS	NS	40.23	NS	2.21
Between O & C		NS	NS	NS	NS	7.23	NS	NS
Between M& C		1.83	NS	NS	NS	3.05	NS	NS

Table 3. Diversity and species richness of tree, shrub and herb layer in open, moderate and close canopy

Parameters	Canopy	Tree layer	Shrub layer	Herb layer
Species richness	Open canopy	6.42	13.92	32.83
	Moderate canopy	6.50	13.92	31.25
	Close canopy	5.50	14.33	31.42
Diversity value	Open canopy	1.31	3.01	4.29
	Moderate canopy	1.34	3.10	4.17
	Close canopy	1.31	3.16	4.29
Simpson index	Open canopy	0.47	0.09	0.07
	Moderate canopy	0.48	0.07	0.08
	Close canopy	0.49	0.08	0.07

Discussion

The present study deals with the analysis of a relative rich forest vegetation between 1350 and 1500 m altitude in Kumaun Himalaya. The Himalaya embodies adverse and characteristic vegetation distribution over a wide range of tropical variation (Dhaulkhandi *et al*. 2008) [7]. The vegetation characteristics showed dominance of one or more species in the area. Disturbance promotes undergrowth species diversity possible by allowing several species to maintain their populations in open condition. 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 indicated that several other factors, such as history of disturbance, leaf chemistry of canopy species and spatial arrangement of individual can verify diversity (Kumar 2000) [9].

In pine dominated and mixed broadleaf forest, the tree basal area for several central Himalayan forests was reported in the ranged of 16.6-69.5 m²/ha by Saxena and Singh 1982 [11], Tewari 1982 [17]. Singh *et al*. (1994) [16] have reported that tree basal area for *P. roxburghii* forest was 17-47 m²/ha, *Q. leucotrichophora* forest 12-74 m²/ha and pine mixed broadleaf forest 41-110 m²/ha. In the present study the average total tree basal area was found higher at close canopy of pine dominated forest and minimum for close canopy of mixed broadleaf forest. This indicated that most of the environmental factors support radial growth of the tree.

In this transect the value of tree, shrub and herb species diversity were generally higher in close canopy. A number of broadleaf tree species were found in moderate canopy. The average diversity of tree layer was 1.31, 1.34 and 1.31 for open canopy. Moderate canopy and close canopy forest respectively (Table 3). The shrub layer showed higher diversity (3.16) at close canopy than at open canopy (3.01) and moderate canopy (3.10). Herb diversity was higher at open canopy compared to moderate and close canopy (Table 3). In this transect the value of species richness was higher in the open canopy. The average species richness of tree layer was 6.42, 6.50 and 5.50 for open canopy, moderate canopy and close canopy respectively (Table 3). Shrub richness was also higher for close canopy. The open and moderate canopy is generally poor in top soil because of relentless erosion. Herb species richness was higher in open canopy. The presence of favorable environmental condition especially the availability of light, soil nutrient and moisture may be responsible for this herb species richness.

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