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Full Length Research Paper

Structure and composition of vegetation in subtropical forest of Kumaun Himalaya

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An extensive sampling was conducted for vegetational analysis in different forest sites between 1600 and 2600 m asl in Kumaun Himalaya. *Quercus leucotrichophora* A. Campus, *Quercus floribunda* Lindl. ex Rehder, *Quercus semecarpifolia* J.E. Smith and *Pinus roxburghii* Sarg. are the dominant tree species in banj- oak, tilonj-oak, kharsu-oak and chir- pine forests, respectively. Among the sampling sites, total density of tree, shrub and herb species was ranged from 10 to 28.6 individuals (indv/100 m^2) 1.8 to 21.7 indv/25 m^2, and 28.1 to 103.7 indv/m^2, respectively. The total abundance-frequency (AF) ratio of tree, shrub and herb species across the sampling sites varied from 0.23 to 1.25, 0.25 to 1.79 and 3.4 to 27.3, respectively. The abundance- frequency ratio in the present study showed contagious distribution pattern in tree, shrub and herb species.

Key words: Species composition, density, frequency, distribution pattern, Kumaun Himalayan forest.

INTRODUCTION

The Himalayan forest vegetation ranges from tropical dry deciduous forest in the foothills to alpine meadow above timberline (Singh and Singh, 1992). Composition of the forest is diverse and varies from place to place because of varying topography such as plains, foothills and upper mountains (Singh, 2006). Economically and environmentally, the natural resources are the main source for people in this region (Ram et al., 2004). In addition, environmental problems are particularly noticeable in this region as a form of degradation and depletion of the forest resources (Sati, 2005).

Forests are mainly dominated by chir-pine and oak species. Highly diverse compositional pattern of forests characteristic of central Himalaya, has been explored by Singh and Singh (1987). Besides the ecosystem functions the distribution and occurrence of species had been affected by human interventions (Singh and Singh, 1987). Among human influence, commercial exploitation, agricultural requirements, forest fire, and grazing pressure are the important sources of disturbance (Singh and Singh, 1992).

Vegetation plays an important role in soil formation (Chapman and Reiss, 1992). Plant tissues (from aboveground litter and belowground root detritus) are the main source of soil organic matter, which influences physiochemical characteristics of soil (Johnston, 1986) resulting differences in plant community structure and production (Ruess and Innis, 1977). Earlier studies in the Kumaun region has been explored on various aspects that is, about the forest vegetation by following (Singh and Singh, 1987; Dhar et al., 1997), altitudinal variation (Saxena et al., 1985; Adhikari et al., 1995; Kharkwal et al., 2005), phytosociology (Ralhan et al., 1982, Saxena and Singh, 1982) and population structure (Saxena et al., 1984; Singh et al., 1987). The main objective of this paper is to describe structural attributes of the tree, shrub and herb species in different forest sites.

MATERIAL AND METHODS

The study sites are located between 29°21' - 29°24' N latitude and 79°25' - 79°29' E longitude in Nainital catchments in Kumaun region of central Himalaya. Some details of the study sites' characteristics are given in Table 1.

The climate is monsoon type, which occurs from mid-June to mid-September. The average amount of annual rainfall is 2488mm/yr. The year is divisible into three seasons, rainy (mid-June to mid-September), winter (October to April) and summer

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Table 1. General characteristics of the study sites.

Site	Elevation (m)	Forest type	Aspect	Dominant tree species
S1	1580 - 1700	Chir-pine	E, SW	*P. roxburghii*
S2	1700 - 1800	Chir-pine	NE	*P. roxburghii*
S3	1800 - 1950	Banj-oak	E, W	*Q. leucotrichophora*
S4	2000 - 2300	Tilonj-oak	E, SW	*Q. floribunda*
S5	2300 - 2600	Kharsu-oak	NE, NW	*Q. semecarpifolia*

E, east; SW, southwest; NE, northeast; W, west; SW, southwest; NW, northwest.

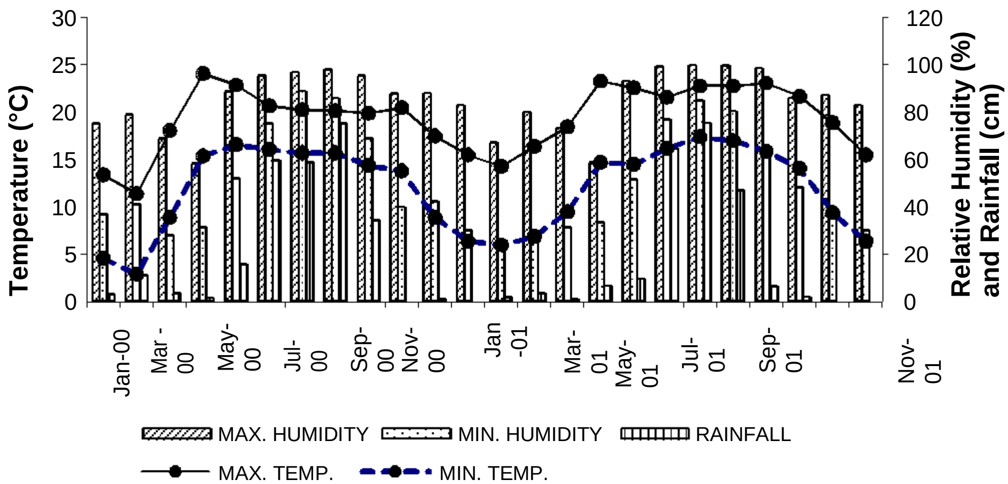

Figure 1. Ombrothermic graph for the study region (Source: State Observatory, Manora Peak, Nainital).

(May to mid-June). Spring and autumn are the transition zones. Snowfall is frequent during the winter months (December - February). The mean monthly maximum temperature ranged from 13.0 to 23.7°C. The mean monthly minimum temperature varied between 4.9 and 16.6°C (June). The low temperature values occurred in February and high in July (Figure 1).

Soil moisture (0 - 30 cm) varied from 42 to 57% in the rainy season. Soil pH was in the range of 5 to 6 indicating the acidic nature of the soil. Percentage of sand, silt and clay varied from 50 to 65%, 17 to 30% and 11 to 28%, respectively. Organic matter and water holding capacity ranged from 3 to 5% and 55 to 80%, respectively.

The rocks of Nainital belong to Krol series. The pyretic, carbonaceous rocks exposed in banj-oak forest belong to the Infra Krol Member. The limestone rocks of tilonj-oak forest are in the form of isolated massive blocks and kharsu-oak forest has a thin layer of limestone followed by a singular shale or slate series with interbedded bonds of sand-stones and limestone with dolomite or siliceous in nature (Valdia, 1983).

Phytosociological analysis of tree and shrub species in each sampling site was carried out randomly by using 15 10 × 10 and 5 × 5 m^2 quadrats, respectively. The size of the quadrats was determined by the running mean method (Kershaw, 1973). Species area curve was developed for herb species (Kharkwal, 2002) and it was sampled randomly by using 15 1 × 1 m^2 quadrats in each forest site. Vegetational data were analyzed following Curtis (1959) and A/F ratio by Whitford (1949) for the distribution pattern. According to Curtis and Cottam (1956), the ratio of abundance to frequency below 0.025 indicates regular distribution, between 0.025 and 0.050 indicates random distribution and when exceeds 0.05, indicates contagious distribution.

RESULTS AND DISCUSSION

Tables 2a and b shows statistical analysis between different parameters. Significant relation ($P < 0.05$) found between soil moisture vs. density (Tree, shrub and herb). Similarly, there is significant relation ($P < 0.05$) between soil carbon vs. tree and herb density (Td and Sd), and soil organic matter vs. herb density (Hd). Herb density indicated a positive relation to tree density ($P < 0.01$) whilst it showed a negative relation between tree and shrub density ($P < 0.01$). Hussain et al. (2008) and Sharma et al. (2009) found similar relationship between vegetational and soil parameters.

Frequency is a measure of the uniformity of the distribution of a species; thus a low frequency indicates that a species is either irregularly distributed or rare in a particular stand or forest. Frequency distributions of plant density, cover, biomass per unit area, and height, as measures for expressing biological abundance and biological dominance of vegetation, have been used to describe species composition and spatial patterns of vegetation in

Table 2a. Statistical analysis of soil and vegetational parameters one-way ANOVA.

Summary statistics				
Dataset	**N**	**Mean**	**SD**	**SE**
Data1_C	27	0.20444	0.0471	0.00906
Data1_clay	27	17.80741	4.802	0.92414
Data1_Hd	27	21.11556	10.58095	2.03631
Data1_Moisture	27	43.31111	10.16057	1.9554
Data1_Organicmatter	27	5.18148	0.61459	0.11828
Data1_Sand	27	57.20741	4.5969	0.88467
Data1_Sd	27	2.42963	2.02139	0.38902
Data1_Silt	27	24.47037	3.77948	0.72736
Data1_Td	27	6.97037	1.90401	0.36643

Table 2b. ANOVA.

ANOVA					
			Sum of mean		
Source	**DF**	**Squares**	**Square**	**F Value**	**P Value**
Model	8	82176.8884	10272.1110	328.11254	0
Error	234	7325.76087	31.3066704		

Null Hypothesis: The means of all selected datasets are equal.
Alternative Hypothesis: The means of one or more selected datasets are different.
At the 0.05 level, the population means are significantly different.

different plant communities (Chen et al., 2008) . In the present study, the dominant tree, shrub and herb species base on frequency (%) in different sampling sites are depicted in Table 3. From this table it is evident that *Pinus roxburghii* was the dominant tree species followed by *Myrica esculenta* at S1 (east and southwest) site. At S2 (Southwest) site, *P. roxburghii* was the dominant tree species followed by *Rhododendron arboreum. Quercus leucotrichophora* was the dominant tree species at S3 (east and west) site followed by *Fraxinus micrantha*, *M. esculata* and *Cornus oblonga*, *Biota orientalis*, respectively. S4 (East and Southwest) site was dominated by *Quercus floribunda* followed by *Q. leucotrichophora* and *Quercus semecarpifolia* was the dominant tree species at S5 (Northeast and Northwest) site (Table 3).

Similarly, *Eupatorium adenophorum* and *Cassia laevigata* were the dominant shrub species at S1 (East and Southwest) site. S2 (Southwest) and S3 (East and West) sites were dominated by *Boenninghausenia albiflora* and *Daphne cannabina*. *B. albiflora* and *Randia tetrasperma* were dominant shrub species at S4 (East and Southwest) site whereas S5 (northeast and northwest) site was dominated by *Colquehonia coccinea* and *D. cannabina*, respectively (Table 3).

The dominant herb species at S1 (east and southwest) site was *Ageratum haoustonianum.* S2 (Southwest) site was dominated by *Neanotis calycina. Pilea umbrosa* and *Care cruciata* were dominant herb species at S3 (East and West) site. At S4 (East and Southwest) site, the dominant herb species were *Thalictrum foliolosum* and *Pilea scripta* however; *Sanicula elata* and *Plectranthus striatus* were the dominant herb species at S5 (Northwest and Northeast) site (Table 3).

The density and abundance-frequency ratio of tree, shrub and herb species are depicted in Figure 2. The total density of tree, shrub and herb species in different sampling site ranged from 10 to 28.6 individuals (indv/100 m^2), 1.8 to 21.7 indv/25 m^2 and 28.1 to 103.7 indv/ m^2, respectively. Tree density was maximum at S3 (east) site and minimum at S5 (Northeast) site. Shrub density was maximum at S5 (Northeast) site and minimum at S2 (Northeast) site whereas, herb density was maximum at S2 (Northeast) site and minimum at S5 (northeast) site. The research results obtained by Chen et al. (2008) indicates that the density of any species in a given stand or forest type depends largely upon environmental conditions and the area covered by each individual stem.

The total abundance-frequency (AF) ratio of tree, shrub and herb species in different sampling sites ranged from 0.23 to 1.25, 0.25 to 1.79 and 3.4 to 27.3, respectively. The ratio of tree species was maximum at S1 (Southwest) site and minimum at S2 (Northeast) site. In case of shrub species the ratio was maximum at S5 (Northeast) site and minimum at S2 (Northeast) site

Table 3. Dominant and co-dominant species in different forest sites.

Site	Tree species	Frequency (%)
S1_E	*Pinus roxburghii*, *Myrica esculenta*	100, 30
S1_SW	*P. roxburghii*, *M. esculenta*	100, 30
S2_NE	*P. roxburghii*, *Rhododendron arboreum*	100, 30
S3_E	*Quercus leucotrichophora*, *Fraxinus micrantha*, *M. esculenta*	100, 20, 20
S3_W	*Q. leucotrichophora*, *Cornus oblonga*, *Biota orientalis*	100, 20, 20
S4_E	*Quercus floribunda*, *Q. leucotrichophora*, *R. arboreum*	100, 50, 20
S4_SW	*Q. floribunda*,*Q. leucotrichophora*	100, 60
S5_NE	*Quercus semecarpifolia*, *Cedrus deodara*, *Cupressus torulosa*	100, 50, 40
S5_NW	*Q. semecarpifolia*, *Q. floribunda*, *Acer oblongum*	100, 50, 40
	Shrub species	
S1_E	*Eupatorium adenophorum Berberis asiatica*, *Pyracanthus crenulata*	50, 40, 30
S1_SW	*Cassia laevigata*, *Rubus ellipticus*	60, 50
S2_NE	*Boenninghausenia albiflora*, *Cotoneaster microphylla*	40, 30
S3_E	*Daphne cannabina*, *Hypericum cernuum*, *Indigofera heterantha*	50, 40, 20
S3_W	*D. cannabina*, *Berberis asiatica*	40, 30
S4_E	*B. albiflora*, *D. cannabina*	60, 50
S4_SW	*Randia tetrasperma*, *Celtis tetrasperma*, *I. heterantha*	60, 40, 30
S5_NE	*Colquehonia coccinea*, *Sarcococa hookeriana*, *I. heterantha*	70, 60, 50
S5_NW	*D. cannbina*, *Viburnum cotinifolium*	70, 50
	Herb species	
S1_E	*Ageratum haustonianum*, *Stachys sericea*, *Micromeria biflora*	86.7, 60, 40
S1_SW	*A. haustonianum*, *Bidens biternata*, *Urena Lobata*	100, 60, 30
S2_NE	*Neanotis calycina*, *Carex nubigena*, *Setaria glauca*	100, 53.3, 33.3
S3_E	*Pilea umbrosa*, *Oxalis corniculata*, *Achyranthes bidentata*	66.6, 53.3, 43.3
S3_W	*Carex cruciata*, *Erigeron karvinskianus*, *P. umbrosa*	60, 53.3, 40
S4_E	*Thalictrum foliolosum*, *Ainsleae aptera*, *Leucas lanata*	86.7, 53.3, 40
S4_SW	*Pilea scripta*, *Setaria homonyma*, *Justicia simplex*	100, 86.7, 73.3
S5_NE	*Plectranthus straitus*, *Sanicula elata*, *Synotis rufinervis*	100, 86.7, 66.7
S5_NW	*S. elata*, *S. rufinervis*, *Erigeron karvinskianus*	86.7, 66.7, 46.7

however, the ratio for herb species was maximum at S3 (East) and minimum at S4 (Southwest) sites (Figure 2). Present study indicates that the tree, shrub and herb species are contagiously distributed in all forest sites. Similar findings has been reported by Greig-Smith (1957), Odum (1971), Kershaw (1973), Verma et al. (1999), Kumar

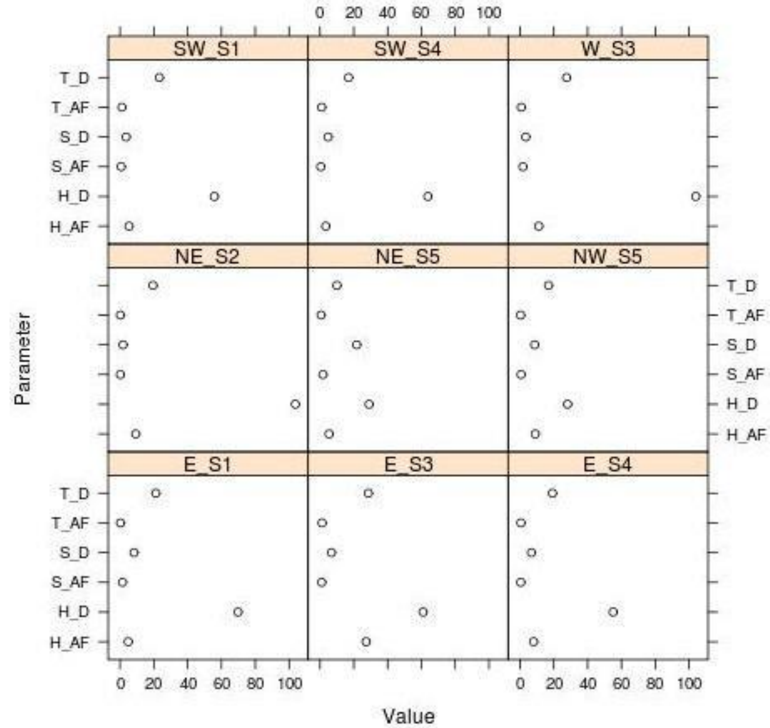

Figure 2. Distribution pattern in different forest sites (T, tree; S, shrub; H, herb; D, density; AF, abundance-frequency ratio).

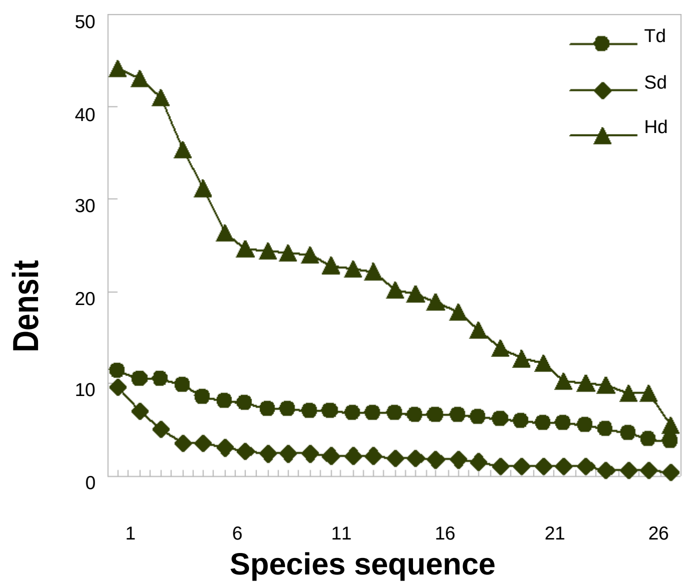

Figure 3. Dominance-diversity curve for different plant species (Td, tree density; Sd, shrub density, Hd, herb density).

et al. (2004) and Chen et al. (2008).

Dominance-diversity curves plotted between density and species sequence of tree, shrub and herb species indicates a relationship between different species showingimportance value. The curve showed similar steepness in shrub and tree species with the steepest slope for herb species (Figure 3). In case of herb species, there was a sharp drop in density, even on a log-scale, from the first- to the six-sequenced species, whereas in others, the decrease in density as a function of sequence was gentler among the highly sequenced species.

The log normal series in most cases of tree and shrubs is indicative of the highly mixed nature of vegetation (Whittaker, 1975; Saxena and Singh, 1982; Rawal, 1991). The geometric form is often shown by vascular plants having lower density (Whittaker, 1975). Magurran and Henderson (2003) stated that abundant species are log normally distributed while occasional species occur infrequently which are typically low in abundance and also follow a log series distribution.

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