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Qualitative analysis of tree species in evergreen forests of Kumaun Himalaya, Uttarakhand, India

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Current study provides information on the characteristics of tree species in five forests types in the Kumaun Himalaya. On the basis of importance value index, it was observed that *Pinus roxburghii* is the common tree species at site 1 and 2, *Quercus leucotricophora* is common at site 3, 4 and 5 is dominated by *Quercus floribunda* and *Quercus semecarpifolia,* respectively. Tree density (individual/100 m^2) varied from 5.3 to 9.4 in different forest sites. Diversity and dominance indices showed a range of 0.1 to 1.6 and 0.6 to 1.0, respectively. Equitability index in different sites varied from 1.1 to 4.4. It was noticed that with an increase in species richness, diversity and equitability increases. Dominance value decreases with an increase in equitability and diversity indicating inverse relationship between diversity and dominance.

Key words: Diversity index, dominance index, equitability, Kumaun Himalaya.

INTRODUCTION

A number of qualitative and quantitative indices of species diversity have been proposed by several workers (Simpson 1949; Margalef 1972; Shannon and Wiener 1963; Pielou 1975; Whittaker 1972) which provided information on compositional change at different analytical levels, includes species diversity in relation to size of area, relationship between local and regional species diversity and diversity along gradients across space or environmental factors (Busing and White, 1997; Gaston, 2000). Kumaun region of the Central Himalaya harbors rich biodiversity because of its unique and diverse climate. The high altitudinal belt of Central Himalaya can be divided into two sub-groups, that is, dry alpine zone (about 2750 to 4000 m a.s.l.), with very low annual precipitation, comprising dry alpine scrub and dwarf juniper scrub; and the wet alpine zone (about 2500 to 4000 m a.s.l.) characterized by high annual precipitation, with characteristic vegetation of birch-rhododendron scrub, deciduous alpine scrub and dwarf rhododendron scrub. Mountain meadow and glacial soils characterize the high altitude belt.

At about 2700 m a.s.l., the forests comprise higher level oaks such as tilonj and kharsu, giving way to rhododendron and grassy slopes at 3000 m a.s.l. The middle belt (1500 to 2750 m a.s.l.), is the temperate zone, consisting of two climatic zones: the dry temperate characterized by pine forests and the wet temperate region, dominated by mixed broad-leafed and coniferous species. The soils of the mid altitude belt varies from brown forest soils to brown deciduous and grey and coniferous forest soils. The lower altitude belt (600 to 1500 m a.s.l.) is characterized by a mix of alluvial and brown forest soils, sal and chir pine forests (Champion and Seth, 1968; Singh and Singh, 1992). The present work provides detailed information, qualitative analysis on the characteristics of different forest sites in the study region.

MATERIALS AND METHODS

The study-sites are located between 1500 - 2600 m a.s.l. in Kumaun Himalaya around Nainital area (29°22' N lat. and 79°26' E long). Each forest site was divided into stands, that is, hill base (HB), hill slope (HS) and hill top (HT). The climate is monsoon temperate, and annual rainfall of the area is 2668 mm/year. The average monthly temperature ranges from 11.5°C in winter and 18.5°C during summer. 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 (Valdia, 1983). Phytosociological analysis of the study area was carried out by using 10 numbers, 10 × 10 m quadrants placed randomly for tree layer circumference at breast height (cbh), that is, 1.37 m from ground;

Table 1. Importance value index (IVI) of different species in the study-sites.

Species	Site 1	Site 2	Site 3	Site 4	Site 5
Pinus roxburghii	200	200	-	-	-
Rhododendron arboretum	8.9	27.4	-	-	-
Ilex dipyrena	-	-	7.2	13.6	13.00
Cornus oblonga	-	-	7.2	-	7.1
Quercus leucotricophora	-	-	180	9.4	28.4
Quercus floribunda	-	-	-	171.8	40.2
Quercus semecarpifolia	-	-	-	-	200
Acer oblongum	-	-	8.2	-	7.1
Myrica esculenta	27.4	-	16.0	-	-
Lyonia ovalifolia	-	-	7.2	-	-
Fraxinus micrantha	-	-	14.4	-	-
Litsea umbrosa	-	-	8.6	-	-
Biota orientalis	-	-	17.1	-	-
Aesculus indica	-	-	17.1	-	-
Cupressus torulosa	-	-	-	36.6	14.4

trees with cbh ≥ 31.5 cm were considered). Vegetation analysis was quantitatively analysed for abundance, density and frequency following Curtis and McIntosh (1950) and the relative values were summed up to represent Importance Value Index (IVI) as per Curtis (1959). Species richness was calculated by the number of species per unit area (Whittaker, 1960). Equitability or Evenness value represent the distribution of individuals among the species and calculated following Whittaker (1972) as:

E = S / (log Ni - log Ns)

Where, S is the total number of species, Ni is the number of individuals of most important species, Ns is the number of individuals of least important species and E is the evenness index. Species diversity (H') was calculated by following Shannon and Wiener (1963) as:

$$H' = -\sum_{n=1}^{i} (N_i/N) \log 2 (N_i/N)$$

Where, Ni is the total number of species i and N is the number of individuals of all species in that site. Concentration of dominance (Cd) was calculated by following Simpson (1949) as:

Cd = Σ (Ni/N)²

Where, Ni and N are the same as for the Shannon-Weiner information function.

RESULTS

Analysis of tree vegetation and their Importance Value Index (IVI) are depicted in Table 1. From the table, it is evident that total number of species ranged from 2 to 11 with maximum number in site 3 and minimum in site 2. *Pinus roxburghii* was common at site 1 and 2, and *Quercus leucotricophora* was common at site 3. 4 and 5 are dominated by *Quercus floribunda* and *Quercus semecarpifolia*, respectively. At site 1, *P. roxburghii* was found to be most dominant species (IVI, 200) followed by *Rhododendron arboretum* (8.1). At site 2, *P. roxburghii* was found to be most dominant species (IVI, 200) and *R. arboretum* exhibited lowest IVI (27.4). *Q. leucotricophora* was observed to be dominant species (IVI, 180) at site 3. The next two dominant species on that site were *Biota orientalis* and *Asculus indica.* Analysis of vegetation at site 4 revealed that *Q. floribunda* was observed to be the most dominant species (171.8) followed by *Cupressus torulosa* (36.6). At site 5, *Q. semecarpifolia* exhibited the maximum IVI value (200) followed by *Q. floribunda* and *Q. leucotricophora.*

Table 2, represents vegetational parameters in different forest sites. From the table it is evident that density (individual/100 m²) of tree species ranged from 6.6 to 8.5 at site 1. Species richness (per m²) varied from 1.0 to 1.3 and diversity value varied from 0 to 0.3. Equitability and concentration of dominance value ranged from 0.4 to 2.7 and 0.9 to 1.0 respectively. At site 2, density (individual/100 m²) of tree species varied from 4.7 to 7.8 and species richness (per m²) ranged from 1.0 to 1.3. Diversity and equitability value ranged from 0 to 0.3 and 0.4 to 2.5. Concentration of dominance value varied between 0.9 and 1.0 on the basis of density values. Tree density (individual/100 m²) at site 3 ranged from 6.7 to 11.4 per 100 m². Species richness (per m²) ranged from 1.2 to 1.6. Diversity value ranged from 0.2 to 6.2.

Equitability and concentration of dominance value ranged from 3.1 to 3.8 and 1.0 to 2.4, respectively. At site 4, tree density (individual/100 m²) varied from 5.0 to 6.7 and species richness (per m²) ranged from 1.3 to 2.2. Diversity and equitability values varied from 0.3 to 0.8

Table 2. Vegetation parameters in different forest stands.

Site	Aspect	Stand	S	D	H′	E	Cd
S1	E	HB	1.3	6.6	0.3	2.5	0.9
		HS	1.3	6.7	0.3	2.6	0.9
		HT	1.0	7.2	0	0.4	1.0
	SW	HB	1.3	8.2	0.3	2.3	0.9
		HS	1.3	8.5	0.3	2.7	0.9
		HT	1.0	6.6	0	0.4	1.0
S2	NE	HB	1.0	7.8	0	0.4	1.0
		HS	1.3	7.0	0.3	2.5	0.9
		HT	1.0	4.7	0	0.4	1.0
S3	E	HB	1.5	11.4	0.4	3.8	0.9
		HS	1.6	10.5	0.4	3.8	1.0
		HT	1.2	6.7	0.2	2.4	0.8
	W	HB	1.4	9.8	6.2	3.1	0.9
		HS	1.3	10.6	0.4	3.1	0.9
		HT	1.4	7.2	0.4	3.1	0.9
S4	E	HB	2.2	6.7	0.6	3.6	0.8
		HS	1.9	6.6	0.8	3.9	0.9
		HT	1.3	5.9	0.3	2.4	0.9
	SW	HB	1.4	6.1	0.5	3.1	0.9
		HS	1.7	5.8	0.5	4.2	0.8
		HT	1.4	5.0	0.4	3.1	0.9
S5	NE	HB	2.9	5.5	2.0	7.7	0.3
		HS	2.3	3.7	1.6	5.1	0.5
		HT	2.1	5.8	3.6	4.4	0.5
	NW	HB	1.9	4.0	1.2	5.1	0.5
		HS	1.9	6.5	0.9	4.0	0.7
		HT	1.0	6.4	0	0.4	1.0

E, east; SW, southwest; NE, northeast; W, west; NW, northwest; HB, hill base; HS, hill slope; HT, hill top; S, species richness (per m^2); D, density (individual/100m^2); H', diversity; E, Equitability; Cd, concentration of dominance.

and 2.4 to 4.2 respectively. Concentration of dominance value varied from 0.8 to 0.9. Tree density (individual/100 m^2) at site 5 varied from 3.7 to 5.8. Species richness (per m^2) ranged from 1.0 to 2.9 and diversity value varied from 0 to 3.6. Equitability and concentration of dominance values ranged from 0.4 to 7.7 and 0.3 to 1.0, respectively (Table 2).

DISCUSSION

From the above results, it is evident that species number is found to be maximum at site 3 and minimum at site 2 (Table 1). Species diversity in different sites indicated maximum diversity at site 5 and minimum at site 2. (Table 2) may be due to relatively more moisture level which considered as some of the factors for higher diversity in that site. Maximum concentration of dominance value at site 2 and minimum at site 5 indicate the trend of inverse relationship between diversity and dominance (Figure 1).

Analysis of variance (ANOVA) was applied following Snedecor and Cochran (1967) to test for significant differences among different parameters of diversity. Analysis of variance in the tree species (between species richness and diversity), the F-value (5.54) with 1 and 52 df, were significant at the 5% level.

In temperate forests, highest values for diversity index were recorded 2 to 3 (Risser and Rice, 1971). Braun (1950) reported tree diversity between 1.7 and 3.4 in an eastern forest of North America. For tropical rain forests, higher diversity (5.40) was calculated by Knight (1975). In certain forests of the Kumaun Himalaya the value ranged from 0.8 to 2.3 (Garkoti, 1992; Srivastava, 2002). These results are consistent with the present study.

Whittaker (1972) stated that the dominance of one stratum might affect the diversity of another stratum. For temperate forests, the value of concentration of dominance in the range of 0.10 to 0.99 has been reported by Risser and Rice (1971). For tropical rain forests, an average value of 0.06 was reported by Knight (1975) and 0.06 to 0.14 by Singh and Krishnamurthy (1981). Adhikari (1992), Arvind (2000) and Srivastava (2002) reported the value from 0.2 to 0.9 in the central Himalayan forests. The value in the present study was in the range of 0.6 to 3.4.

The Shannon-Wiener index is used as a diversity index because it combines the variety and equitability components. However, this may obscure the individual behavior of two components since an increase in the equitability may counteract a decrease in number of species. This index increased with an increase in number of species. Present study indicates that diversity and equitability (Ec) were positively correlated (P < 0.01) with species richness (S) and inversely correlated (P < 0.01) with concentration of dominance (Cd) (Figure 1). Similar trend was obtained by Kumar and Bhatt (2006). Significant relation was found between Altitude and equitability (P < 0.01). With increasing elevations, diversity increases across aspects (P < 0.01).

The higher diversity at higher elevations across these sites may be due to interaction of different species on these sites. Higher number of species with generally overlapping niches may coexist and it may be concluded that higher diversity always give higher stability. Various climatic factors are influences by the altitude. Aspect also plays an important role at the development of forest particularly in high altitudes. In the temperate regions, most of the soil belongs to the group of pod sol soils which is found on the northern aspect carry in coniferous vegetation. In addition, from the above results it may be concluded that, particularly in a forest type contribution is shared by one or more species.
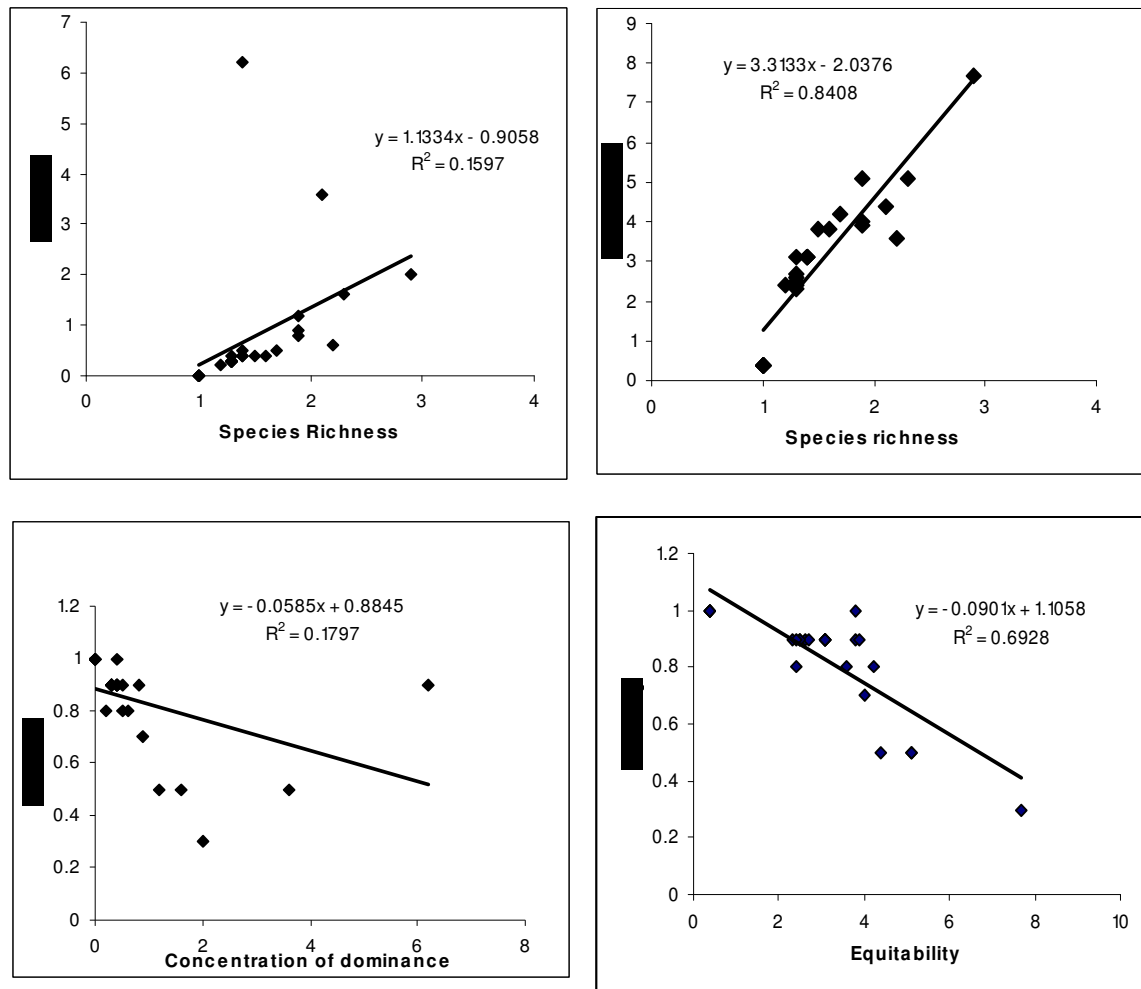
Figure 1. Correlation between different parameters.

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