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Analysis of forest vegetation at Kasar Devi hill of north-west Almora division in Kumaun Himalaya

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Abstract. The present study was conducted around the Almora town involving 12 forest sites on south, north and west slopes along an altitudinal gradient of 1600–2000 m. *Pinus roxburghii* Sarg. was the dominant species at lower altitude and *Quercus leucotrichophora* A. Camus. at higher altitude. Except for the dominant species, most of the species are contagiously distributed. Data of community coefficients indicate that the forests of lower elevations are most dissimilar compared to those at higher elevation. However, the community of same elevations are most similar to each other. Regeneration status was good in the experimental forest sites. However, regeneration of *Quercus leucotrichophora* was better on the north and west aspects and of *Pinus roxburghii* on south aspect.

Keywords. Basal cover; species diversity; community coefficient; importance value index; forest ecosystem; regeneration.

1. Introduction

Whereas the general pattern of Indian forest distribution has been known for many years (Champion and Seth 1968), some progress has been made to understand the functional dynamics of forest ecosystems only recently. Vegetation analysis has been carried out at different places in India (Gaur and Satyanarayan 1967; Meher-Homji 1973; Sharma 1977; Sprangers and Balasubramanian 1978). For the forests of Kumaun Himalaya, the recent studies of Saxena *et al* (1978), Pandey and Singh (1981a, b), Saxena and Singh (1980, 1982), Upadhyay and Singh (1985), Mehra *et al* (1985), Singh and Singh (1986, 1987) are noteworthy.

The structure and function of natural forests of Eastern Uttar Pradesh were studied by Singh and Misra (1978). Singh (1979) worked on the ecology of *Pinus patula* in Darjeeling Himalaya. But the details of structure, composition, distribution of Himalayan forests are left untouched. In the present study the vegetation of Kasar Devi forest situated in Almora District of Central Himalayan region was analysed.

2. Study area and methods

2.1 *Sites*

The study site is situated about 10 km north-west of Almora town (29° 37′ to 29° 38′ N latitude, 79° 39′ to 79° 41′ E longitude) along altitudinal gradients of 1600–2000 m. The forest covers an area of about 327 ha. Pine forests were present all around the hill slopes covering 242 ha i.e. 74% of the total forest area whereas oaks covered 75 ha (23%).

2.2 *Climate*

Since no climatic data are available for the present forest sites, the information of rainfall and temperature given here are based on the climatic data of Almora town. The climate is monsoon temperate with 3 distinct seasons, namely winter (October–March), summer (April to 15th of June), and rainy (June 15th to September) seasons. Further details of the climate are given in Pandey and Singh (1981a).

The minimum and maximum monthly average temperature fluctuate from 2·3°C (January) to 21·5°C (May) and from 12·8°C (January) to 32·0°C (May) respectively. Average annual rainfall is 797 mm. August and September were the wettest months of the year with about 70% of the total precipitation.

2.3 *Methods*

Phytosociological study of forest was done by laying 10×10 m quadrats (Misra 1968) at different altitudes of 1600, 1700, 1800, 1900 and 2000 m along south, north and west aspects during 1984. The percentage of frequency (F), abundance (A), A/F, density (trees ha^{-1}) dominance, basal area (m^2 ha^{-1}), Importance value index (IVI) and height (metres) were calculated at each altitudinal zone on 3 aspects separately following Curtis and McIntosh (1950). A total of 20 quadrats were studied at each altitude on south, north and west aspects. Based on A/F ratio, regular $<0{\cdot}025$ random (between 0·025–0·05) and contagious $>0{\cdot}05$ distribution (Curtis and Cottom 1956) were measured. Circumference at breast height (Cbh) of trees (i.e. at 1·37 m) were calculated. Plants with cbh more than 31·5 cm (Knight 1963) were considered trees and those that had 10·5–31·4 cm cbh were considered as saplings or shrubs as the case may be, and individuals $<10{\cdot}5$ cm cbh were considered as seedlings. Shrub layer was studied for the above parameters in detail. Community coefficients for tree and shrub layers between different forest sites were calculated following Jaccard (1912), using density value. The tree and shrub diversity for different forests on different aspects was determined by using Shannon-Wiener information function (H) (Shannon-Wiener 1963). Concentration of dominance (Cd) was measured by Simpson's index (Simpson 1949).

To represent the population structure of dominant tree species on south, north and west aspects, the following cbh classes were established: (i) 0–10·4 (seedlings); (ii) 10·5–31·4 (saplings); (iii) 31·5–60·5; (iv) 61·0–90·0; (v) 91·0–120·0; (vi) 121·0–150·0; (vii) 151·0–180·0; (viii) 181·0–210·0; (ix) 211·0–240·0. The total number of individuals belonging to different individual girth classes were marked for south, north and west aspects separately. The density values for different girth classes were calculated.

3. Results and discussion

3.1 *Analytical characters*

On the basis of density, total basal cover and IVI, *Pinus roxburghii* Sarg. which covers 74% of the total forest area is dominant on south, north and west aspects of

Table 1. Analysis of the forest on south, north and west aspects of Kasar Devi hill in Kumaun Himalaya.

Species	Density (trees ha⁻¹)	Mean basal cover (cm² trees⁻¹)	Total basal cover (m² ha⁻¹)	IVI	Abundance/ frequency
			South aspect		
			Site-1 (1700 m and 1600 m*, **)		
P. roxburghii	192·50	1418·81	26·72	242·63	0·02
	288·75*	879·38*	25·39*	233·49*	0·02*
	280·00**	1461·60**	40·92**	266·86**	0·03**
Cedrus deodara Hook. f.	15·00	1087·54	1·57	22·93	0·05
	60·00*	1071·18*	6·42*	54·15*	0·09*
	NP**	NP**	NP**	NP**	NP**
Q. leucotrichophora	5·00	659·20	0·32	6·95	0·20
	5·00*	1016·22*	0·50*	6·64*	0·20*
	40·00**	693·37**	2·77**	33·12**	0·17**
M. esculenta	5·00	509·24	0·25	6·71	0·20
	NP*	NP*	NP*	NP*	NP*
	NP**	NP**	NP**	NP**	NP**
Alnus nepalensis D. Don.	5·00	1184·81	0·59	7·86	0·20
	NP*	NP*	NP*	NP*	NP*
	NP**	NP**	NP**	NP**	NP**
Sapium insigne Trim.	5·00	459·72	0·22	6·61	0·20
	5·00*	305·85*	0·15*	5·65*	0·20*
	NP**	NP**	NP**	NP**	NP**
Celtis australis Sensu Hook. f.	5·00	215·27	0·11	6·21	0·20
	NP*	NP*	NP*	NP*	NP*
	NP**	NP**	NP**	NP**	NP**
			Site-2 (1800 m and 1700 m*, **)		
P. roxburghii	153·75	1186·74	18·20	202·04	0·04
	167·50*	1248·15*	20·88*	201·51*	0·02*
	235·00**	963·27**	22·63**	244·17**	0·03**
Q. leucotrichophora	31·66	1267·36	2·50	35·31	0·10
	40·00*	1111·10*	4·44*	39·27*	0·12*
	65·00**	575·23**	3·73**	55·81**	0·16**
Toona ciliata Roem.	15·00	2058·54	3·35	24·06	0·60
	NP*	NP*	NP*	NP*	NP*
	NP**	NP**	NP**	NP**	NP**
M. esculenta	10·00	581·62	0·58	15·32	0·10
	12·50*	421·91*	0·54*	12·76*	0·33*
	NP**	NP**	NP**	NP**	NP**
C. deodara	5·00	1345·45	0·67	9·14	0·20
	22·50*	1198·26*	2·73*	36·24*	0·04*
	NP**	NP**	NP**	NP**	NP**
C. australis	5·00	249·55	0·12	6·98	0·20
	NP*	NP*	NP*	NP*	NP*
	NP**	NP**	NP**	NP**	NP**
S. insigne	5·00	305·88	0·15	7·10	0·20
	NP*	NP*	NP*	NP*	NP*
	NP**	NP**	NP**	NP**	NP**
Cupressus torulosa Don.	NP	NP	NP	NP	NP
	5·50*	2438·07*	1·21*	10·21*	0·20*
	NP**	NP**	NP**	NP**	NP**

Table 1. (*Contd.*)

Species	Density (trees ha⁻¹)	Mean basal cover (cm² trees⁻¹)	Total basal cover (m² ha⁻¹)	IVI	Abundance/ frequency
		Site-3 (1900 m and 1800 m*·**)			
P. roxburghii	110·00	1398·62	15·38	202·55	0·02
	131·25*	1335·15*	16·95*	100·35*	0·06*
	195·00**	1245·97**	24·29**	158·99**	0·07**
Q. leucotrichophora	40·00	1253·48	5·01	61·49	0·17
	63·75*	882·42*	5·25*	44·13*	0·09*
	190·00**	787·84**	14·96**	134·12**	0·07**
M. esculenta	25·00	963·27	2·40	35·92	0·25
	55·00*	863·31*	4·74*	33·11*	0·24*
	5·00**	644·79**	0·32**	6·84**	0·20**
C. deodara	NP	NP	NP	NP	NP
	138·33*	1265·40*	14·80*	93·23*	0·13*
	NP**	NP**	NP**	NP**	NP**
C. torulosa	NP	NP	NP	NP	NP
	15·00*	1921·11*	2·88*	10·31*	0·06*
	NP**	NP**	NP**	NP**	NP**
Pyrus pashia Buch-Ham. ex d. Don.	NP	NP	NP	NP	NP
	5·00*	447·64*	0·22*	4·78*	0·20*
	NP**	NP**	NP**	NP**	NP**
S. insigne	NP	NP	NP	NP	NP
	5·00*	616·31*	0·30*	4·96*	0·20*
	NP**	NP**	NP**	NP**	NP**
		Site-4 (1900 m* and 1900 m**)			
Q. leucotrichophora	125·00*	1037·80*	12·97*	137·96*	0·05*
	195·00**	673·45**	13·13**	234·82**	0·03**
P. roxburghii	50·00*	1418·57**	7·09*	61·97*	0·12*
	10·00**	1407·91**	1·40**	22·02**	0·10**
M. esculenta	30·00*	945·75*	2·83*	34·60*	0·13*
	40·00**	522·12**	2·08**	43·12**	0·17**
C. deodara	40·00*	1150·30*	4·60*	57·42*	0·04*
	NP**	NP**	NP**	NP**	NP**
P. pashia	5·00*	1052·70*	0·52*	8·01*	0·20*
	NP**	NP**	NP**	NP**	NP**
		Site-5 (2000 m**)			
Q. leucotrichophora	110·00**	817·46**	8·99**	118·03**	0·01**
R. arboreum	145·00**	364·89**	5·29**	103·25**	0·03**
L. ovalifolia	45·00**	81·51**	0·36**	37·71**	0·01**
P. roxburghii	35·00**	718·32**	2·51**	34·72**	0·05**
C. deodara	5·00**	963·27**	0·48**	6·23**	0·20**

*Values of north aspect. **Values of west aspect.
NP = Values not present.

On north aspect *Myrsine africana* L. was most dominant species on all sites indicating its better adaptability to cooler climate. Per cent moisture content in soil ranges between 17–25% on north aspect between 10–16% on south aspect across sites. *M. africana* was the dominant species on west aspects.

The community coefficient values for shrub layers (table 4) indicate that the forest

Table 2. Community coefficients calculated on the basis of density of tree species for different forest sites on south, north and west aspects.

	South aspect			North aspect				West aspect				
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 4	Site 1	Site 2	Site 3	Site 4	Site 5
South aspect												
Site 1	100·00	82·00	58·89	74·84	80·21	49·94	33·16	71·49	74·18	77·51	8·38	15·72
Site 2		100·00	75·75	58·78	84·76	60·40	44·87	67·99	70·58	73·89	21·96	25·35
Site 3			100·00	43·91	76·92	59·49	54·12	60·61	63·16	66·67	35·71	29·13
North aspect												
Site 1				100·00	65·41	52·82	31·73	85·23	73·99	62·62	5·05	13·07
Site 2					100·00	63·93	50·25	73·13	75·79	79·07	25·38	27·23
Site 3						100·00	56·91	46·70	54·67	56·87	34·56	30·20
Site 4							100·00	31·58	41·82	66·67	66·67	50·85
West aspect												
Site 1								100·00	88·71	77·05	17·70	22·73
Site 2									100·00	88·14	27·52	31·25
Site 3										100·00	76·64	46·03
Site 4											100·00	41·03
Site 5												100·00

Table 3. Analysis of shrub layer under different forests on south, north and west aspects

Species	Density (ha^{-1})			IVI		
	S	N	W	S	N	W
	Site 1 (S = 1700 m, N and W = 1600 m)					
Berberis asiatica Roxb.	210·00	140·00	NP	58·80	40·17	NP
Rubus ellipticus J. E. Smith	182·50	610·00	NP	63·85	76·12	NP
R. paniculatus Smith.	102·50	NP	NP	24·45	NP	NP
M. africana	455·00	672·50	110·00	101·61	102·93	160·79
Asperagus gracilis Royle.	95·00	117·00	65·00	19·94	13·85	63·23
C. crenulata	75·00	200·00	NP	31·28	66·84	NP
Crotoleria mysorensis Roth.	NP	NP	35·00	NP	NP	75·95
	Site 2 (S = 1800 m, N and W = 1700 m)					
R. ellipticus	320·00	212·50	NP	68·03	30·69	NP
R. paniculatus	235·00	NP	NP	24·70	NP	NP
A. gracilis	380·00	261·25	NP	50·41	35·43	NP
M. africana	345·00	1105·00	175·00	52·79	202·46	144·87
B. asiatica	92·50	150·00	90·00	11·38	31·37	56·99
C. crenulata	275·00	NP	125·00	92·64	NP	98·12
	Site 3 (S = 1900 m, N and W = 1800 m)					
C. crenulata	110·00	296·66	NP	191·70	108·50	NP
A. gracilis	65·00	NP	45·00	68·66	NP	35·80
R. paniculatus	45·00	60·00	NP	39·59	10·23	NP
M. africana	NP	1406·25	160·00	NP	133·55	124·79
B. asiatica	NP	40·00	NP	NP	12·75	NP
R. ellipticus	NP	210·00	NP	NP	35·38	NP
C. mysorensis	NP	NP	125·00	NP	NP	139·29
	Site 4 (N and W = 1900 m)					
C. crenulata	NP	95·00	NP	NP	130·42	NP
M. africana	NP	160·00	210·00	NP	122·64	171·83
B. asiatica	NP	55·00	125·00	NP	29·64	90·42
D. papyracea Wall.	NP	35·00	NP	NP	17·24	NP
A. gracilis	NP	NP	60·00	NP	NP	37·70
	Site 5 (W = 2000 m)					
A. gracilis	NP	NP	105·00	NP	NP	107·47
Sageratia filiformis Roth.	NP	NP	60·00	NP	NP	76·21
C. crenulata	NP	NP	10·00	NP	NP	116·30

NP, Species not present.

sites of west aspect are most dissimilar to that of other forest sites between hill base and hill top on all aspects.

3.2 *Statistical treatments*

The relationship between diameter and height of some important trees were established at Kasar Devi forest. Significant positive correlations were noted between DBH and height. The coefficient correlation (r) and regression parameters are given

Table 4. Community coefficients calculated on the basis of density of shrub species for different forest sites on south, north and west aspects.

	South aspect			North aspect				West aspect				
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 4	Site 1	Site 2	Site 3	Site 4	Site 5
South aspect												
Site 1	100·00	64·50	27·61	66·27	56·34	51·87	39·59	26·32	45·03	28·28	52·15	16·22
Site 2		100·00	18·74	63·45	53·98	50·81	31·12	18·84	38·28	20·73	35·49	12·62
Site 3			100·00	17·86	6·67	13·88	33·63	30·23	36·07	16·36	19·51	37·97
North aspect												
Site 1				100·00	31·25	59·83	29·74	17·95	36·62	19·81	37·01	12·01
Site 2					100·00	72·42	20·74	18·06	25·01	19·91	37·20	11·03
Site 3						100·00	25·02	9·89	28·29	13·66	20·76	1·06
Site 4							100·00	39·64	84·35	47·41	58·11	3·85
West aspect												
Site 1								100·00	36·67	70·37	56·19	33·77
Site 2									100·00	44·44	44·58	3·54
Site 3										100·00	56·55	17·82
Site 4											100·00	21·05
Site 5												100·00

Table 5. Coefficient of correlation (r) and regression parameters of some dominant trees between DBH (x) and height (y).

Plant species	Intercept	Slope	'r' value
Q. leucotrichophora	6·84	0·19	0·87
L. ovalifolia	−5·17	0·89	0·97
P. roxburghii	−0·21	0·55	0·98
S. insigne	−5·52	0·52	0·96
M. esculenta	−4·14	0·59	0·92
R. arboreum	2·89	0·19	0·88
C. deodara	9·54	0·28	0·96

All the values are significant at $P < 0{\cdot}001$.

in table 5. Lesser variability (65%) between these two parameters for *Q. leucotrichophora* and *R. arboreum* and about 81–85% for other species indicate that in the former set of species the DBH versus height relationship is not strong.

3.3 *Species diversity*

On the west aspect greater number of species and diversity index were observed at the hill top site 5 west aspect. The data also indicate that diversity index as calculated here is not only dependent on number of species but is rather strongly influenced by the equitability of distribution of the quantity used in calculations among the species present. Shrub exhibited maximum diversity at site 2, on south and west aspects, whereas, the diversity was maximum at site 1 on the north aspect. Ralhan *et al* (1982) found diversity index zero in *P. roxburghii* forest and 0·46–2·02 in oak forests in Naini Tal district of Kumaun Himalaya. Thus the diversity index for different forests on north, south and west aspects in the present study fall in the range of value reported by Ralhan *et al* (1982).

On south and north aspects of site 1 and on west aspect of sites 1 and 2 concentration of dominance were considerably greater since on these sites *P. roxburghii* had high relative dominance. The lower values on sites 3 and 5 of north and west aspect respectively, indicate that in these sites, the dominance is shared by many species.

Dominance-diversity curves for the tree layer (on the basis of IVI) have been drawn for all the forest sites on south, north and west aspects for eliciting the community organisation in terms of resource share and niche space (figure 1). These curves for all the forest sites fit the geometric series which corroborates the niche pre-emption hypothesis (Whittaker 1975), though they some times approach Preston's (1948) log normal situation. According to Whittaker (1972) the geometric form is often exhibited by vascular plant communities having low diversity. Among all the forest sites, the dominant species in general occupied a greater equitable share of resources. The dominance-diversity curves for shrubs (figure 2) indicate a behaviour almost similar to that of the trees.

3.4 *Population structure of dominant trees*

The population structure of *P. roxburghii* and *Q. leucotrichophora* occurring in different forest types is given in figure 3. This shows a decreasing proportion of

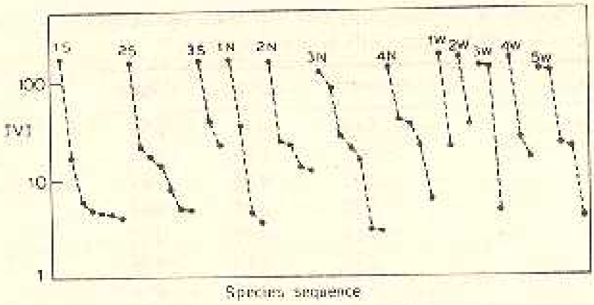

Figure 1. Dominance-diversity curves for different forest sites for tree layer. S, south aspect; N, north aspect; W, west aspect. The values 1–5 represent different forest sites.

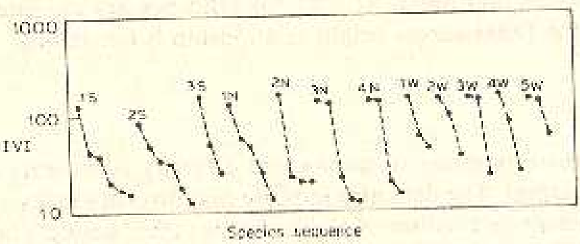

Figure 2. Dominance-diversity curves for different forest sites for shrub layer. Same notations as in figure 1.

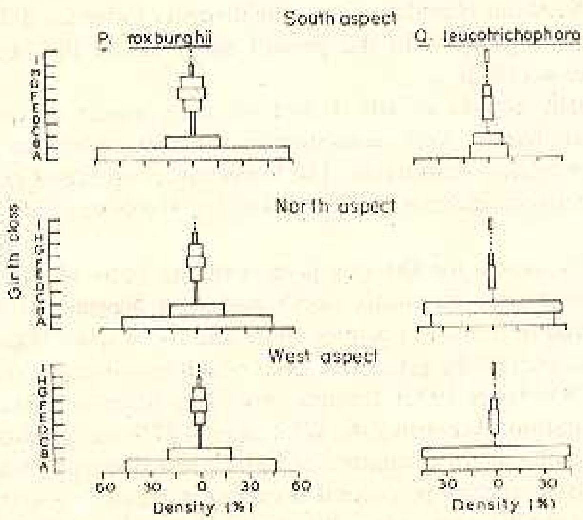

Figure 3. Population structures of species.

individuals from lower to higher girth classes. However, both the species in all aspects are characterized by the presence of seedlings and saplings and indicates higher frequency on frequent reproduction (Knight 1975). The regeneration of *Q. leucotrichophora* on west and north aspects is greater than on south aspect whereas, *P. roxburghii* had better regeneration on south aspect compared to north and west aspects across all sites. This indicates that sufficient moisture and protection is needed for the establishment of *Q. leucotrichophora* seedlings.

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sites 1, 2 and 3 (table 1). *Quercus leucotrichophora* A. Camus exhibited dominance on site 4 on north and west aspects, respectively. *Rhododendron arboreum* Smith showed dominance only on the west aspect of site 5. *P. roxburghii* and *Q. leucotrichophora* were however, present on all sites but the preponderance of the former gradually decreased with increase in elevation and the latter decreased with decrease in elevation. The oaks were the dominant tree species at higher altitude and cover 23% of the total forest area. Other associates apart from the dominants across the aspects are *Myrica esculenta*, *R. arboreum*, *Lyonia ovalifolia* (Wall.) Drude. and *Cedrus deodara*, which have lesser density value and are sparsely distributed.

The total basal cover across all species was maximum on the north aspect of site 3 (45·17 m^2 ha^{-1}) and minimum on west aspect of site 4 (16·61 m^2 ha^{-1}). On south aspect total basal cover across sites was maximum at site 1 (29·78 m^2 ha^{-1}) and was minimum at site 3 (22·79 m^2 ha^{-1}). The south aspect data of total basal cover indicated that the forest at sites 1 and 2 was younger than at site 3. On the north aspect maximum total basal cover was recorded at site 3 (45·17 m^2 ha^{-1}) and minimum at site 4 (28·01 m^2 ha^{-1}). The total basal cover did not exhibit any relation with total tree density among the sites (table 1). On the north aspect there were not any significant difference in the mean basal cover across all sites. However, for this aspect site 3 seems to be older than sites 1, 2 and 4. Similarly on the west aspect tree density was almost similar but remarkably lower on site 4 compared to sites 1–3. Among sites 1–3, the density was almost similar but basal cover was markedly lower on site 2 than 1 and 3, similarly higher tree density with lower basal cover was obtained on site 5 compared to site 4. Total basal cover indicated that on west aspect, sites 2, 4 and 5 were younger than sites 1 and 3. The forest sites 4 and 5 of west aspect were younger than those of other sites of north and south aspects.

The values for basal cover and density in several temperate forests as reported by different authors vary from 15·61–59·31 m^2 ha^{-1} and from 350–2080 trees ha^{-1}, respectively (Saxena 1979). The basal cover values on the present sites, thus were in the range reported for the temperate forests (16–45 m^2 ha^{-1}) but density values were not in the range reported for the temperate forest but less (175–413 trees ha^{-1}). It may be due to the greater biotic pressure viz illicit felling, lopping and frequent burning in the present forest sites.

Across all sites and aspects *P. roxburghii* contributes about 62–87·5% of the total tree layer composition except for the west aspect of sites 4 and 5 and north aspect of site 4, where *Q. leucotrichophora* and *R. arboreum* are the dominant contributers (43–80%).

The *A/F* ratio indicates that most of the species of all sites across all aspects are contagiously distributed, whereas only two species i.e. *P. roxburghii* and *Q. leucotrichophora* on a few sites show regular and random distribution. The contagious distribution in natural vegetation has been reported by Greigh Smith (1957), Kershaw (1973) and Singh and Yadav (1974).

It is evident that the forest sites of higher elevations across all aspects are similar. Similarly the forest site of the lower elevations are most similar to each other and are dissimilar to the forest sites of higher elevations (table 2), with broad-leaved species dominating at higher elevations and conifers at lower elevations.

The shrub species richness decreased at all forest sites from hill base to top on south and north aspects excluding sites 2 and 3 (table 3). According to IVI *Cretaegus crenulata* Roxb. was dominant species on south aspect in all sites except site 1.