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Research Article

ANALYSIS OF FOREST VEGETATION IN RANIKHET, KUMAON HIMALAYAS, UTTRAKHAND, INDIA

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ABSTRACT
This study deals with the floristic composition and distribution pattern of the different plant species with reference to density, ivi, diversity index and the structural characteristics of tree and shrub communities in a moist temperate forest. The study was conducted in ranikhet of kumaon himalayas along an elevational gradient of 1818-2125 masl. The oak-pine forest in the study area is dominated by banj oak (*quercus leucotricophora*) in tree layers and is regarded as the climax species. Four major tree associations are recognized in this forest type: a) oak forest, b) oak-pine forest, c) oak-scrub, d) chir-pine forest. Phytosociological characteristics differ among different tree species. The oak-pine forest has the highest species richness and also exhibits the highest species diversity of 0.838. The tree density has been found to be 136.1/ha. The concentration of dominance varied between 0.237 and 0.561. The highest has been recorded in the chir-pine forest. The lower density and consequently greater concentration of dominance could be due to a lower rate of evolution and diversification of the communities and severity in the environment**.**

Key Words: *Concentration of Dominance, Diversity Index, Ivi (Importance Value Index), Moist Temperate Forest and Species Richness*

INTRODUCTION
This paper deals with the floristic composition, distribution pattern of the different species and structural characteristics of tree and shrub communities of forests in Ranikhet region of Kumaon Himalayas. Following is the description of of the vegetation in the study area within an elevational range of 1818-2125 masl. Champion and Seth, (1968) classified the forest within this range as Himalayan moist temperate type. The oak-pine forest in the study area is dominated by Banj-oak (*Quercus leucotricophora*) in tree layer and is regarded as the climax species by Singh & Singh, (1986). Four major tree associations can be recognized in this forest type:
Oak-forest
Oak-pine forest
Oak-scrub
Chir-pine forest
The oak forest is mainly composed of Banj (*Quercus leucotricophora*). The oak forms a close canopy in places where the trees are well developed. Puri *et al.*, (1989) have also made the same observation. In the damp ravines there is an appreciable mixture of deciduous trees contributing to the main canopy. *Rhododendron arboreum* and *Lyonia ovalifolia* (both unfit for cattle feed and bad fuels) are typical associates usually below the oak canopy. There is also a well defined, largely evergreen, second storey of *Pyrus pashia* and *Symplocos theifolia* which occur on damp sites. In areas which are not too heavily browsed there is generally a good deal of undergrowth of both deciduous and evergreen shrubs. Climbers are few, *Rosa moschata* and *Hedera helix* being the commonest. There is a luxuriant growth of mosses and lichens on the trees and in the monsoon a copious development of epiphytic ferns *Arum* and *Sedum* also appear.

The oak-pine forest comprises oak (*Quercus leucotricophora*) in close association of *Pinus roxburghii***,** *Myrica nagi* and varying groups of deciduous tree genera notably *Litsea, Ilex, Prunus, Aesculus, Viburnum, Maytenus* and *Pyrus*. Among the shrubs *Indigofera, Desmodium, Viburnum, Wikstroemia* are the other species. This composition (deciduous trees and shrubs) is generally met in depressions, damp sites, ravines and gentler slopes.

In the oak-scrub the oak has been reduced to low stunted, diminutive trees, usually coopice. With it are bushes of *Berberis, Crataegus* and *Myrsine* (all thorny) and sometimes *Spiraea, Scutellaria, Boenninghausenia, Wikstroemia* and *Indigofera***.** The factors responsible for the stunted growth of oak are lopping for fodder combined with browsing and pole felling. Practically all the oak stands are subject to heavy animal pressure and lopping. The older trees usually perish but the smaller tend to end up as coppice scrub.

The Chir-pine forests are frequently met with. They have a tendency to form monospecific stands with sparse shrub undergrowth (Singh & Singh, 1987). Occasionally stray trees of *Myrica, Quercus, Cuperossus* and *Cedrus* can be seen in association.

The shrubs common to all the four habitat types are *Rubus biflorus, Rubus ellipticus, Berberis asiatica, Berberis aristata, Myrsine africana* and *Pyracantha crenulata*.

Study Area

The study area lies within the limits of the Ranikhet cantonment in Pali sub-division of Almora district. Ranikhet (29°29'50" North, 79°26'East) is situated on one of the ridges of the Kumaon Himalayas, which stretches half way across the district west to east and forms the northern boundary of the kosi basin.

The cantonment comprises three distinct areas, Alma Barracks 1818 m, Deolikhet 1823m, and Chaubatia 2125m. Most of the area around Ranikhet is reserved forest and is more or less protected. The cantonment forest where the intensive studies were carried out, are bounded practically on all sides by the forest of the Ranikhet range of West Almora Forest Division.

The forest is spread over a tract of rounded or flat ridges with subsidiary spurs and slopes of gentle-to-moderate gradient. The moderate slopes have given rise to deep and well drained-soils. In moist ravines and in places, generally north facing slopes, there is a good leaf-mold layer making the soil well suited to the growth of oak. On some of the ridges and southerly aspects in the chir-zone, more especially where grazing has been heavy in the past, the soil is poorer, shallow and dry.

The basic pattern of weather and climate over the Himalaya is governed by the summer and winter monsoon system of Asia (Mani, 1981). For all the seasonal regularity of the monsoon winds and rainfall, the local climate along the Himalayas is quite variable. Weather changes are unpredictable and erratic.

MATERIALS AND METHODS

The analysis of all the forests was accomplished by Point Centered Quarter (PCQ) method of vegetation sampling to determine the density and the species composition in each of the habitat types following Dombois & Ellenberg, (1974). The sampling was done at five different sites and a random selected compass line was projected for the quantitative measurements of the plants at each site. Each sampling point was divided into four quarters and the distance to the nearest tree was measured. Tree girth at breast height, (1.37m from the ground) was also measured and recorded individually for each species. The data were analyzed quantitatively for basal cover, density and importance value index (IVI) following the methods of Dombois & Ellenberg, (1974). The IVI was determined as the sum of relative frequency, relative density and relative dominance.

The species diversity was determined by using the Shanon-Weiner information function as:

$H= \sum p_i \cdot \log p_i$

Where p_i is the proportion of *i*th species in the sample.

The concentration of dominance (CD) was calculated using Simpson's, (1949) index as:

$CD= \sum (n_i /N)^2$

Where n*i* is the importance value for the species *i* and N is the total importance value of all the species in a stand. Dominance and diversity indices were calculated on the basis of density values.
The index of similarity (S) was calculated to compare the two forests (Sorensen, 1948) as:
S= 2C/A + B x 100
Where A and B represent the numbers of species in forests A and B respectively and C is the number of species common to both the stands.
The ground cover vegetation was assessed by the "2 Step" method (Riney, 1982). Ten transects of equal length(100 paces each) were randomly selected and walked. The ground cover immediately under the mark (notch at the toe of the right shoe) was recorded. One transect of 100 paces thus contained 50 sample points. At the end of the exercise the figures for each category of all transects were added and divided by the number of sample points to arrive at the mean. The general calculations were done as follows:
% ground cover = no. of hits on X x 100/total no. of sample hits
for all habitat types.

RESULTS AND DISCUSSION

Oak forest

Quercus leucotricophora exhibits absolute dominance in terms of density (587.3 trees/ha), total basal cover (288387.7 cm²/ha) and IVI (129.9). The mean basal cover of this species is 491.0 cm²/tree (Table 1). The co-dominant species in this forest is *Pinus roxburghii* having a density of 130.4/ha and an IVI of 69.7. *Myrica nagi* (IVI=37.9), *Rhododendron arboreum* (IVI=16.8) are the other important trees in the forest. *Pinus roxburghii* has the highest mean basal area (1928.0 cm²/tree). *Malus domestica* is the least important of all the species with a density of 2 trees/ha and an IVI of 0.61. The diversity index was 0.722 with a species richness of 17 (Table 5).

Table1: Density (No./ Ha) Percentage Frequency, Mean Basal Area (Cm²/Tree), Dominance (Cm²/ Ha) and Importance Value Index (IVI) of Different Trees in Oak Forest

S.No.	Tree Species	Density	Frequency	Mean basal area	Dominance	IVI
1	*Aesculus indica*	6.0	1.4	397.3	2383.8	1.8
2	*Cedrus deodara*	14.1	4.2	991.7	13982.9	5.4
3	*Cupressus torulosa*	4.0	1.4	669.3	2677.3	1.5
4	*Ilex dipyrena*	22.2	7.1	467.5	10378.5	7.8
5	*Litsea umbrosa*	2.0	0.7	687.9	1375.8	0.79
6	*Lyonia ovalifolia*	50.9	15.0	311.8	15870.6	16.3
7	*Malus domestica*	2.0	0.7	86.6	173.2	0.61
8	*Myrica nagi*	124.2	31.4	324.9	40352.53	7.9
9	*Pinus roxburghii*	130.4	30.7	1928.0	251411.2	69.7
10	*Pyrus pashia*	38.4	11.4	479.1	18397.4	13.3
11	*Quercus glauca*	14.2	3.5	773.9	10989.3	5.2
12	*Quercus lanata*	10.1	5.7	216.7	2188.6	4.3
13	*Quercus leucotricophora*	587.3	88.5	491.0	288387.7	129.9
14	*Rhododendron arboreum*	48.6	15.7	404.5	19658.7	16.8
15	*Stranvaesia nussia*	4.0	0.7	216.6	866.4	1.0
16	*Symplocos theifolia*	4.0	2.1	231.9	927.6	1.6
17	*Viburnum coriaceum*	18.2	2.8	228.6	4160.5	4.7

Oak-pine forest

Quercus leucotricophora is dominant interms of density (183.2 trees/ha). The mean basal area and the IVI are 625.3 and 99.9 respectively. The total basal cover (Dominance) was 114598.7 cm²/ha. The co-dominant species is *Pinus roxburghii* with a density of 136.1 trees/ha and IVI 98.1 (Table 2). The other important trees in association are *Myrica nagi, Rhododendron arboreum, Cedrus deodara, Cupressus torulosa, Ilex dipyrena* and *Viburnum coriaceum* with their respective densities of 68.0 trees/ha, 26.2 trees/ha, 26.1 trees/ha, 15.7 trees /ha,6.8 trees/ha, and 6.8 trees/ha. In order of their importance the IVI's are 32.5, 16.0, 15.8, 7.1, 3.5, and 2.8 respectively. The mean basal area is highest, 916.9 cm²/tree in *Rhododendron arboreum* and lowest, 318.7cm²/ tree, in *Cupressus torulosa*. *Pinus roxburghii* has the highest mean basal area of 1322.4 cm²/tree. *Persea duthiei* and *Prunus napaulensis* are the least important species with the dominance of 27.7 cm²/ha and 16.8 cm²/ha respectively. The diversity index was 0.838 with a species richness of 21 (Table 5).

Table2: Density (No./ Ha) Percentage Frequency, Mean Basal Area (Cm²/Tree), Dominance (Cm²/ Ha) and Importance Value Index (IVI) of Different Trees in Oak-Pine Forest

S.No.	Tree Species	Density	Frequency	Mean basal area	Dominance	IVI
1	*Aesculus indica*	1.9	1.5	189.1	366.4	1.6
2	*Alnus nepalensis*	1.9	1.5	450.2	872.0	0.9
3	*Cedrus deodara*	26.1	12.7	872.4	22839.4	15.8
4	*Cupressus torulosa*	15.7	8.2	318.7	5006.4	7.1
5	*Ilex dipyrena*	6.8	5.2	583.5	3971.8	3.5
6	*Lyonia ovalifolia*	5.2	4.5	175.2	917.3	2.2
7	*Maytenus rufa*	10.4	5.2	296.3	3102.8	4.6
8	*Myrica nagi*	68.0	38.3	366.0	24919.0	32.5
9	*Persea duthiei*	0.9	0.7	29.5	27.7	0.3
10	*Pinus roxburghii*	136.1	58.6	1322.4	180031.5	98.1
11	*Prunus napaulensis*	0.9	0.7	17.9	16.8	0.3
12	*Pyrus pashia*	4.9	3.7	415.2	2043.1	2.3
13	*Quercus glauca*	1.9	1.5	458.3	887.7	0.9
14	*Quercus lanata*	2.9	3.0	237.2	700.2	1.2
15	*Quercus leucotricophora*	183.2	80.4	625.3	114598.7	99.9
16	*Rhododendron arboreum*	26.2	16.5	916.9	24006.2	16.0
17	*Rhus wallichi*	2.9	3.0	296.5	869.3	1.3
18	*Stranvaesia nussia*	1.9	1.5	212.0	410.7	0.8
19	*Symplocos crataegoides*	1.9	6.0	12.1	23.4	0.6
20	*Symplocos theifolia*	2.9	6.0	10.3	30.1	1.1
21	*Viburnum coriaceum*	6.8	3.7	829.6	5647.0	2.8

Oak scrub

Pinus roxburghii is a dominant tree species in terms of density (300.9 trees/ha). The mean basal area is 359.8 cm²/ ha and the IVI 138.1. The dominance for this species is 108274.6 cm²/ ha. The co-dominant species is *Quercus leucotricophora* with a density of 223.9 trees/ ha and IVI 102.2 (Table 3). The other important trees are *Myrica nagi* with a density of 104.9 trees/ ha and IVI 37.3, *Symplocos theifolia* (34.9 trees/ ha and 11.0) and *Cupressus torulosa* (139 trees/ ha and 4.2*). Rhododendron arboreum* and *Stranvaesia nussia* are poorly distributed and both occupy the same density of 6.9 trees/ ha. The diversity index was found to be (0.591) with a species richness of 7 (Table 5).

Table 3: Density (No./ Ha) Percentage Frequency, Mean Basal Area (Cm²/Tree), Dominance (Cm²/ Ha) and Importance Value Index (IVI) of Different Trees in Oak-Scrub

S.No.	Tree Species	Density	Frequency	Mean basal area	Dominance	IVI
1	*Cupressus torulosa*	13.9	11.4	41.9	586.18	4.2
2	*Myrica nagi*	104.9	45.7	147.1	15441.0	37.3
3	*Pinus roxburghii*	300.9	97.1	359.8	108274.6	138.1
4	*Quercus leucotricophora*	223.9	82.8	354.3	79345.4	102.2
5	*Rhododendron arboreum*	6.9	5.7	239.7	1677.4	2.8
6	*Stranvaesia nussia*	6.9	5.7	142.8	998.1	2.4
7	*Symplocos theifolia*	34.9	20.0	70.3	2459.7	11.

Chir-pine forest

Pinus roxburghii is dominant in terms of density (583.2 trees/ ha), the mean basal area (347.9cm²/ tree) and IVI (218.2) The dominance is 202916.8 cm²/ ha. The co-dominant species are *Cupressus torulosa* and *Quercus leucotricophora* with a similar density of 61.3 trees/ ha but different IVI's value (22.4 and 31.7), respectively. The mean basal area has been observed as 254.5 cm² /tree and 148.7 cm²/ tree, respectively (Table 4). *Myrica nagi* is the least important species in order of dominance, (1388.3 cm²/ha). The IVI of this species is observed as 5.3. The diversity index (DI) was found to be 0.377 with a species richness of 6 (Table 5).

Table 4: Density (No./ Ha) Percentage Frequency, Mean Basal Area (Cm²/Tree), Dominance (Cm²/ Ha) and Importance Value Index (IVI) of Different Trees in Chir-Pine Forest

S.No.	Tree Species	Density	Frequency	Mean basal area	Dominance	IVI
1	*Cedrus deodara*	7.6	6.6	286.7	2200.1	5.7
2	*Cupressus torulosa*	61.3	13.3	254.5	15630.1	22.4
3	*Maytenus rufa*	23.0	13.3	197.7	4552.7	12.8
4	*Myrica nagi*	7.6	6.6	180.9	1388.3	5.3
5	*Pinus roxburghii*	583.2	93.3	347.9	202916.8	218.2
6	*Quercus leucotricophora*	61.3	33.3	148.7	9129.9	31.

Table 5: Species Richness, Diversity, Evenness and Concentration of Dominance (CD) in Different Habitat]

S.No.	Habitat type	Species richness	Diversity index	Species evenness	Concentration of of dominance
1	Oak	17	0.722	0.587	0.237
2	Oak-pine	21	0.838	0.633	0.246
3	Oak-scrub	07	0.591	0.699	0.349
4	Chir-pine	06	0.377	0.484	0.561

Table 6: Similarity Index (%) in Trees, Shrubs and Lower Plants Between the Habitat
1= Trees, 2= Shrubs and Lower Plants

S.No.	Habitat pair	Similarity Index (S)	
		1	2
1	Oak and Oak pine	79	96
2	Oak and oak-scrub	58	65
3	Oak-scrub and oak-pine	50	85
4	Oak-scrub and chir-pine	61	21

The maximum similarity index in tree species is found between the oak and oak pine forest (79%) followed by the value of index for oak-scrub and chir-pine forest (61%). Oak-scrub and oak-pine forest (Table 6) show the minimum similarity index (50%).

The maximum similarity index in shrubs and lower plants is also found between oak and oak-pine forest (96%) followed by the value of index for oak-scrub and oak-pine (85%). Oak-scrub and Chir-pine forest (Table 6) show the minimum similarity index (21%).

Ground Cover

In the oak forest the maximum values (18.2%) are exhibited by pine needles. Dung and rocks have the minimum values and show similar coverage (1.5%). Grasses, herbs, dead wood and leaf litter are found in their respective orders as 17.5%, 15.5%, 14.0% and 11.6%. Weathered stones formed 7.7% of the area and the bare ground 5.14%. Tree saplings and shrubs are observed as 5.8% and 4.2% respectively (Table 7).

Table 7: Percent Ground Cover Values in Different Habitat Types

S.No.	Habitat type	PN	LL	G	H	S	DW	TS	D	P	BG	R	WS
1	Oak	18.2	11.6	17.5	15.5	4.2	14.0	5.8	1.5	1.9	5.14	1.5	7.7
2	Oak-pine	23.6	19.2	17.5	14.9	2.2	17.7	0.0	0.0	1.25	3.94	2.0	2.2
3	Oak-scrub	66.9	4.6	5.3	1.0	1.8	2.9	8.4	0.5	0.0	4.4	3.1	0.7
4	Chir-pine	29.0	30.0	9.0	2.0	0.0	5.0	6.0	0.0	0.0	17.0	0.9	0.0

PN= Pine needles, LL=Leaf litters, G=Grass, H=Herbs, S=Shrub
DW=Dead Wood, TS=Tree saplings, D=Dung, P=Pellet, BG=Bare ground
R=Rock, WS=Weathered stone

Similarly, the oak-pine forest collects a maximum amount of cover for pine needles (23.6%) followed by leaf litter, (19.2%). Grasses and dead wood have been found in almost equal percentages of 17.5% and 17.7% respectively. Rocks and weathered stones cover 2.0%, and 2.2% of the area. Herbs an important element, comprise 14.9% of the ground cover. The bare ground covers only 3.94% of the area (Table 7). There was no tree sapling and dung in this forest.

The oak-scrub has a maximum cover of 66.9% of pine needles. Weathered stones covered only 0.7% of the area. Tree sapling comprise of 8.4% of the ground cover. Bare ground and the land under leaf litter have been found in almost equal percentages of 4.4% and 4.6% respectively. Grass at 5.3% also constitutes an important ground cover (Table 7).

Leaf litter is the most dominant cover at 30% in chir-pine forest. Pine needles, bare ground and grasses have been found in the order of their importance as 29%, 17%, and 9% respectively. Rocks were minimum at 0.9% and were the least important element at the ground level in this habitat (Table 7). There were no shrubs, no dung, no pellets and no weathered stones in this habitat.

DISCUSSION

Phytosociological characteristics differ among different habitat types and among tree species. In oak, oak-scrub and chir-pine forest the maximum IVI, density and dominance have been exhibited by the dominant

species of that forest. But this is not true in the oak-pine forest. Here the maximum dominance is exhibited by trees other than the dominant species (Table 2).

Pinus roxburghii in the oak forest occupies the maximum mean basal cover (1928.0 cm²/tree) while the oak in-spite of being the dominant species (in terms of density) occupied less cover (491.0 cm²/ tree). Nayak *et al*,(1991) also found that the dominant species occupies less basal cover in comparison to other species (*Myrica nagi* in that case in their studies) having a maximum mean basal cover of 733.75 cm²/tree.

In this study species richness in oak-forest has been found to be 17, which is slightly more than the finding of Rajwar & Dhobal, (1991). In their study they found species richness in the oak forest to be 14.

Similarly in the oak-pine forest the highest mean basal cover is exhibited by *Pinus roxburghii* (*1*322.4 cm²/tree). The tree density has been found to be 136.1 trees/ha. An almost similar density (130.4 trees/ha has been found in the oak forest and therefore *Pinus roxburghii* is found sub-dominant in both the forest types. The density of *Pinus roxburghii* is higher (583.2 trees/ha) in the chir-pine forest than in other forest types (oak forest, 130.4 trees/ ha; oak-pine forest, 136.1trees/ ha; oak-scrub, 300.9 trees/ ha). The mean basal area of *Pinus roxburghii* in the chir-pine forest has been found to be 347.9 cm²/ tree and IVI 218.2. Singh & Singh, (1987) have reported a density of 200 trees/ ha in a mono-specific stand of *Pinus roxburghii* with an IVI of 250. But in species richness and diversity the results have been found to be similar. It has also been observed that in this stand of forest the species richness and the diversity is very low, though in the adjacent forest both are quite high. The major cause for this situation, according to Singh & Singh, (1987), is the rule of *Pinus roxburghii* preventing the re-invasion of broad leaf species.

In the oak-scrub the density of *Pinus roxburghii* has been found to be 300.9 trees/ ha with a mean basal area of 359. 8 cm²/ tree. *Quercus leucotricophora* has been found to be a sub-dominant species in terms of a density of 223.9 trees/ha in this habitat type. It occupies a higher mean basal area of 354.3 cm²/tree. In the chir-pine forest it is 148.7 cm²/tree.

The structure of the forest types described here is different in regard to the dominance (in terms of density) of different species. The total tree density values in this study range between 524 -767 trees/ha which fall within the range of values 350-2840 trees/ ha for the temperate forest of the world (Dabel and Day, 1977; Crow, 1978; Killingbeck &Wali ,1978; Saxena and Singh, 1982).

The oak-pine forest has the highest species richness (21) and also exhibits the highest species diversity of 0.838 (Table 5). This has been confirmed by Singh & Singh, (1987) and Puri *et al*.,(1989).

Species diversity varies widely in different forests. The concentration of dominance (CD) varied between 0.237 and 0.561 (Table 5). The highest CD of 0.561 has been recorded in the chir-pine forest. The variance indicates that dominance is shared by several species. The high value in the chir-pine stand indicates that the dominance is acquired by a few species only. The low diversity and consequently greater concentration of dominance could be due to a lower rate of evolution and diversification of the communities (Simpson, 1964; Ralhan *et al*., 1982) and severity in the environment.

The growth of saplings of *Pinus roxburghii* in all the habitat types and a marginal high concentration of 8.4% in the oak-scrub is due to its ruderal nature (Singh & Singh, 1987). This species can be considered as an early successional community thriving on natural and man-made disturbances such as land slides, erosion, burning, selective lopping and cutting of broad leaf forests (Champion & Seth, 1968).

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