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Altitudinal Variation and Soil Characterstics Effect on Forest Communities of North Western Himalayan Region of Uttarakhand, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study was conducted at Dandachali forest of Tehri Forest Division, North-Western part of Himalaya. Surveys and sampling of the vegetation were done using standard ecological assessment methods with an aim to study the soil status at community level. During the study six different forest communities' *viz*., *Pinus roxburghii- Quercus leucotrichophora* mixed forest,

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Pinus roxburghii pure forest, *Pinus roxburghii- Rhododendron arboreum* mixed forest, *Cedrus deodara- Pinus wallichiana* mixed forest, *Cedrus deodara- Rhododendron arboreum* mixed forest and *Rhododendron arboreum- Quercus leucotrichophora* mixed forest were taken for the above mentioned study. Importance Value Index (IVI) were observed maximum (271.57) in *Pinus roxburghii* community then *Pinus roxburghii- Quercus leucotrichophora* mixed forest IVI (166.69). The soil pH recorded highest (pH 6.60) in *Cedrus deodara - Pinus wallichiana* mixed forest. *Cedrus deodara - Rhododendron arboreum* mixed forest community reflected maximum (27.44%) soil moisture content. However organic carbon (1.39%), nitrogen (1202.49 kg/ha.) and phosphorus (31.36 kg/ha) was highest in *Pinus roxburghii – Quercus leucotrichophora* mixed forest. Potassium observed maximum (351.00 kg/ha.) in *Cedrus deodara - Rhododendron arboreum* mixed forest. Community wise there was change in soil nutrient status whereas, altitude showed no such variations.

Keywords: Soil status; different communities; Tehri division; Himalaya.

1. INTRODUCTION

The Himalayan temperate forests are more generative and vigorous rather than the mountainous forest of the temperate region with similar amount of rainfall [1]. A huge portion of nutrients is gathered together in the biomass constituent of the Himalayan forests than in the temperate forest [2]. Movement of the nutrients most often forms in the form of litter of standing crop, litter fall at which rate, regulation of energy follow, primary productivity, and nutrient cycling in the forest ecosystem [3,4]. In another word, it is the main source of the organic matter from the plant tissues such as above and below ground litters which influence the chemical status like nutrients and physical status viz., moisture, texture, etc [5].

The forest soil capacity have an effect on the character, development, and behavior of the composition of the forest stand and ground cover, rate of tree growth potency, and ability of natural reproduction, and other silvicultural factors [6]. Physiochemical characteristics of forest soil differ in a period and unoccupied area because of slight differences in climate, topography, physical weathering processes, vegetation cover, microbial activities, and many other biotic variables. The vegetation plays a vital act in soil makeup [7]. The topography like elevation and slope aspect play a great significance act in determining the temperature regime of the sites. The forest composition is affected by co-factors such as topography, aspect, an inclination of slop, and soil nature, and type within the same elevation (Shank and Noorie 1950). The Forest communities and soil studies are necessary and essential for protecting, conserving the natural plant communities [8].

The present study had been carried out at Dandachali forest, Tehri forest division to evaluate physical and chemical or nutrient status of different forest communities which shows the IVI relation of species in various communities with soil properties.

1.1 Study Area

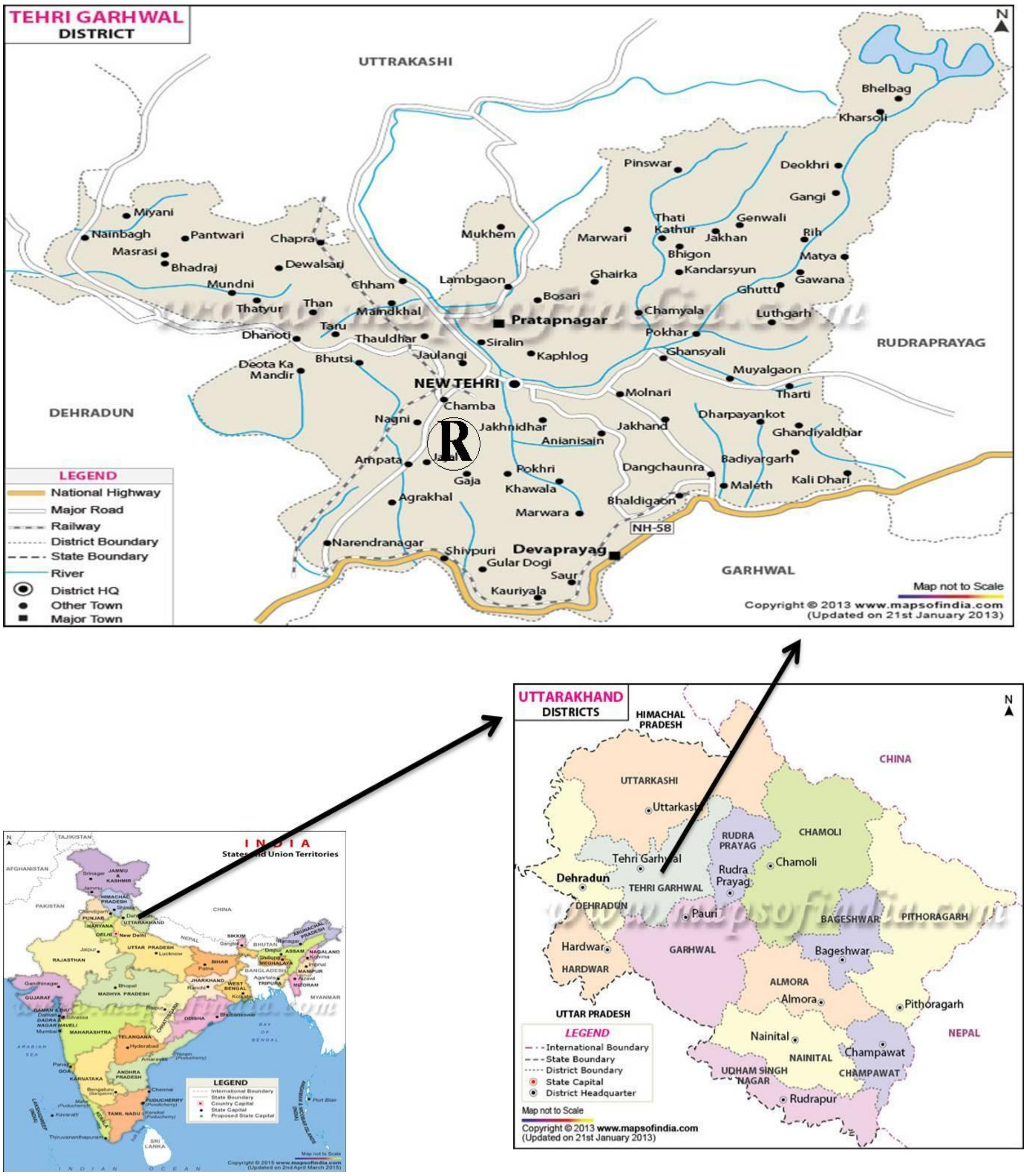
The study was carried out in Dandachali forest of Tehri Forest Division, Tehri Garhwal (district), Uttrakhand (State) part of North West Himalaya. Tehri Range of the division lies between 30^0-22’077” North latitude and 30^0-25’599” East longitude which covers 16144.70 ha area at Tehri Forest Division, [8-10].

2. METHDOLOGY

Selection of sites and habitats for vegetation sampling, Data analysis and Formulae used and Importance value index (IVI) [8-10].

2.1 Soil Sampling and Analysis

The soil samples were collected randomly from each study site / plot with five samples from each site / plot. One Sample was taken from the center and likewise four samples were taken from four different corners of the site / plot up to 20 cm depth. These samples were mixed together to prepared the composite sample homogenized mixture weighing 200g. Thereafter soil samples were made and packed in airtight polythene bags in the laboratory for physico-chemical analysis. Moisture (%), pH, organic carbon, nitrogen, phosphorus and potassium of the soil were analyzed accordingly. Samples were air dried, sieved with 2 mm mesh and used for analysis to take for total organic carbon, nitrogen, phosphorus, potassium and organic matter according to Allen [11].



Map 1. Study area

$$\text{Moisture } (\%) = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

2.2 Statistical

Data was analyzed by using SPSS.

3. RESULTS AND DISCUSSION

3.1 Site and Habitat Characteristics

The study area physical characteristics are shown in Table 1. There was covered a total of 16 sites surveyed in the study area. These sites were located between $30^0$18.808'N and 30^0 17.995'N latitudes; 078^0 25.154'E and 078^0 25.009'E longitudes and covers an altitudinal range of 1482 to 2200 m amsl [8-10,12].

3.2 Community Composition

Community composition is made on the basis of the highest value of IVI of individual tree species given in Fig. 1 and table respectively reported by [8].

3.3 Community Structure

There were six communities; *Pinus roxburghii* was the highest IVI (271.57) at pure *Pinus roxburghii* community; however others communities' tree species IVI values are given in the graph [8]. *Pinus roxburghii* community represented the (06) sites. In the other forest communities, site representations were the minimum as compared to the *Pinus* community, therefore recorded the lowest IVI value. *The Pinus roxburghii* community was reported maximum number of *Pinus trees* with better space and growth in comparison to other species. Among the major species of Central Himalaya, re translocation of nutrients is maximum in *Pinus roxburghii* as compared to *Quercus* species and *Shorea robusta*. Therefore C: N ratio is maximum in *Pinus roxburghii* than others. Stoppage of nutrients by the decomposers (The high initial carbon, nitrogen ratio and high initial lignin content in leaves restricts the decomposition of leaf litter) of the litter with high C: N ratio is one of the principle strategies of *Pinus roxburghii* which invades other forests and occupy the site against reinvasion by Oaks Singh and Singh [13].

3.4 Altitudinal Variation

Statistical analysis, a correlation was applied among the altitude, density, frequency, and abundance. It was shown that tree density showed strong significant positive correlation (r =0.852, P<0.01; P=0.001) with altitude. Also strongly significant positive correlation (r =0.908, P<0.01; P=0.001) between the frequency and attitude was reported. Same was seen in between abundance and altitude where strong significant positive correlation (r =0.771, P<0.01; P=0.001) was reported. Only altitudinal variation showed effect excluding the effect of soil characteristics Table 4 & Fig 2. Devlal and Sharma [14] had reported maximum density (1025/ha) and IVI (138.79) in stand III (1600 m. amsl) as compare to other altitudes viz. stand I (1200m. amsl) and stand II (1400m. amsl) an altitude wise.

3.5 Soil Characteristics

Data pertaining to soil moisture, pH, organic carbon, nitrogen, phosphorus and Potassium are presented in Table 3.

3.6 Soil Moisture Percent

The soil moisture was found maximum (27.44%) in *C. deodara - R. arboreum* mixed and minimum (15.14%) in *P. roxburghii- Q. leucotrichophora* mixed community. Low moisture retention in *P. roxburghii* forest is a general observation [15].

3.7 Soil pH

The pH was reported maximum (6.60) in *C. deodara- P. wallichiana* mixed forest and minimum (6.30) in *R. arboreum- Q. leucotrichophora* mixed community. These values are very much similar to the findings of Rawat et al. [15] for *Deodar* and *Chir pine* forests and Nandan et al. [16] for *R. arboreum* in Kumaun Himalaya.

3.8 Organic Carbon Percent and Soil Nitrogen

The organic carbon was obtained maximum (1.39%) from *P. roxburghii- Q. leucotrichophora* mixed in the north-east aspect, however in *Pinus roxburghii* pure community reported minimum (1.09%) from the north-west aspect. These values are comparatively lower than the findings of Rawat et al. [15] for *Deodar* and *Chir pine* forests (2.45 and 2.46, respectively). Organic carbon was recorded higher in the north-east aspect its due to the presence moisture, because the north-facing aspect receives less sunlight as compared to the north-west facing which has very high light intensity from 12 pm onwards, while less intensity of sunlight at morning time in the north-east aspect, it is a comparative study with Sharma et al. [17].

The available nitrogen was recorded maximum (1202.49 kg/ha) from *P. roxburghii- Q. leucotrichophora* mixed community and minimum (937.43 kg/ha) in the *P. roxburghii* community. There is better vegetation growth due to better status of nitrogen, influenced by organic carbon in the north-east aspect which exhibited dominance of *Pinus roxburghii* and *Quercus leucotrichophora* species. A similar study had been done by Airi et al. [18]. A higher elevation stand exhibited increase in nitrogen and organic carbon as compare to the lower elevation, These results are comparable to that of Jha and Dimri [19] for *Q. leucotrichophora- Q. floribunda* mixed community (1400 kg/ ha) in four natural stands [20,21] reported deforested area regarding carbon and nitrogen stocks and concluded that both were increased after the period 13 years.

Statistically in soil organic carbon and nitrogen had found strongly significant positive correlation (r =1.000, P<0.01; P=0.001) it is already given in Table 4.

Table 1. Physical characteristics of study sites

Sr. No.	Altitude (m)	Aspect	Latitude	Longitude	Dominated species
1.	1482	NE	30^0 18.808'N	078^0 25.154'E	*P. roxburghii – Q. leucotrichophora*
2.	1525	NW	30^0 18.080'N	078^0 25.137'E	*P. roxburghii*
3.	1586	N	30^0 18.727'N	078^0 25.135'E	*P. roxburghii*
4.	1684	NE	30^0 18.570'N	078^0 25.090'E	*P. roxburghii*
5.	1784	NW	30^0 18.368'N	078^0 24.957'E	*P. roxburghii*
6.	1787	NW	30^0 18.472'N	078^0 25.066'E	*P. roxburghii*
7.	1791	NE	30^0 18.470'N	078^0 25.073'E	*P. roxburghii*
8.	1863	N	30^0 18.242'N	078^0 25.995'E	*P. roxburghii – R. arboreum*
9.	1873	N	30^0 18.189'N	078^0 25.936'E	*C. deodara – P. wallichiana*
10.	1928	NW	30^0 18.101'N	078^0 25.145'E	*R. arboreum- C. deodara*
11.	1968	NE	30^0 18.213'N	078^0 25.104'E	*P. roxburghii – R. arboreum*
12.	1987	NE	30^0 18.197'N	078^0 25.061'E	*R. arboreum- C. deodara*
13.	2015	NE	30^0 18.204'N	078^0 25.059'E	*R. arboreum- P. roxburghii*
14.	2015	NW	30^0 18.204'N	078^0 25.059'E	*C. deodara – P. wallichiana*
15.	2116	NW	30^0 17.893'N	078^0 25.004'E	*C. deodar - R. arboreum*
16.	2200	NE	30^0 17.995'N	078^0 25.009'E	*Q. leucotrichophora – R. arboreum*

Abbreviations used: N=North; NW=North West and NE=North East P=Pinus; QL= Quercus; R=Rhododendron; C=Cedrus

(Source Lal et al. [9])

Table 2. Community types, their distribution, habitats and major associated species in study sites. This table had already reported

Community types	SR	AR (m)	Aspect	Latitude	Longitude	Major associated spp.
P. roxburghii – Q. leucotrichophora mixed	1	1482-1495	NE	30^0 18.808'N 30^0 18.900'N	078^0 25.154'E 078^0 25.204'E	*P. roxburghii, Q. leucotrichophora,,*
P. roxburghii	6	1525-1791	NW, NE	30^0 18.080'N 30^0 18.470'N	078^0 25.137'E 078^0 25.073'E	*L. valifolia, M. esculenta, R. arboreum*
P. roxburghii- R. arboreum mixed	3	1863-2015	N, NE	30^0 18.204'N 30^0 18.242'N	078^0 25.059'E 078^0 25.995'E	*L. ovalifolia,C. capitata,C. deodara*
C. deodara - P. wallichiana mixed	2	1873-2015	N, NW	30^0 18.204'N 30^0 18.189'N	078^0 25.059'E 078^0 25.936'E	*R. arboreum, P. roxburghii, P. ciliate*
C. deodara- R. arboreum mixed	3	1928-2116	NW, NW	30^0 18.101'N 30^0 17.893'N	078^0 25.145'E 078^0 25.004'E	*L. ovalifolia,P. roxburghii,P. ciliata*
R. arboreum- Q. leucotrichophora mixed	1	2116-2200	NE	30^0 17.893'N 30^0 17.995'N	078^0 25.004'E 078^0 25.009'E	*C. deodara,L. ovalifolia,P. wallichiana*

Abbreviations used: SR=Site representation; AR= Altitudinal range; N=North; NW=North West and NE=North East P=Pinus; QL= Quercus; B=Berberis;R=Rhus; L=Lyonia;M=Myrica or Myrsine; C=Cornus or Cedrus; R=Rhododendron or Rubus; I= Indigofra; P= Pogostemon or Populus

(Source [8,9])

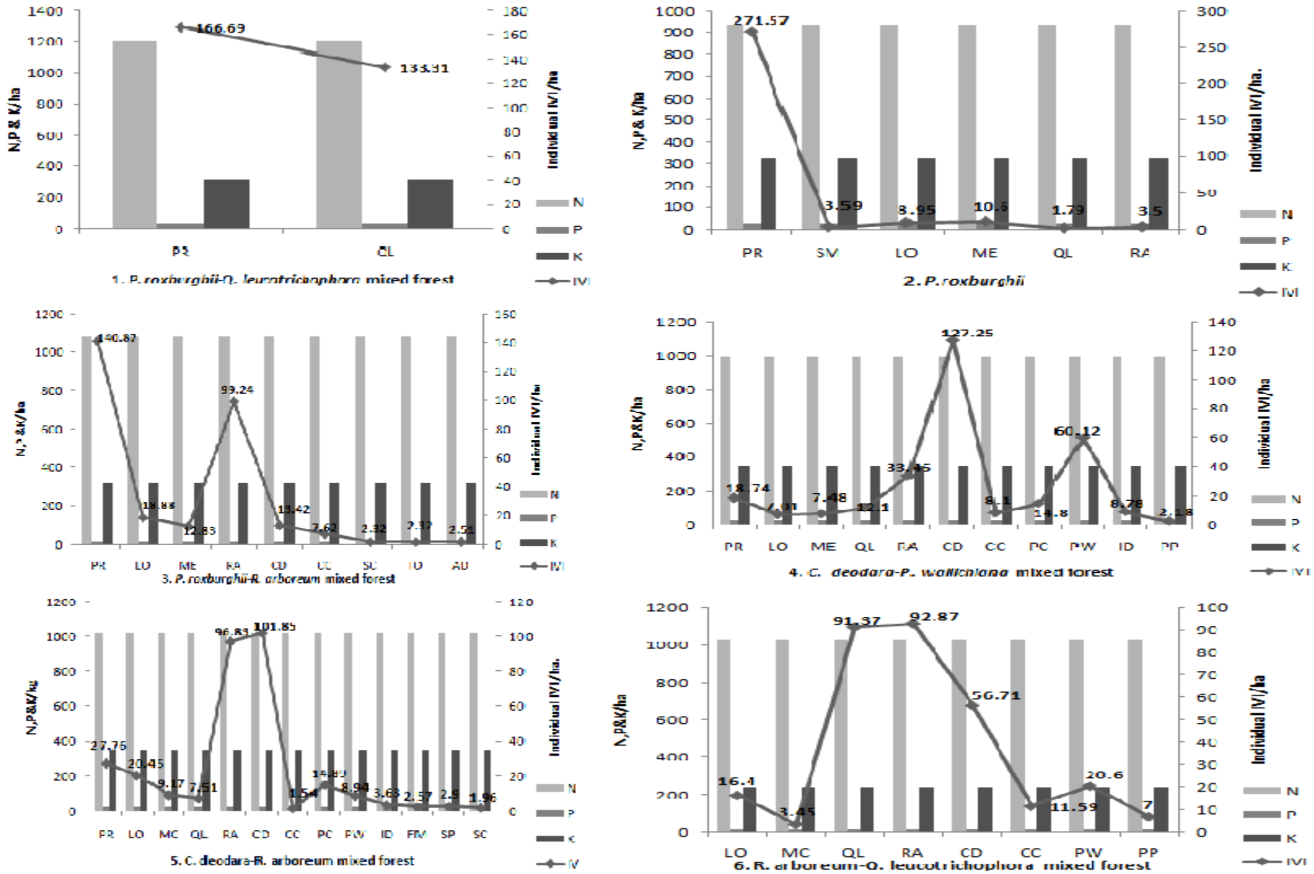


Fig. 1. Community wise highest Importance Value Index (IVI) individuals and soil characteristics viz OC, N, P and K in different forest community in study area; The IVI table was already reported [8]

Abbreviations used: PR=Pinus roxburghii;SM=Swida macrophylla; LO=Lyonia ovalifolia; ME=Myrica esculenta; QL=Quercus leucotrichophora; RA=Rhododendron arboretum; CD=Cedrus deodara;CC=Cornus capitata; PC=Populus ciliate; PW=Pinus wallichiana; ID=Ilex dipyrena; PP=Pyrus pashia; FM= Fraxinus micrantha; SP=Symplocus paniculata; SC=Symplocus crataegoides; TO=Trema orientalis; AD=Acacia dealbata

Table 3. Physical and chemical characteristics of soil of study area

Community types	MC (%)	pH	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
Pinus roxburghii – Quercus leucotrichophora mixed	15.14	6.40	1.39	1202.49	31.36	310.50
Pinus roxburghii	17.40	6.40	1.09	937.43	24.64	261.00
Pinus roxburghii - Rhododendron arboreum mixed	19.06	6.37	1.25	1077.50	16.43	322.50
Cedrus deodara - Pinus wallichiana mixed	25.04	6.60	1.15	989.15	24.64	344.25
Cedrus deodara - Rhododendron arboreum mixed	27.44	6.47	1.18	1021.47	20.91	351.00
Rhododendron arboreum - Quercus leucotrichophora mixed	19.78	6.30	1.20	1034.40	17.92	238.50
Maximum value	27.44	6.60	1.39	1202.49	31.36	351.00
Minimum value	15.14	6.30	1.09	937.43	16.43	238.50

Table 4. Statistics correlation table

Correlations									
	Altitude	**Density**	**Frequency**	**Abundance**	**Basal Cover**	**OC**	**N**	**P**	**K**
Altitude	1								
Density	.852**	1							
Frequency	.908**	.951**	1						
Abundance	.771**	.882**	.893**	1					
Basal cover	0.021	0.174	-0.04	-0.103	1				
OC	0.22	0.178	0.178	0.2	0.058	1	1.000**		
N	0.22	0.178	0.178	0.2	0.058	1.000**	1		
P	-0.301	-0.04	-0.146	-0.25	0.277	-0.136	-0.136	1	
K	0.378	0.275	0.407	0.41	-0.111	0.266	0.266	-0.154	1

***. Correlation is significant at the 0.01 level (2-tailed)*

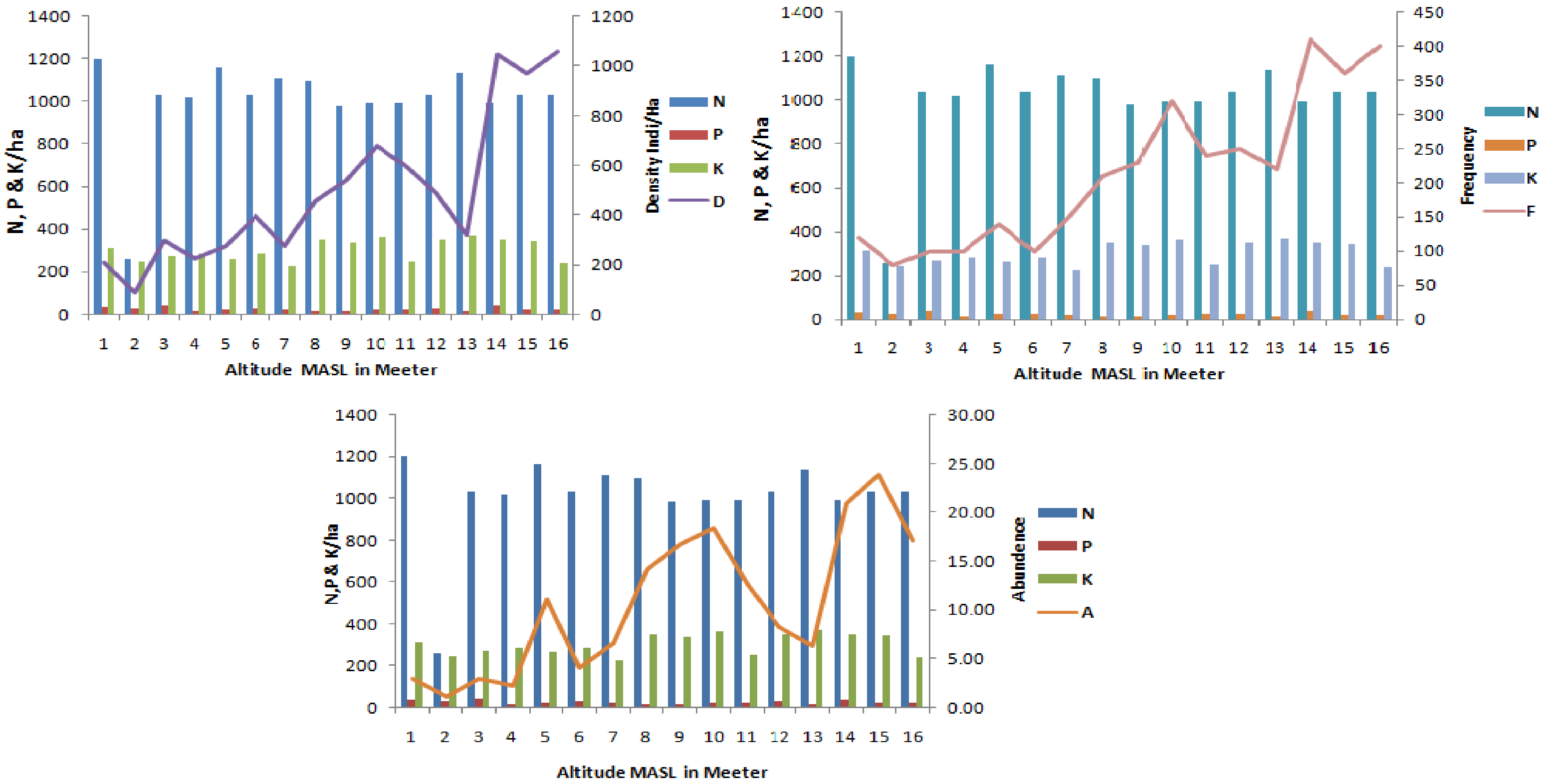


Fig. 2. Density, Frequency and Abundance. Table was already reported [8]

Abbreviations used: 1=1482, 2=1525, 3=1586, 4=1684, 5=1784, 6=1787, 7=1791, 8=1863, 9=1873, 10=1928, 11=1968, 12=1987, 13=2015, 14=2015, 15=2116, 16=2200

3.9 Soil Phosphorus

The available phosphorus content was maximum (31.36 kg/ha) from *P. roxburghii - Q. leucotrichophora* mixed community and minimum (16.43 kg/ha) from *P. roxburghii- R. arboreum* mixed community. Mehraj et al. [5] observed higher phosphorus in oak forest (17.99 kg ha^{-1}) as compared to the *Pine* forest (16.88 kg ha^{-1}). Sardans et al. [22] had reported in *Pine*, Phosphorus fertilization tended to increase the biomass of all diameters when it was accompanied by neighbor removal. *P. roxburghii - Q. leucotrichophora* the mixed community had been reported maximum (309.85 m^2 ha^{-1}) total basal area of *P. roxuburghii* as compared to others, already published by [8].

3.10 Soil Potassium

A potassium value was observed maximum (351.00 kg/ha) from *C. deodara- R. arboreum* mixed and the minimum (238.50 kg/ha) from *R. arboreum- Q. leucotrichophora* mixed community. In the *C. deodara- R. arboreum* mixed community was observed the maximum potassium, while in these communities are having sufficient quantity of nitrogen too. Bhandari et al. in [23] reported in Garhwal Himalaya oak forests more or less similar values for soil potassium and Mehta et al. in [24] reported the same findings in Conifer-oak mixed forest [25-29].

4. CONCLUSION

The result of the study concludes that altitudinal variation in forest communities. The study shows the relationship among the altitude, forest community (density, frequency and abundance) and soil nutrients availability. The study revealed density, frequency and abundance increase with altitude; however soil nutrients have not shown any effect on the forest community. Even an altitudinal variation did not observe in soil characteristics of different forest communities. Aspects also play vital role in soil nutrient availability status in the different forest communities. *Pinus roxburghii-Quercus leucotrichophora* mixed community showed maximum nutrient availability.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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