

ALTITUDINAL VARIATION AND SOIL CHARACTERISTICS EFFECT ON FOREST COMMUNITIES OF NORTH WESTERN HIMALAYAN REGION OF UTTARAKHAND, INDIA

Comment [I1]: CHARACTERISTICS

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, *Pinus roxburghii*, *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. (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 (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 (1.30%), 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. There is change soil nutrient status community wise, altitude wise did not see more variation in soil except to forest community.

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Keyword: Soil Status, Different Communities, Tehri Division, Himalaya

INTRODUCTION

The Himalayan temperate forests are more generative and vigorous rather than the mountains forest of the temperate region with similar amount rainfall possibly due to the long the season continues to exist and occurring continuously over a period of time favorable temperature (Mani 1974). A huge portion of nutrients is gathered together in the biomass constituent of the Himalayan forests than in the temperate forest (Singh et al. 1985). Nutrients movement in cycle forms (output and input) from the litter of standing crop and litterfall at which rate, sequentially

there is decay, regulate energy flow, primary productivity, and nutrient cycling in the forest ecosystem (Pragasam and Parthasarathy, 2005; Sundarpandian and Swamy, 1999). 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 like moisture, texture, etc. (Mehraj et al. 2010).

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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 silviculturally important factors (Bhatnagar 1965). 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 (Chapman and Reiss 1992). The topography like elevation and slope aspect play of great significance act in determining and conclusive the temperature regime of the sites. The forest composition is affected by cofactors 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 and biodiversity also understanding the changes observed in the past and continuing into the future and other words say its complete documentary of studied forest (Lal et al. 2017).

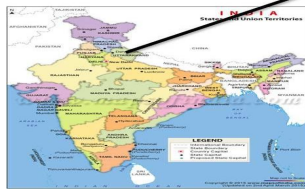
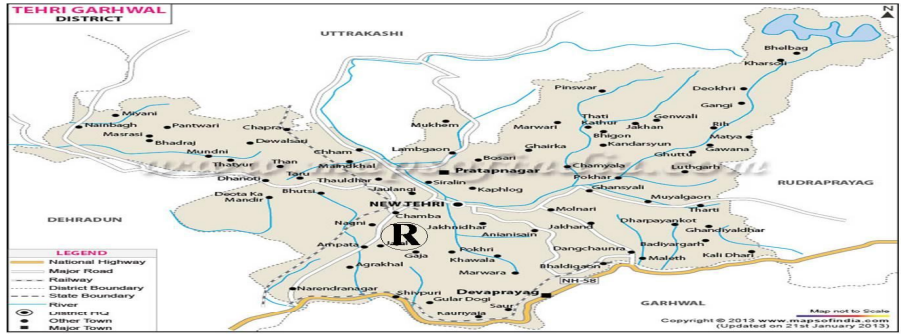
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The present study had been carried out at Dandachali forest, Tehri forest division to evaluate physical and chemical or nutrient status of different forest communities and show the IVI relation of species in various communities with soil properties.

STUDY AREA

The study was carried out in Dandachali forest of Tehri Forest Division, Tehri Garhwal (district), Uttarakhand (State) part of North West Himalaya. Tehri Range of the division lies between 30°-22'077" North latitude and 30°-25'599" East longitude which covers 16144.70 ha area at Tehri Forest Division.

Fig 1. Study Area



METHODOLOGY

Selection of sites and habitats for vegetation sampling, Data analysis and Formulae used and Importance value index (IVI), this is already mentioned in published paper in (Lalet al. 2017, Lalet al. 2018 & Lalet al. 2018)

Soil sampling and analysis

The soil sample was collected from the each study plot or each site, collected randomly five sample from the plot, there was one form center and four sample pick up from four corner of study plot and dugout only up to 20 cm depth. These samples were mixed together to prepared the composite sample its weighing 200g homogenized and soil made and packed in airtight polythene bags, still brought to the laboratory for physic-chemical analysis. Moisture (%) and pH and organic carbon, nitrogen, phosphorus and potassium of the soil were measured. Samples were air dried and sieved with 2 mm mess and, used for analysis of total organic carbon, nitrogen, phosphorus and potassium and organic matter following Allen (1974).

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

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Statistical

Statistically was applied correlation among the altitude, density, frequency and abundance soil nutrient in community to find out the relation of plant species with soil in each community.

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RESULT AND DISCUSSION

Site and habitat characteristics

The study area is shown physical characteristics in Table 1. There was covered a total of 16 sites surveyed in the study area. These sites were fall between $30^{\circ}18.808'N$ and $30^{\circ}17.995'N$ latitudes; $078^{\circ}25.154'E$ and $078^{\circ}25.009'E$ longitudes and cover an altitudinal range of 1482 to 2200 m amsl. It is detail mentioned and published in (Lalet *al.* 2017, Lalet *al.* 2018, Lalet *al.* 2018 & Lalet *al.* 2018)

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Community composition

Community composition made on the basis of highest value of IVI of individual tree species have been given in fig.2, respectively and IVI table and community diversity were already reported by (Lalet *al.* 2017).

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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 and it was already published in (Lalet *al.* 2017). *Pinus roxburghii* community had recorded the highest IVI value because that representing the (06) site. In the other forest community, site representation is the minimum as compare to *Pinus* community therefore recorded the lowest IVI value. *Pinus roxburghii* community had reported maximum *Pinus* trees which having better growth to occupy space of other species. Among the major species of Central Himalaya, retranslocation of nutrients are the maximum in *Pinus roxburghii* as compare to *Quercus* species and *Shorea robusta* therefore C:N the ratio is the maximum in *Pinus roxburghii* than others. Stoppage of nutrients by the decomposers (The high initial carbon and nitrogen ratio and high initial lignin content in leaves and decomposition of leaf litter are very slow so immobilization of nutrient to litter) of the litter with high C:N ratio is one of the principle strategies therefore *Pinus roxburghii* invades other forests and occupied the site against reinvasion by Oaks Singh and Singh (1987). In other word say it, there was the dominance of other species are very low due to *Pinus roxburghii* does not support to other species; it is shown negative interaction with other associated species by the allelochemical effect.

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Altitude variation

An Altitude variation community wise is seen when applied statistics. Statistically, a correlation was applied among the altitude, density, frequency, and abundance. There is shown tree density strongly significant positive correlation ($r = 0.852$, $P < 0.01$; $P = 0.001$) with altitude. There is shown a strongly significant positive correlation ($r = 0.908$, $P < 0.01$; $P = 0.001$) between the frequency and altitude. Same case was seen in between abundance and altitude there is a strongly significant positive correlation ($r = 0.771$, $P < 0.01$; $P = 0.001$). There is seen only altitudinal variation in a community not coming to any effect from the soil characteristics in community, these are given in table 4. & fig 3. Devlal and Sharma (2008) 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.

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Soil characteristics

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

Soil moisture percent

The maximum (27.44%) soil moisture was found 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 (Rawat et al., 2003).

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 similar to the report of Rawat et al. (2003) for Deodar and Chir pine forests and Nandan et al. (2015) for *R. arboreum* in Kumaun Himalaya.

Comment [129]: a minimum

Organic carbon percent and Soil Nitrogen

The maximum organic carbon was obtained from *P. roxburghii*- *Q. leucotrichophora* mixed (1.39%) from the north-east aspect and *P. roxburghii* community minimum (1.09%) from the north-west aspect. These values are comparatively lower than Rawat et al. (2003) 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 occurrence moisture is favorable environment on the northern aspect because the north-facing receive less sunlight but the north-west facing light intensity is very

high from 12 pm onward, while less intensity of sunlight at morning time in the north-east aspect, it is a comparative study with Sharma *et al.* (2011).

Comment [I30]: sunlight in the morning time

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 so it is influenced by organic carbon in the north-east aspect exhibited dominance of *Pinus roxburghii* and *Quercus leucotrichophora* species. A similar study had been done by Airiet *et al.* (2000). higher elevation stand exhibited increase nitrogen and organic carbon as compare to the lower elevation, These results are comparable to that of Jha and Dimri (1991) for *Q. leucotrichophora*- *Q. floribunda* mixed community (1400 kg/ ha) in four natural stands. (Silver *et al.* 2000; Feldpausch; 2004 and Macedo 2008) were reported deforested area carbon and nitrogen stocks conclude that both were increased and carbon and nitrogen recovered area after 13 years.

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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.

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Soil Phosphorus

The available phosphorus content was found to be 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.* (2010) 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.* (2004) 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 m² ha⁻¹) total basal area of *P. roxburghii* as compare to others were very low, it is already published by (Lalet *et al.* 2017)

Comment [I35]: Mehraj. and Munesh. (2010)

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Soil Potassium

The maximum (351.00 kg/ha) value of potassium was recorded 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 recorded in these communities sufficient quantity nitrogen. If applying large amounts of nitrogen, when is too little exchangeable potassium in the soil but where is recorded sufficient nitrogen and observed higher quantity of potassium it has reported by Malvi (2011). Bhandari *et*

Comment [I38]: of nitrogen

al. (2000) in Garhwal Himalaya oak forests and Mehta *et al.* (2014) in Conifer-oak mixed forest also recorded more or less similar values for soil potassium.

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 and soil nutrients is not coming to any effect on the forest community. Even an Altitudinal variation did not observe in soil characteristics of different forest communities. There is also play vital role aspect in soil nutrients availability status in the different forest community. *Pinusroxburghii-Quercusleucotrichophora* mixed community show maximum nutrients availability.

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UNDER PEER REVIEW

Table 1. Physical characteristics of study sites (Source Lalet *et al.* 2018).

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

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

Table 2. Community types, their distribution, habitats and major associated species in study sites. This table had already reported (Source Lalet *et al.* 2017 and 2018).

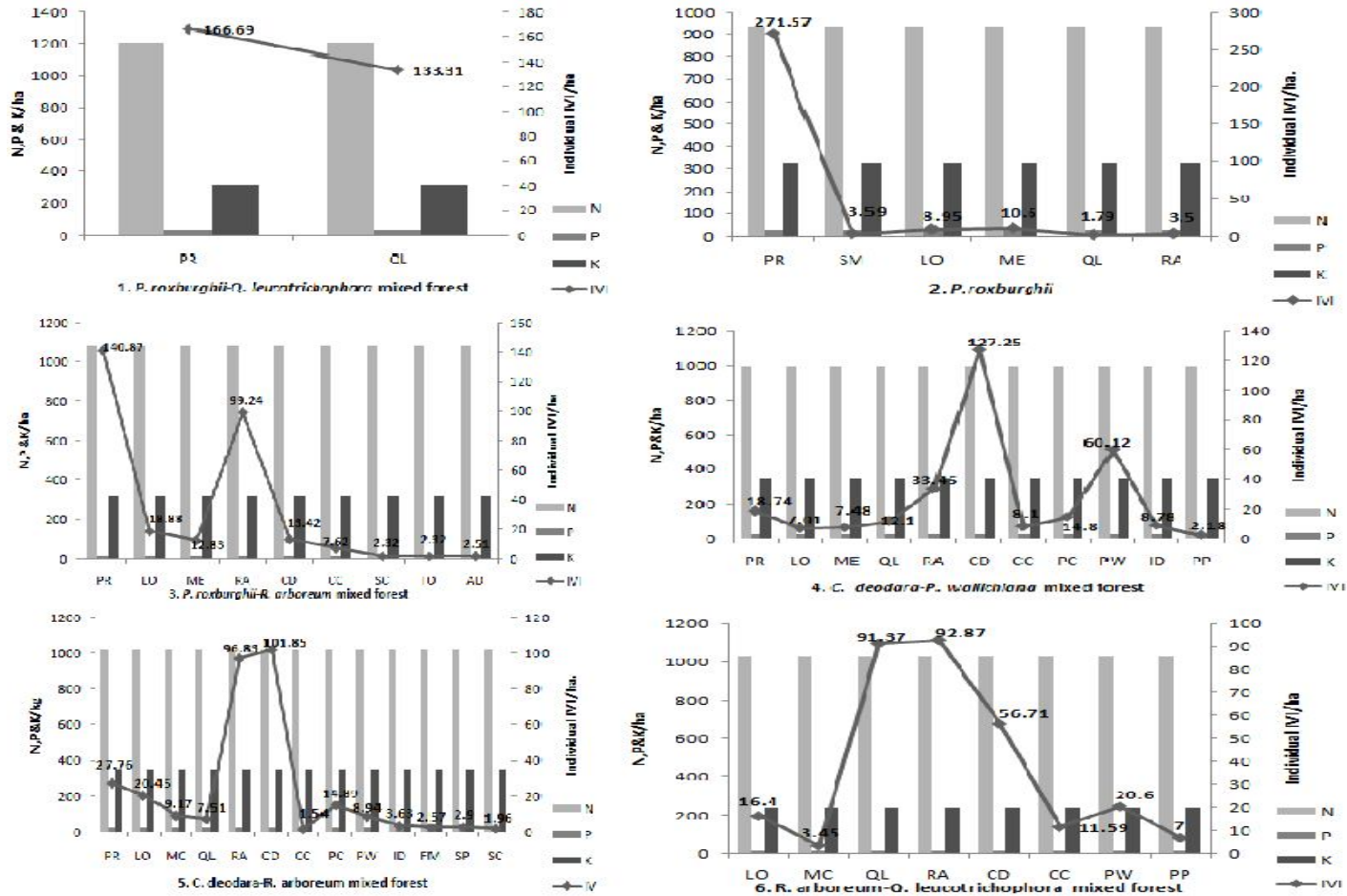
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Community types	SR	AR (m)	Aspect	Latitude	Longitude	Major associated spp.
<i>P. roxburghii</i> – <i>Q. leucotrichophora</i> mixed	1	1482-1495	NE	30 ⁰ 18.808'N 30 ⁰ 18.900'N	078 ⁰ 25.154'E 078 ⁰ 25.204'E	<i>P. roxburghii</i> , <i>Q. leucotrichophora</i> ,
<i>P. roxburghii</i>	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	<i>L. valifolia</i> , <i>M. esculenta</i> , <i>R. arboreum</i>
<i>P. roxburghii</i> - <i>R. arboreum</i> 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	<i>L. ovalifolia</i> , <i>C. capitata</i> , <i>C. deodara</i>
<i>C. deodara</i> - <i>P. wallichiana</i> 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	<i>R. arboreum</i> , <i>P. roxburghii</i> , <i>P. ciliata</i>
<i>C. deodara</i> - <i>R. arboreum</i> 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	<i>L. ovalifolia</i> , <i>P. roxburghii</i> , <i>P. ciliata</i>
<i>R. arboreum</i> - <i>Q. leucotrichophora</i> 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	<i>C. deodara</i> , <i>L. ovalifolia</i> , <i>P. wallichiana</i>

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= *Indigofera*; P= *Pogostemon* or *Populus*.

Fig 2. 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 (Lalet *et al.* 2017)

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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 dipyrrena*; PP=*Pyrus pashia*; FM=*Fraxinus micrantha*; SP=*Symplocos paniculata*; SC=*Symplocos crataegoides*; TO=*Trema orientalis*; AD=*Acacia dealbata*.

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

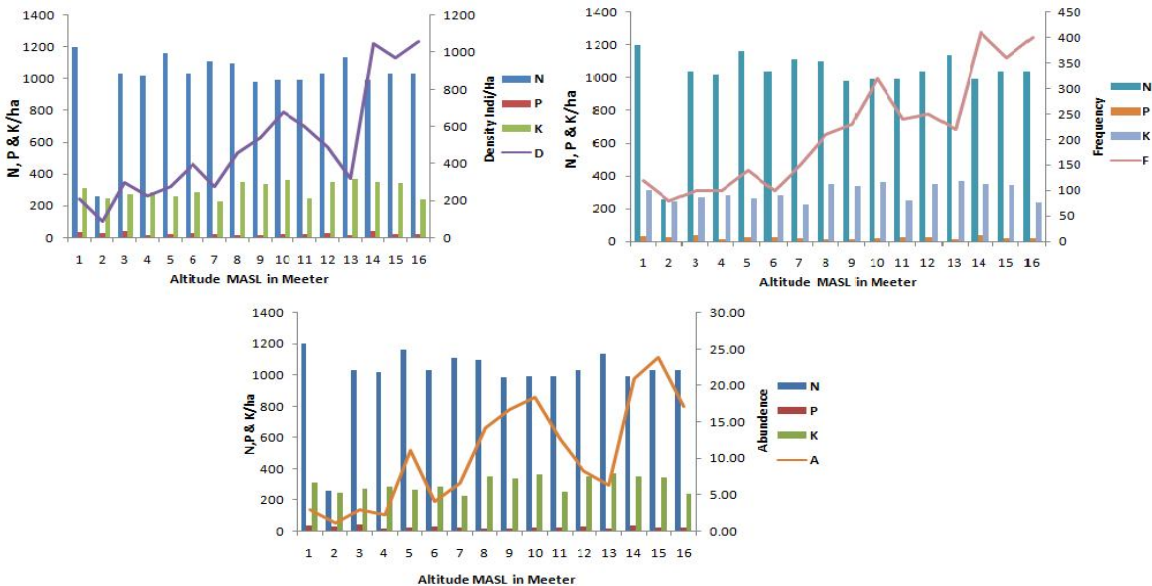
Community types	MC (%)	pH	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
<i>Pinus roxburghii</i> – <i>Quercus leucotrichophora</i> mixed	15.14	6.40	1.39	1202.49	31.36	310.50
<i>Pinus roxburghii</i>	17.40	6.40	1.09	937.43	24.64	261.00
<i>Pinus roxburghii</i> - <i>Rhododendron arboreum</i> mixed	19.06	6.37	1.25	1077.50	16.43	322.50
<i>Cedrus deodara</i> - <i>Pinus wallichiana</i> mixed	25.04	6.60	1.15	989.15	24.64	344.25
<i>Cedrus deodara</i> - <i>Rhododendron arboreum</i> mixed	27.44	6.47	1.18	1021.47	20.91	351.00
<i>Rhododendron arboreum</i> - <i>Quercus leucotrichophora</i> 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 3. Density, Frequency and Abundance. table was already reported (Lalet al. 2017)



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.

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