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

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 (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 (1.30%), 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.

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 litter fall at which rate, sequentially

there is decay, regulate energy follow, primary productivity, and nutrient cycling in the forest ecosystem (Pragasan 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).

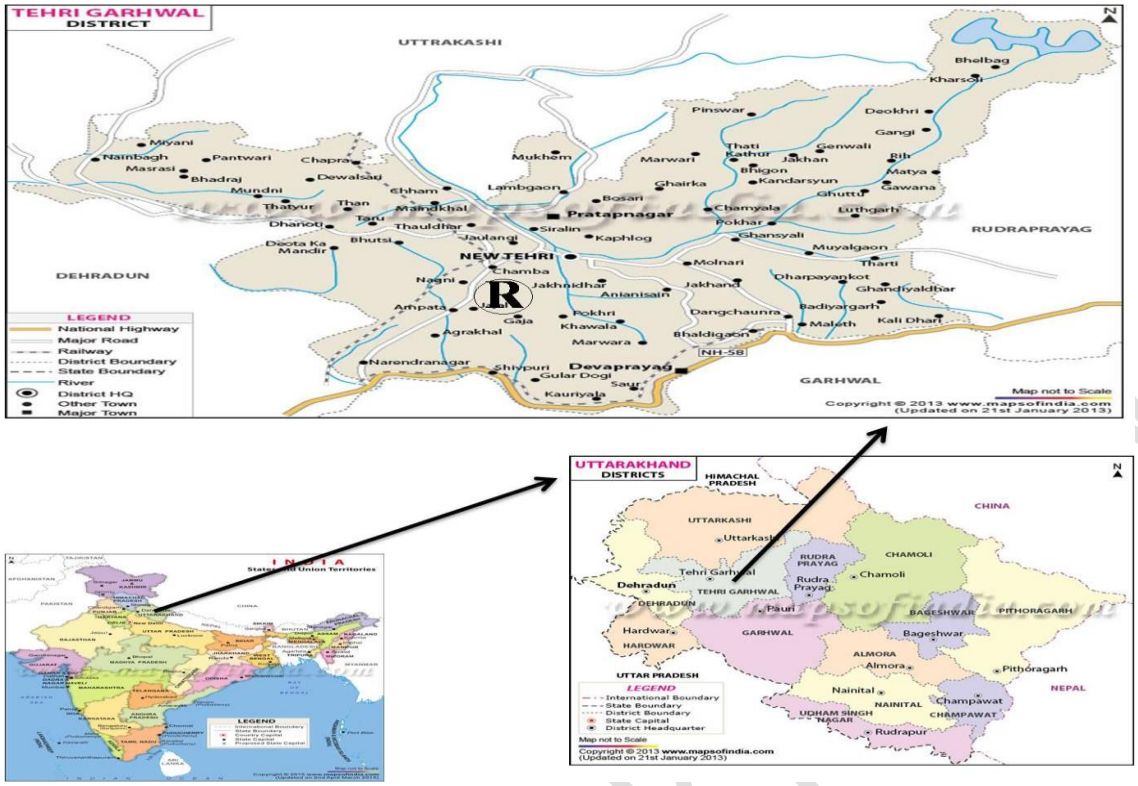
The forest soil capacity have an effect on the character, development, and behavior of the composition of the forest stand and ground cover, rate of tree growth potency, and ability of natural reproduction, and other silviculturally important factors (Bhatnagar 1965). Physiochemical characteristics of 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).

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), 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.

Fig 1. Study Area



METHDOLOGY

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 (Lal *et al.* 2017, Lal *et al.* 2018 & Lal *et 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).

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

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.

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 $30^0$18.808'N and 30^0 17.995'N latitudes; 078^0 25.154'E and 078^0 25.009'E longitudes and cover an altitudinal range of 1482 to 2200 m amsl. It is detail mentioned and published in (Lal *et al.* 2017, Lal *et al.* 2018, Lal *et al.* 2018 & Lal *et al.* 2018)

Community composition

Community composition made on the besis 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 (Lal *et al*. 2017).

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 (Lal *et 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, re translocation 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 roxuburghii* does not support to other species; it is shown negative interaction with other associated species by the allelochemical effect.

Altitude variation

An Altitude variation community wise 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 attitude. 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.

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.

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).

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 Airi *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.

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.

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 m^2 ha^{-1}) total basal area of *P. roxuburghii* as compare to others were very low, it is already published by (Lal *et al*. 2017)

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*

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. *Pinus roxburghii-Quercus leucotrichophora* mixed community show maximum nutrients availability.

Table 1. Physical characteristics of study sites (Source Lal *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	*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*

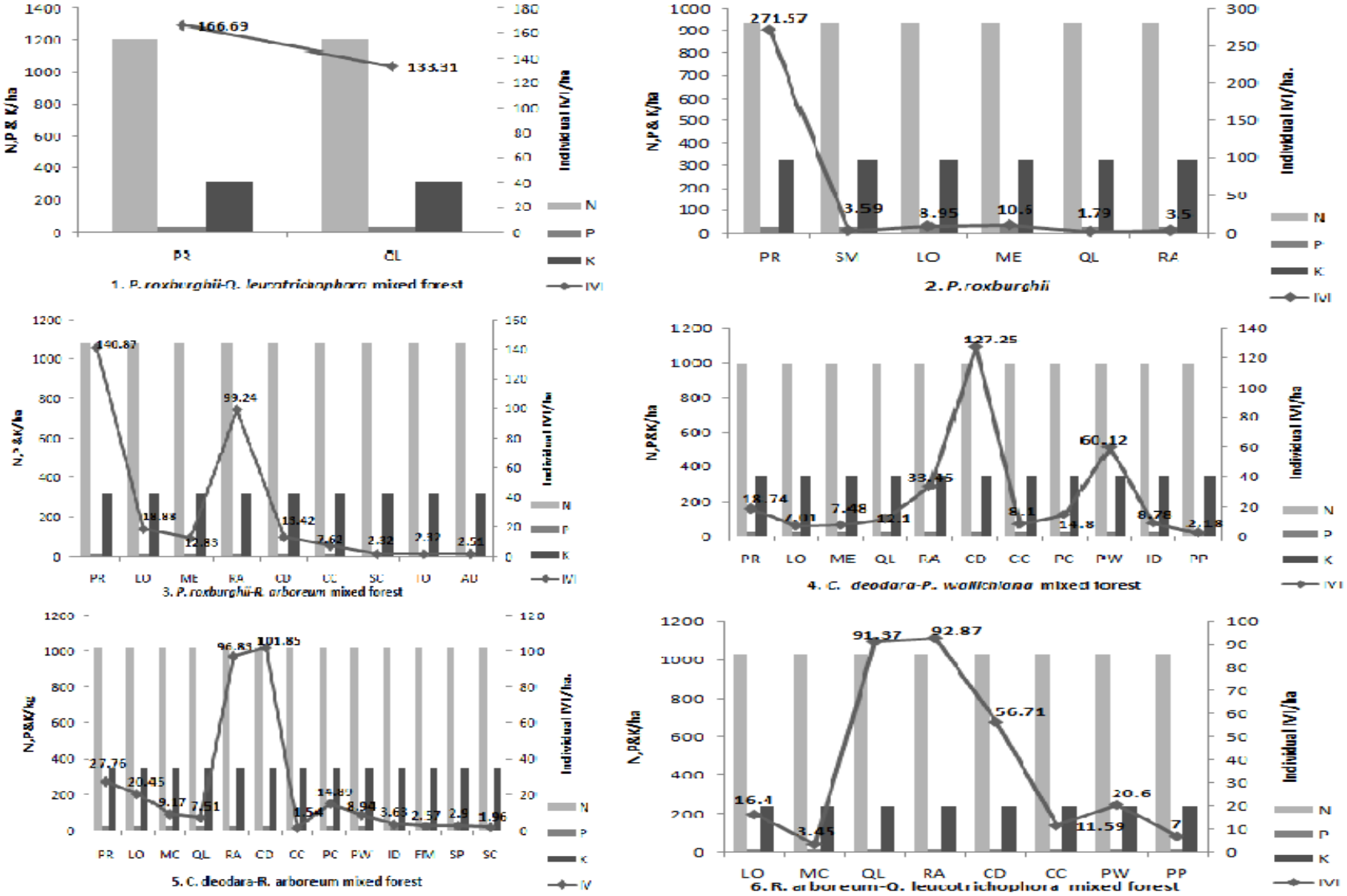
Abbreviations used: N=North; NW=North West and NE=North East P=*Pinus*; QL= *Quercus*; R=*Rhododendron*; C=*Cedrus*

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

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.*

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 (Lal *et al*. 2017)



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.*.

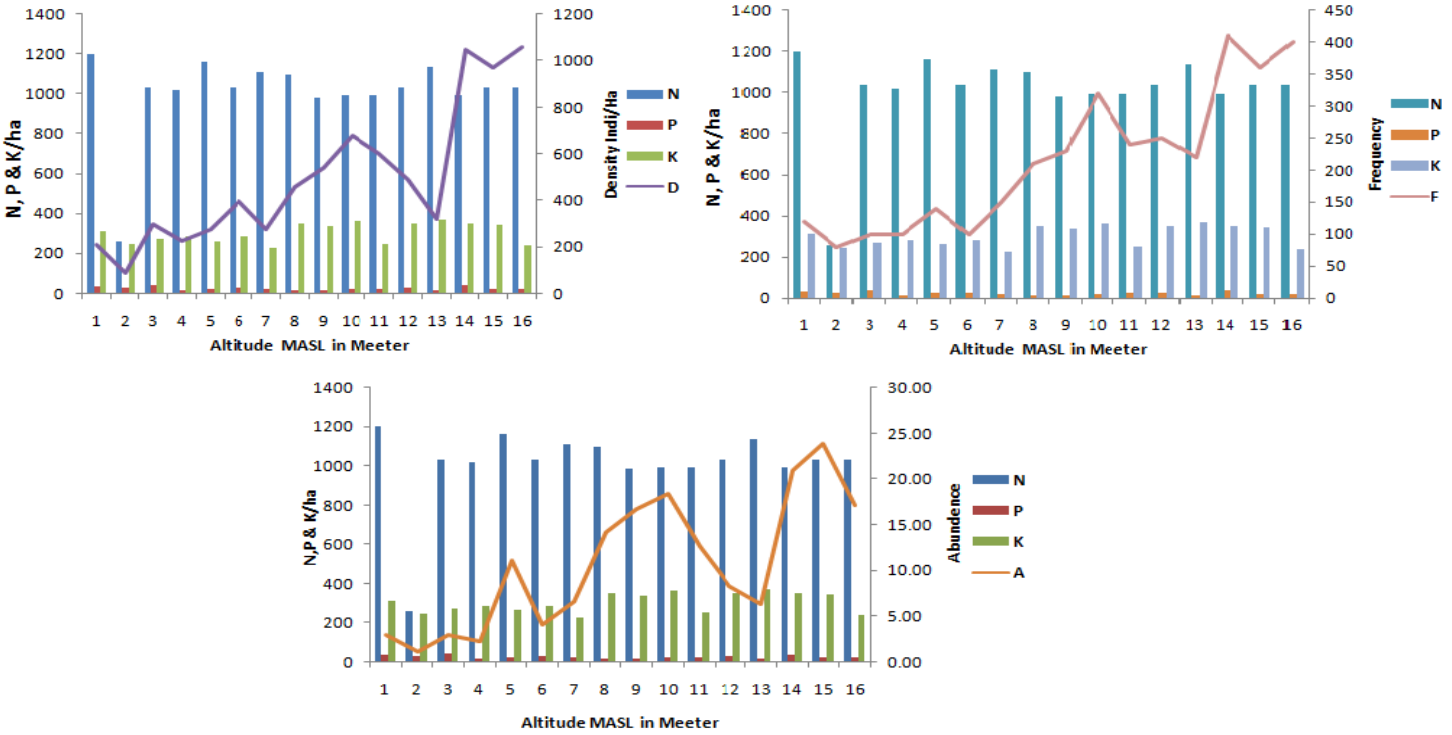
Table: 3. Physical and chemical characteristics of soil of study area

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 3. Density, Frequency and Abundance. table was already reported (Lal *et 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.

References

Airi, S., Rawal, R. S., Dhar, U. and Purohit, A. N. (2000). Assessment of availability and habitat preference of Jatamansi – a critically endangered medicinal plant of west Himalaya. *Current Science*, vol. **79**, NO. (10), pp1467-1471.

Allen, S.E. 1974. Chemical Analysis of Ecological Materials. Blackwell Scientific Publications, Oxford. PP368.

Bhatnagar, H.P. 1965. Soils from different quality sal (S. robusta) forests of Uttar Pradesh. Trop Ecol 6: 56-62.

B. S. Bhandari, J. P. Mehta and S. C. Tiwari. (2000). Dominance And Diversity Relations Of Woody Vegetation Structure Along An Altitudinal Gradient In A Montane Forest Of Garhwal Himalaya. *Journal of Tropical Forest Science*, **12**(1), pp. 49-61.

Chapman, J.L. and Reiss, M.J. 1992. Ecology: Principles and applications. Cambridge: Cambridge University Press. 294 p

Cambardella, C.A., Moorman, T.B., Noval, J.M., Parkin, T.B., Karlen, D.L. Turco, R.F. and Konopka, A.E. 1994. Field-Scale Variability of Soil Properties in Central Iowa Soil. Soil Sci. Soc. Am. J. 58: 1501-1511

Curtis, JT and Mc Intosh. 1950. The interrelation of certain analytic and phytosociological character. *Ecology*, **31**: 434-455.

Devlal, R. and Sharma, N. (2008). Altitudinal changes in dominance-diversity and species richness of tree species in a temperate forest of Garhwal Himalaya. *Life Science Journal*, Vol 5, No 2, pp 53-57.

Dhar, U, Rawal, RS and Samant, SS. 1997. Structural diversity and representativeness of forest vegetation in a protected area of Kumaun Himalaya India, Implications for conservation. *Biodiversity & Conservation*, **6**: pp1045 -1062.

Feldpausch, T.R., Rondon, M.A., Fernandes, E.C., Riha, S.J., Wandell, E., 2004. Carbon and nutrient accumulation in secondary forests regenerating on pastures in central Amazoˆnia. Ecol. Appl. 14, S164–S176.

Garkoti, S.C. and Singh, S.P. 1994. Nutrient cycling in the three central Himalayan Forest Ranging From Close Canopied to Open Canopied Treeline Forests, India. Artic and Alpine Research, vol. 26 No. 2. 339-348.

Greig-Smith, P. 1957. Quantitative plant ecology, Academic Press, New York.

Jha, M.N Dimri, B.M. 1991. Soil nutrients and forest productivity in four natural stands. *J Indian Soc Soil Sci*. **39**: 735-783.

222265 , KA. 1973. Quantitative and dynamic plant ecology, Second edition, Edward Arnold Limited, London.

Lal, P., Butola, J.S., Khanduri, V.P., and Prasad, R.K. (2018). Smallest Life Studies At The Various Societies in Uttrakhand North-West Himalaya. Journal of Plant Science, 2(3).

Lal, P., Butola, J.S. and Khanduri, V.P. (2018).Natural Regeneration Status of Forest Community at Dandachali Forest Tehri Forest Division in North West Himalaya Uttrakhand, India. Plant Archives, 18(1).

Lal, P., Chauhand, D.S., Butola, J.S. and Khanduri, V.P. (2018). Native, Endemic and Utilization Pattern of Woody Species of Dandachali Forest of Tehri Forest Division, North- West Himalaya. Indian Journal of Ecology 54(1)

Lal. P., Butoal, J.S., Khanduri, V.P. (2017). Community Structure of Dandachali Forest of Tehri Forest Divison, North-West Himalaya. Journal of Plant Development Sciences, Vol. **9** (10) , pp933-939.

Macedo, M.O., Resende, A.S., Garcia, P.C., Boddey, R.M., Jantalia, C.P., Urquiaga, S., Campello, E.F.C. and Franco, A.A. (2008). Changes in soil C and N stocks and nutrient dynamics 13 years after recovery of degraded land using leguminous nitrogen-fixing trees. Forest Ecology and Management 255, pp1516–1524.

Mani, M.S. 1974. Ecology and biogeography in India. The hague junk. Pp773.

Malvi, U.R. (2011). applying large amounts of nitrogen when, there is too little exchangeable potassium in the soil. *Karnataka J. Agric. Sci.*, **24** (1) pp106-109.

Mehraj, A. S. and Munesh, K. (2010). Nutrient Status and Economic Analysis of Soils in Oak and Pine Forests in Garhwal Himalaya. *Journal of American Science*, **6**(2), pp117-122.

Mehta, JP Shreshthamani and Bhatt, VP.2014. Analysis of the physico-chemical properties of the soil and climatic attribute on vegetation in Central Himalaya. *Nature and Science*, **12** (11): 46-54.

Misra, R. 1986. *Ecology Work Book*, Oxford and IBH publishing co, New Delhi, P. 244.

Mueller-Dombois, D and Ellenberge, H. 1974. Aims and methods of vegetation ecology. John Willey and Sons, New York.

Nandan, S Ram, J Tewari, A and Yadav, RP. 2015. Phenological events along the elevation gradient and effect of climate change on *Rhododendron arboreum* Sm. In Kumaun Himalaya. *Current Science.* **108** (1): 1-10.

Pragasan LA, Parthasarathy N (2005). Litter production in tropical dry evergreen forests of south India in relation to season, plant life forms and physiognomic groups. Cur. Sci. 88: pp1255-1263.

Paudel S. Sah JP.(2003) Physiochemical characteristics of soil in tropical sal (Shorea robusta Gaertn.) forests in eastern Nepal. *Himalayan Journal of Sciences*, 1(2)107-110

Rawat, PS Ginwal, HS Singh, RP and Dubey, RC. 2003. Vertical distribution of ectomycorrhizae in Deodar and Chir pine forest in relation to their soil characterstics. *The Indian forester* **129** (5): 624-630.

Samant, SS and Joshi, HC. 2004. Floristic diversity, community pattern and changes of vegetation in Nanda Devi National Park In: Biodiversity Monitoring Expedition, Nanda Devi 2003 (18 June to 8 July, 2003), *Uttaranchal Forest Department Dehradun*, PP. 39-54.

Sardans, J., Roda, F. and Penuelas, J. (2004). Phosphorus limitation and competitive capacities of Pinus halepensis and Quercus ilex subsp. rotundifolia on different soils. *Plant Ecology* **174**, pp305–317.

Saxena, AK, and Singh, JS. 1982. A phytosociological analysis of forest communities of a part of Kumaun Himalaya. *Vegetatio,* **50**: 3-22.

Sharma, C.M., Gairola, S., Baduni, N.P., Ghildiyal, S.K. and Suyal, S. (2011). Variation in carbon stocks on different slope aspects in seven major forest types of temperate region of Garhwal Himalaya, India. *J. Biosci*, **36**(4), pp701-708.

Sharma, C.M., Suyal, S., Gairola, S. and Ghildiyal, S.K. (2009). Species richness and diversity along an altitude gradient in moist temperate forest of Garhwal Himalay. *Journal of American Science*, **5**(5), pp119-128.

Silver, W.L., Ostertag, R., Lugo, A.E., 2000. The potential for carbon sequestration through reforestation of abandoned tropical agricultural and pasture lands. Rest. Ecol. 8, 394–407.

Singh, S.P. Khanna, R.K. and Singh, J.S. 1985. Accumulation in wood a nutrient conserving strategy of tropical forest. Environment conservation 12: pp 170-173.

Singh, J.S. and Singh, S.P. 1987. Forest Vegetation of The Himalay. *The Botanical Review*, **53**(1), pp80-1987.

Sundarpandian SM, Swamy PS (1999). Litter production and leaf-litter decomposition of selected tree species in tropical forests at Kodayar in the Western Ghats, India. For. Ecol. Manage. 123:231–244.

Tripathi, O.P., Pandey, H.N. and Tripathi, R.S. 2009. Litter production, decomposition and physico-chemical properties of soil in 3 developed agroforestry systems of Meghalaya, Northeast India. African Journal of Plant Science, Vol. 3(8): 160-167.