# STRUCTURE AND DIVERSITY OF TREE SPECIES IN NATURAL FORESTS OF KUMAUN HIMALAYA IN UTTARAKHAND

**L.S. Lodhiyal[1], Neelu Lodhiyal[2] and Bhawana Kapkoti[3]**

*[1]Department of Forestry and Environmental Science, D.S.B. Campus, Kumaun University, Nainital*
*[2&3] Department of Botany, D.S.B. Campus, Kumaun University, Nainital*
*E mail: lslodhiyal@yahoo.com*

**Abstract:** Present study deals with density, basal area, population structure, species diversity and concentration of dominance of natural forests in Lohaghat of Champawat district in Kumaun Himalaya, Uttarakhand. The data were collected from each forest for different six classes such as seedling, sapling, young tree, pole size tree, mature tree and old tree. Soil bulk density was 1.02-1.18gcm-3. Soil porosity, water holding capacity and soil moisture ranged from 41.8-48.5, 56.4-65.5 and 27.1-32.2 percent respectively. The soil texture was in order: sand (42.6-47.3%)>silt (31.6-34.3%)>clay (21.1-23.1%). Soil pH and soil carbon ranged from 6.2 to 6.8 and 6.2to 6.8 percent. Density of seedling sapling and tree ranged from 270 to 1790, 365 to 1040 and 920 to 1345, respectively. Species diversity in each category was 0.757-1.500 for tree, 0.950 to 2.050 for seedling and 1.000 to 1.810 for sapling. The good regeneration structure depicted by *Rhododendron arboreum* in site 1, *Myrica esculenta, Cedrus deodara* and *Pinus roxburghii* in site-2, *Myrica esculenta, Prunus cerasoides* and *Pinus roxburghii* by site-3, while poor regeneration was depicted by *Quercus leucotrichophora, Myrica esculenta* and *Pinus roxburghii* in site-1, Quercus *leucotrichophora* in site-2 and *Cedrus deodara and Pinus roxburghii* in site-4. However, fair regeneration was shown by *Cedrus deodara* in site-1 and *Quercus leucotrichophora* in site-3. The *Quercus leucotrichophora* seedlings were less in number than other tree species. Decreasing regeneration pattern of *Quercus leucotrichophora* in each site indicated that increased anthropogenic pressure on oak tree species for fuel and fodder may be one of the reasons of poor regeneration in each studied forest.

**Keywords:** Species diversity, population structure, seedlings, saplings, tree size class, Kumaun Himalaya

## INTRODUCTION

Forests contribute in economic and ecological development by providing various tangible and intangible benefits to the society and environment. The aim of forest ecologists is to understand dynamics of plant species of landscapes particularly in relation to structure and function of forests ecosystem (Barnes *et al.*, 1998). The deforestation and degradation of forest in many parts of central Himalayan region and elsewhere showed that the diversity, species composition and regeneration pattern have changed consequently influencing the productivity and sustainability of the forest ecosystems. The reason behind it is the recent anthropogenic pressure as well as changes in land use patterns in natural habitats. Forest is one of the major renewable resources for livelihood development of communities but the recent human activities; most of the forests have been deforested and degraded in the region. Consequently, growing stocks, regeneration, species diversity and structure of forest have changed. Oaks (*Quercus* species) are considered an important tree species in the region because they provide fuel wood and wood for agricultural implements and fodder but such broad-leaved forests not occurred in a regular way due to gregarious distribution of species. The second important species is Pine that provides wood to local people for construction and fuel purposes.

Population structure of tree species in forest can convey partly its regeneration behaviors in relation to the reproductive strategy (Lodhiyal and Lodhiyal, 2012). For this the importance is given to the number of saplings under adult tree for predicts future comparison of a forest community (Singh and Singh, 1992). Thus keeping in mind the variation of forest composition and structure due to human pressure in the hill region, present study was done to find out the exact picture of population structure and species diversity of forests located in Lohaghat in Kumaun region. In the past few decades, most of the natural forests have been seriously affected in the region. A few studies were conducted in central Himalayan forests by Saxena and Singh (1982; 1984). Uma Shankar (2001) had summarized the eastern Himalayan forests as the presence of sufficient number of seedlings, saplings and young trees in a given population indicated a successful regeneration which in turn is influenced by various biotic and abiotic factors. Thus they considered forest regeneration in such a way: (1) Good regeneration: when the order is seedlings> saplings> adult, (2) Fair regeneration- if the order is seedlings.>saplings≤ adult, (3) Poor regeneration, if species survived in only sapling stage or sapling population was less than that of adult and (4) No regeneration-if only adult individuals were present in the population. Singh and Singh (1992) recognized the following five patterns of population structure for the central Himalayan forests: (i) The greater population in the lower size classes than larger size classes indicated the frequent reproduction (ii) The more number of individuals in middle size classes than lower to higher classes means the population in on the way to extinction (iii) The lower age of seedlings than saplings means the fair reproduction in the past but the continuation of reproduction at the lower rate (iv)

The occurrence of seedlings and saplings or saplings only other than dominant species may form a sub-canopy species (v) Absence of seedlings means, the species reproduced well earlier but at present the reproduction is stopped.

In the past, vegetation analysis of forests were studied only in concentrated the central portion of the region because of easy approaches of the sites but no information and studies was available on the forests those were located in the highly remote and border areas in the region therefore present study is an attempt to know the actual picture of forests particularly on the structure and diversity of tree species occurring in the region of central Himalaya.

As far as species diversity and population structure of forests are concerned, it varied from forest to forest located in any specific site or region. Thus it is very essential and prerequisite to know the appropriate and exact condition of forests so that scientific tools and techniques can implies in the forest conservation and management to enhance and maintain the productivity and sustainability. Thus keeping in view, present study was carried out based on the following objectives. These objectives were: (1) to determine the population structure and regeneration pattern of species in each forest site, and (2) to assess the diversity and concentration of dominance of species in each forest site.

## MATERIAL AND METHOD

Present study sites were located in Lohaghat of Champawat district in Kumaun of Uttarakhand which lies between 1700 and 2000m elevation, $29^0$ 24' N lat. And$79^0$ 28' E long. Tree analysis was carried out by using 10x10m size quadrat placed randomly in each forest site along the altitudinal gradient. The sampling size and number of quadrat were determined following Misra (1968) and Saxena and Singh (1982; 1984). In each quadrat the tree species was sampled and categorized into: Trees with >30cm Cbh (circumference at breast height, i.e. 1.37m) from ground level and sapling with 10-30cm and seedling<10cm Cbh were measured at ground level and were grouped into different category as mentioned above. Species diversity of tree species in each studied forest was calculated by using Shannon-Weiner information index (Shannon and Weiner, 1963) while the concentration of dominance (Cd) was measured by Simpsons Index (Simpson, 1949). The soil characteristic such as physical and chemical were determined by Jackson (1958) and Misra (1968).

## RESULT

### Soil characteristics

The soil of the studied forest sites was sandy loam and also found with the sudden occurrence of boulders. The soil bulk density and soil porosity ranged from 1.02 to 1.18 $gcm^{-3}$ and 41.8 to 48.5% respectively. However the soil moisture and water holding capacity was 27.1-32.2 and 56.4 -65.5% respectively. The soil texture such as sand, silt and clay ranged from 42.6-47.3, 31- 6-34.3 and 2.1-23.1 %respectively (Table 1). The soil pH was 6.2-6.8 while the soil carbon was 2.7-3.1 % (Table1).

**Table 1.** Soil characteristics of study forest sites

| Parameter | Studied forest sites | | | |
|---|---|---|---|---|
| | Site 1 | Site 2 | Site 3 | Site 4 |
| Soil bulk density (gcm-3) | 1.02 | 1.12 | 1.17 | 1.18 |
| Soil porosity (%) | 48.5 | 45.0 | 44.6 | 41.8 |
| Soil moisture (%) | 32.2 | 29.8 | 28.4 | 27.1 |
| Water holding capacity (%) | 65.5 | 62.3 | 59.2 | 56.4 |
| Soil texture (%) Sand | 42.6 | 43.2 | 45.5 | 47.3 |
| Silt | 34.3 | 34.5 | 33.1 | 31.6 |
| Clay | 23.1 | 22.3 | 21.4 | 21.1 |
| Soil pH | 6.2 | 6.4 | 6.6 | 6.8 |
| Soil carbon (%) | 3.1 | 3.0 | 2.9 | 2.7 |

### Quantitative analysis of forests

Total seven tree species were reported from the studied forest sites (Table 2). Each tree species were categorized into seedling, sapling and tree in each forest site. The density of each category varies from species to species and also within the sites. The density of seedling, sapling and tree ranged from 270-1790, 365-1043 and 920-1345 individuals/ha (Table 2). For the assessment of population structure of tree species in each category in each forest site, the following six size classes were arbitrarily established based on circumference at breast height (Cbh, 1.37m) i.e. seedling<10cm, sapling10-30cm, young tree 30.1-60cm, pole size tree 60.1-90cm, mature tree category I 90.1-120cm, and old tree>120cm.

**Table 2.** Density (Ind/ha) of seedling, sapling and tree of different tree species in each studied forest site of Lohaghat in Kumaun Himalaya.

| Species | Category | Forest sites | | | |
|---|---|---|---|---|---|
| | | Site-1 | Site-2 | Site-3 | Site-4 |
| *Quercus leucotrichophora* | Seedlings | 365 | 400 | 515 | - |
| | Saplings | 640 | 605 | 485 | - |
| | Tree | 910 | 925 | 720 | - |
| *Myrica esculenta* | Seedlings | 360 | 365 | 390 | - |
| | Saplings | 40 | 35 | 315 | - |
| | Tree | 155 | 185 | 225 | - |
| *Cedrus deodara* | Seedlings | 175 | 16 | - | 170 |
| | Saplings | 85 | 125 | - | 175 |
| | Tree | 125 | 185 | - | 200 |
| *Pinus roxburghii* | Seedlings | 50 | 50 | 195 | 100 |
| | Saplings | 60 | 40 | 120 | 190 |
| | Tree | 50 | 25 | 260 | 720 |
| *Rhododendron arboreum* | Seedlings | 135 | - | - | - |
| | Saplings | 35 | - | - | - |
| | Tree | 25 | - | - | - |
| *Acacia mearnsii* | Seedlings | - | - | - | - |
| | Saplings | - | - | - | - |
| | Tree | - | 25 | - | - |
| *Prunus cerasoides* | Seedlings | - | - | 690 | - |
| | Saplings | - | - | 120 | - |
| | Tree | - | - | 30 | - |
| Total | Seedlings | 1085 | 831 | 1790 | 270 |
| | Saplings | 860 | 805 | 1043 | 365 |
| | Tree | 1265 | 1345 | 1235 | 920 |

**Population structure**

For the assessment of population structure of tree species in each category in each forest site, the following 6 size classes were arbitrarily established based on circumference at breast height (Cbh, 1.37m) i.e. seedling<10cm, sapling10-30cm, young tree 30.1-60cm, pole size tree 60.1-90cm, mature tree category I 90.1-120cm, and old tree>120cm.

**Forest site 1:** In this forest site, total 05 tree species were reported. Population structure of *Cedrus deodara and Rhododendron arboreum* are depicted in the Fig1c and 1d showed better regeneration compare to *Quercus leucotrichophora, Myrica esculenta and Pinus roxburghii* shown in fig 1a,1b and 1e because the presence of seedlings than other tree category and size classes. *Quercus leucotrichophora* represented by all the tree category and tree size classes from C to F while the *Cedrus deodara* and *Pinus roxburghii* only showed the D to F while the C tree size class was absent. *Myrica esculenta* and *Rhododendron arboreum* showed only C and D tree size classes; however, the E and F size classes were absent (Fig1b and Fig 1d).

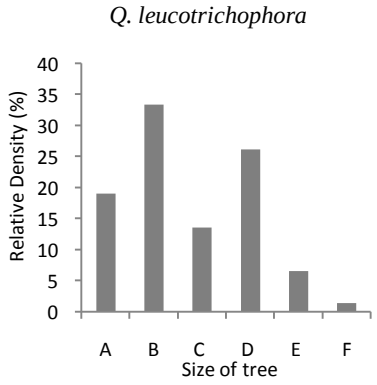



**Fig.a**

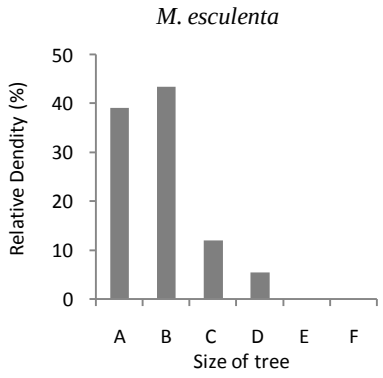



**Fig.b**

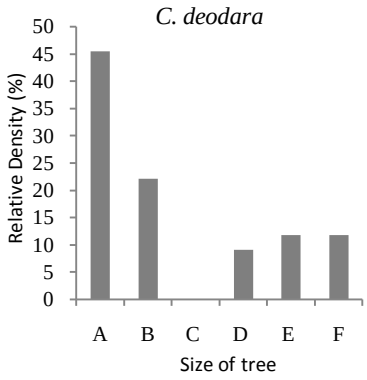



**Fig.c**

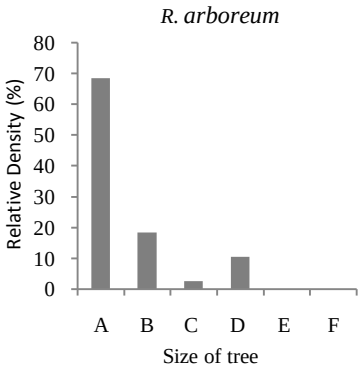



**Fig.d**

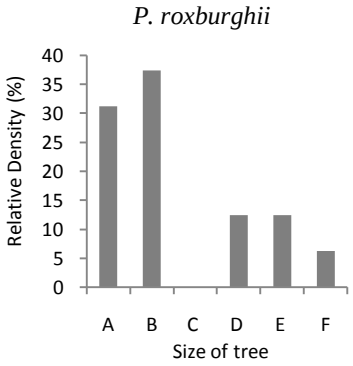



**Fig.e**

**Fig 1.** Population structure of tree species and their different size classes i.e. A= seedling, B= sapling, C=30.1-60cm, D=60.1-90 cm, E= 90.1-120cm and F=>120cm in site-1.

**Forest site 2**: In this site, total 04 tree species were occurred. The population structure of individual tree species is depicted in Fig 2a, 2b, 2c & 2d. In this forest site, *Myrica esculenta, Cedrus deodara* and *Pinus roxburghii* showed good regeneration because of the presence of seedlings and saplings compared to the other tree size classes. *Quercus leucotrichophora* had represented well because this species showed the entire tree category and size classes and showed fair regeneration. Thus the structure and composition of this species was considered good in this forest site (Fig 2a).

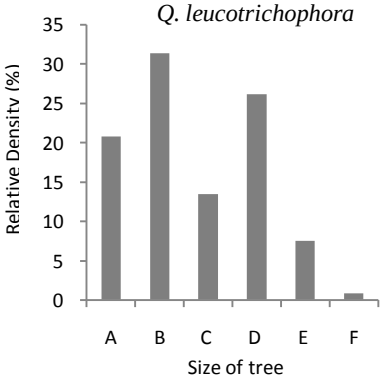



**Fig.a**

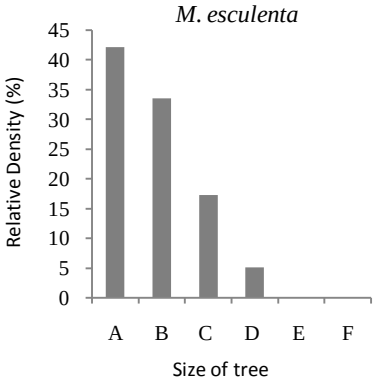
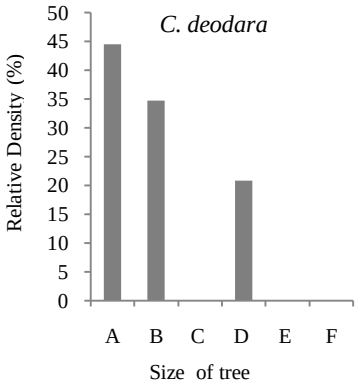



**Fig.b**



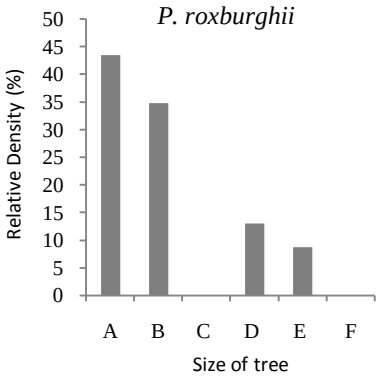
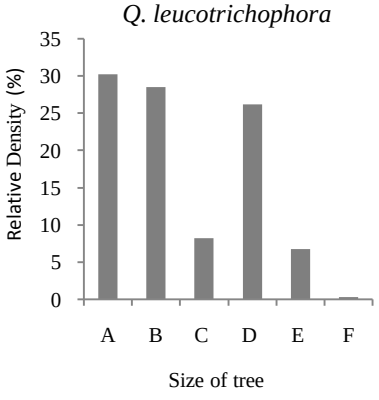




**Fig.c** **Fig.d**

**Fig 2.** Population structure of tree species and their different size classes i.e. A= seedling, B= sapling, C=30.1-60cm, D=60.1-90 cm, E= 90.1-120cm and F=>120cm in site 2.

**Forest site 3**: The total 04 tree species were present in the forest site, the population structure of each tree species have showed good regeneration because of presence of seedlings and saplings in each tree species (Fig 3a-d). *Quercus leucotrichophora* showed all the tree category and tree size classes while other either lacking one or more tree size classes (Fig 3c-d).



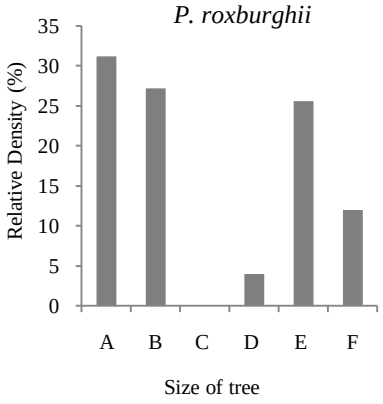
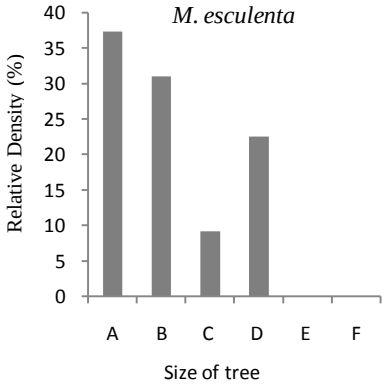




**Fig.a** **Fig.b**



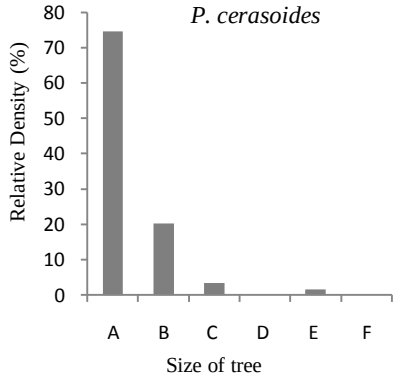




**Fig.c** **Fig.d**

**Fig 3.** Population structure of tree species and their different size classes i.e. A= seedling, B= sapling, C=30.1-60cm, D=60.1-90 cm, E= 90.1-120cm and F=>120cm in site 3.

**Forest site 4**: In this forest site, only 02 tree species were present i.e. *Pinus roxburghii* and *Cedrus deodara.* The population structure of each tree species along with each tree categories is depicted in Fig 4a and 4b. *Cedrus deodara* species showed better regeneration due to occurrence of seedlings and saplings than *Pinus roxburghii*. But the one tree size class was lacking in each case. Thus there was not clear cut representation of each tree size classes because of anthropogenic pressure, therefore, requires for proper conservation and management of forest.

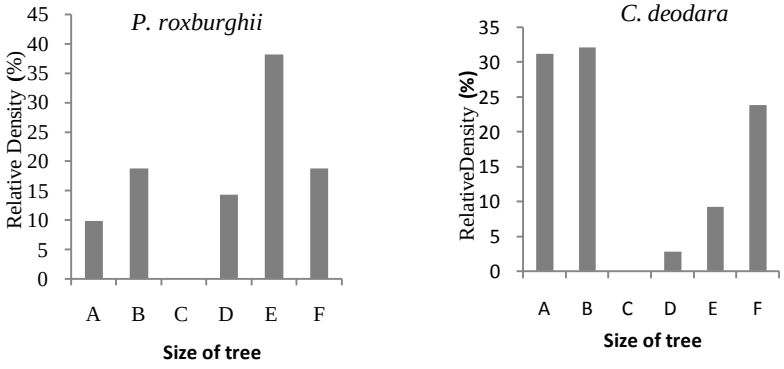



**Fig.a** **Fig.b**

**Fig 4.** Population structure of tree species and their different size classes i.e. A= seedling, B= sapling, C=30.1-60cm, D=60.1-90 cm, E= 90.1-120cm and F=>120cm in site 4.

**Population structure forest site**

The findings related to population structure of each tree species in each tree category in each forest site are depicted in the Fig. 5a, 5b, 5c & 5d.

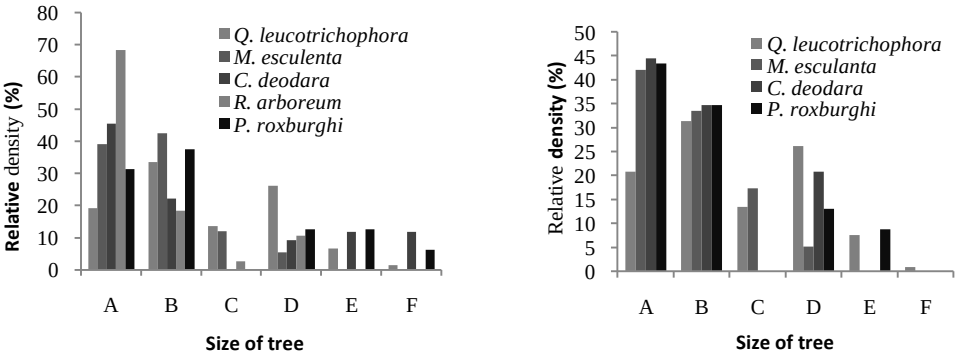



**Fig.**5a (site-1) **Fig.** 5b (site-2)

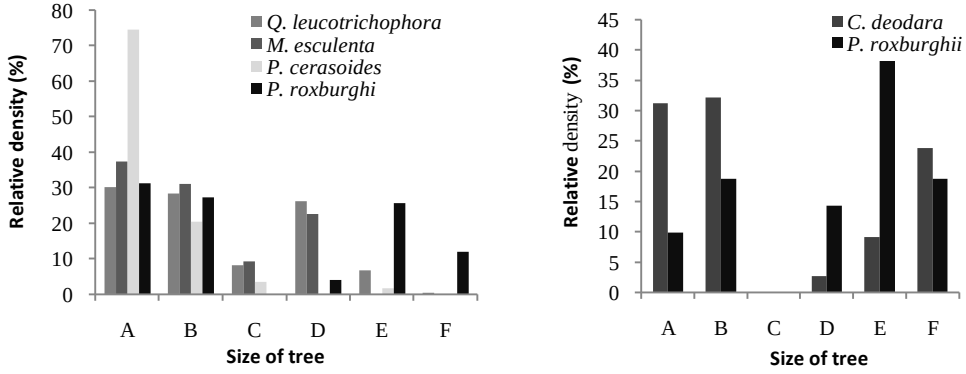



**Fig.** 5c (site-3) **Fig.** 5d (site-4)

**Fig 5.** Population structure of tree species along with each category occurred in each forest site.

**Species Diversity**

**(i). Seedling diversity of tree species**

Seedling diversity of tree species ranged from 0.200 to 0.530 in site-1, 0.230 to 0.530 in site-2, 0.346 to 0.529 in site-3 and 0.419 to 0.527 in site-4. However, the concentration of dominance was 0.002-0.011 in site 1, 0.003-0.0.170 in site-2, 0.012-0.148 in site-3 and 0.137 -0.397 in site-4 (Table 1). The maximum diversity was reported for *Quercus leucotrichophora and Myrica esculenta* for site 1 and 2, *Quercus leucotrichophora* in site 3, *Pinus roxburghii* in site 4 (Table 1).

**Table 1 .** Species diversity and concentration of dominance (Cd) of seedlings of tree species in the studied forest sites.

| Species | Studied forest sites | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Site 1 | | Site 2 | | Site 3 | | Site 4 | |
| | H | Cd | H | Cd | H | Cd | H | Cd |
| *Q. leucotrichophora* | 0.530 | 0.110 | 0.530 | 0.170 | 0.516 | 0.082 | - | - |
| *M. esculenta* | 0.530 | 0.110 | 0.530 | 0.140 | 0.477 | 0.047 | - | - |
| *C. deodara* | 0.420 | 0.026 | 0.430 | 0.030 | - | - | 0.419 | 0.395 |
| *R.arboreum* | 0.370 | 0.015 | - | - | - | - | - | - |
| *P. roxburghii* | 0.200 | 0.002 | 0.230 | 0.003 | 0.346 | 0.012 | 0.529 | 0.137 |
| *Acacia mearnsii* | - | - | - | - | - | - | - | - |
| *P. cerasoides* | - | - | - | - | 0.529 | 0.148 | - | - |

**(ii). Sapling diversity of tree species**

Sapling diversity ranged from 0.140 to 0.530 in site 1, 0.170 to 0.520 in site 2, 0.350 to 0.519 in site-3 and 0.488 to 0.507 in site 4. However, the concentration of dominance was 0.002-0.011 in site 1, 0.003-0.0.170 in site 2, 0.012-0.148 in site 3 and 0.137-0.397 in site 4 (Table 2). The maximum diversity was reported for *Myrica esculenta* for site 1 and 2, *Quercus leucotrichophora* in site 3 and *Cedrus deodara* in site 4 (Table 2).

**Table 2 .** Species diversity and concentration of dominance (Cd) of saplings of tree species.

| Species | Studied Forest sites | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Site 1 | | Site 2 | | Site 3 | | Site 4 | |
| | H | Cd | H | Cd | H | Cd | H | Cd |
| *Q. leucotrichophora* | 0.490 | 0.27 | 0.480 | 0.29 | 0.519 | 0.197 | - | - |
| *M. esculenta* | 0.530 | 0.11 | 0.520 | 0.97 | 0.516 | 0.082 | - | - |
| *C. deodara* | 0.270 | 0.01 | 0.350 | 0.01 | - | - | 0.507 | 0.229 |
| *R. arboretum* | 0.140 | 0.0008 | - | - | - | - | - | - |
| *P. roxburghii* | 0.210 | 0.024 | 0.170 | 0.0012 | 0.416 | 0.024 | 0.488 | 0.080 |
| *Acacia mearnsii* | - | - | - | - | - | - | - | - |
| *P. cerasoides* | - | - | - | - | 0.350 | 0.012 | - | - |

**(iii). Tree species diversity**

The tree species diversity ranged from 0.110 to 0.370 in site 1, 0.100 to 0.390 in site 2, 0.129 to 0.472 in site-3 and 0.275 to 0.477 in site 4. However, the concentration of dominance was 0.0004-0.510 in site 1, 0.0003-0.0.470 in site 2, 0.0006-0.338 in site 3 and 0.047 -0.610 in site 4 (Table 3). The maximum diversity was reported for *Myrica esculenta* for site 1, *Myrica esculenta and Cedrus deodara* in site 2, *Pinus roxburghii* in site 3 and *Cedrus deodara* in site 4 (Table 3).

**Table 3.** Species diversity and concentration of dominance of tree species in each forest site.

| Species | Forest studied sites | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Site 1 | | Site 2 | | Site 3 | | Site 4 | |
| | H | Cd | H | Cd | H | Cd | H | Cd |
| *Q. leucotrichophora* | 0.340 | 0.510 | 0.370 | 0.470 | 0.454 | 0.338 | - | - |
| *M. esculenta* | 0.370 | 0.020 | 0.390 | 0.020 | 0.446 | 0.033 | - | - |
| *C. deodara* | 0.330 | 0.010 | 0.390 | 0.020 | - | - | 0.477 | 0.047 |
| *R.arboreum* | 0.110 | 0.0004 | - | - | - | - | - | - |
| *P. roxburghii* | 0.180 | 0.002 | 0.104 | 0.0003 | 0.472 | 0.044 | 0.275 | 0.610 |
| *Acacia mearnsii* | - | - | 0.100 | 0.0003 | - | - | - | - |
| *P. cerasoides* | - | - | - | - | 0.129 | 0.0006 | - | - |

**Total diversity of species in forest sites**

Total species diversity species and concentration of dominance of seedling, sapling and tree species in all the forest sites are given Table 4. The diversity ranged from 0.757 to 1.500 for tree species, 0.950 to 2.050 for seedlings of tree species and 1.000 to 1.810 for saplings of tree species, respectively, while the concentration of dominance (Cd) for each forest site is also given in Table 4. The lower value of concentration of dominance (Cd) showed the higher range of species diversity in each site (Table 4).

**Table 4.** Total species diversity (H) and concentration of dominance (Cd) of tree species in each category in each forest site.

| Forest site | Forest tree category | | | | | |
|---|---|---|---|---|---|---|
| | Seedlings | | Saplings | | Trees | |
| | H | Cd | H | Cd | H | Cd |
| Site-1 | 2.050 | 0.263 | 1.640 | 0.415 | 1.330 | 0.542 |
| Site-2 | 1.720 | 0.343 | 1.520 | 0.400 | 0.964 | 0.510 |
| Site-3 | 1.880 | 0.290 | 1.810 | 0.315 | 1.500 | 0.414 |
| Site-4 | 0.950 | 0.179 | 1.000 | 0.310 | 0.757 | 0.657 |

## DISCUSSION AND CONCLUSION

The functioning of forest varies from one forest ecosystem to another which depends on the relationship of biotic and abiotic components including the existing micro-climate and human influences. Forests in the hills are very complex ecosystem and located in the very fragile geographical topography, hence it is very imperative to know actual picture of forests in relation to the tree structure, species composition and diversity as the conservation and management are the utmost important to the sustainability of forest ecosystem in the region. Forests have been degraded and suffered from various types of disturbances such as extraction of timber, fuel wood and fodder as well as conversion of forest lands for the infrastructure development such as roads, dams, buildings and other purposes. Since then a large scale deforestation and degradation of forests occurred in the region, consequently the growing pressure on forests for the multifarious needs of people and government severely threatened the floral and faunal biodiversity and forest genetic resources in the region. Busing (1995) had stated that the rate of disturbances and its variation altered the succession pattern, species composition, diversity and structure of forests. However, Kumar and Ram (2005) described that the proportion of early succession species was higher in disturbed forests while the proportion of the late succession species was greater in lowly disturbed forests.

Present study was conducted in natural forests of Lohaghat in the Champawat district of Kumaun Himalaya in Uttarakhand to determine the quantitative analysis of forests in relation to the structure and species diversity of tree layer in the four forest stand sites. The total number of species in the studied forests sites ranged from 2 to 5. The maximum number was occurred in site-1 while the minimum in the site-4 (see Fig 5). Tree density in the studied forests fall within the range 590-1630ind/ha reported for Pine forests by Chaturvedi and Singh (1987) and 570-760ind/ha for Oak forests by Rawat and Singh (1988), 257-2144 trees/ha for Dewalgarh watershed forests of Garhwal Himalaya (Uniyal *et al.,* 2010) but higher than 43-170ind/ha reported for reserve forests (Bisht and Lodhiyal, 2005) and 484 ind/ha for lowland sal forest of eastern Himalaya (Uma Shankar, 2001). However, the present estimates were slightly on the lower side than 1090-1980 ind/ha reported for temperate and sub-tropical forests (Raturi, 2012). The human activities severely impacted the forests in central Himalaya because of their needs and high population density (Kumar and Ram (2005). The species diversity for tree ranged from 0.757 to 1.500 in the studied forest sites which fall between the ranges 0.78-3.45 reported for temperate and sub-tropical forests (Raturi, 2012) but lower side than 1.2-2.7 reported for central Himalayan forests by Kumar and Ram (2005), 1.69-1.77 and 1.46-1.52 reported for undisturbed forests and disturbed forests (Borah and Garkoti, 2011) and 2.0-3.7 for tropical evergreen forests of western Ghats (Swamy *et al.,* 2010). Bisht and Lodhiyal (2005) described that presence of species diversity in the forests influenced by various factors such as climate, altitude, soil, biotic pressure etc. Population structure of tree species occurred in each forest site has showed the condition of forests whether they are sustainable or needs the certain inputs of management. Presence of sufficient number of seedlings and saplings in each forest site have shown good regeneration potential while lesser number of older tree category depicted that these forest are under anthropogenic pressure. Lesser number of seedlings of *Q. leucotrichophora* in all sites indicates that the species was under pressure due to heavy extraction of fuel and fodder while presence of more number of seedlings of *M. esculenta*, *C. deodara*, *R. arboreum* and *P. roxburghii* in all forest sites predict the change for species composition in future forest.

On the basis of findings, it is concluded that forest sites did not show any regular pattern as species diversity and population structure of species varied from site to site in the studied forests. It is because of

growing anthropogenic pressure on forests in the region. The forest site which was close to human habitations got affected much and heavily disturbed, therefore, species diversity, regeneration pattern and population structure of tree species showed variation in each tree category. In nutshell, it is concluded that forests were not in good conditions as the different categories of tree species varied in studied forest sites. However, regeneration of certain tree species shown by seedlings and saplings in the respective forest site indicate the growth of future forest crop. In this context, we also suggest that such forest sites must be conserved and managed for good tree structure, species composition and diversity as well as for future sustainability point of view. However, it requires the judicious and sustainable forest management as such natural forests not only a source of timber wood but also meet out the various livelihood needs of communities residing close to the forest sites. These forests may also conserve and protect the biodiversity and environment from recent climate change. The human disturbances is one of the reasons of low species diversity in the forests as it causes the soil and water erosion and make the site poor in terms of resources. The biodiversity and ecosystem functioning have largely taken the form of rapid, large and frequent changes in land and resource use and increased frequency of biotic invasions, reduction in species number, stresses and frequent potential for changes in the climatic system. Consequently such changes directly affect the forest biodiversity causing the habitat destruction and over-exploitation of resources by human beings and also by the changes in the atmospheric composition and climate (Heywood and Watson, 1995).

## REFERENCES

**Barnes, B.V., Zak, D.R., Denton, S.R. and Spurr, S.H**. (1998). Forest ecology (4ed), John Wiley and Sons Inc, New York.

**Bisht, S. and Lodhiyal, L.S.** (2005). Various aspects of soils and tree layer vegetation analysis in reserve forest of Kumaun in central Himalaya. *Indian Journal of Forestry* **28(1):** 37-50.

**Borah, N. and Garkot, S.C.** (2011). Tree species composition, diversity and regeneration patterns in undisturbed and disturbed forests of Barak valley, south Assam, India. *International Journal of ecology and Environmental Science*, **37(3):**131-141.

**Busing, R.T.** (1995). Disturbance and population dynamics of *Liriodendron nilifera:* simulations with a spatial model for forest succession. *Journal of Ecology* **83:**45-53.

**Chaturvedi, O.P. and Singh, J.S**. (1987). The structure and function of Pine forests in Central Himalaya, I. Dry matter dynamics. *Annals of Botany* **60:**237-252.

**Haywood, V.H. and Watson, R.T.** (1995). Global Biodiversity Assessment. Published for the United Nations Environment Programme. Cambridge University Press, Pages 1125.

**Jackson, M.L.(** 1958) Soil chemical analysis . Prentice Hall Inc; USA, 498p.

**Kumar, A. and Ram, J.** (2005). Anthropogenic disturbances and plant biodiversity in forests of Uttarakhand, central Himalaya. *Biodiversity and Conservation* **14:** 300-331.

**Lodhiyal, N. and Lodhiyal, L.S**.(2012). Tree layer composition and carbon content of oak and Pine in Lohaghat forests of Kumaun Himalaya. *Journal of Plant Development Sciences* **4(1):** 55-62.

**Misra , R**. (1968). Ecology Work Book. *Oxford and IBH Publishing Co.,Calcutta*.

**Raturi, G.P.** (2012) Forest community structure along an altitudinal Gradient of District Rudraprayag of Garhwal Himalaya, India. *Ecologia* **2(3):**76-84.

**Rawat, Y.S. and Singh, J.S.** (1988) Structure and function of oak forests in Central Himalaya. I. Dry matter dynamics. *Annals of Botany* **62:**397-411.

**Saxena, A.K. and Singh , J.S.** (1984). Tree population structure of certain Himalayan forest associations and implications concerning their future composition. *Vegetatio*, **58:** 61-69.

**Saxena, A.K. and Singh, J.S.** (1982). Quantitative profile structure of certain forest in the Kumaun Himalayan: *Proceeding of the Indian Academy of Sciences*, **91:** 529-49.

**Shankar, U.** (2001). A case study of high tree diversity in a sal (*Shorea robusta*)-dominated lowland forest of Eastern Himalaya: Floristic composition, regeneration and conservation. *Current Science* **81:**776-786.

**Shannon, C. and Wiener, W.** (1963). *The mathematical Theory of communication* (Urban: University of Illinois Press).

**Simpson, E.H.** (1949). Measurement of diversity.*Nature.***163:**688-692.

**Singh, J.S. and Singh, S.P.**(1992). Forests of Himalaya: Structure, Functioning and Impact of man. *Gyanodaya Prakashan, Nainital, India.*

**Swamy, S. L., Dutt, C.B.S., Murthy, M.S.R, Mishra, Alka and Bargali, S.S**.(2010) Floristic and dry matter dynamics of tropical wet evergreen forests of Western Ghats, India. *Current Science* **99(3):** 353-364.

**Uniyal, Pooja, Pokhariyal, P., Dasgupta, S., Bhatt, D. and Todaria, N.P**. (2010). Plant diversity in two forest types along the disturbance gradient in Dewalgarh Watershed, Garhwal Himalaya. *Current Science* **98 (7):**938-943.