

# TREE LAYER COMPOSITION AND CARBON CONTENT OF OAK AND PINE IN LOHAGHAT FORESTS OF KUMAUN HIMALAYA

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**Abstract:** Present study deals with composition of tree species, biomass and carbon content of forests in Lohaghat (Champawat) in Kumaun Himalaya. Total 06 tree species were reported from the study forest sites i.e. *Quercus leucotrichophora*, *Pinus roxburghii*, *Cedrus deodara*, *Myrica esculenta*, *Prunus cerasoides* and *Xanthoxylum alatum*. The *Quercus leucotrichophora* was dominant tree (82.7%) in the study forest site. Oak tree shared maximum basal area (24.96m<sup>2</sup>ha<sup>-1</sup>) and important value index (210.72). Total density of trees, seedlings and saplings was 2860 ind ha<sup>-1</sup>. Of this, tree, seedling and sapling shared 46.5, 21.0 and 32.5 percent. The biomass and carbon content of oak and pine was 128.10 t ha<sup>-1</sup> and 72.87 t ha<sup>-1</sup>, respectively. Of these, oak trees shared 79.19 % biomass and 81.5 % carbon, respectively. The findings of density, basal area, biomass and carbon content depicted that forest is in young stage with less number of tree species, needs a proper management and conservation so that tree layer species composition, biomass and carbon stocks could be increased.

**Keywords:** Basal area, Biomass, Carbon content, Density, Tree species

## INTRODUCTION

Forests play a significant role in economy and ecology of any region, state and country in the world as they are one of the major natural resources covering 3952 million hectares (nearly 4 billion ha), which accounted for about 30 percent. Of this, natural forests and plantations accounted for about 95 and 05 percent, respectively. The rate of increase of forest plantation area is 2.8 million hectares per year. The carbon stocks in forest biomass are 283 Giga tons (Gt) but it is decreasing at the rate of 1.1 Gt per year. India still accounted for 23.41% forests area however; forest area should be at least 1/3<sup>rd</sup> (33.3%) of the total geographical area of country as per the national forest policy.

Forest area in Uttarakhand accounted for about 3.5 million hectares (65 %) of the state's geographical area (FSI, 2009). However, the forest cover is about 45% of its forest area. The growing population pressure on forests for their basic needs such as wood, fuel, fodder and other forest products has created a serious concern about the sustainability of forest ecosystem. Thus the delicate relationship between man and forest has shattered, which requires a concrete policy for management and development of forest in the Himalaya region. In Uttarakhand, Sal(*Shorea robusta* Gaertn. F.) and Chir-pine(*Pinus roxburghii*) are the dominated tree species in forests occurred upto 1000m and 1200-1800m elevation, respectively. Apart from these species, Banj oak (*Quercus leucotrichophora*) and other oak species i.e. Tilonj Oak (*Quercus floribunda*), Kharsu oak (*Quercus semecarpifolia*) and Rianj oak (*Quercus lanuginosa*) grow upto 1600-3000m. Beyond 3000m elevation the alpine scrubs and alpine meadows are existed (Bisht and Lodhiyal, 2005). The forests and plantations in the Himalayan region were studied by Champion and Seth (1968), Ralhan *et al* (1982), Tewari and Singh (1981; 1985), Saxena and Singh

(1982 a; b), Saxena and Singh (1985), Rao and Singh (1985), Singh and Singh (1987), Chaturvedi and Singh (1987), Rawat and Singh (1988), Adhikari *et al* (1991), Lodhiyal (2000) and Lodhiyal *et al* (2002) and Lodhiyal and Lodhiyal(2003). The structure and function of plantations such as poplar and eucalyptus studied by Lodhiyal (1990), Bargali *et al* (1992), Lodhiyal *et al* (1995) and Lodhiyal and Lodhiyal (1997).

Population structure of a species in forest can convey partly its regeneration behaviors, in relation to the reproductive strategy. Importance is given to the number of saplings under adult tree for predicting future comparison of a forest community (Singh and Singh, 1992). Saxena and Singh (1982) have analyzed the size class distribution of major species in several forest types of Central Himalaya. However, Singh and Singh (1992) recognized five patterns of population structure in Central Himalaya forests i.e. (i) The greater population of individuals in lower size classes than larger size classes indicates 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 from a sub canopy species, (v) Absence of seedlings means, the species reproduced well earlier but at present the reproduction is stopped. The aim of forest ecologists is to understand dynamics of plant species of landscape particularly in relation to structure and function of forest ecosystem (Barnes *et al.*, 1998).

The over exploitation of forests in the central Himalayan region resulted a loss of biodiversity and species composition in their native habitats/sites. The impact of human influence on natural forests is so severe that the loss of biological pool due to

reduction of species diversity as well as it also leading towards the end of birth of forest species. The great loss is the loss of rich vegetation of the Himalayan region is increasing. In the recent years, Central Himalayan forest ecosystem witnesses the biotic disturbances. Such disturbances do not provide time for the ecosystem recovery and arrest the regeneration of important plant species in the forests of the region. This not only widens the gap but also changing the species composition of forests (Singh, 1998).

As far as biomass of forest is concerned, which is the main product of forests? It can be measured in the form of timber and non-timber products. How much biomass is stored in forest? Such information is important for every type of developmental needs of society, region and country. Biomass is estimated by the methods such as harvesting, chlorophyll, leaf area index, and remote sensing satellite data. In this study, we used the regression equation as developed by Rawat & Singh (1988) and Chaturvedi & Singh (1987).

As far as carbon storage and carbon sequestration is concerned, it is a burning issue of global warming and climate change, which become a global concern to mitigate the increasing concentration of green house gas specially the carbon dioxide gas in the atmosphere. How to combat this problem? Scientists are trying to evolve such a methods that could be reduced the excess amount of  $\text{CO}_2$  from the atmosphere and to balance its equilibrium. In this regard, forest vegetation is considered as one of the best solution tool for mitigation of carbon concentration of the atmosphere. As forest play a significant role in sequestering the atmospheric  $\text{CO}_2$  as well as act as a carbon sink.

Keeping this in view, we tried to estimate the carbon storage in the studied forests. The carbon stored both in living biomass (standing timber, branches, foliage/leaves and roots) and in dead biomass (litter, woody debris, soil organic matter and other related forest products. Deforestation results in the loss of a major sink for carbon. However, any human activity that affects the amount of biomass in forest vegetation and soils has a potential either to sequester carbon from or to release carbon into the atmosphere.

One hectare of closed tropical forest can contain upto 220 tons of Carbon (t C), most of which when burnt, is released into atmosphere. However, one-hectare agroforestry established on deforested land in tropics perhaps as much as 2200 tC could be prevented from going into the atmosphere but it may be more or less productive because of varying forms of agroforestry. The natural regeneration in tropics stored 195 t C/ha over a period of 50 years is the highest rate of biomass productivity of natural ecosystem in the humid tropics. Afforestation in temperate latitude stored 120 t C/ha through high growth rates of plantations on the lands. Through agroforestry practice in tropics one-hectare land shows a medium

value 95t C/ha. Such practice is also important from the standpoint of supporting the local populations. The reforestation practices in tropics and temperate latitudes have a medium carbon sequestration value 65 t C/ha and 56 t C/ha, respectively. Through carbon sequestration, the amount or rate of carbon accumulation could be increase by creating or enhancing carbon sinks through land use practices such as afforestation, reforestation and restoration of degraded lands, improved silvicultural techniques to increase growth rates and agroforestry practices. However, by carbon conservation strategy, we can reduce or prevent the rate of release of carbon already fixed in existing carbon sinks. It requires to conserve the biomass and soil carbon in the existing forests, By using the improved harvesting techniques that minimize the logging impacts, To improve the efficiency of wood processing, By using the effective fire protection measures and To use more effective burning carried out in both the forests and agricultural systems. The carbon substitution strategy will reduce the demand of fossil fuels by increasing use of wood either for durable wood products i.e. substitution of energy intensive material such as steel and concrete or for bio-fuel.

Thus, it is to conclude that the judicious forest management technique can contribute towards the emissions reduction and to carbon sequestration. The conservation of existing carbon stocks in forests is potentially a more powerful tool than carbon sequestration. However, forestry measures alone will not be enough to halt the increase in atmospheric  $\text{CO}_2$  concentrations; thus, it requires various strategic tools and techniques with local people involvement in the resource conservation and management perspectives

The study objectives were: (i) to determine the density, frequency, abundance, A/F ratio tree species in forest site. (ii) to determine relative density, relative frequency, relative dominance and important value index (IVI) of tree species in forest and (iii) to calculate biomass production and carbon sequestration potential in forest.

## MATERIAL AND METHOD

The study site lies between  $29^{\circ} 24'$  N lat. And  $79^{\circ} 28'$  E long. Of the total annual rainfall of 2000 mm about 75 % occurred in rainy season. The present study was carried out in the forests, located in Lohaghat, district Champawat, which fall between 1700 and 2000m elevation. The climate of entire study area is influenced by monsoon pattern of rainfall. On the basis of seasons, the whole year is divided mainly into rainy (mid-June-September), winter (November-February) and summer season (April-mid- June). There is a transitional period known as spring (March) and autumn (October), respectively. The temperature of Lohaghat was maximum ( $29.9^{\circ}\text{C}$ ) in June and minimum ( $11.2^{\circ}\text{C}$ ) in

January. The annual rainfall was 44.2 mm, which was maximum (11.6mm) in September (DST-U-Probe 2005). Geologically, the sites are consisting of sedimentary and metamorphic rocks consisting of sandstone, boulders, gneiss, alluvial with gravel, coarse and fine sand. The soil of the forests contains stones, gravels, sand, silt, and clay in different proportion. However, the colour of the soil varies from dark brown to reddish brown. The soils of the forests are mostly acidic in nature.

### Quantitative analysis of vegetation

The quantitative information was carried out for density, frequency, abundance, A/F ratio, IVI (important value index) of tree layer composition of forest. The woody layer analysis was done using quadrat method of 10 x 10m size. Total 30 quadrats were placed randomly in each forest site during December 2009. The diameters of tree species at breast height (dbh at 1.37m) were measured with the help of tree Caliper. On the basis of field data, the tree density, frequency, abundance, A/F ratio and IVI were calculated based on the formulas as given by Density of tree species, the biomass of respective components of tree was estimated. Thereafter, by summing up of biomasses of each tree component, we determined the total forest tree biomass for each forest stand.

Carbon sequestration for each component of tree species *i.e.*, Banj oak, Tilonj Oak and Pine in each forest site was estimated. There is no information about the tree carbon in this forest area. Most of the carbon research has been described by researchers in many research journals and available literature suggested that forest carbon constitute between 45 to 50 percent of the dry matter (biomass) (Chan, 1982; Schlesinger, 1991) To estimate the carbon sequestration, we followed the methods as developed and mentioned by Magnussen and Read (2004) and Singh and Lodhiyal (2009), respectively. We have estimated the carbon sequestration simply by taking the fraction of biomass using the following formula: Carbon sequestration= biomass multiplied by factor as:  $C=B \times 0.475$

Curtis and McIntosh (1950) and Saxena and Singh, (1982). For quantitative analysis, forest tree species were divided into different diameter classes viz. seedlings were considered to be individuals 0-15cm (diameter at basal height), saplings, 15-30cm (diameter at breast height) and trees above 30cm Dbh ( (diameter at breast height 1.37 m) as followed by Saxena *et al.* (1982).

### Biomass and carbon allocation

For the estimation of tree biomass, the regression equations were used as developed by Rawat and Singh (1988) for banj oak (*Quercus leucotrichophora*,) and Chaturvedi and Singh (1987) for pine (*Pinus roxburghii*). The biomass of each component of tree species as bole, branch, twigs, foliage (leaves) and roots (stump root= the main root of tree having the small portion of stem with tape root), lateral roots= roots that aroused from the stump root part) and from roots=roots having lower diameter originated from the portion of lateral root) were calculated.

Where 'C' is the Carbon Content or Carbon sequestration potential and 'B' is the biomass (oven dry matter) of tree component. Thus summing up the carbon content of each tree component we, estimated the total carbon of tree species. The carbon of selected tree species was calculated by multiplying density of respective tree species. Carbon of all species was summed up to get total carbon sequestration potential of forest.

## RESULT

### Quantitative analysis of forest

The quantitative parameters of trees, seedlings and saplings of forests were studied. The data of each forest stand were collected by randomly placed 10 quadrats for seedlings, saplings and trees of different species in forest stand site is given in Table 1. The findings for each forest stand site are described below.

**Table 1.** Vegetation analysis of trees, seedlings and saplings of tree species in studied forest.

Tree species	Trees	Seedlings	Saplings
Oak ( <i>Quercus leucotrichophora</i> )	1100	56	39
Pine( <i>Pinus roxburghii</i> )	70	03	09
Deodar( <i>Cedrus deodara</i> )	20	01	04
Kaphal( <i>Myrica esculenta</i> )	140	-	06
Paiya( <i>Prunus cerasoides</i> )	-	-	33
Timor( <i>Xanthoxylum alatum</i> )	-	-	02
Total	1330	60	93

**Trees:** The six (06) tree species viz., *Quercus leucotrichophora*, *Pinus roxburghii*, *Cedrus deodara*, *Myrica esculenta*, *Prunus cerasoides* and

*Xanthoxylum alatum* were present. Total density of trees was 1100.0 trees ha<sup>-1</sup>. The tree density ranged between 0.2 (*Cedrus deodara*) and 11.0 tree 100m<sup>2</sup>

(*Quercus leucotrichophora*). The frequency of tree species ranged between 10 and 100% and maximum for *Quercus leucotrichophora* and minimum for *Cedrus deodara* (Table 2). The abundance and A/F

ratio ranged from 1.00 to 11 trees and 0.038 to 0.300. The A/F ratio showed that the species were distributed in all the patterns (Table 2).

**Table 2.** Density, frequency, abundance, A/F ratio and distribution pattern of tree species in studied forest stand in site.

Species	Category of layer	D (ind. ha <sup>-1</sup> )	F (%)	A	A/F ratio	DP
Oak	Trees	1100	100	11.00	0.110	Contagious
	Seedlings	560	90	6.22	0.069	Contagious
	Saplings	390	90	4.33	0.048	
Pine	Trees	70	50	1.40	0.028	Random
	Seedlings	30	10	3.00	0.300	Contagious
	Saplings	90	40	2.25	0.056	Contagious
Deodar	Trees	20	10	2.00	0.200	Contagious
	Seedlings	10	10	1.00	0.100	Contagious
	Saplings	40	20	2.00	0.100	Contagious
Kaphal	Trees	140	50	2.8	0.056	Contagious
	Seedlings	-	-	-	-	-
	Saplings	60	40	1.5	0.038	Random
Paiya	Trees	-	-	-	-	-
	Seedlings	-	-	-	-	-
	Saplings	330	90	3.66	0.041	Random
Timor	Tree	-	-	-	-	
	Seedlings	-	-	-	-	
	Saplings	20	10	2.00	0.200	Contagious

**Note:** D=Density, F=Frequency and A=Abundance; A/F ratio= Abundance of a species/frequency of same species dictates distribution pattern of a species and DP=distribution pattern. When A/F ratio value is < 0.025, means that the species is regularly distributed. When A/F ratio of a species ranges from 0.025 to 0.05, it means that species is randomly distributed. Whenever the A/F ratio is >0.05 and more means species are contagiously distributed (or clumped).

The total basal area of tree species was 36.76.59 cm<sup>2</sup> 100 m<sup>2</sup> or 36.77 m<sup>2</sup> ha<sup>-1</sup>. The basal area ranged from 36.66 to 2495.51 cm<sup>2</sup> 100 m<sup>2</sup>. It was maximum for Banj oak (*Quercus leucotrichophora*) and minimum for Paiya (*Prunus cerasoides*). The total IVI was reported 299.83 for all species occurring in forest site (Table 3). The most dominant species was *Quercus leucotrichophora* (IVI=210.72) in the site followed by Kaphal (*Myrica esculenta*) (IVI= 39.96) and Chir-Pine (*Pinus roxburghii*) (IVI= 35.48) (Table 3). The value for each species is mentioned in Table 3.

**Table 3.** Basal area, relative density, relative frequency, relative dominance and important value index of different tree species in studied forest stand.

Tree Species	BA (cm <sup>2</sup> /100 m <sup>2</sup> )	BA (m <sup>2</sup> ha <sup>-1</sup> )	RD (%)	RF (%)	RD (%)	IVI
<i>Quercus leucotrichophora</i>	2495.51	24.95	82.7	46.45	81.57	210.72
<i>Pinus roxburghii</i>	320.75	3.21	5.26	22.72	10.5	35.48
<i>Cedrus deodara</i>	36.66	0.37	1.19	9.09	1.50	11.78
<i>Myrica esculenta</i>	823.88	8.24	10.52	22.72	6.72	39.96
	3676.50	36.77				299.94

**Note:** BA= Basal Area; RD= Relative density, RF= Relative frequency; RD=Relative dominance and IVI= Important value Index

**Seedlings:** The total 60 seedlings of four (04) tree species viz., *Quercus leucotrichophora*, *Pinus roxburghii*, *Cedrus deodar*, and *Myrica esculenta* were present. Seedlings of *Quercus leucotrichophora*

were dominant in forest site. The total density of seedlings of all species was 60 ind.100 m<sup>2</sup> (6000 seedlings ha<sup>-1</sup>). However, the individual density of seedlings among species ranged from 70 to 560 ind.100 m<sup>2</sup> (see Table 2). The frequency of tree species ranged between 10 and 90% and maximum for *Quercus leucotrichophora* and *Myrica esculenta*

(see Table 2). However, abundance and A/F ratio of seedlings ranged from 1.00 to 6.22 individual ha<sup>-1</sup> and 0.069 to 0.300, respectively (see Table 2). The **IVI**

of seedlings was ranged from 9.13 to 155.67 for the tree species seedlings (Table 4).

**Table 4.** Relative density, relative frequency, relative dominance and important value index of seedlings of different species in studied forest stand site.

Seedlings of tree Species	RD(%)	RF(%)	RD(%)	IVI
<i>Quercus leucotrichophora</i>	76.71	64.28	24.68	165.67
<i>Pinus roxburghii</i>	6.84	7.14	1.98	15.96
<i>Cedrus deodara</i>	1.37	7.14	0.62	9.13
<i>Prunus cerasoides</i>	15.06	21.42	72.73	109.21
Total				299.97

**Note:** RD= Relative density, RF= Relative frequency; RD=Relative dominance and IVI= Important value Index

**Saplings:** The total 93 saplings of six (06) tree species i.e. *Quercus leucotrichophora*, *Quercus floribunda*, *Pinus roxburghii*, *Cedrus deodara*, *Myrica esculenta* and *Prunus cerasoides* were

present in forest stand site. The density ranged from 0.2 (Timor) to 3.9 ind/100m<sup>2</sup> (Banj oak). However, the total density of saplings was 9.3 individual 100 m<sup>2</sup> or 930 ind ha<sup>-1</sup> (see Table 2). The IVI of saplings of *Quercus leucotrichophora* was maximum (130.77.67) followed by *Xanthoxylum alatum* (20.06) (Table 5).

**Table 5.** Relative density, relative frequency, relative dominance and important value index of saplings of different species in studied forest stand in site.

Seedlings of tree Species	RD (%)	RF (%)	RD (%)	IVI
<i>Quercus leucotrichophora</i>	47.56	31.03	52.18	130.77
<i>Pinus roxburghii</i>	10.97	13.79	4.59	29.35
<i>Cedrus deodara</i>	4.87	13.79	3.67	22.33
<i>Myrica esculenta</i>	7.31	13.79	12.08	33.18
<i>Prunus cerasoides</i>	26.82	24.13	13.28	64.23
<i>Xanthoxylum alatum</i>	2.44	3.45	14.17	20.06
Total				299.92

**Note:** BA= Basal Area; RD= Relative density, RF= Relative frequency; RD=Relative dominance and IVI= Important value Index

**Tree biomass and carbon storage:** The total number of Banj-oak (*Quercus leucotrichophora*) trees was 133 in studied forest. Of this, Oak, pine, deodar and Kaphal was 110, 07, 02 and 14, respectively. The average diameter of oak and Pine trees was 17.07 and 24.0cm.

**Tree biomass:** Total biomass of Banj-oak trees was 1014.55.73 kg /100m<sup>2</sup> or 101.45 tone ha<sup>-1</sup>. Of this, maximum (25.30 t ha<sup>-1</sup>) and minimum (0.81 t ha<sup>-1</sup>) biomass was shared by bole and fine roots, respectively (Table 6). However, the biomass of Chir-pine was 266.53 kg/100m<sup>2</sup> or 26.65 t ha<sup>-1</sup>. The maximum (8.16 t ha<sup>-1</sup>) and minimum (1.53t ha<sup>-1</sup>) shared by branch and cone component, respectively (Table 7).

**Table 6.** Biomass and carbon content of Banj oak (*Quercus leucotrichophora*) tree species in forest stand site.

Components	Biomass (Kg in 100m <sup>2</sup> )	Biomass (t ha <sup>-1</sup> )	CSP (Kg 100m <sup>2</sup> )	Carbon (t ha <sup>-1</sup> )
Bole	253.31	25.3	120.30	12.03
Branch	238.83	23.8	113.40	11.34
Twig	168.92	16.9	80.24	8.02
Foliage	169.99	16.9	80.75	8.07
Stump root	189.25	18.9	89.89	8.99
Lateral roots	149.88	14.9	71.19	7.12
Fine roots	80.81	0.81	38.38	3.84
Total	1014.55	101.45	594.15	59.41

**Note:** CSP = Carbon sequestration potential

**Carbon storage:** The total Carbon content of Banj oak trees was 594.15 kg /100m<sup>2</sup> or 59.41 t ha<sup>-1</sup>. Of

this, bole accounted for maximum (12.30 t ha<sup>-1</sup>) (Table 6). However, total carbon storage in Chir-pine

was 134.56kg /100m<sup>2</sup> or 13.46 t ha<sup>-1</sup>. Of which branch accounted for maximum 4.68 t ha<sup>-1</sup>(Table 7).

**Table 7.** Biomass and carbon content of Chir-pine (*Pinus roxburghii*) tree species in forest stand site.

Components	Diameter (cm)	Density trees /100m <sup>2</sup>	Biomass (Kg /100m <sup>2</sup> )	Biomass (t ha <sup>-1</sup> )	CSP (Kg/100m <sup>2</sup> )	Carbon (t ha <sup>-1</sup> )
Bole	24.20	0.7	39.51	3.95	18.77	1.88
Branch: I order	24.20	0.7	43.56	4.36	28.69	2.87
Branch: II order	24.20	0.7	38.01	3.80	18.05	1.81
Foliage	24.20	0.7	27.43	2.74	13.03	1.30
Cone	24.20	0.7	15.34	1.53	7.29	0.73
Stump root	24.20	0.7	36.41	3.64	17.29	1.73
Lateral roots	24.20	0.7	37.51	3.75	17.82	1.78
Fine roots	24.20	0.7	28.76	2.88	13.62	1.36
Total			266.53	26.65	134.56	13.46

**Note:** CSP =Carbon sequestration potential

## DISCUSSION AND CONCLUSION

Forests of Himalaya play a significant role in sustainable development of society and conservation of resources. They not only protect and conserve the soil, water and biodiversity of the hills regions but also have a very vital role in the development of society and watershed management. Forests provide the timber and non-timber products and also protect environment polluted and degraded by human activities. Plant diversity has affected by various climatic, edaphic, topographic and biotic pressures such as animals and human beings that are carried out in forest ecosystem. The sustainability of forest ecosystem can be determined and assessed on the basis of presence, structure and function of existing plant species therein. Himalayan ecosystems are facing many problems that are associated directly and influencing the conservation and development of natural resources like soil, water land, forest and biodiversity in the regions. Present study was

basically to know the tree layer composition in selected forest. The vegetation analysis was carried out for trees, seedlings and saplings existing in the forest. For the analysis of forest, first, we divided the whole forest into three forest sites. In each forest stand site, we studied, density, frequency, abundance, A/F ratio, distribution pattern of each vegetation category i.e. trees, seedlings and saplings. Apart from these, the basal area, relative density, relative frequency, relative dominance, important value index (IVI), tree biomass and carbon sequestration of trees were also determined in each forest site. The data presented in each table and in the text are the average of each forest site.

All the above parameters were studied by using quadrat method, regression equations for tree species as given by the earlier researchers as mentioned in materials and methods. The carbon sequestration for Banj-oak and Chir-pine tree species was studied in each selected forest site. The average findings of studied forest sites are given in Table 8.

**Table 8.** Comparative accounts of important vegetation parameters of forest stand in studied sites are given here.

S. No.	Parameters	Results
1.	Density (ind.ha <sup>-1</sup> )	
	Forest trees	1330(46.5)
	Seedlings	600(21.0)
	Saplings	930(32.5)
	Total	2860(100)
2.	Basal area (m <sup>2</sup> ha <sup>-1</sup> )	
	Oak tree	36.77(60.0)
	Pine tree	24.95(40.0)
	Total	61.72(100.)
4	IVI	
	Oak trees	299.94(210.72)
	Seedlings	299.97(165.67)
	Saplings	299.92(130.77)

5	Tree biomass (tha <sup>-1</sup> )	
	Banj oak tree	101.45(79.19)
	Chir-pine tree	26.65(20.80)
	Total	128.10(100.0)
6	Carbon storage (t ha <sup>-1</sup> )	
	Banj tree	59.41(81.5)
	Pine tree	13.46(18.5)
	Total	72.87(100.0)

**Note:** In parenthesis the value of oak and pine species are given, which showed the maximum shared among the associated species.

The vegetation parameters of studied forest site are mentioned in Table 8. Total density of tree layer was 2860 ind. ha<sup>-1</sup>. Of this, tree, was higher in both forest site as compare to seedlings and saplings. The maximum basal area (60%) was shared by oak trees. The important value index (IVI) of Banj-oak tree species shared maximum followed by its seedlings and saplings in forest (Table 8).

The total biomass of tree species was 132.12 t ha<sup>-1</sup>. The maximum biomass of forest was shared by *Quercus leucotrichophora* and followed by Chir-pine trees (Table 8). Present finding of density of banj oak trees, seedlings and saplings are on higher side than the values reported for Banj -oak tree, seedlings and saplings in reserve forest of Nainital forest division i.e. 43-170 trees, 323-1200 seedlings and 123-500 saplings per ha<sup>-1</sup>(Swati and Lodhiyal, 2005). Our findings are on higher side than the value reported for oak forest of central Himalayan region (Rawat and Singh, 1988). The values reported for pine trees in present study are lower side than the values of pine forests studied by Chaturvedi and Singh (1987). However, the values of biomass of oak and pine are on lower side than the values of oak forests studied by Rawat and Singh (1988) and Chaturvedi and Singh (1987). However, there is no information about carbon sequestration potential of the present studied forests. The carbon sequestration was 72.87 t ha<sup>-1</sup> in studied forest. In the context of global warming and climate change processes, vegetation has significant role in mitigation of carbon through forest carbon sink. Thus it is imperative to know that what type of stand structure, composition, species diversity, biomass and carbon potential existing in forests occurring in different geographical locations. It is concluded that present findings provide the quantitative information of forest. These findings would be useful in conservation and management strategies in the Himalayan forest ecosystems as well as researchers working in the ecological and developmental aspects of forests and community.

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