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Analysis of forest vegetation in Binsar Wildlife Sanctuary, Kumaun Himalaya, Uttarakhand, India

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Abstract
Forest vegetation and regeneration were studied along different aspects and altitudinal gradient in Binsar wildlife sanctuary Almora district of Uttarakhand Himalaya (India) using standard phytosociological random sampling quadrat method. A total of six stands were laid. The result reveals that the along different altitudes and aspects a total of ten tree species were recorded. Across the stands, the total tree density ranged between 300-560 Ind/ha, sapling density between 20 to 380 Ind/ha and seedling density from 640 to1880 Ind/ha. The shrub density varied from 540 to 8520 Ind/ha. *Pinus roxburghii* was the dominant species on western, southern, eastern and western facing aspects with IVI 135.32, 218.41, 214.63 and 167.06 respectively. While *Lyonia ovalifolia* and *Quercus leucotrichophora* were the most dominant species on the northern and eastern facing aspects respectively. Across the stands, total basal area and diversity of tree layer ranged from 26.66-117.41 m2/ha and 0.45-1.57 respectively. The regeneration of *Pinus roxburghii* and *Myrica esculenta* was excellent. The *Pinus roxburghii* was shown good regeneration even in northern and eastern facing aspects. The occurrence and increasing regeneration of *Pinus roxburghii* in these aspects might be due to global warming as this species requires warm and drier slopes for growth. Whereas The *Quercus leucotrichophora* had a complete absence of complete absence of saplings and decrease of young tree classes, but greater proportion of individuals in seedling class, indicates that seedlings from recent past had failed to attain sapling class, if the trend continues; the populations of species will decrease in near future.

Keywords: binsar wildlife sanctuary, forest vegetation, regeneration status, Uttarakhand, India

1. Introduction
Himalayan region is exceptionally rich in biodiversity and is recognized as one of the global biodiversity hotspot that harbours nearly 8000 species of flowering plants including 25-30% endemic ones [1,2]. During the recent decade Biological diversity has become a topic of increasing scientific and popular interest [3, 4]. This growing interest is a result of increase concern about the problem of species loss [5]. The growing pressure of populations on Himalayan regions and their existing forests has depleted the good forest cover have become threatened and are on the verge of extinction. The exploitive management practices and the biotic stress exerted by hill population in relation to oak species have encouraged the pine in various ways [6]. In order to promote in-situ conservation, the protected area network programs were initiated in India [7]. Across the Himalaya a total of 105 protected areas have established covering a total of 6% geographic area of region [8]. For the conservation of Banj oak Binsar wildlife sanctuary was established in 1988. Keeping in mind decline of forest cover, replacement of banj oak with pine and extinction of plant species it is therefore necessary to highlight phyto-diversity for its future conservation.

Study area
The present study has been carried out in the Binsar wildlife sanctuary situated between 29°32.98'- 29°34.32' N latitudes and 79°41.44'-79°43.2' E longitude of Takula block of Almora district. It was established in 1988 for the conservation and protection of broadleaf oak (*Quercus* spp.) forests. Since the wildlife sanctuary is rich in flora and fauna, it has been declared as important bird area by Bird Life International with over 200 species.

2. Materials and methods
The field surveys were conducted during May -October 2016. A total of 6 stands were laid based on altitude and aspect. Standard phyto-sociological quadrat methods were followed to obtain data [9, 10]. Generally circumference at breast height (CBH) of all trees (i.e., 1.37m) was measured by meter/inch tape. Trees were considered to be the individuals having cbh >30.5cm, saplings 10.5- 30.5cm cbh and seedling those with their circumference < 10.5 cm [11]. Vegetational analysis was carried out for four layers of forests, i,e tress, saplings, seedlings and shrubs by using random sampling quadrat method. Ten Quadrats (10x10m) were placed in each stand for tress and sapling layers assessment. Each 10x10m quadrat were having two 5x5 subquadrat for enumeration of seedlings and shrubs. Generally Plants of seedling and shrub species in each sample plot were counted to determine their densities and Frequencies. The Vegetational data was assessed for density, frequency [12]. Importance Value Index (IVI) for tree and sapling were determined as the sum of their relative density, relative frequency and relative dominance [13]. The species richness was simply the number of species per unit area [14, 15]. The diversity index for the all four layers at each stand was calculated by using the Shannon-Weiner index [16]. The concentration of dominance by Simpson's index [17] and evenness or equability by log cycle index respectively [18] During the field survey a total of six stands were laid in different aspects and altitudes, the various aspects related to the study sites are given are given in table 1.

Table 1: Different forest stands, with aspect, altitude and coordinates

Studied sites	Altitude in (meter)	Aspect	GPS. Coordinates
1	1900-1950	West	N29^0 41′. 241″ E 79^0 44′. 252″
2	1900-1950	South	N29^0 40′. 625″ E 79^0 43′. 318″
3	1900-1950	North	N29^0 41′. 080″ E 79^0 44′. 018″
4	1900-1950	East	N29^0 40′. 756″ E 79^0 43′. 442″
5	2050-2100	East	N29^0 41′. 287″ E 79^0 44′. 214″
6	2050-2100	West	N29^0 41′. 207″ E 79^0 49′. 153″

3. Results and discussion

3.1. Tree layer

The total tree density ranged between 300-500 Ind/ha and total basal area ranged between 34.40-227.70 m2/ha among all the six stands. The *Pinus roxburghii* was the most dominant species in term of IVI in four stands (IST, 2nd, 4th and 6th) with IVI 135.32, 218.41, 214.63 and 167.06 respectively. Whereas *Lyonia ovalifolia* was dominant in stand 3rd and *Quercus leucotrichophora* in stand 5th with an IVI of 77.32 and 136.59 respectively (Table 2). Across the stands Species richness, diversity, concentration of dominance and Evenness ranged from 4-7 and 0.45-1.57, 0.25-0.80 and 0.32-0.85 respectively. In all stands species richness and species diversity value was highest for stand 3rd. whereas values of concentration dominance was highest for stand 4th and lowest for stand 3rd (Table 5). The values of total tree densities (300-560 ind/ha) reported in present study are lower than the earlier reported values (1103 2460ind/ha) in five Panchayat forests [19]; 280- 1680ind·ha-1from Kumaun Central Himalaya [20], and are are more than earlier reported values (320 to 420 Ind/ha from forest of Almora Kumaun Himalaya [21]; 193 to 324.3 ind/hectare from Lamgarah Developmental Block of Almora District, Uttarakhand [22].

3.2. Sapling layer

The total sapling density varied from 20-380 (Ind/ ha) across all stands. The sapling density of *Pinus Roxburghii* ranged from 20-280 Ind/ha and was present in all stands. The *Pinus roxburghii* showed its dominance in three stands Ist, 2nd and 6th with IVI 186.15, 180.16, 300. *Lyonia ovalifolia* was dominant in stand 3rd with IVI 112.60, *Myrica esculenta* Was dominant in Stand 4th With IVI 159.02 and *Quercus leucotrichophora* was dominant in Stand 5th with IVI 165.63 (table 2). Species diversity value for sapling layer varied from 0.01-1.08 which was highest on stand 3rd and lowest on stand 6th whereas the concentration of dominance value ranged between 0.35-1.0 (Table 5). The total value of tree density of sapling layer in present study were lower than the earlier values 260-610ind/ha reported [22] and are highest from earlier reported values 30-180ind/ha [21]

Table 2: Vegetational parameters for tree and sapling

				Tree			Sapling	
Stand	**Aspect**	**Species**	**Density/ha**	**TBA (m2/ha)**	**IVI (%)**	**Density/ha**	**TBA (m2/ha)**	**IVI (%)**
1	West	*Pinus roxburghii*	160	18.94	135.32	130	0.66	186.15
		Quercus leucotrichophora	70	8.16	81.25	-	-	-
		Lyonia ovalifolia	40	1.2	33.98	10	0.01	41.07
		Rhododendron arboretum	30	2.22	49.45	-	-	-
		Myrica esculenta	-	-	-	10	0.06	72.78
		Total	300	30.52	300	150	0.73	300
2	South	*Pinus roxburghii*	390	26.32	218.41	300	2.04	180.16
		Myrica esculenta	50	1.28	34.76	70	0.32	69.19
		Lyonia ovalifolia	30	0.58	29.01	-	-	-
		Quercus leucotrichophora	20	0.57	17.82	-	-	-
		Symplococus racemosus	-	-	-	10	0.06	50.65
		Total	490	28.76	300	380	2.42	300
3	North	*Pinus roxburghii*	120	5.62	60.44	30	0.11	109.35
		Quercus leucotrichophora	60	8.90	61.6	-	-	-
		Lyonia ovalifolia	130	4.88	77.32	20	0.12	112.6
		Rhododendron arboretum	10	0.6	17.95	20	0.08	78.05
		Alnus nepalensis	20	3.28	37.88	-	-	-
		Cornus capitata	10	0.45	15.37	-	-	-
		Symplococus racemosus	30	2.93	29.43	-	-	-
		Total	380	26.66	299.99	70	0.31	300
4	East	*Pinus roxburghii*	500	33.3	214.63	10	0.05	140.98
		Quercus leucotrichophora	20	0.29	29.57	-	-	-
		Lyonia ovalifolia	30	0.73	40.17	-	-	-
		Symplococus racemosus	10	0.08	15.63	-	-	-
		Myrica esculenta	-	-	-	10	0.07	159.02
		Total	560	34.4	300	20	0.12	300
5	East	*Pinus roxburghii*	10	0.33	19.62	-	-	-
		Quercus leucotrichophora	210	23.51	136.59	60	0.19	165.63
		Lyonia ovalifolia	90	2.19	54.31	20	0.07	87.42

		Myrica esculenta	60	1.34	50.18	-	-	-
		Cornus capitata	10	0.09	10.5	10	0.02	46.95
		Ilex dipyrena	10	0.56	28.02	-	-	-
		Total	390	28.02	299.22	90	0.28	300
6	West	*Pinus roxburgii*	340	24.61	167.06	45	0.18	300
		Quercus leucotrichophora	30	2.75	59.36	-	-	-
		Lyonia ovalifolia	20	0.19	14.22	-	-	-
		Acacia dealbata	10	0.64	32.57	-	-	-
		Rhododendron arboreum	20	0.54	26.8	-	-	-
		Total	420	28.73	300	45	0.18	300

3.3. Seedling layer

The total seedling density ranged from 640-1880 Ind/ha. The seedling density of *Pinus roxburghii* remained dominated in three stands (I^{ST}, 2nd and 6th) and its density varied from 480 to 800 individuals/ha. *Quercus leucotrichophora* remained highest in stand 3rd with density of 880 individuals/ha. Data analysis reveals that *Pinus roxburghii* was present in all stands, whereas *Quercus leucotrichophora* made its appearance in Five (5) stands. Densities of *Lyonia Ovalifolia* and *Myrica esculenta* was higher in stand 5th and 6th respectively (table 3). Across all the stands Species Richness, diversity and concentration dominance ranged from 3-7, 0.73- 1.42 and 0.27-0.57 respectively. The highest seedling density was found in stand 5th followed by stand I^{ST} (table 5). The total value of tree density of sapling layer in present study were higher than the earlier reported values of 100 to 180 ind/ha reported by earlier values [21]. 249.98 to 845 Ind/ha reported [22] 260-970ind·hectare [23]

3.4. Shrub Layer

The total shrub density ranged from 540-8520 Ind/ha. The shrub density of *Indigofera tinctoria* remained dominated in four stands 2nd, 4th, 5th and 6th with densities of 1900, 5500, 180 and 1620 individuals/ha respectively. *Flimingia strobilifer* was highest in stand 1st with 460 individual/ha. In stand 3rd the most abundant species was *Rubus ellipticus* with density of 400 individuals/ha (table 4). Across the stands value of species diversity varied from 0.86 to 1.74. The value was highest in stand 3rd (1.74) and lowest in stand I^{ST} (0.86), however the concentration of dominance value varied from 0.21 to 0.49. The highest value was for stand 4th and lowest for stand 3rd (table 5). Present values of total shrub density were higher than the earlier reported values of 199.32 to 406.32ind·ha-1 [22] and lower than earlier values 609.98 to 3265.63ind/ha [21].

Table 3: Density/ha of seedling layer

Seedling			**Aspect/ Stand**			
Species	West/ 1st	South/2nd	North/3rd	East/4th	East/5th	West/6th
Pinus roxburghii	800	460	720	180	180	660
Acacia dealbata	80	280	-	-	-	80
Quercus leucotrichophora	380	360	880	-	40	260
Ilex dipyrena	20	-	-	-	-	-
Myrica esculenta	40	40	80	40	220	-
Lyonia ovalifolia	60	40	120	560	-	180
Rhododendron arboretum	100	-	80	-	160	-
Pyrus pashia	-	-	-	-	40	60
Total	1480	1180	1880	780	640	1240

Table 4: Density/ha of shrub layer

Shrub			**Aspect/ Stand**			
Species	West/ 1st	South/2nd	North/3rd	East/4th	East/5th	West/6th
Pyracantha crenulata	-	220	120	-	140	-
Berberis asiatica	-	100	-	-	80	20
Rubus ellipticus	-	1360	400	2160	100	240
Cotoneaster microphyllus	-	-	40	-	40	-
Indigofera tinctoria	260	1900	200	5500	180	1620
Asparagus racemosus	20	-	100	-	-	-
Rhus parviflora	-	700	-	440	-	-
Viburnum sp.	20	-	-	-	-	-
Flemingia strobilifera	460	-	-	420	-	1360
Desmodium elegans	-	540	-	-	-	-
Rosa macrophylla	-	-	160	-	-	-
Daphne cannabina	-	-	100	-	-	-
Total	760	4820	1120	8520	540	3240

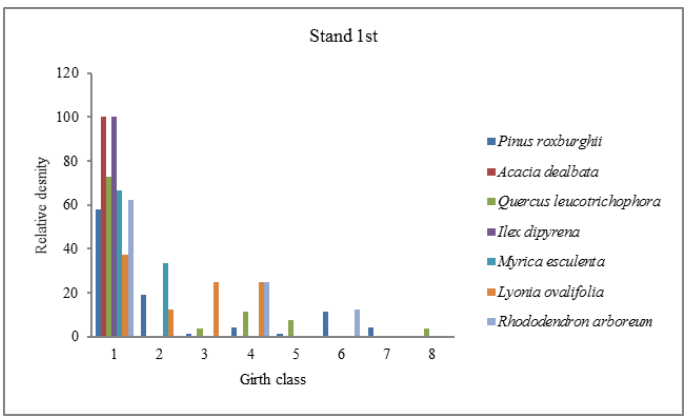
Table 5: Species richness, diversity, concentration of dominance, evenness of various vegetation layers.

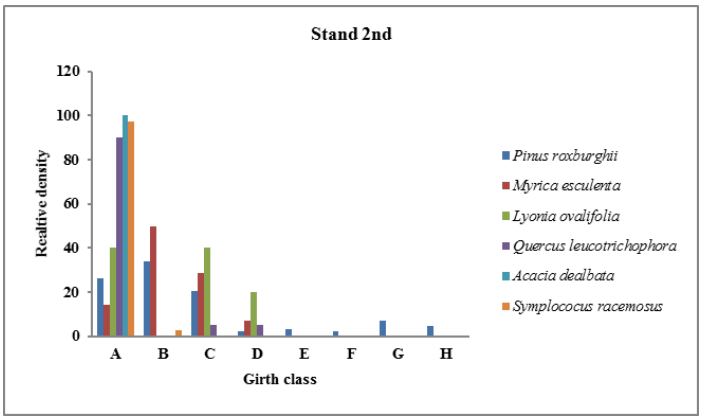
Aspect/stand	Parameters	Tree	Sapling	Seedling	Shrub
West/1st	SR	4.00	3.00	7.00	4.00
	SD	1.17	0.49	1.31	0.86
	CD	0.37	0.76	0.37	0.48
	EN	0.85	0.44	0.67	0.62
South/ 2nd	SR	4.00	3.00	5.00	5.00
	SD	0.71	0.59	1.30	1.14
	CD	0.66	0.66	0.30	0.36
	EN	0.51	0.54	0.81	0.71
North/3rd	SR	7.00	3.00	5.00	7.00
	SD	1.57	1.08	1.17	1.74
	CD	0.25	0.35	0.37	0.21
	EN	0.81	0.98	0.73	0.90
East/4th	SR	4.00	2.00	3.00	4.00
	SD	0.45	0.69	0.73	0.93
	CD	0.80	0.50	0.57	0.49
	EN	0.32	1.00	0.66	0.67
East/5th	SR	6.00	3.00	5.00	5.00
	SD	1.24	0.85	1.42	1.50
	CD	0.37	0.51	0.27	0.24
	EN	0.69	0.77	0.88	0.93
West/6th	SR	5.00	1.00	5.00	4.00
	SD	0.74	--------	1.27	0.94
	CD	0.67	1.00	0.35	0.43
	EN	0.46	----------	0.79	0.67

3.5. Population structure and Regeneration

A total of ten tree species were recorded in six stands of study area. In the study sites seedlings of *Pinus roxburghii* and *Myrica esculenta* were present in all stands, whereas seedlings of *Quercus leucotrichophora* and *Lyonia ovalifolia* were present in four and five sites respectively. The *Quercus leucotrichophora* had a complete absence of sapling indicates that seedling failed to attain sapling size, further complete absence of saplings and decrease of young tree classes of *Quercus leucotrichophora* indicates that seedlings from recent past had failed to attain sapling class, if the trend continues; the populations of species will decrease in near future. The Quercus *leucotrichophora* shows poor regeneration from decades and is one way to extinct were already reported by [28].

The *Pinus roxburghii* and Myrica *esculenta* have greater proportion of individuals in lower and young size classes indicate good generation potentials of these species. *Pinus roxburghii* shows excellent regeneration not only it's forest but in broadleaved forests as well have been already [24, 25]. Similarly [26] suggested that it has been invading and gaining dominance in disturbed broadleaved forests from last few decades. Though the *Lyonia ovalifolia* had greater proportion of seedlings and young girth classes, but like *Quercus leucotrichophora* its seedlings also fails to attain sapling size. Furthermore, in stand 3rd (northern aspect) *Quercus leucotrichophora* was represented in seedling class and older trees, whereas *Pinus roxburghii* was present in same aspect in seedling and young classes indicates good regeneration of the species in northern aspect. The occurrence and increasing regeneration of *Pinus roxburghii* in northern aspect might be due to global warming as this plant species requires warm and drier slopes for growth and regeneration has been reported by various studies [27, 24]. *Acacia dealbata* had a complete absence of saplings intermediate classes and higher size classes indicates throughout the sites, but had recorded their presence in few sites in the form of seedling stage, that indicates fair reproduction at present and will be invader in future as it tolerates all environmental conditions because of its invasive nature. The population structure of dominant and co-dominant species for the all stands are presented in Figure 1st, 2nd, 3rd, 4th, 5th and 6th





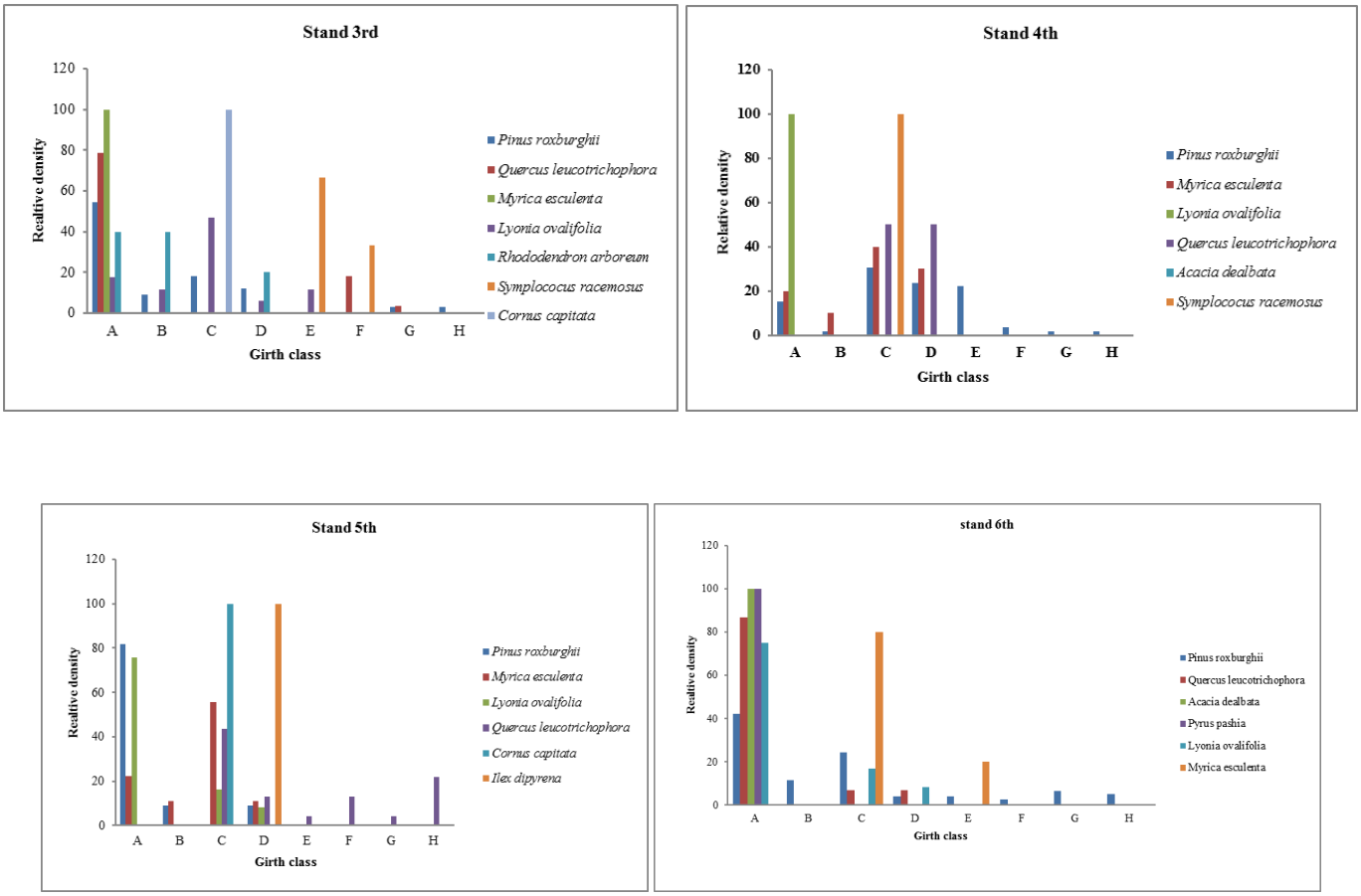


Fig 1: Population structure of dominant and co- dominant plant species in different stands.
Figures 1, 2, 3, 4, 5 and 6. Population structure of study sites, (A=seedling, B=sapling, C= 31.5cm- 60cm, D=61cm-90cm, E=91cm-120cm, F=121cm-150cm, G=151cm-180cm, H<181cm)

4. Conclusion

In the present study overall 10 tree species and 12 shrub species were recorded in six forest stands of study area. The *Pinus roxburghii* was the dominant species in four stands; whereas, *Lyonia ovalifolia* and *Quercus leucotrichophora* was dominant in one stand each. The species richness was value for tree layer was highest in northern facing aspect followed by eastern aspect. In case of shrub layer *Indigofera tinctoria* was dominant in four stands, whereas *Flimingia strobilifer and Rubus ellipticus* was most abundant species in western (1st stand) *and* northern aspect (3rd stand) respectively. Furthermore, the *Pinus roxburghii and Myrica esculenta were shown* excellent regeneration in all most all aspects, while as regeneration status of *Quercus leucotrichophora* was not found good as its seedling fails to attain sapling size, if the trend continues, the Binsar wildlife sanctuary which was established for conservation and protection of quercus spp. will become pine dominant in near future.

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