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Vegetation analysis and regeneration status of Sauni-Binsar sacred natural forest, Ranikhet (Kumaun Himalaya)

Sonam, * Balwant Kumar, Vijay Arya, Mahesh Kumar Arya
Department of Botany, Kumaun University, SSJ. Campus Almora, Uttarakhand, India

Abstract
Present study aims to assess community structure and regeneration status of Sauni-Binsar sacred natural forest of Kumaun Himalaya (1500 – 2200 m asl). A sum of 30 sampling quadrats of 10 m x 10 m size was placed randomly in the sacred grove. The grove was categorized into three zones- hill base, hill slope and hill top. Circumference at breast height of tree species was measured and their individual number was counted within the sampling quadrats. Various phytosociological attributes such as density, frequency, abundance, Importance Value Index, diversity indices and regeneration status of tree species were analyzed. Tree density ranged from 265 and 375 Ind. ha^{-1}. *Cedrus deodara* (Roxb.) G. Don was recorded as dominant tree species with the highest IVI of 84.6 at hill base while *Quercus leucotrichophora* A. Camus was dominant species at hill slope (93.4 IVI) and hill top (125.9 IVI). Shannon-Weaver diversity index (H) ranged from 1.05 to 1.34. In the hill base overgrazing by cattle, pine tree cutting for timber; resin extraction; frequent forest fire in summer was observed that led to no regeneration and forest degradation. Various anthropogenic activities such as overgrazing, resin extraction, fodder and fuel wood collection, forest fire should be controlled by imparting knowledge among local communities regarding sustainable utilization of forest resources with the help of forest department.

Keywords: importance value index, Kumaun Himalaya, regeneration, sauni-binsar

1. Introduction
Kumaun as a part of Uttarakhand state is well known for its floral and faunal diversity as well as its cultural value. This sacred land is also famous for its natural beauty, religious faith and feasibility for socio-cultural, archeological, environmental and ecological research. Sacred groves are the forest patches traditionally protected by local communities in the name of a local deity. Gokhale and Pala (2011) [3] described Sauni-Binsar Mahadev forest of Kumaun Himalaya under sacred natural sites of Uttarakhand. The inhabitants from surrounding villages like Sauni, Devalikhet, Daanth, Chamarkhan get various ecosystem services such as fuel wood, fodder, and pine needles for bedding material and water sources, etc. from this sacred grove. This sacred natural forest is investigated first time for vegetational as well as other botanical studies. This first study of the region also contributes to popularize the religious spot Binsar Mahadev for the research.

Assessment of forest community composition and structure is very helpful in understanding the status of tree population, regeneration, and diversity for conservation purposes (Mishra *et al.* 2013) [6]. Quantitative information on composition, distribution, and abundance of woody species is of key significance to understanding the form and structure of a forest community and also for planning and implementation of conservation strategy of the community (Singh *et al.* 2016) [15]. Regeneration is also a key process for the existence of species in a community under varied environmental conditions (Khumbongmayum *et al.* 2005) [4]. Reliable data on regeneration trends are required for successful management and conservation of natural forests (Eilu and Obua, 2005) [2]. Therefore, the present study was carried out to assess the vegetational analysis and regeneration status in Sauni-Binsar sacred grove of Kumaun Himalaya.

2. Material and Methods
2.1 Study area
The present study was carried out during the year 2015-16 in three altitudinal zones of Sauni-Binsar sacred natural forest. The grove is located along the Kunjgaar-Bhainskuri local river between 1500-2200 m asl. Geographically the study area lies between 29° 35' 60" N latitude and 79° 17' 28" E longitude in Almora district (Fig. 1). There is also a temple dedicated to lord *Shiva*, situated at a distance of 15 Km from Ranikhet town. The grove was categorized into three zones- hill base (1500-1800 m), hill slope (1800-2100 m) and hill top (above 2100 m). The studied forest zones are represented by *Pinus roxburghii*, *Cedrus deodara*, and *Quercus leucotrichophora*.

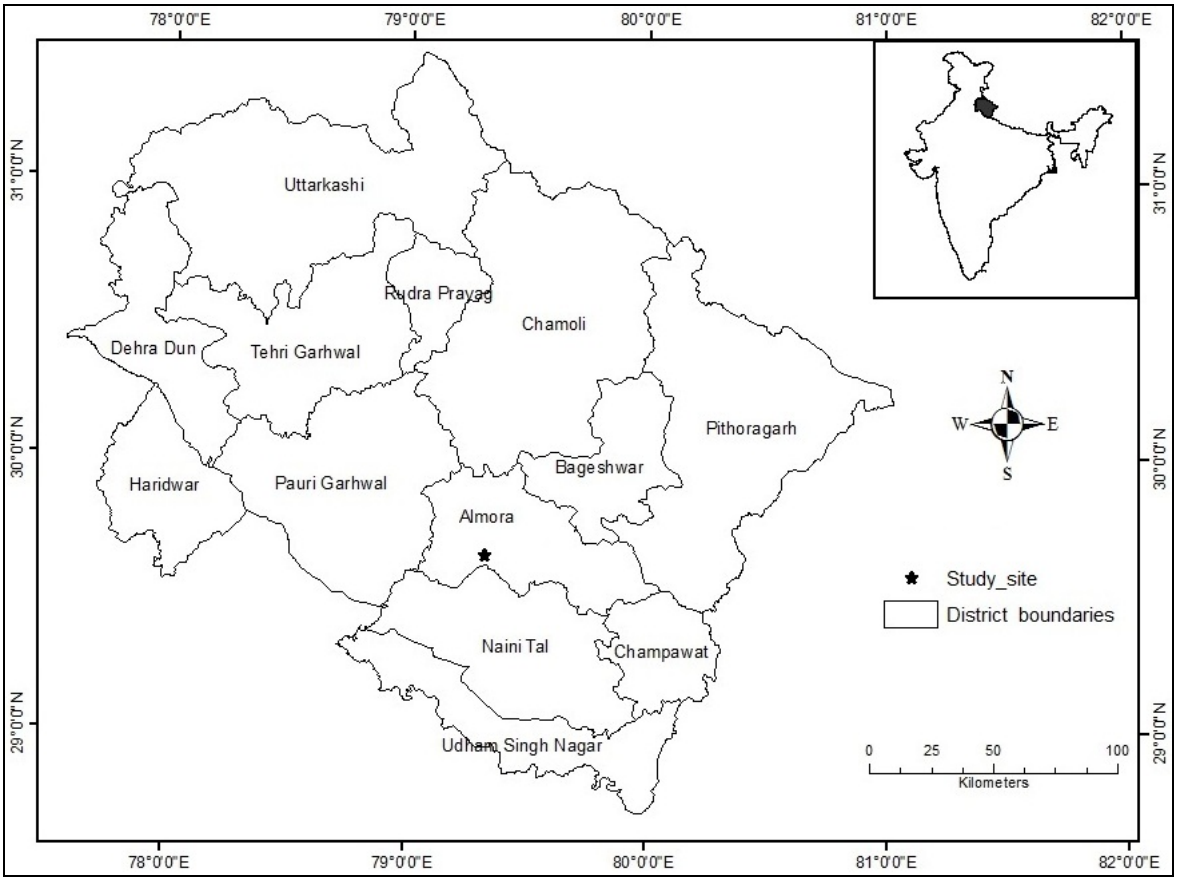

Fig 1: Location map of the study area

2.2 Sampling

A sum of 30 sampling quadrats of 10 m x 10 m (0.1 ha) size were randomly placed to study the composition of trees, saplings and seedlings along the altitudinal gradient. Within each sampling quadrat, individuals of tree species were counted and their circumference at breast height (cbh) was measured. On the basis of cbh, the individuals were categorized into tree (> 31.5cm cbh), sapling (10.5 to 31.5cm cbh) and seedling (<10.5cm cbh) following Knight (1975) [5]. Various phytosociological attributes such as density, frequency, abundance, Importance Value Index, were calculated following Curtis and McIntosh (1951) [1]. Basal area was calculated following Mishra (1968) [7].

2.3 Measurements of diversity indices

The simple count of species was considered as species richness. Evenness or equitability(J') was calculated using the formula given by Pielou (1969) [9]:

$$\text{Equitability } (J') = \frac{H'}{H'_{max}}$$

Where H' = observed diversity; H'_{max} = maximum possible diversity of a community with the same species richness

The Shannon-Weaver diversity index (Shannon and Weaver, 1963) [12] was calculated as:

$$H' = -\sum_{i=1}^{S} P_i \ln P_i$$

Where S = number of species; P_i = Proportion of individuals or abundance of the i^{th} species expressed as a proportion of total cover; and ln = log base n.

Simpson's index (Simpson, 1949) [13] was calculated as

$$D = \frac{\sum n\,(n-1)}{N\,(N-1)}$$

Where n = total number of individuals of a particular species; and N = total number of individuals of all species

Concentration of dominance (C_d) was calculated following Simpson's index (D).

$$C_d = \sum_{i=1}^{S} (n_i/N)^2$$

Where n_i = IVI of i^{th} species; N = Total IVI of all species in a community.

2.4 Regeneration status

Regeneration status of tree species was based on phytosociological data (Shankar, 2001) [11].

3. Results and discussion

3.1 Distribution analysis of tree species

All the three zones showed the difference in terms of various phytosociological attributes viz. density, frequency, abundance, IVI etc. The overall tree density varied between 265 Ind. ha^{-1} (hill top) to 375 Ind. ha^{-1} (hill base). *Pinus roxburghii* was found as dominant tree species with the highest IVI of 127 at hill base while *Quercus leucotrichophora* was dominant at hill slope and hill top with the highest IVI of 93.4 and 125.9 respectively. Basal area (m^2 ha^{-1}) ranged from 1.7 (*Myrica esculenta*) to 31.1 (*Cedrus deodara*); 0.9 (*Aesculus indica*) to 11.5 (*Rhododendron arboreum*); and 1.1 (*Alnus nepalensis*) to 7.1 (R. arboreum) at hill base; hill slope and hill top, respectively. In the sapling layer, Q. leucotrichophora was found dominant with the highest IVI of 161 and 116 at hill slope and hill top respectively (Table 1). However, individuals in sapling stage were not found at hill base.

Table 1: Distribution analysis of tree species in tree and sapling layer of the study area

	Tree layer					Sapling layer				
	BA	**RD**	**RF**	**RDo**	**IVI**	**BA**	**RD**	**RF**	**RDo**	**IVI**
Hill base										
Cedrus deodara	31.1	25.3	23.1	36.2	84.6	–	–	–	–	–
Cupressus torulosa	13.3	9.3	11.5	15.5	36.3	–	–	–	–	–
Myrica esculenta	1.7	4	3.9	2	9.9	–	–	–	–	–
Pinus roxburghii	22.5	50.7	50	26.3	127	–	–	–	–	–
Quercus leucotrichophora	7.9	2.7	3.8	9.2	15.7	–	–	–	–	–
Rhododendron arboretum	9.3	8	7.7	10.8	26.5	–	–	–	–	–
Hill slope										
Aesculus indica	0.9	35.3	30.3	29.4	95	0.26	6.9	7.1	20.9	35
M. esculenta	5.2	1.5	3.1	2.6	7.2	0.39	10	29	31.3	70.2
P. roxburghii	10.6	20.6	24.2	14.4	59.2	–	–	–	–	–
Q. leucotrichophora	7.9	38.2	33.3	21.9	93.4	0.28	81	57	22.6	161
R. arboretum	11.5	4.4	9.1	31.7	45.2	0.31	1.7	7.1	25.1	34
Hill top										
Alnus nepalensis	1.1	1.9	3.6	4.2	9.6	0.4	2	8.3	14	24.4
Betula alnoides	–	–	–	–	–	0.2	2	4.2	7.7	13.9
Lyonia ovalifolia	–	–	–	–	–	0.3	2	4.2	10	16.3
M. esculenta	6.6	20.8	28.5	24.1	73.4	0.3	4	13	9.9	26.4
P. roxburghii	4.6	1.9	3.6	16.7	22.2	–	–	–	–	–
Pyrus pashia	–	–	–	–	–	0.5	2	4.2	18	24.1
Q. leucotrichophora	3.7	62.3	50	13.6	125.9	0.4	66	38	12	116
R. arboretum	7.1	7.5	3.6	25.9	37.1	0.6	2	8.3	19	29.1
Symplocos chinensis	4.2	5.6	10.7	15.5	31.8	0.3	20	21	9.3	50.1

BA= Basal Area, RD= Relative Density, RF= Relative Frequency, RDo.= Relative Dominance, IVI= Importance Value Index

3.2 Diversity indices and other relative measurements

Species richness (α) was found to be ranging from 5-6 and evenness ranged from 0.59-0.75. Shannon-Weaver diversity index varied from 1.05-1.34 which is comparable with earlier studies reported by Raturi (2012; 0.78-3.45) [10], Pant and Sammant (2012; 0.74-2.66) [8], Singh *et al.* (2014; 0.66-2.69) [14] and Singh *et al*. (2016; 1.49-1.86) [15] from various parts of the Kumaun Himalaya. Concentration of dominance (Cd) ranged from 0.26-0.28 (Table 2). Maximum five species were found in contagious distribution at hill base followed by four species at hill top. A minimum of one species was found in random distribution at hill base (Fig. 2).

Table 2: Diversity measures for tree layer in the study area

Site	Richness (α)	Evenness (J)	Shannon (H)	Simpson (D)	Dominance (Cd)
Hill base	6	0.75	1.34	0.33	0.28
Hill slope	5	0.78	1.26	0.31	0.26
Hill top	6	0.59	1.05	0.43	0.27

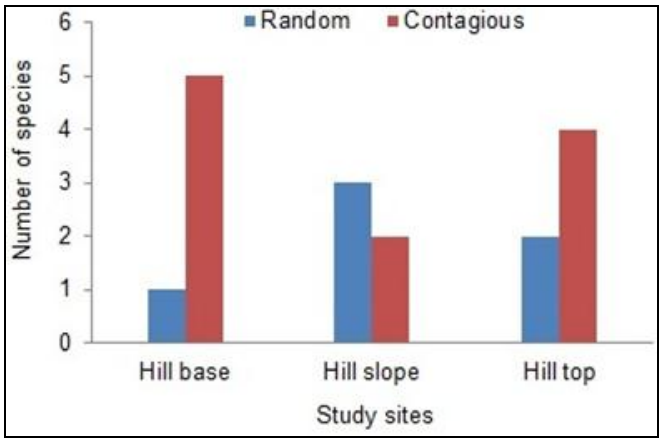

Fig 2: Distribution pattern of tree species in the study sites

3.3 Regeneration status

Individuals in sapling and seedling stages were not found at hill base because of anthropogenic pressure in terms of fodder

collection, grazing, lopping, quarry of stone, resin extraction, forest fire, etc. At hill slope, three species had good regeneration while three species were found having fair regeneration. At hill top, maximum four species were recorded with fair regeneration followed by two species having good regeneration. However, two species were found as new in the hill top (Table 3). The new regeneration at hill top (i.e. towards upper altitude) shows the appropriate condition for growing and survival of the species towards increasing altitude. The hill base and hill top were moderately and less disturbed as there were observed less and no sign of lopping, grazing, human encroachment, etc., respectively.

Table 3: State of regeneration in the study area

Species	Density (Individuals ha^{-1})											
	Hill base				Hill slope				Hill top			
	TR	SP	SD	RS	TR	SP	SD	RS	TR	SP	SD	RS
Aesculus indica	–	–	–	–	5	20	30	Good	–	–	05	Fair
Alnus nepalensis	–	–	–	–	–	05	160	Good	05	10	305	Good
Betula alnoides	–	–	–	–	–	–	–	–	–	10	–	New
Cedrus deodara	95	–	–	No	–	–	–	–	–	–	–	
Cupressus torulosa	35	–	–	No	–	–	–	–	–	–	–	
Lyonia ovalifolia	–	–	–	–	–	–	–	–	–	10	–	New
Myrica esculenta	15	–	–	No	70	30	195	Fair	55	20	15	Fair
Pinus roxburghii	190	–	–	No	120	–	165	Fair	05	–	–	
Pyrus pashia	–	–	–	–	–	–	–	–	–	10	–	New
Quercus leucotrichophora	10	–	–	No	130	235	1095	Good	165	330	195	Good
Rhododendron arboreum	30	–	–	No	15	05	05	Fair	20	10	05	Fair
Symplocos chinensis	–	–	–	–	–	–	–	–	15	100	30	Fair

TR= Trees, SP=Sapling, SD=Seedling, RS=Regeneration Status

4. Conclusion

Sauni-Binsar sacred grove is an excellent source of water for more than 200 surrounding village communities. Besides it is a place of faith and serenity for thousands of devotees and tourists who visit here throughout the year. Habitats have destroyed due to heavy anthropogenic activity as in the hill base overgrazing by cattle, pine tree cutting for timber; resin extraction; frequent forest fire in summer was observed that led to no regeneration and forest degradation. The anthropogenic activities such as overgrazing, resin extraction, fodder and fuel wood collection, forest fire should be controlled by imparting knowledge among local communities regarding sustainable utilization of forest resources with the help of forest department. Regeneration status of the plant species could also be improved by restriction on grazing, controlling of forest fire, resin extraction, and prohibition of stone quarries.

5. Acknowledgement

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