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NATURAL REGENERATION STATUS OF FOREST COMMUNITY AT DANDACHALI FOREST, TEHRI FOREST DIVISION IN NORTH WEST HIMALAYA UTTRAKHAND, INDIA

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Abstract

Studies on forest vegetation pertaining to diversity, natural regeneration status of plant communities. The present investigation was conducted in Dandachali forest of Tehri Forest Division, North-Western part of Himalaya. Surveys and sampling of the vegetation were done using standard ecological assessment methods with an aim to study plant species natural regeneration pattern at community level. nineteen woody species (19) in 6 forest communities *viz*., *Pinus roxburghii-Quercus leucotrichophora* mixed, *Pinus roxburghii, Pinus roxburghii- Rhododendron arboreum* mixed, *Cedrus deodara- Pinus wallichiana* mixed, *Cedrus deodara- Rhododendron arboreum* mixed and *Rhododendron arboreum- Quercus leucotrichophora* mixed, have been recorded in 16 sites between 1482- 2200 m asl. Among the communities, total tree density ranged from 263.34-1493.33 Ind ha^{-1}, TBA 260.2- 310.7 m^2 ha^{-1}. All the communities showed optimum regeneration of dominant species. Total seedlings density ranged from 280-2470.0 Ind ha^{-1} and saplings density 140-446.7 Ind ha^{-1}. *R. arboreum – C. deodara* showed maximum regeneration in terms of higher seedling and sapling density in this community.

Key words : Regeneration, recruitment, seedling, sapling, status.

Introduction

The Phytosociological characters express the quantitative information on analytical characters, composition and pattern of distribution of the species (Saxena, 1982; Ralhan *et al*., 1982; Sharma and Kumar, 1992). It is useful to collect such data to describe the population dynamics of each species studied and how they relate to the other species in the same community. Regeneration dynamics is one of the thrust areas for intensive research. The plant diversity and regeneration status of particular forests is baseline information for the management and conservation of biodiversity. Regeneration studies are important in view predicting structure and composition of the species. Regenerating forests can be characterized by presence of seedlings, saplings and trees of different age groups, from young to old (Chauhan, 2001; Chauhan *et al*., 2001). Characteristic of size and age distribution provides important information about regeneration probability of a species. Successful regeneration of tree species might be considered to a function of three major components: (i) ability to initiate new seedlings, (ii) ability of seedlings and saplings to survive and (iii) ability of seedlings and saplings to grow. Measurement of these parameters provides an insight into the regeneration of species in a forest community. Natural regeneration is a central component of tropical forest ecosystem dynamics and is essential for preservation and maintenance of biodiversity (Getachew *et al*., 2010, Rahman *et al*., 2011). Several authors have predicted regeneration status of tree species based on the age and diameter structure of their population (Khan *et al*., 1987; Bhuyan *et al*., 2003). Successful management therefore depends on good natural regeneration of valuable species. The final goal of these research programs should be to evolve methods to harmonise the rates of exploitation and regeneration.

Study area

The study was carried out in Dandachali forest of Tehri Forest Division, Tehri Garhwal (district), Uttrakhand (State) part of North West Himalaya. Tehri Forest

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Division covers 143268.90 ha total forest areas, situated between latitude N-30^0-03'05" and 30^0-52'077" and longitude E-78^0-56'35" and 79^0-02'45". Tehri Range of the division lies between 30^0-22'077" North latitude and 30^0-25'599" East longitude which covers 16144.70 ha area. Lohital beat of this range covers 1117.30 ha area, comprises of 14 compartments. Quadrates were laid only in Four Compartments Lohital-3 B (97.10 hectares areas), Lohital-4 (46.50 hectares areas), Lohital-11 (55.40 hac areas), and Lohital-12 A (56.70 hectares areas), a total of 255.7 ha in Lohital Beat. Present observations were conducted from Veetgaon (Lowest point at 1482 mtr) to Lohital (peak 2200 mtr). The climate of Ranichauri is humid temperate. The mean monthly minimum and maximum temperature varies between 2.2^{0}C-16.9^{0}C and 12.0^{0}C - 24.6^{0}C, respectively. The average rainfall of 1278.4 mm is experienced, annually. Monsoon arrives in second fortnight of June and ends in September last. However, drizzling continues up to first week of October. Major portion of annual rainfall (above 61%) occurs during Monsoon. Winter rains and snowfall occur during December-February and hailstorms are frequent from April-May. Winter is very severe, light to heavy snowfall is a regular feature of this area and summer is mild (Department of Agro-meteorology, College of Forestry, Ranichauri).

Methods

Selection of sites and habitats for vegetation sampling

Sites were selected on each and every accessible aspect along an altitudinal gradient. For each species, information on altitudinal range, habitat (s), life forms, etc. was gathered. The habitats were identified based on the physical characters and dominance of the vegetation. Sites having closed canopy with high percentage of humus and moisture were considered as moist habitats whereas low percentage of the same as dry habitats. The sites facing high anthropogenic pressures had been considered as degraded habitat.

Assessment of the forest vegetation

In each site, a plot of 50x50m (0.25 ha) was laid. Trees, saplings and seedlings were sampled by randomly placed 10, 10x10m quadrats and seedling by 20, 5x5m quadrats. For the collection of data from these quadrates standard ecological methods (Curtis and McIntosh, 1950; Grieg-Smith, 1957; Kersaw, 1973; Muller-Dombois and Ellenberge, 1974; Dhar *et al*., 1997 and Samant and Joshi, 2004) were followed. The circumference at breast height (cbh at 1.37m from ground) for each tree individual was recorded. Based on cbh, the tree individuals were considered as tree (cbh ≥ 31.5 cm), sapling (cbh 10.5-31.4 cm) and seedling (cbh < 10.5 cm) (Saxena and Singh, 1982).

Sampling and Identification of the Species

The field surveys and samplings were carried out in the Dandachali Forest falls under Lohital beat of Tehri range, Tehri Forest Division, District Tehri Garhwal, Uttrakhand since August 2014 to March, 2015. The samples of the plant species were collected, bought to the laboratory and identified with the help of local flora (Gaur, 1999) and subject experts.

Data analysis and formulae used

Data analysis has been done following standard ecological methods (Curtis & McIntosh, 1950; Grieg-Smith, 1957; Kersaw, 1973; Muller-Dombois & Ellenberge, 1974; Dhar *et al*., 1997 and Samant and Joshi 2004).

- **Density (D)**

It represents the numerical strength of species in a community calculated as :

$$\text{Density (D)} = \frac{\text{Total number of individuals}}{\text{Total number of quadrates studied}}$$

- **Frequency (%F)**

It is the indicator of number of samples in which the given species occurs, thus expresses the distribution of various species in the community.

$$\text{Frequency (\%)} = \frac{\text{Number of sampling units in which the species occurs}}{\text{Number of sampling units studied}} \times 100$$

- **Abundance**

$$\text{Abundance} = \frac{\text{Total number of species}}{\text{Number of quardrat in which species occurred}}$$

- **Relative density, relative frequency and relative abundance**

These parameters were obtained from the per cent frequency, density and abundance according to procedure given by Phillips (1959).

$$\text{Relative density (RD)} = \frac{\text{No. of individuals of the species}}{\text{No. of individuals of all species}} \times 100$$

$$\text{Relative frequency (RF)} = \frac{\text{No. of occurrence of the species}}{\text{No. of occurrence of all species}} \times 100$$

$$\text{Relative abundance (RA)} = \frac{\text{Abundance of individual species}}{\text{Total abundance}} \times 100$$

- **Importance value index (IVI)**

The IVI, which is an integrated measure of the relative frequency, relative density and relative basal area, was calculated for all species of trees and shrubs separately for different elevation classes in study areas of all the three forest divisions.

IVI = Relative Density (RD) + Relative Frequency (RF) + Relative abundance (RA)

The abundance data of different sites were pooled to get community averages in terms of density and IVI. Communities were identified based on the IVI.

Species diversity

Species diversity (H') was determined by Shanon Wiener's information statistic (Shanon and Weiner, 1963). Diversity is usually considered as a function of relative distribution of individuals among the species. Shannon-Weiner information index (Shannon and Wiener, 1963) was used for estimating the diversity.

$$H = -\Sigma\ (Ni/N) \log 2\ (Ni/N)$$

Where, Ni is the total number of individuals of a species and N is the total number of individuals of all species in that stand.

Statistically one-way ANOVA and correlation applied on data by SPSS software.

Results

Community diversity

The community types, their altitudinal distribution, representation in sites, habitats, coordinates and major associates are presented in table 2. A total of 6 forest communities were delineated in the study area. *Pinus roxburghii* community represented in maximum sites (#6), followed by *Cedrus deodara - Rhododendron arboreum* mixed and *Pinus roxburghii -Rhododendron arboreum* mixed (#3, each), *Cedrus deodara- Pinus wallichiana* mixed (#2) and *Pinus roxburghii- Quercus leucotrichophora* mixed and *Rhododendron arboreum - Quercus leucotrichophora-* mixed (#1, each). These communities fall between $30^0$18.808'N and 30^0 17.995'N latitudes; 078^0 25.154'E and 078^0 25.009'E longitudes and cover an altitudinal range of 1482 to 2200 m amsl and 30-70^0 slopes. These communities were represented in the North, North West and North East. Similar to present study Joshi and Samant (2004) have reported the various numbers of communities of the different angiosperms and gymnosperms species in different habitats in the Nanda Devi Biosphere Reserve, Western Himalaya. However, Samant and Joshi (2005) studied plant diversity and conservation status of high land Nanda Devi National parks.

Regeneration Status at community structure

Community wise total density, total basal area (TBA) and IVI of tree species have been presented in table 2, respectively.

1. *Pinus roxburghii- Quercus leucotrichophora* mixed

The physical characteristics of the community have been presented in table 1. This community has been represented only in 1 site.

Regeneration status at community structure

A total of species (trees: 8) were recorded in the community. Total tree density and total basal area were 380.00 Ind ha^{-1} and 296.42 m^2 ha^{-1}, respectively (Table 2). The total density and regeneration pattern of tree species in *Pinus roxburghii-Quercus leucotrichophora* mixed community are shown in table 4. Total seedlings and total saplings density were 280 Ind ha^{-1} and 140 Ind ha^{-1}, table 2 respectively. Among the seedlings, the highest density was shown by *P. roxburghii* (820 Ind ha^{-1}), followed by *Myrica esculenta* (270 Ind ha^{-1}). *P. roxburghii* (90 Ind ha^{-1}) also showed the highest saplings density. The remaining species showed good regeneration. In comparison of the present study, Joshi *et al*. (2013) recorded higher number of seedling and sapling density of *P. roxburghii* in an Oak and Pine mixed forests of Kumaun central Himalaya, where the maximum total seedling and total sapling density of *P. roxburghii* was found 530 Ind ha^{-1} and 610 Ind ha^{-1}, respectively, in north western aspect.

2. *Pinus roxburghii*

The physical characteristics of the community have been presented in table 1. This community has been represented in 6 sites.

Regeneration status at community structure

A total of species including trees (14 spp.) were recorded in the community. Total tree density, TBA and IVI were 263.33 Ind ha^{-1} and 310.74m^2 ha^{-1}, respectively (table 2). The total density and regeneration pattern of tree species in *P. roxburghii* community are shown in table 4. Total seedlings and total saplings density were 711.7 Ind ha^{-1} and 168.3 Ind ha^{-1}-, respectively (table 2). Among the seedlings, the highest density was shown by *P. roxburghii* (318.33 Ind ha^{-1}), followed by *Q. leucotrichophora* (171.67 Ind ha^{-1}). *P. roxburghii*

(70.00 Ind ha^{-1}) also showed the highest saplings density, followed by *Q. leucotrichophora* (48.33 Ind ha^{-1}). The remaining species showed relatively poor regeneration. Mehta (2015) observed that the density of *P. roxburghii* seedlings varied considerably with altitude ranging between 530 individuals ha^{-1} at 1900m and 10000 individuals ha^{-1} at 1280m asl. Lower number of seedling recruitment in the study area may be due to impact of forest fire occurred during the last year.

3. *Pinus roxburghii- Rhododendron arboreum* mixed

The physical characteristics of the community have been presented in table 1. This community has been represented only in 3 sites.

Regeneration status at community structure

A total of species (trees: 18) were recorded in the community. Total tree density and TBA were 980.1 Ind ha^{-1} and 264.7 m^2 ha^{-1}, respectively (table 2). The total density and regeneration pattern of tree species in this community are shown in table 4. Total seedlings and total saplings density were 1533.3 Ind ha^{-1} and 393.3 Ind ha^{-1}, respectively. Maximum seedling density was shown by *Trema orientalis* (300.0 Ind ha^{-1}), followed by *Q. leucotrichophora* (283.3 Ind ha^{-1}), however, *R. arboreum* (120.0 Ind ha^{-1}) showed the highest saplings density. The remaining species showed medium good regeneration similar study was conducted by Dhaulkandi *et al*. (2008) at Gangotri site achieved good regeneration of five species except to one species.

4. *Cedrus deodara- Pinus wallichiana* mixed

The physical characteristics of the community have been presented in table 1. This community has been represented only in 2 sites.

Table 1 : Community types, their distribution, habitats and major associated species in study sites.

Community types	SR	AR (m)	Habitat	Slope(^{0})	Aspect	Latitude	Longitude	Major associated spp.
Pinus roxburghii –Quercusleucotrichophora mixed	1	1482-1495	D, Deg	45	NE	30^0 18.808'N 30^0 18.900'N	078^0 25.154'E 078^0 25.204'E	*Pinus roxburghii, Quercus leucotrichophora, Berberis aristata, Rhus parviflora, Rhus cotinus*
Pinus roxburghii	6	1525-1791	D, Deg	35-50	NW, NE	30^0 18.080'N 30^0 18.470'N	078^0 25.137'E 078^0 25.073'E	*Lyonia ovalifolia, Myrica esculenta, Rhododendron arboreum, Berberis aristata, Myrsine Africana, Asparagus adscendens*
Pinus roxburghii- Rhododendron arboreum mixed	3	1863-2015	D, SM	30-50	N, NE	30^0 18.204'N 30^0 18.242'N	078^0 25.059'E 078^0 25.995'E	*Lyonia ovalifolia, Cornus capitata, Cedrus deodara, Myrsine africana, Rubus ellipticus, Indigofra atropurpurea, Pogostemon plectranthoides*
Cedrus deodara- Pinus wallichiana mixed	2	1873-2015	M, SM	50-70	N, NW	30^0 18.204'N 30^0 18.189'N	078^0 25.059'E 078^0 25.936'E	*Rhododendron arboreum, Pinus roxburghii, Populus ciliata, Rubus ellipticus, Pogostemon plectranthoides, Rubus paniculatus*
Cedrus deodara- Rhododendron arboreum mixed	3	1928-2116	SM	60-50	NW, NW	30^0 18.101'N 30^0 17.893'N	078^0 25.145'E 078^0 25.004'E	*Lyonia ovalifolia, Pinus roxburghii, Populus ciliata, Myrsine africana, Rubus ellipticus*
Rhododendron arboreum-Quercus leucotrichophora mixed	1	2116-2200	SM	55	NE	30^0 17.893'N 30^0 17.995'N	078^0 25.004'E 078^0 25.009'E	*Cedrus deodara, Lyonia ovalifolia, Pinus wallichiana, Myrsine africana, Berberis aristata*

Abbreviations used: SR=Site representation; AR= Altitudinal range; SM=Shady Moist; D=Dry and Dgr=Degraded; N=North; NW=North West and NE=North East.

Table 2 : Community wise total density, TBA, IVI, total sapling and seedling density.

Total density, TBA, IVI, sapling and seedling density	Community types					
	1	2	3	4	5	6
Total density (Ind ha$^{-1)}$	380.00	263.34	980.10	795.00	1493.30	1060.00
Total Basal area	296.42	310.74	264.71	281.92	260.23	273.80
IVI	300	300	300	300	300	300
Total sapling density (Ind ha$^{-1)}$	140	168.33	393.30	175.00	446.70	240.00
Total seedling density (Ind ha$^{-1)}$	280.00	711.67	1533.30	315.00	2470.00	390.00

Abbreviations used: 1= *Pinus roxburghii- Quercus leucotrichophora* mixed; 2= *Pinus roxburghii*; 3= *Pinus roxburghii- Rhododendron arboreum* mixed; 4= *Cedrus deodara- Pinus wallichiana* mixed; 5= *Cedrus deodara- Rhododendron arboreum* mixed; 6= *Rhododendron arboreum- Quercus leucotrichophora* mixed

Table 3 : Community wise sapling and seedling diversity (H^1).

Community type	Species diversity (H^1)	
	Saplings	Seedlings
Pinus roxburghii - Quercus leucotrichophora mixed	0.65	0.15
Pinus roxburghii	1.47	1.57
Pinus roxburghii- Rhododendron arboreum mixed	1.74	2.24
Cedrus deodara - Pinus wallichiana mixed	1.92	1.53
Cedrus deodara- Rhododendron arboreum mixed	2.10	2.14
Rhododendron arboreum- Quercus leucotrichophora mixed	1.47	0.78
Maximum	**2.10**	**2.24**
Minimum		

Regeneration status at community structure

A total of species (trees: 12) were recorded in this community. Total tree density and TBA were 795.0 Ind ha^{-1} and 281.9 m^2 ha^{-1}, respectively (table 2). The total density and regeneration pattern of tree species in this community are shown in table 4. Total seedlings and total saplings density were 315.0 Ind ha^{-1} and 175.0 Ind ha^{-1}, respectively. Among the seedlings, the highest density was shown by *Q. leucotrichophora* (105 Ind ha^{-1}), followed by *C. deodara* (90.0 Ind ha^{-1}). However, the highest saplings density was recorded for *C. deodara* and *R. arboreum* (40 Ind ha^{-1}, each). The remaining species showed very poor regeneration. In terms of higher sapling density of *C. deodara*, results are comparable with Singh and Samant (2010) in North Western Himalaya.

5. *Cedrus deodara - Rhododendron arboreum* mixed

The physical characteristics of the community have been presented in table 1. This community has been represented only in 3 sites.

Regeneration status at community structure

A total of 18 species of trees were recorded in the community. Total tree density and TBA were 1493.33 Ind ha^{-1} and 260.23 m^2 ha^{-1}, respectively (table 2). The total density and regeneration pattern of tree species in this community are shown in table 4. Total seedlings and total saplings density were 2470 Ind ha^{-1} and 446.7 Ind ha^{-1}, respectively (Table 2). Among the seedlings, the highest density was shown by *Q. leucotrichophora* (646.67 Ind ha^{-1}), followed by *R. arboreum* (486.67 Ind ha^{-1}). However, highest saplings density was recorded for *Q. leucotrichophora* (103.33 Ind ha^{-1}). The remaining species showed relatively poor regeneration. Mehta *et al.* (2015) observed tremendous occurrence (9000 individuals ha^{-1}) of *C. deodara* seedlings stratum between 1900m and 2500m but lower at higher elevations, whereas, *R. arboreum*(3000 individuals ha^{-1}) performed poorly in case of newly recruited individuals.

6. *Rhododendron arboreum - Quercus leucotrichophora* mixed

The physical characteristics of the community have been presented in table 1. This community has been represented in only 1 site.

Regeneration status at community structure

A total of 8 species trees were recorded in this community. Total tree density and total basal area were 1060.0 Ind ha^{-1} and 273.8 m^2 ha^{-1}, respectively (table 2).

Table 4 : Community wise seedling and sapling density.

Species	Community											
	1		2		3		4		5		6	
	A	B	A	B	A	B	A	B	A	B	A	B
Pinus roxburghii	90.00	820	70.00	318.33	86.67	63.33			30.00	80.00		
Swida macrophylla				1.67								
Lyonia ovalifolia			18.33	53.33	30	163.33			20.00	330.0	50.00	
Myrica esculenta		270	20.00	45.00	30	200.0	25.00	10.00	60.00	290.0		
Quercus leucotrichophora	50.00	140.00	48.33	171.67	66.67	283.33			103.33	647.67	60.00	260.0
Quercus serrata		20.00				10.00						
Rhododendron arboreum				8.33	120	150.0		20.00	80.00	486.67	80.00	110.0
Cedrus deodara							40.00	50.00			10.00	20.00
Cornus capitata			1.67	3.33	30	60.00	20.00	50.00		40.00		
Pinus wallichiana			6.67	38.33			40.00	90.00			40.00	
Pyrus pashia		60.00				10.00	15.00	105.0	30.00	20.00		
Ilex dipyrena							10.00					
Fraxinus micrantha				5.50						60.00		
Symplocus paniculata				3.33		30.00			10.00			
Symplocus crataegoides			3.33							80.00		
Celtis australis		10.00										
Celtis eriocarpa				3.33		20.00						
Ficus pamata		30.00		3.33								
Ficus roxburghii	30.00	20.00										
Ficus cunia				6.67								
Betula alonides						170.0						
Trema orientalis						300.0				160.0		
Prunus cerasoides								10.00	13.33			

Abbrebation: 1 = *Pinus roxburghii- Quercus leucotrichophora* mixed; 2 = *Pinus roxburghii*; 3 = *Pinus roxburghii- Rhododendron arboreum* mixed; 4 = *Cedrus deodara- Pinus wallichiana* mixed; 5 = *Cedrus deodara- Rhododendron arboreum* mixed; 6 = *Rhododendron arboreum- Quercusleucotrichophora* mixed, A = Sapling and B = Seedling.

The total density and regeneration pattern of tree species in this community are shown in table 4. Total seedlings and total saplings density were 390.00 Ind ha^{-1} and 240.00 Ind ha^{-1}, respectively. The highest seedling density was shown by *Q. leucotrichophora* (260 Ind ha^{-1}), followed by *R. arboreum* (110 Ind ha^{-1}), which also showed the highest saplings density (80 Ind ha^{-1}). The remaining species showed very low regeneration. The seedling and sapling densities for these species are in range of Pant and Samant (2012) in Khokhan wildlife sanctuary, north Himalaya.

Species diversity (H^1)

Community wise diversity of saplings and seedlings are shown in table 3. Diversity saplings had been observed from 0.65-2.10, and seedlings from 0.15-2.24. The diversity of sapling was maximum in *C. deodara- R. arboreum* mixed community (2.10), followed by *P. roxburghii- R. arboreum-* mixed (1.74) and *P. roxburghii* and *R. arboreum- Q. leucotrichophora* mixed (1.47) communities. The highest diversity of seedling was recorded in *P. roxburghii- R. arboreum* mixed community (2.29), followed by C. *deodara- R. arboreum* (2.14) and *P. roxburghii* mixed (1.57) communities. Results are comparable with Pant and Samant (2007) where species diversity in Mornaula Reserve Forest in case seedlings from 0.86-2.65, saplings from 0.44-2.78.

Numerous studies are available on species diversity in temperate Himalaya (Saxena and Singh, 1982; Tripathi *et al*., 1987, Rikhari *et al*., 1989; Tripathi *et al*., 1991; Giri *et al*., 2008). The increased disturbance intensity may favor higher natality and survival of seedling. Particularly, anthropogenic disturbance first decrease the tree diversity with increasing intensity of disturbance decreased trees and sapling diversity and increased seedling diversity. The diversity of disturbance decreased the overall richness and diversity of the ecosystem.

Conclusion

On the whole, the study provides information natural regeneration pattern in the community level there is an immediate need to develop an adequate strategy and action plan for augmentation of natural regeneration and to employ artificial regeneration of the plant species for long term conservation management of habitats, species, and communities, so that sustainable utilization of the resources could be ensured. Results of the present study can be used for development of conservation management and micro planning of this areas and thus, socio-economic development of the inhabitants, in particular and biodiversity of the Himalaya, in general.

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