VEGETATION STRUCTURE AND REGENERATION OF VAN PANCHAYAT FORESTS IN KUMAUN HIMALAYA, UTTARAKHAND

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Abstract

Study deals with the vegetation structure and regeneration in Van Panchayat forests in Nainital of Kumaun Himalaya. The analysis of forest was done in three sites i.e. hill top, hill slope and hill base forest site. Tree density in Jungalia and Soangaon Van Panchayats ranged from 80-2070 and 50-5270 individual ha^{-1} respectively. Importance value index was 8.11-137.29 in Jungalia gaon Van Panchayat while 15.65-143.04 in Soangaon Van Panchayat. Species diversity ranged from 0.09-1.97 in Jungalia gaon and 0.17-0.44 in Soangaon Van Panchayat. The occurrence of higher number of seedlings in both the Van Panchayat showed good regeneration potential of tree species.

Key Words: Van Panchayat forest, tree density, species diversity, regeneration, importance value index, Kumaun Himalaya

Introduction

The Kumaun Himalaya is one of the Himalayan ecological zones with very fragile topography because of varied aspects, slopes, soils and vegetation. The region consist different land use systems such as forest, agriculture, pasture and associate wastelands. These land use systems directly and or indirectly supports to human beings and environment therein. Among these, forests play a vital role in the economic and ecological development of the region but vary from one part to another in the region based on the ownership and management control. This region of Uttarakhand is covered with above 65% of geographical area and maximum parts (>80%) of the forests are being managed by the foresters (forest department) but only a small segments (<20%) of forests are under the ownership of villagers and managed by them. Being a diverse nature of climate and soils, the forests represent several species such as flora and fauna in the region.

Among the natural resources, forest is one resource, playing a significance role in socio-economic development and climate change mitigation. But due to recent anthropogenic pressure (i.e. fuel wood and fodder requirement of villagers) on these resources, they are depleting very fast from their native site, therefore many acts and policies are being implemented to conserve forests in a sustainable manner in the regions of Uttarakhand.

Van Panchayats are playing important roles for the livelihood needs of local residents and in the conservation of biodiversity and climate. The recent dramatic change are due to concentrations of population increment in villages, the size of forests and their cover has been reduced; consequently such pressure exerted in these forests had reduced many valuable plant species and also the top fertile soils which led to poor productivity of the site.

Van Panchayats are known to be one of the earliest and unique examples of decentralized forest governance in the world (Lodhiyal *et al*., 2002) and one of the oldest participatory methods of forest management but, in most of the cases the Van Panchayat forests could not have the sufficient land area with regard to existing village populations. Nowadays there are more than 12,000 VPs in Uttarakhand manages nearly 20% forests. The villagers meet livelihood needs from their Van Panchayat forests where the rights and concessions for small timber, fuel, fodder etc. have been given by concern forest department. In addition to rights and concessions of livelihood needs, these Van Panchayat forests are providing many indirect services such as ecological and environmental. Increased pressure has degraded the existing forests therefore requires an urgent management inputs so that they could be conserved and managed in a sustainable way. Keeping in view, the objectives of study were to carry out the analysis with special reference to the vegetation structure, regeneration and important values of Van Panchayat forests.

Material and methods

Study area- The study was carried out in the year 2013-2014 and conducted in two ecological village sites i.e. Soangaon and Jungalia Van Panchayat forests (community forests) in Nainital region of Kumaun Himalaya in Uttarakhand. The Jungalia Van Panchayat was legally formed. Jungalia gaon and Soangaon was pre-dominated by pine and oak forest respectively. For the purpose of research study, each selected forest was divided into three sub-sites i.e. hill top, hill slope and hill base forest site.

Methods- The vegetation analysis was done on the basis of quadrat method using the size 10x10m size placed randomly in each sub-plot of respective Van Panchayat village forest. Trees were measured for girth at breast height i.e. 1.37m by meter tape from the ground level and all the

measured tree were recorded individually for each species in each quadrat. Quantitative analysis or different parameters such as density, species diversity and importance value index (IVI) was done in each site of respective Van Panchayat forest. The IVI was determined as the sum of relative frequency, relative density and relative dominance (Misra, 1968; Curtis, 1959). The species diversity was determined by using the Shanon-Weiner index (1963) and concentration of dominance (CD) was calculated using Simpson's, (1949) index.

The following formulae were used for the calculations:

$$\text{Density} = \frac{\text{Total number of individuals}}{\text{Total number of quadrats studied}} \times 100$$

Importance Value Index (IVI): The IVI was done by using the values of relative density, relative frequency and relative dominance

$$\text{Relative frequency (RF)} = \frac{\text{Number of occurrences of the species}}{\text{Number of occurrences of all species}} \times 100$$

$$\text{Relative density (RD)} = \frac{\text{Number of individuals of the species}}{\text{Total number of individuals of all species}} \times 100$$

$$\text{Relative dominance (RDo)} = \frac{\text{Basal area of individual species}}{\text{Total basal area of all species}} \times 100$$

Thus the   IVI = RF + RD + RDo

The Provenance value (PV) index was calculated for seedlings by using the values of relative frequency (RF) and relative density (RD)

Thus the   PV = RF + RD

Species diversity (H) for each vegetation layer was calculated by using Shannon- Weiner (Shannon and Weiner, 1963) information index.

$$H = -\sum S \left(\frac{Ni}{N}\right) \times 3.322 \times \log(Ni/N)$$

Where, 'Ni' is total number of individuals of a species and 'N' is the total number of individuals of all species.

Concentration of dominance (Cd) was measured by Simpson's Index (Simpson 1949).

$$Cd = (Ni/N)^2$$

Where, 'Ni' is total number of individuals of a species and 'N' is total number of individuals of all species. In each Van Panchayat forest, the trees were divided into six size classes based on circumferences (Cbh at breast height); Total number of individuals belonging to these size classes was calculated for each species on each site. Density of seedling and sapling was considered as an indicator of the regeneration potential which was structured for their regeneration pattern in each forest.

The population structure and regeneration of tree species was assessed on the basis of girth classes (cbh) as per Good and Good (1972), the details are as follows- A = seedling (<10 cm), B = Saplings (10 -30cm), C = Young trees (30-60 cm), D = Pole size trees (60 - 90 cm), E = Mature trees category-I (90-120 cm), F = Mature trees category-II (120-150 cm) and G = Old trees (> 150 cm).

Results

Van Panchayat forest (Jungalia gaon)

The density of seedlings, saplings and trees was 5500, 270 and 1020ind ha^{-1}, respectively in hill top forest site (Table 1). In hill slope forest site, density of seedlings, saplings and trees was

6060,780 and 960ind ha^{-1}, respectively. The density of seedling, sapling and trees was 8710, 530 and 1170ind ha^{-1}, respectively for hill base forest site. Range of density among the tree species each category of tree species is given (Table 1).

Among all of the seven species in all the three forest sites *Q. leucotrichophora* was the dominant species and has higher density as compared to the other species. The maximum density for seedling and trees was in hill base forest site, while for sapling it minimum in hill slope forest site (Table 1).

Table 1. Seedling, sapling and tree density in Jungalia Van Panchayat forest

Species	Hill top			Hill slope			Hill base		
	Seedling	Sapling	Tree	Seedling	Sapling	Tree	Seedling	Sapling	Tree
Q. leucotrichophora	2070	260	810	2670	650	520	3470	320	840
Myrica esculenta	980	10	100	1560	20	170	2060	80	210
Lyonia ovalifolia	1270	-	90	1230	-	210	1100	10	70
Pyrus pashia	80	-	20	400	110	60	420	10	20
R. arboreum	480	-	-	-	-	-	410	10	30
Aesculus indica	240	-	-	-	-	-	-	-	-
Ficus numoralis	380	-	-	200	-	-	1250	100	-
Total	**5500**	**270**	**1020**	**6060**	**780**	**960**	**8710**	**530**	**1170**

Van Panchayat forest (Soangaon)

The density of seedling, sapling and tree was 3120, 50 and 340ind ha^{-1}, respectively in hill top forest site (Table 2). The seedling and tree density was 4040 and 440ind ha^{-1} in hill slope forest site. The seedling and tree density was 5270 and 530ind ha^{-1}, respectively for hill base forest site (Table 2).

Among all the five species present in all the three forest sites *P. roxburghii* was dominant tree species compare to the other tree species. The maximum density of seedling and trees was in hill base forest site, while sapling of this tree species occurred in hill top forest site (Table 2).

Table 2. Seedling, sapling and tree density in Soangaon Van Panchayat forest

Species	Hill top			Hill slope		Hill base		
	Seedling	Sapling	Tree	Seedling	Tree	Seedling	Tree
P. roxburghii	2550	50	340	3330	440	4610	530
Q. serrata	370	-	-	710	-	230	-
Q. leucotrichophora	-	-	-	-	-	190	-
Myrica esculenta	120	-	-	-	-	240	-
B. variegata	80	-	-	-	-	-	-
Total	**3120**	**50**	**340**	**4040**	**440**	**5270**	**530**

Van Panchayat forest (Jungalia)

The importance value index of seedling, sapling and tree ranged from 6.10- 60.9, 15.64-284.36 and 16.39-188.10 respectively in hill top forest site. The IVI ranged from 12.12-73.47, 17.44-222.04 and 24.61-130.49 for seedling, sapling and tree, respectively in hill slope forest site (Table 3). The IVI of seedling, sapling and tree in hill base forest site ranged from 16.62-56.50, 7.32-151.66 and 12.18-185.51, respectively (Table 3).

In all the three forest sub sites of Jungalia Van Panchayats, the importance value index was higher for *Q. leucotrichophora* species in seedling, sapling and trees.

Table 3. Importance value index of seedling, sapling and tree species in Jungalia Van Panchayat forest

Species	Hill top			Hill slope			Hill base		
	Seedling	Sapling	Tree	Seedling	Sapling	Tree	Seedling	Sapling	Tree
Q. leucotrichophora	60.9	284.4	188.1	73.5	222.0	130.5	56.5	151.7	185.5
Myrica esculenta	36.4	15.6	51.2	52.2	17.4	78.0	47.4	57.9	58.2
Lyonia ovalifolia	44.0	-	44.3	43.8	-	66.9	31.7	7.3	27.9
Pyrus pashia	6.1	-	16.4	18.4	60.5	24.6	16.7	9.2	12.2
R. arboreum	15.7	-	-	-	-	-	16.6	7.3	16.1
Aesculus indica	11.3	-	-	-	-	-	-	-	-
Ficus numoralis	25.5	-	-	12.1	-	-	31.0	66.5	-
Total	**199.9**	**300**	**300.0**	**200.0**	**299.9**	**300.0**	**199.9**	**299.9**	**299.9**

In hill top forest site, *Q. leucotrichophora* has maximum IVI (60.90) for seedlings 284.36 for sapling and 188.10 for tree followed by *L. ovalifolia* (44.02) for seedling and *M. esculenta* (36.41) for seedling, 51.23 for tree showed the more dominant tree species than others in hill top forest site. *Q. leucotrichophora* has maximum IVI of seedling (73.47), for sapling (222.04) and for tree (130.49) and followed by *M. esculenta* (52.21) for seedling, (17.44) for sapling and 78.04 for tree and *L. ovalifolia* 43.83 for seedling and 66.86 for tree in hill slope forest site (Table 3).

Q. leucotrichophora has maximum IVI of seedling (56.50), for sapling (151.66) and for tree (185.51) and followed by *M. esculenta* (47.3) for seedling, 57.92 for sapling and 58.23 for tree and for *L. ovalifolia* 31.67 for seedling, 7.32 for sapling and 27.96 for trees in hill base forest site (Table 3).

Van Panchayat forest (Soangaon)

The IVI of seedlings was ranged from 8.11-137.29, 58.75-141.25 and 15.65-143.04, respectively in hill top, hill slope and hill base forest site (Table 4). In all the three forest sites of Soangaon Van Panchayat, the importance value index was found to be higher for *P. roxburghii* species in seedling, sapling and tree composition followed by *Q. serrata.*

Table 4. Importance value index of seedling, sapling and tree in Soangaon Van Panchayat forest

Species	Hill top			Hill slope		Hill base	
	Seedling	Sapling	Tree	Seedling	Tree	Seedling	Tree
P. roxburghii	137.29	299.9	300	141.25	300	143.04	300
Q. serrata	45.19	-	-	58.75	-	21.03	-
Q. leucotrichophora	-	-	-	-	-	20.28	-
Myrica esculenta	9.41	-	-	-	-	15.65	-
B. variegata	8.11	-	-	-	-	-	-
Total	**200.00**	**299.9**	**300**	**200**	**300**	**200.0**	**300**

Van Panchayat forest (Jungalia)

The species diversity of seedling, sapling and trees ranged from 0.092-1.968, 0.052-0.176 and 0.113-0.264 for in hill top forest site, while the concentration of dominance was varied between 0.015-0.178, 0.04-0.96 and 0.0004-0.63, respectively. In hill slope forest site the species diversity of seedling, sapling and trees ranged from 0.259-0.521, 0.137-0.399 and 0.251-0.480, respectively, while the concentration of dominance was varied between 0.066-0.441, 0.03-0.83 and 0.063-0.54 in hill slope forest site. The species diversity of seedling, sapling and trees ranged from 0.207-0.529, 0.109-0.412 and 0.017-0.720, while the concentration of dominance was varied between 0.047-0.398, 0.02-0.19 and 0.017-0.72 in hill base forest site (Table 5). Species diversity of seedling ranged from 1.913-3.762 in the three forest site. It was highest in hill top forest site and lowest in hill slope forest site. The *Q. leucotrichophora* showed maximum diversity (0.521-1.968) in hill top forest site. Sapling diversity ranged from 0.755-1.633 in the three forest site. The tree diversity ranged from 1.014-1.652 in the three forest site.

Table 5. Species diversity and concentration dominance of tree, sapling and seedling in Jungalia Van Panchayats forest

Species	Hill top						Hill mid/ slope						Hill base					
	Seedling		Sapling		Tree		Seedling		Sapling		Tree		Seedling		Sapling		Tree	
	H	CD	H	CD	H	CD	H	CD	H	CD	H	CD	H	CD	H	CD	H	CD
Q. leucotrichophora	1.968	0.141	0.052	0.96	0.264	0.6300	0.521	0.441	0.219	0.83	0.479	0.540	0.529	0.398	0.440	0.6	0.341	0.72
Myrica esculenta	0.443	0.178	0.176	0.04	0.328	0.0100	0.504	0.257	0.137	0.03	0.442	0.180	0.492	0.237	0.412	0.15	0.445	0.18
Lyonia ovalifolia	0.488	0.049	-	-	0.309	0.0080	0.467	0.203	-	-	0.480	0.220	0.381	0.126	0.109	0.02	0.243	0.06
Pyrus pashia	0.092	0.015	-	-	0.113	0.0004	0.259	0.066	0.399	0.14	0.251	0.063	0.21	0.048	0.109	0.19	0.099	0.017
R. arboreum	0.306	0.087	-	-	-	-	-	-	-	-	-	-	0.207	0.047	0.109	0.02	0.137	0.026
Aesculus indica	0.199	0.044	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ficus numoralis	0.266	0.069	-	-	-	-	0.162	0.033	-	-	-	-	0.401	0.144	0.454	0.19	-	-
Total	**3.762**	**0.583**	**0.228**	**1**	**1.014**	**0.6484**	**1.913**	**1**	**0.755**	**1**	**1.652**	**1.003**	**2.22**	**1.0**	**1.633**	**1.17**	**1.265**	**1.003**

Note- Species diversity (H), Concentration of dominance (CD)

Table 6. Species diversity and concentration dominance of seedling in Soangaon Van Panchayats forest

Species	Hill top		Hill mid/ slope		Hill base	
	Seedling		Seedling		Seedling	
	H	CD	H	CD	H	CD
Pinus roxburghii	0.238	0.440	0.230	0.460	0.169	0.766
Quercus serrata	0.363	0.0002	0.441	0.031	0.199	0.002
Q. leucotrichophora	-	-	-	-	0.173	0.001
Myrica esculenta	0.366	0.0002	-	-	0.205	0.002
B. variegata	0.179	0.000001	-	-	-	-
Total	**1.146**	**0.44039**	**0.671**	**0.491**	**0.746**	**0.771**

Note- Species diversity (H), Concentration of dominance (CD)

Van Panchayat forest (Soangaon)

Species diversity of seedling, sapling and trees ranged from 0.179-0.366, 0.230-0.441 and 0.169-0.205 in hill top, hill slope and hill base forest site. The concentration of dominance of seedling varied between 0.00001-0.44, 0.031-0.46 and 0.001-0.766 in hill top, hill slope and hill base forest site, respectively (Table 6).

The population structure showed regeneration pattern of different species. For the assessment of population structure of tree species in each category in forest site, the following seven size classes were established based on circumference at breast height (Cbh, 1.37m) i.e. seedling <10cm (A), sapling 10-30cm (B), young tree 30.1-60cm (C), pole size tree 60.1-90cm (D), mature tree category- I 90.1-120cm (E), mature tree category- II: 120.1-150 (F) and old trees <150cm (G).

Van Panchayat forest (Jungalia)

The population structure of tree species are shown in fig.1. Hill top and hill base forest site showed the following order of regeneration: seedling > young tree > sapling. Only few species are growing naturally and therefore site has fair regeneration. In hill slope forest site was seedling > sapling > tree species presented good regeneration. Most of the species showed maximum number of seedlings of tree species which indicates that the species not growing well naturally in site are being planted recently by villagers of concern Van Panchayat forest. Among all the species present in the forest area *Q. leucotrichophora* was found in maximum number and therefore declared to be the dominant species of that area (Fig.1).
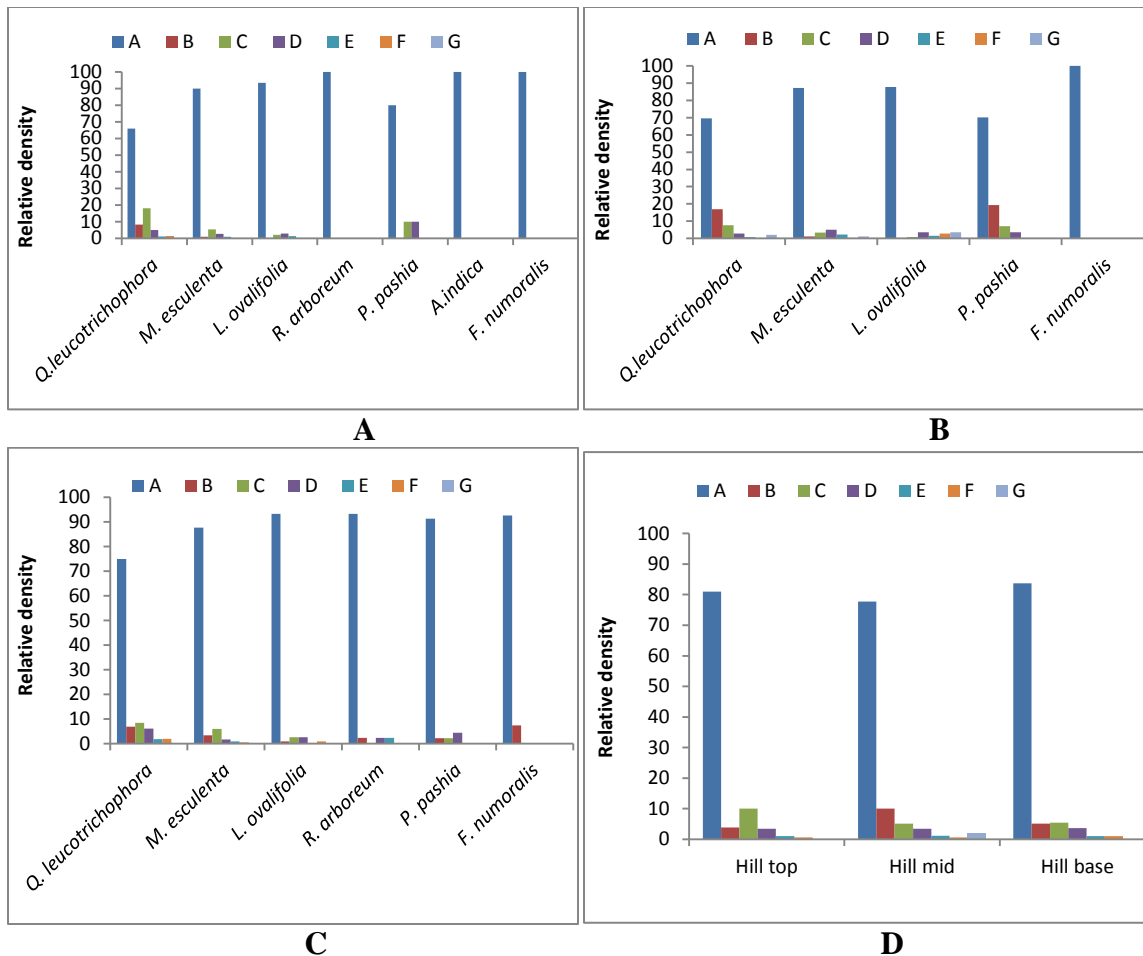
Fig.1. Regeneration pattern and population structure of tree species in hill top (A), hill slope (B) and hill base (C) of Jungalia Van Panchayat forests. Graphs of different tree classes A= seedling, B= sapling, C= young tree, D= pole size tree, E= mature tree category- I, F= mature tree category- II and G= old trees.
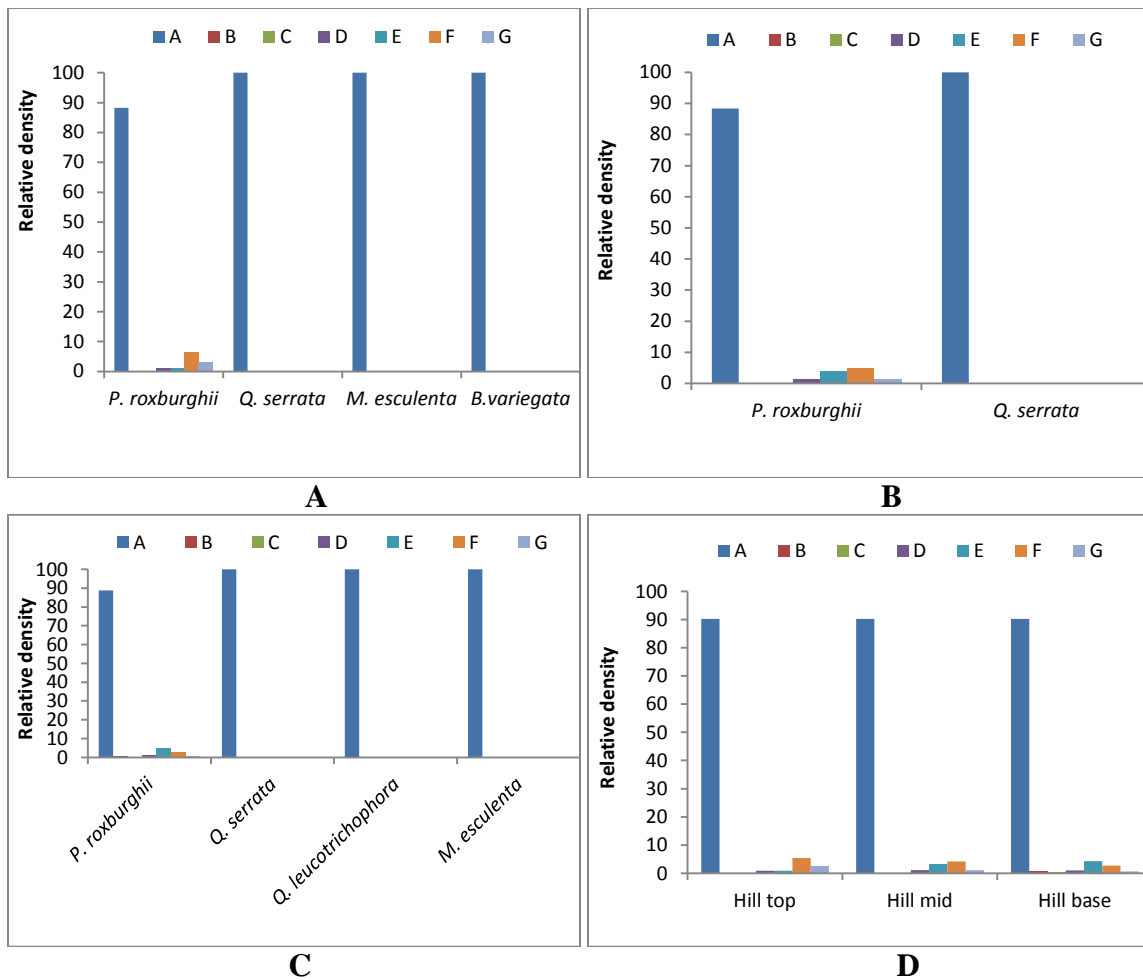
Van Panchayat forest (Soangaon)

In Soangaon Van Panchayat forest the population structure in hill base forest site showed seedling > young tree > sapling species pattern so the regeneration was said to be fair. The sequence of regeneration was recorded as A > F > G > E = F.

In hill top and hill slope forest site the pattern recorded was seedling > tree species while the saplings were completely absent. The order of regeneration was A > F > E > D = G for slope and A > F > E > G > D > B > C for base. All the species showed large number of seedlings with complete absence of saplings. Among all the species present in the forest area

P. roxburghii was found in maximum number and therefore declared to be the dominant species of that area (Fig.2).

Fig.2. Regeneration pattern and population structure of tree species in hill top (A), hill slope (B) and hill base (C) of Soangaon Van Panchayat forests. Graphs of different tree classes A= seedling, B= sapling, C= young tree, D= pole size tree, E= mature tree category- I, F= mature tree category- II and G= old trees.

Discussion and conclusion

The number of species in a particular forest varies markedly along the altitudinal range which depends on the factors and complexity of the site with regard to interaction between components and finally characterizes the habitat of individual species in the ecosystem.

Present findings of density, importance value index, species diversity and concentration of dominance in Jungalia and Soangaon Van Panchayat forests revealed the condition of forest. The findings show that forest was dominated by two tree i.e. *Q. leucotrichophora* and *P. roxburghii*, respectively. The density of seedling, sapling and trees was varied between 270-8710ind ha^{-1} for Jungalia Van Panchayat and that of Soangaon Van Panchayat was 50-5270ind ha^{-1}, respectively. The tree density 340-1020ind ha^{-1} falls within the range 280-1680ind ha^{-1} reported for different central Himalayan oak and pine forest (Singh *et al.,* 1994 and Kharkwal, 2009) but close to 350-2840ind ha^{-1} reported for temperate forest in the world and 540-1630 ha^{-1} for pine forest (Dabel and Day, 1977; Crow, 1978; Killingbeck & Wali, 1978; Saxena and Singh, 1982 and Chaturvedi and Singh, 1987.

In the Jungalia Van Panchayat forest the density of *Q. leucotrichophora* seedling was highest followed by sapling and young trees indicating an expanding type of population structure. On the basis of density of oak and pine forest *Q. leucotrichophora* showed dominance in the forest of Central Himalaya (Ahmed, 2012)

Importance value Index (IVI) is the measurement of ecological amplitude of species suggesting the ability of a species to establish over an array of habitats. However, there is no single perfect way of assessing the ecological amplitude of a species. The abundance of a species can be represented by several measures such as relative density, relative frequency and Importance Value Index (IVI). The importance value index for Jungalia and Soangaon Van Panchayats ranged from 6.10-284.36 and 8.11-300, respectively. The IVI of oak (130.49-188.10) showed its dominance in each site of Jungalia Van Panchayat forest, which is on the higher side than IVI (129.9) for *Quercus leucotrichophora* (Ahmed, 2012). The IVI of pine (300) showed its dominance in Soangaon Van Panchayat, which is on higher side than IVI (218.2) for *Pinus roxburghii* (Ahmed, 2012).

In Jungalia Van Panchayat forest species diversity values varied from 0.092 to 1.968 for tree layer and concentration of dominance from 0.0004 to 0.960. In Soangaon Van Panchayat species diversity values varied from 0.169-0.441 for tree layer and concentration of dominance from 0.000001 to 0.766. These values are generally comparable with the values reported earlier for sub-tropical forests (Kharkwal, 2009). The more diversity means that the sites were suited to all type of vegetation and lesser influence of biotic factors. Consequently lesser concentration of dominance means due to the influence of communities (Simpson, 1964; Ralhan *et al*., 1982) and severity in the environment. The growth of saplings of *Pinus roxburghii* in the site was completely absent due to natural (erosion, forest fires) and human disturbances such as lopping- pruning and cutting of broad leaf tree species in a forest (Champion & Seth, 1968).

The regeneration of tree species in Jungalia Van Panchayat forest was good. The good regeneration for oak represents more care and conservation, sustained use by villagers. Apart from these the better regeneration of plants has been indicated that people in village

are using other alternatives like LPG, solar cooker and biogas plants, while for Soangaon regeneration was fair because of pressure on pine, which is species that always invades the rocky and barren sites and apathy of villagers about its conservation as it not provide better fuel and fodder. The absence of saplings showing the conversion deficit from seeding to further stage this may be due to the anthropogenic pressure forest fire and weed invasion by *Lantana camara* and other. The forests are dominated by a single species i.e. oak and pine and these facts suggest that forest types of the study area are highly representative in their composition.

So from this study we would like to conclude that there is need to aware the villagers for conservation and management of these Van Panchayat forests by planting and caring of species. The government should take the forward step to provide the technical know-how so that the MPTS could be planted in Van Panchayat forest through the involvement of villagers.

Acknowledgement

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