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Research Article

Phyto-diversity of selected stress sites of Garhwal Forest Division of Pauri Garhwal, Uttarakhand, India.

Anup Chandra*, Anil Kumar Kewat
Systematic Botany Discipline, Botany Division, Forest Research Institute, Dehradun – 248006, Uttarakhand, India.

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Abstract: Species richness, IVI and plant diversity indices of selected biotic stress sites of Garhwal Forest Division were studied. Total density range for the tree species (Plants $100m^{-2}$) was 6.7 to 8.1; for shrubs was 48.9 to 84.9 and for herbs was 490 to 700. Total basal cover (cm^2 $100m^{-2}$) ranged from 386.1 to 1571 for tree, 1466.7 to 2372.5 for shrub and from 223.9 to 622.5 for herbs at different sites. Diversity index was invariably higher for herb and shrub than tree layer. Concentration of dominance showed reverse trend. It is concluded from study that site-III is highly stressed followed by site-II and site-I. Suitable measures should be adopted to conserve the invaluable plant diversity of the area.

Keywords: Plant Diversity Density, Stress

Introduction

Forest biodiversity with the principal species and the variability in the gene diversity of different communities plays significant role in providing value added products of great socio-economic and economic value. Man has been exploiting biodiversity for his livelihood since time memorial. However, due over population requirement of forest based products has been increased many fold. In addition to this, there are other factors such as invasive species, developmental activities, fire, firewood, etc. which are responsible for biodiversity decline. District has invaluable diversity, which should be sustainably managed. However, due to conversion of forestland for agriculture, industrialization, introduction of exotics with invasive nature, etc., various sites of biodiversity and genetic resource significance are under tremendous pressure.

Various studies indicate that structure and composition of vegetation is influenced by several environmental and biotic stresses. Natural or manmade disturbances are an important force capable of moulding plant community structure and dynamics (Shrestha *et al.* 2013). Anthropological disturbances are considered as major divers of diversity in plant communities (Garbarino *et al.* 2014). Grazing affects the frequency and density of the species (Sundriyal *et al.* 1987, Nautiyal *et al.* 1997). Severity of the grazing decreases the density. Also there are many reports suggesting that moderate level of grazing promotes diversity (Looman, 1983; Mcnaughton, 1983; Collins and Barber, 1985). Invasive species marked changes in community composition, diversity and functioning (D'antonio & Vitousek, 1992). In the present study, diversity indices of three biotic stress sites were estimated.

Study Area

The state of Uttarakhand is endowed with high plant diversity. Total forest cover is about 38,000 sq. km (71.05%) of total geographical area (53483 sq. km) of the states (Anon, 2015). Forest cover of the Pauri district is 3269 sq. km. It is 61.34% of the total geographical area (5329 sq. km) of the district which is distributed as VDF (519 sq. km), MDF (1954 sq. km) and OF (796 sq. km).

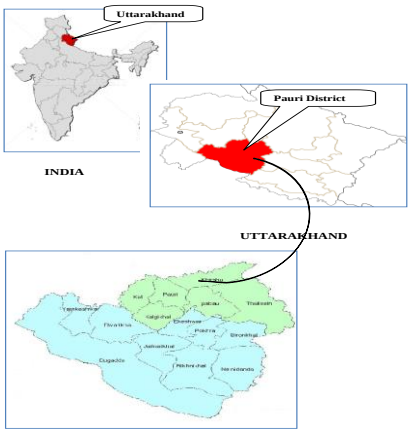

FIG. 1. MAP OF STUDY AREA

Study area is located at Khirshu. It is situated in Pauri District of the Garhwal, Uttarakhand (Fig.1). It lies between latitude 30^0 10'20.04" and longitude 78^0 52'04.75", Alt 1768m. Area is affected by invasive species, grazing, garbage dumping,

*Corresponding Author:
Dr. Anup Chandra,
Scientist - E & In-charge,
Systematic Botany Discipline, Botany Division Forest Research Institute,
P.O. New Forest Dehradun-248006, Uttarakhand, India.
E-mail: bhupendra_thakrejnkvv@rediffmail.com

developmental activities etc. Three site viz. Site-I: Towards Pithundi, Site - II: Pawo Road and Site-III: Below Pithundi were identified for the study.

Materials and Methods

Phytosociological studies were conducted during 2010 using quadrat method (size of the quadrat: 10 x10m for trees; 3 x 3 m for shrubs and 1 x 1 m for herbs). Plant specimens were collected and identified with help of relevant floras (Gaur, 1999; Kanjilal, 1928). Ten quadrats were laid down randomly in each location. In each quadrat, g.b.h. (girth at breast height at 1.37m above ground level) of each tree was measured and recoded individually. In case of herb and shrub, diameter was measured 2.5 cm above ground level. Quantitative analysis of vegetation for frequency, density and dominance was calculated following Mishra (1968). Values of Relative fervency, density and dominance were summed to get Importance Value Index (IVI).

Shannon-Wiener information function (Shannon & Wiener, 1963) was calculated using the formula:

$$H = -\sum pi \ln pi$$

Where pi is the proportional of individuals of i^{th} species.

Concentration of dominance (cd) was measured by Simpson Index (Simpson, 1949).

$$Cd = \sum (pi)^2$$

Pielou's evenness index (Pielou, 1966) was calculated using formula:

$$J = H'/\ln(S)$$

where **H'** is Shannon Weiner diversity and **S** is the total number of species

Results

The vegetative analysis of tree, shrub and herbaceous layer of threatened sites-I of Khirsu forest is presented in table 1. A total of 9, 6 and 8 species were observed in the tree, shrub and herb layers respectively. On the basis of Important Value Index (IVI), *Quercus leucotrichophora* (91.1) was the most dominant species in the area followed by *Pinus roxburghii* (71.0), *Rhododendron arboretum* (57.8), *Myrica esculenta* (22.3) etc. in the tree layer. Highest IVI for shrubby and herbaceous layer was reported for *Rubus ellipticus* (80.4) and *Eupatorium adenophorum* respectively.

Table 1. Vegetative analysis of tree, shrubby and herbaceous layers of Khirshu Forest (Site- I, Towards Pithundi)

S.N.	Species	Frequency (%)	Density (P 100m^{-2})	Total Basal Area (cm^2 100m^{-2})	IVI
Tree layer					
1	*Quercus leucotrichophora* A. Camus	100	3	500.7	91.1
2	*Pinus roxburghii* Sarg.	80	1.7	506.9	71.0
3	*Rhododendron arboretum* Sm.	90	1.6	283.9	57.8
4	*Myrica esculenta* Buch.-Ham. ex D. Don	50	0.5	78.2	22.3
5	*Lyonia ovalifolia* (Wall.) Drude	30	0.3	73.0	15.0
6	*Prunus cerasoides* Buch.-Ham. ex D.Don	30	0.3	53.2	13.8
7	*Cinnamomum tamala* (Buch.-Ham.) T.Nees & Eberm.	30	0.3	37.8	12.8
8	*Acacia nilotica* (L.) Delile	20	0.2	24.9	8.5
9	*Acer oblongum* Wall. ex DC.	20	0.2	12.8	7.7
			8.1	**1571**	**300.0**
Shrubby layer					
1	*Rubus ellipticus* Sm.	80	14.4	429.7	80.4
2	*Berberis asiatica* Roxb. ex DC.	70	10.0	254.8	56.9
3	*Rhododendron arboretum* Sm.	50	8.9	235.9	47.8
4	*Quercus leucotrichophora* A. Camus	60	6.7	185.7	42.8
5	*Myrica esculenta* Buch.-Ham. ex D. Don	50	6.7	185.7	40.0
6	*Rubus niveus* Thunb.	40	4.4	174.9	32.0
			51.1	**1466.7**	**300.0**
Herbaceous layer					
1	*Eupatorium adenophorum* Spreng.	80	150	97.9	94.3
2	*Rubus ellipticus* Sm.	60	60	23.8	37.9
3	*Potentilla fulgens* Lehm.	70	80	8.6	37.7
4	*Berberis asiatica* Roxb. ex DC.	30	40	39.2	33.2
5	*Rumex hastatus* D. Don	40	40	24.8	29.2
6	*Begonia picta* Sm.	40	40	13.5	24.2
7	*Ajuga bracteosa* Wall. ex Benth.	40	40	9.8	22.5
8	*Viola canescens* Wall.	40	40	6.5	21.1
			490	**223.9**	**300.0**

The vegetative analysis of tree, shrubby and herbaceous layers of threatened sites-II of Khirsu forest is presented in table 2. In the tree layer, a total of 5 species with total density (P100 m^{-2}) of 6.7 was reported from the site. Highest IVI was estimated for *P. roxburghii* (128), *Q. leucotrichophora* (63.5), *R. arboretum* (44.2) etc. Total numbers of species in shrubby and herbaceous layers were 8 and 7 respectively. Highest IVI for shrubby layer was estimated to be 62.8 (*Q. leucotrichophora*) and for herbaceous layer was 69.9 (*E. adenophorum*).

Table 2. Vegetative analysis of tree, shrubby and herbaceous layers of Khirsu forest (Site –II, Pawo Road, towards Khirsu)

S.N.	Species	Frequency (%)	Density (P 100m^{-2})	Total Basal Area (cm^2 100m^{-2})	IVI
Tree layer					
1	*Pinus roxburghii* Sarg.	100	3.1	214.0	128.0
2	*Quercus leucotrichophora* A. Camus	80	1.2	94.8	63.5
3	*Rhododendron arboreum* Sm.	80	0.9	37.4	44.2
4	*Lyonia ovalifolia* (Wall.) Drude	60	0.8	19.7	32.8
5	*Myrica esculenta* Buch.-Ham. ex D. Don	60	0.7	20.1	31.5
			6.7	**386.1**	**300.0**
Shrubby layer					
1	*Quercus leucotrichophora* A. Camus	100	17.8	505.5	62.8
2	*Berberis asiatica* Roxb. ex DC.	90	17.8	505.5	60.7
3	*Rubus ellipticus* Sm.	70	13.3	429.7	48.2
4	*Lantana camara* L.	60	11.1	241.9	35.6
5	Rosa webbiana Vilm. & Bois	40	7.8	237.4	27.4
6	*Rhus parviflora* Roxb.	40	6.7	226.7	25.6
7	*Pinus roxburghii* Sarg.	50	5.6	91.9	20.7
8	*Myrica esculenta* Buch. -Ham. ex D. Don	40	4.4	133.9	19.1
			84.4	**2372.5**	**300.00**
Herbaceous layer					
1	*Eupatorium adenophorum* Spreng.	90	150.0	143.6	69.9
2	*Lantana camara* L.	70	100.0	107.6	50.9
3	*Quercus leucotrichophora* A. Camus	70	80.0	89.6	44.6
4	*Rubus ellipticus* Sm.	50	100.0	94.0	44.0
5	*Pinus roxburghii* Sarg.	50	70.0	75.9	36.0
6	*Rosa webbiana* Vilm. & Bois	50	50.0	67.1	31.2
7	*Bauhinia racemosa* Lam.	40	40.0	44.7	23.5
			590	**622.5**	**300**

The vegetative analysis of tree, shrub and herbaceous layers of threatened site-III of Khirsu forest is presented in table 3. Total number of species observed in tree, shrubby and herbaceous layers were 4, 4 and 6 respectively. On the basis of Important Value Index (IVI), most dominant species in tree, shrub and herb layers were *R. arboretum* (111.8), *B. asiatica* (102.0) and *E. adenophorum* (110.7) respectively.

Table 3. Vegetative analysis of tree, shrubby and herbaceous layers of Khirshu Forest (Site III -Below Pithundi)

S.N.	Species	Frequency (%)	Density (P 100m^{-2})	Total Basal Area (cm^2 100m^{-2})	IVI
Tree layer					
1	*Rhododendron arboreum* Sm.	100.0	2.7	274.6	111.8
2	*Quercus leucotrichophora* A. Camus	100.0	2.5	283.8	110.5
3	*Pinus roxburghii* Sarg.	80.0	1.2	49.7	48.5
4	*Rhus parviflora* Roxb.	60.0	0.7	10.2	29.2
			7.1	**618.4**	**300**
Shrubby layer					
1	*Berberis asiatica* Roxb. ex DC.	90	18.9	636.7	109.0
2	*Rubus ellipticus* Sm.	90	14.4	512.9	92.2
3	*Rhus parviflora* Roxb.	60	10.0	318.9	60.8
4	*Rubus niveus* Thunb.	50	5.6	151.3	37.9
			48.9	**1619.9**	**300.0**
Herbaceous layer					
1	*Eupatorium adenophorum* Spreng.	90	310.0	250.1	110.7
2	*Berberis asiatica* Roxb. ex DC.	100	150.0	138.4	72.1
3	*Quercus leucotrichophora* A. Camus	40	70.0	75.9	33.7
4	*Rumex hastatus* D. Don	50	80.0	40.3	32.0
5	*Rubus niveus* Thunb.	40	50.0	54.5	27.3
6	*Rhus parviflora* Roxb.	40	40.0	44.7	24.2
			700.0	**603.9**	**300.00**

Total density range for the tree species (Plants 100m^{-2}) was 6.7 to 8.1; for shrubs was 48.9 to 84.9 and for herbs was 490 to 700. Total basal cover (cm^2 100m^{-2}) ranged from 386.1 to 1571 for tree, 1466.7 to 2372.5 for shrub and from 223.9 to 622.5 for herbs at different sites. Diversity indices viz., Shannon-Wiener diversity index (H), Concentration of dominance (cd), evenness (E) and species richness (SR) for different growth forms at different sites of Khirsu Forest is presented in Table 4. Table indicates that in tree layer species richness was higher in site I followed by site II and Site III. Tree diversity index was in order of site I > site-II > site-II. Concentration of dominance was in order of site III > site II > site I. In the shrubby layer species richness was maximum in site-II followed by site-I and site-III. Diversity index was lowest in the Site-III. In the herbaceous layer, area was dominated by *E. adenophorum*. Species richness was highest in site-I and lowest in site –II.

Table 4: Diversity indices for different growth forms at different sites of Khirsu forests of Uttarakhand

Site	Trees				Shrubs				Herbs			
Stand	**SR**	**H**	**cd**	**E**	**SR**	**H**	**cd**	**E**	**SR**	**H**	**cd**	**E**
I	9	1.639	0.245	0.746	6	1.737	0.188	0.962	8	1.683	0.253	0.809
II	5	1.203	0.382	0.747	8	1.943	0.157	0.934	4	1.892	0.158	0.972
III	4	0.988	0.414	0.712	4	0.988	0.414	0.712	6	1.553	0.257	0.867

(SR=species richness; H=Diversity index; cd=Concentration of dominance; E=evenness

Discussion

Several workers (Dabel and Day, 1977; Killingbeck and Wali, 1978; Sexena and Singh, 1980; Pande *et al.* 1996; Bhandari *et al.* (1997) have reported the value of TBC and density of tree species varying from 1561 to 5930 cm^2 $100m^{-2}$ and 3.5 to 20.8 tree $100m^{-2}$ respectively. Ralhan *et al.* (1982) reported the value of TBC and density varying from 2686 to 6045 cm^{-2} and 3.8 to 16.33 trees 100 m^{-2} for temperate forests of Kumaon Himalaya. Singhal *et al.* (1986) reported TBC and density varying from 1455 to 5672 cm^{-2} and 0.7 to 3.7 trees $100m^{-2}$ respectively. In the present study, tree TBA and density of Khirsu forest was reported from 386.1 to 1571cm^2 $100m^{-2}$ and 6.7 to 8.1 trees $100m^{-2}$ respectively. The value of tree density for the present study falls in this range. The lower value of basal cover for threatened site suggests that there is disturbance in the site. TBA (cm^2 $100m^{-2}$) and density (plant $100m^{-2}$) value are reported between 205 to 2027 and 9050 to 39398 respectively for herbaceous layer and same for the shrub layer are in the range of 7.24 to 74.33 and 9.86 to 306 respectively for temperate Himalaya forests (Pande *et al.* 1996). In the present study, TBA (cm^2 $100m^{-2}$) of herbaceous layer showed ranges from 223.9 to 622.5 and density ranges from 490 to 700. Lower ranges showed disturbance in the sites due to the biotic factors. Various workers reported diversity index values between 1.16 to 3.14 for temperate forests (Monk, 1967; Risser and Rice, 1971; Saxena and Singh, 1982; Singh and Singh, 1984 and Pande *et al.* 1996). The lower value of present study indicates the disturbances in the area.

Conclusion

It is concluded from the present study that there are various biotic factors such as invasive species, grazing, fire, conversion land for agriculture etc. which are putting tremendous pressure on the indigenous plant diversity. Diversity parameters such as tree diversity index, concentration of dominance and species richness showed declining trend. Shrub and herb species diversity index (H) also showed the similar kind of trend. A lower value of diversity index indicates that there is impact of biotic factors in the area which causes disturbances. Therefore, suitable conservation measures should be taken to restore the declining plant diversity of the impacted sites. Local people can be educated through training programmes on forest fire and its prevention, invasive species, grazing etc. It will not only help invaluable biodiversity of the area but also improve environment and livelihood of the people.

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