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PHYTOSOCIOLOGY OF WOODY VEGETATION UNDER DIFFERENT MANAGEMENT REGIMES IN GARHWAL HIMALAYA

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MEHTA, J.P., TIWARI, S.C. & BHANDARI, B.S. 1997. Phytosociology of woody vegetation under different management regimes in Garhwal Himalaya. The present paper deals with the species composition, distribution pattern, diversity, concentration of dominance, community coefficient, beta diversity and equitability under four management regimes at the end of a study period of two years, i.e. in a forest grazing land located at Pauri (Garhwal): burnt protected (BP), burnt grazed (BG), unburnt protected (UP) and unburnt grazed (UG). On the burnt sites, tree, sapling and seedling strata were dominated by *Pinus roxburghii*, except in the BG site where the seedling stratum was co-dominated by *Quercus leucotrichophora*. In the shrub stratum, *Berberis asiatica* (BP) and *Rhus parviflora* (BG) dominated. On the UP and UG sites all the three strata were dominated by *Cupressus torulosa*, and within the shrubs *Berberis asiatica* was dominant. On the majority of the sites, most of the trees, saplings, seedlings and shrubs were widely distributed; however, only the UG site showed regular distribution in the sapling stratum. The diversity index for the tree stratum was higher on the burnt sites than the unburnt sites. The sapling stratum followed the opposite trend to the tree stratum. The diversity index for the seedling stratum ranged from 1.141 in the UG site to 1.876 in the BG site. The results of the study indicate that phytosociological changes of the woody vegetation are brought about by grazing and burning in terms of species composition, frequency, density and distribution. The shrub stratum recorded maximum index on BP (2.291) and minimum on UP (1.811). The values of dominance of concentration in general, followed an opposite trend to that of the diversity index for each stratum on all the study sites. The maximum similarity in the tree, sapling and shrub strata was recorded between the UP and UG sites. Beta diversity and equitability did not show any proper trend in all the sites in the different strata.

Key words: Species composition - diversity - concentration of dominance - community coefficient - beta diversity - equitability - Garhwal Himalaya

MEHTA, J.P., TIWARI, S.C. & BHANDARI, B.S. 1997. Fitososiologi pertumbuhan kayu pada regim pengurusan yang berbeza di Garhwal Himalaya. Kertas kerja ini berkaitan dengan komposisi spesies, pola taburan, kepelbagaian beta dan kesamarataan di bawah empat regim pengurusan di peringkat akhir tempoh kajian selama dua tahun, iaitu di tanah hutan ragut di Pauri (Garhwal): perlindungan bakar (BP), ragut bakar (BG), perlindungan tidak bakar (UP) dan ragut tidak bakar (UG). Di tapak yang dibakar, strata pokok, anak pokok dan anak benih dikuasai oleh *Pinus roxburghii*, kecuali di tapak BG yang stratum anak benih turut didominasi oleh *Quercus leucotrichophora*. Dalam stratum pokok renik, ia didominasi oleh *Berberis asiatica* (BP) dan *Rhus parviflora* (BG). Di tapak UP dan UG ketiga-tiga strata didominasi oleh *Cupressus torulosa*, manakala *Berberis asiatica* mendominasi pokok renik. Bagi sebahagian besar tapak, kebanyakan pokok, anak pokok, anak benih dan pokok renik bertaburan dengan meluasnya. Bagaimanapun, hanya tapak UG menunjukkan taburan biasa dalam stratum anak pokok. Indeks kepelbagaian bagi stratum pokok lebih tinggi di tapak yang dibakar berbanding tapak yang tidak dibakar. Stratum anak pokok mengikut tren yang berlawanan dengan stratum pokok. Indeks kepelbagaian stratum anak benih berjulat antara 1.141 di tapak UG hingga 1.876 di tapak BG. Keputusan kajian menunjukkan bahawa perubahan fitososiologi pertumbuhan kayu dari segi komposisi, kekerapan, kepadatan dan taburan ialah akibat daripada ragutan dan pembakaran. Stratum pokok renik mencatatkan indeks maksimum bagi BP (2.291) dan indeks minimum bagi UP (1.811). Nilai kepekatan dominan secara umumnya mengikut tren berlawanan dengan indeks kepelbagaian setiap stratum di semua tapak kajian. Persamaan maksimum dalam pokok, anak pokok dan strata pokok renik dicatatkan di antara tapak UP dan tapak UG. Kepelbagaian beta dan kesamarataan tidak menunjukkan kecenderungan yang sewajarnya di semua tapak dalam strata berbeza.

Introduction

Fire plays an important role in the biotic community of different land forms. Its effect depends on the type, duration and extent of fire, topography, weather conditions and phenophase of the community (Tiwari *et al.* 1986). Usually precribed fires yield desirable results if applied scientifically and wild fires destroy the forest wealth. The effects of fire also vary with the structure of the community. Immediate effects can be visualised in the lower strata (herb composition) of the biotic communities and long-time effects are the characteristic features of the upper strata (tree composition).

Although fires have been a frequent feature in most of the lower and middle altitude grasslands in the Garhwal Himalaya, only few reports are available on the role of fire in managing such grasslands (Mehta 1990). For this reason, the present work was undertaken to establish the short term effect of fire on the chir pine community of the Garhwal Himalaya.

Materials and methods

Study area and general experimental design

Geographically, the Garhwal Himalaya is situated between 29° 31' 9" - 31° 26' 5" N and 70° 35' 5" - 80° 6' E, exhibiting submontane to alpine climates with distinct characteristics of the specific vegetation types.

The study was conducted at Pauri, Garhwal (39° 9' N, 78° 46' E; covering an elevation between 1700 and 2000 m a.s.l.). Four sites were selected in the Ransi-Nagadev forest area, of which two were burnt (SW aspect) and the other two were unburnt (SE aspect). The sites, each of about 2 ha, were very close together within an area of 1 km^2. The two burnt sites were burnt protected (BP) and burnt grazed (BG); the other two were unburnt protected (UP) and unburnt grazed (UG). These sites were studied starting one month after a prescribed ground and surface burning conducted by forest officials on 2 and 3 February 1986. There was no history of prior burning on the unburnt sites, although the burnt sites had experienced frequent fires at 2 - 5 years intervals. The protected sites were kept free of grazing by cattle and herbage removal by natives during the study period.

The sites experience a montane climate with hot summers and cold winters. During the study period, the mean minimum and maximum temperatures were 12 °C (January) and 33°C (June) respectively for the first post-burnt year, and 12 °C (December) and 31°C (June) respectively for the second. The total rainfall was 878 mm in 1986 and 519 mm in 1987; of the total rainfall 22, 59 and 19 mm were contributed in the 1st year, and 2, 87 and 71 mm in the 2nd year, in summer, the rainy season and winter respectively.

Methods

The phytosociology of woody vegetation was examined at the end of the 2-y study period using fifteen 10×10 m^2, randomly placed, quadrats on each of the (burnt and unburnt) sites. In each quadrat, all trees (> 31.5 cm cbh) and saplings or shrubs (10.5 - 31.4 cm cbh) were individually measured for cbh (circumference at breast height, i.e. 1.37 m from the ground). The individuals of trees with less than 10 cm cbh were recorded as seedlings.

The vegetational data were quantitatively analysed, separately for each species, for frequency, density and abundance (Curtis & McIntosh 1950). The importance value index (IVI) for all species in the tree, sapling, seedling and shrub layers was determined following Phillips (1959). The ratio of abundance to frequency (A/F) was used to interpret the distribution pattern of the species (Whitford 1949). The A/F ratio indicates regular distribution if the value is less than 0.025, random distribution if it falls between 0.025 and 0.05, and contagious distribution if the value is greater than 0.05 (Curtis & Cottam 1956). Total basal cover (TBC) of all species was measured to reflect the area occupied by the particular species (Misra 1968). Community coefficients between different forest sites for tree, sapling, seedling and shrub layers were calculated following Jaccard (1912) on the basis of density.

Species diversity ($\bar{H}$) and concentration of dominance (CD) for different sites were calculated separately for each stratum (tree, sapling, seedling and shrub) from density data. In the present study, the diversity was calculated following Shannon and Weaver (1963) and concentration of dominance following Simpson (1949). Beta diversity (BD) was calculated following Whittaker (1975) and equitability (Ec) or species index for log cycle was calculated following Whittaker (1972).

Results

Vegetation analysis

On the burnt protected (BP) site, tree, sapling and seedling strata were dominated by *Pinus roxburghii*. The associated species in the latter two strata was *Myrica esculenta* while in the tree stratum, *Pinus roxburghii* was associated with *Rhododendron arborium*. Among the shrubs, *Berberis asiatica* owed its dominance to its high IVI, but its TBC was lower than that of *Rhus parviflora*, which was its associated shrub species in this stratum. The data indicate *Rhododendron arboreum* and *Quercus leucotrichophora* as the competing species in the sapling stratum. These two species were also competing with *Myrica esculenta* in the seedling stratum, and among the shrubs, *Berberis asiatica* and *Rhus parviflora* were competing with *Asparagus adscendens, Rhus cotinus* and *Rubus niveus* (Table 1).

Table 1. Plant density, total basal cover (TBC) and importance value index (IVI) of woody species at the burnt protected and burnt grazed (in parenthesis) sites

Species	Density (plant ha^{-1})	TBC ($m^2 ha^{-1}$)	IVI
Trees			
Pinus roxburghii	290 (312)	13.92 (13.1)	236 (174)
Rhododendron arboreum	70 (-)	2.17 (-)	64 (-)
Myrica esculenta	- (87)	- (2.52)	- (50)
Quercus leucotrichophora	- (150)	- (3.90)	- (75)
Saplings			
Cupressus torulosa	- (62)	- (0.19)	- (30)
Myrica esculenta	140 (75)	0.42 (0.15)	78 (40)
Pinus roxburghii	300 (487)	0.90 (1.46)	129 (193)
Rhododendron arboreum	60 (-)	0.18 (-)	54 (-)
Quercus leucotrichophora	100 (62)	0.30 (0.19)	39 (36)
Seedlings			
Lyonia ovalifolia	- (162)	- (0.02)	- (46)
Myrica esculenta	100 (100)	0.03 (0.03)	67 (46)
Pinus roxburghii	290 (312)	0.09 (0.16)	140 (81)
Rhododendron arboreum	80 (-)	0.05 (-)	58 (-)
Quercus leucotrichophora	60 (262)	0.03 (0.13)	44 (127)
Shrubs			
Asparagus adscendens	130 (125)	0.01 (0.01)	32 (33)
Berberis asiatica	410 (187)	0.05 (0.02)	91 (59)
Pyracantha crenulata	- (75)	- (0.01)	- (33)
Rhus parviflora	300 (150)	0.05 (0.03)	78 (68)
Rhus cotinus	170 (-)	0.04 (-)	58 (-)
Rubus ellipticus	50 (237)	0.01 (0.02)	18 (64)
Rubus niveus	100 (112)	0.02 (0.01)	24 (39)

On the burnt grazed (BG) site, considering the same parameters, *Pinus roxburghii* was dominant in the tree, sapling and seedling strata, with co-dominance of *Quercus leucotrichophora* in the tree and seedling strata. *Myrica esculenta* and *Quercus leucotrichophora* were competing species in the sapling stratum, and *Myrica esculenta* and *Lyonia ovalifolia* in the seedling stratum. *Rhus parviflora* and *Rubus ellepticus* were the dominant shrub species associated with *Berberis asiatica* in the shrub stratum, and the competing species were *Asparagus adscendens, Pyracantha crenulata* and *Rubus niveus.*

On the unburnt protected (UP) site, the tree stratum was occupied by the single species *Cupressus torulosa.* The sapling and seedling strata were dominated by *Cupressus torulosa* and co-dominated by *Cedrus deodara.* In the sapling stratum, *Cedrus deodara* and *Pinus wallichiana* were the competing species, and among the seedlings there was great competition between *Pinus roxburghii* and *Pinus wallichiana.* In the shrub stratum, *Pyracantha crenulata* was dominant, followed by *Berberis asiatica* and *Rubus ellepticus,* the competing species (Table 2).

Table 2. Plant density, total basal cover (TBC) and importance value index (IVI) of woody species at unburnt protected and unburnt grazed (in parenthesis) sites

Species	Density (plant ha^{-1})	TBC (m^2ha^{-1})	IVI
Trees			
Cupressus torulosa	275 (187)	14.570 (10.28)	300 (244)
Pinus roxburghii	- (37)	- (1.25)	- (56)
Saplings			
Cedrus deodara	162 (87)	0.486 (0.26)	78 (62)
Cupressus torulosa	250 (275)	0.751 (0.83)	113 (182)
Pinus roxburghii	100 (75)	0.203 (0.23)	46 (56)
Pinus wallichiana	100 (-)	0.300 (-)	63 (-)
Seedlings			
Cedrus deodara	312 (7)	0.097 (0.01)	92 (38)
Cupressus torulosa	450 (150)	0.201 (0.05)	150 (143)
Pinus roxburghii	50 (125)	0.016 (0.05)	30 (119)
Pinus wallichiana	62 (-)	0.006 (-)	28 (-)
Shrubs			
Berberis asiatica	237 (262)	0.018 (0.02)	96 (119)
Pyracantha crenulata	187 (125)	0.032 (0.02)	110 (61)
Rhus parviflora	112 (137)	0.017 (0.02)	60 (73)
Rubus ellipticus	50 (112)	0.003 (0.01)	34 (47)

On the unburnt grazed (UG) site, *Cupressus torulosa* was dominant in all the strata. It was associated with *Pinus roxburhgii* in the tree stratum and *Cedrus deodara* in the sapling and seedling strata. *Pinus roxburhgii* and *Pinus wallichiana* were the competing species in the latter two strata. In the shrub stratum, *Berberis asiatica* and *Pyracantha crenulata* were dominant. *Rhus parviflora* and *Rubus ellipticus* were competing species (Table 2).

Table 3. Distribution pattern (%), diversity ($\bar{H}$), concentration of dominance (CD), beta diversity (BD) and equitability (Ec) of tree, sapling, seedling and shrub species for different montane land sites

Site	Component	Regular	Random	Contagious	Diversity ($\bar{H}$)	CD	BD	Ec
BP	Trees	-	50.0	50.0	0.71	0.69	1.54	3.24
	Saplings	-	25.0	75.0	1.74	0.34	2.35	5.72
	Seedlings	-	25.0	75.0	1.69	0.37	2.50	5.85
	Shrubs	-	-	100.0	2.29	0.23	2.23	6.56
BG	Trees	-	33.5	66.5	1.39	0.42	1.71	4.41
	Saplings	-	20.0	80.0	1.32	0.53	2.35	4.47
	Seedlings	-	-	100.0	1.88	0.29	1.88	8.10
	Shrubs	-	-	100.0	2.49	0.18	2.40	12.00
UP	Trees	-	-	100.0	1.00	0.61	1.34	0.96
	Saplings	-	25.0	75.0	1.79	0.35	2.00	10.05
	Seedlings	-	50.0	50.0	1.53	0.40	2.14	4.19
	Shrubs	-	25.0	75.0	1.81	0.31	2.14	5.92
UG	Trees	-	50.0	50.0	0.65	0.72	2.29	2.84
	Saplings	23.0	12.0	65.0	1.32	0.46	2.00	5.32
	Seedlings	-	66.5	33.5	1.14	0.48	2.00	2.31
	Shrubs	-	-	100.0	1.90	0.28	2.67	10.84

Distribution pattern

On the majority of the sites, most of the trees, saplings, seedlings and shrubs were contagiously distributed. Regular distribution of tree, seedling and shrub species has so far not been observed on the BP, BG and UP sites (Table 3); however, only the UG site showed regular distribution (23.0%) in the sapling stratum.

Diversity and dominance concentration

The values of species diversity ($\bar{H}$) and concentration of dominance (CD) in the tree stratum were respectively, 0.71 and 0.69 (BP), 1.39 and 0.42 (BG), 1.00 and 0.61 (UP) and 0.65 and 0.72 (UG) (Table 3). The diversity indices for the tree stratum were higher on the burnt sites than on the unburnt sites. The diversity indices for saplings were higher on the protected sites than on the grazed sites, whether burnt or unburnt. The species diversity for seedlings ranged from 1.14 on UG to 1.88 on BG. The diversity index for the shrubs stratum was recorded maximum on BP (2.29), and minimum on UP (1.81).

Beta diversity and equitability

The beta diversity for the tree stratum ranged from 1.34 on UP to 2.29 on UG and equitability from 0.96 on UP to 4.41 on BG. For the sapling stratum, the beta diversity ranged from 2.00 on UP and UG to 2.35 on BP and BG, and equitability from 4.47 on BG to 10.05 on UP. The beta diversity for the seedling and shrub strata ranged from 1.88 on BG to 2.50 on BP, and from 2.14 on UP to 2.67 on UG respectively. The equitability for the seedling and shrub strata ranged from 2.31 on UG to 8.10 on BG, and from 5.92 on UP to 12.00 on BG respectively (Table 3).

Community coefficient

The maximum similarity in tree stratum between UP and UG (74.9%) was due to relative dominance of *Cupressus torulosa.* The minimum similarity was recorded between BG and UG (9.6%) (Table 4). The composition of sapling stratum also differed markedly among various sites. The highest degree of similarity was observed in the sapling stratum between UP and UG (78.6%). The lowest degree of similarity was recorded between BP and UG (14.5%). The composition of the seedling stratum also differed markedly among various sites. The maximum degree of similarity was recorded between BP and BG (65.9%). The minimum value of similarity was recorded between BG and UP (12.00%). Similar to the tree and sapling strata, the maximum similarity in the shrub stratum was between UP and UG (85.8%), the minimum value was recorded between BP and UP (45.7%).

Discussion

The values for tree basal cover and density in several temperate forests reported by different authors range from 15.61 to 59.31 $m^2 ha^{-1}$ and from 350 to 2080 trees ha^{-1} respectively (Saxena 1979). The basal cover and density values for the present study sites were not in the ranges reported for temperate forest but lower (1.25 to 14.76 $m^2 ha^{-1}$, basal cover; 37 to 312 trees ha^{-1}, density). The age of the forest and felling for wood might have been responsible for the reduction.

The A/F ratio indicates that most of the species on all sites were contagiously distributed. The only tree species on UP, *Cupressus torulosa*, showed contagious distribution. Contagious distribution in natural vegetation has been reported by Greig-Smith (1957), Kershew (1973) and Singh and Yadava (1974). Odum (1971) stressed that contagious distribution is the commonest pattern in nature, and it is due to small but significant variations in the environment. This is reflected in the results.

Table 4. Community coefficients calculated on the basis of density of tree, sapling, seedling and shrub species for different montane land sites

	BP	BG	UP	UG
BP				
Trees	100.0	63.8	00.0	12.7
Saplings	100.0	67.9	16.5	14.5
Seedlings	100.0	65.9	18.9	30.8
Shrubs	100.0	59.8	45.7	50.0
BG				
Trees		100.0	00.0	9.6
Saplings		100.0	25.0	24.4
Seedlings		100.0	12.0	22.4
Shrubs		100.0	57.6	67.1
UP				
Trees			100.0	74.9
Saplings			100.0	78.6
Seedlings			100.0	35.9
Shrubs			100.0	85.8
UG				
Trees				100.0
Saplings				100.0
Seedlings				100.0
Shrubs				100.0

The lower diversity in temperate vegetation could be due to lower rate of evolution and diversification of communities (Simpson 1949, Fisher 1960). Saxena and Singh (1982) reported diversity index values from 0.0 to 1.436 for trees + saplings and 0.0 to 0.943 for shrubs + seedlings, on the pine (*Pinus roxburghii*) forests of Kumaun Himalaya.

According to one current model of succession (Odum 1969, 1971, Cooke 1967,), there is a positive relation between biomass (here biomass is represented by basal cover) and diversity. However, as Loucks (1970) stated, the diversity of species may not necessarily approach maximum in mature stable stages of succession; at times diversity may actually decline as the successional stage reaches maturity. Hence, a very high value of diversity but relatively lower value of TBC of the mixed forest might be an indication of its being at a stage immediately proceeding to the climax stage (as is the case with the BG site) where, although *Pinus roxburghii* was a dominant species, another two species were also present. That it is not possible to predict the diversity in one stratum of the vegetation from the diversity values strata is also reported by Whittaker (1972).

Whittaker (1965) and Risser and Rice (1971) have reported the concentration of dominance values for certain temperate vegetation, ranging from 0.10 to 0.99, Knight (1975) an average value of 0.06 for a tropical forest, and Saxena and Singh (1982) values between 0.131 and 1.00 for woody species of forest communities of Kumaun Himalaya. Ralhan *et al.* (1982) reported values of 0.313 to 1.00, and Tiwari (1983) values of 0.106 to 0.933 for the tree layers in different forests of Kumaun Himalaya. In the present study, the concentration of dominance values for trees, saplings, seedlings and shrubs are more or less similar to those reported by these authors.

The beta diversity for the tree stratum was highest on the UG site and for the sapling stratum it was higher on the burnt sites than in the unburnt sites. The equitability for the tree and seedling strata was higher on the burnt sites in comparison to the unburnt sites. Less difference in the value of beta diversity indicates that the growth forms in the stands respond in similar fashion (Adhikari *et al.* 1991).

Saxena and Singh (1982) reported community coefficient values between 1.30 and 32.50%, Ralhan *et al.* (1982) between 8.11 and 64.18 %, and Tiwari (1983) between 0.0 and 67.43% for different forests of Kumaun Himalaya. However, Bankoti (1990) reported similarity between 63.30 and 74.60% for the *Pinus roxburghii* forest and Tiwari (1983) between 14.0 and 55.0% for the shrubs of different forests of Kumaun Himalaya. Saxena and Singh (1982) reported that shrub layers are relatively sensitive to changes in the aspects.

In the present study, the similarity values for different forest sites in the different strata are higher than those reported by these authors for Kumaun Himalaya. This may be attributed to the variations in the microclimate due to different aspects. Wikum and Wali (1974), and Saxena and Singh (1982) among others have pointed out the significant role of aspect in plant distribution.

Cupressus torulosa was the only tree species on the unburnt protected site. The results indicate that grazing on the unburnt site gave rise to the random growth in the tree stratum of *Pinus roxburghii* to compete with the *C. torulosa* (Table 2), but burning with or without grazing suppressed *C. torulosa* and encouraged the growth of *P. roxburghii* together with *Rhododendron arboreum* on the burnt protected site, which was replaced by *Myrica esculenta* and *Quercus leucotrichophora* on the burnt grazed site (Table 1). In the sapling and seedling strata, grazing of the unburnt site eliminated the growth of *Pinus wallichiana* and on burnt site, that of *Rhododendron arboreum*. In the shrub stratum, grazing of the unburnt site did not give rise to significant changes in terms of species composition, density and basal cover. However, this was not so for the burnt site. While the growth of *Rhus cotinus* was suppressed, that of *Pyracantha crenulata* was promoted. It is clear from the results that grazing and burning led to changes in the phytosociology of the vegetation.

It is presumed on the basis of observations that in future both the burnt forest sites will be dominated by *Pinus roxburghii*, (with some competition from *Myrica esculenta* and *Quercus leucotrichophora*, especially on grazed areas), and unburnt sites will be dominated by *Cupressus torulosa* which will be associated with either *Cedrus deodara* or *Pinus roxburghii* depending upon the level of competition in the sapling and seedling strata.

The present findings indicate that ground fire had not significantly affected the growth and mortality in the tree stratum. However, crown fire which results from the ascending ground fire often spreads from the pine forest to the adjacent oak forests and destroys the canopy, thus disturbing nutrient cycling and affecting the ecosystem functions. Opening up of the oak forests through fire provides suitable conditions for the pine (an early successional, low nutrient demander and shade intolerent species) to invade, thereby posing a serious threat to the ecological balance of this region (Singh *et al.* 1984). Thus we can establish a clear relationship among man, fire, pine forests and replacement of the oak forest in this part of the Himalaya (Semwal & Mehta 1996).

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