Research Paper Environment

Effect of Canopy Opening on Species Richness in P. Roxburghii Sarg (Chir-Pine) Forests in Uttarakhand Himalaya

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ABSTRACT

Increasing anthropogenic pressure and dependence on plant products have led to widespread exploitation of natural forests in Uttarakhand Himalaya. The study area is located between 29°20' and 29°30'N latitude and 79°23' and 79°42'E longitude between 1350-2000 m elevations in Uttarakhand Himalaya. In present study total 12 sites were selected in two forest types at low and high elevation. A total of 225 species were recorded from the study area out of which 32 were trees, 51shrubs and 142 herbs. Numbers of tree and shrub species richness were high in moderate canopy while herb species richness was maximum in open canopy. Herbs species richness was greater in pine dominated forest and low elevation. Mean tree species richness was not significantly varied from one canopy cover to another. Mean tree species richness increase from open to close canopy while reverse for shrub and herb species richness. High proportion of early successional species in disturbed forests indicated that disturbance induces succession.

Keywords : cover, forest, elevation, richness.

INTRODUCTION

Disruption of forest structure by natural and anthropogenic disturbance alters species richness and other ecosystem properties (Kumar and Ram 2005).The variation in total species richness is mostly influenced by the herbaceous species, whereas woody plants have no detectable response pattern (Grime 1979, Huston 1979 and Tilman 1988). Species richness is one component of the concept of species diversity, which also incorporates evenness, that is, the relative abundance of species. Species diversity is one component of the broader concept of biodiversity. The human induce disturbance is one of the major factor for opening of forest canopy and as a consequent the change in environmental conditions which may responsible for change in community structure in the forest. Principal environmental factors such as climate, soil type and disturbance strongly influence ecosystem functioning (Macgillirary et al. 1995 and Wardle et al. 1997), but like wise organisms can affect their environment (Jones et al. 1997). This can come about as a result of variation in the frequency, timing, or intensity of events such as forests, rainfall, soil disturbances, herbivore outbreak, or drought, as long as species exhibit such difference in their responses to one or more of these factors. In many communities, species richness is greatest at intermediate frequency and/or intensity of disturbance. Species richness varies in scale from global to local (Huston 1994 and Rosenzweig 1995), but there are no studies in which local-scale species richness patterns are considered at the global scale.

Biodiversity has often been considered as a structural community attribute, in terms of species richness and derived informational indices (Samules and Darke 1997). Its relationship with plant species richness and other parameters in the Himalaya were described by(Grytenes and Vetaas 2002, Battarai et al. 2004, Vetaas and Chaudhary 1998, Vetaas and Grytenes 2002, Ram et al. 2004 and Kumar and Ram 2005). Increasing anthropogenic pressure on forest biodiversity over the few decade and consequent dependence on plant products has led to vast exploitation of natural flora in Uttarakhand Himalaya. Anthropogenic disturbances play an important role in change, loss or maintenance of plant biodiversity and more recent phenomenon of climate change will also be responsible for the change in species composition and other ecosystem activities.

The aim of the present study was to identify the variation in species richness and other community characteristics in Pinus roxburghii dominated forest and mixed broadleaf forest.

MATERIAL METHODS

The sites of the present study are located between 29º 20´ and 29º 30´N and 79º 23´ and 79º 42´E. The Kumaun hills lie in the North-Eastern part of the Uttarakhand Himalaya. The forest were thoroughly surveyed and identified as P. roxburghii sarg (chir-pine) are dominated at low to high elevation (1200-2000m). The chir-pine either present in pure stand or mixed with other broadleaf evergreen and deciduous species at low elevation while it mixed with oak and other broadleaf species toward high elevation.

The climate of the study area is influenced by monsoon pattern of rainfall. The rainfall and temperature data were taken from Aryabhatt Research Institute of Observational Science (ARIS), Nainital during the study period (2003-2006). All the study sites have close proximity to this meteorological station. The total rainfall ranged between 1486.8 and 2213.4 mm. The mean monthly rainfall (average of three year) was 2.25 mm (November) and 498.5 mm (July). The mean maximum temperature varied from 12.5ºc (January) to 24.9ºc (June) and mean minimum temperature from 5.0ºc (January) to 17.4ºc (June). Rocks of the study area are mainly sandstones, conglomerates, limestone, quartzite, schists, granites and gneisses (Valdiya 1980). Except for the foothill area where soil is alluvial, it is residual and generally shallow. However, on gentle slope, it may be fairly deep and colluvial. The forest soils are predominantly brown earth.

A total of 12 sites were selected in two forest types at low (1300-1600m) and high (1700-2000m) elevations. In each site, 3 canopy treatments (12x3) were identified and selected for the detailed study of species richness. Thus, in each forest

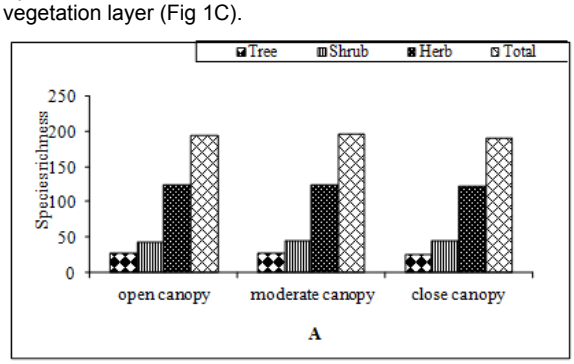
it was 2 elevation x 3 site x 3 canopy (18 plots). Similarly, in each elevation it was 2 forest x 3 site x 3 canopy (18 plots). In each site, almost all species present (>90%) were collected, preserved, brought to the laboratory and identified with the help of plant taxonomist. Forest Flora of Kumaun (Osmaston 1926), Flora Simlensis (Collet 1902) and Flowers of the Himalaya (Pollunin and Stainton 1984) were also consulted for plant identification.

All species present in a site were considered as total species richness. Species richness was determined as the number of species per unit area (Whittaker 1972 and 1975). Mean species richness for tree, shrub and herb was analyzed in 20 randomly placed plots on each site. Trees were analyzed in 10 x 10 m, shrub in 5 x 5 m and herb in 1 x 1 m plots. The variation in species richness was studied along the canopy cover, forest types, elevations and sites. Comparison of total species richness for tree, shrub and herb were made between the canopy cover, forest types and elevations. The percent common and distinct species between canopy cover, forest types and elevations were also analyzed. Variation in growth forms in relation to canopy gap, forest type and elevation were also analyzed for herbs. Therefore, herbs were categorized in different growth forms based on their growing habit as: Erect tall: grow straight vertically with height generally >30cm, Erect short: grow straight vertically with height generally <30cm, Spreading and Climber/Creepers: spreading on the ground or several leaves arose from the base or creeping on ground surface including climbers and Grasses and Sedges: graminoides and members of cyperacae.

Data were analyzed using SPSS ver 12.0 program (SPSS 2003). Variation in species richness for canopy gaps, forest type and elevation was also analyzed using GLM univariate ANOVA program. Mean species richness were analyzed for each canopy cover as, 3 cover x 2 forest x 2 elevation x 3sites x 20 plots (total 720 plots), forest types as, 2 forest x 3 cover x 2 elevation x 3 sites x 20 plots (total 720 plots) and elevation as, 2 elevation x 3 cover x 2 forest x 3 sites x 20 plots (total 720 plots). Least significant difference (LSD) was also determined to differentiate richness among canopy gaps (disturbance). Comparison of mean (t- test) was also applied to differentiate species richness between forest type and elevation.

RESULT

A total of 225 species were recorded from the study area out of which 32 were trees, 51 shrubs and 142 herbs. Across all canopy the total species richness was maximum in moderate canopy followed by open and close canopy. Total trees and shrubs species richness were maximum in moderate canopy compared to open and close canopy while herbs species richness was maximum in open canopy (Fig 1A). Between the forests, total richness was greater in pine dominated forest compared to mixed broadleaf forest. Greater number of tree species richness was present in mixed broadleaf forest (30) in contrast to this shrub (45) and herb species richness were greater (138) in pine dominated forest (Fig 1B). Tree and herb species richness was greater at low elevation while shrub species richness was similar between low and high elevation. Species richness was maximum at low elevation for the entire vegetation layer (Fig 1C).



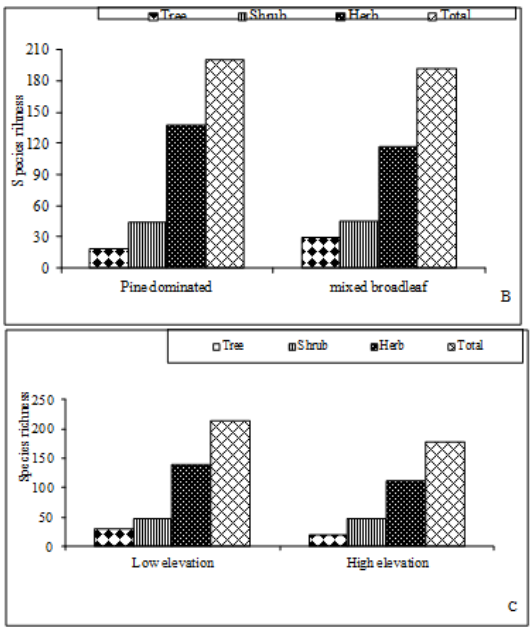


Fig. 1 Variation in species richness, a. among the canopy cover; b. between forest types and c. between low and high elevation

The maximum percent common species (81.3%) was in open-moderate canopy for tree layer, moderate-closed canopy for shrub (80.4%) and moderate-close canopy (82.4%) for herb layer (Fig 2a).The percent common species between pine dominated-mixed broadleaf were 50% for tree, 78.4% for shrub and 86.6% for herb (Fig 2b), while it was 71.9% for tree, 86.3% for shrub and 89.4% for herb between low and high elevation forests (Fig 2c).

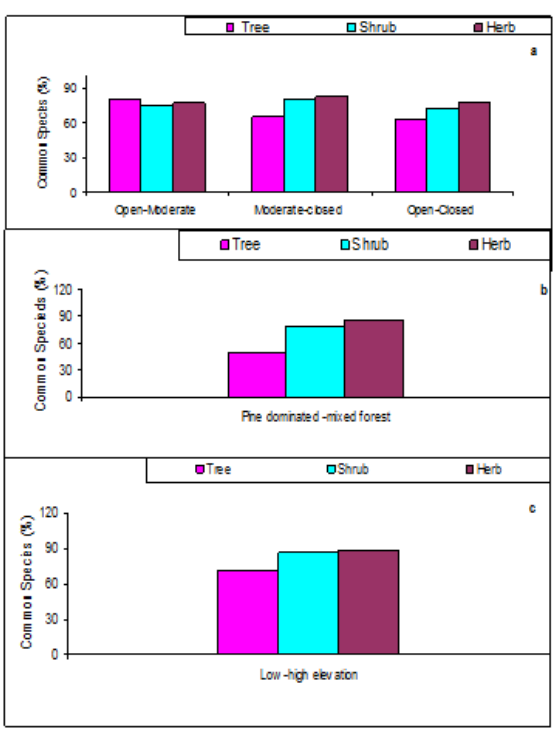


Fig 2. Variation in common species: a. among the canopy covers; b. between in forest types and c. between low and high elevation

Only one or two tree and shrub species were restricted in moderate and close canopy while greater numbers of herbs

were restricted in open and moderate canopy. Almost similar amount of shrub species restricted in both the forest types. Within elevation, restricted number of tree, shrub and herb were greater at low elevation compared to high elevation. Thus, forest may have greater control over species composition compared to disturbance and elevation (Table 1).

	FOREST		ELEVATION		CANOPY COVER		
	Pine dominated forest	Mixed broadleaf forest	Low elevation	High elevation	Open canopy	Moderate canopy	Close canopy
Tree	2	15	5	4	0	1	2
Shrub	5	5	4	3	1	2	2
Herb	9	2	7	6	5	4	1
Total	16	22	16	13	6	7	5

Table 1 Number of restricted species

VARIATION IN HERB GROWTH FORMS

The proportion of herb in different growth forms ranged between 27.0 and 31.9% for erect tall, 31.9 and 35.7% for erect short, 16.8 and 19.8% for grass/sedge and 17.5 and 18.5% for spreading herbs/climber along the canopy cover (Fig 3a). Species richness between forest types ranged from 28.8-29.4% for erect tall, 33.1-33.8% for erect short, 19.4-19.9% for grass/sedge and, 17.6-18.0% for spreading herbs/climbers. Little or no variation in growth forms between forest types indicated that the growth forms were least affected by the forest types (Fig 3b). Erect tall varied from 30.4-30.8%, erect short 28.6-31.2%, grass/sedge 20.3-21.3% and spreading herbs/climbers 18.1-20.3.0% between low and high elevation (Fig3c). Erect short herbs were greater at low elevation whereas spreading herbs/climber were low. Erect tall and erect short comprised >60% composition in pine forest (Fig 4 b) as well as at low elevation (Fig 3c).

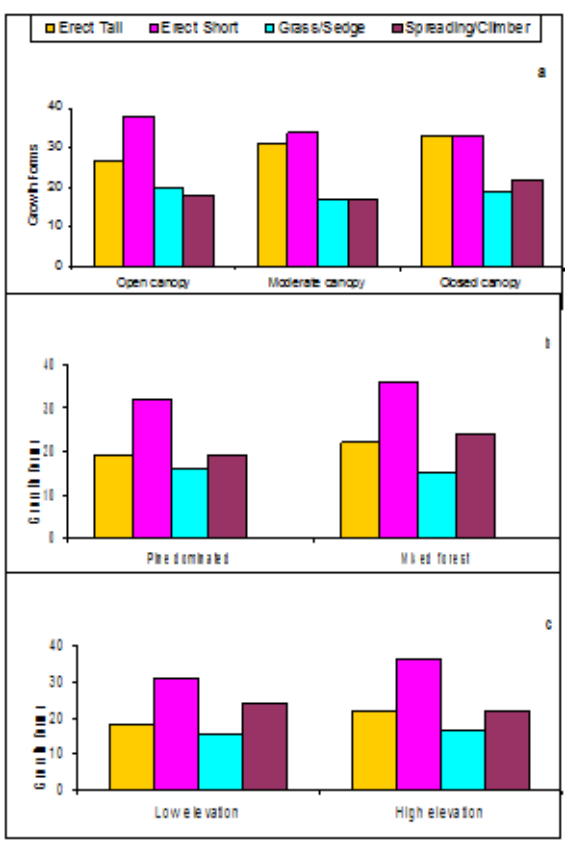


Fig 3. Variation in Growth forms: a. among the canopy cover; b. between in forest types and c. between low and high elevation

VARIATION IN MEAN SPECIES RICHNESS ALONG THE CANOPY

ANOVA indicated that mean tree species richness was not significantly varied from one canopy cover to another (Table 2), whereas mean shrub ($p<0.01$) and herb species richness ($p<0.01$) varied from one canopy cover to another. Mean tree species richness varied from 1.7±0.06 tree/100m² for open canopy and 1.8±0.06 tree/100m² for closed canopy forest. Mean shrub richness was 4.3±0.13 shrub/25m² for closed canopy and 5.0±0.17 shrub/25m² for open canopy forest. LSD indicated that shrub richness was significantly low in close canopy compared to moderate and open canopy. Herbs richness ranged between 6.5±0.12 herb/m² for moderate canopy and 7.0±0.12 herb/m² for open canopy forest (Table 3). LSD indicated that herb richness was significantly low ($p<0.01$) in moderate canopy compared to open and close canopy. It was not significant different for open and close canopy.

Source	Mean square	df	F	Sig (p<)
Tree				
Cover	0.6	2	1.1	NS
Forest	54.2	1	119.3	0.01
Elevation	0.3	1	0.6	NS
Shrub				
Cover	28.1	2	9.3	0.01
Forest	2.9	1	0.9	NS
Elevation	22.1	1	7.3	0.01
Herb				
Cover	47.8	2	7.8	0.01
Forest	12.4	1	2.0	NS
Elevation	79.0	1	12.9	0.01
Season	2937.9	2	479.2	0.01

Table 2 ANOVA for mean species richness for different treatments

Parameter	Tree (tree/100m²)	Shrub (shrub/25 m²)	Herb (herb/ m²)
Open canopy	1.7±0.06	5.0±0.17	7.0±0.12
Moderate canopy	1.7±0.06	4.9±0.13	6.5±0.12
Closed canopy	1.8±0.06	4.3±0.13	6.9±0.12

Table 3 Effect of canopy cover on mean species richness

VARIATION IN MEAN SPECIES RICHNESS BETWEEN FORESTS

ANOVA indicated that the mean tree species richness significantly varied ($p<0.01$) from one forest to another forest (Table 2). It was high (2.0±0.05 tree/100m²) in mixed forest ($t0.05=8.7$) as compared to pine dominated forest. Mean shrub species richness was not significantly different from one forest to another forest. It varied from 4.7±0.11 to 5.1±0.13 shrub/25m² (Table 4). Mean herb species richness was not significantly different from one forest to another forest. It was greater (7.1±0.14 herb/m²) in pine dominated forest as compared to mixed broadleaf forest (Table 4). Tree and shrubs species richness were high in mixed broadleaf forest and herb in pine dominated forest.

Parameter	Pine dominated forest	Mixed broadleaf forest
Tree (tree/100m²)	1.4±0.04	2.0±0.05
Shrub (shrub/25m²)	4.7±0.11	5.1±0.13
Herb (herb/m²)	7.1±0.14	6.6±0.13

Table 4 Effect of forest types on mean species richness

VARIATION IN MEAN SPECIES RICHNESS BETWEEN ELEVATION

ANOVA indicated that the mean tree species richness was not significantly varied from one elevation to another, while mean shrub ($p<0.01$) and herb ($p<0.01$) species richness was significantly varied from one elevation to another (Table 2). The Mean tree (1.7±0.07 tree/100m²) and herb (6.9±0.21

herb/m²) species richness was greater at low elevation while shrub (5.1±0.0.16) shrub/25m² at high elevation (Table 5). Comparison of mean between low and high elevation for shrub (t0.05=2.2) and herb (t0.05=1.8) was not significant.

Parameter	Pine dominated forest	Mixed broadleaf forest
Tree (tree/100m²)	1.7±0.07	1.6±0.07
Shrub (shrub/25m²)	4.7±0.18	5.1±0.16
Herb (herb/m²)	6.9±0.21	6.7±0.21

Table 5 Effect of elevation on mean species richness

DISSCUSION

The forest of Uttarakhand Himalaya are witnesses various disturbances which influence the distribution and composition of species in different canopy openings, forests and elevations. Number of total species was high in moderate canopy, because it contains species both from open as well as close canopy. Trees and shrubs were maximum contributor for this high richness in moderate canopy. Moderate canopy favours the species richness because it develops various environmental conditions especially the availability of light, soil nutrients and moisture. While open canopy witnesses the continuous disturbance in the form of removal of seedling through grazing and cutting of grasses of almost all species. The moderate and low disturbed forests were situated far away from the human habitation except pure P. roxburghii forest and used by the local inhabitant when resources are not available in nearby forest (Kumar and Ram 2005). The high number of herbs in close canopy may be due to retention of moisture for longer period in the soil which favour the regeneration of many herbs.

Percent common tree species was maximum in open-moderate canopy, while shrub and herb species in moderate-close canopy. Thus, canopy species varied from one canopy to another while greater than ¾ shrubs and herbs were common among the canopy opening. This indicated that opening of canopy does not indicate much effect on shrub and herb richness, while, its effect the regeneration of tree species supports regeneration of other tree species with opening of canopy. This may be due to presence of both early and late successional shrub and herb species in open-moderate canopy. The requirement of light varies with species. In other words, various species show varying tolerance to light intensity as light demanders species required sufficient light for early growth and development of plant species, shade bearers species grow and developed in low light condition while shade demanders species required low light during germination and early growth. Between pine dominated and mixed broadleaf forests the common species was low. This may be due to the fact that dominant forest forming species may decide the composition of other species. The canopy openings and likely in influence the ability of different species establish and grow in the environmental mosaic in a forest (Whitmore 1978). Restricted tree species were high in close canopy and herbs in open canopy. Similar numbers of restricted shrubs were present in moderate and close canopy.

In the present study, the total numbers of species reported were 225 out of which open (194), moderate (197) and close (191) canopy. Between the forests, 201 species were present in pine dominated forest and 192 species in mixed broadleaf forest. Thus, the value is greater than that reported for these forests by several other workers in different tropical and temperate forest (Table 6). Species richness reported for Pinus roxburghii forest varied from 12-142 (Ram et al. 2004, Rawal 1991 and Chandra 1991). Similarly, 35-160 species were reported for mixed broadleaf forest (Khera et al. 2001). The diverse ecological condition like variation in canopy cover, forest types, topography, soil and climate may favour the greater number of species in the area. High richness may be of diverse habitats and suitable edaphic and climatic factors supporting growth and survival of the species (Pant and Samant 2007). Tree and herb was higher in mixed broadleaf forest compared to pine dominated forest while herbs were high in pine dominated forest. >60% species were erect tall and short in pine dominated forest as well as in low elevation, indicated the presence of favorable soil and other growth conditions which provide wide niche for the growth and development of various species. Grasses contributed less than one-fifth of the total herbaceous species. The mean tree species richness was increased in mixed broadleaf forest and herb species richness was increased in pine dominated forest. High species richness in the Pinus roxburghii- mixed broadleaf forest (Rathor 1993 and Singh and Singh 1987).

The total species richness was greater in low elevation because the mixtures of tropical and subtropical species are present while high elevation increase the dominance of few species. The distribution of species richness along elevation gradients is governed by a series of interacting biological, climatic and historical factors (Collwell and Lees 2000). Different historical and climatic variable have been used to explain the variation of species richness along elevational gradients (Rahbek 1995, 1997, Vetaas 1997, Grytenes et al. 1999, Odland and Briks 1999, Lomolino 2001, Bhattari and Vetaas 2003 and Grytenes 2003). Further elevation represents a complex gradient along which many environmental variable changes simultaneously (Austin et al. 1996). The temporal pattern of disturbance can coincide with the timing of reproduction and recruitment, which may result in an increase in the variability of both individual taxa and assemblages due to fluctuating resources level and competitive interactions (Benedetti-Cecchi 2000 and Bertocci et al. 2005). When the disturbance continues for long periods, the forest ecosystems are degraded and eventually transformed into other land uses. However, if the factors causing the disturbance ceases to act, secondary succession process sets in, leading to recovery towards the original state (Srivastava and Singh 2005).

In shrubs, mean species richness was maximum in high elevation, while mean herb species richness was maximum in low elevation. The observed species richness reaches a maximum at the lower end of the altitudinal gradient (Vetaas and Geytens 2002). The elevation gradient of species richness is intricately related to species-latitude and species-area relationship (Lomolino 2001). Thus, it concluded that Pinus roxburghii dominated forest with periodic disturbance important to maintain species richness, conservation of soil and ecosystem as whole compare to mixed broadleaf forest.

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