Forest disturbance and its impact on species richness and regeneration of Uttarakhand Himalaya

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Abstract: Increasing anthropogenic pressure and dependence on plant products have led to widespread exploitation of natural forest in Uttarakhand Himalaya. The study area is located between 29^0 20' and 29^0 30' N latitude and 79^0 23' and 79^0 42' E longitude between 1350-2000 m elevation in Uttarakhand Himalaya. A total of 225 species were present in different canopy cover out of which open (194), moderate (197) and close (191). Mean species richness was maximum in close canopy, while mean shrub and herb species richness was open canopy. Mean tree species richness was not significantly varied from one canopy cover to another. High proportion of early successional species in disturbed forest indicated that disturbance induces succession.

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Introduction

The most striking features of the earth is the existence of life and most striking features of life is the diversity. Topography, soil, climate and geographical location of the region influence the vegetation diversity of the forest ecosystem of Himalaya. The Himalayan vegetation ranged from tropical dry deciduous forests in the foothills to alpine meadows above the timberline (Singh and Singh 1992). Trees of Pinus roxburghii, the dominant species from low to mid elevation, were harvested on a large-scale in 1960s and 1970s for timber and other industrial raw materials and thereafter the continued disturbances either geological or anthropogenic is severely threatening the biological diversity. The geological disturbances are landslide, soil erosion and earthquakes while the anthropogenic disturbances include deforestation, grazing, lopping of tree branches for fodder and fuel wood, removal of leaf and wood litter from the forest floor and frequent fire. Both the disturbances are affecting ecosystem stability and retarding the successional process. Anthropogenic disturbances occur in chronic form involving removal of small amount of biomass on any given time, but persisting all the year, without any respite for recovery (Singh 1998). Structural characteristics of the Himalayan forest have been studied by various workers (Ralhan et al. 1982, Saxena and Singh 1982, Saxena et al. 1984, Upreti et al. 1985, Singh and Singh 1986, 1987, 1992, Singh et al. 1994, Rathore et al. 1997). Biodiversity of the Himalayan forest and hot spots were studied by Dhar et al. (1997), Silori (2001) and Khera et al. (2001) have been studied the biodiversity and vegetation characteristics of degraded Himalayan forests.

The Indian subcontinent is a region of moderate to very high biodiversity including two of the global hot spot of vascular plant endemism in the Western Ghats and Eastern Himalaya (Myers et al. 2000). In Uttarakhand, Composition of the forest diverse and varies from place to place because of varying topography such as plains, foothills and upper mountains (Singh 2006). Species richness is a simple and easily interpretable indicator of biological diversity (Peet 1974). Many types of environmental changes influence the process that can both augment or erode diversity (Sagar et al. 2003). Ellu and Obua (2005) have suggested that different altitudes and slops influence the species richness and dispersion behaviour of tree species. Moreover, Kharakwal et al. (2005) have pointed out that altitude and climatic variables like temperature and rainfall are determinants of species richness. Diversity of life-forms usually decreases with increasing altitude and one or two life-forms remain at extreme altitudes (Pavon et al. 2000). Austin et al. (1996) have analyzed association between species richness, climate, slope position and soil nutrient status.

Most of the human populations are concentrated between 1000 and 2000m elevation in mountainous zone of Uttaranchal, Central Himalaya (hereafter Uttaranchal Himalaya) where the forest are severely impact by human activities. The earlier studies were concerted on general vegetation analysis and biodiversity of a particular forest. Thus, the present study is an attempt to describe the disturbances and its influence on the biodiversity. The objectives of the present study were: (i) to identify the different anthropogenic disturbances present in various canopy cover (ii) influences of disturbance in species richness and diversity (iii) to observe the variation in different community characteristics in relation to disturbance.

Material method

The study area is located between 29^0 20' and 29^0 30' N latitude and 79^0 23' and 79^0 42' E longitude at an elevation of about 1300-2000m in Uttaranchal Himalaya. The study site was dominated by Pinus roxburghii sarg. and Quercus leucotrichophora A. camus forest. Monsoon pattern rainfall influences the climate of the area. The study sites were located within 2-10 km distance from one-another. The total rainfall was 1486.8 to 2213.4mm (2003-2006). The mean monthly rainfall (average of three year) was 2.25 mm (November) and 498.5mm (July). The mean maximum temperature varied from 12.5^0 C (January) to 24.9^0 C (June) and mean minimum temperature from 5.0^0 C (January) to 17.4^0 C (June). The rocks of the study area are mainly sand, stone, conglomeration, lime stone, quartzite, schist's and granites (Valdiya 1980).

A total of 36 sites were selected in the three different canopy treatment (open canopy <30%, moderate canopy 30-60% and >60%) were identified and selected for the detailed study of vegetation analysis. All the three layers of forest vegetation i.e. trees, shrubs and herbs were analyzed for detailed vegetation parameters. The size and number of the samples were determined according to Saxena and Singh (1982). The trees were sampled as above 30cm cbh (circumference at breast height). Circumferences at breast height (1.37m) were taken for btree to determine the basal area while cover was taken for shrub and herb. 20 quadrats of 10x10m were randomly placed for analysis of tree vegetation while shrubs were analyzed in 2, 5x5m quadrats. Similarly, herbs were analyzed in 20, 1x1m quadrats at each site. Tree basal area was measured as:

Basal area = $C^2/4\pi$

Where 'C' is the circumference at breast height.

The cover of shrubs was measured by taking line transect of 5m. Herb cover was determined by placing a transects of 1m on the ground and percent ground cover occupied by each herb species was noted avoiding overlapping (Mishra 1968). The vegetational parameters were quantitatively analyzed for density (Curtis and Mc Intosh 1950).

Species diversity was calculated using Shannon-Wiener information index (Shannon and Weaver 1963).

$$H = -\sum (Ni/N) \log_2 (Ni/N),$$

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

Index of similarity (IS) between forests was calculated following Sorenson (1948) using species richness in different forests as:

$$\text{Index of similarity (IS)} = \frac{2C}{A+B} \times 100$$

Where, C is the common species in comparison forests. A and B are the total number of species in forest A and B, respectively.

Data were analyzed using SPSS Ver 12.0 program (SPSS 2003). Variation in vegetation for canopy gaps was analyzed using GLM univariate ANOVA program. Mean density and total basal area were analyzed for each canopy cover.

Result

Tree canopy cover is one of the important parameters for the measurement of disturbances. Actual canopy cover in high disturbed forest was 28% while it was 59% for moderate and 74% for low disturbed forest.

A total of 225 species were present in different canopy cover out of which open (194), moderate (197) and close (191) (Arya 2009). Mean tree species richness was maximum for close canopy and minimum for open canopy cover. ANOVA indicated that tree species richness was not significantly varied from one canopy cover to another, while shrub ($P<0.01$) and herb ($P<0.01$) was significantly varied from one canopy cover to another (Table 1). Tree and shrub diversity was maximum in close canopy compared to open and moderate canopy, while herb diversity was maximum in open canopy compared to moderate and close canopy.

Community structure

Tree layer

Species composition of this canopy indicates the dominance of few species in these canopy cover. 4 trees, 7 shrubs and 6 herbs have IVI≥10% out of total 225 species, while large numbers of species have IVI≥10%**.** Thus, only less than one forth species were dominated the canopy cover. Pinus roxburghii and Quercus leucotrichophora were found in open, moderate and close canopy cover while Myrica esculanta was widely distributed from open and close canopy cover. Thus, Quercus leucotrichophora was the late successional potential tree species of these forests and have under great anthropogenic pressure. It used for fodder, fuel wood and in agricultural activities. Distribution of Lyonia ovalifolia was restricted only in open canopy.

Total tree density ranged from 307.8-376.5 trees/ha and total basal area 28.4-35.1 m^2/ha. In open canopy, individual tree density ranged from 0.5-183.5 trees/ha. It was maximum for Pinus roxburghii and minimum for Ficus roxburghii, Oliea glandulifera and Toona ciliate. Basal area of individual species varied from 0.01-18.9 m^2/ha and it was maximum for Pinus roxburghii and minimum for Oliea glandulifera and Sapium insigns. Pinus roxburghii (IVI=180.1) was the dominant species followed by Ouercus leucotrichophora (IVI=49.3). In moderate canopy, individual density ranged from 0.5-200.5 trees/ha. It was maximum for Pinus roxburghii and minimum for Cedrus deodara, Litsea umbrosa, Prunus cericeoidis, Quercus glauca and Shorea robusta. Basal area of individual species varied from 0.01-24.9 m^2/ha and it was maximum for Pinus roxburghii and minimum for Cedrus deodara and Prunus cericeoidis. Pinus roxburghii (IVI=190.9) was the dominant species followed by Quercus leucotrichophora (IVI=47.1). In close canopy, individual density ranged from 0.5-203.3 trees/ha. It was maximum for Pinus roxburghii and minimum for Bauhinea varigata, Cornus macrophylla, Glochidum spp. And Simplocos ferrugioria. Basal area of individual species ranged between 0.01 and 24.9 m^2/ha and it was maximum for Pinus roxburghii and minimum for Cedrus deodara and Cornus macrophylla. Pinus roxburghii was the dominant species (IVI=174.8) followed by Quercus leucotrichophora (IVI=52.3).

ANOVA indicated that mean tree density and total basal are was significantly varied ($P<0.01$) from one canopy cover to another (Table 4.2). LSD indicated that tree density was high in close canopy ($P<0.01$) compared to open and moderate canopy.

Shrub layer

Total shrub density ranged between 26107 and 28546 shrubs/ha and total cover 45.8 and 50.6%. in open canopy, individual density ranged between 26.7 and 4265 shrubs/ha and shrubs cover between 0.04 and 5.0%. Both density and shrub cover were maximum for Eupatorium cannabinum and for Jasminum humile. There was no clear cut dominance of any shrub species in open canopy and thus a large number of species contributed to the community. The highest IVI was shown by Eupatorium cannabinum (IVI= 32.0) followed by Rubus ellepticus, Berbaris asiatica, Messia indica, Myrsine africana and Lantana camara. In moderate canopy, individual shrub density ranged between 33.3 and 2908 shrubs/ha. It was maximum for Eupatorium cannabinum and minimum for Jasminum humile. Individual shrub cover ranged between 0.03 and 5.1%. It was maximum for, Berbaris asiatica and Eupatorium cannabinum and minimum for Desmodium pulchalum. Similar to open canopy, there was no clear cut dominance of any shrub species in moderate canopy. The highest IVI was shown by Messia indica (IVI= 29.1) followed by, Berbaris asiatica, Rubus ellepticus, Eupatorium cannabinum, Lantana camara, Myrsine africana and Flemingira bractcata. In close canopy, individual shrub density was maximum in Myrsine Africana (2658 shrubs/ha) and minimum for Woodfordia fruticosa (21.7 shrubs/ha). Shrub cover was maximum for Eupatorium cannabinum (5.8%) and minimum for Woodfordia fruticosa (0.02%). Again there was no clear cut dominance of any shrub species in close canopy. The highest IVI was shown by Eupatorium cannabinum (IVI= 13.7) followed by Messia indica, Rubus ellepticus, Myrsine Africana, Berbaris asiatica and Lantana camara.

ANOVA indicated that mean shrub density was not significantly varied from one canopy cover to another while shrub cover was significantly varied ($P<0.01$) from one canopy cover to another (Table 4.2). LSD indicated that shrub cover was high in moderate canopy ($P<0.01$) compared to open and close canopy.

Herb layer

Total herb density ranged from $11.4x10^5$-$13.4x10^5$ herbs/ha and herb cover 15.3-20.4% during rainy season. In open canopy, individual herb density varied from 166.7-$1.5x10^5$ herbs/ha. Density was maximum for Carex nubigena and minimum for Arsaema consangiuineum and Cinus orgyracanthus. Individual herb cover varied from 0.01-1.2% and it was maximum for Justicea simplex and minimum for Arudinella nepalens, Bigonia ruregulate, Dicrocephala neaplense, Oplismenu undulatifolium, Origanum valgare, Sctelleria angulosa, Smilex parviflia and Sonchus asper. None of the species was dominated in open canopy. Justicea simplex and Carex nubigena (IVI= 21.0) followed by Oplismenus compositus, Polygonum capitatium and Pouzolzia hitra were the important herb species. In moderate canopy, individual density ranged between 83.3 and $0.9x10^5$ herbs/ha. It was maximum for Justicea simplex and minimum for Androsaceae lanuginose. Individual herb cover varied from 0.01-0.9%. it was maximum for Polygonum fulganes. Polygonum fulganes indicated high dominance (IVI=18.3) followed by Justicea simplex, Pouzolzia hitra and

Oplismenus compositus were the dominated herb species. In close canopy, individual herb density varied from 125.0-0.7x9x10^5 herbs/ha and it was maximum for Justicea simplex and minimum for Dipsacus inermis, Vicalia achilliofalia and Verbasecum thapsus. Individual herb cover varied from 0.01-0.09%. it was maximum for Justicea simplex and minimum for Clematis Montana, Conyza stricta, Csassia mumasoidis, Dicrocephala neaplense, Pouzolzia hitra, Sedum linearifolium and Swertia chirata. Oplismenus compositus indicated high dominance (IVI= 18.1) followed by Justicea simplex were the dominant herb species.

ANOVA indicated that herb density and herb cover were significantly varied from one canopy cove to another ($p<0.01$). LSD indicated that herb density and herb cover were high in open canopy ($p<0.01$) compared to moderate canopy.

Population structures were developed to observe the regeneration status of important species. Four dominant tree species (based on vegetation analysis) were considered to understand regeneration pattern in different canopy cover.

Vegetation analysis data indicated that P. roxburghii was the dominant species followed by Q. leucotrichophora, M. esculenta and L. ovalifolia in open canopy. P. roxburghii was the dominant species followed by Q. leucotrichophora in moderate canopy and P. roxburghii was the dominant species followed by Q. leucotrichophora and M. esculenta in close canopy (fig. 1). The seedling density of all the species were low as compared to the sapling density. The individuals in older size classes was almost absent for all the species. Seedling of P. roxburghii and Q. leucotrichophora were present in all canopy gaps. Seedlings of M. esculenta were present in open canopy and absent in close canopy. Similarly, no seedling was observed for L. ovalifolia. Saplings were available for all the important species across the canopy gaps.

Similarity

High similarities in tree and shrub species richness were present between open-moderate canopies. These canopies have greater than 90% similarity and all other comparison canopy had low. High similarity in herb species richness in moderate-close canopies. Similarity between 50-80% was for same moderate and close canopy (Table 3).

Discussion

The biodiversity is the main source of livelihood of the people living in the Uttarakhand, Central Himalaya. Agriculture is the main occupation around which all the human activities are centered. Agriculture is mainly managed at the cost of surrounding natural forests. Forest present around the crop fields are highly degraded due to continuous anthropogenic disturbances. Thus, biodiversity of these forests is under great anthropogenic pressure.

In the present study, the total numbers of species reported were 225 out of which open (194), moderate (197) and close (191) canopy. Total species richness was maximum in moderate canopy sites. Trees and shrubs were greater in moderate canopy while herb in open canopy. The presence of favourable environmental condition especially the availability of light, soil nutrient and moisture may be responsible for this greater herb species richness. However, total tree, shrub and herb richness were not much varied among the canopy gaps. Kumar and Ram (2005) reported that the moderate and low disturbed forest were situated for away from the human habitation except pure P. roxburghii forest and used by the local inhabitant. Richard (1952) reported that most of the vascular plant species in the forest, especially understory herbaceous species, grow in the high light environment of canopy gaps and absent from the surrounding closed forest.

Tree density was high in close canopy while shrub and herb density was greater in open canopy cover the high density of trees with close canopy provides moisture and humus which are essential or the seed germination and growth of most of the shade bearer species. The high density of trees may be due to low disturbance which provide opportunity for formation of seeds, seed germination and seedling growth. However, establishment and survival of the entire seedling also depends upon several other factors (Samant et al. 2002 and Joshi 2002). The shrub density was not significant along the canopy gap but relatively high in open canopy while herb density was significantly high in open canopy. This indicated that the shrub and herb required abundant light for there growth and development apart from other resources. Competition among shrub and herb for light as a limiting resource that determines the understory of a forest tends to be denser in an open canopy patch than in one where there large gaps absent between tree canopies (Moore and Vankal 1986 and Welder et al. 1991). Nath et al. (2005) reported that the low density of herb in the moderate disturbed stand is due to low insulation on the forest floor owing to close canopy cover. The total tree basal area was high in moderate and close canopy indicated that the tree size is not much influence by opening of space. Tree and shrub diversity was high in close canopy and herb diversity in open canopy. Great diversity in a close canopy had also been observed by Moral (1972) and Zobel et al. (1976). Herbaceous diversity was comparatively high where forest was open (Kharakwal et al. 2007).

The density value of seedling and saplings are considered as an indicator of regeneration potential of the species. The presence of good regeneration potential shows suitability of a species to the environment while climatic factors and biotic influence the regeneration of different species of the vegetation (Dhaulichandi et al. 2008). The regeneration of tree generally depends upon the ability of trees to provide sufficient seeds, their ability to germinate and grow as seedlings, and survive in the undercanopy environment, where soil moisture and light may often be limiting (Kozlowaki 1971 and Good and Good 1972).

The regeneration was poor in moderate canopy compared to open and close canopy. This could be attributed to poor soil depth, frequent grazing and trampling of the area. In open, moderate and close canopy, P. roxburghii was the dominant tree species while Q. leucotrichophora, M. esculenta and L. ovalifolia were co-dominant. Seedlings of P. roxburgii and Q. leucotrichophora were present in all canopy gaps while seedling of L. ovalifolia absent in open canopy and M. esculenta seedling in close canopy. The presence of good regeneration potential shows suitability of a species to its environment. In the case of declining population, the absence of seedling and sapling, probably indicates recent disturbance, preventing the regeneration (Upreti et al. 1985). The light demanding species germinate faster, grow rapidly and can rarely be found growing in the forest understory (Hubbell and Foster 1986), while shade tolerant species are in different to gaps and can grow both in a high and low light environment. In moderate canopy, the dominant tree species P. roxburghii shows relatively higher sapling density as compared to seedling, indicating that regeneration has become a problem in this pine since last several years. Established communities are generally resistant to competitive displacement but are susceptible during regeneration (Shugrat 1984). Higher seedling density value gets reduced to sapling due to biotic disturbance and competition for space and nutrients (Dlaukhandi 2008). Good and Good (1972) have considered three major components which cause the successful regeneration of tree species. These components are the ability to initiate new seedlings, ability of seedling and saplings to survive and ability of seeding and sapling to grow. Clark et al. (1999) revealed that tree seedling recruitment is either limited by low or uncertain seed supply and establishment, or limited by lack of suitable microsites and factors that affect early seedling growth and mortality. The regeneration of shade intolerant species continuously increases as gap size increases (Brokaw 1985 and Whitmore 1989).

Tree and shrub richness indicated that the moderate canopy had similarity for all vegetation layers. Ashton (1992) reported that most abundant species play a major role in controlling the rate and direction of many ecosystem processes. These dominant same often crucial for maintaining their communities because they typically provide the major energy flow and physical structure that support and shelter other organism.

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