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Structure, Composition and Dominance – Diversity Relations in Three Forest Types of a Part of Kedarnath Wildlife Sanctuary, Central Himalaya, India

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Abstract

Plant diversity assessment was carried out on the basis of species richness, tree crown cover and dominance-diversity pattern in different forests of Kedarnath Wildlife Sanctuary (KWLS), Central Himalaya, India during 2006-2009. The maximum tree species richness (10 spp.) was observed in *Rhododendron arboreum* Sm. dominated mixed forest and minimum in *Quercus leucotrichophora* A. Camus. forest (8 spp.). Maximum tree density (170 trees/ha) and high importance value index (89.68) was found in *Q. semecarpifolia* Sm. forest. Mixed *Rhododendron arboreum* Sm. forest showed high tree diversity (H=0.96), while shrub were found highest in *Quercus leucotrichophora* A. Camus forest (H=0.62) and herb diversity in *Q. semecarpifolia* Sm.forest (H=0.73) respectively Maximum tree crown cover (82%) was observed in *Rhododendron arboreum* Sm. dominated mixed forest while minimum tree crown cover (58%) was observed in *Q. semecarpifolia* Sm. forest. In general random distribution pattern (A/F ratio) was observed in all three types of forest. Alterations of land use pattern and population pressure are found to be main cause of increase in resources exploitation and that ultimately decreases species richness and diversity. Agro-forestry, alternate use of sites for resources and providing a recovery period to the forests are some of the strategies suggested for forest conservation, management and sustainable utilization of resources by the local people.

Keywords: conservation, crown cover, dominance-diversity, IVI, species richness

Introduction

Himalayas is the world's sixth largest bioregions. It is recognized as one of the hotspots of biodiversity that harbours nearly 8,000 species of flowering plants including 25.3% endemic (Singh and Hajra, 1996). Physical structure in terms of topographical setup, soil types, geographical location and climate of a region influence the vegetation diversity of the forest ecosystems. Biodiversity is being eroded as fast as today at any time since the dinosaurs ended some 65 million years ago (Wilson, 2006). The biodiversity has been increasingly threatened by the environmental crisis and phases of mass extinction of species (Singh, 2002).

Western Himalaya, although dry and less dense as compared to the Eastern Himalaya, is still one of the rich floristic regions of India (Meher-Homji, 1978). The area harbours many rare and endemic plant and animal species. Forest products and agriculture are the main source of livelihood of the people living in this region. Forest diversity is used variously for edible fruits, vegetables, medicine, fodder, fuelwood, agricultural instruments, timber, industrial raw materials and several non-timbers forest products (Singh and Singh, 1992). Garhwal region form an important zone of western Himalaya forests are mainly dominated by *Pinus roxburghii* Sarg. and *Quercus* species. *P. roxburghii* Sarg. forest is found mainly in mid-altitude (1000-2200 m) as pure patch but mostly mixed with broad leaved forest in the valleys and shaded areas closely associated with *Lyonia ovalifolia* (Wall.), *Pyrus pashiya* Buch. Ham. ex. D. Don., *Mallotus phillipensis* and *Shorea robusta* at lower altitude and *Cedrus deodara, Myrica esculenta* Buch. Ham. ex. D. Don., *Q. leucotrichophora* A. Camus, *Q. glauca* Thunb and *Rhododendron arboreum* Sm. at higher altitudes of this region. *Q. leucotrichophora* A.Camus grows in north aspect mainly cooler region below 2000 m and is found either pure or mixed with other broadleaved and conifer species (Ram *et al.,* 2004; Semwal *et al.,* 2007).

Rapid demographic changes and continuous unplanned collection of the valuable forest species and plant products has led to the over exploitation of natural flora and fauna of this region (Singh and Singh, 1987; Dhar *et al.,* 1997). Biodiversity has attracted world attention because of the growing awareness of its importance on one hand, and the anticipated massive depletion on the other (Dhar *et al.,* 1997). For sustainable development and for the betterment of land, livestock, human population and environment, the conservation of biodiversity in the region is urgently required. The present study is undertaken to analyse plant species associated with three forest types and to record quantitative data in terms of tree cover, density and plant diversity in relation to human disturbances in different forest types of Kedarnath Wildlife Sanctuary (KWLS), Garhwal Himalaya, Uttarakhand, India, so that the steps can be taken to maintain the diversity pattern.

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Material and methods

STUDY AREA - The study area KWLS, Uttarakhand is located between 30°, 30 ° - 30°, 45° N Latitude and 79°, 0° - 79°, 15° E Longitude (Semwal *et al.,* 2007). In Garhwal Himalya, western part (Kalimath valley) of the sanctuary is selected for vegetation analysis in different forest types and each forest possesses 2 ha as sampling area. The altitude of the region ranges between 1400-1700 m, 1800-2100 m and 2400-2700 m above sea level.

The area receives 330 cm of annual precipitation of which the rainy months (June-August) contribute approximately 62%. The relative humidity varies from 30 to 80% annually. There is moderate to heavy snowfall during December-February (Semwal *et al.,* 2007). The mean maximum temperature varies between 4°C (January) and 33.5°C (June). The rocks of the study areas are a complex mixture of mainly sedimentary, low-grade metamorphosed and igneous (Valdiya, 1980). The soil classified as hill soil type which is dark brown at surface and brown to yellowish at sub-surface level (Raychaudhary, 1968).

METHODS - The study was conducted in three forest types of Kedarnath Wildlife Sanctuary, Uttarakhand, India, as a part of biodiversity research project. Each forest type is named on the basis of gross dominant structure and high importance value index (IVI) of particular tree species (Tab. 1). Random sampling of vegetation was made using the quadrat method (Misra, 1968).

Diameter at breast height (dbh) of all trees in each quadrat was measured and recorded individually for different species. Tree species were analysed in 100 m^2, shrub in 25 m^2, herbs in 1 m^2 quadrats randomly in each forest type. A total of 60 quadrats were studied for the present study. The vegetational data were quantitatively analysed for phytosociological parameters (Misra, 1968), A/F ratio (Whitford, 1949). Tree crown cover was measured by randomly placing seven transects of 400 m^2 in each forest. Different forest sites were also designated as Slope-I (20 - 40°) and slope II (41-60°) for crown cover study. Herbs were analysed in all season for low altitude forest types and June to October in those forest types which are located in high altitude areas. Plants were identified with the help of a flora key of the local region (Gaur, 1999, Naithani, 1984).

Species richness was estimated as the number of species per unit area (Misra, 1968; Magurran, 1988). Shannon's and Simpson's indices (Shannon and Weaver, 1963; Simpson, 1949) were used to evaluate species richness, plant diversity and dominance in a particular forest types. Dominance and diversity parameters were analysed on the basis of total basal cover value of each species. Linear correlation was developed for tree crown cover and species richness.

Results and discussion

Species Richness

The present investigation involved the quantitative analysis of three forest types of Kedarnath Wildlife Sanctuary, Uttarakhand in relation to tree crown cover, dominance-diversity and species richness of tree, shrub and herb species. A total of 116 species of angiosperms and gymnosperms were recorded from the sampling area, out of which 16 were trees, 35 shrubs and 65 herbs. In the third site maximum tree density (170 trees/ha) and high IVI (89.68) value was found in *Q. semecarpifolia* Sm. forest. While minimum tree density (20 trees/ha) was observed each in *Fraxinus micrantha* Lingesh and *Q. glauca* Thunb species. It was observed that *Q. semecarpifolia* Sm. had highest IVI (89.68) value, while *Madhuca indica* (Roxb.) had lowest IVI (9.87) value (Tab. 1). Maximum tree crown cover (82%) was observed in *Rhododendron arboreum* Sm. mixed forest while minimum tree crown cover (58 %) was observed in *Q. semecarpifolia* Sm. forest (Fig. 1). The random distribution pattern (A/F ratio) was observed in all three types of forest. Maximum tree richness (10 spp.) was observed in *Rhododendron arboreum* Sm. dominated forest and minimum in Q. leucotrichophora A. Camus forest (8 spp.). Maximum shrub richness was 12 in *Rhododendron arboreum* Sm. mixed forest followed by *Q. leucotrichophora* A. Camus mixed forest (10 spp.) while minimum shrub richness was observed in *Q. semecarpifolia* Sm.mixed forest (4 spp). Herb richness was found 43 and 39 in *Q. leucotrichophora* A. Camus mixed forest and *Q. semecarpifolia* Sm. forest respectively. The forest trees around village's locality are found lopped for fodder and fuel-wood purposes. This may be one of the reasons for low crown cover in some forest types in the region.

Importance value index (IVI) of all dominant tree species of different forest types ranges 9.87 to 89.68 in the study area. All dominant tree species were found to show less importance values in all mixed forest types. A comparative account of the present study regarding IVI of dominant tree species with other studies revealed that most of the dominant species had less importance value index, but the values are comparable with other forests of Uttarakhand (Singh and Singh, 1987; Bhandari, *et al.,* 1997; Semwal and Bhatt, 1994; Singh *et al.,* 2008). Crown cover was estimated between 35 to 85% in different forest types and slope conditions (Fig. 1). *Rhododendron arboreum* Sm. dominated mixed forest found to have highest crown cover (82%) as compared to *Q. semecarpifolia* Sm. dominated mixed forest (35%). Shrub species always play very important role in identifying relationship with tree species and their micro-climate (Dhar *et al.,* 1997). Under storey herb species were analysed for their associations with different major forest types (Tab. 1).

Tab. 1. Structure and composition frequency (%), density (tree/ha) and importance value index (IVI) of three forests types of KWLS, Central Himalaya, India

Site I *Rhododendron arboreum* mixed forest				
Species richness	Family	A/F ratio (Distribution pattern)	Density (Tree/ha)	IVI
Rhododendron arboreum Sm.	*Ericaceae*	0.021	120	56.68
Myrica esculenta Buch.Ham.ex D.Don.	*Myricaceae*	0.018	90	42.81
Quercus leucotrichophora A.Camus.	*Fagaceae*	0.022	80	52.06
Pinus roxburghii Sarg.	*Pinaceae*	0.031	50	30.12
Lyonia ovalifolia (Wall.)	*Ericaceae*	0.024	60	27.25
Prunus cerasoides D.Don.	*Rosaceae*	0.044	70	29.35
Fraxinus micrantha Lingesh	*Oleaceae*	0.050	20	10.17
Quercus glauca Thunb.	*Fagaceae*	0.050	20	11.37
Alnus nepalnensis D.Don.	*Betulaceae*	0.044	70	30.05
Madhuca indica (Roxb.)	*Sapotaceae*	0.050	70	09.87
Site II *Quercus leucotrichophora* forest				
Q. leucotrichophora A.Camus.	*Fagaceae*	0.024	170	78.94
Myrica esculenta Buch.Ham.ex D.Don.	*Ericaceae*	0.028	70	28.51
Prunus cerasoides D.Don.	*Rosaceae*	0.089	80	31.11
Quercus dilatata Lindl.	*Fagaceae*	0.040	80	34.27
Lonicera quinquelocularis Hardw.	*Caprifoliaceae*	0.070	70	18.75
R. arboretum Sm.	*Ericaceae*	0.024	60	28.22
Lyonia ovalifolia (Wall.)	*Rosaceae*	0.031	110	41.07
Pyrus pashia Buch.Ham.ex D.Don.	*Rosaceae*	0.020	100	39.04
Site III *Q. semecarpifolia* forest				
Q. semecarpifolia Sm.	*Fagaceae*	0.028	170	89.68
R. campanulatum D.Don.	*Ericaceae*	0.029	160	64.61
Abies pindrow Royal	*Pinaceae*	0.025	30	38.91
Cedrus deodara (D.Don.) G.Don.	*Pinaceae*	0.125	30	15.88
Viburnum mullaha Buch.Ham.	*Caprifoliaceae*	0.083	30	17.67
Litsea elongata (Nees) Hook.	*Lauraceae*	0.050	20	12.15
R. barbatum Wall ex.G.Don.	*Ericaceae*	0.083	100	46.14
Taxus wallichiana (Zucc.) Pilger.	*Taxaceae*	0.050	20	14.96

Mixed forest has different soil nutrients requirement as well as decomposition capability in hill regions (Singh and Singh, 1992).

Diversity Indices

The values of species diversity (H) in different forest types varied between 0.75-0.96 for tree, 1.22-2.46 for shrub and 1.96-3.12 for herb layer. Overall, *Q. semecarpifolia* Sm. forest showed maximum diversity (H=0.96) and *Rhododendron arboreum* Sm. mixed forest exhibit minimum diversity (H=0.75). The values for concentration of dominance are reverse to those of diversity (Fig. 2). *Q. leucotrichophora* A. Camus and *Rhododendron arboreum* Sm. were widely distributed and found in most of the forest types of this region. *Berberis asiatica, Pyracantha crenulata, Rubus ellipticus* and *Randia tetrasperma* were the dominant shrub species of the different forests while other species were restricted to one or two forest types. Total shrub and herb richness significantly decreased with increasing tree crown cover (Fig. 3). The relationship between tree crown cover (in %) and species richness clearly indicated that low crown cover support high shrub (r^2 =0.96) and herb diversity (r^2 =0.94).

Disturbance factors

The people of hills are dependent for their livelihood on forest biodiversity, agriculture and other immediate natural resources (Semwal *et al.,* 2007). Agriculture area is increasing in the region at the cost of forest cutting and mis-management in forest planning. In recent past, horticulture has become more popular in the area along with cereal crops. The forest area nearby habitation is degraded by local people for their needs and to generate money.

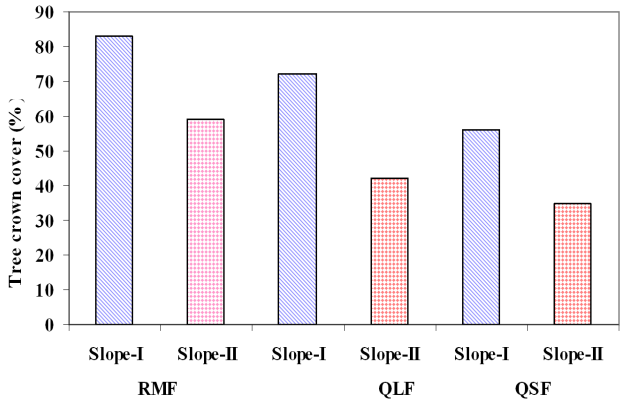

Fig. 1. Relationship between forest types, 1. *Rhododendron arboreum* mixed forest (RMF); 2. *Quercus leucotrichophora* forest (QLF) and 3. *Q. semecarpifolia* mixed forest (QSF) and tree crown cover of three forest types of KWLS, Central Himalaya, India

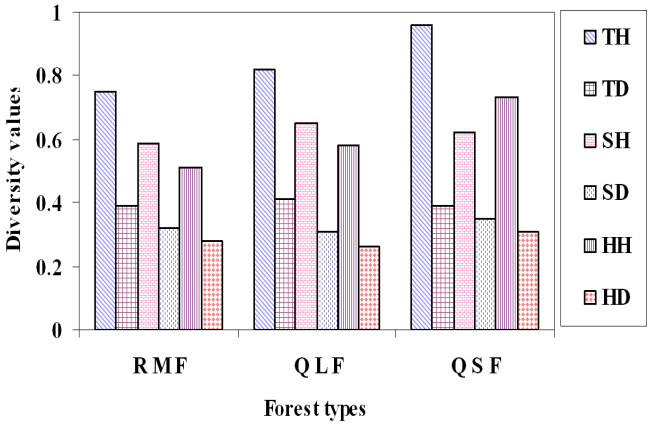

Fig. 2. Relationship between three forest types and diversity in different forests layers; TH=tree diversity; TD=tree dominance; SH=shrub diversity; SD=shrub dominance; HH=herb diversity; HD=herb dominance

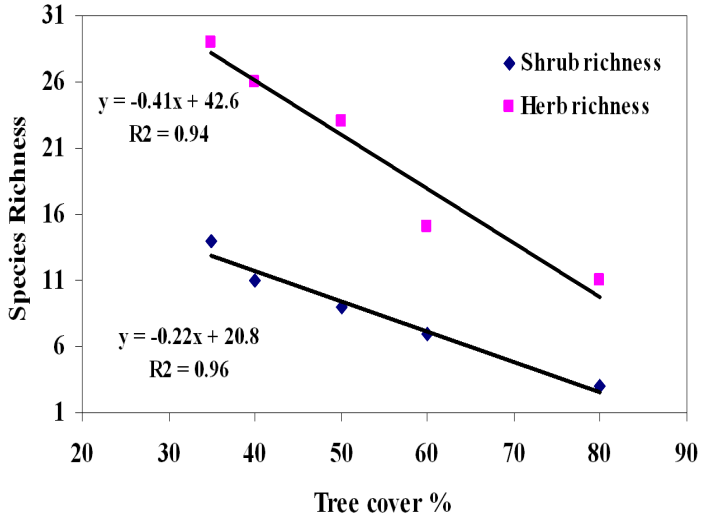

Fig. 3. Relationship between tree crown cover and shrub & herb species richness in three selected forest types of KWLS, Uttarakhand, India

Thus the biodiversity of these forests is under heavy anthropogenic pressure.

The forest area near the point of anthropogenic activity was found to have low crown cover while forest located away form such habitation posses high crown cover. It has been observed that high crown density (more than 65%) disfavoured the shrub population. Canopy/crown disturbance frequently enhances plant biodiversity (Collins and Pickett, 1987). It was found that less crown cover of different forest types has shown increase in shrub as well as herb diversity.

Management strategies

Our study indicates that large-scale anthropogenic activities can disrupt regeneration of major broad-leaved forest species such as *Q. leucotrichophora* A. Camus, *Q. glauca* Thunb. and *R. arboreum* Sm.

Sustainable utilization of forest resources in this part of Himalaya is urgently required. The sustainability of people oriented management initiatives like joint forest management can be revived by involving the communities in applying and monitoring the sustainability by criteria and indicators approach (Rawat *et al.,* 2008). The forests initiatives managed through agro-forestry and village authority are very important for betterment of the people of Himalayan region (Semwal *et al.,* 2006). Globally, there is a movement towards accepting only those forest products which have originated from sustainable managed forests (Singh, 2006; Rametsteiner and Simula, 2003). The pure and mixed forests of the present study area as well as other parts of the Uttarakhand Himalaya need better forest management policies such as allocation of government

managed forest to local people for their maintenance, conservation and sustainable use. It must be realized that these forests are under extremely heavy pressure of overgrazing, lopping, removal of bark, litter and illegal felling of trees and would continue to degenerate until effective efforts are made to control such type of activities in the region. It is also suggested that broad leaves species particularly oak species of the region should be given first priority for reforestation in the Himalayan region as this taxon is valuable in maintaining the nutrient and water balance in the soil. Local people are suggested to utilize these forests in an alternate gap period of a year, giving time to regenerate the forest. Such practice can be applied turn wise to all sites so that forest regenerates and peoples livelihood be sustained.

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