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

Dinesh Prasad SEMWAL1, Prem Lal UNIYAL2, Ajay Ballabh BHATT2

1) University of Delhi, Department of Botany, Delhi, India; dinuSEM@rediffmail.com
2) H.N.B. Garhwal University, Department of Botany, Srinagar, Uttarakhand; India

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 ovatifolia (Wall.), Pyrus pashia Buch. Ham. ex. D. Don., Mallotus philippensis 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.
**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 m², shrub in 25 m², herbs in 1 m² 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 m² 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 type. 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 mircantha Lingesh and Q. glauca Thumb 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 arboream 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).
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*, *Pyranantha 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 (r² =0.96) and herb diversity (r² =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.
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 *Quercus 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.

Acknowledgements
I am thankful to the University authority for providing all necessary facilities. We thank Prof. R. D. Gaur, emeritus Professor, H. N. B. Garhwal University, Srinagar, Uttarakhand for identification of specimens.

References
Bhandari, B. S., J. P. Mehta, B. P. Nautiyal and S. C. Tiwari (1997). Structure of Chir pine (Pinus roxburghii Sarg.) community along an altitudinal gradient in Garhwal Himalaya. Int. J. Ecol. Env. Sci. 23:67-74.
Collins, B. S. and S. T. A. Pickett (1987). Influence of canopy opening on the environment and herb layer in a northern hardwood forest, Vegetatio. 70:3-10.
Dhar, U., R. S. Rawal and S. S. Samant (1997). Structural diversity and representativeness of forest vegetation in a protected area of Kumaon Himalaya, India, Implications for conservation Biodiv. Conser. 6:1045-1062.
Gaur, R. D. (1999). Flora of the District Garhwal North West Himalaya with Ethnobotanical Notes. Transmedia Publication, Srinagar, Garhwal, Uttarakhand.
Magurran, A. E. (1988). Ecological diversity and its measurement. Croom Helm, London.
Meher-Homji, V. M. (1978). Vegetation classification. Need we disseminate environmental terminologies from the physiognomic nomenclature, Ind. Forester 104:653-660.
Misra, R. (1968). Ecology Work Book. Oxford and IBH Publishing Company, New Delhi.
Naithani, B. D. (1984). Flora of Chamoli, I and II. Botanical Survey of India, Howrah.
Ram, J. A. Kumar and J. P. Bhatt (2004). Plant diversity in six forest types of Uttarakhand, Central Himalaya, India. Curr. Sci. 86:638-647.
Raychaudhary, S. P. (1968). Indian Soil-Their classification, occurrence and properties. In: Land resources of India, Planning commission Government of India, New Delhi.
Rawat, T. S., B. L. Menaria, D. Dugya and P. C. Kortwal (2008). Sustainable forest management in India Curr. Sci. 94:996-1002.
Rameetsteiner, E. and Simula, M. (2003). Forest certification-An instrument to promote sustainable forest management J. Environ. Manage. 67:87-98.
Semwal, D. P., P. P. Saradhi and A. B. Bhatt (2007). Current status, distribution and conservation of rare and endangered medicinal plants of Kedarnath Wildlife Sanctuary, Central Himalaya, India. Curr. Sci. 92:1733-1738.
Semwal, R. L. and J. P. Mehta (1996). Ecology of forest fires in chir pine (Pinus roxburghii Sarg.) forest of Garhwal Himalaya. Curr. Sci. 70:426-427.
Semwal, D. P. and A. B. Bhatt (1994). Impact of biotic stress on composition and structure of some temperate forest in Garhwal Himalaya J. Hill. Res. 7:17-22.
Semwal, D. P., P. P. Saradhi and A. B. Bhatt (2006). Comparing structure and composition of Taxus baccata subsp. wallchiana Zucc. (Himalayan Yew) with other associates in a part of Garhwal Himalaya, Uttarakhand, Phytomorphology 56:127-131.
Shannon, C. E. and W. Weaver (1963). The Mathematical Theory of Communication, University of Illinois Press, Champaign, IL, USA. 144.
Simpson, E. H. (1949). Measurement of diversity. Nature 163:688.
Singh, J. S. and S. P. Singh (1992). Forests of Himalaya: Structure, Functioning and Impact of Man, Gyanodaya Prakashan, Nainital.
Singh, D. K. and P. K. Hajra (1996). Floristic diversity, p.23-38., In: Changing Perspective of Biodiversity Status in the Himalaya, Gujral, G. S. and V. Sharma Eds., British Council Division, British High Commission Publ. Wildlife Youth Services, New Delhi.
Singh, J. S. (2002). The biodiversity crisis: A multifaceted review Curr. Sci. 82:638-647.
Singh, J. S. and S. P. Singh (1987). Forest vegetation of the Himalaya, Bot. Rev. 53:80-192.
Singh, J. S. S. P. Singh and S. R. Gupta (2008). Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi.
Singh, J. S. (2006). Sustainable development of the Indian Himalayan region: Linking ecological and economic concerns. Curr. Sci. 90:784-788.
Valdiya, K. S. (1980). Geology of Kumaun Lesser Himalaya, Wadia Institute of Himalayan Geology, Dehradun.
Wilson, E. O. (2006). The Creation: An appeal to Save Life on Earth, W.W.Norton and Company, New York.