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A COMPARATIVE STUDY ON PLANT BIODIVERSITY OF OAK (*QUERCUS SEMECARPIFOLIA* SMITH.) AND MIXED OAK-DEODAR (*CEDRUS DEODARA* D. DON.) FORESTS IN CENTRAL HIMALAYAN REGION OF UTTARAKHAND

PUSHKAR SINGH, BRIJ LAL ATTRI AND BISWAJIT DAS

Central Institute of Temperate Horticulture,
Regional Station, Mukteshwar (Uttarakhand), India-263 138

ABSTRACT

Present study concluded that the total plant species was greater in oak-deodar mixed forest in Central Himalayan region. This type of forest recorded more trees and shrubs whereas oak dominated forest constituted higher herbs. The tree and herb density was 1700 and 92000 respectively in oak dominated forest whereas shrub density was 2356 per ha. The A/F ratio of trees and shrubs was 0.363 and 1.39 in the mixed forest as compared to 0.023 and 0.89 in oak dominated forest. Further, A/F ratio of herbs was 1.45 in the latter to that of 0.6 in the former. The total cover (%) of shrubs was 5.23 and 6.18 whereas for herbs it was recorded as 13.46 and 10.29 in oak dominated and mixed oak-deodar forest respectively. The diversity of trees and shrubs was better in mixed oak-deodar forest whereas for herbs it was higher in oak dominated forest. The assessment of the plant biodiversity in different forests revealed that various disturbances do not provide time for the ecosystem recovery and widen the forest gap and fragmentation of the land in the region.

Key words : Central Himalayan Region, Biodiversity, Oak, *Qurecus semicarpifolia*, Mixed forest, Tree and herb density.

Introduction

Biodiversity is the nested composite of plants, animals and microbes which is the basis for ecosystem processes and the fountain of human kind's life support systems. Biodiversity or biological diversity is sum of all the different species of animals, plants, fungi and microbial organisms living on the earth and the variety of habitats in which they live. Scientists estimate that upward of 10 million and some suggest more than 100 million different species inhabit the earth from peaks of mountains to the depth of deep sea hydrothermal vents, and from polar ice caps to tropical rain forests. Scientists have discovered and named only 1.75 million species (less than 20 per cent of those estimated to exist) and of those identified only a fraction has been examined for potential medicinal, agricultural or industrial value. Most biologists agree that life on the earth is now faced with the most severe extinction episode since the event that drove the dinosaurs to extinction 65 million years ago. Species of plants, animals, fungi and microscopic organisms such as bacteria are being lost at alarming rate, in fact, that biologists estimate that three species go extinct every hour. India is one of the 12 mega diversity countries and comprise of two hot spots *viz*. Eastern Himalayas and Western Ghats. Himalayas are one of the world's sixth largest bioregions which harbours approximately 8,000 species of flowering plants including 25.30% endemic (Semwal *et al*., 2008). The Indian Himalayan region alone supports about 18,400 species of plants used by human beings in various ways as medicine, edible parts, fodder, fuel, timber and many other purposes. Various aspects of biodiversity of these forests have been studied by Dhar *et al*., 1997; Kumar, 2000 and Khera *et al*., 2001. The biodiversity has been increasingly threatened by the environmental crisis and phases of mass extinction of species.

Rapid demographic changes, continuous unplanned collection of the valuable forest species and plant products have led to the over exploitation of natural flora and fauna of this region (Singh and Singh, 1987 and Dhar *et al.,* 1997). The Himalayan vegetation ranges from tropical dry deciduous forests in the foothills to alpine meadow above tree line (Singh and Singh, 1992; Ram *et al*., 2004). A large variety of wild-growing plants of this zone are used for food and other subsistence needs like medicine, edible fruits, fodder, fuel, timber and many other purposes by the local communities (Sundriyal and Sundriyal, 2003). For sustainable development and for the betterment of land, livestock, human population and environment, the conservation of biodiversity in the region is urgently required because of which close relationship and dependence has been established between forest and community.

The human disturbances through selective logging, wood extraction, grazing, fire and land clearing

In oak-deodar mixed and oak dominated forest, various disturbances do not provide time for ecosystem recovery and widen the forest gap and fragmentation of the land.

for permanent agriculture may influence many plant communities and heir succession patterns. All these factors are severely threatening the biological diversity in this part of the Himalayas in terms of ecological, genetic/species and organism diversity. Species composition of major forest types of the central Himalayas described by Ralhan *et al.* (1982); Upreti *et al.* (1985); Sexena and Singh (1982) and Kumar *et al.* (2001) also analyzed the vegetation along the disturbances gradient in the forests. Khan *et al.* (2001) has assessed the plant biodiversity in relation to disturbances in mid-elevation forests of central Himalayas.

The distribution of the trees, shrubs and herbs in these forests was governed mainly by the gradients of altitude, slope and canopy cover. Biodiversity in oak forest recorded lower as compared to mixed oak-deodar forest. Oak is a multipurpose tree species in central Himalayan region. These are highly preferred by the local inhabitants for their livelihood and also serve vital ecosystem services in the Himalayan region. Oaks in the Himalayas are intimately linked with subsistence hill agriculture as they protect soil fertility, watershed and local biodiversity. They also supply fodder, leaf litter, firewood and timber. The shrinking of the biodiversity would have a huge impact on the lives of human.

The present study was undertaken to analyze plant species associated with two forest types at temperate region of central Himalayas and to record quantitative data in terms of tree cover, density and plant diversity and other phytosociological parameters in relation to human disturbances in these types of forests.

Material and Methods

Study area

The present study was carried out during 2009-10 in mid hills of Uttarakhand which is a hill state located in the central Himalayan zone of India. Uttarakhand extends from $28^0$43' N to 31^0 27' N longitude and 77^0 34' to 81^0 02' E latitude. The state, with a total area of 53,483 sq. km, accounts for nearly 15.5% of the total geographical area of western Himalayas (Negi *et al*., 2011). Estimated area under forests in the state is 34662 km^2 which amounts for 64.79% of total area of the state. In the state, 71.08%, 28.51% and 0.41% of the total forest areas are under reserved forests, unclassed forests and protected forests, respectively. The study was conducted in 6 sites *i.e.* 3 sites dominated with oak forest and 3 sites having oak-deodar forest in Bageshwar district (central Himalayas) of Uttarakhand at an altitude of 2400 m in temperate region. Central Himalayas is altitudinally divisible into subtropical (300 to 1500 m), temperate (1500 to 3500 m) and alpine (>3500 m) zones (Saxena *et al*., 1985). Annual rainfall peaks at about 1200 m altitude (4100 mm) which gradually declines to 670 mm at 2700 m. The climate of the selected region is wet temperate and the cold season (winter) begins from mid-last week of October and lasts up to March. Onset of rain occurs during first week of June (pre-monsoon), June-July-August (Monsoon) and September (post-monsoon). There is occasional rainfall during fall (October-November) and winter season experiences light to medium rainfall with snow. Late winter and early spring season also experience low temperature when there is light-medium rainfall with hail-storm. The heaviest precipitation occurs in the month of July and August and annual rainfall ranges from 40-428 mm. There is high degree of relative humidity throughout the year. Temperature during winter may fall to sub zero degrees and in other season it may go as high as 25^0C with a minimum of 8-13^0 C.

Data collection and analysis

Study materials in the oak dominated forest and mixed oak-deodar forests were defined as trees, shrubs and herbs, and all the three layers of forest vegetation were analyzed. The forests were thoroughly surveyed and identified as *Quercus semecarpifolia* (Kharshu oak) dominated forest and mixed *Quercus semecarpifolia* (Kharshu oak)- *Cedrus deodara* (Deodar) forest. Various species present in the forest were identified as per the procedures and guidelines with the help of a flora key of the local region (Gupta, 1969; Gaur, 1999; Naithani, 1984). The tree analysis was done by sampling methods. Ten samples of 10x10 m quadrates were selected randomly from each site. The size and number of samples were determined according to Saxena and Singh (1982). Seedlings and saplings were recorded by 1 x 1 m and 5 x 5 m quadrates, respectively. Shrub layer was analyzed by placing 5 x 5 m and herbs by 1 x 1 m quadrates randomly from each site. The basal area was measured by taking circumference at breast height (c.b.h.). The tree basal area was determined and calculated as r^2, where r is the radius. Tree basal area of a species was the multiple of mean tree basal area and density while total cover of a shrubs and herbs species was the multiple of mean cover and density. Total basal area/cover was the sum of basal area/cover of all species present in the forest. Circumference at breast height (c.b.h.) of all trees in each quadrate was measured and recorded individually for different species. The cover of shrub was measured by taking length x width of crown. Herbs cover was determined by placing a transect of 1 m on the ground and per cent ground cover occupied by each herb species

as described by Mishra (1968). Tree species were analysed in 100 m^2, shrub in 25 m^2, herbs in 1 m^2 quadrates randomly in each forest type. A total of 60 quadrates were studied for the present study. The vegetational data were quantitatively analysed for phytosociological parameters, *i.e.* density, abundance, frequency, A/F ratio, relative density, relative frequency, relative dominance, IVI and diversity index. Species richness was estimated as the number of species per unit area (Mishra, 1968; Magurran, 1988). Shannon-Weiner diversity index (Shannon and Weiner, 1963) was used to evaluate species richness, plant diversity and dominance in a particular forest types. Species richness was determined as the number of species per unit area (Whittaker, 1975). Species diversity was calculated using Shannon-Wiener information index as:

$$H = - \Sigma (ni/n) \log 2 (ni/n)$$

Where, ni is the density of a species and n the total density of all species in that forest

Results and Discussion

Forest types

The present investigation involved the quantitative analysis of two forest types of central Himalayas, Uttarakhand in relation to density, frequency, abundance, IVI, diversity and species richness of tree, shrub and herb species. A total of 36 species were recorded from sampling area out of which 8 were trees, 16 shrubs and 12 herbs (Table 1).

Tree species richness ranged between 4 to 7 and shrub species richness was 8 to 13 in different forest sites, which are less than that reported by Upreti *et al.* (1985). The herb species richness varied from 6 to 11 species. Total species richness was found between 23 to 26 species. The mixed oak–deodar forest showed highest species richness followed by oak dominated forest. Oak forest showed greater variation in herb while mixed oak-deodar forest showed greater variation in shrub and tree species. The decrease in species richness may be due to increased biotic pressure and opening of the tree canopy, which arrest the regeneration of some tree species. The opening of canopy increases the number of shrub species in highly disturbed forests. Over storey trees influences the structural and functional characteristics of ecosystem and, consequently, shape the biota of a forest. Over storey trees regulate ecosystem structure and function by virtue of their physical dominance. Both local and regional habitat characteristics influence species richness and community structure. Wilson and Tilman (2002) have studied old field species richness along disturbances and nitrogen gradient and found that the growth varied quadratically with species richness.

Table 1 : Species richness in forest site

	Oak forest	Mixed oak–deodar forest
Tree		
Cedrus deodara	–	+
Myrica esculenta	+	–
Picea smithiana	–	+
Pinus wallichiana	–	+
Quercus semecarpifolia	+	+
Quercus leucotricophora	+	+
Cupressus torulosa	–	+
Rhododendron arboretum	+	+
Total (8)	4	7
Shrub		
Vaccinium angustifolium	+	–
Asparagus racemosus	–	+
Berberis asiatica	+	+
Lantana camera	–	+
Randia tetrasperma	+	+
Rumex hastatus	–	+
Utrica dioica	+	+
Rubus ellepticus	–	+
Viburnum stelluatum	+	–
Cotoneaster macrophylla	–	+
Clematis Montana	+	–
Viburnum grandiflorum	–	+
Jasminum humile	+	+
Desmodium elegans	+	+
Artimisia vulgaris	–	+
Myrsine africana	–	+
Total (16)	8	13
Herb		
Justicia simplex	+	+
Heteropogon contortus	+	–
Anaphalis contorta	+	–
Carex nubigena	+	+
Frageria indica	+	–
Apluda cristatus	+	+
Geranium nepalens	+	–
Chimphila maculate	+	+
Rubia coridifolia	+	+
Oxalis corniculata	+	–
Nepta leucophylla	+	–
Thalactrum japonica	–	+
Total (12)	11	6

Forest diversity and density

Total species richness was greater in mixed oak–deodar forest. Greater number of trees and shrubs were present in mixed oak-deodar forest whereas herb richness was higher in oak forest. Total tree diversity index ranged from 0.89-1.78 whereas shrub diversity index ranged from 2.04-2.56 for oak dominated forest and oak-deodar mixed forest respectively. Tree and shrub diversity was maximum for oak–deodar mixed forest. Herb diversity index varied from 2.10-2.89 for oak-deodar mixed forest and oak dominated forest respectively (Table 2).

Total tree density varied from 1250 to 1700 trees

/ha and total abundance ranged between 1973-2250 trees/ha for mixed oak deodar forest and oak dominated forest. A/F ratio varied from 0.023-0.363 and total basal area ranged from 24.47 to 50.5 m²/ha. It was maximum in mixed oak-deodar forest compared to oak dominated forest. In shrub, total density ranged between 1967-2356 shrubs/ha and total abundance varied from 2446 to 2890 shrubs/ha for oak dominated forest and mixed oak-deodar forest respectively. A/F ratio for shrub varied from 0.80 to 1.39 and it was maximum for mixed oak-deodar forest. Total shrub cover ranged between 5.23-6.18% for oak dominated forest and mixed oak-deodar forest respectively and it was maximum for mixed oak-deodar forest. In herb, total density ranged between and 68200 to 92000 herbs/ha and total abundance recorded varied from 73650 to 96540 herbs/ha for mixed oak-deodar forest and oak dominated forest respectively. A/F ratio for herb varied from 0.6 to 1.45 with total herb cover of 10.29% and 13.46% for mixed oak-deodar forest and oak dominated forest respectively. It was maximum in oak dominated forest compared to mixed oak-deodar forest (Table 2). Singh *et al*. (1994) have reported density ranging from 250 to 2070 tree/ha for different central Himalayan forests. The shrub density was observed between 1967 to 2356 shrubs/ha. The herb density ranged between 68200 to 92000 herbs/ha. Greater variation in tree density was in mixed oak-deodar forest compared to oak dominated forest. The oak dominated forest may favour the growth of herbaceous vegetation with decreasing richness and density of other woody vegetation.

Table 2 : Species richness in forest site

Parameter	Oak dominated forest	Mixed Oak-deodar forest
Trees		
Density (tree/ha)	1700.000	1250.000
Abundance (tree/ha)	2250.000	1973.000
A/F ratio	0.023	0.363
T.B.A ($m^{2/}$ ha)	24.470	50.500
Diversity index	0.890	1.780
Richness	4.000	7.000
Shrubs		
Density (shrub/ha)	1967.000	2356.000
Abundance shrub/ha)	2446.000	2890.000
A/F ratio	0.800	1.390
Total cover (%)	5.230	6.180
Diversity index	2.040	2.560
Richness	8.000	13.000
Herbs		
Density (herb/ha)	92000.000	68200.000
Abundance (herb/ha)	96540.000	73650.000
A/F ratio	1.450	0.600
Total cover (%)	13.460	10.290
Diversity index	2.890	2.100
Richness	11.000	6.000

In the present study, the total tree basal area of different forests was 24.47 m^2/100 m^2 to 50.5 m^2/100 m^2, which is lower than that reported by Singh *et al*. (1994). The shrub cover was observed 5.23% to 6.18% whereas, the herbs cover was observed 10.29% to 13.46%. The density and basal area also varied in mixed oak- deodar forest compared to other forest. Low tree density and high basal area in mixed oak–deodar forest indicates the presence of trees with greater diameter. The higher tree density may increase the competition between the individuals that adversely affect the diameter growth. Higher shrub density means higher shrub cover.

Shannon–Weiner diversity index ranged for tree between 0.89 to 1.78 in oak dominated forest and mixed oak-deodar forest respectively. The shrub diversity ranged between 2.04 and 2.56 in former than latter forest respectively. The herb layer diversity ranged between 2.10 to 2.89 for mixed oak-deodar forest and oak dominated forest respectively. The tree diversity index analysed for the forest was lower than that reported by earlier worker (Upreti *et al.,* 1985). Similar observations were also reported by Gurarni *et al.* (2010) where mixed forests always comprised more species diversity. The increased disturbance intensity may favour the invasion of herbs while moderate disturbance in mixed oak-deodar forest favours the shrubs. Anthropogenic disturbances decrease the trees diversity with increasing herbs diversity. The further increasing intensity of disturbances decrease trees and shrubs diversity and increase herbs diversity. The severity of disturbances decrease the overall richness and diversity of the ecosystem.

The geographical and geological peculiarities make the Himalayas a very diverse system subtending a wide range of vegetation types. The Himalayan biodiversity is severely threatened by natural and anthropogenic disturbances. One of the foundations for conservation of biological diversity in forest landscape is understanding and managing the disturbances regime under past natural and semi-natural conditions. Only a few decades ago disturbances were viewed as extraordinary events, un-natural deviation from the normal succession development of equilibrium communities (Oliver and Larson, 1990). Conservation biologist warns that 25% of all species could become extinct during the next 20 to 30 years. The cause for the loss of species is numerous but the most important is the loss and fragmentation of natural habitats.

उत्तराखंड के मधय हिमालयी क्षेत्र में बांज ¼*क्वेरकस सेमीकार्पी* फोलिया स्मिथ½ तथा मिश्रित बांज-देवदार ¼*सेडरम देवदारा* डी डोन½ के पादप वैविध्य का तुलनात्मक अध्ययन

पुष्कर सिंह, बृजलाल अत्तरी तथा विश्वजीत दास

सारांश

वर्तमान अध्ययन से यह निष्कर्ष निकला कि मध्य हिमालयी क्षेत्र के बांज-देवदार मिश्रित वनों में कुल पादप प्रजातियां सर्वाधिक थी। इस किस्म के वनों में अधिक वृक्ष तथा झाड़िया पाई गई जबकि बांज बाहुल्य वाले वनों में शाकीय मात्र अधिक थी। बांज बाहुल्य वाले वनों में वृक्षों और शाकों का घनत्व क्रमशः 1700 और 92000 था। जबकि झाड़ियों का घनत्व 2356 प्रति0 हे0 था। मिश्रित वनों में वृक्षों और झाड़ियों का अनुपात 0.363 तथा 1.39 था जबकि बांज बाहुल्य वाले वनों में यह अनुपात 0.023 तथा 0.89 था। शाकों का घनत्व क्रमशः 1.45 और 0.6 था। झाड़ियों का कुल आच्छादन क्षेत्र 5.23 तथा 6.18 था जबकि शाकों का घनत्व बांज बाहुल्य तथा बांज-देवदार मिश्रित वनों में क्रमशः 13.46 और 10.29 था। बांज बाहुल्य वाले वनों की तुलना में बांज-देवदार मिश्रित वनों में वृक्षों और झाड़ियों का घनत्व अधिक था। विभिन्न वनों में पादपीय वैविध्य के आकलन से पता चलता है कि विभिन्न गड़बड़ियों के कारण पारिपद्धति की भरपाई नहीं हो पाती है जिसमें क्षेत्र में वनों का असंतुलन बढ़ता है और भूमि का विखंडन होता है।

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