Global Journal of Science Frontier Research: C
Biological Science
Volume 14 Issue 3 Version 1.0 Year 2014
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Studies on Vegetational Analysis and Regeneration status of Pinus Roxburghii, Roxb. and Quercus Leucotrichophora Forests of Nainital Forest Division

By Nandan Singh, Kamini Tamta , Ashish Tewari & Jeet Ram
Kumaun University, India

Abstract- The present study was carried out on two dominant forest types were identified along and elevational gradient in Nainital Forest Division. The dominant tree species were *Quercus leucotrichophora* and *Pinus roxburghii Roxb*. Followed by *Acer oblongum, Rhododendron arboreum, Quercus floribunda, Cedrus deodara, Myrica esculenta, Ficus nerifolia, Cupressus torulosa and Prunus cerasoides*.Tree and sapling species richness, density and diversity were high in *Quercus leucotrichophora* dominated forest and total basal area and concentration of dominance were maximum in *Pinus roxburghii* dominated forest. Seedling species richness was maximum in *Pinus roxburghii* dominated forest and density, diversity and concentration of dominance were maximum in *Quercus leucotrichophora* dominated forest.

Keywords: *vegetation, regeneration, Q. leucotrichop- hora, P. roxburghii, forest.*

GJSFR-C Classification : *FOR Code: 070599*

Strictly as per the compliance and regulations of :

Studies on Vegetational Analysis and Regeneration status of Pinus Roxburghii, Roxb. and Quercus Leucotrichophora Forests of Nainital Forest Division

Nandan Singh [α], Kamini Tamta [σ], Ashish Tewari [ρ] & Jeet Ram [ω]

Abstract- The present study was carried out on two dominant forest types were identified along and elevational gradient in Nainital Forest Division. The dominant tree species were *Quercus leucotrichophora* and *Pinus roxburghii Roxb*. Followed by *Acer oblongum, Rhododendron arboreum, Quercus floribunda, Cedrus deodara, Myrica esculenta, Ficus nerifolia, Cupressus torulosa and Prunus cerasoides*.Tree and sapling species richness, density and diversity were high in *Quercus leucotrichophora* dominated forest and total basal area and concentration of dominance were maximum in *Pinus roxburghii* dominated forest. Seedling species richness was maximum in *Pinus roxburghii* dominated forest and density, diversity and concentration of dominance were maximum in *Quercus leucotrichophora* dominated forest.

Keywords: vegetation, regeneration, Q. leucotrichophora, P. roxburghii, forest.

I. Introduction

The Himalayan Mountain is the tallest, most complex and the youngest among the major mountain systems of the world extending for about 2500 km from east to west. The Himalayan forests are rich in biodiversity and distributed over a large extent from lower to higher elevation. The tree vegetation is the dominant components of these forests. Himalayan forests are crucial not only for the people for the living in the Himalaya but also for many more living in the adjoining plains. Various aspect of biodiversity of these forests has been studied by (Dhar et al. 1997, Silori 2001, Kumar 2000 and Khera et al. 2001). If biodiversity is to be used as a resource for sustainable development of local communities, one has to deal with problem related to in identification to potential economic species and their ecology and biology, land use, market demand and supply trends (Tewari and Singh, 1981). Disturbance is a key component of all ecosystems. It affected every level of biological organization and spans a board range of spatial and temporal scales with origins that can be either natural or anthropogenic, and either endogenous or exogenous, disturbances are inherently diverse (White 1979 and White and Jentsch 2001). Anthropogenic disturbances play an important role to change, loss recent phenomenon of climatic change, loss or maintenance of plant biodiversity and more recent phenomenon of climate change will also responsible for the change in species composition and other ecosystem activities (Ram et al. 2005). In the Himalayan region the biotic disturbance occur in the chronic form in which people remove only at a given time. The problem with the chronic form of forest gets time to recover adequately because human onslaught never stops (Singh 1998). Bormann et al. (1970) revealed that along an altitudinal gradient, the total basal area per tree, density and species diversity increased.

Oak (Quercus spp.) occupy most of the area from 1000 to 3000 m altitude in the central and western Nepal, Uttarakhand and HimanchalPardsesh (Singh et al. 2000). Banj oak (*Quercus leucotrichophora*) is the most common broadleaf tree in the mid - elevation central Himalaya in India. These forests have been under a tremendous biotic stress as they provided fuel, fodder and leaf fodder. Concentration of human settlements in the oak forest areas, lopping and felling and occasional fire spreading from pine forest, have reduce the area under oak forest (Champion and Seth 1968). Banj oak forms the matrix species of forest in this zone (Singh and Singh 1986), and is used by the villagers mainly for fuel, fodder, leaf litter and timber. Therefore, one of the immediate ecological problem is this region is revival of the oak forests, which is turn involves vegetational study, evaluation of regeneration status and subsequently the factor influencing the regeneration.

Chir – pine (*Pinus roxburghii* Roxb.)the dominant species from low to mid elevation and it is a frequent reproducer not only in its own forests but also in other forests where it has intruded following disturbance and creation of open canopy. The pine forests have witnessed severe anthropogenic disturbances. The disturbances were mainly in the form of deforestation, animal grazing, lopping, surface burning and litter removal. These continued disturbances are affecting the stability of the ecosystem and retarding the succession

Author α σ ρ ω : Department of Forestry and Environmental Science, D. S. B. Campus, Kumaun University, Nainital.
e-mail: nandansinghm@yahoo.com

process. Both natural and anthropogenic caused disturbance are considered since vegetation response do not distinguish between natural and human activities (Oliver and Larson 1990).Other species is occurring in Chir – pine forests usually fail to regeneration (Singh and Singh 1987).). It is important to note that the regeneration mode of tree species in gap may be changeable, however, in warm – temperate forest, it has been suggested that the regeneration mode of tree species in gaps is not an unchangeable property, but becomes a changeable one in relation to the presence or absence of other species such as key dominant species (Yamamoto 1994).

The Himalayan vegetation range from tropical dry deciduous forest in the foothill to alpine meadow above tree line (Singh and Singh 1992 and Ram et al. 2004). Vegetation in the mountain area is affected by several factors of which altitude, aspect, slope and soil depth are predominant as they modify regimes of moisture and exposure to sun. Vegetation within forest is greatly affected by differences in the microclimate, aspect and altitude (Pande et al. (1996). The lesser Himalayan region is colonized by subtropical broad leaved forest is dominated by Chir - pine (*Pinus roxburghii*) and Oak (*Quercus*) species. Various ecological aspects of biodiversity of this forest have been studied by various workers. The vegetation of lesser Himalaya to alpine zone is led by vast exploitation of natural plant diversity or flora due to increasing anthropological pressures.

Regeneration is the process of Sylvigenesis (=Forest building) by which trees and forest survive over time (Halle et al. 1978). Successful regeneration of tree species might be considered to a function of three major components: (i) ability to initiate new seedlings, (ii) ability of seedlings and saplings to survive and (iii) ability of seedlings and saplings to grow (Good and Good, 1972). The future composition of forests depends on potential regeneration status of tree species within a forest stand in space and time (Ayyaapass and Parthasarathy, 1999 and Henle et al. 2004). Regeneration status of a species is one of the most important phenomena for maintaining the forest cover. Regeneration status of a forest community can be indicated by computing the age (or size) structure of individual species. Regeneration is an important phenomenon of development process, which indicates its composition, structure, stand distribution and future crop.

II. Material and Method

The study area is located between 29° 20' and 29° 30' N latitude and 79° 23' and 79° 42' E longitude between 1650 – 1950m elevations in Nainital district of Kumaun Himalaya. The forest were thoroughly surveyed and identified as Banj - oak *(Quercus leucotrichophora*) forestand *Pinus roxburghii* Roxb. (Chir -pine) dominated forest. These forests were selected between 1650 – 1950m elevations and further categorized as low elevation (1650 – 1750m) and high elevation (1850 – 1950m). *Quercus leucotrichophora* is mixed with *Pinus roxburghii* at both the elevation. In each forest two replicated sites were selected. After thoroughly reconnaissance, tree, sapling and seedling species were listed from all the forests. Species richness was determined as the number of species per unit area (Whittaker 1972 and 1975).10 plots of 10x10m were randomly established in each forest for determination of species richness and other vegetation parameters. Three vegetation layers that are trees, saplings and seedlings were analyzed for species richness, density, diversity and concentration of dominance of tree species in different forest. Tree layer were analyzed in 10x10m, sapling in 5x5m (Curtis and Mc Intosh 1950 and Phillips 1959) and seedling were analyzed in 10, 1x1m within each plot. Circumference at breast height (cbh) was taken for the determination of tree basal area and calculated as πr^2, where r is the radius. Tree basal area of a species was the multiple of mean of tree basal area and while total cover of a sapling and seedling species was multiple of mean cover and density. Total basal area/cover was the sum of basal area/cover of all species present in the forest. Density and basal area were converted to per hectare (ha), sapling and seedling cover were given as percent for vegetational parameter. Tree basal area was used to determine the relative dominance of a species while cover was used for saplings and seedlings. Importance Value Index (IVI) was the sum of relative density, relative frequency and relative dominance (Phillips 1959). Species diversity was calculated using Shannon – Wiener information index (Shannon and Weaver 1963) as:

$$H = - \sum (Ni/N) \log 2 (Ni/N)$$

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

Concentration of dominance was measured by Simpson's index (Simpson 1949).

$$C D = \sum (Ni/N)$$

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

III. Result

a) Species richness, species diversity and concentration of dominance

A total 10 trees, 8 saplings and 6 seedlings species were recorded from study area. Total species richness was greater in oak dominated forest at 1650m

elevation. Greater number of tree and sapling species was present in oak dominated forest at 1650m elevation, in contrast to this seedling in pine dominated forest (Table 1).

Table 1 : Species richness indifferent elevations

Species	Oak dominated forest		Pine dominated forest	
Trees	1650m	1750m	1850m	1950m
Acer oblongum	+	-	-	-
Cedrus deodara	+	+	-	-
Cupressus torulosa	-	+	-	-
Ficus nerifolia	+	-	-	-
Myrica esculenta	+	-	+	+
Pinus roxburghii	+	+	+	+
Prunus cerasoides	+	+	-	-
Quercus floribunda	-	-	-	+
Quercus leucotrichophora	+	+	+	+
Rhododendron arboreum	+	-	+	+
Total (10)	8	5	4	5
Sapling				
Acer oblongum	+	-	-	-
Cupressus torulosa	-	+	-	-
Ficus nerifolia	+	+	-	-
Pinus roxburghii	-	+	+	+
Prunus cerasoides	+	-	-	-
Quercus floribunda	-	-	+	+
Quercus leucotrichophora	+	+	+	+
Rhododendron arboreum	+	-	-	-
Total (8)	5	4	3	3
Seedling				
Acer oblongum	-	+	-	-
Cupressus torulosa	-	+	-	-
Pinus roxburghii	+	+	+	+
Quercus floribunda	-	-	-	+
Quercus leucotrichophora	+	-	+	+
Rhododendron arboreum	-	-	+	-
Total (6)	2	3	3	3

Total tree diversity ranged from 0.66 – 2.69 and sapling diversity from 1.25 – 1.84. It was maximum in oak dominated forest at 1650m elevation, similarly seedling diversity ranged from 0.87 – 1.50. It was also maximum in oak dominated forest in 1750m elevation compared to pine dominated forest. Total tree concentration of dominance ranged from 0.44 – 0.76 and sapling concentration of dominance from 0.32 – 0.74. It was maximum in pine dominated forest at 1950m elevation compared to oak dominated forest. Seedling concentration of dominance ranged from 0.46 – 0.65. It was maximum in oak dominated forest at 1650m elevation compared to pine dominated forest (Table 2).

IV. Community Structure

Total tree density varied from 510 – 1250 tree/ha. It was maximum at 1650m elevation and minimum at 1750m elevation in oak dominated forest. Total basal area 33.88 – 70.90 m^2/ha, it was maximum in pine dominated forest at 1850m elevation and minimum in oak dominated forest at 1650m elevation. In sapling, total density ranged between 275 and 950 sapling/ha. It was maximum in oak dominated forest at 1650m elevation and minimum in pine dominated forest at 1950m elevation. Total coverranged between 5.86 and 11.96%. It was maximum at pine dominated forest at 1850m elevation compare to oak dominated forest at 1650m elevation. In seedling, total seedling density varied from 405 – 660 seedling/ha. It was maximum in oak dominated forest at 1650m elevation and minimum in pine dominated forest at 1950m elevation. Total cover varied from 8.44 – 12.89%. It was maximum in pine dominated forest at 1950m elevation and minimum in oak dominated forest at 1650m elevation (Table 2).

Table 2 : Diversity, concentration of dominance and Important vegetational parameters of different forest.

Parameter	Oak dominated forest		Pine dominated forest	
	1650m	1750m	1850m	1950m
Tree				
Density (tree/ha)	1250	510	935	540
T.B.A. (m^2/ha)	33.88	62.6	70.90	49.32
Diversity	2.69	1.31	1.10	0.66
Concentration of dominance	0.51	0.44	0.49	0.76
Richness	8	5	4	5
Sapling				
Density (sapling/ha)	950	500	280	275
Total cover (%)	5.86	11.22	11.96	10.98
Diversity	1.84	1.78	1.25	1.26
Concentration of dominance	0.32	0.34	0.42	0.74
Richness	5	4	3	3
Seedling				
Density (seedling/ha)	660	610	465	405
Total cover (%)	8.44	9.19	12.02	12.89
Diversity	0.87	1.50	1.17	1.16
Concentration of dominance	0.65	0.47	0.51	0.46
Richness	2	3	3	3

V. Discussion

The Himalaya is one of the largest mountain systems of the world and is considered as the great repository of biological and culture diversity. However, a wide variation in species richness across sites with similar tree crown cover may indicate that several other factors, such as history of disturbance, leaf chemistry of canopy and spatial arrangement of individuals can verify diversity (Kumar 2000). The Himalaya embodies a diverse and characteristics vegetation distribution over a wide range of topographical variations (Dhaulkhandi et al. 2008). The vegetation characteristics show dominance of one or more species in the area. Disturbance promotes undergrowth species diversity possibly by allowing several species to maintain their population in open condition. More penetration of light in open canopy forest may enable each species to develop large population, and large population may be less vulnerable to local extinction. In the present study, plant biodiversity is assessed by quantitative analysis of forest vegetation in different forest including anthropogenic and natural disturbance do not provide time for the ecosystem recovery and widen the forest gap and fragmentation of the land in the region.

The oak dominated forest showed highest species richness followed by chir–pine dominated forest. The chir-pine dominated forest was characterized by low species richness. Oak dominated forest showed greater variation in all three layers tree, sapling and seedling species richness. The decrease in species richness may be due to change in climatic condition, un-matured seed fall, increase biotic pressure and close of the tree canopy which arrest the regeneration of the some tree species. The opening of canopy increase the number of sapling species in the high disturbed forest. The different studies on the temperate forest oak and oak mixed forest indicate that the tree richness ranged between 3 and 43 species (Tewari and Singh 1982, Baduni and Sharma 1997, Rekhari et al. 1997, Ghildiyal et al. 1998 and Kharakwal 2005. Ram et al. 2004 have the tree richness at 1800 – 2000m (11 species). Burns (1995) and Austin et al. (1996) have analyzed association between species richness and climate, slope position and soil nutrient status. Both studies found that total species richness was greater at low elevation, warm site with moderate canopy, moderate rainfall and intermediate to high nutrient level.

Total tree density varied from 510 – 1250 tree/ha. Singh et al. (1994) have reported density value ranging from 250 – 2070 tree/ha for different Central Himalayan forests. Semwal (2006) has reported 640 tree/ha to 1146.69 tree/ha in forest of Kumaun Central Himalaya. Earlier tree density reported from 320 – 1670 ind/ha and 360 – 1787.5 ind/ha from low to high altitude forests of western Himalaya (Saxena and Singh 1982; Ralhan et al. 1982;Tewari 1982; Kalakoti et al. 1986; Chandra et al. 1989; Rawal et al. 1994 and Samant et al. 2002). The sapling density was observed between 275 – 950 sapling/ha and seedling density ranged between 405 – 660 seedling/ha. Greater variation in tree density was in oak dominated forest compare to chir-pine dominated forest. Similarly, sapling and seedling density varied in oak dominated forest. The oak dominated forest may favour the growth and of herbaceous vegetation with decreasing richness and density of the other woody vegetations.

In the present study, the value of total basal area of different forest and elevation was 33.88 - 70.90 m^2/ha. The tree basal area for several Central Himalayan

forest was reported in the ranged of 16.6 – 69.5 m^2/ha (Sexana and Singh 1982, Tewari 1982). Singh et al. (1994) have reported that total tree basal area for *P. roxburghii* forest (17 – 47 m^2/ha), *Q. leucotrichophora* forest (12 – 74 m^2/ha). The sapling cover of the forest ranged between 5.86 – 11.96%, whereas, the seedling cover was observed between 8.44 – 12.89%.

Shannon-weiner index tree diversity ranged between 0.66 and 2.69 in different forests and elevations. The sapling diversity ranged between 1.25 and 1.84, while the seedling layer diversity ranged between 0.87 and 1.50. The tree diversity index analyzed reported for most of the low elevation Central Himalayan forest (0.33 - 2.95) by Saxena and Singh (1982), Ralhan et al. (1982), Upreti et al.(1985), Bargali et al. (1987) Tripathi et al. (1987) and Rikhari et al. (1989). Tripathi et al. (1991) have reported tree diversity values 2.69 - 3.82 from low to high elevation. Giri et al. (2008) have reported tree diversity between 0.88 and 2.11 Monk (1967) and Risser and Rice (1971) obtained 2 - 3 as the highest values for diversity index of temperate forest. The diversity was lowest for the pine dominated forest and highest for oak dominated forest. The increased disturbance intensity may favour the invasion of seedling while moderate disturbance in oak forest favour the sapling. Anthropogenic disturbance first decrease the tree diversity with increasing intensity of disturbance decreased trees and sapling diversity and increased seedling diversity. The diversity of disturbance decreased the overall richness and diversity of the ecosystem.

Simpson's index tree concentration of dominance ranged between 0.44 and 0.76in different forests. The sapling concentration of dominance ranged between 0.32 and 0.74, while the seedling concentration of dominance ranged between 0.46 and 0.65. Whittaler (1965) and Risser and Rice (1971) reported concentration of dominance for tree layer in the range of 0.10 – 0.99 for temperate forests. Sexena and Singh (1982) and Ralhan et al. (1982) have reported similar value in the range of 0.25 – 1.00. The species richness and species diversity was greater in oak dominated forest at low elevation and moderate canopy sites. It is apparent from the current study that moderate disturbance is helpful in the regeneration of *Q. leucotrichophora* dominated sites.

References Références Referencias

1. Austin, M. P., Pausas, J. G. and Nicholls, A. O. 1996.Patterns of tree species richness in relation to environment in Sourtheastern New South Wales, Australia. 21: 154-164.
2. Ayyappan, N. and Parthsarathy, N. 1999.Biodiversity inventory of trees in large scale permanent plot of tropical evergreen forest at Varagalaiar, Anamalaris, Western Ghats, India. *Biodiversity and conservation;* 8: 1533-1554.
3. Baduni, N. P. and Sharma, G. M. 1997.Effect of aspect on the structure of some natural stands of *Cupressus torulosa* in Himalayan Moist temperate forests. Proceeding of Indian National Science Academy; 1362: 345-352.
4. Bargali, S. S., Tewari, J. C., Rawat, Y. S. and Singh, S. P. 1987.Woody vegetation in blue pine-mixed oak forest of Kumaun Himalaya, India: In Y. P. S. Pangtey and S. C. Joshi. (eds.), Western Himalaya: *Environmental problems and development.* Pp. 121-135, Gyanodaya Prakashan, Nainital.
5. Bormann, F. H., Sicamma, T. G., Likens, G. E. and Whittaker, R. H. 1970.The Hubbard Brook Ecosystem Study: composition and dynamics of the tree stratum. *Ecol. Monogr.* 4: 373-388.
6. Burns, B. R. 1995. Environment correlates of species richness at Waipoua Forest Sanctuary New Zealand. New Zealand journal of Ecology; 19:153-162.
7. Champion, H. G. and Seth, S. K. 1968.A revised survey of the forest types of India. Govt. of India press. Nasik, India.
8. Chandra, R., Upadhyaya, V. P., Bargali, S. S. 1989.Analysis of herbaceous vegetation under oak and pine forests along an altitudinal gradient in central Himalaya. Environment and Ecology. 7(3):521-525.
9. Curtis, J. T. and McIntosh, R. P. 1950.The interrelationship of certain analytic and synthetic phytosociological characters.*Ecology;*31: 438-455.
10. Dhar, U*., Rawal, R. S. and Samant, S. S. 1997.Structure diversity and representatives of forest vegetation in a protected area of Kumaun Himalaya, India: implication for conservation. Biodiversity and Conservation; 6: 995-1006.*
11. Dhaulkhandi, M., Dobhal, A., Bhatt, S. and Kumar, M. Community structure and regeneration potential of natural forest site in Gangotri, India.*Journal of basic and applied sciences;* 2008.Vol. 4: 49-52.
12. Ghildiyal, S, N.P. Baduni, V.P. Khandari and C.M. Sharma, 1998. Community structure and composition of oak forest along altitudinal gradients in Garhwal Himalaya Indian Journal of Forestry; 21(3): 242-247.
13. Giri, D., Tewari, A. and Rawat, Y. S. 2008.Vegetation analysis in mixed banj (*Q. leucotrichophora* A. Camus) Tiloj-oak (*Q. floribunda* Lindl.) Forest in Nainital catchment, *Indian Journal of Forestry;* Vol. 31(2): 167-174.
14. Good, N. F. and Good, R. E. 1972.Population dynamics of three seedlings and saplings in a mature eastern hardwood forest. Bull. *Torrey Bot. Club;*39: 172-178.
15. Halle, F., Oldemann, R. A. A. and Tomlinson, P. B. 1978.Tropical Tree and Forests.An Architectural Analysis.Springer, Berlin.

16. Henle, K., Davies, K. F., Kleyer, M., Margules, C. and Settele, J. 2004.Predictors of species sensitivity of fragmentation.*Biodiversity and Conservation.*13: 207-251.
17. Kalakoti, B. S., Y. P. S. Pangtey and A. K. Saxena, 1986.Quantitative analysis of high altitude vegetation of Kumaun Himalaya. J. India, Bot.Sec.65: 384-396.
18. Kharkwal, G., Pehrotra, P. and Pangtey, Y. P. S. 2005.Comparative studies on species richness, diversity and composition of oak forest in Nainital District, Uttaranchal, *Current science.*Vol. 89: 668-672.
19. Khera, N., Kumar. A., Ram, J. and Tewari, 2001.APlant biodiversity assessment in relation to disturbances in mid elevational forest of Central Himalaya, India.*Tropical Ecology;*42: 83-95.
20. Kumar, A. 2000.*Plant biodiversity in forests of middle Central Himalaya in relation to various disturbances.*Ph. D. thesis, Kumaun University, Nainital.
21. Kumar, A. and Ram, J. 2005.Anthropogenic disturbances and plant biodiversity in forests of Uttaranchal, Central Himalaya.*Biodivers.Conserv*. 14: 309-331.
22. Monk, C.D. 1967.Tree species diversity in the eastern deciduous forest with particular reference to North Central Florida.*Am. Nat.* 101: 173-187.
23. Oliver, C. D. and Larson, B. C. 1990.*Forest stands dynamics.* Mcgraw Hill inc. New York.
24. Pande, P. K., Negi, J. D. S. and Sharma, S. C. 1996. Species diversity, turn over resource apportionment among various plant species in western-Himalaya forests. *Abstract.* First Indian Ecological Congress, New Delhi. 27-31.
25. Phillips, E. A. 1959.Method of vegetation study. Henry Holt and Co. Inc. New York.
26. Ralhan, P. K., Saxena, A. K. and Singh, J. S. 1982.Analysis of forest vegetation in and around Nainital in Kumaun Himalaya.*Proc. Indian Natl. Science Acad;*48: 122-138.
27. Ram, J., Kumar, A. and Bhatt, J. 2004.Plant diversity in six forest types of Uttaranchal, Central Himalaya, India.*Current science*. Vol. 86: 975-978.
28. Ram, Jeet. Tewari, Beena. And Arya, Neeta. 2005.Variation in plant biodiversity of chir-pine and baj-oak forests of Uttaranchal Himalaya. 54-56 pp. In Muthuchelian (ed.). Biodiversity resources management and sustainable use.*Centre for biodiversity and forest studies,* Madurai.
29. Rawal, R.S. and Pangtey, Y. P. S., 1994.High altitude forest vegetation with spedial reference to timberline in Kumaun Central Himalaya. In: High Altitude of the Himalaya, Pangtey, Y. P. S. and Rawal, R. S. (des.).pp. 353-399. Nainital, India. Gyanodaya Prakashan.
30. Rekhari, H.C. Adhrikari, B. S. and Rawat, Y.S. 1997.Woody species composition of temperate forests along an elevation gradient in Indian central Himalaya. Jour. of Tropical Forest Science; 10 (2):197-211.
31. Rikhari, H. C., Chandra, R. and Singh, S. P. 1989.Patterns of species distribution and community along a moisture gradient within and Oak Zone of Kumaun Himalaya.*Proc. Indian Nat. Acad.* B. 55: 431-438
32. Risser, P. G. And Rice, E. L. 1971.Diversity in tree species in Oklahoma upland forests.*Ecology;*52: 876-880.
33. Amant, S.S., Joshi, H. C., Arya, S. C. and Pant, S. 2002.Studies on the structure, composition and change of the vegetation in Nanda Devi Biosphere Reserve of West Himalaya-Final Technical report submitted to Ministry of Environment and Forest. New Dehli.
34. Saxena, A. K. and Singh, J. S. 1982.A phytosociological analysis of woody species in forest communities of a part of Kumaun Himalaya.*Vegetatio.*50: 3-22.
35. Semwal, S. 2006.*Studies on phytosociology, Diversity patterns and competition along an altitudinal gradient in a part of lesser Himalaya, Garhwal, Uttarakhand,* Ph. D. thesis, H. N. B. Garhwal University, Srihagar, Garhwal, Uttarakhand, India.
36. Shannon, C. E. and Weaver, W. 1963.The Mathematical theory of communication.University of Illinois Press, Urbana.
37. Simpson, E. H. 1949. Measurment of Diversity. *Nature;*163: 688.
38. Singh, S. P., Adhikari, B. S. and Zobel, D. B. 1994.Biomass productivity, leaf longevity and forest structure in Central Himalaya, *Eco. Monog.*64: 401-421.
39. Singh, J. S. and Singh, S. P. 1986. Structure and function of Central Himalayan oak forests. Proc. *Indian. Sci.* (Plant Sci.) 96: 443-455p.
40. Singh, J. S. and Singh, S. P. 1992.Forest of Himalaya. Structure and Functioning and Impact of man. Gynodya Prakashan, Nainital, India.
41. Singh, J. S. and Singh, S.P. 1987.Forest Vegetation of the Himalaya.*Bot. Rev.,* 53: 80-192.
42. Singh, S. K. and Rawat, G. S. 2000.*Flora of Great Himalaya National Park.*Bishen Singh Mahendra Pal Singh, Deheradun, India.
43. Singh, S. P. 1998. Chronic disturbance, a principal cause of environmental degradation in developing countries (Editorial). Environ. Conserv. 25: 1-2.
44. Silori, C. S. 2001.Status and distribution of anthropogenic pressure in the buffer zone of Nanda Devi Biosphere Reserve in Western Himalaya, India.*Biodiversity and Conservation;* 10: 1113-1130..

45. Tewari, I. C. and Singh, S. P. 1981.Vegetational analysis of a forest lying in transitional zone between lower and upper Himalaya moist temperate forest. pp. 104-119. In: G. S. Paliwal (eds.). *The Vegetational Wealth of Himalaya.*Priya Publishes, New Delhi.
46. Tewari, J. C. 1982.*Vegetational analysis along altitudinal gradient around nainital,* Ph. D. Thesis, Kumaun University, Nainital.
47. Tripathi, B. C., Rikhari, H. C., Bargali, S. S. and Rawat, Y. S. 1991.Species composition and regeneration in disturbed forest sites in oak zone in and around Nainital.*Proc. Indian Nation.Cei. Acad.* Pp. 381-390.
48. Tripathi, B. S., Rikhari, H. C. and Singh, R. P. 1987.Dominance and diversity distribution in certain forest of Kumaun Himalayas, IX *International symposium on tropical ecology;*235pp.
49. Upreti, N., Tewari, J. C. and Singh, S. P. 1985.The oak forests of the Kumaun Himalaya (India) 1: Composition, diversity and regeneration. *Mountain Research and Development;*5 (2): 163-174.
50. White, P. S. 1979. Pattern, process and natural of disturbance in vegetation. Bot *Rev.*, 45: 229-299.
51. White, P. S. and Jentsch, A. 2001.The search for generality in studies of disturbance and ecosystem dynamic.*Prog. Bot.,* 62: 399-450.
52. Whittaker, R. H. 1975. Communities and ecosystems.2nd ed. Macmillan Pub.Co., New York; 385 pp.
53. Whittaker, R. H. 1972.Evolution and management of species diversity.*Taxon;*21: 213-251.
54. Yamamoto, S.1994.Gap regeneration in primary evergreen broad-leaved forests with or without a major canopy tree, *Distyliumracemosum,* southwestern Japan: A comparative analysis. *Ecol. Res.* 9: 295-302.

This page is intentionally left blank