Effect of anthropogenic disturbances on plant diversity in Oak dominated forests of Nainital, Kumaun Himalaya, India

Anita Joshi and Anil Kumar Yadava

Department of Forestry and Environmental Sciences, Kumaun University, Soban Singh Jeena campus, Almora.
akyadava09@gmail.com

Abstract: The present study was conducted during 2012-14 between 29º22´ and 29º23´ N latitude and 79º 26´ and 79º 28´E longitude, located in Nainital catchment to assess variation and impact of disturbances in oak-dominated (*Quercus leucotricophora and Quercus floribunda)* forest. Forest structure, species composition and biodiversity changes due to anthropogenic disturbance through foliage removal (lopping), deforestation, grazing, surface burning, and litter removal. In *Q. leucotrichophora* forest, tree species richness, declined with increasing level of disturbances, the tree density ranged from (715-765ind/ha), sapling density (115-190ind/ha), seedling density (420-580ind/ha), shrub density (1420-2360ind/ha) and herb density (861000-1032000). The anthropogenic pressure were high on *Quercus* species at disturbed sites as a result the tree and herb species richness, density, total basal area and diversity were low in disturbed forest compared to undisturbed forest. Shrub and herb richness were maximum in moderate forest.

[Anita Joshi and Anil Kumar Yadava. **Effect of anthropogenic disturbances on plant diversity in Oak dominated forests of Nainital, Kumaun Himalaya, India.** *N Y Sci J* 2015;8(1):22-27]. (ISSN: 1554-0200). http://www.sciencepub.net/newyork. 4

Key words: anthropogenic disturbance, biodiversity, conservation, diversity, oak-forest

Introduction

The Himalayan vegetation ranges from tropical dry deciduous forests in the foothill to alpine meadow above tree line (Singh and Singh, 1992 and Ram *et al.,* 2004). Species compositions of major forests types of Central Himalaya have been described by Ralhen *et al (*1982), Saxena and Singh (1982), Saxena *et al.,* (1984), Singh and Singh (1987), Tewari and Singh (1981) and Upreti *et al.,* (1985). Singh and Singh (1992) have summarized the information on the structure and functioning of the Himalayan forest ecosystem. Himalayan forest ecosystem has a major contribution to the mega-biodiversity of India; it is one of the 'hot spots' of biodiversity. The usually wide altitudinal range (over 3000m), rapid change in altitude and high endemism (Singh and Singh, 1992; Zobal and Singh, 1997), make it interesting area for studies on biodiversity. Biodiversity is the totality of genes, species and ecosystem in the region. Various aspect of biodiversity of these forests has been studied by (Dhar *et at*. 1997; Silori, 2001; Kumar, 2000 and Khera *et al.,* 2001). Increasing anthropogenic pressure on forest over the few decades has led to vast exploitation of natural flora in Uttarakhand Himalaya.

Anthropogenic disturbances play an important role in change, loss or maintenance of plant biodiversity and more recent phenomenon of climate change will also be responsible for the change in species composition and other ecosystem activities (Ram *et al*., 2005). Several authors have studied the effect of disturbance on Himalayan forests. The effect of anthropogenic disturbance on plant diversity and community structure in the forest of north eastern Himalaya, India was studied by Khan *et al*. (1987); Misra *et al.* (2004) and Rao *et al*. (1990). Plant diversity in six forest types in Uttarakhand by Ram *et al*. (2004), and tree diversity and population structure in undisturbed and human-impacted stands of tropical wet ever-green forest in Arunanchal Pradesh were studied by Bhuyan *et al*. (2003). All of the above studies reported that increased degree of disturbance caused loss of plant diversity and brought about a change in community characteristics. Banj oak *(Quercus leucotrichophora*) and Tilonj oak (*Quercus floribunda*) are the two dominant forest forming species of Central Himalayan occurring between 1800-2300m elevations, both are evergreen species. In the recent years various human generated disturbances occurred in the forest of Uttarakhand Himalaya and Oak happens to be the most effected species, this disturbances includes deforestation; grazing, surface burning, looping and litter removal these disturbances are not only changing the structure of ecosystem but also affecting the biodiversity of the forest as a result many of living species are shifting towards endangered and threatened. It is clearly indicated from various study that banj-oak (*Quercus leucotrichophora*) are failing to regenerate adequately over large areas on the other hand chir-pine *(Pinus roxburghii*) is regenerating copiously (Saxena and Singh, 1984; Singh and Singh, 1985; Rao and Singh, 1986). However depletion of oak forest has contributed to expansion of *Pinus roxburghii*. Therefore, the conservation and scientific management of this species for socio-economic development, betterment of soil, livestock and human assumes a great significance. In this study, an attempt has been made to assess the impact of disturbance on forest vegetation in Kumaun Himalaya, Uttarakhand.

Materials and Methods

The present study was conducted during 2012-14 between 29º22´ and 29º23´ N latitude and 79º 26´ and 79º 28´E longitude, located in Nainital catchment to assess variation and impact of disturbances in oak-dominated (*Quercus leucotricophora and Quercus floribunda)* forest. The forest were thoroughly surveyed and identified as *Q. leucotrichophora* (Banj-oak) dominated forest and mixed (*Q. leucotrichophora and Q. floribunda*) oak forest. The present study was conducted in four different sites each site is further divided into disturbed and undisturbed sites, to assess impact of disturbances in plant community on eight different aspects. The climate of Nainital is monsoonal. The minimum temperature in year 2012 ranged from 0-1.5^{0}C in February to 18.70^{0}C in June, while maximum temperature from 12.5^{0}C in January to 28.4^{0}C in June. The maximum rainfall occurred in July (833.8mm) and lowest in May and October (1mm). Vegetation analysis was made for all the three layers of forest, i.e. trees, shrubs and herbs, for identification Osmaston (1926) 'Forest Flora of Kumaun' was used the phyto-sociological analysis was done by twenty sampling of 10x10m quadrats on each site. The size and number of samples were determined following Saxena and Singh (1982). The vegetational data were calculated for abundance density and frequency (Curtis and Mc Intosh, 1950). Importance Value Index (IVI) for the tree was determined as the sum of relative density, relative frequency and relative dominance (Curtis, 1959). Tree considered to be individuals > 30cm cbh (circumference at breast height), saplings 10-30 cm cbh and seedlings <10cm circumference (Saxena and Singh, 1984; Upreti, 1982). The shrub layer were analysed by sampling quadrats of 5x5m and the herbs layer by placing quadrats of 1x1 m randomly on each site. The diversity index for all the three layers at each study site was calculated by using Shannon-Wiener (1963) and Concentration of dominance by using Simpson's (1949) Index.

Disturbance regime

A reconnaissance survey showed disturbances over the area this was also confirmed by interviews of local population because the area is dotted with Human habitation, anthropogenic pressure was most visible. The level of disturbance in the forests was estimated in terms of tree density, canopy cover, looping percentage, cut stumps and dug piles (Misra *et al.,* 2004). On the basis of these parameters, three stands viz. (i) highly disturbed (HD), (ii) moderately disturbed (MD) and (iii) less disturbed (LD) were identified in each forest type (**Table 1**). Canopy cover was recorded directly in the field by spherical densiometer and expressed as the percent ground area covered by the canopy. Densiometer has 24 grids and readings were taken in four directions amounting to total 96 grids. The number of covered grids was converted into % by multiplying with 1.04 (derived from 100/96).

Results

Canopy cover, lopping, cut stumps and dug piles of different forests

In the undisturbed stand of *Q. leucotrichophora* forest, canopy cover was more 65-70% compared to 45-50% in moderately disturbed stand and 35 % in highly disturbed stand. Lopping %, cut stumps and dug piles were found to be more in highly disturbed forest 60%, 55%, and >250, respectively, compared to moderately disturbed forest where lopping % was 44-45.8% and cut stumps were 48-49.7% and no dug piles were found for this site and in less disturbed forest lopping% and cut stumps was 31.25% 34.8%, respectively, and no dug piles were found for this site (**Table 1**).

Table 1. Range of disturbance indicator used for different disturbance categories:

Stand	Distribution indicators			
	Canopy cover (%)	Lopping (%)	Cut Stumps (h^{-1})	Dug piles
Undisturbed Banj-oak forest	65	*	*	*
Disturbed Banj-oak forest	35	60.00	55.0	>250
Undisturbed Mixed-oak forest	68	*	*	*
Moderately Disturbed Mixed-oak forest	45	44.00	48.0	*
Undisturbed Mixed oak-oak forest	66	*	*	*
Moderately Disturbed Mixed-oak forest	50	45.80	49.7	*
Undisturbed Tilonj-oak forest	70	*	*	*
Less Disturbed Tilonj-oak forest	60	31.25	34.8	*

Density and total basal area

Species density for tree, saplings, seedlings, shrub and herb were recorded low for disturbed sites compared to undisturbed sites. At undisturbed sites the density for tree, saplings, seedlings, shrub and herb were recorded viz., 765-1000, 220-410, 1020-1300, 1400-1460 and 796000-1034000, respectively, while for disturbed site it was recorded 715-765, 115-190, 420-580, 1420-2360 and 861000-1032000, respectively, total basal area for tree was high (88.884m^2/ha) for undisturbed S_3 aspect and the low (31.075m^2/ha) for less disturbed S_4 site. Total shrub cover was high 7.3% for highly disturbed S_1 site and minimum 4.8% for undisturbed S_4 site. Herb cover was high 25.02% for undisturbed S_4 site and minimum 19.0% for undisturbed S_4 site. (**Table 2a,b,c and 3a,b**).

Species richness and diversity

A total of 120 species were recorded from the study area out of which 20, 29 and 71 were trees, shrubs and herbs, respectively. Species diversity for tree, saplings and seedlings, shrub and herb were recorded low from disturbed sites as compared to undisturbed sites. In undisturbed sites the diversity of tree, saplings, seedlings, shrub and herb were recorded 1.139-2.491, 2.100-2.807, 2.230-2.681, 2.598-3.650 and 4.049-4.477, respectively, while for disturbed sites it were recorded 1.096-2.306, 2.181-2.707, 1.477-2.611, 2.748-3.880 and 4.238-4.574, respectively (**Table 2a,b,c and 3a,b**).

Table 2(a). Species richness, Diversity and Important vegetational parameters for trees in different forest.

Undisturbed Site	Density (ind./ha)	T.B.A (m²/ha)	Diversity	Richness
S_1	1000	87.500	2.491	11
S_2	765	59.407	2.479	10
S_3	990	88.884	2.435	10
S_4	985	56.958	1.139	5
Disturbed Site				
S_1 (HD)	715	35.449	1.967	8
S_2 (MD)	740	50.800	2.306	6
S_3 (MD)	765	79.749	2.032	7
S_4 (LD)	720	31.075	1.096	5

Table 2(b). Species richness, Diversity and Important vegetational parameters for Saplings in different forest.

Undisturbed Site	Density (ind./ha)	T.B.A (m²/ha)	Diversity	Richness
S_1	280	0.502	2.807	9
S_2	220	0.447	2.764	8
S_3	410	0.808	2.718	9
S_4	250	0.502	2.100	5
Disturbed Site				
S_1 (HD)	190	0.388	2.143	6
S_2 (MD)	115	0.273	2.707	7
S_3 (MD)	155	0.190	2.423	6
S_4 (LD)	130	0.230	2.181	5

Table 2(c)). Species richness, Diversity and Important vegetational parameters for Seedlings in different forest.

Undisturbed Site	Density (ind./ha)	T.B.A (m²/ha)	Diversity	Richness
S_1	1300	0.514	2.609	8
S_2	1020	0.369	2.681	8
S_3	1300	0.530	2.230	7
S_4	1240	0.483	2.262	6
Disturbed Site				
S_1 (HD)	520	0.344	1.477	5
S_2 (MD)	580	0.261	2.611	7
S_3 (MD)	560	0.290	2.031	6
S_4 (LD)	420	0.108	2.128	5

Table 3(a). Species richness, Diversity and Important vegetational parameters for Shrubs in different forest.

Undisturbed Site	Density (ind./ha)	T.B.A (m²/ha)	Diversity	Richness
S_1	1460	5.44	3.650	17
S_2	1440	5.102	3.346	15
S_3	1420	4.900	3.340	15
S_4	1400	4.800	2.598	13
Disturbed Site				
S_1 (HD)	2360	7.300	3.880	17
S_2 (MD)	1480	5.220	3.445	15
S_3 (MD)	1460	5.110	3.371	15
S_4 (LD)	1420	4.950	2.748	13

Table 3(b). Species richness, Diversity and Important vegetational parameters for herbs in different forest.

Undisturbed Site	Density (ind/ha)	T.B.A (m^2/ha)	Diversity	Richness
S_1	1034000	25.02	4.477	31
S_2	991000	24.03	4.458	30
S_3	961000	22.74	4.391	30
S_4	796000	19.00	4.049	28
Disturbed Site				
S_1 (HD)	898000	21.90	4.238	31
S_2 (MD)	1032000	24.90	4.574	30
S_3 (MD)	994000	24.20	4.572	30
S_4 (LD)	861000	20.40	4.270	28

Discussion

The anthropogenic disturbances are the major causes of forest destruction in the Uttarakhand Himalaya (Tucker, 1983). Even today broadleaf evergreen species like *Quercus* are extensively lopped for fodder, fuel wood and for making agricultural implements by the local people. At higher altitudes, lopping of tree leaves is done for animal bedding especially during winter, which is then used for compost. High concentration of grazing animals is another major cause of forest destruction in the region (Negi and Todaria, 1993). Regular human interventions for collection of fuel wood and minor forest product and grazing and trampling by animal are also common in *Q. leucotrichophora* forest. However, due to disturbances in these forests, the canopy cover was less and the soil became poorer in moisture and fertility compared to undisturbed forests.

The tree species richness was higher at moderately disturbed site and less at highly disturbed site. In *Q. leucotrichophora* forest, tree species richness, declined with increasing level of disturbance. In the present study the tree density varied from (715-765ind/ha) which were comparatively lower than the value reported by Singh *et.al*. (1994) they have reported tree density values ranging from (250-2070ind/ha) for different central Himalayan forests. This decline may be due to a gradual and consistent increase in the extraction of fuel wood and fodder as *Q. leucotrichophora* and *Q. floribunda* are the dominant species in these forests which are extensively used as fuelwood and fodder.

On the basis of total basal area of these forest the disturbed forest had basal area generally between (31.075-79.7491m^2/ha) and undisturbed forests had basal area generally between (56.958-87.3m^2/ha) Upreti (1982) have reported total basal area for disturbed area generally below (38.7m^2/ha) and relatively higher basal area (33.71-74.17m^2/ha) for undisturbed forests. Here total basal area also declined with disturbance level that agreed with earlier findings (Bhuyan *et al.,* 2001; Bhuyan *et al.,* 2003; Ramirez *et al.,* 2001), that showed decreasing density and total basal area with increasing disturbance Intensity. Total basal area has also been correlated with the rate of disturbance (Ramirez *et al.,* 2001). The seedlings and saplings are less in numbers and the density of trees for disturbed forest were less compared to undisturbed forest. Total sapling density varied from (220-410ind/ha) for undisturbed forest and (115-190ind/ha) for disturbed forest. Seedlings density at undisturbed site ranged between (1020-1300ind/ha) while it was (420-580ind/ha) for disturbed forest. Total basal area for saplings and seedlings were low for all disturbed sites compared to undisturbed sites. In general the sapling and seedlings density of dominant tree species was much lower in disturbed forest this could be the attributed to the heavy extraction of dominant tree species for use as fuel and fodder and timber decreased number of sapling and seedling at disturbed forest is another consequence of anthropogenic pressure number of saplings and seedlings of dominant species was lower than the number at undisturbed site in the present study, which might be due to the inability of all seedlings to graduate into saplings and saplings into trees the saplings could be cut down for fuel by men and grazed as a fodder by animals and the seedlings could possibly trampled out either by men or by the grazing animals at the disturbed forest further the highly disturbed forest had poor regeneration of dominant tree species due to higher disturbances the soil of the aspect became poorer in moisture and fertility so the moisture observing capacity of the soil become less which led to the other lesser altitudinal forest species *i.e. P. roxburghii* to grow, that can grow in very poorer soil and barren areas (Tewari, 1982, Saxena *et.al*., 1985; Gurarani *et al*., 2010) in the present study at highly disturbed S_1 site the pine sapling and seedlings increasing in numbers which indicates the impact of disturbances this shows the depletion of oak forest gradually and expansion of pine. Banj-oak is failing to regenerate adequately over large areas on the other hand chir pine is regenerating copiously and increasing in numbers (Saxena and Singh, 1984, Singh and Singh, 1985., Rao and Singh 1986). Similar pattern were observed in the present study. Absence of saplings and seedlings in disturbed S_1 and also the conversion of seedlings into saplings of dominant species were low for all the disturbed sites indicate that it may have a significant bearing on the forest structure in coming years. Severe disturbances may reduce vegetation structure by destroying vegetation structure or moving it off site. While mild and moderate severely disturbances may enhance structure complexity by increasing the density of structure type (Franklin, 1992).

In the present study shrub diversity was measured high at highly disturbed site while herbs density was observed less at highly disturbed site but found more at moderately disturbed sites. (Garkoti, 1992) reported the herb diversity in the range of (4.09-4.22) for certain high altitude forests of central Himalaya. In the present study the value of herb diversity was in the range of (4.238-4.574) for disturbed forest and (4.049-4.477) for undisturbed forest in certain forests of Kumaun Himalaya. The diversity and species richness for tree, saplings seedlings were higher at undisturbed forest except shrub diversity which was higher at disturbed site. Species diversity for shrub and herb was higher at moderately disturbed forest. Species diversity at highly disturbed forest was low while moderately disturbed forest had high species richness. This indicates that moderate disturbances maintains high number of shrubs and herbs by opening the canopy disturbance at moderate level providing favourable conditions for undergrowth to grow , where forest canopy was moderately opened as compared to high and less disturbed forest. This may provide opportunity for invasion of more shrub and herb in the area. According to intermediate disturbance hypothesis (Connell 1978; Huston 1979), with no or little disturbance, only the competitive dominants can survive, while at sufficient high level of disturbance only fugitive species can survive, therefore, the diversity is maximum at the intermediate level of disturbance (Abugov, 1982). The mild disturbance provides greater opportunity for species turnover, colonization and persistence of high species richness (Whittaker, 1975).

References

1. Abugov, R. 1982. Species diversity and phasing of disturbance. *Ecology* 63: 289-293.
2. Bhuyan, P., Khan, M. L. and Tripathi, R.S. 2003. Tree diversity and population structure in undisturbed and human impacted stands of tropical wet evergreen forest in Arunachal Pradesh, Eastern Himalayas, India. *Biodiversity and Conservation* 12:1753-1773.
3. Connell, J. H. 1978. Diversity in tropical rain forests and coral reefs. *Science* 199: 1302-1310.
4. Curtis, J.T. and Mc Intosh, R.P. 1950. The interrelations of certain analytic and synthetic phytosociological characters. *Ecology* 31: 434-455.
5. Curtis, J.T. 1959. *The Vegetation of Wisconsin. An Ordination of Plant Communities*. University Wisconsin Press, Madison, Wisconsin.
6. Garkoti, S.C. 1992. High altitude forest of Central Himalaya: Productivity and nutrient cycling. Ph.D. Thesis, Kumaun University, Nainital.
7. Gurarani, D., Arya, N., Yadava, A and Ram J. (2010). Studies on plant biodiversity of pure *Pinus roxburghii* Sarg. Forest and mixed pine-oak forest in Uttarakhand Himalaya. *New York Science Journal*. Vol. 3(8):1-5.
8. Huston, M. A. 1979. A general hypothesis of species diversity. *The American Naturalist* 113: 81-101.
9. Khan, M. L., J. P. N. Rai and R. S. Tripathi 1987. Population structure of some tree species in disturbed and protected sub-tropical forests of north-east India. *Acta Oceologia Oceology Aplicata (France)* 8: 247-255.
10. Kumar, A. and Ram, Jeet 2005. Anthropogenic disturbances and plant biodiversity in forests of Uttaranchal, Central Himalaya. *Biodiversity and Conservation* 14: 309-331.
11. Misra, B. P., Tripathi, O. P., tripathi, R. S. and Pandey, H. N. 2004. Effects of anthropogenic disturbance on plant diversity and community structure of a sacred grove in Meghalaya, Northeast India. *Biodiversity and Conservation* 13: 421-436.
12. Osmaston, A.E. 1926. *A Forest Flora for Kumaun*. International Book Distributors, Dehradun, India.
13. Ralhan, P.K., Saxena, A.K., and singh, J.S. 1982. Analysis of forest vegetation at and around Nainital in Kumaun Himalaya. *Proceedings of Indian National Science Academy* 48B: 122-138.
14. Ram Jeet, Kumar, A. and Bhatt, J. 2004. Plant diversity in six forest types of Uttaranchal, Central Himalaya, India. *Current Science* 86: 975-978.
15. Ramirez - Marcial, N., M. Gonzalez- Espinosa & G. Williams - Linera. 2001. Anthropogenic disturbance and tree diversity in montane rain forests in Chiapas, Mexico. *Forest Ecology and Management* 154: 311-326.
16. Rao, P., Barik, S. K., Pandey, H. N., and Tripathi, R. S. 1990. Community composition and tree population structure in a sub-tropical broad leaved forest along a disturbance gradient. *Vegetatio* 88: 151-162.
17. Saxena, A.K and Singh, J.S. 1982. A phyto-sociological analysis of woody species in forest

communities of a part of Kumaun Himalaya. *Vegetatio* 50: 3-22.
18. Saxena, A.K., Singh, S.P., and Singh, J.S. 1984. Population structure of forests of Kumaun Himalaya. Implications for management. *Journal of Environmental Management* 19: 307-324.
19. Shankar. U. 2001. A case of high tree diversity in a Sal (*Shorea robusta*)-dominated lowland forest of Eastern Himalaya: Floristic composition, regeneration and conservation. *Research article Current Science, vol. 81, No. 7.*
20. Shannon, C.E. and Weaver, W. 1963. *The Mathematical Theory of Communication*. University of Illinois Press, Urbana.
21. Simpsons, G. 1964. Species diversity of North American recent mammals. *Syst. Zoo.,13:*57-73.
22. Singh, J.S. & S.P. Singh. 1987. Forest vegetation of the Himalaya. *Botanical Review* 52: 80-192.
23. Singh, J.S. and Singh, S.P. 1992. *Forests of Himalaya; Structure, Functioning and Impact of Man*. Gyanodaya Prakashan, Nainital, India.
24. Singh, S.P. and Singh, J.S. 1991. Analytical and conceptual plan to reforest Central Himalaya for sustainable development. *Environmental Management* 15: 369-379.
25. Singh, S.P. 1998. Chronic disturbance, a principal cause of environmental degradation in developing countries (Editorial). *Environmental Conservation* 25:1-2.
26. Singh, S.P., Adhikari, B.S. and Zobel, D.B. 1994. Biomass productivity, leaf longevity and forest structure in the Central Himalaya. *Ecological Monograph* 64: 401-421.
27. Tewari, J.C. and Singh, S.P. 1981. Vegetation analysis of a forest lying in transitional zone between lower and upper Himalayan moist temperate forests. pp. 104-119. *In*: G.S. Paliwal (ed.). *The Vegetational Wealth of Himalaya*. Puja Publishers, New Delhi.
28. Tilman, D. 1988. *Plant Strategies and the Dynamics and Structure of Plant Communities*. Princeton University Press, Princeton, New Jersey.
29. Turner, M.G., Romme, W.H., Gardener, R.H., O'Neill, R.V. and Kratz, T.K. 1993. A revised concept of landscape equilibrium: disturbance and stability on scaled landscapes. *Landscape Ecology* 8: 213-227.
30. Uniyal, P., Pokhariyal, P., Dasgupta, S., Bhatt, D. and Todaria, N. P. 2010. Plant diversity in two forest types along the disturbance gradient in Dewalgarh watershed, Garhwal Himalaya. *Current Science* 98: 938-943.
31. Upreti, N. 1982. A study on phytosociology and state of Regeneration of Oak Forest at Nainital. Ph.D. thesis, Kumaun University, Nainital, India.
32. Upreti, N., Tewari, J.C. and Singh, S.P. 1985. The Oak forests of the Kumaon Himalaya (India): Composition, diversity and regeneration. *Mountain Research and Development* 5: 163-174.
33. Whittaker, R.H. 1975. *Communities and Ecosystems*. 2nd Edition, Macmillan Publishing Co., New York.

1/7/2015