ANTHROPOGENIC DISTURBANCE AND PLANT DIVERSITY IN INDIAN -A REVIEW

Abstract

Forests wealth of India comprising with tropical, sub tropical, temperate and alpine type of vegetation. At present all these forest types experience with threats of natural and anthropogenic disturbance. Different disturbance factors and their effect on the concerning plant diversity have been worked out at research front throughout the world. Some workers determined the disturbance in form of canopy openings, plant density, elicit felling, lopping, over grazing and forest fires. In India, the major threats to forest depletion can be seen as alternation of forest areas for developmental activities, felling, lopping, shifting cultivation and other anthropogenic disturbances.

Keywords: plant diversity, disturbance factor, forest fires, cultivation.

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I. INTRODUCTION

A significant loss of biodiversity worldwide continuing take place due to deforestation and forest degradation at alarming rates. Some 420 million hectares of forest have been lost since 1990 through conversion to other land uses, although the rate of deforestation has decreased over the past three decades(SOFO, 2020).At present the India have 24.62 % area under forest, out of which the forest cover and tree cover contribute 21.71 % and 2.91 % respectively (ISFR, 2021). With a wide range of vegetation governed by diversified landforms, relief and environmental conditions, India has been a botanist's paradise (Rana et al., 2010). The over exploitation of forests has resulted into loss of biodiversity due to the loss of their habitat. The impact of human influence on natural forests is severe resulting into the loss of biological pool, which not only reduces the species diversity but also leading towards the end of birth of forest species (Bisht and Lodhiyal, 2005). Encroachment may disrupt understory resources and vegetation pattern (Breshears, 2006). Disturbance in the form of encroachment has increased over story tree density and canopy cover and has altered tree composition, since encroaching species are frequently different than the pre-encroachment over story dominants (Archer, 1990; Abrams, 1992).

Any form of disturbance, whether natural or anthropogenic tends to change the forest structure, dynamics and composition. Depending upon the degree of disturbance, the colonization by pioneer or other species is likely to vary and, therefore, the species composition and stand structure of a forest stand would depend on its ambient environment (Sahoo et al., 2008). The geological disturbance are natural and include landslides, soil erosion and earthquakes whereas the anthropogenic disturbances include deforestation, grazing , lopping of tree branches for fuel wood and fodder, removal of leaf and wood litter and frequent fires (Kumar and Ram, 2005).

Generally, post-disturbance change in regeneration, dominance and diversity of woody species are related to characteristics of the overall disturbance regime, including the intensity, frequency and scale of disturbance (Kennard et al., 2002; Mori and Takeda, 2004; Zhu et al., 2007). Forest disturbance can alter environmental conditions by changing light availability and soil conditions (Fredericksen and Mostacedo, 2000). Disturbance also influences processes that can either augment or erode the ecological functions of a forest community (Sagar et al., 2003). Both natural and human disturbances influence forest dynamics and tree diversity at local and regional scales (Hong et al., 1995; Hubbell et al., 1999; Sheil, 1999; Ramirez-Marcial et al., 2001).

Clements (1936) viewed disturbance as a negative force that destroys climax assemblages and brings instability in the system, while Paine (1966) and Lubchenco (1978) considered them as a positive force that might increase species diversity in the community by preventing competitive exclusion by dominant species. Earlier various workers has been explored the IDH (Intermediate Disturbance Hypothesis) with combining various phenomena in different forest (Connell, 1978, Hustan, 1979, Sheil and Burselm, 2003, Roxburgh et al. 2004, Shea et al., 2004, Haddad et al. 2008). The nature of disturbance regime and type of forests also determine the influence on diversity as reported by Cochrane, 2003 and Englbrecht et al, 2007. According to Pederson et al., (2008) disturbance in form of natural (i.e. wind, flooding, fire) and anthropogenic (i.e. timber harvesting, land abandonment) are attributed for current stand development, composition and structure.

II. DISTURBANCE AND PLANT DIVERSITY IN DIFFERENT FOREST TYPES OF INDIA

Forests wealth of India comprising with tropical, sub tropical, temperate and alpine type of vegetation. At present all these forest types experiences with threats of natural and anthropogenic disturbance. Different disturbance factors and their effect on the concerning plant diversity have been worked out at research front throughout the world. Some workers determined the disturbance in form of canopy openings, plant density, elicit felling, lopping, over grazing and forest fires. Disturbance and its effect on diversity, composition and regeneration studies in different Indian forest types indicates the required management and conservation practices of these forests (Kumar et al., 2004, 2005, 2009, Uniyal et al., 2010, Prasad et al, 2017, Singh et al., 2018, Kumar and Jeetram, 2005).

III. WESTERN HIMALAYAN REGION

In terms of plant diversity, different forest parts of Indian Himalayan region has been explored for research in past decades (Singh and Singh 1986, 1987, 1992, Singh et al., 1994, Baduni and Sharma 1996, Kala, 2000, Khera et al., 2001, Uniyal et al., 2002, Mishra et al., 2004,Jeetram et al., 2004, Kumar and Jeetram 2005, Negi et al., 2008,Semwal et al., 2010,Pokhariyal et al., 2010, Chauhan et al., 2014,Puspwan et al., 2019). Studies of anthropogenic effects on the plant diversity in Indian Himalayan region was taken as research interest due to reducing plant diversity along disturbance reported by various workers (Kumar and Jeetram 2005, Jina et al., 2008, Uniyal et al.,2010,Prasad et al., 2019 and Singh et al., 2018).

In Dewalgarh watershed a comparative study was carried out by Uniyal et al., (2010) in two forest types of Garhwal Himalaya. The study results indicate that the moderately disturbed stands in both forests, there was higher density and species richness of herb and shrub growth due to opening of canopies. An anthropogenic disturbance and plant biodiversity relationship was investigated by Kumar and Jeetram (2005) in central Himalayan forests of Uttarakhand. In the study, eight forest types were explored along altitudinal gradient. They concluded that periodic disturbance might be essential for increasing richness and diversity of early and late successional species.

Studies also reported that anthropogenic disturbance is not only effect the diversity of plants but also influence the soil and environmental conditions. Plant diversity of six forest types at Central Himalaya, Uttarakhand, was accessed by Jeetram et al., (2004). The conclusion of study indicate that due to unmanaged utilization of tree, shrub and herb in form of lopping, construction and industrial purpose influence the soil, nutrient, water condition and climatic conditions.

The diversity, regeneration and anthropogenic disturbance in major Indian Central Himalayan forest types have been studied by Kaushal et al., (2021). The study was carried out along an altitudinal gradient of 333 m. to 3375 m. using of standard quadrat techniques. The findings of study shows that surface fires was major anthropogenic disturbance parameter in the sub tropical Pine forest while grazing and lopping was in the temperate and sub alpine forest type in the accessed study area. The recommendation from the study regarding efficient management of these forests is monitoring the regeneration of important native and climax species along with local people participation. A temperate forest of western

Himalaya was accessed by Tiwari et al. (2019) to investigate disturbance, diversity, regeneration and composition. The study was carried out in Baghirathi catchment of Garhwal Himalaya, part of western Himalaya. Finding of this study shows that an increasing in anthropogenic disturbances, relatively impact the overall diversity and dispersion of species in the studied forest areas. Moreover, Abies pindrow and Quercus semicarpifolia may lead the reduction in seedling and sapling growth in these forest types.

Bisht et al. (2021) conducted a study in the Oak forests of the protected area of Askot wildlife Sanctuary in western Himalaya. The study focused on the resilience of Oak forest in the sanctuary area. Under this study four temperate broad leaved Oak species were found in majority in whole plant composition. The conclusion of study shows that despite the extractive pressure on Oak forest, the regeneration of Quercus leucotrichophora, and Quercus lunginosa was fair but in case of Quercus semicarpifolia and Quercus floribunda the regeneration status was poor. Therefore an urgent need of protection against livestock grazing with appropriate management inputs and sustainable harvesting practices recommended.

In an Oak belt of Garwhal Himalaya, the disturbance requirement investigated by Prasad et al. (2017) at different aspect and altitudes. The study concludes a positive effect of mid-level disturbance on plant community for better regeneration and recommends a minimum resource extraction from these valuable Oak forests. A study conducted by Malik et al. (2014) in Kedarnath Wildlife sanctuary and its adjoining areas of Garhwal Himalaya along different intensity of disturbance. The findings of this study revealed that due to anthropogenic disturbance, reduction of tree richness and diversity in form of disruption of forest structure and changes in species composition.

IV. NORTH EASTERN HIMALAYAN REGION

In a montane evergreen forest of Meghalaya, recently a study was carried out by Mir et al., (2021) to access the impact of disturbance on community structure, biomass and carbon stock. The study revealed that due to human disturbance, there is alteration on the forest structure that reduces the biomass and carbon sequestration potential of the forests. While a study in subtropical humid forest of Meghalaya conducted by Upadhaya et al., (2004) shows that mild disturbance is favorable for increasing species richness of secondary species. Saikia et al., (2017) accessed plant diversity pattern and conservation status of Eastern Himalayan Forest of Arunachal Pradesh, Northeast India. The study concluded that intensive monitoring and management is need to protect the fragile ecosystem from the ever-increasing anthropogenic pressure and changing climatic condition in studied area.

An investigation based on effects of anthropogenic disturbance on plant diversity and community structure in some sacred groves of Meghalaya, Northeast India was conducted by Mishra et al., (2004). In the study canopy (%), light interception (%) and tree density ha^{-1} were parameters used to classify anthropogenic disturbance classes. The conclusion of the study shows that small loss in plant diversity and community structure at mild disturbance sites however increased degree of disturbance causes adverse effect.

Tree structure and biomass investigation in Mamlay watershed, Sikkim was carried out by Sundriyal and Sharma (1996) with reference to effect of anthropogenic pressure. This study analyzed five different forest sites in different level of biotic pressure as high, medium, low-medium, very high and low medium. Among all these disturbance classes, site with

medium and very high biotic pressure achieved greater number of trees species and regenerating species. On the other hand regeneration (number of seedling and sapling) was associated with sites having high biotic pressure.

V. NORTHERN INDIA

Sagar et al. (2003) accessed tree composition, dispersion and diversity long disturbance gradient in dry tropical forest of northern India. The observation was made in permanent plots along disturbance gradients. The study results showed changed dispersion behavior due to disturbance as species were found changing from clumped distribution to uniform distribution for some species. Further in terms of diversity pattern along the disturbance it was reported that diversity of species decline with increasing level of disturbance. In the same forest type, Sagar and Singh (2005) examined the effect of disturbance on structure and regeneration. In terms of structure study results that α-diversity and its components decreased with increasing disturbance intensity, reflecting change utilization pressure with increasing disturbance. The regeneration was also found strongly affect by level of disturbance.

VI. CENTRAL INDIAN

In a dry tropical forest of Chhattisgarh, disturbance induced changes in diversity of medicinal plants observed by Singh et al., (2022). Under this study six forest regions of dry tropical forests were investigated to variable intensity of disturbance in form of illegal logging, cattle grazing and fire. The results indicated that many of important medicinal plants which are potential constituents of several Ayurvedic preparations as well as traditional medicine system are lacking from the high disturbed sites. . In a mixed deciduous forest of Madhya Pradesh, Fayiah et al. (2018) conducted a study to evaluate regeneration status and species diversity. The study concluded that climate change and disturbance such as grazing, collection of fuel wood, harvesting of poles or saplings has contributed immensely to the decline of plant diversity and regeneration of these forests. A study on the basis of ecological disturbance impact on forest structure was made by Kumar et al. (2022) in tropical deciduous forest of Central India. In the studied forest, the major disturbance factors were recorded as grazing (53.2%), fuel wood collection (23.1%), forest fires (20.6%) and NTFP collection with 19.4%.

VII. EASTERN INDIA

The forest fragmentation and the disturbance regimes were assessed by Bhatt et al. (2015) in south Gujarat forests. The study used satellite image-based forest and land mapping in tropical moist mixed deciduous and tropical mixed dry deciduous of the South Gujarat forests. Result showed that high disturbance recorded in riverine forest of tropical mixed dry deciduous forests as compare to in the tropical moist dry deciduous forests.

The collection of NTFP, browsing, lopping and man -made fire were major causes of disturbance. In Sal forests of Ranchi, population structure and regeneration status has been assessed by Kumar and Saikia (2020).

In terms of tree density of Shorea robusta and associated tree species, the study shows decline for with increasing in tree girth classes which signifies the ongoing disturbances

factors by natural and anthropogenic means. Furthermore for the conservation and management of these Sal forests, study indicates an urgent protection against grazing pressure and other anthropogenic disturbances.

VIII. SOUTHERN INDIA

In a dry deciduous forest of Godawari valley in Telangana state, Suthari and Raju (2018) conducted a study to explore tree species composition and forest stratification along different gradients and recognized grazing, timber, fuelwood and NTPF collection as major biotic factors. The conclusion of the study indicates that increased non tribal population and their demand for teak timber is the plausible anthropogenic reason. Shola forest in Kerala was studied by Chandrashekara et al., (2006) to analyze the anthropogenic pressure on structure and composition.

The study suggested that some agroforestry practices i.e. enrichment planting in disturbed parts of Sholas, raising energy plantations, development of lemon grass, firewood based Agroforestry systems and reduction of grazing pressure by developing silvopastoral system for the conservation of these Shola forests. In Western Ghats, South India, the Agathysmalai range was investigated by Parthsarathy (2001) to find out the tree diversity pattern and abundance in the undisturbed and human impacted sites.

The range was consists to tropical wet evergreen forest, the part of Kalakad Mundanthurai Tiger Reserve (KMTR). The study concluded that the differences in the diversity and abundance of all woody species are related to both natural site variation (small scale elevation, slope, nearness to water bodies) and human impacts. Table 1 summarized some common natural and anthropogenic disturbance factors found in different forest types of India.

Table 1: Reported disturbance factors in different forest part of India.

S. No.	Disturbance factors	Study area	Reference
1	Lopping, cutting, grazing, weed and wildfire	Western Himalaya	Bisht et al. (2021)
2	Natural: recurring soil erosion Anthropogenic: grazing , lopping, litter removal and surface burning	Central Himalaya	Khera et al. (2001)
3	Canopy cover, Lopping, grazing, litter removal, fire	Central Himalaya	Kumar and Ram (2005)
4	Natural: landslide, lightening, cloud burst, competition, diseases Anthropogenic: logging, grazing, browsing, deforestation, litter removal and surface burning	Garhwal Himalaya	Kumar et al. (2009)
5	Grazing, browsing, trampling and repeated forest fire	Garhwal Himalaya	Kumar et al. (2005)

6	Lopping, grazing, browsing, fuelwood and fodder collection	Garhwal Himalaya	Kumar et al. (2005)
7	Canopy cover (%), light interception (%) and tree density (ha^{-1})	Northeast India	Mishra et al. (2004)
8	Natural: soil erosion, and rockyness Anthropogenic: forest area distance from road, agricultural lands, human habitations, cutting and lopping	Northern India	Sagar et al. (2003, 2005)
9	Tree density, canopy cover and cut stumps	Garhwal Himalaya	Uniyal et al. (2010)

IX. CONCLUSION

In India, the major threats to forest depletion can be seen as alternation of forest areas for developmental activities, felling, lopping, shifting cultivation and other anthropogenic disturbances. These all not only impact of reducing plant diversity but also cause threats to habitats of wildlife and further influence the imbalance ecosystems. Steps should be taken in research front to conserve the plant and animal diversity at local level with the active people participation. Awareness regarding importance of local biodiversity and cultural diversity which are the part of the heritage of a region should be need to all group of society in rural as well as urban.

REFERENCES

[1] Abrams, M.D. (1992). Fire and the development of oak forests. Bio Science 42: 346–353.
[2] Archer, S. (1990). Development and stability of grass/woody mosaics in subtropical savanna parkland, Texas, U.S.A. J. Biogeography 17, 453–462.
[3] Baduni, N.P. and C.M. Sharma (1996). Effect of aspect on the structure of some natural stands of Cupressus torulosa in Himalayan moist temperate Forest. Proceedings Indian National Science Academy, B62: 345-352.
[4] Bhatt, G.D., Kushwaha, S.P.S., Nandy, S., Bargali, K., Nagar, P.S. and Tadvi, D.M. (2015). Alnalysis of fragementation and disturbance regimes in south Gujarat forests, India. 56(3): 275-288.
[5] Bisht, S. and Lodhiyal, L.S. (2005). Various aspects of soil and tree layer vegetation analysis in reserve forests of Kumaun in Central Himalaya. Indian Journal of Forestry 28(1): 37-50.
[6] Bisht, S., Bargali, K., Bargali, S.S. and Rawat, Y.S. (2021). How resilience are the Oak forests of Askot Wildlife sanctuary, Western Himalaya? Indian Journal of Forestry. 42(2): 87-97.
[7] Breshears, D.D. (2006). The grassland–forest continuum: trends in ecosystem properties for woody plant mosaics? Front Ecol. Environ. 4, 96–104.
[8] Chandrashekara, U.M., Muraleedharan, P.K. and Sibichan, V. (2006). Anthropogenic pressure on structure and composition of a Shola forest in Kerela, India. Journal of Mountain Science Vol 3 No 1 (2006): 58-70
[9] Chauhan, D.S., Prasad, S., Singh, V. and Todaria, N.P. (2014). Community Composition, Tree population structure in a temperate broad-leaved evergreen Oak forest along a disturbance gradient in Garhwal Himalaya. Indian Forester, 140 (4), 395-406.
[10] Clements, F. E. (1936). Nature and Structure of the Climax. Journal of Ecology. 24: 252-284.
[11] Cochrane, M.A. (2003). Fire science for rainforests.Nature, 421, 913-919.
[12] Connell, J.H. (1978). Diversity in tropical rain forests and coral reefs. Science 199: 1302-1310.
[13] Engelbrecht, B.M.J., Comita, L.S., Condit, R., Kursar, T.A., Tyree, M.T. and Turner, B.L. (2007). Drought sensitivity shapes species distribution pattern in tropical forests. Nature, 447, 80-82.
[14] Fayiah, M., Singh, S., Mengesha, Z. and Chen, B. (2018). Regeneration status and species diversity of a mix dry deciduous forest: A case of Barah forest, Jabalpur, Madhya Pradesh, India. Indian Journal of Tropical Forestry. 26(1): 17-29.
[15] Fredericksen, T.S. and Mostacedo, B. (2000). Regeneration of timber species following selection logging in a Bolivian tropical dry forest. Forest Ecology and Management 131, 47– 55.

[16] Haddad, N.M., Holyoak, M., Mata, T.M., Davies, K.F., Melbourne, B.A. and Preston, K. (2008). Species traits predict the effects of disturbance and productivity on diversity. Ecol. Lett. 11, 348-356.
[17] Hong, S.K., Nakagoshi, N. and Kamada, M. (1995). Human impacts on pine-dominated vegetation in rural landscapes in Korea and western Japan. Vegetatio. 116: 161-172.
[18] Hubbell, S.P., Foster, R.B., O'Brien, S.T., Harms, K.E., Condit, R., Wechsler, B., Wright, S.J., Loode Lao, S. (1999). Light gap disturbance, recruitment limitation and tree diversity in a Neotropical forest . Science. 283: 554-557.
[19] Huston, M. (1979). A general hypothesis of species diversity. Am. Nat. 113, 81-100.
[20] Indian State of Forest Report (2021). Forest Survey of India, Ministry of Environment, Forest and Climate Change (MoEFCC). New Delhi.
[21] Jeetram, Kumar, A. and Bhatt, J. (2004). Plant diversity in six forest types of Uttaranchal, Central Himalaya, India. Current Science 86 (7): 975-978.
[22] Jina, B.S., Sah, P., Bhatt, M.D. and Rawat, Y.S. (2008). Estimating carbon sequestration rates and total carbon stock pile in degraded and non-degraded sites of Oak and Pine forest of Kumaun central Himalaya. Ecoprint 15:75-81
[23] Kala, C.P. (2000). Status and conservation of rare and endangered medicinal plants in the Indian Trans Himalaya. Biological Conservation, 93: 371-379.
[24] Kaushal, S., Siwach, A. and Baishya, R. (2021). Diversity, regeneration and anthropogenic disturbance in major Indian, Central Himalayan forest types: implications for conservation. Biodiversity and Conservation. 30: 2451-2480.
[25] Kennard, D.K., Gould, K., Putz, F.E., Fredericksen, T.S., Morales, F. (2002). Effect of disturbance intensity on regeneration mechanisms in a tropical dry forest. Forest Ecology and Management 162: 197–208.
[26] Khera, N., Kumar, A., Ram., J. and Tewari, A. (2001). Plant biodiversity assessment in relation to disturbances in mid elevational forest of Central Himlaya, India. Tropical Ecology. 42, 83-95.
[27] Kumar, A., and Jeetram. (2005). Anthropogenic disturbances and plant biodiversity in forest of Uttaranchal, Central Himalaya. Biodiversity and Conservation 14: 309-311.
[28] Kumar, A., Kumar, G., Saikia, P., Khare, P.K. and Khan, M.L. (2022). Spatial pattern of tree diversity and impacts of ecological disturbances on forest structure in tropical deciduous forests of Central India. Biotrpoica. 00: 1-13.
[29] Kumar, M. Sharma, C.M. and Rajwar, G.S. (2004). A study on the community structure and diversity of a sub-tropical forest of Garhwal Himalayas. Indian Forester. 130(2): 207 – 14.
[30] Kumar, M., Sharma, C.M. and Rajwar, G.S. (2009). The effects of disturbance on forest structure and diversity at different altitudes in Grahwal Himalaya. Chinese Journal of Ecology. 28(3): 424-432.
[31] Kumar, R. and Saikia, P. (2020). Population structure and regeneration status of Shorea robusta and associated trees in Sal forests of Ranchi, Eastern India. Tropical Ecology. 62: 34-51.
[32] Lubcheno, J. (1978). Plant species diversity in a marine intertidal community: importance of herbivore food preference and algal competitive abilities. American Naturalist 112: 23-39.
[33] Malik, Z.A., Hussain, A., Iqbal, K. and Bhatt, A.B. (2014). Species richness and diversity along the disturbance gradient in Kedarnath Wildlife Sanctuary and its adjoining araeas in Garhwal Himalya, India. International Journal of Current Research. 6(12): 10918 – 10926.
[34] Mir, A.H., Chaudhury , G., Barbhuyan, A.H.S., Sarma, K. and Upadhaya (2021). Impact of disturbance on community structure, biomass and carbon stock in montane evergreen forest of Meghalaya, Northeast India. Carbon Management. 12 (2): 215-233.
[35] Mishra, 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.
[36] Mori, A. and Takeda, H. (2004). Effect of undisturbed canopy structure on population structure and species coexistence in an old growth sublpine forest in Central Japan. Forest Ecology and Management. 200: 89-100.
[37] Negi, B.S., Chauhan, D.S. and Todaria ,N.P. (2008). Comparative plant diversity between Panchayat and adjoining reserve forests in Garhwal Himalaya. Indian Journal of Forestry 31 (4): 585-593.
[38] Paine, R.T (1966).Food Web Complexity and Species Diversity. The American Naturalist, 100 (910): 65-75.
[39] Parthsarathy, N. (2001). Changes in forest composition and structure in three sites of tropical evergreen forest around Sengalthri, Western Ghats. Current Science. 80(3): 389-393.
[40] Pederson, N., Varner, J.M. and palik, B.J. (2008). Canopy disturbance and tree recruitment over two centuries in a managed longleaf pine landscape. Forest Ecology and Management. 254: 85-95.

[41] Pokhariyal, P., Uniyal, P., Chauhan, D.S. and Todaria, N.P. (2010). Regeneration status of tree species in forest of Phakot and Pathri rao watersheds in Garhwal Himalaya. Current Science 98(2): 171-175
[42] Prasad, S., Singh, V. and Chauhan, D.S. (2017). Aspects and altitudes modify the requirement of disturbance in oak (Quercus leucotrichophora A. Camus) belt of Garhwal Himalaya. Acta Ecologica Sinica. 37 (2) 70-74.
[43] Prasad, S., Singh, V. and Chauhan, D.S. (2019). Consequences of disturbance in Banj Oak forests of Garhwal Himalaya. International Journal of Agriculture Sciences. 11 (7). pp. 9017-9021
[44] Puspwan, K.S.,Singh, V. and Pandey, B.N. (2019). Species richness, plant diversity and composition with respect to altitudinal variation in Western Nayar watershed, Uttarakhand, India. International Journal of recent Science Research. 10 (06), pp. 33177-33182.
[45] Ramirez-Marcial, N., Gonzalez-Espinosa, M. and Williams-Linera, G. (2001). Anthropogenic disturbance and tree diversity in montane rain forests in Chiapas, Mexico. Forest Ecology and Management 154, 311–326.
[46] Rana, J.C., Singh, A., Sharma, Y., Pradheep, K. and Mendiratta, N. (2010). Dynamics of plant bioresources in Western Himalyan region of India- watershed based study. Current Science 98(2): 192-192-203.
[47] Roxburgh, S.H., Shea, K. and Wilson, J.B. (2004). The intermediate disturbance hypothesis: patch dynamics and mechanisms of species coexistence. Ecology. 85, 359-371.
[48] Sagar, R. and Singh, J.S. (2005). Structure, diversity and regeneration of tropical dry deciduous forest of northern India. Biodiversity and Conservation. 14: 935-359.
[49] Sagar,R., Raghubanshi, A.S. and Singh, J.S. (2003). Tree species composition, dispersion and diversity along a disturbance gradient in a dry tropical forest region of India. Forest Ecology and Management 186: 61-71.
[50] Sahoo, U.K., Tomar, J.M.S. and Upadhyaya, K. (2008). Phytosociological analysis of Pinus kesiya stands exposed to varying intensities of disturbance at Umiam watershed in northeast India. International Journal of Ecology and Environmental Sciences. 34(4): 335-344.
[51] Saikia, P., Deka, J., Bharali, S., Kumar, A., Tripathi, O.P, Singha, L.B., Dayanandan, S. and Khan, M.L. (2017). Plant diversity patterns and conservation status of eastern Himalaya forests in Arunachal Pradesh, Northeast India. Forest ecosystems. 4:28.
[52] Semwal, D.P., Uniyal, P.L. and Bhatt, A.B. (2010). Structure, composition and dominance-diversity relations in three forest types of a part of Kedarnath Wildlife Sanctuary, Central Himalaya, India. Notulae Scientia Biologicae. 2(3):128-132.
[53] Sgeil, D. and Burslem, D.F.R.P (2003). Disturbing hypothesis in tropical forests. Trends Ecol. Evol. 18, 18-26.
[54] Sheil, D. (1999). Tropical forest diversity, environmental change and species augmentation: after intermediate disturbance hypothesis. Journal of vegetation science. 10: 851-860.
[55] Shea, K. Roxburgh, S.H. and Wilson, J.B. (2004). Moving from pattern to process: coexistence mechanism under intermediate disturbance regimes. Ecol. Lett., 7, 491-508.
[56] Singh S.P. and Singh, J.S. (1986). Structure and function of the central Himalayan oak forests. Proceeding Indian Academy of Science (Plant Sci.) 96: 159 – 89.
[57] Singh, J.S. and Singh, S.P. (1987). Forest vegetation of Himalaya. Botanical Review. 52 (1): 82-192.
[58] Singh, J.S. and Singh, S.P. (1992). Forests of Himalaya. Structure, Functioning and Impact of Man. Nanital, India: Gyanodaya Prakashan; and Delhi, India: Fine art press.
[59] Singh, J.S., Adhikari, B.S. and Zobel, D.B. (1994). Biomass productivity, leaf longevity and forest structure in Central Himalaya. Ecological Monograph 64: 401-421.
[60] Singh,V., Chauhan, D.S. and Dasgupta, S. (2018). Effect of Stand structure and aspect on the regeneration of an oak (Quercus leucotrichophora A. Camus) forest in Garhwal Himalaya, Uttarakhand, India. Forestry Studies. 68: 33-39
[61] SIngh, P.K., Prajapati, S.K.. Sunita, K. and Chaturvedi, R.K. (2022). Disturbance induced changes in diversity of medicinal plants in a dry tropical forest of India. Frontiers in Forests and Global Change. 4:718930. doi: 10.3389/ffgc.2021.718930
[62] Sundriyal, R.C. and Sharma, E. (1996). Anthropogenic pressure on tree structure and biomass in the temperate forest of Mamlay watershed in Sikkim. Forest Ecology and Management. 81: 113-134.
[63] Suthari, S. and Raju, V.S. (2018). Tree species composition and forest stratification along the gradients in the dry deciduous forests of Godavari valley, Telangana, India. European Journal of Ecology. 4(1): 1-12.
[64] The State of the World's Forests 2020 (SOFO). FAO and UNEP. (2020). Forests, biodiversity and people. Rome. https://doi.org/10.4060/ca8642en.

[65] Tiwari, O.P., Sharma, C.M., Rana, Y.S. and Krishan, R. (2019). Disturbance, diversity, regeneration and composition in temperate forests of Western Himalaya, India. Journal of Forests and environmental Science. 35(1): 6-24.
[66] Uniyal, P., Pokariyal, 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(7): 938-943.
[67] Uniyal, S.K., Awasthi, A. and Rawat, G.S. (2002). Current status and distribution of commercially exploited medicinal and aromatic plants in upper Gori valley, Kumaun Himalaya, Uttaranchal. Current Science, 82 (10): 1246-1252.
[68] Upadhaya, K., Pandey, H.N., Law, P.S. and Tripathi, R.S. (2004). Diversity and population characteristics of woody species in subtropical humid forests exposed to cultural disturbances in Meghalaya, Northeast, India. Tropical Ecology, 45(2): 303-314.
[69] Zhu, J.J., Mao, Z.H., Hu, L., Zhang, J.X. (2007). Plant diversity of secondary forests in response to anthropogenic disturbance levels in montane regions of northeastern China. J. For. Res. 12: 403–416.

