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Seedling diversity and spatial distribution of some conifers and associated tree species in highly disturbed Western Himalayan regions in Pakistan

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Abstract: This article encompasses the impacts of disturbance, regeneration potential of conifers and the dynamics of tree species seedlings along the spatial scale in Murree forest. The seedling status preferably of conifers along with associated broadleaved dominant tree species is determined by a quantitative evaluation of diversity functions. An empirical approach is applied to predicting the future of seedlings under stress as well as the current hypothetical appearance of seedlings in the forest. The need of analysing diversity of this forest is due to highly disturbed conditions there, and this paper is designed to know the recent trends of species diversity in the area. Species diversity and species abundance at a seedling level are estimated by using standard formulas of diversity measurements. Thirty stands are used for the evaluation of seedling abundance in highly disturbed conditions with the examination of diversity in the area. Seedling density is too low in the forest whereas diversity is also in poor condition. Seedlings from four conifers with three broadleaved species in different stands indicated the low density of future trees. The mean density·ha^{-1} of pine seedlings is consecutively low in *Pinus wallichiana* (16 ± 2), *Pinus roxburghii* (11 ± 3), *Cedrus deodara* (9 ± 3), *Abies pindrow* (8 ± 3). The correlation coefficient is as low as 0.76, 0.66 and 0.61 in *Pinus roxburghii*, *Cedrus deodara* and *Abies pindrow*, respectively, while *Pinus wallichiana* showed a significant correlation, i.e. $P > 0.5$. Hence, this study claims that the survival of the forest is threatened as seedling density and diversity are too low. This forest needs serious attention towards preventing and conserving pines and other associated species seedlings for the existence of this forest in future.

Keywords: diversity indices; regeneration potential; logging; anthropogenic activities

Moist temperate habitats are symbolic zones for bearing an extensive range of vegetation or containing massive plant diversity rather than any other habitat. Temperate zones are the most hospitable and productive biomes, therefore, they are the best places for human settlements, natural resources and for tourism. Our study area features Murree hills, a prime example of an old-growth forest which is in a highly disturbed condition. However, previous studies were conducted in undisturbed or least disturbed forests. Forest management requires an affective monitoring of diversity and conservancy of the abundance level of local species. Therefore, the quantitative estimation of demography from seedling stage is necessary to understand forest composition, regeneration potential and its dynamics. Without the knowledge of demography that particularly describes seedling dynamics, the changes that have occurred in the population or species abundance pattern are incomplete (Yang et al. 2013). Under natural conditions, seedling survival is a function of interaction between canopy and understory (Beckage, Clark 2003). The influence of canopy cover on various environmental resources plays an important role in the establishment of seedlings, their recruitment and production of understory vegetation (Augspurger 1984; Denslow et al. 1990). These resources can act as a limiting factor that could be

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responsible for the expansion of diversity in a forest ecosystem as explained by Veblen (1989). The present study area has open canopies due to illegal cutting of mature trees which is the threat to regeneration by losing seedlings, saplings and reproductive trees. Open canopy has adversely affected understory plants, as the current canopy cover inadequately provides shelter to shade-demanding tree species in their early period of growth and development. On the other hand, open canopy helps light-demanding seedlings to grow faster (Ahmed 1984). Moreover, open canopies provide open space in the habitat which is a potential of soil erosion, land sliding. Boose et al. (1994) and Lin et al. (2011) claimed that tropical and temperate forests are prone to cyclones and typhoons that produce soil erosion and land sliding. In addition to natural disturbance, deforestation activities prohibit forest structure formation. As a result of these activities a large number of seedlings has been destroyed, crushed and injured by falling trees, by workers and logging equipment. Himalayan forests in Pakistan have been experiencing human disturbances for many decades but the intensity of disturbance has risen in recent years due to the increasing pressure of population, tourism, land and resource utilization etc. Very little work has been done on future floral optimization in the region when there is an increased level of disturbance by time (Khan 2020). Therefore, the present study reveals the species richness status of the Murree forest that is under the influence of biological interference. The study aims to predict the futuristic approach to dominant tree species in the presence of increasing environmental pressure. For this purpose, seedling density of dominant tree species is a key factor for the analysis of species diversity. In the present study area, forest cover is predominantly maintained by conifers. Due to the disturbed condition of forest, the forest species (preferably conifers) are under stress and it is necessary to explore the trend of these species. Seedling representation of conifers and other associated tree species would be an assurance of forest cover in the future. This would help foresters to analyse the future structure and expected diversity of forest.

MATERIAL AND METHODS

For this study, the forest in Murree was selected that lies in the western Himalayan region in northern areas of Pakistan. The Digital Cartographic Model (DCM) measurements recognized Murree at 34°03'08.1''N, 73°13'01.08''E and 2 291 m a.s.l. Murree was reported to have 47 285 acres of the forest consisting of two ecological zones, i.e., moist temperate forest zone and sub-tropical forest zone (WWF 2019). The forest represented a combination of mostly younger and some mature trees not more than 1 m diameter at breast height (DBH) (Khan 2020). Sampling was carried out from the elevation of 1 636 m to 2 672 m. Thirty different stands at different locations were used for ecological sampling, in which each stand consisted of one hectare plot. Each sampling site was selected on the basis of disturbance, i.e., presence of humans, grazing animals, livestock, logging, construction etc. in the area. Within each stand, 10 circular plots (1.5 m radius) were drawn within each 1 ha plot to record seedling density according to Bray and Curtis (1957) and Ahmed and Shaukat (2012). Young plants of conifers and associated tree species up to 10 cm DBH were considered as seedlings and saplings that were recorded for density and frequency evaluation.

For diversity measures, Shannon Index (Shannon, Weaver 1949), Dominance Index (Simpson 1949), Equitability or Evenness (Menhinick 1964; Pielou 1966; Margalef 1968) were used, species diversity was calculated by using McIntosh Diversity Index (McIntosh 1967) and Hill's Diversity Index (Hill 1973). Dominance classes were constructed according to Braun-Blanquet (1932) and species abundance classes were suggested by Ahmed (1973). Spatial analysis for the elaboration of seedling diversity in the study area was constructed by Surfer 10 software (Version 16.6, 2019) according to Davis et al. (2002) and Bettinger et al. (2017). Formulae applied for diversity analysis are given below:

Shannon index:

$$H = -\sum_{i=1}^{s} p_i \times \ln p_i \tag{1}$$

Dominance index:

$$\lambda = C = \sum p_i^2 \tag{2}$$

where:

S – number of species in the stand;

$p_i = n_i/N$;

n_i – number of individuals of a species;

N – total number of individuals.

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Equitability or evenness*:*

$$e = \frac{H}{H_{max}} \tag{3}$$

where:

H – species diversity;

H_{max} – maximum species diversity.

Species richness:

$$R_1 = \frac{S^{-1}}{\ln(N)} \tag{4}$$

$$R_2 = \frac{S}{\sqrt{N}} \tag{5}$$

McIntosh diversity index:

$$M_c = 1 - \sqrt{\sum n_i^2} \tag{6}$$

where:

Σn_i^2 – Σ of squares of individuals of each species in the stand.

Hill's diversity index:

$$N_1 = e^H \tag{7}$$

$$N_2 = \frac{1}{\lambda} \tag{8}$$

Dominance classes and species abundance classes (Braun-Blanquet 1932; Ahmed 1986) are given in Table 1.

Table 1. Dominance classes and species abundance classes

Class	Range (%)	Originally (%)
Rare	1–20	< 5
Occasional	21–40	5–20
Frequent	41–60	20–40
Abundant	61–80	40–75
Very abundant	81–100	75–100

RESULTS

The geographical distribution of conifer seedlings in association with broadleaved species is graphically illustrated in Figure 1. A total number of seven tree species was recorded from the study area, namely *Pinus wallichiana* A. B. Jacks., *Pinus roxburghii* Sarg., *Cedrus deodara* (Roxb.) G. Don, *Abies pindrow* (Royle ex D. Don) Royle, *Quercus baloot* Roxb., *Quercus dilatata* Royle and *Aesculus indica* (Wall ex Camb.). Mean seedling density of each species, their relative occurrence in stands and the coefficient that expresses the correlation with density and distribution are represented in Table 2. No stand showed more than four conifer species as the disturbance indicated low species diversity (Table 3). The abundance pattern was portrayed by employing diversity indices (Figure 2A), while normal probability distribution of seedlings of dominant tree species from the study area (30 stands) was drawn by using a semi-log plot (Figure 2B).

Figure 1. Geographical location of Murree in Pakistan and the Galyat (A) and sampling sites in the Murree region (B)

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Table 2. Average density and correlation coefficient of seedlings in the study area

Dominant tree species	Presence in stands	Average seedling density (seedlings·ha^{-1})	Correlation coefficient
Pinus wallichiana	25	16 ± 2	0.96*
Cedrus deodara	7	9 ± 3	0.66
Abies pindrow	4	8 ± 3	0.61
Pinus roxburghii	9	11 ± 3	0.76
Quercus baloot	3	3 ± 1	0.57
Quercus dilatata	3	3 ± 2	0.55
Aesculus indica	1	2 ± 0	0.39

*significant

Table 3. Diversity measures of tree species present in the individual stands (30 stands)

Stand No.	Elevation (m)	Species	Shannon index (H)	Dominance Simpson's index (λ)	Margalef's richness index (R_1)	Menhinick index (R_2)	McIntosh diversity index	N_1	N_2	E_1
1.	1 956	PW, QB	0.45	0.74	0.24	0.24	0.15	1.56	1.35	0.64
2.	2 022	PW, QB, CD	1.28	0.68	0.44	0.30	0.18	3.58	1.48	1.16
3.	2 155	PW, QB	0.13	0.83	0.22	0.21	7.57	1.14	1.19	0.19
4.	2 213	PW, CD, QB	1.10	0.77	0.45	0.32	0.12	3.00	1.3	1.00
5.	2 129	CD, PW	0.60	0.59	0.22	0.20	6.56	1.82	1.69	0.87
6.	2 628	PW	–	–	–	–	–	–	–	–
7.	2 672	PW, AP	0.60	0.59	0.23	0.22	0.23	1.82	1.69	0.86
8.	2 460	PW, CD, QD, AI	1.31	0.29	0.65	0.40	0.47	3.72	3.50	0.95
9.	2 464	PW, CD	0.54	0.64	0.24	0.25	0.20	1.72	1.55	0.78
10.	2 435	PW, AP	0.69	0.50	0.22	0.21	0.30	2.00	2.00	1.00
11.	2 327	PW, CD	0.64	0.55	0.24	0.25	0.25	1.89	1.80	0.92
12.	2 328	PW, CD, AP	0.94	0.43	0.41	0.27	0.34	2.56	2.31	0.86
13.	1 858	PR, QD, PW	0.84	0.58	0.41	0.27	6.95	2.32	1.73	0.77
14.	1 869	PR, PW	0.69	0.51	0.22	0.21	0.29	1.98	1.97	0.99
15.	1 883	PW	–	–	–	–	–	–	–	–
16.	1 893	PW	–	–	–	–	–	–	–	–
17.	1 919	PR, PW, QD	0.89	0.48	0.43	0.3	0.30	2.43	2.07	0.81
18.	1 787	PR	–	–	–	–	–	–	–	–
19.	2 044	PW, QD	0.52	0.66	0.22	0.20	0.19	1.69	1.52	0.76
20.	2 087	PW, AP	0.51	0.67	0.24	0.24	0.18	1.66	1.49	0.73
21.	2 063	PW	–	–	–	–	–	–	–	–
22.	2 072	AP, PW, QD	0.93	0.45	0.42	0.28	0.33	2.52	2.24	0.84
23.	1 918	PW	–	–	–	–	–	–	–	–
24.	1 841	PW	–	–	–	–	–	–	–	–
25.	1 781	PR, PW	0.49	0.69	0.22	0.20	0.17	1.64	1.46	0.71
26.	1 699	PW	–	–	–	–	–	–	–	–
27.	1 636	PR, PW	0.57	0.52	0.21	0.19	0.28	1.77	1.91	0.82
28.	1 638	PR, CD, QB, QD	1.35	0.26	0.63	0.37	0.49	3.88	3.79	0.98
29.	1 858	PR, QD	0.48	0.70	0.21	0.18	0.17	1.62	1.44	0.70
30.	1 789	PR	–	–	–	–	–	–	–	–

PW – *Pinus wallichiana*; PR – *Pinus roxburghii*; AP – *Abies pindrow*; CD – *Cedrus deodara*; QB – *Quercus baloot*; QD – *Quercus dilatata*; AI – *Aesculus indica*; N_1 – Hill's diversity 1; N_2 – Hill's diversity 2; E_1 – Equitability

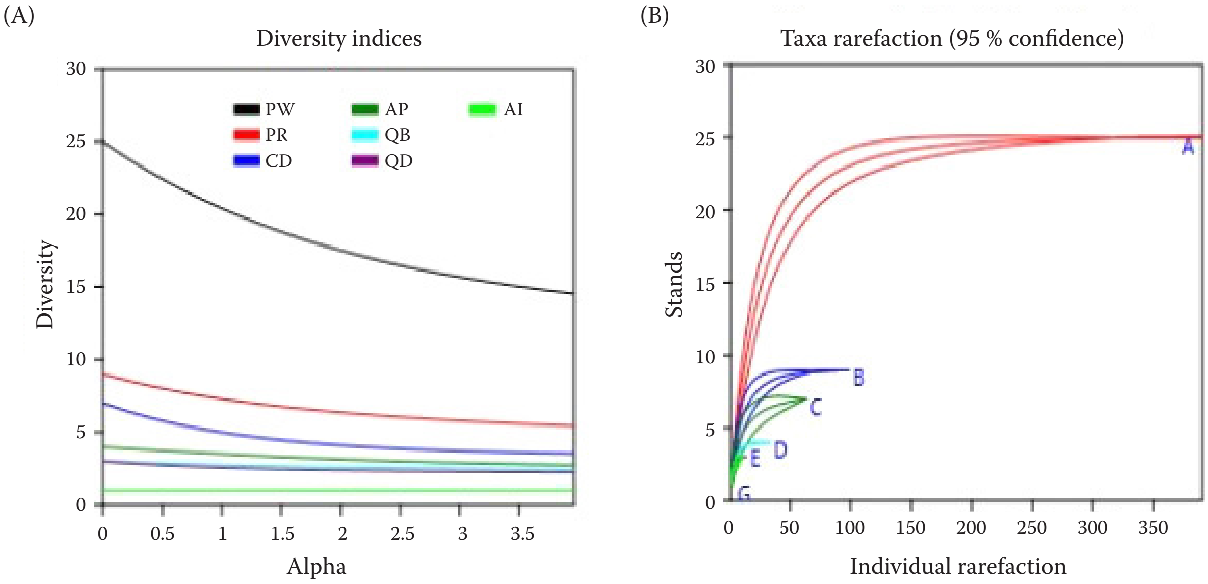

Figure 2. Log graph of relative abundance pattern, normal probability distribution, diversity indices and species distribution of pine species in a semi-log scale from 30 stands

A – *Pinus wallichiana* (PW); B – *Pinus roxburghii* (PR); C – *Cedrus deodara* (CD); D – *Abies pindrow* (AP); E – *Quercus baloot* (QB); F – *Quercus dilatata* (QD); G – *Aesculus indica* (AI)

Stands number 8 and 28 showed the highest abundance pattern while the highest seedling density was attained by *Pinus wallichiana* among other pine species in stand 2 (Figure 2A). Data from conifers and broadleaved seedling density showed a nonlinear pattern from 95% confidence interval of the normal distribution (Figure 2B). In case of *Pinus wallichiana*, the non-linearity of data points possessed a long-tail S shaped pattern bearing departures in the last points from the fitted line. Similarly *Pinus roxburghii* and *Cedrus deodara* showed nonlinear long tails with marked departures in the last few points while *Abies pindrow* possessed a short-tail pattern and marked departures in both the first and last few points. All the species produced fitted distribution in an inadequate manner, however, the correlation coefficients were non-significant in all the species except *Pinus wallichiana*, i.e., $P > 0.5$ that proved to be significant (Table 2).

Diversity indices (Figure 2) elaborated the occurrence of *Pinus wallichiana* in 25 stands as the most frequent species while *Pinus roxburghii* achieved the second highest position by existing in 10 stands whereas the rest of the species like *Cedrus deodara*, *Abies pindrow*, *Quercus baloot*, *Quercus dilatata* and *Aesculus indica* poorly occurred in all stands. However, the difference between *Pinus wallichiana* and *Pinus roxburghii* diversity was greater but *Pinus roxburghii* was found well competitive in the disturbed environment. The individual stance of each dominant species in the area is illustrated in Figure 2. *Pinus wallichiana* appeared in the strongest position while the rest of the species were gradually decreasing their entities from the area.

The seedling regeneration condition was estimated by using the density information from different locations (Table 2). It was obvious from the results that *Pinus wallichiana* seedlings were recorded from 25 stands whereas *Pinus roxburghii* achieved the second highest position throughout the area, seedling density was recorded from 9 stands. *Cedrus deodara* seedlings were recorded from 7 stands. *Abies pindrow* seedlings found in a critical regenerative condition were recorded from only 4 locations. The other associated angiosperm species also occurred with pine vegetative groups composed of *Quercus baloot*, *Quercus dilatata* and *Aesculus indica*. Their seedling presence was very low as they appeared only in 3, 3 and 1 stands, respectively.

Average density (Table 2) perceived by *Pinus wallichiana* was 16 ± 2 seedlings·ha^{-1}. Seedlings of *Pinus roxburghii* were observed as 11 ± 3 seedlings·ha^{-1} whereas in case of *Cedrus deodara* and *Abies pindrow*, seedling density was found to be 9 ± 3 and 8 ± 3 seedlings·ha^{-1}, respectively, which were the

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lowest among pine species. All tree species showing an extremely poor number of seedlings indicated a poor potential of regeneration in such conditions, therefore proper recruitment could not be possible. *Cedrus deodara* and *Abies pindrow* are supposed to disappear as the first in future in the light of current observations. The cutting of older trees from the stands seems to be at a greater rate for these diminishing pine species. The associated broadleaved species like *Quercus baloot*, *Quercus dilatata* and *Aesculus indica* showed 3 ± 1, 3 ± 2 and 2 ± 0 seedlings·ha^{-1}. These angiosperm tree species were widely distributed with conifer species but due to fuel demand, they were logged extensively with pine species. Low seedling frequency and density indicated that they would disappear soon.

The relative density (%) of seven tree species recorded in the study area is presented in Figure 3. *Pinus wallichiana* (31%), *Pinus roxburghii* (21%), *Cedrus deodara* (17%) and *Abies pindrow* (15%) while in case of other broadleaved tree species it could be expected that *Quercus baloot* and *Quercus dilatata* would be represented by 6% each, while seedling density of *Aesculus indica* was only 4%.

Current diversity examinations (Table 3) clearly showed that the highest diversity was achieved by stands 28, 8, 2 and 4, based on the Shannon diversity index. Furthermore, by utilizing different important diversity measures, the lowest values were attained from stand 3 indicating *Pinus wallichiana* and *Quercus baloot* seedlings among the dominant tree species in the stand. Simpson's index represented the first three highest positions of dominance achieved by stands 3, 4 and 28 and the lowest dominance that occurred in stand 8. Species richness was estimated by applying Margalef's and Menhinick's indices (R_1 and R_2, respectively). Both statistics showed the highest richness in stand 8 while the second and third highest level of richness was attained by stand 28 and 4, respectively. All these stands were composed of *Pinus wallichiana* and *Cedrus deodara* as the commonly found conifer species with the association of broadleaved trees, i.e., *Quercus baloot*, *Quercus dilatata* and *Aesculus indica*. The lowest richness was recorded from stands 27 and 29, which represented *Pinus roxburghii* as the commonly and dominantly found conifer species in both stands in the form of community with *Pinus wallichiana* and *Quercus dilatata*. McIntosh diversity index defined the highest diversity in stand 3 while the second and third highest diversity was achieved by stands 13 and 5, respectively. The lowest diversity was calculated in stand 4, however this stand consisted of three species, i.e., *Pinus wallichiana*, *Cedrus deodara* and *Quercus baloot* but the density of the last two species was very low that might result in the lower diversity level as both the species were statistically considered as negligible. Hill's methods (N_1 and N_2) were also applied for diversity measurements that resulted in the highest diversity in stand 28 and the second highest diversity in stand 8. Stand 3 showed the lowest diversity

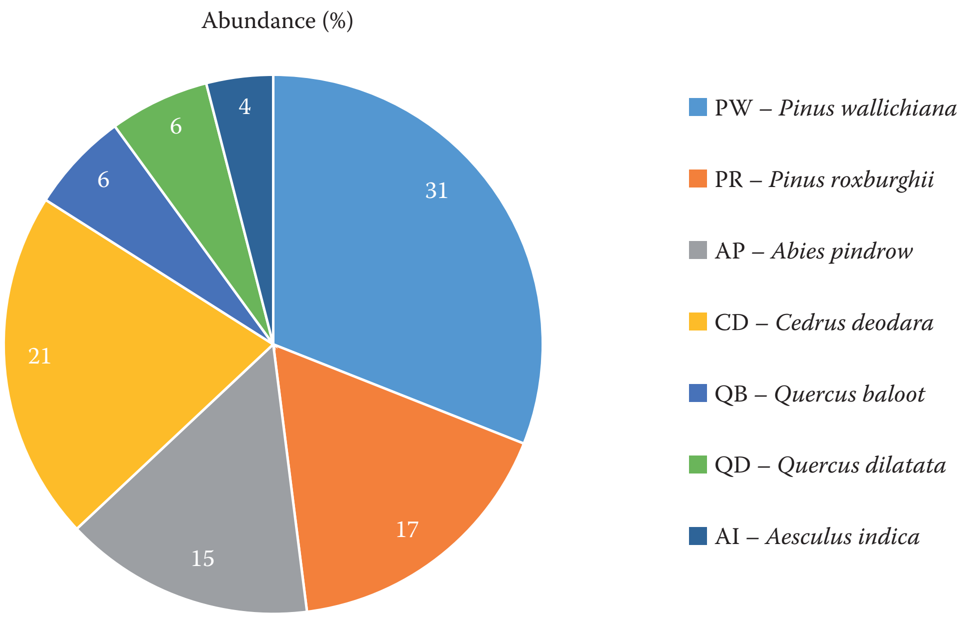

Figure 3. Relative density occupied by pine seedlings and seedlings of associated trees in 30 stands

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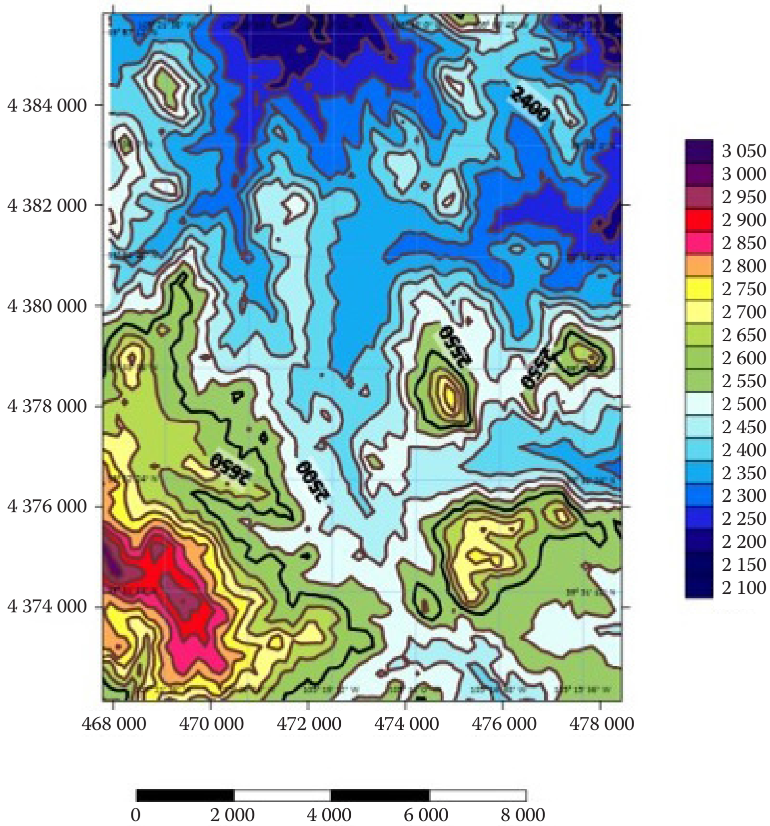

Figure 4. Distribution gradient and distribution of conifers and associated tree diversity in the disturbed sites in the forest; green colour indicates high levels of diversity (71–90%) while blue tones show lower and moderate diversity levels, i.e. 31–70%; yellow and orange colours show 21–30% diversity while red shows the lowest diversity, i.e. 0–20% in the disturbed sample sites

among all the stands. Equitability is also an important parameter for future community analysis, the highest value was attained from stand 2 that consisted of *Pinus wallichiana*, *Cedrus deodara* and *Quercus baloot* while the lowest equitability value was recorded in stand 3.

Hence, the mean diversity in the sample sites was presented along with the geographical distribution as shown in Figure 4. The stands that showed a higher diversity range were most likely in the range of 2 550 to 2 650 m a.s.l. These stands usually possess *Pinus wallichiana* as the main represented pine species while the rest of the species like *Cedrus deodara* and *Abies pindrow* were poorly present with low degrees of association capability. In case of *Pinus roxburghii*, the community formation range was observed to be higher than in other conifers.

DISCUSSION

Relative abundance and growth forms of currently dominant species are the indicators of future community structure in the forest. Proportions of seedlings, saplings and juvenile trees are greatly influenced by the presence of mature trees and abiotic (natural and unnatural) resources (Paul et al. 2019). The results obtained from the present study revealed the seedling dynamics of Murree in terms of species richness, diversity level and equitability in the forest along with the present and expected conditions in future. The diversity of stand 28 was remarkable due to the formation of a community based on *Pinus roxburghii*, *Cedrus deodara*, *Quercus dilatata* and *Quercus baloot* as the dominant tree species in the stand. This rare combination was achieved by planting both the species together by Department of Forest of Punjab and seedlings were also recorded from the stand in previous findings. *Pinus roxburghii* and *Cedrus deodara* community was also reported by Singh et al. (2014) from an oak-dominated forest in Nainital at the Himalayan foothills (1 650 and 1 750 m elevation) that also might be a planted specimen. Ahmed et al. (2006) found the *Pinus wallichiana* and *Pinus roxburghii* community at this elevation from Himalayan ranges, and they concluded

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it was an ecotonal zone. They recorded 25% density of *Pinus wallichiana* while *Pinus roxburghii* dominated in the area as the homeland of the species. Siddiqui (2011) observed seedlings of *Taxus wallichiana* from the same area while *Pinus wallichiana* was suggested to be replaced by *Taxus wallichiana*. He also found another community of *Pinus wallichiana-Pyrus pashia* from this area with no record of seedlings of *Pinus wallichiana*. Formerly *Taxus wallichiana* was reported from the area with association of *Quercus ilex* while in the present study both the species were absent. The other successful specimen was observed among highly disturbed areas of stand 8 that represented seedlings of four species, i.e., *Pinus wallichiana*, *Cedrus deodara*, *Quercus dilatata* and *Aesculus indica*. This indicated potential development of a diversified community in the stand, as *Aesculus indica* has never been reported growing with *Cedrus deodara* and *Quercus dilatata*. Siddiqui (2011) reported *Pinus wallichiana*, *Cedrus deodara* and *Abies pindrow* from the same area (stand 8) whereas in the present study, there were found neither trees nor seedlings of *Abies pindrow* showing complete elimination of the species. In another finding by Siddiqui (2011) from undisturbed forests of Murree *Quercus baloot* and *Quercus incana* were claimed as dominant tree species. Current findings claimed a consistent disappearance of *Quercus incana* from the stands, which may be due to the disturbed condition of the forest. However, a greater number of *Pinus wallichiana*, *Cedrus deodara*, *Pinus roxburghii* and *Abies pindrow* trees in mature classes was recorded by previous authors (Ahmed et al. 2006; Siddiqui 2011; Ahmed, Shaukat 2012) that could ensure seed production in the forest, whereas the present studies of disturbed forests showed the lowest number of seedlings and the lowest representatives of mature seed-bearing trees (Khan et al. 2018a, b; Khan 2020).

Paul et al. (2019) concluded that the habitat destruction was a consequence for alteration in the population structure of *Rhododendron* spp. dominated temperate forest in Arunachal Pradesh, India. Sometimes open canopies and forest gaps augment seedling regeneration and promote diversity among woody plant species (Zhang et al. 2004; Zhu et al. 2014). Besides, local edaphic conditions play a significant role in the promotion of diversity (Gao et al. 2017; Khan et al. 2018a, b, 2020). Tiwari et al. (2018) found low regeneration and declining seedling diversity in spite of the presence of adult tree species, they found the low regeneration status due to the poor soil condition caused by anthropogenic activities. A prominent decline in the species diversity was observed in temperate forests of Kashmir due to increased logging events and destruction of the habitat (Shaheen et al. 2012). Contrarily, some studies from undisturbed forests of Himalayas reported the good regeneration and diversity status composed of conifers and broadleaved species mainly *Abies* spp., *Cedrus deodara*, *Pine* spp., *Quercus* spp., *Rhododendron*, *Populus* spp. etc. (Pokhriyal et al. 2010; Malik, Bhatt 2016; Singh et al. 2016; Rawat et al. 2018).

Shaukat and Khan (1979) conducted a comparative study of the statistical behaviour of diversity and equitability indices in response to desert vegetation, however, very little literature has been cited on seedling diversity of forest vegetation in Pakistan (Khan and Ahmed, 2019). Following McIntosh and Margalef's method (*S*, *H*), better results for general diversity were produced while equitability was best measured by McIntosh. They mentioned that depending on the growth of different communities it may produce different results. These indices would produce the diversity pattern of the study area. These illustrations of the diversity distribution pattern, i.e., number of species and their abundance observed in the area, were supposed to be essential for the development of a multidimensional concept of regeneration potential. Brun et al. (2019) hypothesized that productive forests have higher capability to expand their phylogenetic diversity and traits in natural conditions. Talal and Santelmann (2019) found similar results of diversity assessment conducted in urban national parks in Portland, Oregon. In forests, disturbances like mowing and grazing may reduce competition and increase biodiversity, as the seedlings get chances for establishment (Chalmandrier et al. 2017; Graham et al. 2018), which is true of those forests where there occurred only grazing problems while habitats facing other disturbances can give random outcomes (Brun et al. 2019). Even in natural forests with low disturbances, diversity may alter or decrease due to the introduction of invasive species in the habitat that cause depletion of native species (Taylor, Santelmann 2014).

In this study, all the stands showed lower diversity and species richness values as they were extremely interfered by human and other agencies but the lowest values of all were shown by stand 3 which was located in Khanaspur; the *Pinus wallichiana* and

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Quercus baloot community with a low density of seedlings of the species was revealed there. *Quercus baloot* was in the negligible condition and the stand was dominated by *Pinus wallichiana* trees. The stand was at a higher elevation (2 155 m) near Barracks of Army, hence it was in highly disturbed conditions and very few opportunities for regeneration were expected. The diversity and spatial gradients helped in producing the bottom line of the disturbance causes, i.e., the lower and higher elevations showed the lowest diversity while the middle elevations were relatively better in their species composition. The smaller density of *Pinus roxburghii* might be due to the construction in the area and higher interference of humans for their excessive requirements for space and also to the presence of grazing animals as the areas were subjected to these problems.

Thus this state of species and seedling diversity has knocked an alarming condition as these might be removed or disappear in future and is responsible of turning it into the lowest diversity indicator.

CONCLUSION

The present study shows that a lower number of tree seedlings has survived in these stands due to anthropogenic activities, therefore regeneration and recruitment processes could not support the future forest population. If this situation could not be controlled, these tree species would disappear soon. Therefore, prompt action should be taken to protect these species, forest, environment and landscapes.

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