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RESEARCH PAPER

TITLE

NATURAL FACTORS AFFECTING THE DENSITY OF REGENERATION IN SUBTROPICAL CHIR PINE FOREST OF MALAKAND REGION, KHYBER-PAKHTUNKHWA, PAKISTAN

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ABSTRACT

Chir pine botanically called Pinus roxburghii of family Pinaceae, found in sub-tropical chir pine zone providing valuable services to the locals. The anthropogenic disturbances in sub-tropical Chir pine forest are mostly affecting natural regeneration in coniferous forest of Pakistan. However, natural factors like slope, aspect, elevation, sunshade etc. also responsible for low density of natural regeneration in these forests. Therefore, we formulated a study to investigate the effect of slope and aspect on natural regeneration of chir pine forest in Malakand region in Khyber Pakhutnkhwah. Regeneration was studied on three different slopes (steep slopes of 27° and above, the moderate slope of 18-27° and gentle slope 18° and below and northern and southern aspect. A total of 45 random samples were thoroughly studied in the form of circular plots of radius 8.4 meters, 15 from each category of slope in each study area. Similarly, 20 plots on southern and 20 northern aspect were also selected randlomly in each study area. Analsysis was carried out through two way analysis of variance for slopes and two sample independent t- test for aspect through SPSS and significance difference among slope was determined through tukey test. The result showed that moderate slope and southern aspect was the best for optimum natural regeneration. The less number of regeneration on gentle slope corresponds to heavy anthropogenic activities, grazing pressure and inadequate mother trees. The study recommend to focus efforts of regeneration protectoin mainly on moderate slope, prohibit individuals from collecting seeds, and raise public understanding of natural regeneration.

Key words: aspect, chir pine, malakand, natural, regeneration, slope

1. INTRODUCTION

Forests ecosystems on earth not only provide provision services, but also provide regulation, support and cultural services in the form of climate, water, carbon regulation , pollution control, erosion control, pollination, habitat, biodiversity, nutrient cycling, recreation, eco-tourism etc. However, these ecoystems face many distrurbances and decline the resouces. Therefore, identification of threshold for such decline in forest resources is critical for its rapid restoration (**Trumbore *et al.*, 2015**). Being the source of livelihoods in developing countries, these ecosystems require strategies to prevent their degredation and utilizing the resources with minimum depletion (**Negi, 2009**). Resotoration efforts both on long and large-scale bases are urgently required to prevent deforestation and forest degradation at global level. However, despite rapidly growing knowledge regarding the feasibility and the environmental and economic benefits of natural regeneration, tree plantation remains the major focus of restoration programs while natural regeneration is often ignored as a viable land-use option **(Chazdon and Uriarte, 2016**).

In Pakistan, the sub-tropical chir pine foerst of Hindukush mountain range is deteriorating and lack proper attention by the policy makers for its restoration (**Hussain *et al.*, 2019**). These forests are commonly situated around the agricultural fields and exposed to high pressure of grazing, forest fires, lopping etc. resulting very low density of mature stand of chir pine in the region. The changing environmental conditions coupled with high anthropogenic pressures also lead to depletion and replacement by spiny species with no or very little economic value. Thus, fire and grazing have significant impact on the regeneration of pine trees in study area and it deserves more attention for conservation (**Sharma and Ahmad, 2014**). Although Pakistan has 5.2% forest cover, yet it has great diversity in composition and structure. The major forest types are coniferous, irrigated, riverine, scrub, coastal, mazri (*Nannorrhops ritchiana* (Griff) Aitch.) and linear plantation. Coniferous forest constitutes 40% of the whole cover, they grow naturally in northern hilly areas of Pakistan. scrub forest, which act as protective cover for soil erosion and provide fuel wood and fodder for livestock holders is another category which constitutes 34.75%. Tab.1 show the distribution of various forest of Pakistan (**Jan, 1993**).

From the above review it is obvious that few studies have been conducted for the regeneration assessment of chir pine forest generally in Pakistan and particularly in the Khyber Pakhtunkhwah province. Based on the complications of natural regeneration due to anthropogenic activities and research gap, it is important to consider this area for further research. The study will help to identify selected variables responsible for low regeneration of chir pine forests. The current study will also help the policy makers and stakeholeders to take more effective measures for forests protection and improvement of the regeneration capcity of chir pine forests in the study area.

2. MATERIAL AND METHODS

2.1 STUDY AREA

The current study was carried out in sub-tropical chir pine zone of Malakand region located between 35°29'59.99" N 72°00'0.00" E with elevation range from 700 to 7708 meters with land area of 952 km^2 in northern Pakistan. The area has rough terrain supporting diverse forest types including sub-tropical chir pine forest. This forest type is found between altitude of 800 and 1700 meters above sea level in the Western Himalaya within range of south-west summer monsoon. It is found in Lower Dir, Swat, Hazara, AJK and in the foothills of Murree. According to Land Cover Atlas of Khyber-Pakhtunkhwa, the sub-tropical chir pine forest covers 2.9% of the existing forest of the province with a total area of 217,753 hectares (**Bukhari *et al.*, 2012**). The study area included Swat, Dir, Shangla, Buner, Malakand and Chitral. In this region sub-tropical chir pine forest is the dominant forest type that occurs mostly in pure stand. However, in depression, evergreen broad leave tree species of *Quercus incana* (oak) and some deciduous plants also occur. Mean annual temperature lies between 60 – 70F°. The forest occurs on slopes of rocky mountains; hence its soil is well drained and often dry. Fire is the characteristic of this forest type due to resinous material in summer season. The forest overlaps with *Pinus wallichiana* at the upper limit and with subtropical broad leaf at lower limit. Three sites (Talaash from Dir and Karakar and Marghuzar from Swat district) were selected in stratified sampling for the purpose of this study (Fig. 1). A preliminary survey was conducted after stratification to find out the variation in the vegetation of the study area. A total of 12 random plots (four in each slope and aspect) of 8.4-meter radius were selected (Fig.2) From the preliminary survey, standard deviation and mean was calculated in the excel sheet. From the standard deviation and mean, co-efficient of variation was calculated using the formula.

$$\text{Co} - \text{efficient of variation} = \frac{\text{standard deviation}}{\text{mean}} \times 100$$

From the above equation, sample sizes both for aspect and slope were calculated using the formula.

$$\text{Sample size } n = CV2 \times t2 \; / E2$$

Where t is 1.96 for 95% confidence interval; n is number of sample plots; CV, coefficient of variations; E is allowable error (**Asrat and Tesfaye 2013**)

2.2 EXPERIMENTAL DESIGN

All the three study areas were divided into three imaginary portions i.e. transect line which were based on slope percentage. The sampling units with steep slopes gradient from 60% (27°) and above, the moderate slope having gradient from 40 to 60% (18-27°) and gentle slope having gradient 40% (18°) or below was separated and analyzed for the effect 'slope' on regeneration (**Sharma *et al.*, 2010**). Random sampling in each of the three slopes was carried out to cover each portion completely. A total of 45 random samples plots were thoroughly studied. The plots were laid in the form of quadrates of 2 × 2 m at all the three sites 15 from each category of slope in each study area (**Adil *et al.*, 2022**). Similarly, 20 plots on southern and 20 northern aspect were also selected randlomly in each study area. Seedlings below 31.5 cm CBH (circumference at breast height, i.e., 1.37 m above the ground) were considered as regeneration according to the criterion set by **Knight, (1963).** Similarly, 20 plots on southern and northern aspect were also selected randomly from each study area.

2.3 STATISTICAL ANALYSIS

The data were compiled and entered into IBM Statistics 21. After testing of normality of the data through Shapiro-Wilk test (α=0.05) and Levene's test for equality of variances, two-way ANOVA for slopes (Treatments=3 categories of slopes and blocks=3) and two sample independent t- test for aspect was run through SPSS. ~~Turkey~~ test was applied to determine significance between treatments and blocks in case of slope and result was interpreted in the form of charts and graphs.

3. RESULTS

The study result of all the three sites indicated that slope and aspect both has significant effect on the chir pine regeneration establishment. Fig.3 and Fig.4 reflect the median and quartiles of the data for both slope and aspect. There was no variation on the same slope and aspect of the three locations. Moderate slope and southern aspect support maximum regeneration in all of three study sites. However, different aspects and slopes reflected significant variations in one as well as all the three places. Table 2 reflects statistical characteristics of the data.

3.1 EFFECT OF SLOPE AND ASPECT ON REGENERATION

The result indicated that the difference between the three treatments (gentle, moderate, and steep slope) is statistically significant at (α=0.05). However, no such variation occurred in blocks (Talaash, Karakar and Marghuzar).

Similarly, there was significant variation recorded for the two treatments (southern and Northern aspects) after application of two sample independent t-test at (α=0.05). The southern aspect supported a greater number of regeneration than the northern slope. The tucky test for slope analysis further explained that moderate slope is significantly different from steep and gentle slope. However, there was no significant difference recorded between gentle and steep slopes in any study area. The result affirmed that moderate slope was best for the establishment of regeneration of chir pine. Results are reflected in Fig.5.

4. DISCUSSION

The aim of the study was to explore the effect of aspect and slope on the natural regeneration of chir pine establishment in Malakand region. The study found that due to good physiographic conditions of moderate slopes, maximum number of regenerations was recorded. However, the low regeneration on gentle slopes may be due to abundance of *Dodonaea viscosa* species, *Olea ferruginea* and many other species, grazing load and trampling effect that prevent the seed from germination. While the smaller number of regenerations on steep slopes was either due to poor physiographic conditions or cone collection by locals living in hills. The compacted soil can have a negative effect on the height and diameter. Development of seedlings has also demonstrated by (Sohrabi *et al.*, 2019) further revealing that most soil disturbances occurred on the slopes >20%, as well as the highest levels of traffic intensity. (Picchio *et al.*, 2019) also validated that soil compaction has major influences on growth and/or mortality rates of forest seedlings. Similarly, the aspects of ground surface indicated a close relationship with natural regeneration and the best possible reason for greater number of regenerations on southern aspect is sunshine. The north aspect is mostly covered in snow during winter, receiving less sunshine as compared to the southern aspect and as a result, the south side was greatly endowed with natural regeneration. In this context (**Ghomi *et al.*, 2020**) while working on aspect, elevation, and slope along with other parameters in 60 experimental plots reported that soil and physiological conditions positively influenced the regeneration process and provided a variety of sites favorable for seed generation and establishment of different plant species. The other parameters studied in their study were soil type and canopy closure (50-70% and >70%). According to (Shah and Shah, 2016), natural regeneration of conifers is well distributed at south aspects than its growth on north aspects. Besides, a close relation was observed between the regeneration and terrain slope. Different threats like forest logging and cutting, forest fire, grazing pressure, trampling, fuel wood, and severe climatic condition adversely affect the natural regeneration indicating negative impact of anthropogenic activities on natural regeneration. (Hussain *et al.*, 2019) also concluded from their study from Swat area that slope and aspect had significant effect on the establishment of natural regeneration in sub- tropical chir pine forest. The main objective of this study was to compare the natural regeneration of chir pine along the slopes aspect the findings are correlating with other studies so far conducted that natural regeneration is mostly abundant on moderate slope and southern aspect due to less anthropogenic activities, good physiographic and favorable growth conditions.

5. CONCLUSION

In conclusion, this study highlights the importance of slope and aspect in controlling the regeneration density, particularly emphasizing sub-tropical chir pine forest of Malakand region. It is imperative to not disregard the effects of these two factors on regeneration of these forest resources. Based on the findings, it is advisable to focus restocking efforts for natural regeneration on such slope and aspect. Furthermore, aspects also play an important role in regeneration, while the southern aspect commonly has more regeneration than northern aspect due to sunshine. It is also recommended to limit animal grazing, prohibit individuals from collecting seeds, and raise public understanding of forests and natural regeneration.

6. ACKNOWLEDGMENT

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Table 1 Showing Forest Types, Total Area, and Percentage.

Forest types	Productive forest	Protective (conservation)forest	Total	Percentage
Coniferous	867	1092	1959	42.8
Scrub	158	1568	1726	37.6
Riverine	158	138	296	6.5
Mangrove	--	347	347	7.6
Irrigated	083	151	234	5.1
Plantation	--	-	0	
Linear Plantation	-	17	17	0.4
Total	**1266**	**3313**	**4579**	**100**

Source: Pakistan Forest Institute

Table.2 Mean, standard deviation (SD) and standard error (SE) of the consolidated data for the three study locations.

Talaash					
Slope type	**Gentle Slope**	**Moderate slope**	**Steep slope**	**Southern Aspect**	**Northern Aspect**
Mean	34.93	58.60	37.00	58.70	36.05
SD	9.38	10.63	9.60	9.77	9.71
SE	2.42	2.74	2.48	2.18	2.17
Karakar					
Slope type	**Gentle Slope**	**Moderate slope**	**Steep slope**	**Southern Aspect**	**Northern Aspect**
Mean	36.80	58.07	38.93	58.95	36.10
SD	10.52	10.57	10.53	10.02	9.58
SE	2.72	2.73	2.72	2.24	2.14
Marghuzar					
Slope type	**Gentle Slope**	**Moderate slope**	**Steep slope**	**Southern Aspect**	**Northern Aspect**
Mean	34.00	62.67	36.27	59.65	36.45
SD	9.69	8.60	9.54	9.31	9.22
SE	2.50	2.22	2.46	2.08	2.06

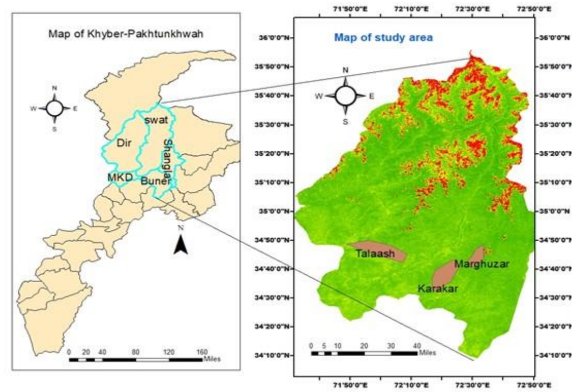

Figure 1 Map showing Talaash, Karakar and Marghuzar in Dir and Swat

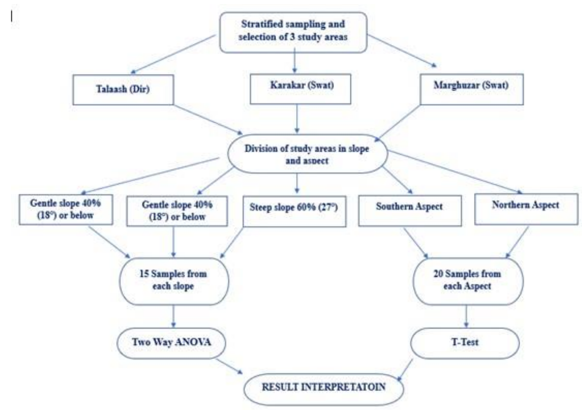

Figure 2 Flow chart of sampling along the slope and Aspect

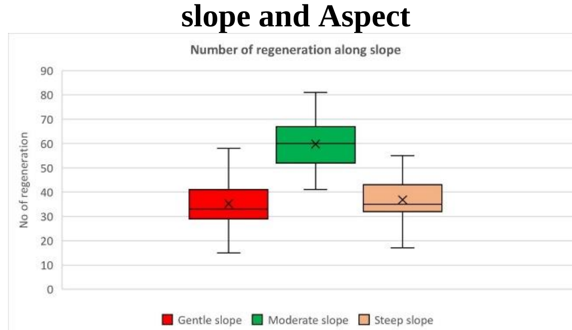

Figure 3 Distribution of regeneration data on southern and northern aspects

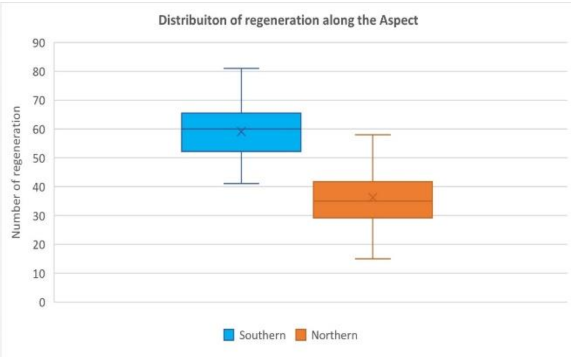

Figure 4 Distribution of regeneration data on southern and northern aspects

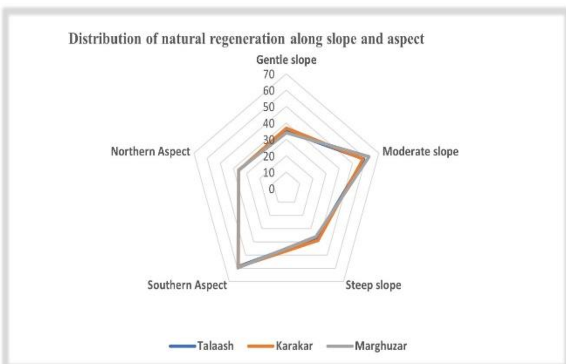

Figure 5 Number of regeneration along various slope

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