

Impacts of Conservation Practices on Plant Density, Frequency and Herbaceous Biomass in the Chel–Beshigram Forest, Pakistan

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SUMMARY

Forests in mountainous regions of Pakistan are increasingly threatened by anthropogenic pressures, leading to biodiversity loss and ecosystem degradation. Therefore, understanding the effectiveness of conservation practices is essential for sustainable forest management. The study was carried out to quantify the impacts of protection and conservation measures on the diversity of plant species and on herbaceous biomass in a forestland. For this purpose, two forestlands were selected for comparative analysis in the Chel-Beshigram valley of district Swat. It was ensured that factors like altitude, aspect, and slope remained the same in both forestlands. The only difference was that one forestland was protected while the other was open to grazing, medicinal plant collection, fuelwood collection, and all sorts of other anthropogenic activities. The total number of plant species in the forest land that has been preserved was 52 and the number of plant species in the open forest land is just 30. The median densities and percentage frequency of medicinal herbs in the open forestland were extremely low as compared to the conserved forestland, and two important medicinal herbs, namely *Bergenia ciliata* and *Plantago major*, were lost in the open forestland. The average fresh and dry weight of herbaceous biomass for the fenced forestland was 4800 and 940 kg/ha, respectively. In the unprotected forestland, the average values for fresh and dry biomass reduced to 1300 and 260 kg/ha, respectively. Seventy percent of the area of unprotected forestland showed poor regeneration of conifer trees, and only 30% of the area had medium to good regeneration. In contrast, more than 80% of the land in the protected forest showed medium to good regeneration status. These findings highlight the critical role of conservation practices in maintaining biodiversity, enhancing biomass productivity, and supporting forest regeneration. The study provides strong evidence for policymakers to implement and enforce sustainable forest management strategies, including controlled grazing, community-based conservation, and strict protection measures to preserve fragile forest ecosystems in Pakistan.

Keywords: Diversity; forestland, medicinal plant, protection, regeneration

INTRODUCTION

Forest ecosystems are some of the most valuable natural resources in mountainous areas, offering a broad spectrum of ecological, economic, and social services (Glushkova et al., 2020). The distribution and richness of the vegetation especially the variety of herbaceous species, plant density, prevalence, and biomass are sensitive indicators of ecosystem wellness and levels of disturbance in such ecosystems (Spicer et al., 2022). Pakistan is considered a forest-poor nation, with forest cover significantly below the average for the world and the region. The Food and Agriculture Organization states that forests cover less than 5% of the total land in Pakistan (Ali et al., 2015). This small base of forest resources is constantly stressed by population increase, reliance on forest products, agricultural development and climate change. Consequently, forest degradation, rather than full deforestation, has become the common process in most regions of the country, leading to declining vegetation cover, low productivity, and reduced regeneration ability (Maja et al., 2021).

Forest ecosystems in Khyber Pakhtunkhwa (KP) are comparatively larger than in other provinces, but they are also some of the most overexploited. The northern KP forests, particularly in the Swat region, experience high levels of grazing, fuelwood harvesting, and commercial harvesting of medicinal plants, which put significant pressure on understory vegetation and the regeneration of young trees (Ali et al., 2023). In the regions of the Himalayas and the Hindukush, medicinal plants are an important part of forest understory vegetation (Painuli et al., 2021). Population reduction and local extinction of some medicinal plant species in northern Pakistan have been caused by unsustainable harvesting, grazing pressure, and habitat disturbance. The destruction of these species not only influences biodiversity but also affects the functioning of the ecosystem and the livelihoods in rural areas (Sher et al., 2022).

Conservation strategies, such as fencing, grazing exclusion, and limiting resource harvesting, are types of protection-based conservation strategies that are regularly utilized to prevent forest degradation and encourage ecosystem restoration (Bizuru et al., 2025). Protection has been found to increase the development of the understory, ameliorate soil status, and enhance the regeneration of coniferous species in

temperate and sub-alpine forests (Zhao et al., 2025). Numerous past studies have been conducted considering either a floristic inventory or general land-use transformation, with little consideration of the overall impact of protection on plant diversity, medicinal species survival, herbaceous biomass, and regeneration condition within the same landscape. These types of integrated assessments are necessary to understand how effective conservation practices are ecologically and to guide sustainable forest and rangeland management plans (Singh et al., 2022).

The Chel-Beshegram Valley of District Swat offers the best environment to assess the outcome of conservation since the protected and non-protected forestlands are located in such close proximity under similar topographical conditions. A comparative approach provides the ability to assess anthropogenic disturbance as the main discerning variable and to have a strong assessment of conservation effects on vegetation structure and productivity (Naeem et al., 2020). This research was designed to examine how protection impacts the diversity, density, frequency, herbaceous biomass, and regeneration condition of plants in the forestlands in the Chel-Beshegram Valley, Swat, by comparing the effect of protection on the sites and the control by protection, thus empirically demonstrating why conservation-based forest management can be applied in the forestlands of northern Pakistan.

MATERIAL AND METHODS

The study was conducted in the Chel-Beshigram Valley, Swat. Chel-Beshigram is a combination of two sub-valleys, i.e., Chel and Beshigram, and is situated on the left bank of the River Swat at 35° 8'40.45"N latitude and 72°32'15.37"E longitude. Ecologically, the Chel-Beshigram valleys fall in the moist temperate ecological zone, with major land cover types including agriculture, grasslands, forests, sub-alpine, and alpine pastures. The reconnaissance survey was done before data collection, to ensure that variables such as aspect, altitude and slope were the same in both of the study locations. The only difference was that in one forestland, some conservation interventions had been made by WWF-Pakistan, while in the other forestland, no such measures had been taken.

Occurrence of Plant Species in the Study Area

The study area was carried out on line transect walks with experts to identify the maximum number of plant species found in both forestlands. The frequency of the

plant species within the study area was measured using the line transect method (Amaludin et al., 2021). After the detection of the species in the transect line in each forestland, a comparison of the species richness in the protected and unprotected forestlands was done.

Sample Design for Density and Frequency of Plant Species

The information about the plant species can be gathered through random or systematic sampling. Systematic sampling promotes fair data collection and provides fairly close estimations of the actual features of the stand. Hence, the study used a systematic sampling technique to achieve the required quality of information on the diversity of the plant species in the study area (Dengler et al., 2016). The systematic sampling assumes that there is a decent sampling design; hence, the dimensions of the sample (square) and the distance between two samples should be mentioned. The study quadrat was 1 by 1 square meter with the first quadrat of the two study areas being picked randomly at the transect line and the second quadrat being fixed at every 200 meters. To collect data on the ten most significant selected species, 30 samples in each area were used to collect information.

Density and Frequency of the Selected Plant Species

The scarcity of resources and time limitations did not allow for the determination of the density and frequency of all plant species existing in the field of study. Hence, only the economically important medicinal herbs were considered in evaluating the comparison of the densities of different plant species and the frequencies in both forestlands. Density is the quantity of plants of a given species that are within an area. The quadrats were counted to establish the total number of plants of each individual species that was selected. Lastly, the individual plants of specific species were summed up, and therefore, the average densities of all the chosen species were calculated in the two study areas. The plant species that have been chosen are important both medicinally and economically.

The frequency is the distribution and the number of a given plant species in a particular region. High density patches of plants of a species may be present but the frequency is not necessarily high. It means that such species will not be distributed evenly on the site, and any incidental harvest can ruin the life of the species in this

place. The frequency of the selected species of plants was calculated and tabulated in percent frequency (Hill et al., 2012).

Diversity Indices

Diversity index is a mathematical tool that is used to quantify the diversity of a group of species. It, actually, gives vital information on the abundance and occurrence of the various species in a community. The reason why ecologists are typically interested in determining the structure and composition of communities is the fact that diversity indices can measure the abundance and distribution of species. The two aforementioned areas of study use the Shannon diversity index and the Shannon evenness index to compare the density and frequency of species in the specified regions (Wang et al., 2018).

Shannon Diversity and Evenness Indices

The equation of computing Shannon diversity index H is;

$$H = - \sum P_i \ln P_i$$

Where N = the total abundances of the th species, $n_i = i$ the proportionate prevalence of the ith species. N = number of the members of all the species. ln = Natural log. E is evenness index of Shannon and calculated by the following formula;

$$E = \frac{H}{\ln S}$$

Shannon diversity index ln = Natural logarithm S = Number of total species Shannon evenness or index of equitability lies between 0 and 1 and index of equitability is 1 and 0 respectively.

Biomass

Biomass refers to the weight of the plant material in a given area and is one of the important commonly measured vegetation attributes. Usually, terms like yield and phytomass are used synonymously with biomass. It is considered an important indicator of management and ecological processes in any kind of vegetation, from dense forestlands to barren rangelands. It indicates the density of vegetation at a particular site, can assess the potential productivity of a forest or rangeland, and thus can evaluate the carrying capacity of a site under investigation, especially regarding

browsing and grazing. Biomass in a rangeland can be measured using direct and indirect sampling methods. The direct method was used in this study, i.e., measuring the total plant biomass present in a sample quadrat (Barnetson et al., 2020). Data was recorded for both fresh and dry (weight) biomass in both study areas.

Fresh Weight Biomass

The systematic sampling method was used for the evaluation and comparison of herbaceous biomass in the protected and unprotected study sites (Zamin et al., 2025). One square meter quadrats were used for harvesting biomass samples. The first quadrat was placed randomly along the transect line in each study site, and the rest of the samples were taken subsequently at regular intervals. A total of twenty samples were weighed in each of the protected and unprotected study sites. All the plants present in each quadrat were clipped with the help of plant clippers and sickles at about 5 cm height from ground level and weighed on the spot to determine fresh biomass. Though this clip-and-weigh method is usually considered laborious and time-consuming, it is the most direct and objective way to determine herbaceous biomass.

Dry Weight Biomass

The weight of the fresh plant material includes internal moisture content, which consists of intercellular and intracellular water, as well as external moisture like precipitation and dew. Thus, the weight of fresh plant material is highly variable, depending on the current weather and atmospheric conditions. Therefore, the fresh weight of biomass is not a very reliable parameter for determining the herbaceous status of the forestland. For a more appropriate and meaningful interpretation, biomass is expressed as oven-dried or air-dried mass. All the samples that were weighed in the field were brought back to the lab. Those samples were then dried in the oven for 24 to 48 hours at 60-70 °C. To determine whether a sample is completely dried, samples were removed from the oven, weighed, and returned to the oven (Huang et al., 2019). This process was repeated until a constant weight was achieved (the final dry weight); this is called drying to a constant weight.

RESULTS AND DISCUSSION**Species Richness**

Species richness simply means the number of species available in a particular area. The results revealed that in the study area, a greater number of plants were identified in the protected area compared to the unprotected one. The fenced area had 52 plant species whereas there were only 30 plant species found in the other study site. The names of plant species found in the protected and unprotected forestlands are listed in Tables 1 and 2, respectively. Higher plant diversity in the protected forestland is mainly due to the abandonment of human activities, including medicinal plant collection, fuelwood collection, grass cutting, timber collection, and livestock grazing in the fenced forestland (Singh et al., 2022). On the other hand, because there is no such protection in the open forestland, a comparatively lesser number of plant species were identified.

Table 1: Identification of Plant Species in Protected Forests

S. No	Scientific Name	S. No	Scientific Name	S. No	Scientific Name
1	<i>Abiespindrow</i>	19	<i>Corydalis govaniiana</i>	36	<i>Plantagolanceolata</i>
2 ^T	<i>Aconitum violaceum</i>	20	<i>Cynodondactylon</i>	37	<i>Plantago major</i>
3 ^a	<i>Acoruscalamus</i>	21	<i>Diospyros lotus</i>	38	<i>Podophyllummodi</i>
4 ^b	<i>Adiantumcapillus</i>	22	<i>Fagoniaarabica</i>	39	<i>Podophyllumhexandrum</i>
5 ^l	<i>Adiantumvenustum</i>	23	<i>Ficus palmate</i>	40	<i>Primula denticulate</i>
6 ^l	<i>Aesculusindica</i>	24	<i>Fragaria vesica</i>	41	<i>Quercusdialatata</i>
7 ^e	<i>Allium sativum</i>	25	<i>Geranium wallichianum</i>	42	<i>Rubiaccordifolia</i>
8 [•]	<i>Amaranthusviridis</i>	26	<i>Hypericumperforatum</i>	43	<i>Salvia moorcorfiana</i>
9 ²	<i>Arisaemajacquemontii</i>	27	<i>Indegoferaheterantha</i>	44	<i>Sambacusswightina</i>
10 ^q	<i>Artemisia scoparia</i>	28	<i>Male fern</i>	45	<i>Solanumnigrum</i>
11	<i>Artemisia vulgaris.</i>	29	<i>Menthalongifolia</i>	46	<i>Swartiaelata</i>
12	<i>Asparagus adsendens</i>	30	<i>Micromeriabiflora</i>	47	<i>Taxusbuccata</i>
13 ^T	<i>Avena sativa</i>	31	<i>Myrsineafricana</i>	48	<i>Valerianajatamansi</i>
14 ^a	<i>Berberislycium</i>	32	<i>Orostagalimbata</i>	49	<i>Valerianawallichii</i>
15 ^b	<i>Bergenia ciliate</i>	33	<i>Paeoniaemodi</i>	50	<i>Vibernumgrandiflorum</i>
16 ^d	<i>Bistortaampilexicaulis</i>	34	<i>Piceasmithiana</i>	51	<i>Viola biflora</i>
17 ^e	<i>Cedrusdeodara</i>	35	<i>Pinuswallichiana</i>	52	<i>Viola serpens</i>
18 [.]	<i>Celtisaustralis</i>				

Table 2: Identification of Plant Species in Open Forestland

S. No	Scientific Name	S. No	Scientific Name	S. No	Scientific Name
1	<i>Abiespindrow</i>	11	<i>Cannabis sativa</i>	21	<i>Piceasmithiana</i>
2	<i>Acoruscalamus</i>	12	<i>Corydalis govaniana</i>	22	<i>Pinuswallichiana</i>
3	<i>Adiantumvenustum</i>	13	<i>Cynodondactylon</i>	23	<i>Podophyllumemodi</i>
4	<i>Aesculusindica</i>	14	<i>Cynoglossumlanceolatum</i>	24	<i>Quercusdialatata</i>
5	<i>Arisaemajacquemontii</i>	15	<i>Fragariavesica</i>	25	<i>Solanumnigrum</i>
6	<i>Artemisia vulgaris</i>	16	<i>Geranium wallichianum</i>	26	<i>Taxusbuccata</i>
7	<i>Berberis lyceum</i>	17	<i>Hypericumheterantha</i>	27	<i>Valerian wallichii</i>
8	<i>Bergenia ciliate</i>	18	<i>Indigoferaheterantha</i>	28	<i>Valerianajatamansi</i>
9	<i>Bistortaamplexicaulis</i>	19	<i>Male fern</i>	29	<i>Viburnumgrandiflorum</i>
10	<i>Cedrusdeodara</i>	20	<i>Paeoniaemodi</i>	30	<i>Viola serpens</i>

Density of the Target Species

Some of the key medicinal herbs that have been chosen to be used in this study are; the *Bistorta amplexicaulis*, *Viola biflora*, *Indigofera heterantha*, *Adiantum venustum*, *Geranium wallichianum*, *Valeriana wallichii*, *Bergenia ciliata*, *Plantago major*, *Berberis lycium* and *Viburnum grandiflorum*. Average densities of these herbs were shown in Table 3 (m² and hectares). It is evident from the table that the densities of the plant species are considerably larger in the protected forestland compared to the unprotected area. The apparent disparity between the plant species density in the two forestlands is largely due to two factors: the collection of medicinal plants and the grazing of livestock. The majority of these medicinal plants are highly priced in the markets; hence, when and where they are found by local collectors, they ruthlessly uproot them and sell them in the local markets. Uncontrolled overgrazing is another apparent cause of the decline in the density of the plant cover. The decline in the density of valuable medicinal herbs is also attributed to forest fires as well as fuelwood collection (Boampong et al., 2023).

Table 3: Target Species Densities in Both Forestlands

S. No	Botanical Name	Protected		Unprotected		Decrease in %age
		Per m ²	Per ha	Per m ²	Per ha	
1	<i>Bistortaampilexicaulis</i>	3.033	30333	2.000	20000	34
2	<i>Indigoferaheterantha</i>	1.5333	15333	0.800	8000	48
3	<i>Adiantumvenustum</i>	1.267	12670	0.733	7300	42
4	<i>Geranium wallichianum</i>	1.067	10670	0.600	6000	44
5	<i>Valerianawallichii</i>	0.633	6333	0.500	5000	21
6	<i>Viburnumgrandiflorum</i>	1.533	15330	0.433	4330	72
7	<i>Bergenia ciliate</i>	1.000	10000	0.000	0	100
8	<i>Berberis lyceum</i>	0.700	7000	0.167	1670	76
9	<i>Viola biflora</i>	0.900	9000	0.267	2670	70
10	<i>Plantago major</i>	1.000	10000	0.000	0	100

The table 3 shows that there is a 100 percent decrease in *B. ciliata* and *P. major*, which means that they no longer exist in the unprotected forestland. *B. ciliata* is very useful in controlling diabetes (Sapkota et al., 2022); thus, being a valuable medicinal herb, the plant has been ruthlessly collected and has therefore completely vanished from the unprotected forestland. In the same way, the locals commonly use *P. major* to get relief from any itching and swelling caused by bee stings or insect bites. Consequently, the uncontrolled extraction of this curative herb has posed a danger to the survival of this plant in the region. Following the same pattern, the densities of *B. lycium*, *V. grandiflorum*, and *V. biflora* also decreased by 76%, 72%, and 70%, respectively, from protected to unprotected study sites. Although less than 50%, a decrease is also observed in the densities of all the remaining plant species.

Frequency of the Target Species

The frequency examines the appropriate frequency of the plant species within a given region (Pysek et al., 2017). Suppose the distribution of the species is uniformly spread over all the area, the frequency will be high; whereas, the frequency will be low under circumstances that the distribution of that particular species is not uniformly distributed. Plants may be thick but of low frequency when the vegetation is typically lump clumped. Table 4 gives the percent frequencies of the medicinal herbs of the two forestlands.

Table 4: Target Species Frequencies in both the Forestlands

S. No	Botanical Name	Percent Frequency	
		Protected	Unprotected
1	<i>Bistortaamplexicaulis</i>	97	67
2	<i>Indigoferaheterantha</i>	93	70
3	<i>Adiantumvenustum</i>	73	67
4	<i>Geranium wallichianum</i>	80	40
5	<i>Valerianawallichii</i>	63	47
6	<i>Viburnumgrandiflorum</i>	77	40
7	<i>Bergeniaciliata</i>	43	0
8	<i>Berberislycium</i>	67	17
9	<i>Viola biflora</i>	73	27
10	<i>Plantago major</i>	53	0

It is evident that there is a contrast in the occurrence of the plants in the study area that is under protection and the one that is not. The analysis has found that the grazing-forbidden sites had equal distribution of all the target species. In the unprotected site, on the other hand, the presence of the plant species did not follow a uniform distribution, and some of the target species could be found in only a few patches. The greatest reduction in frequency was observed in *B. lycium*, followed by *V. biflora*, as *P. major* and *B. ciliata* had altogether disappeared from the open study site. The minimal effect on frequency was observed in *A. vensutum*, and a medium reduction was also noted in all the other target species. We can therefore conclude that not only have the densities of the plants been impacted by the processes of grazing and medicinal plant collection, but their frequencies have also been influenced. Plants with poor densities may still have good frequencies in the circumstance that they are uniformly distributed in an area. The harvests of such plants are generally deemed to be safe due to their presence throughout the site, and thus, they will not pose any danger to the plants in the event that there are a few limitations on harvesting.

Evenness and Shannon Diversity Index

The data obtained (Table 5) in both forestlands concerning target species were subjected to Shannon diversity and evenness indices to further elucidate the differences in diversity and evenness between the two study sites. All the target species were

summed in the individual plants of each sample quadrat in the forestlands and the obtained data was used to arrive at the Shannon diversity and evenness indices of each forestland.

Table 5: No. of Individual Plants of the Target Plant Species in both the Forestlands

S. No	Species Name	No of Individual Plants	
		Protected	Unprotected
1	<i>Bistortaamplexicaulis</i>	91	60
2	<i>Indigoferaheterantha</i>	46	24
3	<i>Adiantumvenustum</i>	38	22
4	<i>Geranium wallichianum</i>	32	12
5	<i>Valerianawallichii</i>	19	15
6	<i>Viburnumgrandiflorum</i>	46	13
7	<i>Bergeniaciliata</i>	30	0
8	<i>Berberis lyceum</i>	21	5
9	<i>Viola biflora</i>	27	8
10	<i>Plantago major</i>	30	0
Total		380	159

Shannon diversity and evenness indices were calculated and finally the “t” test was carried out and the resultant values are tabulated in the following table 6.

Table 6: Shannon Diversity and Evenness Indices of the Selected Plant Species

Study Site	S	N	H	E	“t” Value
Protected	10	380	2.191	0.951	7.66
Unprotected	8	159	1.808	0.869	

$$t_{95} = 1.960 \quad t_{99} = 2.326$$

S is the number of species, N denotes the number of individual plants, H is the Shannon Diversity Index, while E is the Shannon Evenness Index

Table 6 shows that the values of diversity and evenness indices are high in the protected forest compared with unprotected forestland. This means that due to conservation interventions, the protected study site is not only more diverse compared to the unprotected one, but the species are also evenly spread. However, distribution of species in the unaltered forestland is not uniform. At the 99% confidence level, the obtained t-value of 7.66 is still greater than the t-value. This implies that the two forestlands differ greatly concerning the diversity of the herbaceous vegetation.

Herbaceous Biomass

Biomass determines the productivity of a landmass and carrying capacity when subjected to grazing. Fresh and dry weight herbaceous biomass was evaluated for both forestlands. The resultant data revealed that there is a significant difference in the biomass status of the fenced and open forestlands, the former having much higher values than the latter. The average fresh biomass in the protected land was found to be 4,800 kg/ha, while in the unprotected land, the average fresh biomass was only 1,300 kg/ha. Similarly, dry weight biomass for protected and open forestlands was recorded as 940 kg/ha and 260 kg/ha, respectively. The results of all the sampled quadrats harvested in protected and unprotected forestlands are given in Table 7.

Table 7: Herbaceous Biomass of Sampled Quadrates in Protected and Open Forestlands

Sample Quadrate No.	Fresh Weight g/m ²		Dry Weight g/m ²	
	Protected	Open	Protected	Open
1	492	130	104	26
2	543	140	110	28
3	477	78	103	16
4	475	85	98	17
5	470	40	95	8
6	430	140	87	28
7	460	220	85	44
8	436	75	88	15
9	430	120	87	24
10	447	35	86	7
11	445	137	82	27
12	580	170	105	34
13	448	75	89	15
14	435	330	83	66
15	537	125	98	25
16	557	95	112	19
17	570	60	102	12
18	475	130	98	26
19	463	340	88	68
20	425	75	87	15
Average	479.75	130	94.35	26
Variance	2378.08	6561.4	82.32	262
Standard Deviation	48.76	81.00	9.07	16.18

It is clear from the above table that the values of fresh and dry weight biomass of fenced forestland are much higher compared to those of open forestland. The primary cause of the decrease in the biomass of herbaceous vegetation in open forestland is nomadic livestock grazing (Haq et al., 2021). It has been observed during the study that otherwise unpalatable species of herbs and grasses are also consumed by sheep and goats when nomads spread salt on those species, thus further reducing the biomass. The livestock not only eat the herbaceous vegetation, but the soil under the browsing paths becomes so hard and tough that it cannot support any type of vegetation, converting into patches of barren land. The secondary reason for this difference in herbaceous biomass between the two forestlands is medicinal plant collection. Every year, tons of medicinal herbs are collected from these open forestlands and sold in local markets. The method of plant collection is also unscientific. Even if only the leaves of a particular herb are valuable, the local plant collectors simply uproot the whole plant, thus reducing the population of herbs in open forestland.

From the data, it can also be observed that there is great variation among the biomass values of sampled quadrats in the open forestland. This is because grazing is usually not uniform throughout the forestland, and certain portions of the site were under greater stress from being harvested compared to others. As a result, steep slopes have fair biomass, while comparatively flat patches have very poor biomass. The resultant values of standard deviation and variance were also very high for the sampled quadrats in open forestland compared to the fenced ones.

Percent Dry Mass

The average percent dry weights of the sampled quadrats in both forestlands are almost the same, slightly higher for open forestland than for the fenced one, i.e., 19 and 20 percent respectively. This is because, in herbaceous plants, the leaves have a higher concentration of water than the shoots, and in the open forestland, which is subjected to grazing, the animals tend to consume the upper portion of the plants, which have leaves, leaving the lower portion of the shoots.

Regeneration Status of Conifer Trees

The data for the regeneration status of conifer trees was divided into three groups: poor, medium, and good, as shown in Table 8. The average number of saplings per

sample plot in the conserved forestland was 18, much higher than in open forestland, which was found to be only 9.5. In the protected forestland, out of 30 circular sampled quadrats, more than 80% of the plots have medium to good regeneration status, while only 17% of the plots have poor regeneration status. On the other hand, in the open forestland, 87% of the plots have poor to medium regeneration status, while only 13% of the plots have good regeneration status for conifer trees. Similarly, the average number of saplings per hectare of conifer plants in the protected and unprotected forests was calculated to be 1,800 and 950, respectively.

Table 8: Regeneration Status of both the Forestlands

Status	Good		Medium		Poor	
	No of Plots	Percent	No of Plots	Percent	No of Plots	Percent
Protected	13	43	12	40	5	17
Unprotected	4	13	5	17	21	70

This clear difference in the regeneration status of the two forestlands is mainly because of protection from grazing and browsing. The sheep usually graze on grasses and herbs but the goats browse the young saplings of trees as well, thus reducing the population of trees in the forestland. The anthropogenic pressure in the open forestland seems to be another reason of poor regeneration status of conifer trees in the open forestland (Liu et al., 2025). The difference in the regeneration status of the two study sites is also shown in figure 1.

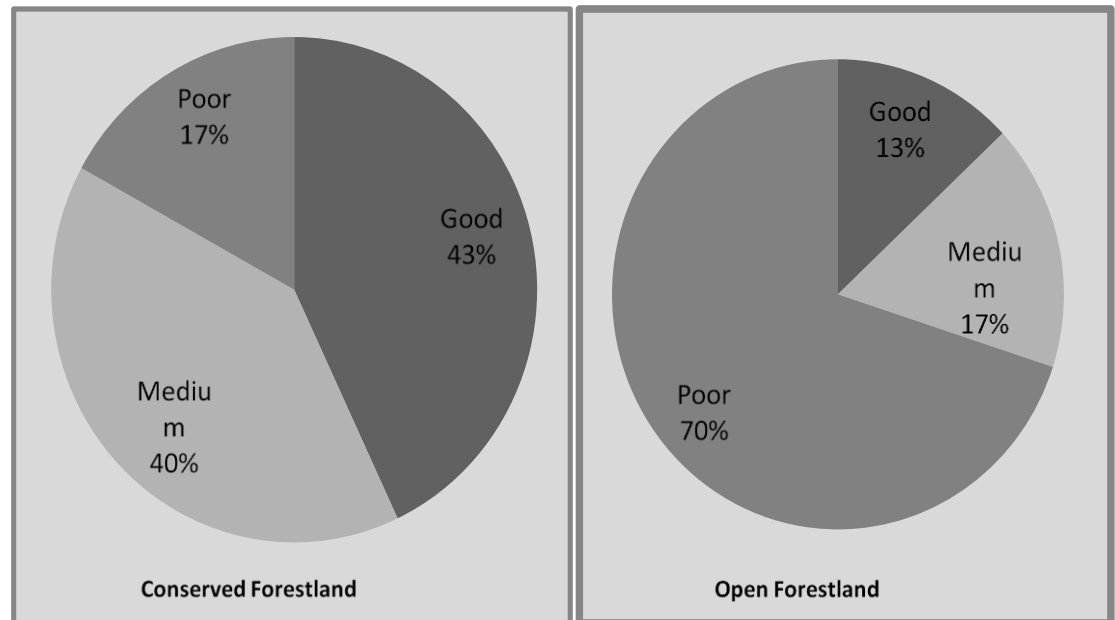


Figure 1: Regeneration Status of Conifer Trees in Conserved and Open Forestland

CONCLUSION

In this research, it was found that the plant diversity, herbaceous biomass, and regeneration of forests in the conserved and open forestlands in the Chel-Beshigram Valley exhibited drastic variation. The forestland that has been conserved had significantly more species richness, with 52 species of plants recorded compared to 30 species in the open forestland. Similarly, the abundance and number of medicinally significant herbs were significantly greater in the sheltered zone, whereas the open forested land had a lower level of herb abundance and a disproportionate distribution of species. The two forestlands differed greatly in herbaceous biomass, with the open forestland having only 1,300 kg/ha fresh biomass and 260 kg/ha dry biomass, as opposed to 4,800 kg/ha and 940 kg/ha, respectively, in the protected forestland. Such disparities show that vegetation productivity and ground cover in the unprotected area have decreased significantly. A similar trend was evident in the regeneration status of the coniferous species, whereby 83% of the forestland that was under protection had medium to good regeneration status, with the character of poor regeneration being 70% in the open forestland. In general, the results clearly indicate that conservation and protection strategies are vital for sustaining plant diversity, medicinal plants, enhancing herbaceous biomass, and successful restoration of forests. The paper highlights the significance of protection-based forest management as a viable and effective method for improving the stability and sustainability of the ecosystem of forest areas in mountains.

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REFERENCES

- Ali, G., Qamer, F. M., Gilani, H., Shehzad, K., and Abbas, S. (2015). Status of the Forest Cover Assessment and Monitoring System in Pakistan in the Context of REDD. *Geospatial Information Systems for Multi-Scale Forest Biomass Assessment and Monitoring in the Hindu Kush Himalayan region*, 59.
- Ali, S., Munazir, M., Shah, S. A., and Qurashi, R. U. (2023). Ethnobotanical studies of some wild plants of Swat valley, KP, Pakistan.
- Amaludin, N. A., Ab Majid, N. A., Zulkafli, N. N. M., Zamri, N. A. Z., Zu, S. A. A., Karim, M. F. A., and Khamis, S. (2021). Assessment of plant species diversity and abundance using line-transect method at Pantai Sabak, Kelantan. *Journal of Tropical Resources and Sustainable Science (JTRSS)*, 9(2), 112-116.
- Barnetson, J., Phinn, S., and Scarth, P. (2020). Estimating plant pasture biomass and quality from UAV imaging across

Queensland's Rangelands. *AgriEngineering*, 2(4), 523-543.

- Bizuru, E., and Ntawuhiganayo, E. B. (2025). Development planning in high-priority areas for biodiversity conservation and tourism development.
- Boampong, E. D. W. A. R. D. (2023). Perception of community members on the impact of logging on medicinal plants; a case on Bobiri forest reserve (Doctoral dissertation, University of Education, Winneba).
- Dengler, J., Boch, S., Filibeck, G., Chiarucci, A., Dembiczy, I., Guarino, R., and Biurrun, I. (2016). Assessing plant diversity and composition in grasslands across spatial scales: the standardised EDGG sampling methodology. *Bulletin of the Eurasian Grassland Group*, 32, 13-30.
- Glushkova, M., Zhiyanski, M., Nedkov, S., Yaneva, R., and Stoeva, L. (2020). Ecosystem services from mountain forest ecosystems: conceptual framework, approach and challenges. *Silva Balcanica*, 21(1), 47-68.
- Haq, S. M., Yaqoob, U., Calixto, E. S., Kumar, M., Rahman, I. U., Hashem, A., and Ijaz, F. (2021). Long-term impact of transhumance pastoralism and associated disturbances in high-altitude forests of Indian Western Himalaya. *Sustainability*, 13(22), 12497.
- Hill, M. O. (2012). Local frequency as a key to interpreting species occurrence data when recording effort is not known. *Methods in Ecology and Evolution*, 3(1), 195-205. *Forestry Ideas*, 25(1).
- Huang, W., Ratkowsky, D. A., Hui, C., Wang, P., Su, J., and Shi, P. (2019). Leaf fresh weight versus dry weight: which is better for describing the scaling relationship between leaf biomass and leaf area for broad-leaved plants? *Forests*, 10(3), 256.
- Liu, J. (2025). Progress in research on the effects of environmental factors on natural forest regeneration. *Frontiers in Forests and Global Change*, 8, 1525461.
- Maja, M. M., and Ayano, S. F. (2021). The impact of population growth on natural resources and farmers' capacity to adapt to climate change in low-income countries. *Earth Systems and Environment*, 5(2), 271-283.
- Naeem, S., Zhang, Y., Tian, J., Qamer, F. M., Latif, A., and Paul, P. K. (2020). Quantifying the impacts of anthropogenic activities and climate variations on vegetation productivity changes in China from 1985 to 2015. *Remote Sensing*, 12(7), 1113.
- Nagashima, H., Terashima, I., and Katoh, S. (1995). Effects of plant density on frequency distributions of plant height in *Chenopodium album* stands: analysis based on continuous monitoring of height-growth of individual plants. *Annals of Botany*, 75(2), 173-180.
- Painuli, S., Semwal, P., Cruz-Martins, N., and Bachheti, R. K. (2021). Medicinal plants of himalayan forests. In *Non-Timber Forest Products: Food, Healthcare and Industrial Applications* (pp. 175-212). Cham: Springer International Publishing.
- Pyšek, P., Essl, F., Lenzner, B., Dawson, W., Kreft, H., Weigelt, P., and Ebel, A. L. (2017). Naturalized alien flora of the world: species diversity, taxonomic and phylogenetic patterns, geographic distribution and global hotspots of plant invasion.

- Sapkota, B. K., Khadayat, K., Sharma, K., Raut, B. K., Aryal, D., Thapa, B. B., and Parajuli, N. (2022). Phytochemical analysis and antioxidant and antidiabetic activities of extracts from *Bergenia ciliata*, *Mimosa pudica*, and *Phyllanthus emblica*. *Advances in Pharmacological and Pharmaceutical Sciences*, 2022(1), 4929824.
- Sher, H., and Ali, H. (2022). Sustainable Use Practices of Medicinal Plants and Environmental Challenges: A Case Study in Pakistan. In *Environmental Challenges and Medicinal Plants: Sustainable Production Solutions under Adverse Conditions* (pp. 281-302). Cham: Springer International Publishing.
- 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.
- 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.
- Spicer, M. E., Radhamoni, H. V. N., Duguid, M. C., Queenborough, S. A., and Comita, L. S. (2022). Herbaceous plant diversity in forest ecosystems: patterns, mechanisms, and threats. *Plant Ecology*, 223(2), 117-129.
- Wang, R., Gamon, J. A., Schweiger, A. K., Cavender-Bares, J., Townsend, P. A., Zyguelbaum, A. I., and Kothari, S. (2018). Influence of species richness, evenness, and composition on optical diversity: A simulation study. *Remote Sensing of Environment*, 211, 218-228.
- Zamin, M., Adnan, M., Begum, S., Murad, W., and Khan, S. (2025). Plant Ecology and Conservation Plant species richness and conservation status of protected and unprotected areas of Kohat District, Northern Pakistan. *Annals of Forest Research*, 68(1), 1-20.
- Zhao, W., Chen, Y., Sardar, M. F., and Li, X. (2025). Restoration of Understory Plant Species and Functional Diversity in Temperate Plantations Along Successional Stages. *Forests*, 16(6), 956.