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Original article

Identification of suitable habitat for *Taxus wallichiana* and *Abies pindrow* in moist temperate forest using maxent modelling technique



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ABSTRACT

Conservation of any species necessitates knowledge of its biology and natural history, as well as prospective locations or newer adaptive landscapes where the species can survive and thrive. This study presents habitat suitability and local conservation status of *Taxus wallichiana* and *Abies pindrow* in moist temperate forest of Hazara division, Pakistan. Data was collected through field surveys based on 363 samples from field, topographical and bioclimatic variables. In the present study, we employed the MaxEnt model exclusively for each tree species along with 23 independent or environment variables (19 bioclimatic and 4 topographic). The jackknife test was used to demonstrate the significance of variables with the highest gain, and it was found that overall tree cover, annual temperature range was the factors with the highest gain, while slope was amongst the least important. The MaxEnt model produced high accuracy for each tree species, with receiver operating characteristic (ROC), area under the curve (AUC), training mean testing values for *Taxus wallichiana* was 0.966 followed by 0.944 for *Abies pindrow*. Local conservation status of *Taxus wallichiana* and *Abies pindrow* was evaluated using IUCN criteria 2001. *Taxus wallichiana* was declared critically endangered locally as the population size reduced by 87%. In contrast, *Abies pindrow* was declared as endangered as population size reduced by 69% falling under endangered criteria A of IUCN. The decline in population size of *Taxus wallichiana* and *Abies pindrow* species were due to human cause anthropogenic activities such as exploitation and loss of habitat, the extent of occurrence, and slow regeneration of tree species. Results and field-based observation revealed that suitable habitat modeling showed unsuitable (0.0–0.2), less suitable (0.2–0.4), moderately (0.4–0.6), highly (0.6–0.7), and very highly (0.7–1.0) suitable habitat for *Taxus wallichiana* and *Abies pindrow*. Results also revealed that both species were distributed irregularly in the moist temperate forest of Hazara division. Habitat suitability of *Taxus wallichiana* and *Abies pindrow* can be considered one of most significant points toward conserving these tree species. Habitat loss is a major threat to their occurrence, which should be overcome by ensuring the protection of suitable habitat and conservation approaches. Considering the species ecological and economic value, it is essential to understand how the species distribution may vary as a result of climate change to establish effective conservation policies. This study also includes significant environmental elements that influence species distribution, which could help locate regions where the species could be planted. Forest tree species require effective, scientific, and long-term management and conservation techniques in the study area. Furthermore, the formulation and implementation of protective laws and policies are required to conserve and protect both the conifer species.

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1. Introduction

People have conventionally exploited resources from different habitats, but temperate forests have seen the most long-term anthropogenic activities (Gilliam, 2016). Forests give environmental benefits to civilization, but Pakistan's remaining forest resources are vulnerable. Despite the government's dire need to increase the area of forest cover, few practical advances have been implemented since 1955. As a result of this circumstance, natural forest conservation levels have remained at an alarmingly low level, making Pakistan one of the worst countries around the globe, which will lose its forest resources in the next 30 years (Aftab and Hickey, 2010). Plants absorb CO₂ and generate O₂ during photosynthesis, hence forest conservation is vital. (Cetin and Sevik, 2016). Some factors, such as extensive deforestation and unrestricted urbanization, have significantly reduced the size of plant communities worldwide (Ashraf et al., 2008). Ecological issues such as habitat loss, deforestation, erosion, high consumption, invasive and introduced species, and disease attack all contribute to the decline in the population size of native plant species (Haq et al., 2022). Environmental pressures such as wildfires, droughts, air pollution, windstorms, pests, floods, and invasive species can be mitigated by healthy and well-managed forests. To defend against the aforementioned environmental constraints and reduce the effects of climate change on forest biological communities, by illustrating species distribution and identifying places where species occur or are expected to occur, conservation efforts can be more effectively focused (Qin et al., 2017; Colwell and Gotelli, 2001). ENM is the process of reconstructing a species requirements based on its range, environmental data, and occurrence. ENM is a quantitative technique for determining a species' various ecological requirements based solely on environmental data and distribution, occurrence (Guisan & Zimmerman, 2000). Based on environmental and occurrence data, ENM can also be used to predict a species' geographic range. Geographic Information System is mostly used to construct endemics species maps, separate distinct conservation zones, and assess the completeness of existing protected area networks. Environmental variables are combined with species presence data to construct a model of the species suitable habitat that recognizes the possibly suitable places for the species' existence, resulting in a map of its prospective range (Peterson and Soberson, 2005). This method necessitates the creation of a database containing presence data and various environmental factors, as well as using GIS tools to evaluate the maps (Peters and Stockwell, 1999). Different types of assessments, such as estimating the influence of climate changes on biodiversity, can be carried out using the ecological niche modeling technique (Peterson and Siqueira, 2003) to depict the conservation status of endangered species (Gaubert et al., 2006) to estimate invasive species occupation patterns and to investigate relation between vegetation patterns and geographical distribution of species (Phillips et al., 2006) or amongst species (Laszlo et al., 2022; Anderson et al 2002). (See Fig. 2.1 Fig. 2.2. Fig. 3.4. Fig. 3.5. Fig. 3.7. Fig. 3.9. Fig. 3.10. Fig. 3.11. Table 3.11.).

Himalayan Yew (*Taxus wallichiana*) is a temperate Himalayan multifunctional tree with significant medicinal potential and ethnobotanical significance that belongs to the Taxaceae family. In Asia, wild medicinal plant species are an essential part of livelihood strategies, with therapeutic and fragrant plant gathering offering a vital source of revenue in many places. This is especially true in areas like the Himalayan high alpine regions, where agricultural outputs are poor, and revenue creation alternatives are limited. The rising demand for medicinal plants, as well as the resulting increase in collection rates, has negatively influenced several species' wild populations; as a result, some species are now

deemed threatened and on the verge of extinction (Shinwari & Qaisar, 2011). *Taxus* species are threatened because of their small population size, narrow range, slow propagation, slow germination from seed, destructive harvesting, habitat specificity, overgrazing, habitat loss and climate change (Iqbal et al., 2020). It is reported critically endangered locally in Pakistan falling under IUCN 2003 criteria A (Haq, 2011). *Taxol* has been extracted from the leaves and bark of the *Taxus wallichiana* tree. It is utilized in treating breast and ovarian cancer because of its unique property of inhibiting the development of cancerous cells (Kovacs et al., 2007). *Taxus wallichiana* has a poor natural regeneration rate due to its protracted seed dormancy, and even under controlled conditions, the seeds pericarp functions as a barrier to seed germination. As a result, *Taxus wallichiana* is at risk of extension. (Rather et al., 2022). *Abies pindrow* (Silver fir) is a coniferous tree native to the Himalayas, growing at an elevation range of 2,000–4,000 m in moisture-rich and cold areas (Ali et al., 2014). It is found throughout the western Himalayas, in Afghanistan, Pakistan, India, and Nepal (Siddiqui et al., 2015). In Pakistan *Abies pindrow* is distributed in the Hazara region, Murree, Dir, Chitral, Gilgit, Kashmir (Ahmed, 1989). The Plant has traditionally been used to treat inflammation, anxiety and pain (Quattrocchi, 2012). *Abies pindrow* were reported endangered locally in Pakistan falling under criteria A.

1.1. Objectives of the study

Having this idea in mind, the ultimate goal of this study was to use the MaxEnt model to combine 363 field data of the occurrence of two native tree species (*Taxus wallichiana* and *Abies pindrow*) with bioclimatic and topographically derived factors.

1. To apply ecological niche modelling (ENM) technique for predicting species distribution and suitable habitat in moist temperate forest of Hazara division, Pakistan.
2. To assess local conservation status of *Taxus wallichiana* and *Abies pindrow* in the study area.
3. To propose better management and conservation plan for *Taxus wallichiana* and *Abies pindrow* in study area.

2. Materials and methods

2.1. Study area

This study was conducted in Abbottabad, Mansehra, Battagram, and Tor Ghar, all of the Hazara division, Pakistan. The Northern Areas and Azad Kashmir border Hazara north and east, respectively. The Capital Territory Islamabad and the Punjab province are to the south, while the rest of Khyber Pakhtunkhwa is to the west. The Indus River runs north–south across the division, forming much of the division's western border. The Moist temperate forest in these districts consist of 147,059 ha or 1470.59 km². Hazara has a total area of 18,013 km². Abbottabad is a district in Hazara division. The north and north-east hill sides are covered in timber forest. Abbottabad district is located in Pakistan's Chir Pine Forests and Moist Temperate Forests, with some parts also falling into the sub-alpine zone of forest types. Mansehra is a district in Pakistan's Khyber Pakhtunkhwa province's Hazara Division. Man Singh, a renowned general of Mughal Emperor Akbar, is honored at the Mansehra district and town. The district is a prominent and popular tourist destination because of the Lulusar-Dudipatsar and Saif-ul-Malook National Park, as well as the Karakoram Highway going through it. The most widely spoken language is Hindko, which was spoken by 72 percent of families in the Mansehra Tehsil according to census statistics from 1981. Pashto

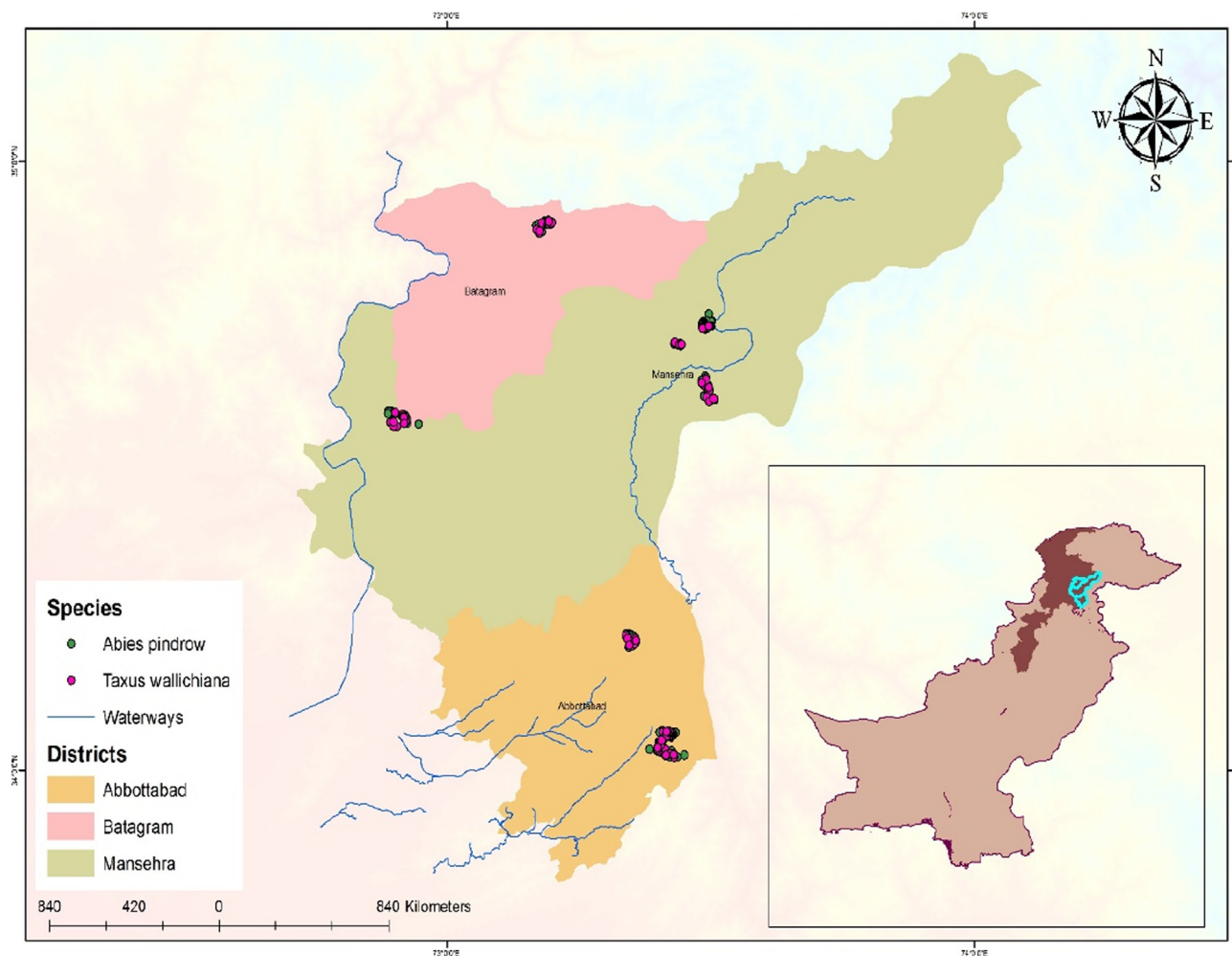


Fig. 2.1. Map of study area showing two native trees species location in Hazara division, Pakistan.

had a 14 percent share. Speakers of the widely spoken Gojjari language can also be found, mainly in the Kaghan Valley. Mansehra is one of Pakistan's richest districts in terms of forest wealth. Tor Ghar is a small district in the Hazara division. It is an 800-kilometer-long harsh, mountainous terrain. It was raised to a district level on January 28, 2011, and given the name Tor Ghar because it was previously part of the Mansehra district (Shah et al., 2015). The district of Battagram is bordered on the north by the Kohistan valley, on the east by the Siran valley, on the south by the Konsh and Agror valleys, and on the west by the Black Mountain and the Indus River (Haq, 2022). The internationally recognized Western Himalayan Moist Temperate Ecology has classified all of the districts' vegetation zones as moist temperate. Based on accessible indicator plant species, these forests can be divided into six types. Sub-tropical Chir-pine forests, moist temperate forests, and alpine meadows are only a few examples.

2.2. Field surveys

Data was gathered in the research area via field surveys. Sites were surveyed where the targeted species was predicted to be present or absent between October 2020 and November 2020. Random circular 363 sample plots of 1,000 m² (0.01 percent of total forest area) were assessed in moist temperate forest of the Hazara division. To get the exact plot radius, a slope of each plot was

recorded. The total number of tree species and geographic coordinates and elevation values were recorded inside each sample plot. In the field, each species was assessed for its historical range of distribution, current frequency, and comparison to its present extent and usual ecological niche. For evaluating the conservation status of the *Taxus wallichiana* and *Abies pindrow*, the total number of trees evaluated, and estimated distribution was compared to IUCN criteria (IUCN, 2001).

2.3. Development of ecological niche models

For ecological niche modeling climatic and occurrence data of species were gathered.

2.4. Species occurrence data collection

MaxEnt v.3.4.4 was used to create preliminary ecological niche modeling. This was used to model the distribution of both species based on data from field surveys on locality and occurrence. All of the locality points were gathered from the field.

2.5. Climatic data collection

The climatic data was taken from the WorldClim database (Shah et al., 2022). We used about 19 bioclimatic 4 topographic

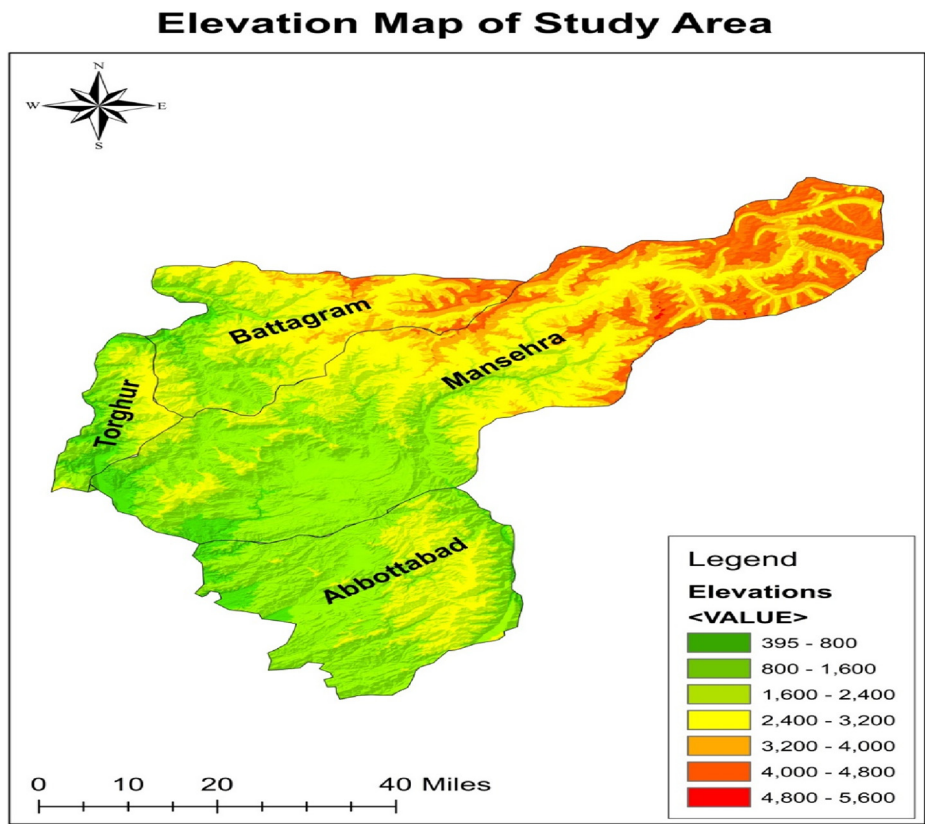


Fig. 2.2. Elevation map of the study area showing different elevations in meters.

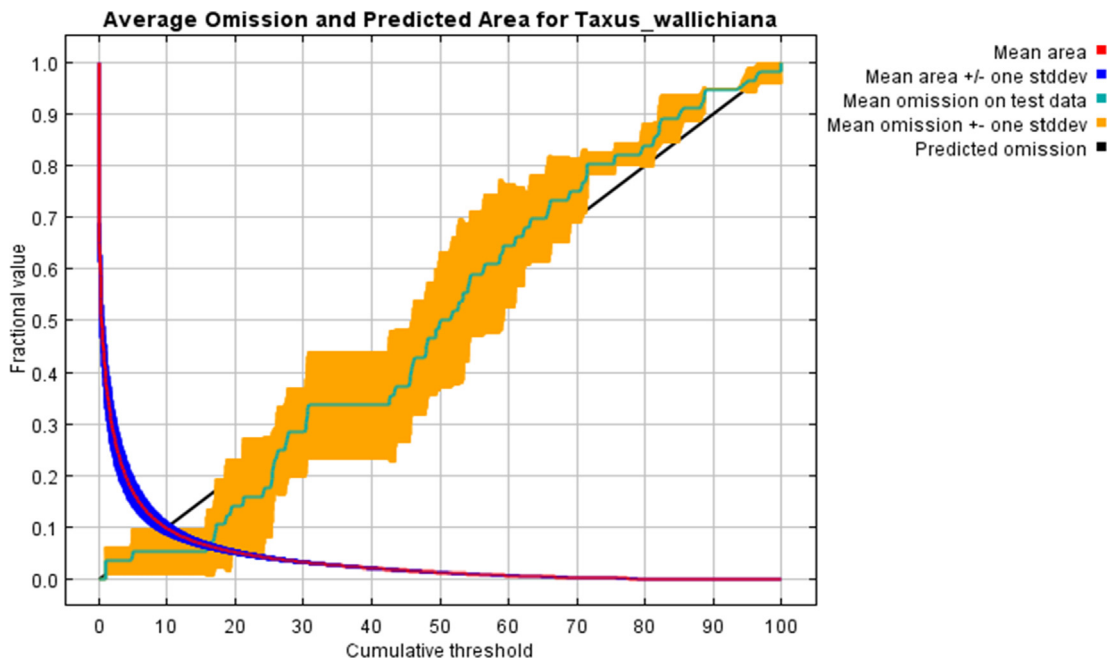


Fig. 3.1. Omission rates versus predicted area for *Taxus wallichiana*.

variables from the WorldClim to evaluate current climatic conditions of the research area. These variables were frequently utilized in the species distribution modeling (Shrestha et al., 2022; Kumar et al., 2009), limited to variation in season, annual ranges, and

limiting factors such as temperature extremes limits monthly and quarterly precipitation (Shah et al., 2022). After downloading, environmental layers were necessary to crop for Pakistan because it was for the entire world.

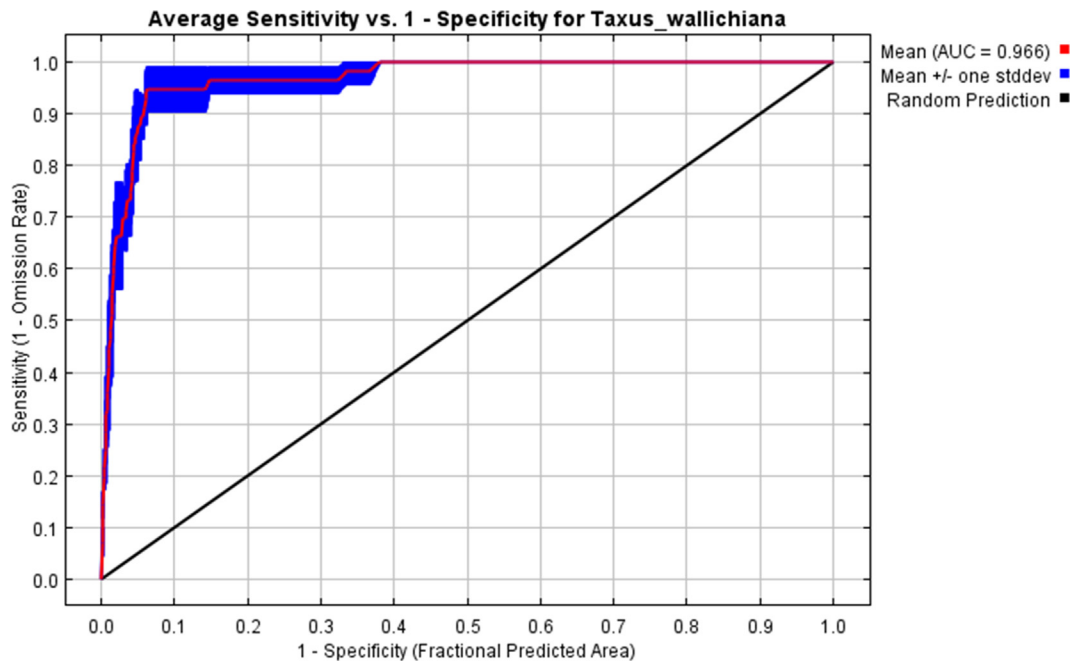


Fig. 3.2. Result of receiver operating characteristics curve (AUC) area under curve analysis of *Taxus wallichiana*.

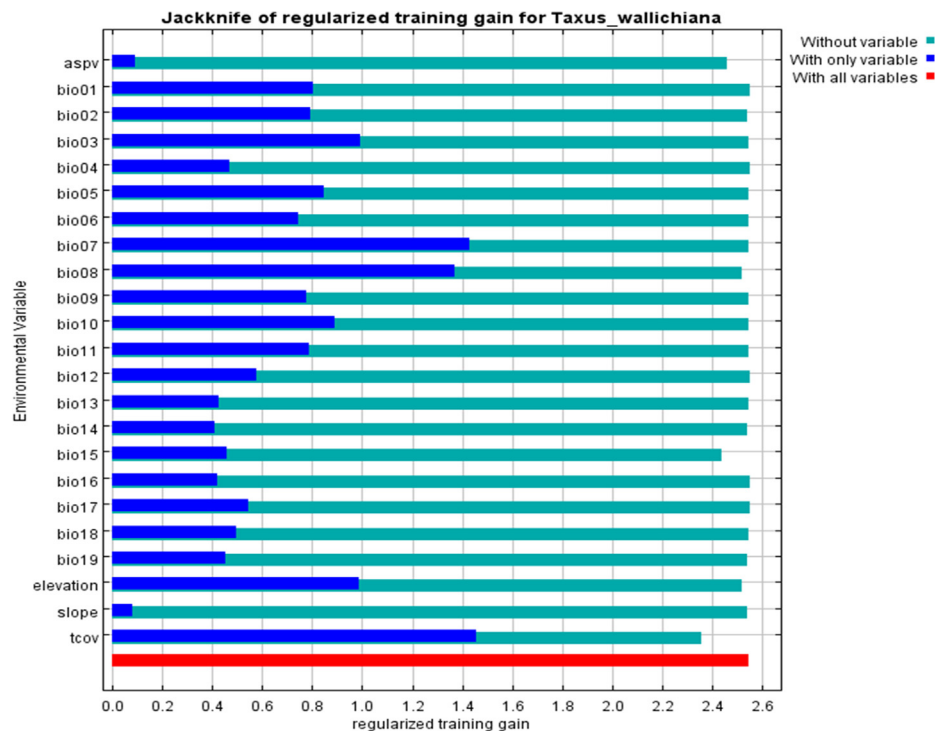


Fig. 3.4. Jackknife plot of training gain for *Taxus wallichiana*.

2.6. How to run maxent software

For one species, the MaxEnt model required three folders. There are three folders: one for ambient layers, one for existing data, and one for output. All cropped environmental layers had the same size and pixel count, and they were stored in a single folder called environmental variables. That indicates all of the downloaded layers were in a single folder. Otherwise, the MaxEnt model will not run. We perform five duplicate runs of MaxEnt on the locality data

acquired from the field surveys, with a fixed number of background points chosen at random for each run. The average anticipated distribution from 5 repeated MaxEnt runs approximated the species entire historic range. We execute the MaxEnt after gathering all of the information (presence data and environmental layers). The MaxEnt model's output was then examined using ArcGIS version 10.5 software. We assessed the species' geographic distribution. The occurrence data collected during the field surveys was utilized to build filters that eliminated over-prediction by

the models, resulting in a limited forecast for both species. The filters eliminated all overlapping regions. The ecological niche models are then overlaid on a current land use map of the research region to calculate the predicted species distribution and percentage of habitat loss.

The procedure for MaxEnt data entry was as follows.

- In the sample, we only looked at the presence data for the selected species.

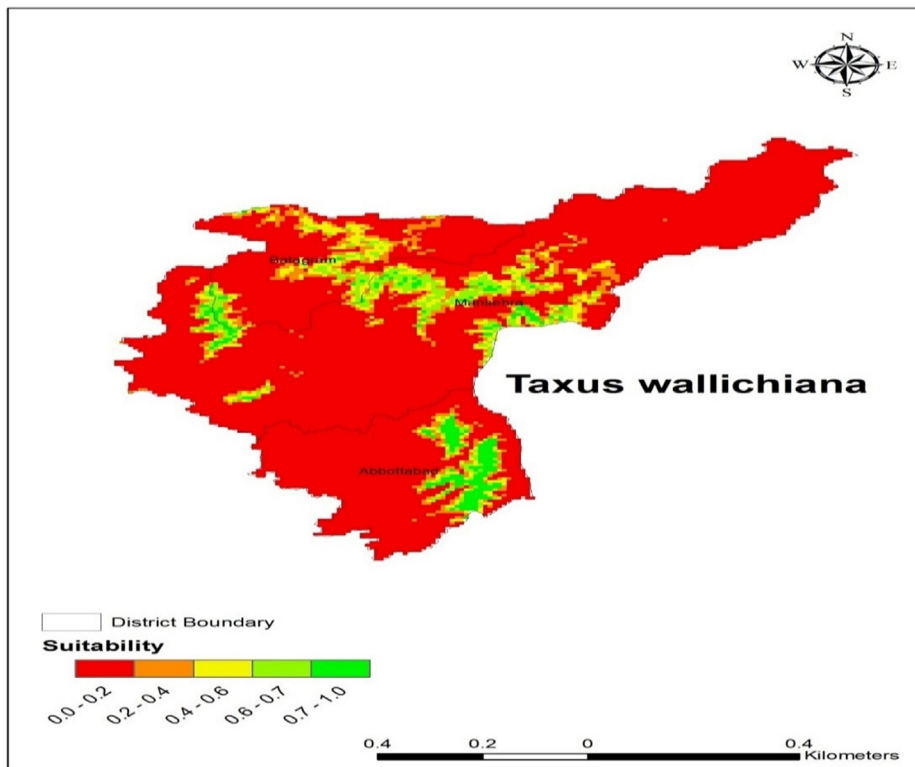


Fig. 3.5. Potential habitat of *Taxus wallichiana* identified using MaxEnt software. Very highly predicted suitable habitat (0.7–1.0): profoundly good living space. Highly suitable habitat (0.6–0.7): exceptionally appropriate environment. Moderately suitable habitat (0.4–0.6): appropriate territory. Less suitable habitat (0.2–0.4): scarcely reasonable living space. Unsuitable habitat (0–0.2): inadmissible natural surroundings.

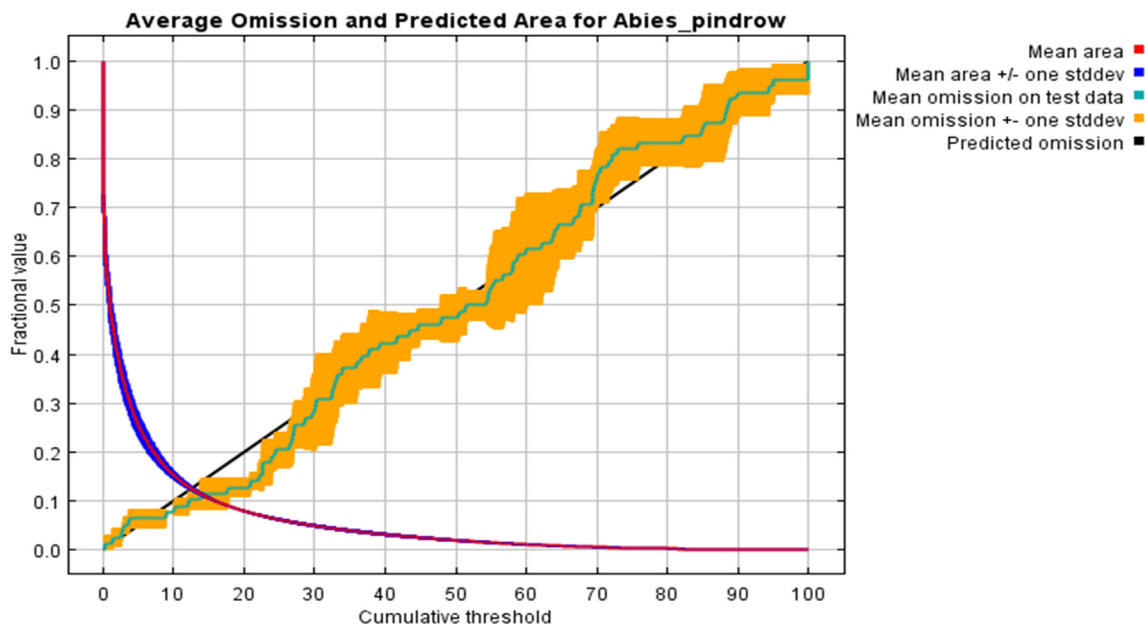


Fig. 3.6. *Abies pindrow* Predicted area vs Omission rates.

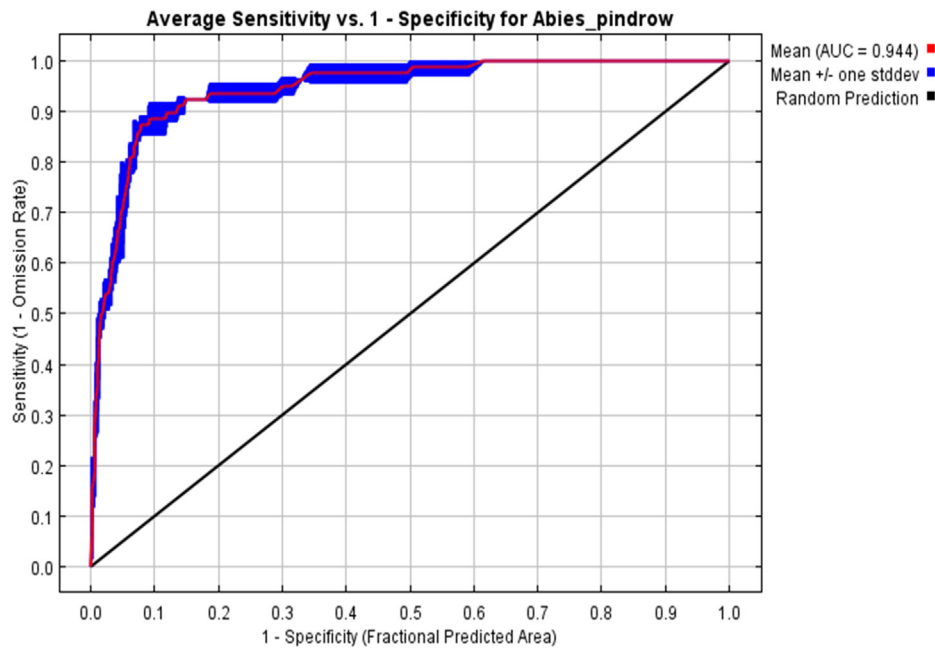


Fig. 3.7. Results of the (AUC) area under the receiver operating characteristics curve analysis.

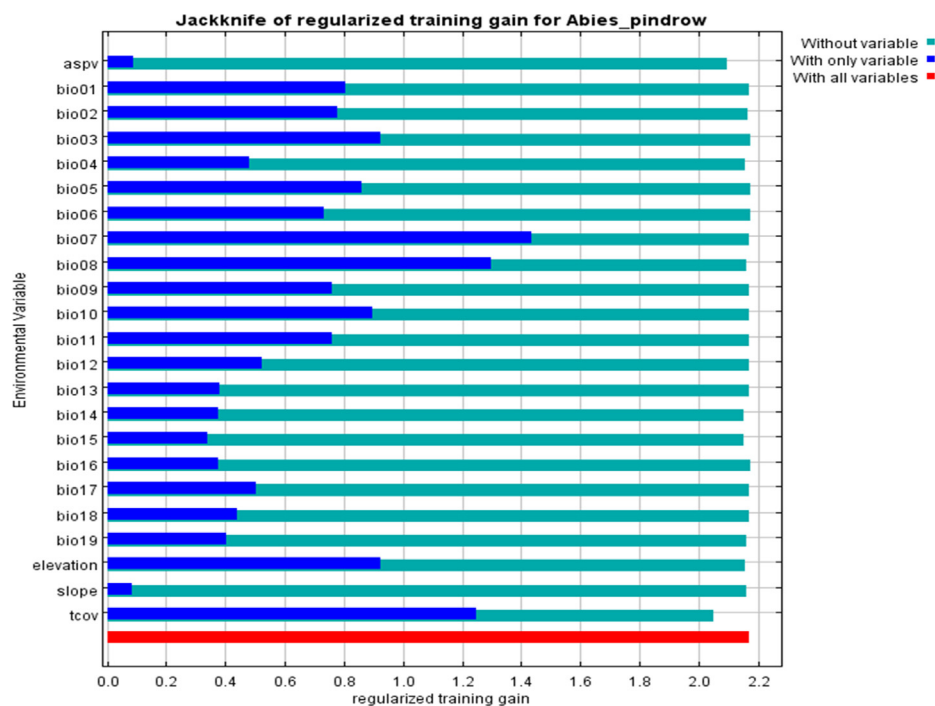


Fig. 3.9. Jackknife plot of regularized training gain for *Abies pindrow*.

- Then we went through all the environmental layers for the species in Hazara division, Pakistan.
- Layers were divided into two types: categorized and continuous. All data linked to land use, soil vegetation, or forest type was classified as categorical data, and we chose categorical from the environmental layer dropdown menu. Others as precipitation or cloud or rainfall, humidity, temperature, frost, and so on, are continuous data, such as precipitation or cloud or rainfall, humidity, temperature, frost, and so on.
- Next, we ran the model, which generated images of predictions and performed a jackknife to determine variable significance.

2.7. IUCN conservation status assessment criteria

Table 3.7.

2.8. Tools

- GPS.
- GIS.
- Clinometer.
- Measuring Tape.

3. Results

3.1. Average omission and predicted area for *taxus wallichiana*

The test omission rate and estimated area are plotted as a function of the cumulative threshold averaged across multiple runs in the graph below (Fig. 3.1.). The more similar the Omission on train-

ing samples line is to the Predicted omission, the more accurate the created model.

3.2. Average sensitivity vs specificity

The Receiver Operating Characteristic (ROC) curve's Area under Curve (AUC) (Fig. 3.2.) was a metric used to assess the predictive

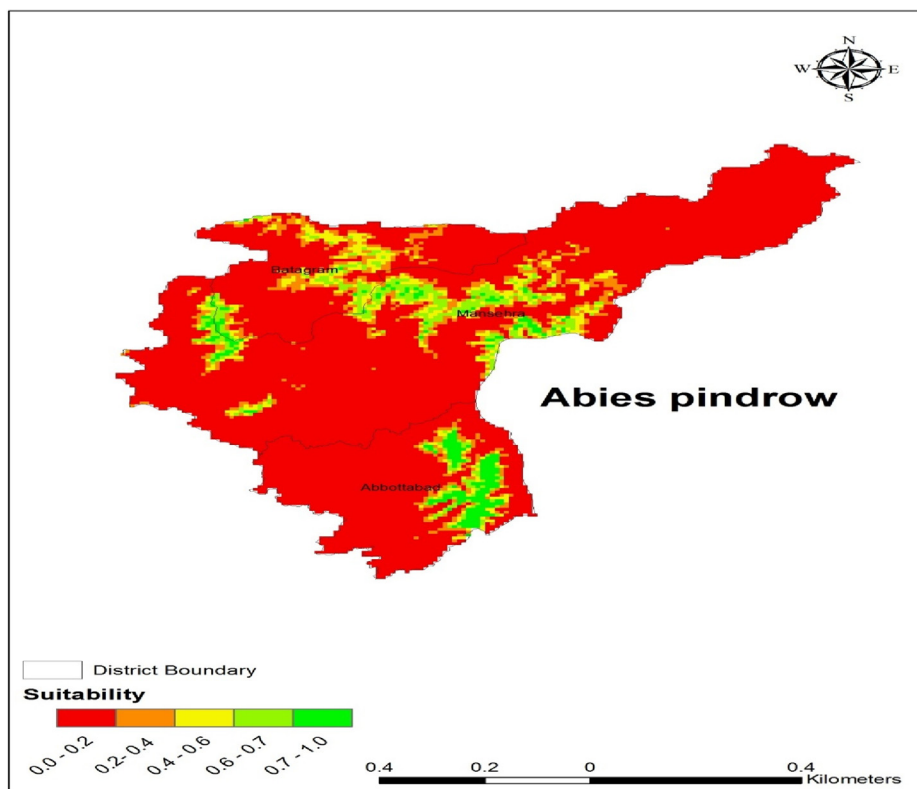


Fig. 3.10. Potential habitat of *Abies pindrow* identified using MaxEnt software. Very highly predicted suitable habitat (0.7–1.0): profoundly good living space. Highly suitable habitat (0.6–0.7): exceptionally appropriate environment. Moderately suitable habitat (0.4–0.6): appropriate territory. Less suitable habitat (0.2–0.4): scarcely reasonable living space. Unsuitable habitat (0–0.2): inadmissible natural surroundings.

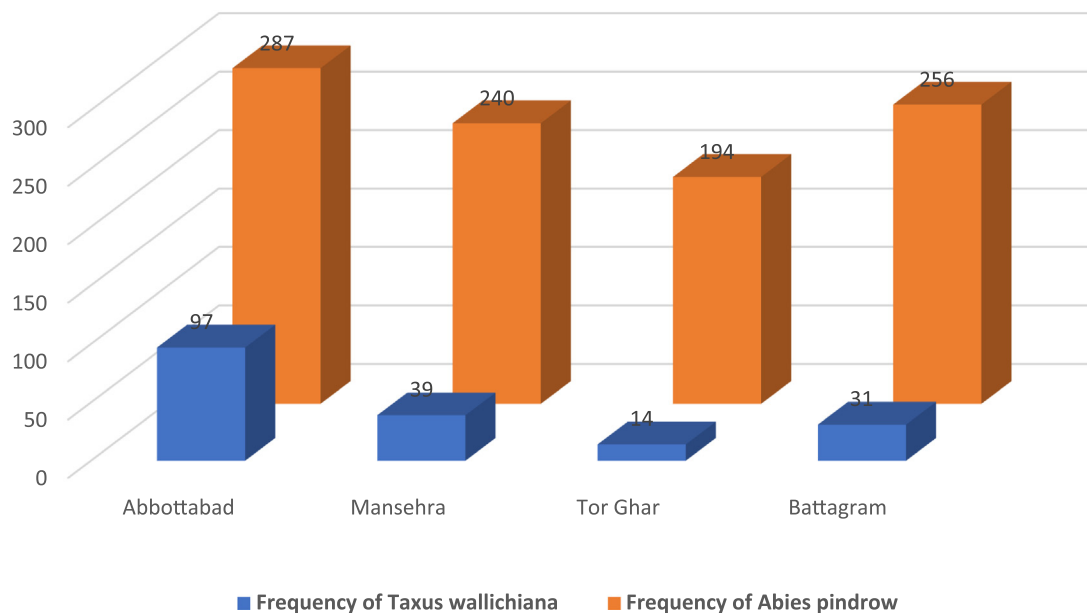


Fig. 3.11. Local conservation status of *Taxus wallichiana* and *Abies pindrow*.

Table 3.3
Environmental variables used for MaxEnt model of *Taxus wallichiana*.

Variable	Percent contribution	Permutation importance
Tree cover	42.4	6.1
Temperature Annual Range (Bio7)	21.9	0.4
Precipitation Seasonality (Coefficient of Variation) (Bio15)	15.3	27.9
Isothermality (Bio3)	8.8	2.5
Elevation	4.1	14.8
Aspect	3.4	2.7
Mean Diurnal Range (Mean of monthly (max temp - min temp) (Bio2)	0.7	7.9
Annual Precipitation (Bio12)	0.6	0
Precipitation of Coldest Quarter (Bio19)	0.5	1
Precipitation of Wettest Month (Bio13)	0.4	0
Mean Temperature of Wettest Quarter (Bio8)	0.4	15.4
Precipitation of Driest Month (Bio14)	0.4	1.3
Slope	0.3	0.4
Mean Temperature of Driest Quarter (Bio9)	0.2	0.9
Mean Temperature of Warmest Quarter (Bio10)	0.2	17.9
Min Temperature of Coldest Month (Bio6)	0.2	0
Annual Mean Temperature (Bio1)	0	0.5
Temperature Seasonality (standard deviation × 100) (Bio4)	0	0
Max Temperature of Warmest Month (Bio5)	0	0.1
Mean Temperature of Coldest Quarter (Bio11)	0	0.3
Precipitation of Driest Quarter (Bio17)	0	0
Precipitation of Wettest Quarter (Bio16)	0	0
Precipitation of Warmest Quarter (Bio18)	0	0

Table 3.7
Conservation Status Assessment of Plant Species using IUCN (2001) categories and criteria version 3.1.

Criteria	
A	Species Population decline
B	Restricted geographic range of species
C	Decline or Small population
D	Restricted species population

capacity of the developed model. It determines if a randomly chosen presence location has a higher likelihood of occurrence of a species than a randomly absence point selected. The standard deviation for repeated runs was 0.011, and the mean test AUC was 0.966.

3.3. Analysis of variable contributions

(Table 3.3. indicates estimates of the contributions of environmental factors to the MaxEnt model. The values of every single environmental variable were randomly permuted in the presence of the training data and the background data for the second estimate. The model is re-evaluated with the permuted data, and the training AUC reduction is presented in the table, normalized to percentages. When the predictive variables are associated, the variable contributions, like the variable switchblade, should be evaluated with caution. The figures depicted are averages of duplicated runs.

3.4. Jackknife test of *taxus wallichiana*

Based on different environmental variables, the jackknife test's findings of various importance are shown in the image below the relative predictive power of jackknife regularized training gain in the MaxEnt model for *Taxus wallichiana*. Environment variable

Table 3.8
Environmental variables used for MaxEnt model of *Abies pindrow*.

Variable	Percent Contribution	Permutation Importance
Temperature Annual Range (Bio7)	41.1	0.1
Tree cover	33.1	4.2
Precipitation Seasonality (Coefficient of Variation) (Bio15)	7.6	1.3
Elevation	3.8	9.9
Aspect	3.5	3.2
Isothermality (Bio3)	3.1	0
Mean Diurnal Range (Mean of monthly (max temp - min temp) (Bio2)	2.5	29.8
Precipitation of Driest Month (Bio14)	1.5	8.4
Precipitation of Coldest Quarter (Bio19)	0.9	4.2
Min Temperature of Coldest Month (Bio6)	0.8	1
Slope	0.6	0.6
Temperature Seasonality (standard deviation × 100) (Bio4)	0.4	17.4
Mean Temperature of Wettest Quarter (Bio8)	0.4	14
Precipitation of Wettest Quarter (Bio16)	0.3	0
Mean Temperature of Warmest Quarter (Bio10)	0.3	5.3
Annual Mean Temperature (Bio1)	0	0.3
Precipitation of Wettest Month (Bio13)	0	0
Precipitation of Warmest Quarter (Bio18)	0	0.3
Max Temperature of Warmest Month (Bio5)	0	0
Mean Temperature of Coldest Quarter (Bio11)	0	0
Precipitation of Driest Quarter (Bio17)	0	0
Annual Precipitation (Bio12)	0	0
Mean Temperature of Driest Quarter (Bio9)	0	0

Table 3.11
Population status of *Taxus wallichiana* and *Abies pindrow*.

The population of <i>Taxus wallichiana</i> and <i>Abies pindrow</i>		
Scientific Name	Local Name	Tree Counts
<i>Taxus wallichiana</i>	Barmi	181
<i>Abies pindrow</i>	Fir	977

with the most significant gain is tree cover; as a result, it looks to have the most critical information. Tree cover was the most crucial variable and hence seems to have the most significant information that is not found in the other variables. The slope was among the least important variable. The values indicated are averages of multiple repeat runs.

3.5. Habitat suitability of *taxus wallichiana*

Taxus wallichiana predicted potential distribution in the below map shows that green color 0.7 to 1.0 is very highly predicted suitable habitat, while 0.6–0.7 is highly suitable, 0.4 to 0.6 moderately suitable, 0.2–0.4 less suitable habitat but on the other hand most of the area in red color is 0–0.2 unsuitable habitat. The total suitable habitat of species was 89.7 km².

3.6. *Abies pindrow* average omission and predicted area

The graph (Fig. 3.6.) below depicts the projected area, and test omission rate as a function of a cumulative threshold averaged across numerous runs. Since the cumulative threshold is established, the anticipated omission rate should be close to the omission rate.

3.7. Average sensitivity vs specificity for *abies pindrow*

The next graph depicts the (ROC) receiver operating characteristic curve for the same data, averaged over the repetition runs once more. It's worth noting that the specificity is calculated based on expected area instead of actual commission. The standard deviation for the duplicate runs was 0.001, and the average test AUC was 0.944.

3.8. Analysis of variable contributions

In each iteration of the training technique, the increase in regularized gain was added to the contribution of the linked variable to estimate the initial prediction or deducted from it if the change in the absolute value of lambda was negative. In the second estimate for each environmental variable, the values of each environmental variable on training presence and background data were randomly permuted. Table 3.8. shows the drop in training AUC, adjusted to percentages, when the model was improved using the permuted data. The table shows the relative contributions of environmental elements to the MaxEnt model.

3.9. Jackknife test of *abies pindrow*

Jackknife test findings are shown in the diagram below based on the relative predictive power of jackknife regularized training gain in MaxEnt Model and environmental variables for *Abies pindrow*. Environmental variable Temperature Annual Range (Bio7) looks to have the most important information that is not found in other variables. The figures reported are averages of duplicate runs. The slope was among the least important variable.

3.10. Habitat suitability of *abies pindrow*

Predicted potential distribution of *Abies pindrow* showed that most of the area in red color 0–0.2 is unsuitable habitat while green color having value of 0.7 to 1.0 is very highly predicted suitable habitat, 0.6–0.7 highly suitable, 0.4–0.6 moderately suitable, 0.2–0.4 less suitable habitat for Taxon in the study area. The total suitable habitat of species was 409.3 km².

3.11. Conservation status of *taxus wallichiana* and *abies pindrow*

The area of moist temperate forest of Abbottabad, Mansehra, Tor Ghar, and Battagram is 147,059 ha. During the present survey, these sites were visited and 363 random plots with a radius of 17.84 m (0.1 ha) with a sampling intensity (0.01 % of the total forest area) were laid out in the study area. The decline in the population size of *Taxus wallichiana* and *Abies pindrow* species were due to human cause anthropogenic activities such as exploitation and loss of habitat, the extent of occurrence, and slow regeneration of species.

Taxus wallichiana was rarely distributed, having only 181 mature individuals in different parts of District Abbottabad, Mansehra, Tor Ghar and Battagram between altitudinal ranges of 2100 to 3400 m. Most of the plants were found in patches in association with *Abies pindrow*. In Abbottabad its population size was much better than other study areas because in Abbottabad most of the data was collected from Ayubia National Park, which is an officially declared and properly managed forest with shallow anthropogenic activities. But overall, its population size reduction is due to medicinal purpose, Taxol, fuel wood collection, timber used in making house palings, and climate change and habitat loss. Under the IUCN criteria of reduction in population size A2 (a, b, c), *Taxus wallichiana* was declared critically endangered as the population size reduced by 87 %. *Abies pindrow* trees were found 977 between altitudinal ranges of 2,000–4,000 m in various parts of

the study area. Population size was reduced by 69 %, falling under endangered criteria A due to its use in construction, fuelwood, and medicines.

4. Discussion

This study depicts the current distribution of *Taxus wallichiana* and *Abies pindrow* using ecological niche modeling with a spatial resolution of 1 km throughout four districts in Hazara division of Pakistan. The accuracy obtained of ROC-AUC of *Taxus wallichiana* was more than 0.966 and 0.944 for *Abies pindrow*. This is a great model because the AUC is more than 0.90, as advised by (Araújo et al., 2005). Many studies on species habitat suitability modeling, methodology and its applications have been conducted in recent years (Leathwick and Elith., 2009; Brotons, 2014). The Pakistan Himalayan region is the least studied and reported on in terms of tree species potential habitat suitability studies for various reasons, including a lack of detailed forest inventory data, rough terrain and a complex forest ecosystem, harsh weather conditions, financial constraints, and so on. Our results align with (Bobrowski et al., 2017; Ranjitkar et al., 2014a; Ali et al., 2014). Based on 217 herbarium samples (Ranjitkar et al., 2014a), multiple ecological niche modeling tools were used to examine two species, *Rhododendrons* (*R. arboreum* and *R. delavayi*) suitable habitat distribution in Himalayas. While working in the same area, (Bobrowski et al., 2017) used generalized linear models based on 590 occurrence point to map *Betula utilis* potential distribution. (Ali et al., 2014) The global climate change scenario HADCM3 A2a to predict the distribution of *Abies pindrow* trees in Swat, Pakistan. To predict species distribution of *Abies pindrow* they collected just 23 sample plots from various places within the area. The amount of species observations, biophysical variable selection, species behavior, research area size, and ecology all have an impact on the effectiveness of tree species distribution models (Bobrowski et al., 2017; Ali et al., 2014; Ranjitkar et al., 2014a) to generate tree species distribution modelling bioclimatic variables were applied. The present study used bioclimatic, species occurrence, and topographical characteristics to estimate and map the current distributions of *Taxus wallichiana* and *Abies pindrow*.

Although spatiotemporal satellite images are the most practical and cost-effective means of determining plant seasonal phenology (Olyae et al., 2015; Leitão and Santos, 2019) bioclimatic variables are employed for future prediction. Satellite data can help with species distribution since it gives knowledge on ecosystem health, function, and structure, as well as the mechanisms that influence regional distributions; a thorough geographical assessment and a fair temporal repeat are required. By combining satellite-based phenology with bioclimatic factors, we can expect improved outcomes inexpect improved outcomes in terms of species occurrenceexpect improved species occurrence (Hereford et al., 2017). To achieve the best results, Saatchi et al., (2011) recommended that MaxEnt model studies use at least 100 samples. In this study 363 sample plots were taken to record both tree species occurrence records for habitat suitability modelling of each tree species for 46 species, 12 algorithms were used to make predictions. Across all sample sizes, they stated that the MaxEnt model had the best prediction power (Rodríguez-Veiga et al., 2016).

The conservation of the ecosystem and the sustainable use of natural resources in Pakistan's moist temperate forest demands special attention. The decline of indigenous plant resources has been attributed to the loss of forest cover and the resulting dramatic changes in community composition (Haq et al., 2022). In the present study local conservation status of 2 coniferous species was explored in Abbottabad, Mansehra, Tor Ghar, and Battagram. *Taxus wallichiana* and *Abies pindrow* trees were evaluated against

IUCN criteria (2001), *Taxus wallichiana* falls under critically endangered, and *Abies pindrow* was designated as endangered based on population decline criterion A. Habitat loss, overexploitation, slow regeneration and deforestation, have all contributed to these species being critically endangered or endangered. The area's chief causes of species loss are extensive grazing and deforestation, which have resulted in forest fragmentation and habitat degradation (Sala et al., 2000). To grow rooted plants and seeds for forestry projects, it is advised that management strategies be developed, as well as in-vitro (labs) and in-situ (nurseries) conservation programs. People in the study region rely heavily on plants for various uses, putting many plants on the verge of extinction (Ahmad et al., 2010). Increased demand for lumber, firewood, fodder, and medicinal purposes are among them. Careless and illegal tree cutting and smuggling, overgrazing, habitat loss, and converting forests for cultivation all cause significant stress to the natural vegetation and thus result in environmental degradation (Haq et al., 2022). The rare species are vital for national and regional biodiversity, as well as for world-wide biodiversity. Plants, coniferous plants in general, are a finite and valuable resource in the study region that require effective, sensible, and long-term management and conservation techniques. As a result, immediate conservation measures, such as those described below, are necessary to save both species from extinction.

5. Conclusion and recommendations

Conservation planning needs a thorough understanding of which species are most endangered and where they can be found. The majority of plant species are now inaccessible to modern conservation methods. We need more significant sample sizes and a more broadly spread collecting effort to ensure more correctly mapped species distributions. Results also revealed that both species were distributed irregularly in the moist temperate forest of the Hazara division. Modeling suitable habitats showed low, moderate, and highly suitable sites for *Taxus wallichiana* and *Abies pindrow*. Conservation status of *Taxus wallichiana* and *Abies pindrow* enlisted as critically endangered and endangered. To do so, we'll need more collaboration and data exchange among plant scientists and a larger gathering effort. The study concluded that Spatial distribution, Ecological niche modelling analysis and identification of suitable habitat of *Taxus wallichiana* and *Abies pindrow* can be considered a substantial step toward conserving the tree species. *Taxus wallichiana* and *Abies pindrow*, as well as other critically endangered or endangered plant species, must be identified and the ability to take advantage of everyday flowering events throughout the moist temperate forest of Pakistan's Hazara division. Plant conservation opportunities were wasted due to a lack of resources and knowledge about the most endangered plant species. As a result, the potential to improve the conservation status of many of the study area's declining plant species was also missed. We proposed large-scale climate change analyses across the Hindu Kush Himalayas and educating the general public about the outcomes of uncontrollable change. We recommend the government and local governments in the area to identify climate change effectively and to implement a better mitigation policy. We also advocate for initiatives such as incorporating GIS and remote sensing technologies into our universities curricula and interdisciplinary approaches through departmental and inter-university collaborations.

Ethical statement

The reported research work did not include any human-based experimentation; therefore, no bioethical approval was required

from Bioethics Committee of the University of Haripur, Pakistan to conduct this study.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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