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PREDICTING THE POTENTIAL HABITAT AND DISTRIBUTION OF WESTERN TRAGOPAN (*TRAGOPAN MELANOCEPHALUS*) IN SELECTED AREAS OF AJ & K, PAKISTAN: A MAXENT MODELING APPROACH

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ABSTRACT

Western Tragopan (*Tragopanmelanocephalus*) is a beautiful pheasant species and is endemic to western Himalayas. It has large distribution range but different populations are fragmented within the western Himalayan moist temperate forests. Its distribution in Pakistan is restricted to some parts of Khyber Pakhtunkhwa and Azad Jammu & Kashmir (AJ&K).This species is globally 'vulnerable' since its fragmented small populations are declining dueto continuing forest loss and habitat destruction throughout its range. This study was carried out to model the potential distribution and habitat of Western Tragopanin Neelam and Muzaffarabad districts of AJ&K by incorporating the physical, biological and climatic variables into MaxEnt model. Land cover data, Digital Elevation Model (DEM), slope, aspect, Normalized Difference Vegetation Index (NDVI), temperature, precipitation, topographic and sighting datasets were processed in Geographic Information System (GIS) to produce meaningful predictor variables, subsequently used in the MaxEnt software. The results showed that 11,112 ha area (2% of the total study area) is highly suitable for Western Tragopan, 30,248 ha area (5.3%) moderately suitable while 525,445 ha (92.7%) area is unsuitable. Jackknife test evaluated the importance of predictor variables and DEM, precipitation and land cover were found to be the most important variables for this study. The study evaluated the species-habitat relationship within the study area and can be helpful in the management and *in-situ* conservation planning of the species in its distribution range.

Key words: Western Tragopan, Potential distribution, MaxEnt modeling, *in-situ* conservation

INTRODUCTION

Western Tragopan (*Tragopanmelanocephalus*) is a beautiful pheasant species and is endemic to western Himalayas (Bird Life International, 2015). It is a shy bird, usually occurs singly, roost on trees but feeds on the ground in early morning and late afternoon (Roberts, 1991). Western Tragopan is a low density and habitat specific species, prefers extremely steep terrain and is closely associated with open moist deciduous (e.g. maple, oak, birch and walnut) and/or coniferous temperate vegetation (especially silver fir, blue pine and spruce) with dense shrubby undergrowth. It can easily survive in extreme cold at high altitudes. Although, it forages close to the upper margins of the forest (i.e. 3,350m) but in winter it descends as low as 2,150m or up to snowline (Roberts, 1991; Whale, 1996; Anwar *et al,* 2006; BirdLife International, 2015).

The Western Tragopan is the most westerly distributed among the five Tragopanspecies occurring in India and Pakistan in the Himalayas. In Pakistan its distribution is patchy and small population survives in Duber and Palas valleys in Indus Kohistan, Kaghan valley, PirHasimar, Machiara, Pir Chinasi and Salkhala in Azad Kashmir. (Roberts, 1991; Whale, 1996; Awan, 2010). This species is globally 'vulnerable' since its fragmented small populations are declining throughout its range (Roberts, 1991; Bird Life International 2015). The reasons for the population decline are attributed tothe habitat loss due to forest degradation, hunting and trapping (Whale, 1996; Ashraf *et al.,* 2004).

There have been very few studies to evaluate the distribution and status of Western Tragopan in Pakistan (Grimmett and Craig, 1984; Roberts, 1991; Bean *et al.* 1994; Whale 1996; Ghafoor and Nawaz, 1999; Awan, 2010).All these studies were primarily conducted through ground-based field surveys. Ashraf *et al.* (2004) evaluated the habitat and distribution of Western Tragopan in Palas Valley using a combination of Landsat based land cover, terrain data and field survey data. Although traditional survey techniques are important in assessing the distribution and habitat preference of the species but the development of geospatial technologies has provided a complimentary system to ground-based wildlife studies (Ali, *et al,* 2010; Qamer *et al,* 2011; Matin *et al,* 2012).

With the development of new statistical and geospatial techniques, the development of predictive species distribution models (SDMs) has increased in ecology, biogeography and conservation biology (Guisan and Zimmerman, 2000; Guisan and Thuiller, 2005). Currently a wide range of species distribution models are being used worldwide (Stockwelland Peters, 1999; Friedman *et al*, 2000; Breiman, 2001; Wikle, 2003; Philips *et al*, 2006). These SDMs mainly use species occurrence data with ecological/environmental variables (vegetation, temperature, precipitation etc.) and topographic variables (elevation model, slope, aspect etc.) to create a distribution and habitat model of a species (Guisan and Thuiller, 2005;Elith *et al.*, 2006; Zimmermann *et al*, 2010)

In this study we used MaxEnt model to study the potential distribution and habitat of Western Tragopan in selected areas of AJ&K Pakistan, based on the geographic distribution data and remote sensing/GIS derived predictor variables. MaxEnt is a predictive species distribution model which is based on the principle of maximum entropy and recognized as the most useful model compared to the other SDMs (Elith *et al*, 2006; Phillips *et al*, 2006). Key objectives of the study were 1) to predict the potential geographic range of the species within the study area and 2) to identify the environmental/geographical variables closely associated with the species influencing its geographical distribution.

MATERIALS AND METHOD

Study Area: The study area includes Muzaffarabad and Neelum Districts of Azad Jammu & Kashmir located in the north eastern part of Pakistan (Fig. 1). The study area falls in the moist temperate zone of western Himalayas with extreme winters and snowfall. The mean annual rainfall is 1526.7 mm, with 84.5 rainy days per year. The rainiest month is July with a mean rainfall of 327.6 mm, while the driest month is November receiving a mean rainfall of only 35.4 mm (Anonymous, 2005). The study area is part of the Western Himalayan Ecoregion that is included in 200 important global ecoregions ranked by WWF based on their conservation status (Wikramanayake *et al*, 2002).

Land cover mapping: For the development of land cover of the study area, ALOS multispectral satellite images with 10m spectral resolution were used. Field surveys were carried out to collect ground truth data using Garmin Map 76 CSX GPS receiver with ± 5m accuracy. A total of 300 GPS-linked data descriptive points were collected during the surveys. Object Based Image Analysis (OBIA) was performed using Definien Developer 7.0 software based on the field survey data and a land cover map of the study area was developed (Fig. 2).

Species sighting data and Ecological/Environmental Variables: Thirty two species sighting points were collected from the unpublished survey reports of AJ&K Wildlife Department (Fig. 2). Ten environmental variables were used for the study viz., land cover derived from ALOS satellite data, 30m resolution digital elevation model (DEM) downloaded from ASTER GDEM (http://gdem.ersdac.jspacesystems.or.jp/), aspect and slope (derived from DEM), temperature & precipitation downloaded from World Clim datasets (http://www.worldclim.org/), normalized difference vegetation index (NDVI) from Landsat and raster layers of distance to drainage, distance to ridges, distance to roads, derived from topographic data.

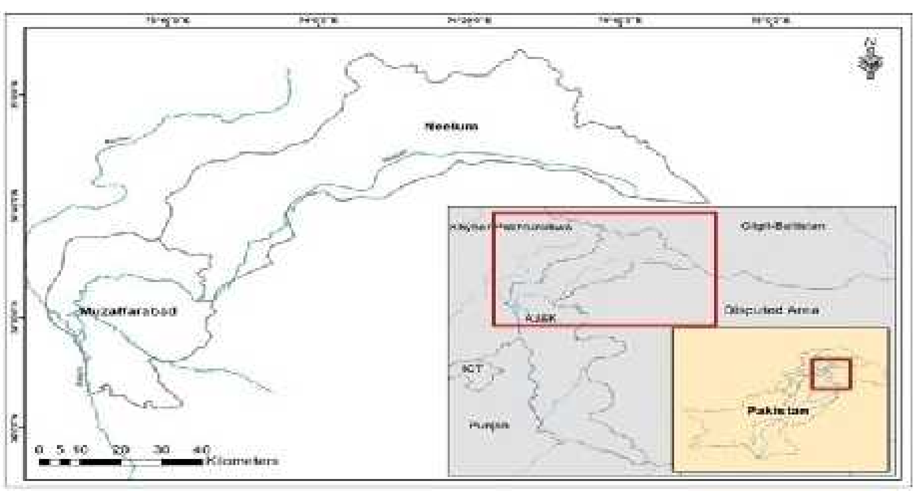

Figure 1: Study area map

Spatial modeling: Maximum Entropy (MaxEnt) modelling software (version 3.3.3e) was used to predict the potential distribution and habitat of the Western Tragopan in the study area. MaxEnt modeling is a general-purpose method which uses presence-only data and makes predictions of species' potential distribution/habitat from incomplete information and its origin lie in statistical process of maximum entropy

(Jaynes, 1963; Phillips *et al.,* 2006). MaxEnt uses the species sighting data with other ecological/ environmental/ geographical variables and calculates the likelihood of presence of a given species or number of species within the study area (Phillips *et al.,* 2006; Phillips and Dudik, 2008).

ArcGIS 9.3 and ENVI 4.5 software were used to process and develop the standardized spatial data layers of DEM, slope, aspect, land cover, distance to drainage, distance to ridges, and distance to roads, precipitation and temperature to be used in MaxEnt modeling software.70% of species sighting data was used as training data and 30% was used as test data. Final potential distribution and habitat map of Western Tragopan was produced with a range of values from 0 to 1 which were regrouped in to three different classes viz., unsuitable, moderately suitable and highly suitable.

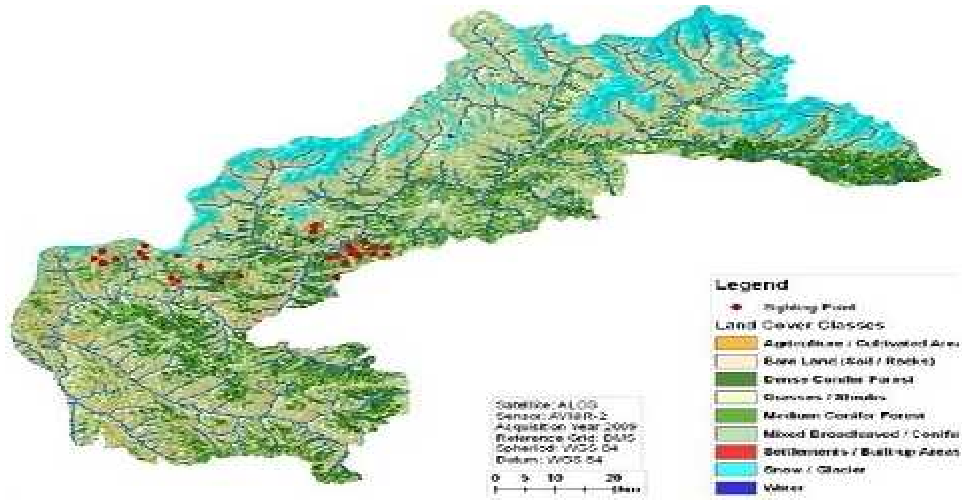

Figure 2: Map showing species sighting data and land cover of the study area

RESULTS AND DISCUSSION

MaxEntmodel produced a continuous prediction with values ranging from 0 to 1. The values are illustrated here using blue color (0-0.5) representing unsuitable habitat for the species, green color (0.51-0.7) representing moderately suitable habitat while red color (0.71-1) which represents highly suitable habitat for Western Tragopan within the study area (Fig. 3). The results of the study revealed that 11,112 ha area was highly suitable which is 2% of the total study area, 30,248 ha (5.3%) area was moderately suitable while 525,445 ha (92.7%) area is unsuitable.

The jackknife regularized training gain results showed DEM, precipitation and land cover, as main variables influencing the Western Tragopan distribution (Fig. 4).Other important variables include NDVI, distance to roads and aspect. This test actually determines the contribution of each variable by testing the impact of the variable removing it from the model and also testing the impact of each variable by running the model only with that variable (Philips *et al,* 2006).

TheMaxEnt model output provided adequate results with the given set of training/test data and the model fitness as measured by area under receiver operating characteristics (ROC) curve (AUC) was with a high value of 0.952 for the training data and 0.871 for the test data (Fig. 5). This showed better ability of the MaxEnt model to discriminate between suitable and unsuitable areas for the Western Tragopan occurrence. The ROC/AUC analysis has been extensively used in species habitat and distribution modeling and is recognized as the best measure of model performance (Philips *et al,* 2006; Elith *et al,* 2011).

Current study predicted the habitat and suitable distribution areas of Western Tragopan in selected areas of its distribution range using SDM tool and for the first time quantified the habitat of the study species in the study area. Earlier, Ashraf *et al.,* (2004) conducted a GIS based overlay analysis to map the habitat and distribution of Western Tragopan in Palas Valley, Indus Kohistan, and Pakistan. The areas which are predicted suitable for Western Tragopan but not occupied currently can be considered for introduction/reintroduction of this species and future field efforts should be focused more on the identified potential habitats to assess the conservation status of this species.

This study is a pioneer effort in habitat suitability mapping for the Western Tragopan in Pakistan and can be of great help in developing effective management strategies for the *in –situ* conservation of this regionally endemic bird within the study area. Further, current predicted species distribution and habitat model developed with MaxEnt can be used with the global climate change scenarios to forecast the potential changes in distribution range.

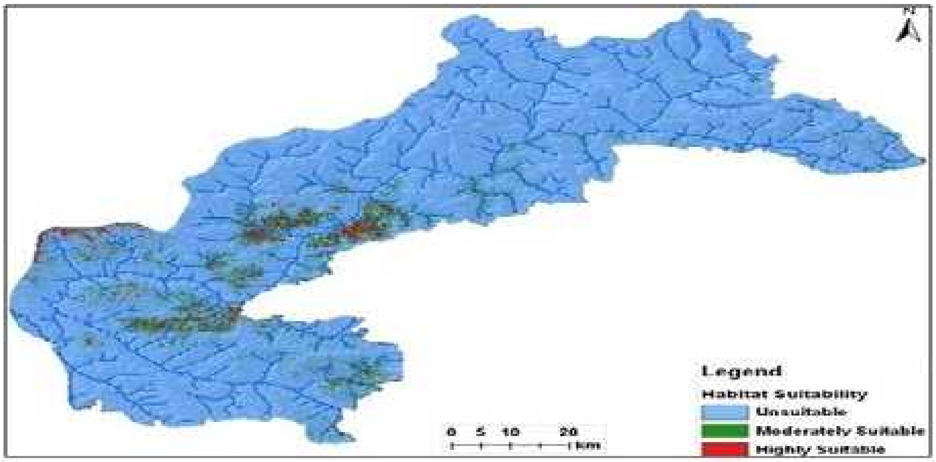

Figure 3: Predicted potential habitat/distribution of Western Tragopan in the study area

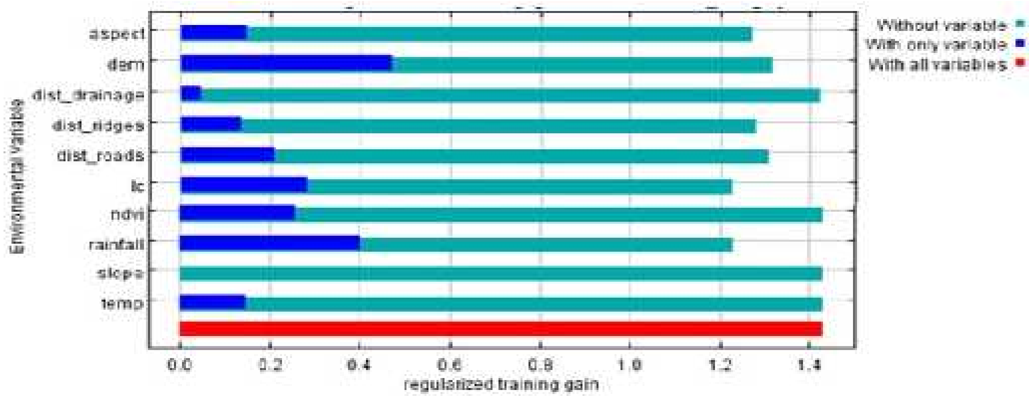

Figure 4. The Jackknife test output showing the relative importance of predictor variables used in the study

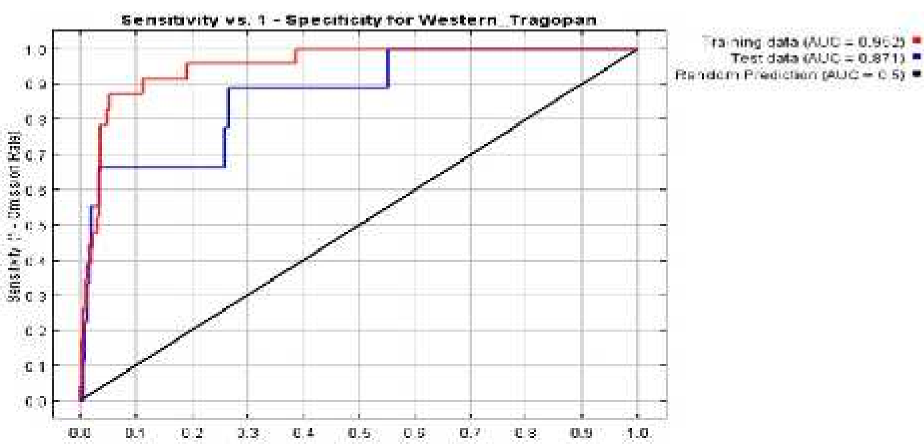

Figure 5: The ROC curve for the training and test data

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