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Research Article

Pleske's Ground Jay Habitat Suitability Modeling: Implications for Conservation

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Abstract
Abbas-Abad Wildlife Refuge is one of the richest protected areas of the Iranian central plateau, hosting different valuable, threatened, and native species, such as the Iranian Pleske's Ground Jay. Habitat features of this native species at the landscape level were investigated using the Maximum Entropy method. Our analysis showed that more than 50 percent of the predicted suitable habitats are located outside the legally protected areas, which require special consideration. We found that the predicted potential habitats for the species in the IUCN database (for Isfahan province) are three times more than our findings in this study. Our analysis indicated that air relative humidity, topography, proximity to seasonal springs, and sand dunes are the main landscape-level habitat variables that affect species distribution. Including unprotected habitats in the reserved areas network can help sustain viable populations of the Ground Jay.
Keywords: Distribution modeling, habitat structure, habitat use, landscape metrics, habitat modeling, Ground Jay.

Introduction

The effectiveness of conservation measures largely depends on the quality of data obtained from nature (Pressey et al., 1999; Wilson et al., 2005). Habitat suitability modeling has been increasingly utilized to better understand the potential distribution of species, and by identifying the habitat suitability for species, a satisfactory level of conservation can potentially be achieved (Zhang et al., 2012). Generally, species presence data are correlated with environmental variables in species distribution modeling to better present the species dispersal map (Franklin and Miller, 2009). Since it is difficult to assess species absence data, it is more rational to use presence-only models in habitat analysis (Chefaoui et al., 2005; Elith et al., 2011; Hirzel et al., 2002; Rood et al., 2010), among which MaxEnt produces the most acceptable results (Pearson et al., 2007). Some previous investigations have employed only environmental factors in habitat suitability modeling, while others have used solely landscape criteria (Narce et al., 2012), and finally, a combination of the two groups of variables (Adra et al., 2013; Bellamy and Altringham, 2015). MaxEnt has been successfully used for various species worldwide (Baldwin, 2009). This presence-only method has several advantages compared to other presence-only methods, as it can rely on small sample sizes while producing lower spatial errors (Baldwin, 2009). The Ground Jay (*Podoces pleskei*) is regarded as the only native passerine species found in the arid and semi-arid plains of the central Iranian plateau (Hamedanian, 2000). Rasekhnia et al. (2012) compared three vegetational variables with a distal factor in nest sites against randomly selected unused areas and concluded that the species is completely dependent on vegetation percent cover and the presence of certain shrub species like *Zygophyllum eurypterum* and *Atraphaxis spinosa*. Although some authors have attempted to model the species' microhabitat selection, we could not find information on its habitat selection and distribution focusing on landscape-scale variables. In this research, we aimed to extract the species' habitat suitability map using landscape metrics and macrohabitat variables, which can be utilized in future conservation planning. We also aimed to answer the question: to what extent do protected areas encompass the suitable habitats of the native Iranian Ground Jay?

Materials and Methods

Study Area

Abbas-Abad Wildlife Refuge can be regarded as one of the richest natural areas of the Iranian central plateau, hosting various valuable, threatened, and native species of Iranian fauna. This wildlife refuge, located in Isfahan Province, Iran (Fig. 1), covers an area of more than 305,000 hectares and consists of several habitats, including mountainous regions, plains, desert dunes, flooded areas, and remnants of ancient *Haloxylon* desert forests. The vast natural desert rangelands provide an excellent habitat for the only native passerine of Iran, the Ground Jay. Since the species can be found in neighboring areas, we also included other protected and no-hunting areas in the vicinity of the Abbas-Abad Wildlife Refuge, such as Siah Kuh, Koohe Bozorgi, Iakhab, Kharu, and Kalateh.

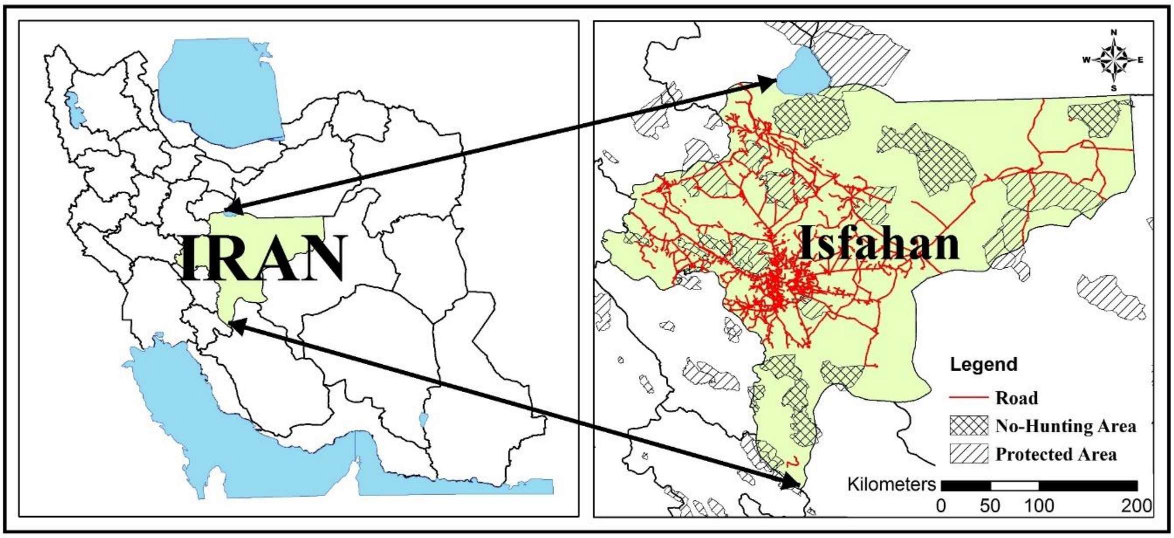

Figure 1. Isfahan province, Iran and the location of protected areas

Habitat Modeling

We employed 165 species presence points (in both feeding and breeding sites) and 17 habitat variables, including: mean annual precipitation, vegetation density (NDVI), slope, distance to water resources (mainly springs), distance to mines, distance to bare lands (mainly sandy lands), mean air temperature, distance to sand dunes, relative air humidity, distance to salt flats, distance to agricultural farms, altitude, distance to human settlements, distance to traffic roads, distance to watercourses, and mean wind velocity to create the species' habitat suitability map. Correlation analysis indicated inter-correlations for some variables, such as distance to roads, distance to agricultural farms, precipitation factors, and air temperature factors, which were omitted from the final analysis. Ultimately, we ran the MaxEnt model with 5 replicates and 5000 maximum iterations, utilizing 13 habitat variables and 165 species presence points, from which we set aside 25 percent of the points for model verification. The AUC criteria were used to interpret the acceptability of the model outputs. MaxEnt (Maxent v3.3.3e) is a general-purpose machine-learning method based on maximum entropy theory developed for species distribution modeling (Phillips et al., 2006). The idea of MaxEnt is to estimate niches by finding the distribution of probabilities closest to uniform (maximum entropy), subject to the constraint that feature values match their empirical averages. The importance of environmental variables is evaluated using Jackknife tests (Elith et al., 2011). Ten random partitions were employed to assess the average behavior of the models (Phillips et al., 2006). Each partition was generated by cross-validation, utilizing 75% of species occurrences as calibration data and the remaining 25% as evaluation data. The area under the ROC (receiver operating characteristic) curve, or AUC, was used to evaluate model performance. AUC values range from 0 to 1 (Fielding and Bell, 1997). AUC of 0.50 indicates that the model's performance did not substantially improve upon random chance, whereas a value of 1 indicates perfect discrimination (Swets, 1988).

After modeling with the aforementioned variables, we applied three landscape variables, including vegetation relative richness, vegetation edge density, and vegetation patch compactness. We used a vegetation map extracted from GlobCover satellite images with a 300 m pixel size, which were verified in some areas using MODIS Terra and Aqua images. The mentioned landscape metrics were calculated using the following formulas and methods: 1) Relative richness was measured using the relative diversity of cover classes (R = n/nmax*100, where n is the number of different classes present in the vicinity and nmax stands for the maximum number of possible classes), 2) Edge density, a simple measurement of habitat fragmentation, can be defined as the number of adjacent pixel pairs within the neighborhood that differ from each other relative to the maximum number of different possible pairs, and finally 3) Patch compactness groups adjacent pixels of similar land cover categories into patches, calculates their compactness, and outputs an image where each pixel reflects the compactness of the patch to which it belongs. Compactness is calculated as C = SQRT(Ap/Ac), where SQRT is the square root function, Ap is the area of the patch being calculated, and Ac is the area of a circle having the same perimeter as that of the patch being calculated.

Results and Discussion

Pleske's Ground Jay distribution modeling indicates that the area mapped by previous investigations (IUCN, 2016) corresponds to our outputs. However, the area designated by IUCN as potential habitat for the species (2,485,500 ha) is more than three times the area mapped in our investigation (726,451.52 ha) (Fig. 1 and 2).

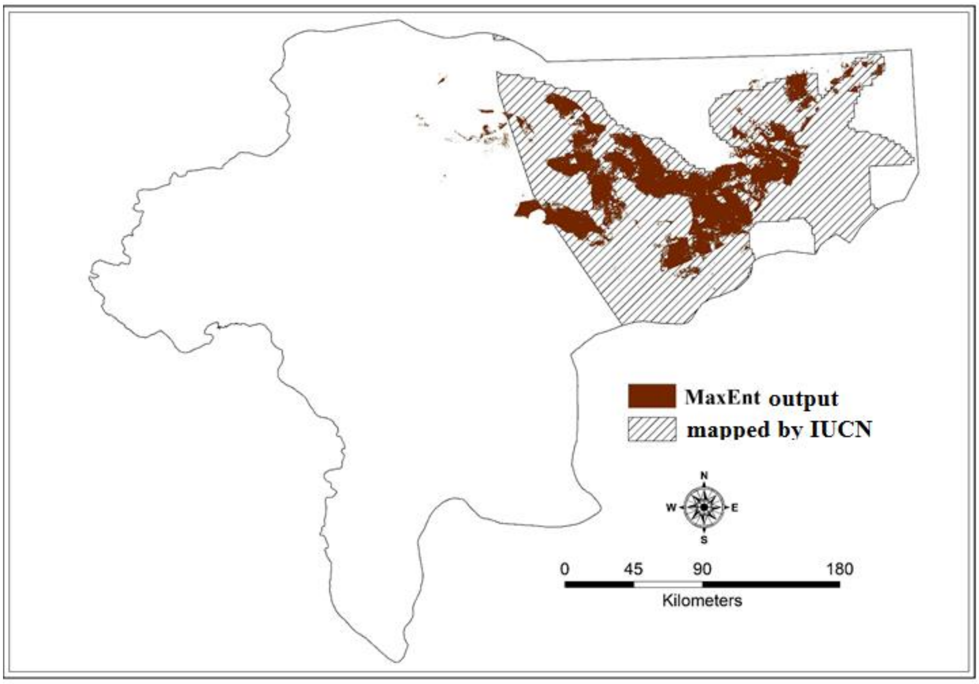

Figure 1. Comparison of the potential distributional range predicted by the IUCN and gained in this study.

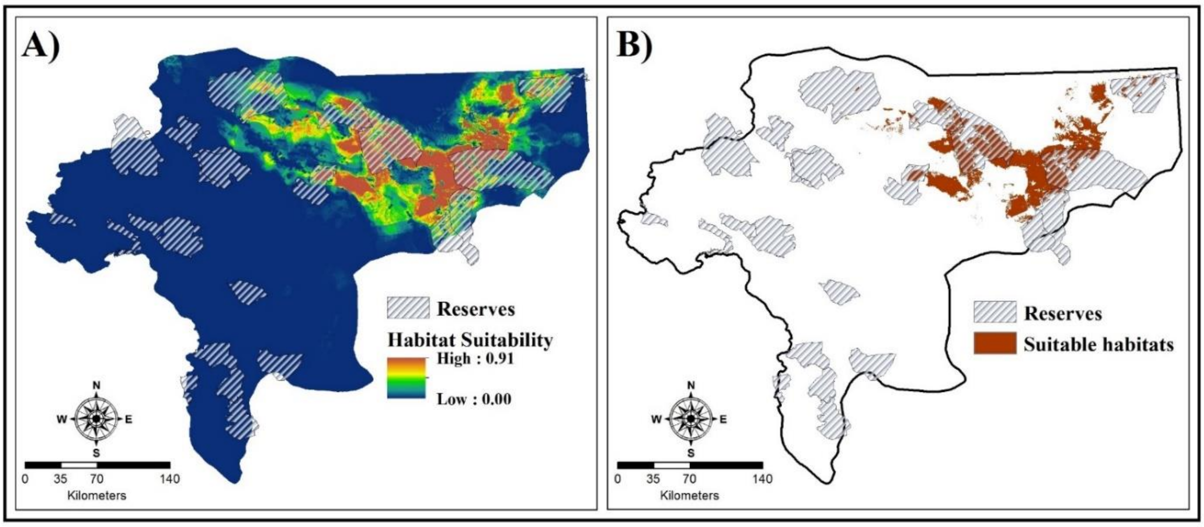

Figure 2. The predicted suitable habitats for the species (left) and the overlap with the protected areas (right).

Mean AUC of 0.937 indicates that the model predicted the species distribution map correctly (fig. 3). MaxEnt modeling approach showed that the species habitat use is controlled mainly by air humidity, earth topography, closeness to the sand dunes and distance to the water resources especially seasonal springs (fig. 3). Analyzing output map showed that more than 50 percent of the predicted suitable habitats located outside the protected areas (fig. 4).

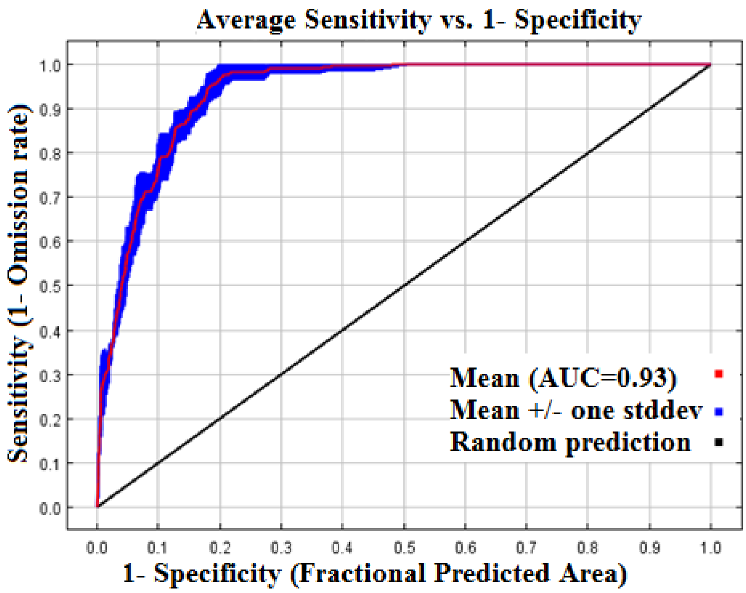

Figure 3: Area Under Curve indicates for the modeling correctness

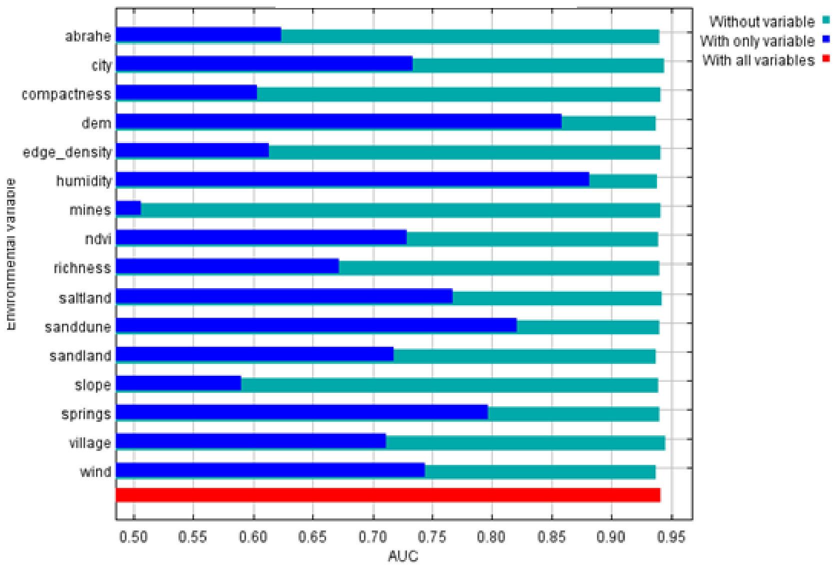

Figure 4. The most important variables which affect the species habitat selection

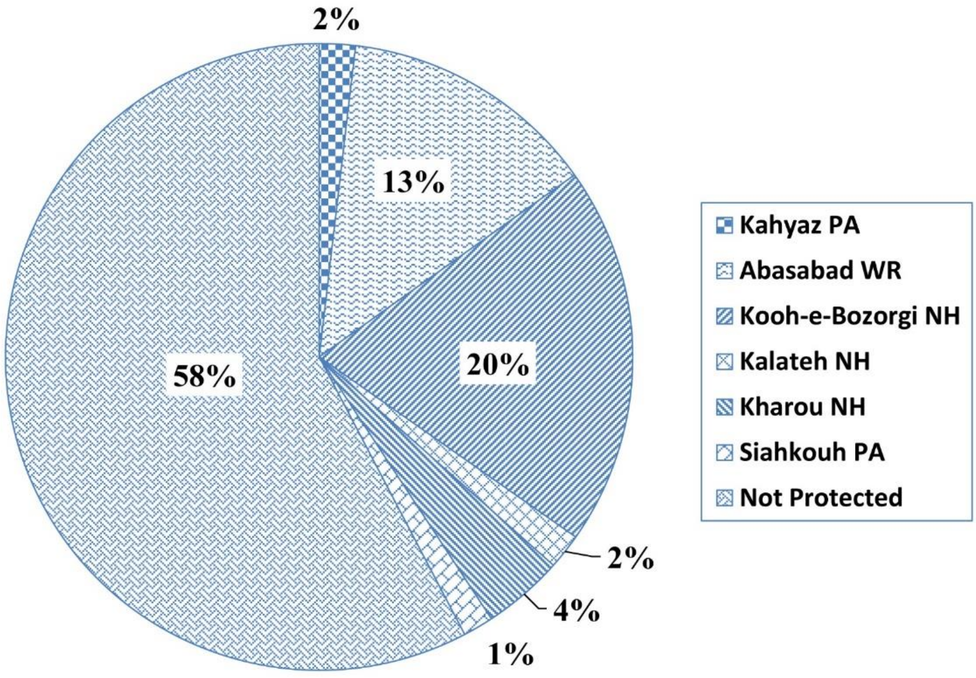

Figure 5. The percent areas of the species predicted suitable habitats with the legally protected areas

Recently, multiple investigations have been done focusing Iranian Native Pleske's Ground Jay biological and ecological characteristics, topics such as distribution and abundance (Mousavi et al. 2012, Radnejad et al. 2013), micro-habitat selection (Radnejad et al. 2011), nest site selection (Ordibi et al. 2012, Rasekhnia et al. 2012), breeding biology (Satei et al. 2011, Mohammadi et al. 2015), population genetics (Mousavinejad et al. 2012), home range estimation (Nazarizadeh et al. 2015). Relatively all papers describing the most important habitat variables in the species habitat selection emphasis on vegetational factors. Some of the authors misunderstood their study scale and couldn't distinguish between micro and macro habitat scales, since they used the same method for investigating such different variables (Ordibi et al. 2012). It is important to recognize the scale concept in such ecological investigations. Meanwhile some of the authors introduced the species habitat requirements based on no predefined methods or any study design for example Sehati (2007) described Ground Jay's habitat feature based on his personal direct observations. MaxEnt modeling approach is a method for investigation the species macro habitat features. Such habitat features can be modeled at the landscape scale and can be used for the species habitat conservation. As our findings showed, Ground Jay is completely affected by the air humidity or climatic variables. Analysis of the environmental variables showed that the influence of air relative humidity on the distribution of species was larger than that of other environmental factors such as Relative humidity can affect either directly or indirectly related to several variables such as temperature, vegetation density, soil properties, presence and abundance of predator or prey species and food supply, and therefore exerts a first order control over the occurrence of species in the study area. Regarding recent sever dry seasons in the study area and disappearing almost all seasonal springs dispersed in the species home range, it can be inferred that the species faces new threats other than human induced ones. Protecting the predicted suitable areas, or on the other hands including remained 38500 hectares of the areas to the reserves' network can be very important in sustaining the species viable population. Protecting the potential habitats ensure the reduction of habitat destruction by the ranchers and local peoples.

The algorithm produced reasonable predictions of the species' potential distribution (areas of suitable environmental conditions). The models perform digital compilations of the species range designed for use in conservation biology and macro-ecological studies (PHILLIPS et al., 2006). Most strikingly, the models correctly indicated the suitable habitats for the species, as may be observed by comparing the resulted maps and tables, showing that the patterns predicted by the model are largely consistent with current knowledge of the species. Unsurprisingly, the species had a larger range size than mapped by the IUCN by demonstrating that the range of the species inhabiting the northern parts of Isfahan province is comparatively larger than protected areas. Moreover, it is important to emphasize that our field sampling in the predicted areas has been validated and confirmed. Mapping the species habitat suitability can be used in estimating the species extent of occurrence as defined by IUCN (2001). Species habitat suitability regularly measures a particular species geographical distribution - which may contain unsuitable or unoccupied habitats, i.e. discontinuities or disjunctions within the overall distributions of taxa and usually it does not represent a detailed map of actually occupied habitats (i.e. areas of occupancy). For removing such uncertainties, we also surveyed new mapped areas and detected the species using those habitats. Our finding confirmed climatic factors like air relative humidity can be shape the species habitat selection behavior as well as land topography. The spatial distribution of the species can be explained by a variety of factors from small to larger-scale. The result of this study can be used in the definition of the new protected areas as some investigators suggest that key biodiversity areas concept can be incorporated by species conservation planning and development of protected areas network (Edgard et al. 2008). Since Pleski ground jay is the only native birds inhabiting Iran, has high potential using a model species in the planning protected areas network. The potential habitat distribution map can be used to propose new protected areas and identify top-priority survey sites regarding the species micro habitat use and population ecology and biology.

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