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Identifying high-priority conservation areas for avian biodiversity using species distribution modeling

Sohrab Moradi[a], Sayyad Sheykhi Ilanloo[b,c,*], Anooshe Kafash[b,c,*], Masoud Yousefi[b,c]

[a] Department of Natural Resources and Environment Engineering, Faculty of Agricultural Sciences, Payame Noor University, Tehran, Iran
[b] Ecology and Conservation Research Group (ECRG), Department of Environmental Sciences, Faculty of Natural Resources, University of Tehran, Karaj, Iran
[c] Department of Environmental Sciences, Faculty of Natural Resources, University of Tehran, Karaj, Iran

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ABSTRACT

Hyrcanian forests are rich in the sense of biological diversity. As a relic of the Arco-Tertiary forests, these habitats are known as the last remnants of primeval deciduous forests in the world. However, they are also ecologically unknown and strongly threatened by human-wide range activities. Because tree-cavity nesters are indicators of avian diversity in forests, they can be used to identify priority conservation areas in these ecosystems. In this study, we used 5 tree-cavity-nesting birds (Black Woodpecker (*Dryocopus martius*), Great Spotted Woodpecker (*Dendrocopos major*), Eurasian Nuthatch (*Sitta europaea*), European Green Woodpecker (*Picus viridis*) and Lesser Spotted Woodpecker (*Dendrocopos minor*)) to identify high-priority areas for conservation in Hyrcanian forests, Iran. We modeled habitat suitability of the 5 species across Golestan Province. We classified the models to suitable/unsuitable maps and multiplied them to determine areas with highest suitability for the five species. We found poor representation of high-priority habitats within protected areas. The high-priority habitats of the Hyrcanian forests identified in this study should be considered for protection of avian biodiversity.

1. Introduction

Birds are important indictors of landscape conditions and environmental changes (O'Connell et al, 2000; Imbeau et al., 2001; Lawton and Gaston, 2001; Niemi and McDonald, 2004; Chambers, 2008). They are good indicators of forest biodiversity and health, however they are seriously threatened by deforestation, wood harvesting (Foley et al., 2005; Fahrig, 2003) and even some keystone resources (White and Jiménen, 2017). Cavity-nesting birds are an essential component of forest ecosystem function (Bai, 2005; Gil-Tena et al., 2007). Considered as keystone "ecosystem engineers" because they provide a critical ecological resource other species' for nesting or roosting (Cockle et al., 2011; Blanc and Martin, 2012; van der Hoek et al., 2017). Cavity-nesting birds are regarded as indicators for diversity of forest birds (Mikusinski et al., 2001; Roberge and Angelstam, 2006; Van der Hoek et al., 2017). Hence, by modeling distributions of cavity-nesting species, high-priority areas for conservation of forest bird diversity can be identified (Cockle et al., 2011; Cockle et al., 2012; van der Hoek et al., 2017).

Hyrcanian forests comprise a continuous 800-kilometers-belt of deciduous forests located between the Caspian Sea and the Elburz Mountains, with an area of over 1.8 million hectares (Akhani et al., 2010). However, these forests are threatened by a wide range of human activities, such as urban development, excess tree harvest, over development of agricultural lands, overgrazing, tourist activities, and development of extensive road networks (Siadati et al., 2010; Sagheb-Talebi et al., 2014; Mahmoudi et al., 2016; Soofi et al., 2018; Ashoori et al., 2018). Although Hyrcanian forests host rich avifaunas (Scott et al., 1975; Madjnoonian et al., 2005), few studies have been carried out on these bird communities (Varasteh Moradi, 2012; Mahmoudi et al., 2016; Setayeshi et al., 2017; Dabbagh et al., 2017). Because gathering data on distributions of all bird species can difficult, time-consuming, and expensive, we focused on tree-cavity nesting species as an indicator for overall avian diversity in these relict forests.

The use of species distribution models (SDMs) in ecology and conservation is increasing (Peterson et al., 2011; Guisan et al., 2013). Development of these models during recent decades has made it possible to detect unknown populations of rare species (Rebelo and Jones, 2010; Yousefi et al., 2015), identify areas with high suitability for species (Hammond et al., 2016; Gottwald et al., 2017), and prioritize

* Corresponding authors at: Ecology and Conservation Research Group (ECRG), Department of Environmental Sciences, Faculty of Natural Resources, University of Tehran, Karaj, Iran.
E-mail addresses: sayyad.sheykhi@ut.ac.ir (S. Sheykhi Ilanloo), anoosheh_kafash@ut.ac.ir (A. Kafash).

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habitats for conservation (Kremen et al., 2008). For example, Kremen et al. (2008) used SDMs to find high-priority areas for conservation in Madagascar, and Vallecillo et al. (2016) applied Maxent method to develop a habitat quality indicator for common birds in Europe.

This study aimed to determine high priority areas for conservation of avian diversity in Hyrcanian relic forests, using cavity-nesting birds as indicator. We modeled distributions of 5 cavity-nesting birds: Black Woodpecker (*Dryocopus martius*), Great Spotted Woodpecker (*Dendrocopos major*), Eurasian Nuthatch (*Sitta europaea*), European Green Woodpecker (*Picus viridis*) and Lesser Spotted Woodpecker (*Dendrocopos minor*). This study covered the full extent of Hyrcanian forests in Golestan Province.

2. Materials and methods

2.1. Study area

Golestan Province is located in the northeast of Iran, with an area of over 20328 km^2 between 36° 25′ and 38° 08′ N and 53° 50′ and 56° 18′ longitude. The province is divided into three sections: plains, foothills, and mountains, with arid, semi-arid, and temperate climates (Jahani and Delbari, 2009; Mosaedi et al., 2009; Salman Mahini et al., 2011). Important tree species in the Golestan Province include Oak (*Quercus* spp.), Hornbeam (*Carpinus* spp.), Beech (*Fagus orientalis*), Alder (*Alnus* spp.), Caucasian walnut (*Pterocarya fraxinifolia*) and Persian ironwood (*Parrotia persica*). Fig. 1 shows Golestan Province's protected areas and location of the study area in Iran.

2.2. Presence points and environmental predictors

Occurrence records of the five species were collected during field work between 2012 and 2014 and downloaded from Global Biodiversity Information Facility (GBIF; https://www.gbif.org/). Using random field surveys (along walking trails or by car) potential habitats of the province were investigated and observed birds were identified following Scott et al. (1975), Mullarney et al. (1999) and Porter et al. (2005). Identification was facilitated with the aid of a telescope, binoculars and a digital Canon 40D camera. We conducted our field study during the day, started from sunrise until 11:00 AM and only in suitable weather conditions (without intense rain or wind). To model the distribution of the five species, we used a suite of variables related to climate, topography, and vegetation (Table 1). Climatic variables were downloaded from WorldClim at a spatial resolution of 30″ (~1 km^2) (Fick and Hijmans 2017). The elevation layer was drawn from the Shuttle Radar Topography Mission (SRTM) elevation model (Jarvis et al., 2008). Given high correlations among environmental variables, the variable correlations were first assessed to make sure all variable pairs had correlation coefficients less than 0.75 using ENMTools 1.4.4 (Warren et al., 2010).

Table 1
Environmental predictors used for modeling the distribution of the five cavity-nesters in Golestan province Iran.

Variable	Abbreviation	Description	Source
Topography	Elevation	Elevation above sea level	Jarvis et al. (2008)
Climate	Bio4	Temperature seasonality	Fick and Hijmans (2017)
	Bio9	Mean temperature of driest quarter	Fick and Hijmans (2017)
	Bio10	Mean temperature of warmest quarter	Fick and Hijmans (2017)
	Bio12	Annual precipitation	Fick and Hijmans (2017)
Vegetation	NDVI	Normalized difference vegetation index.	MODIS 2014

Table 2
AUC values and models performance based on Swets (1988).

AUC value	Model performance
AUC ≥ 0.90	Excellent
AUC ≥ 0.80	Good
AUC ≥ 0.70	Fair
AUC ≥ 0.60	Poor
AUC ≥ 0.50	Fail

Table 3
AUC values and models performance results for 5 cavity-nesting-bird species in Golestan Province, Iran.

Species	AUC test	AUC training	Model performance
Great Spotted Woodpecker	0.946	0.922	Excellent
Lesser Spotted Woodpecker	0.871	0.891	Good
European Green Woodpecker	0.965	0.904	Excellent
Black Woodpecker	0.9	0.886	Excellent
Eurasian Nuthatch	0.893	0.91	Good

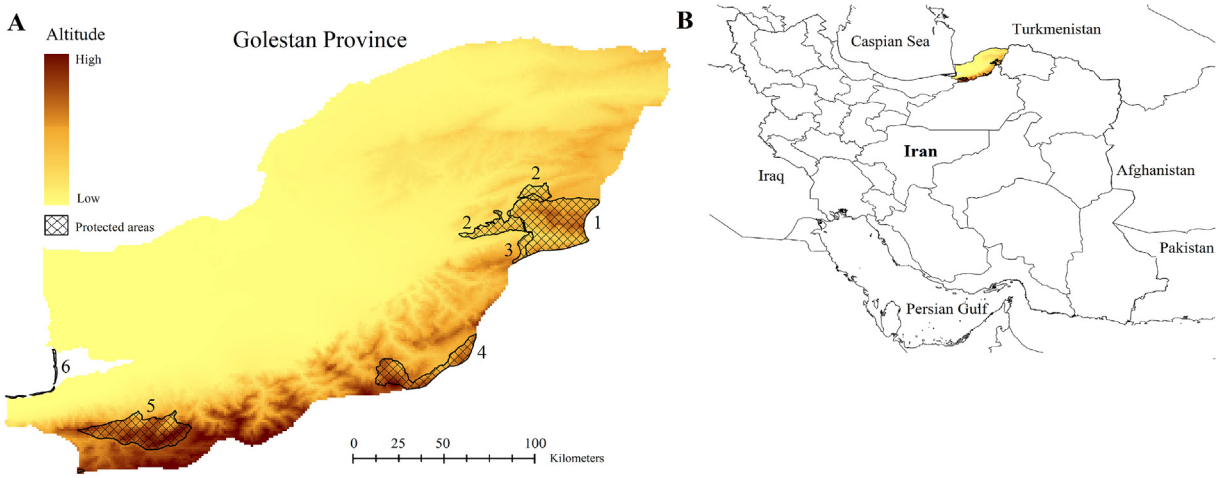

Fig. 1. Golestan Province's protected areas in a topographic overview (A). Golestan National Park (1), Zav Protected Area (2), Loveh Protected Area (3), Khoshyeylagh Wildlife Refuge (4) Jahan Nama Protected Area (5), and Miankaleh Wildlife Refuge (6). Location of the study area in Iran (B).