

MODELLING THE DISTRIBUTION OF THE LITTLE OWL
ATHENE NOCTUA IN BULGARIA

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Abstract

The Little owl *Athene noctua* (Scopoli 1769) is believed to be widespread in Bulgaria but its actual distribution and ecology are insufficiently studied. Historical records and unpublished information on its abiotic requirements, habitat preferences, breeding biology and distribution were analyzed to generate an Ecological Niche Model and documented that *A. noctua* is found across 90.8% of Bulgaria. We also estimated its potential distribution and ecological requirements within part of its range using Maxent. The Environmental Niche Model has a high degree of predictability. The climate changes are affecting the distribution. Our results revealed that the vertical distribution of the species expands by 100 m a.s.l. In Bulgaria, the main factors which determine the status of the population are elevation, type of land use, human population density and demographic structure which seem to account for most of the variation in suitable climatic conditions, and climatic factors – Annual Mean Temperature and Mean, Driest Quarter. Threats to the Little owl in Bulgaria include habitat loss, destruction of breeding sites, vehicle collisions, poisoning, predation, and persecution due to negative stereotypes or beliefs. Bulgaria, with a high number of breeding pairs as compared to elsewhere in Europe has an opportunity and obligation to preserve the species. The results of this study will help inform conservation decisions and efforts to maintain Little owl populations in Bulgaria.

Key words: Little owl, *Athene noctua*, Maxent, modelling, Species Distribution Model

Introduction. Species-specific habitat requirements determine where and how many individuals of a species occur [1]. The Little owl *Athene noctua* (Scopoli 1769) is one of the best-known owls throughout its distribution [2]. Many of the factors that affect its distribution in central and Western Europe are well studied [3]. It prefers agricultural lands with individual or small groups of trees but changes in land use in parts of its range have reduced populations and have limited opportunities to restore such habitats [2].

In Europe the Little owl is categorized as SPEC 3 – declining [4], on Appendix II of the Bern Convention on the Conservation of European Wildlife and Natural Habitats and Appendix II of the Washington Convention. In Bulgaria it is protected by the Law of the Protection of the Nature (Annexes II, III of Biological Diversity Act, 2016).

In Bulgaria it is widespread, mostly in lowlands [2,5] and prefers human settlements [6]. Its distribution appears to have been stable over recent decades when comparing earlier atlas data and updated distribution data [6,7].

Early studies of the Little owl mainly documented its diet based on observations and pellet analysis, as well as its predators [8]. The first distribution map [9] was later updated with data from the Bulgarian Society for the Protection of Birds [7] and again with more current data [6]. A better understanding of the Little owl's ecological requirements is needed to ensure its long-term survival. The development of ecological niche models herein identifies important factors to guide conservation efforts and identify new areas of potential occurrence in Bulgaria.

Material and methods. Study area. Bulgaria is in southeastern Europe and bordered by Romania to the north, Serbia to the West, North Macedonia to the southwest, Greece to the south, Turkey to the southeast and borders the Black Sea. Its biodiverse habitats include mountains (to almost 3000 m a.s.l.), plains, steppes, and Mediterranean habitats such as dense forests.

The present study was carried out in human settlements including villages, towns and even small farms spread across the country. Areas with different owl densities and those without owls present were selected for this study. Large samples of sites were visited to ensure that all Bulgarian administrative regions and different habitats were covered including hard-to-reach border areas.

Volume of work performed. Following the standardization of the ODMAP – overview, data, model, assessment, and prediction in ZURELL et al. [10], this study combined published data, the databases of the Bulgarian Society of the Protection of Birds and Ministry of Environment and Water, and data collected from 2006 to 2016. Used in study observations are in 1126 UTM squares from which 619 are personally registered (Fig. 1). Field work was carried out mostly during the breeding season (March-May) in villages (the standard 10 km UTM grid, 1240 squares of 10 × 10 km). Little owls were detected during playback surveys described by VAN NIEUWENHUYSE et al. [2]. Owl detection records were georeferenced using GPS units or smartphones with a GPS application SmartBirds

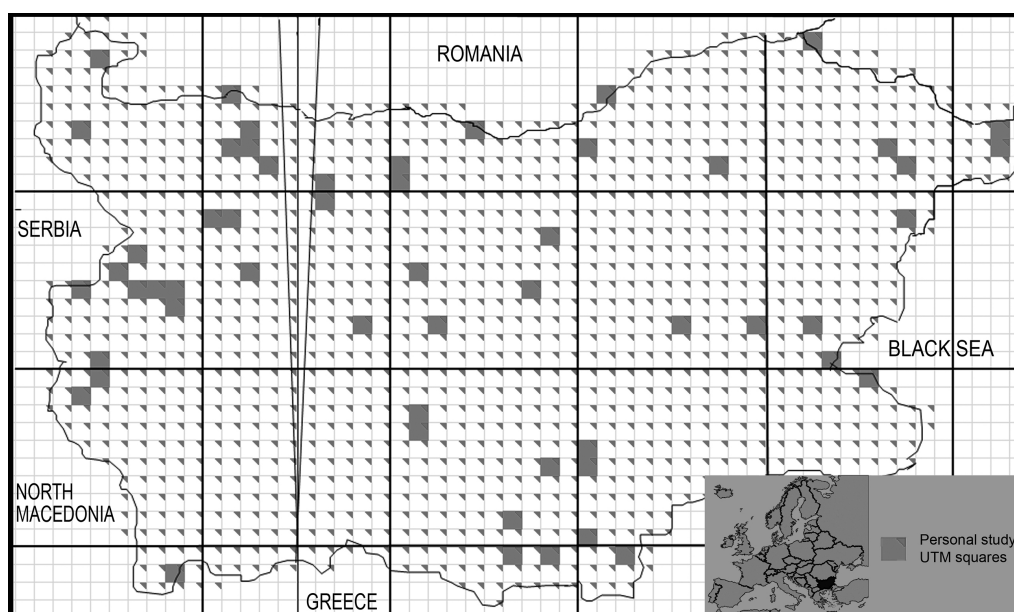


Fig. 1. Location of Bulgaria in Europe and map in UTM squares where there are registered Little owls from personal published and unpublished data

Pro [11] provided by the Bulgarian Society for the Protection of Birds/BirdLife Bulgaria.

The data were processed and modelled in projection coordinate system WGS 84 UTM 35N and were entered into ArcGIS v. 10.3 (ESRI, Redlands, CA, USA), assigned to one of 1240 standard 10 km² UTM grid squares used in the Atlas of Breeding Birds in Bulgaria (<https://atlas.bspb.org/en/>) and manipulated for visualization and analysis. Mapped record data was organized as a data matrix with three columns as follows: *Athene noctua*, UTM 35N longitude (X), UTM 35N latitude (Y). ENM models were generated with 100 Bootstrap iterations and with 25% of the points (randomly selected) used for verification in each iteration cycle. We calculated the Spearman Rank Order Correlations (Statistica v. 10; StatSoft, Tulsa, OK, USA). Data on the demographic variable is freely available (National Statistical Institute 2011). Despite the availability of robust data on Little owl population size in Bulgaria [12] we assumed this was unknown to produce Ecological Niche Models (ENMs). Maxent 3.4.1 software (https://biodiversityinformatics.amnh.org/open_source/maxent/) was used to model the distribution of the species [13]. This open source software is considered one of the best for modelling [14]. Unpublished locations of *A. noctua* were subsequently analyzed with the Maxent program [2].

Maxent reduced the relative instability (entropy) between two probable densities (one calculated from species presence data and the other from random points in the landscape) defined in the covariance space. The selected model has average

values. The model shows the correlation of potential habitats with actual ones and considers the influence of factors most important for the spread itself. These were divided into the following factor categories: climatic (bio_1 and bio_9), settlements, demographic and type of land use (CLC). All but one of these variables was “continuous” with only land being categorical. Settlements (settlementb) was converted from categorical to quantitative variable using the “Euclidean distance” function of ArcGIS 10.3. Climatically suitable areas for Little owl are analyzed and tested on the possible role of climatic fluctuations [15]. Habitat variables CLC [16] were separated into natural and artificial. We converted the categorical data to continuous by calculating the Euclidean distance (ArcGIS tool) for each habitat type in the original vector layers. The habitat in which each location falls is determined by crossing it with a digital layer of ground cover. This map is made by combining three digital vector layers: physical blocks (for open areas and agricultural lands), forest database (for forest habitats), and CLC (in cases where data was absent from other layers). The categories of this merged layer are equated in accordance with nomenclature of CLC. The type of transformation is “centre of the cell” (the polygon that overlaps with the centre of the cell gives the attributive information of the newly obtained cell). Duplicate records were excluded to avoid geographical autocorrelation. The models were tested by several methods: The accuracy of the model was verified with the test Area Under the Curve (AUC) (Fig. 2), which is one of the strongest and most widely used tests to evaluate models [13]. The Jackknife test supported the validity of the model by comparing the variables to each other (with AUC value), Permutation Importance (PI) and Percent Contribution (%) (Table 1). The potential distribution of the species is represented by the mean values from the model. The resulting raster was conditionally divided into three suitability categories: Low, Medium and High. The main purpose of this categorization was to calculate the relevant and priority conservation areas.

Results. Based on the used model the most favourable areas for the *A. noctua* in Bulgaria are the lowlands with temperate conditions and a wide variety of habitats including settlements or the presence of single buildings, especially those close to agricultural land. There were no registered in high mountains and in few places in border areas. The status of squares where it was not detected earlier did not change after being subjected to playback surveys. The variable’s percent contribution to the ENM clearly confirms the strong dependence of the species to proximity to settlements. The factors associated with Little owl’s distribution in Bulgaria according to the multifactor analysis are elevation and CLC (8.3%) which seem to account for most of the variation in suitable climatic conditions. Other important factors like population (26.7%) and demographic structure (7.8%) are associated with its distribution. The factors “Annual Mean Temperature” (15.6%) and Mean, Driest Quarter (6.8%) are the most important climatic predictors (Table 1). It presents some of the variables used to develop the model, with their

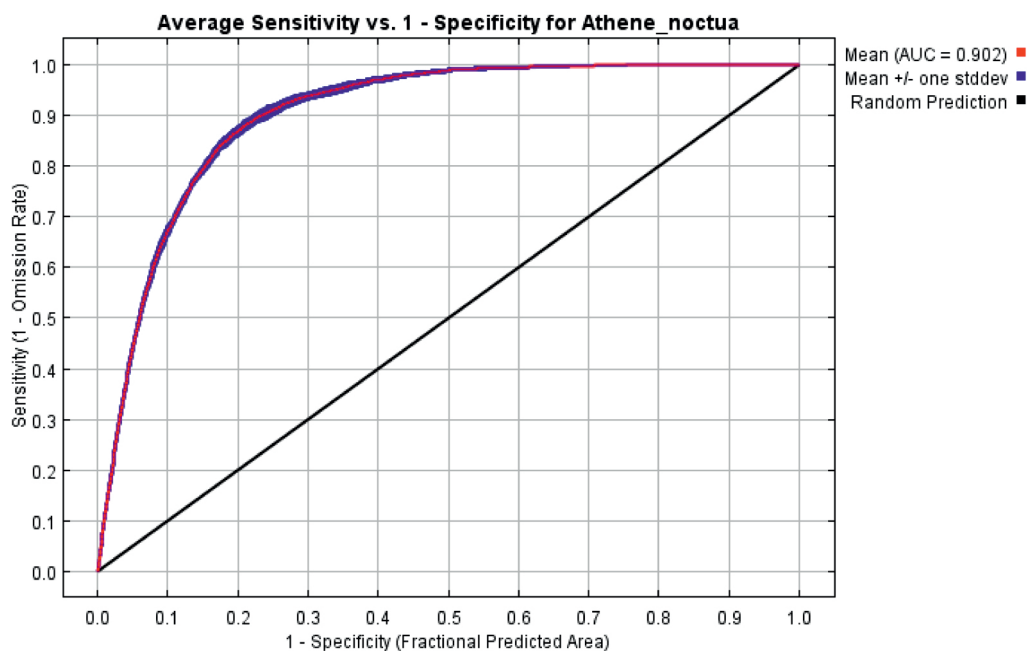


Fig. 2. Precision of the spatial model for the *Athene noctua* in Bulgaria based on “area under curve (AUC)”. The final model had very high average test AUC values

T a b l e 1

Average Percent Contribution (%) and Permutation Importance (PI) of uncorrelated variables, estimated by Maxent in Ecological Niche Models (ENMs) for the *Athene noctua* in Bulgaria. AUC – Area Under the (Receiver Operating Characteristic) Curve

AUC	0.902	
Variable	%	PI
Settlementb	35.2	34
Population	26.7	24
Demographic BG	7.8	20.4
(clc) CORINE Land Cover	8.3	10.2
Temperature (BIOx)		
Annual mean Temperature (1)	15.2	2.7
Mean, driest quarter (9)	6.8	8.7

percentage of influence. A habitat suitability map for the species based on empirical location data was created (Fig. 3). The AUC had high values (AUC = 0.902, Fig. 1) signifying the model’s high degree of predictability of the potential distribution.

Along with the small contributions from the other climatic variables, these results fit well to the known distribution of the species in Bulgaria. The profiles

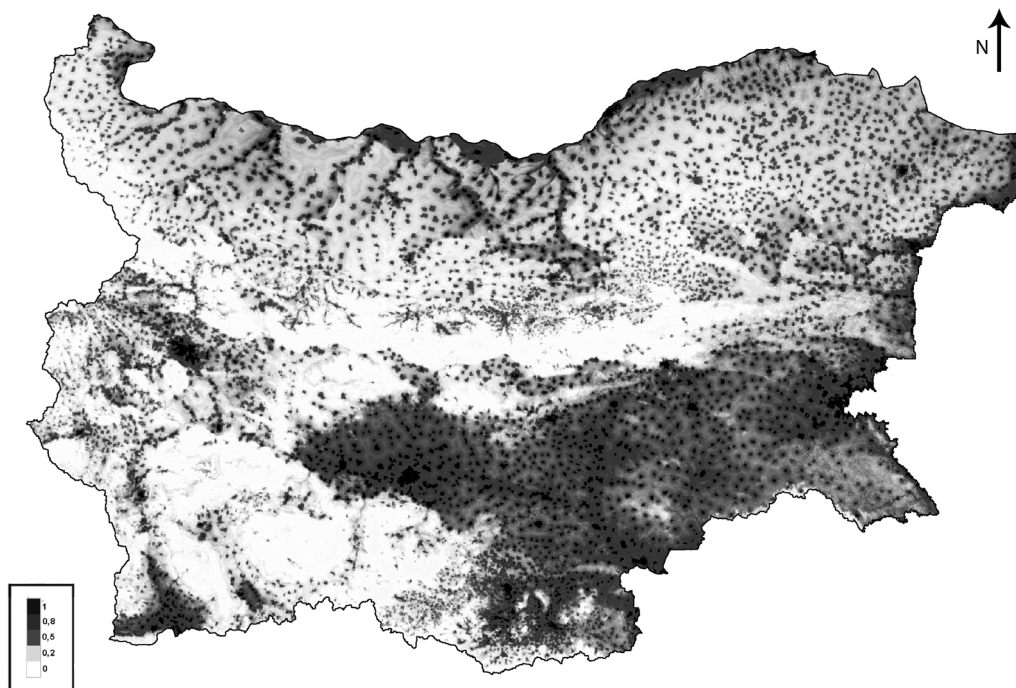


Fig. 3. Maxent average Ecological Niche Model for the *Athene noctua* in Bulgaria. Suitability categories are: Low, Medium and High

of the response curves for major variables related to its distribution allow an easy comparison between some of its eco-physiological requirements. According to KOPARDE et al. [15] the distribution of the Little owl is extending north of its general range. Our results revealed that in vertical aspect of the distribution, the species is extending the main population up to 900 m a.s.l., which is 100 m a.s.l. more than what has already been stated so far.

Discussion and conclusions. The adaptability of the species to different conditions varies, with less suitable areas associated with intensive agriculture, heavy traffic or human overcrowding. Diverse agricultural lands (e.g., extensive agricultural areas) with structurally complex mixed landscapes provide suitable environments for many species of small mammals [17] and insects that are important part of the Little owl's prey [8].

Areas important to the *A. noctua* are in or near the Danube River plain and its tributaries, Struma valley, the Thracian lowlands, Black Sea coast, Eastern Rhodope Mountains and Sofia plain. Urbanization of the Black Sea coastal areas increases nesting opportunities but also reduces hunting areas and increases disturbance, especially during the holiday season. The sustainability of Little owl populations in these areas remains unknown and should be monitored.

The wide distribution of *A. noctua* and its adaptability suggests that its ecological niches are wide and that the relative importance of biotic and climatic

factors may vary within its range. Continuous changes in natural factors, specific threats in certain areas – traffic, fertilizer use (intensive agriculture) and the “stability” of the local population need to be considered to conserve this species.

Our model provides a better understanding of the Little owl’s ecological requirements which can be used to ensure its long-term survival. The development of this ecological niche model identifies important factors to guide conservation efforts and identify new areas of potential occurrence in Bulgaria.

Our results revealed that the vertical distribution of the species expands by 100 m a.s.l. In Bulgaria, the main factors which determine the status of the population are elevation, type of land use, human population density and demographic structure, which seem to account for most of the variation in suitable climatic conditions, and climatic factors – Annual Mean Temperature and Mean, Driest Quarter.

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