BIOLOGICA NYSSANA

7 (1) • September 2016: 41-46

DOI: 10.5281/zenodo.159102

*Original Article*

*Received: 30 Mart 2016*
*Revised: 27 April 2016*
*Accepted: 01 June 2016*

# Species distribution modeling techniques as a tool in preliminary assessment of special nature reserve "Goč-Gvozdac"

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***Abstract*:**

**Čubrić, T.:** ***Species distribution modeling techniques as a tool in preliminary assessment of special nature reserve "Goč-Gvozdac". Biologica Nyssana, 7 (1), September 2016: 41-46.***

Effective conservation actions such as defining new nature reserve require accurate estimates of the spatial distributions of the target species. Species distribution models provide habitat suitability maps for studied species. In this paper we used Maxent software to estimate the distribution and extent of potential suitable habitat of five amphibian and reptilian species (*Mesotriton alpestris*, *Bombina variegata*, *Testudo hermanni*, *Lacerta viridis* and *Vipera ammodytes*) in the special nature reserve "Goč-Gvozdac" (Central Serbia) in order to assess how much of the potential habitats is included in this reserve. Comparing produced suitable habitat maps of the species with a map of the special nature reserve "Goč – Gvozdac" we concluded that the reserve boundaries do not coincide with the proposed distribution of suitable habitats for *M. alpestris*, *T. hermanni*, *L. viridis* and *V. ammodytes*, and therefore this reserve does not contribute much to the protection of local populations of these species.

**Key words**: species distribution modeling, Maxent, nature reserve, reptiles, amphibians

***Apstrakt*:**

**Čubrić, T.:** ***Modelovanje prostornog rasprostranjenja vrsta kao tehnika u preliminarnom ocenjivanju specijalnog rezervata prirode „Goč-Gvozdac". Biologica Nyssana, 7 (1), Septembar 2016: 41-46.***

Efektivne konzervacione mere kao što je definisanje novog zaštićenog područja zahtevaju precizne procene prostornog rasprostranjenja vrsta koja se štite. Uz pomoć modelovanja prostornog rasprostranjenja vrsta, dobijaju se mape pogodnog staništa za istraživane vrste. U ovom radu korišćen je programski paket Maxent sa ciljem procene rasprostranjenja pogodnih staništa za pet vrsta vodozemaca i gmizavaca (*Mesotriton alpestris, Bombina variegata, Testudo hermanni*, *Lacerta viridis* i *Vipera ammodytes*) u specijalnom rezervatu prirode „Goč-Gvozdac" (centralna Srbija), kako bi se procenilo koliko se potencijalnih pogodnih staništa za ove vrste nalazi unutar teritorije ovog rezervata. Poređenjem dobijenih mapa pogodnih staništa sa mapom specijalnog rezervata prirode „Goč-Gvozdac" zaključili smo da se granice ovog rezervata ne poklapaju sa predloženim rasprostranjenjem pogodnih staništa za vrste *M. alpestris, T. hermanni*, *L. viridis* i *V. ammodytes,* te stoga ovaj rezervat ne doprinosi zaštiti lokalnih populacija ovih vrsta.

**Key words**: modelovanje prostornog rasprostranjenja vrsta, Maxent, rezervati prirode, gmizavci, vodozemci

## Introduction

The most effective way to preserve species diversity is conservation of viable populations in their natural habitats through establishment of network of protected areas (Rodriguez-Rey et al., 2013). Knowing where species are likely to occur is a basic part of natural resource management (Ruston et al., 2004). Effective conservation actions such as defining new nature reserve require accurate estimates of the spatial distribution of the target species (Hernandez et al., 2006). With this information in hand conservationists can also predict species' response in form of change in it's local distribution due to landscape alteration and environmental change (Hernandez et al., 2006). Species distribution models (SDMs) are empirical models that relate field observations to environmental predictor variables based on statistically or theoretically derived response surfaces (Guisan & Zimmermann, 2000). Species distribution modeling can provide a measure of a species occupancy potential in areas which are not covered by biological surveys and therefore these techniques are becoming an indispensable tool in conservation planning (Guisan & Zimmermann, 2000; Corsi, 2000; Loiselle et al., 2003), especially when funding and time are limited. Also, predicted species distribution data from SDMs are commonly used for conservation planning because the alternatives (e.g. survey data) are often incomplete or spatially biased (Andelman & Willing, 2002).

One of the SDM software is Maxent (Phillips et al., 2006). Maxent is a general-purpose method for characterizing probability distributions from incomplete information (Phillips et al., 2006). Maxent combines distribution data with environmental factors and assesses the probability of presence of one species in a given cell on the basis of environmental features in that cell. Maxent calculates the range of species distribution in order to find the species distribution of maximum entropy – closest to the uniform (Phillips et al., 2006). Distribution based on maximum entropy means that the species are evenly distributed through environmental variables. Mean task in this modeling program is to predict suitable habitat in relation to environmental variables. It requires only presence data. In this paper Maxent was used in predicting suitable habitats for two amphibian and three reptilian species: *Mesotriton alpestris* (Amphibia: Urodela: Salamandridae), *Bombina variegata* (Amphibia: Anura: Bombinatoridae), *Testudo hermanni* (Reptilia: Chelonia: Testudines: Testudinidae), *Lacerta viridis* (Reptilia: Squamata: Sauria: Lacertidae) and *Vipera ammodytes* (Reptilia: Squamata: Serpentes: Viperidae). Nine amphibian and twelve reptilian species inhabits special nature reserve "Goč - Gvozdac". The five chosen species are the most easy to spot while performing transects. In addition, all five species are protected under national law. Also, they are listed under the IUCN Red List (www.iucnredlist.org) and under the Annexes of Bern Convention (www.coe.int). *M. alpestris*, *B. variegata*, *L. viridis* and *V. ammodytes* are listed in the last concern IUCN Red list category and *T. hermanni* is listed in the near threatened category (www.iucnredlist.org). Also, except *M. alpestris*, all the other selected species are considered of community interest in need of strict protection (Annex IV) in Habitat Directive (Anonymous, 1992); additionally, *B. variegata* and *T. hermanni* are considered also a species which conservation requires the designation of special areas of conservation (Annex II in Habitat Directive).

The objectives of this study are: 1) to use habitat suitability models to determine potential current distribution of chosen species throughout the study area 2) to estimate the distribution and extent of species potential habitat in the special nature reserve "Goč-Gvozdac" and 3) to assess how much of the potential habitats is included in this reserve. The basic question was whether the border of the reserve is set up in a way to contribute to the protection of the most important local habitats of these species.

## Material and methods

### Study area

As the aim of this study was to evaluate special nature reserve "Goč-Gvozdac", study area was wider than the reserve itself (**Fig. 1**) and included the nature reserve (positioned in the middle of study area), the valleys of the Ibar and West Morava rivers and slopes of Kopaonik and Golija mountains. Special Nature Reserve "Goč – Gvozdac" is located in Central Serbia, between 43° 31' and 43° 34' North latitude and 20° 37' and 20° 47' East longitude. It represents a forested mountainous area with its highest peak of 1484 m. and covers 3957 ha in total. The field research lasted from April to September 2014. The survey was carried out through 49 transects of the average length of 5 km set in randomly selected locations. The geographic coordinates of the localities where the species were found were collected and they included 10 records of *M. alpestris*, 22 records of *B. variegata*, 11 records of *T. hermanni*, 25 records of *L. viridis* and 10 records of *V. ammodytes*.

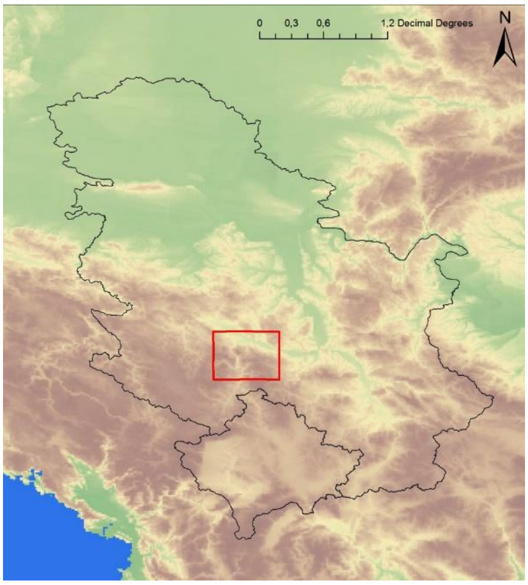


**Fig. 1.** Study area (red polygon with dimensions 50x50km). In the middle of the study area is located special nature reserve "Goč-Gvozdac"

**Table 1.** Climatic variables used in models

| | |
|---|---|
| BIO1 | Annual Mean Temperature |
| BIO2 | Mean Diurnal Range (Mean of monthly (max temp - min temp)) |
| BIO3 | Isothermality (BIO2/BIO7) (* 100) |
| BIO4 | Temperature Seasonality (standard deviation *100) |
| BIO5 | Max Temperature of Warmest Month |
| BIO6 | Min Temperature of Coldest Month |
| BIO7 | Temperature Annual Range (BIO5-BIO6) |
| BIO8 | Mean Temperature of Wettest Quarter |
| BIO9 | Mean Temperature of Driest Quarter |
| BIO10 | Mean Temperature of Warmest Quarter |
| BIO11 | Mean Temperature of Coldest Quarter |
| BIO12 | Annual Precipitation |
| BIO13 | Precipitation of Wettest Month |
| BIO14 | Precipitation of Driest Month |
| BIO15 | Precipitation Seasonality (Coefficient of Variation) |
| BIO16 | Precipitation of Wettest Quarter |
| BIO17 | Precipitation of Driest Quarter |
| BIO18 | Precipitation of Warmest Quarter |
| BIO19 | Precipitation of Coldest Quarter |

### Environmental variables

Climate variables were collected from WorldClim databank while CORINE map was used for land cover data. Worldclim base is a collection of maps having medium, minimum and maximum monthly temperature and precipitation for the entire land area of the planet. The maps are of high resolution (30 arc sec) which corresponds to a resolution of approximately 1 km$^2$. The WorldClim databank consists of 19 climatic variables (**Tab. 1**). CORINE digital map is created for 29 European countries with a scale 1: 100 000 or 25 ha minimum size of the unit. Resolution of all variables was set to a resolution of Corine land cover maps (about 100x100 m). The variables were prepared using ESRI ArcMap 9.3.

### Species distribution modeling

Following basic parameters of the model Maxent were used: calibration (training) data were generated by random selection of 75% occurrence records and 25% for testing. The chosen Maxent default settings were: maximum number of iterations = 500, convergence threshold = $10^{-5}$, maximum number of background points = 10000. We used a regularization multiplier = 2.

In order to validate the obtained models, the predicted values of habitat suitability assigned to presence and pseudo-absence of the data in the test subset were compared by producing the 'Receiver Operating Characteristic' (ROC) plots (Fielding and Bell, 1997) and deriving the relative 'Area Under Curve' (AUC) value (Faraggi and Reiser, 2002) through a jack-knife procedure. The main positive feature of this method consists of being a single threshold-independent measure for model performance.

Maps of suitable habitat (raster maps) were made in Maxent. The maps of suitable habitats were then overlapped with the map of the special nature reserve using DIVA-GIS 7.5. Maps were compared in order to determine which parts of the reserve are suitable. We analyzed the binary maps with suitable and unsuitable habitats for the species. This allowed the calculation of the suitable habitat area. Then, we analyzed the size of suitable habitat area of each species in the reserve and the relation between the area of suitable habitat in the reserve and the total area of suitable habitat in the study area.

## Results

### Model performance

The models got relatively good performance. Training AUC was 0.924 for *M. alpestris*, 0.887 for *B. variegata*, 0.870 for *T. hermanni*, 0.863 for *L. viridis* and 0.754 for *V. ammodytes*,

*Comparing binary maps of suitable habitats with the map of special nature reserve "Goč-Gvozdac"*

Comparing the distribution of suitable habitats with a map of the reserve revealed that the suitable habitats for *M. alpestris* (**Fig. 2**), *T. hermanni* (**Fig. 4**), *L. viridis* (**Fig. 5**) and *V. ammodytes* (**Fig. 6**) are mostly located outside the borders of the reserve and that

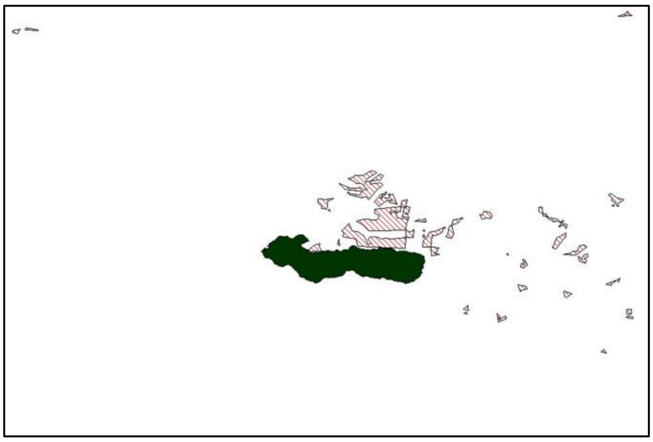

**Fig. 2.** Comparison of binary map of suitable habitat with a map of the reserve. The dark polygon represents the territory of the special nature reserve "Goč-Gvozdac" and hatched part represents the suitable habitat for species *Mesotriton alpestris.*

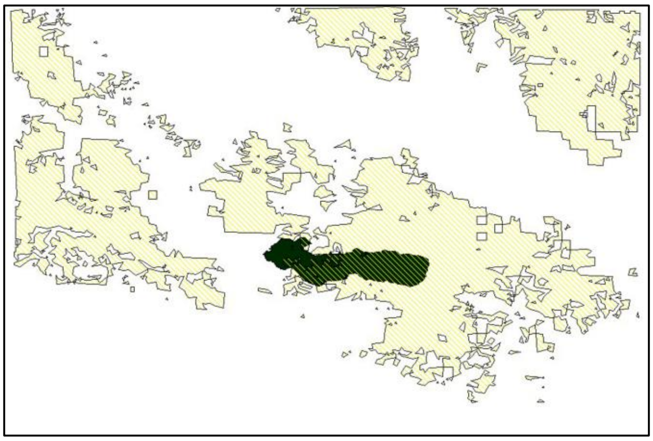

**Fig.** 3. Comparison of binary map of suitable habitat with a map of the reserve. The green polygon represents the territory of the special nature reserve "Goč-Gvozdac" and hatched part represents the suitable habitat for species *Bombina variegata.*

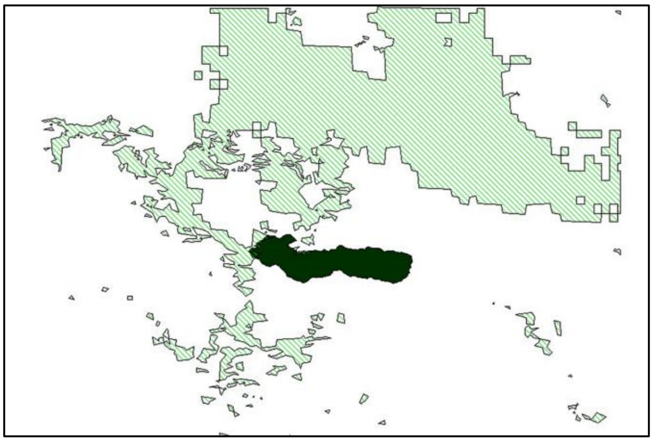

**Fig. 4.** Comparison of binary map of suitable habitat with a map of the reserve. The green polygon represents the territory of the special nature reserve "Goč-Gvozdac" and hatched part represents the suitable habitat for species *Testudo hermanni.*

very small part of the suitable habitat occurs on the northern border of the reserve. The large part of the reserve (75%) has suitable habitats for *B. variegata* (**Fig. 3**), and the surface of suitable habitat in the study area is greater than the surface of the reserve. Consequently, the largest portion of the surface of a suitable habitat in the reserve in relation to the total area of suitable habitat had *B. variegata* (**Tab. 2**), and the lowest *M. alpestris*.

## Discussion

One of the most important aspects of amphibian and reptile biology that should be clarified for the efficient planning of conservation measures is represented by the patterns of species distribution, as well as by the environmental factors that influence such patterns (Bombi, 2010). Comparing the distribution of suitable habitat maps of the studied species with a map of the special nature reserve "Goč - Gvozdac" we can conclude that the reserve boundaries do not coincide with the distribution of suitable habitats for *M. alpestris*, *T. hermanni*, *L. viridis* and *V. ammodytes*. Therefore we can conclude that this reserve does not contribute much to the protection of local populations of these species. On the contrary, the area of suitable habitat for *B. variegata* occupies 75% of the reserve and the proposed reserve boundaries contribute to its protection. For *M. alpestris* it would be good to expand the northern boundaries of the reserve in a way to protect also potentially important habitats north of the reserve. Given the fact that the area of suitable habitat for other analyzed species exceeds the area of the reserve, one of the potential measures to protect their local populations would be the establishment of additional new protected areas. Areas for protection are often selected to cover the maximum number of species (Church et al. 1996; Kiester et al., 1996). Various authors (Pressey & Nicholls, 1989) recommend maximizing biodiversity in a protected area in order to be able to protect them with limited financial resources. Therefore, it would be more economical to establish one large protected area by expanding the boundaries of the existing one, or to design a connected network of small protected areas.

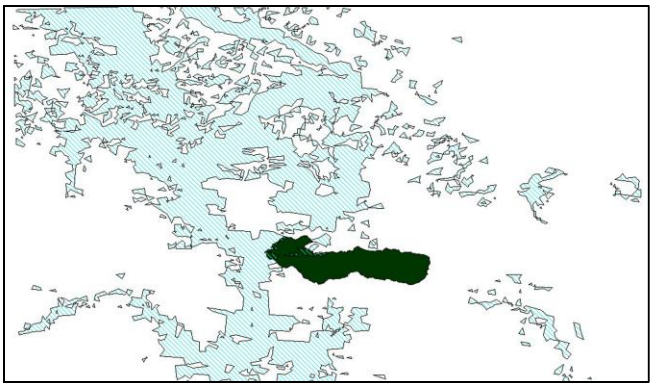

**Fig. 5**. Comparison of binary map of suitable habitat with a map of the reserve. The green polygon represents the territory of the special nature reserve "Goč-Gvozdac" and hatched part represents the suitable habitat for species *Lacerta viridis.*

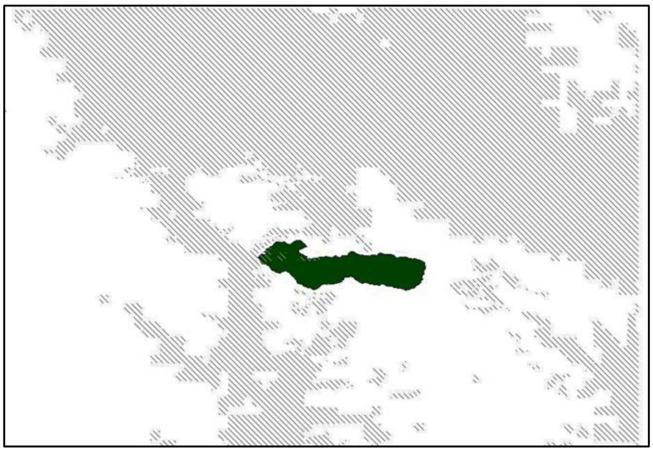

**Fig. 6.** Comparison of binary map of suitable habitat with a map of the reserve. The green polygon represents the territory of the special nature reserve "Goč-Gvozdac" and hatched part represents the suitable habitat for species *Vipera ammodytes.*

Protected parts of nature that have been identified on the basis of their range and predictions of species distribution are likely to be more comprehensive and more representative than those that are identified solely on the basis of available presence data of the species. This is because the species presence is limited to the area where field research was conducted while species distribution models predict species distribution in and out of the researched area (Rondinini at al., 2006). Also, simple probability-based approaches may be considered an alternative to more complex population viability analysis when conservation decisions involve large number of species and there is little time and few resources available (Araújo et al. 2002). In this study it is achieved to evaluate the suitability of the total special reserve for selected species in regard to the wider area, although field work has not been conducted in all spatial segments.

Obviously, this study could be improved. First, vegetation map with better resolution would be more appropriate because finer resolution usually provides better predictions for fixed or very locally mobile organisms (Guisan & Thuiller, 2005) such as species in this study. Also, researched area was relatively small for resolution of variables. Further, identifying small habitat features (such as cave openings, vegetation patches) is also important as *V. ammodytes* and *L. viridis* use their environments at a relatively fine spatial scale. New types of remotely sensed data such as laser altimetry or light detection and ranging (lidar) (Lefsky et al., 2002) should prove useful for generating detailed habitat maps. Various authors (Rondinini at al., 2005) concluded that there are no available maps showing presence of small, temporary water bodies that are important for certain species (e.g. *M. alpestris* and *B. variegata*) and that represents an obstacle in SDM. It may also happen that the resolution of variables does not match the scale at which species use environment. Also, the relatively small number of samples should be taken into account in interpreting the results of this study, although Maxent represents the best of the available programs for modeling with quantity of samples up to 5,10, 15 and 20 (Hernandez et al., 2006). Also,

**Table 2.** Area of suitable habitats for analyzed species (SNR-special nature reserve)

| **Species** | **Size of suitable habitat within the study area** | **Size of suitable habitat within the SNR** | **% of the size of suitable habitat within the SNR in relation to the size of suitable habitat within the study area** | **% of the size of suitable habitat within the SNR in relation to the size of the reserve (3957 ha)** |
|---|---|---|---|---|
| *Mesotriton alpestris* | 2916,8171 ha | 1,8224 ha | 0,062 | 0,046 |
| *Bombina variegata* | 70980,2766 ha | 2998,6221 ha | 4,22 | 75,78 |
| *Testudo hermanni* | 57018,9638 ha | 130,9016 ha | 0,23 | 3,30 |
| *Lacerta viridis* | 57559,7044 ha | 224,1334 ha | 0,39 | 5,66 |
| *Vipera ammodytes* | 120566,0616 ha | 1086,9871 ha | 0,9 | 27,46 |

the model is more accurate for species with a small distribution range and narrow ecological valence (Hernandez et al., 2006).

## Conclusion

Because contemporary research in the field of conservation planning has focused on the development of theories and tools to design reserve networks that protect biodiversity in an efficient and representative manner (Araujo & Williams, 2000; Araujo et al., 2002; Cabeza et al., 2004), SDMs (like models in this study) can be used as a foundation for the development of finer scale models, usable in a) definition of suitable habitat, b) identification of boundaries for new conservation areas and c) assessment of existing area to secure the protection of amphibian and reptilian species.

**Acknowledgements.** I am grateful to Dimitrije Radišić for support and help for realizing my ideas and to Nikola Vuletić for a company in the field.

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