Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 5, No. 1, p. 145-149, 2014
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Developmental impacts on wild goat's (*Capra aegagrus*) ecosystem in Markazi province and its solutions

Amir Ansari*, Mahmode Karami, Hamid Reza Rezai, Borhan Riazi

[1]*Department of Environment and Energy,science and research branch, Islamic Azad University of Tehran, Iran*

[2]*Department of Environment and Energy,science and research branch, Islamic Azad University of Tehran, Iran*

[3]*Department of Environment, Gorgan University, Iran*

[4]*Department of Environment and Energy,science and research branch, Islamic Azad University of Tehran, Iran*

Article published on July 08, 2014

Key words: Wild goat(*Capra aegagrus*), fragmentation of habitat, ecosystem.

Abstract

Markazi province with its elevated mountains is a suitable habitat for the wild goat(*Capra aegagrus*) such that the species has been chosen as the symbol of biodiversity in the province. The fragmentation of habitat due to the human-initiated activities is one of the major threatening factors against the species viability. The study is under taken using the MAXENT method based on the maximum entropy or near to reality approach with 10 different variables. The study results indicate that a 1698.78 Km² area equivalent to 11% in the southern half of Markazi province covers a favorable habitat for the wild goat. The ROC model specifies that the validity of habitat suitability model is 0.978 indicating the superior performance of MAXENT method. Among the development variables, the highest impact on the wild goat ecology is assigned to distance to cities variable (20Km) while the lowest impact is related to distance from unpaved road variable. And among the ecologic variables, the highest impact is determined for slop variable (20%) and the lowest impact is related to height variable.. The protection of the extant population, inter-regional corridors, live capturing, sending the wild goat from other regions to Jasb and Rasvand, and restoring the wild goat in Alvand and Bazerjan in Tafresh, Iran.

***Corresponding Author:** Amir Ansari ✉ a_ansari645@yahoo.com

Introduction

Today, the destruction of natural habitats due to human activities is one of the most important threatening factors against the survival of many species. Then, the remaining areas as wildlife habitats are often very limited and separated by poor lands. The habitat fragmentation has many potential destructive effects on the population residing in these areas including the population confinement and inter-population genetic exchange unfeasibility. This causes the increase of endogamy and at the long term, it heightens the danger of extinction. Different species show variety of reactions to the phenomenon based on their various characteristics and requirements (Malekian, 2007). By far, the largest single threat to biological diversity worldwide is the outright destruction of habitat, along with habitat alteration and fragmentation of large habitats into smaller patches (Meffe *et al.* 1997). The two components of habitat fragmentation are 1) the reduction of the total amount of a habitat type in a landscape; and 2) the reapportionment of the remaining habitat into smaller, more isolated patches of habitat (Harris 1984; Wilcove *et al.* 1986; Saunders *et al.* 1991 *in* Meffe *et al.* 1997). Habitat fragmentation creates landscapes made of altered habitats or developed areas fundamentally different from those shaped by natural disturbances that species have adapted to over evolutionary time (Noss and Cooperrider 1994 *in* Meffe *et al.* 1997). Human activities such as overgrazing, deforestation, bush fires, mining, urbanization. and cultivation are the principle causes of habitat destruction (See e.g. Kauzeni 1995.

Kideghesho 2005; Mwalyosi 1992). As a consequence of habitat fragmentation, different areas with dissimilar geographic structures are formed to which some of the individual species are not compatible. The strongest threatening factor to the biodiversity is the habitat isolation because the large habitat division into the isolated areas endangers the biodiversity (Fahrig, 2003). According to the International Union for Conservation of Nature, the wild goat is classified as a vulnerable species (IUCN, 2012).The MAXENT method is one of the most common algorithms for machine-based learning. The principal of MAXENT method is based on the maximum or close to reality entropy. Shannon (1984) describes the entropy as a criterion for the number of involved choices in the case of an event occurrence. The application of maximum entropy principle in the species distribution is described according to the thermo dynamic rules dominated on the ecology processes. In the absence of other limiting factors effects except the model-included limitations, thus, the species geographic distribution tends to the maximum entropy (Behdarvand, 2012). The receiver operating characteristic (ROC) validation diagram is one of the most common statistic methods that is widely used for modeling the species distribution in the assessment of the accuracy of prediction models. The Area Under Curve is the model's detection power probability between the presence and non-presence points (Phillips *et al.*, 2004). The main objective of this study is to assess the implications of development(of human-based activities e.g. distance to the human-built locations, roads congestion, mines, etc) in the ecosystem of the wild goat.

Material and methods

The study covers a15367.9 thousand Km² area in the southern half of Markazi province, Iran, including Haftadgholle in Arak,Palangdareh in Ghom, Alvand in Khomein, Mouteh in Isfahan, Rasvand in Shazand, and JasbinDelijan.As a symbol of biodiversity in Markazi province, Iran, the wild goat (*Capra aegagrus*) is known as a significant wildlife in the habitats. In the region including Arak, Delijan, Khomein, Mahallat, and Shazand cities, there are several villages, main roads i.e. Tehran-Isfahan, Delijan-Mahalat, Arak-Khomain, and Arak-Azna as well as large industries and numerous mines (Ansari, 2009).

At first, the study region was modeled in the form of a raster map with *n* equal-sized cells. Then, the dependent variable data i.e. the studied species presence/non-presence was collected. In order to

develop the species presence map, the field operation and observation of the species using the GPS device resulted in the detection of the species status, and other information related to the species observation location was recorded in the field visit form. Afterward, the independent ecological variables were identified including topographic features e.g. slope, height, direction, etc., ecological data, and the impacts of human-based activities e.g. distance to the human-built locations, roads congestion, mines, etc. The MAXENT method is based on the comparison of the ecological features of the species presence points with the ecological features of the region as a whole. Data analysis was under taken using MAXENT; data preparation, data verification, data correlation, habitat suitability mapping, models validation, and habitat suitability map classification were also carried out.

Results

Habitat suitability modeling results using MAXENT method.

The percentage of variables contribution in the wild goat habitat suitability model using the MAXENT method (Table1) reveals that the distance from the paved road variable and then the slop variable have the highest contribution in the model while the smallest impact is related to the distance from unpaved road variable.

Table 1. Percentage contribution and significance of each variable in the wild goat habitat suitability model using MAXENT method.

Variable	Percent contribution	Permutation importance	Optimal conditions
slope_s	28.9	12	20%
farm_abi_dis_s	19.7	18.2	2Km
city_dis_s	16.9	9.5	20Km
farm_deim_dis_s	10	20.4	10Km
asph_dis_s	9.9	13.5	10Km
mine_dis_s	7.4	9.4	10Km
shuse_dis_s	5.1	7.8	2Km
roadal_dis_s	1.6	3.8	2Km
malro_dis_s	0.4	4.1	No effect
dem_s	0.2	1.3	3.5Km

Table 2. The percentage and area of habitat suitability models using the MAXENT method.

Class name	MAXENT	
	Area(km²)	Percent
Sutiable	1698.78	11
In Sutiable	13669.11	89
Total	15367.90	100

Comparing the models' validity in Table3 shows that the validity of the maximum entropy model is 0.978, in other words the MAXENT model has a better predictability for the presence points with the probability of 978% that confirms its high validity.

Table 3. The ROC and criterion error for the maximum entropy model.

Model	MAXENT
AUC±S.E.	0.978±0.08

Discussion

The ROC range varies from 0.5 to 1; the 0.5 value indicates that the model is stochastic and 1 specifies that the model is optimally able to separate the presence and non-presence points. If the ROC value is between 0.7-0.8 the model will be assumed as a

suitable model; if the value is between 0.8-0.9 the model will be confirmedas an excellent model; and if the value is more than 0.9 the model will be considered as the best model (Giovanelli *et al.*, 2010). Among the human-based developmental activities variables, the highest rates are related to the irrigated agriculture lands (19.7), the highest significance is determined forrainfed agriculture lands (20.4), the highest optimum distance is obtained for distance to cities variable (20Km), and the lowest contribution is assigned to unpaved roads (0.4). The lowest significance is determined for all roads and the lowest distance from the optimum condition is obtained for unpaved roads(Meffe *et al.* 1997). For the ecological variables, the highest contribution rate (28.9), significance (12), and distance from the optimum condition (20%) are assigned to slope, while the lowest contribution rate (0.2), significance (1.3), and distance from the optimum condition (3.5Km) are obtained for height (Noss and Cooperrider 1994 *in* Meffe *et al.* 1997). Accordingly, among the development variables the highest influence on the wild goat ecosystem is related to distance from cities and the lowest influence is assigned to unpaved roads; and among the ecology variables, the highest and lowest impacts are related to slope and height respectively(See e.g. Kauzeni 1995;Kideghesho 2005; Mwalyosi 1992).Recommendations:

1. The protection of the extant population.

2. Restoring and creating the migratory corridors and enhancing the regional security for linking the populations, especially in Rasvand, Jasb, and Palang-Darreh regions,

3. Because of the high rate of reduction in the genetic diversity in Jasb, Ravand, and Palang-Darreh regions, the genetic study on the adjacent habitats and the identification of the closest genome to these populations is necessary; in this way, some of them will be live captured and sent to the identified regions.

4. Preparing the wild goat restoration plan in other habitats of Markazi provine, especially Alvand in Khomain, and Bazerjan in Tafresh, Iran.

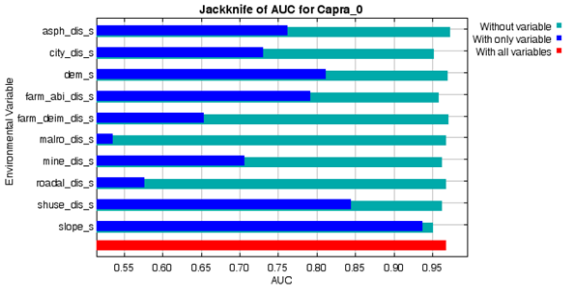

Fig. 1. The jackknife test results for the significance of each variable in the habitat suitability model. As the results of jackknife test (Figure1) indicate, the most significant variables regarding the habitat suitability are respectively slope, distance from unpaved road, height, and water resources while the smallest impact is obtained for the distance from graveled road variable.(Figure 2).

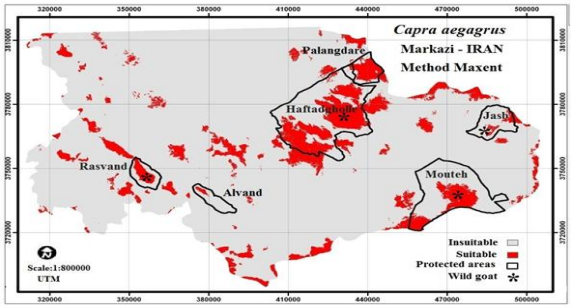

Fig. 2. Habitat suitability modeling using MAXENT method in the southern half of Markazi province, Iran. According to the MAXENT method,the area of habitat suitability is 169878 ha (11%)and the method ROC validity is 0.978 (Figure 3).

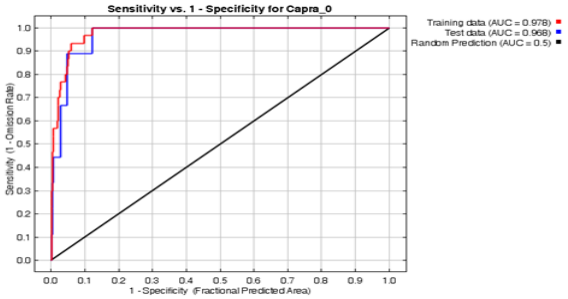

Fig. 3. The ROC validity of wild goat habitat suitability model based on MAXENT method The percentage and area of habitat suitability model using the MAXENT method in Table2 with the

suitable area of 1698.78 Km² (11%).

Acknowledgement

I would like to express my very great appreciation and thanks to Dr. Kaboli, Dr. Alizadeh, Dr. Sadouq, Mr. Engineer Goljani, Dr. Shams, and all personnel and environment watchers of Markazi provinces' Environment Protection General Office for their assistance with the completion of my research.

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