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Desirable Areas and Effective Environmental Factors of Wild goat Habitat (Capra aegagrus)

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ABSTRACT: Capra aegagrus is one of the most highly-valued animals of Iran. This species is also considered as one of the main food sources for the Acinonyx jubatus venaticus, which are critically endangered.Seasonal habitat use of wild goat was studied from January 2011 to September 2012 in Dareh Anjir Wildlife Refuge, Yazd, Iran. We developed Maximum Entropy models in three seasons.This study aims to determine the habitat desirability and factors affecting wild goats using a maximum entropy algorithm. Environmental variables used in modeling the three seasons of winter, spring, and summer include elevation classes, slope, direction, vegetation, distance to water sources, distance to the rocky substrate, distance to roads (asphalt, soil), and distance to mines. The results show that the most important factors affecting habitat desirability of the wild goat in winter, spring, and summer include the ratio of distance variable to the rocky cliffs, slope, and distance to water resources. According to the predictions, wild goats are most likely to be found in the northern, central and southeastern areas of the Dareh Anjir Wildlife Refuge, which are considered the most desirable habitats of the species and its associated predator (Acinonyx jubatus venaticus) over the three seasons.The results of this study can be used as a valuable tool in implementing conservation and management strategies in order to enhance the desirable habitats in the province of Yazd (Dareh Anjir Wildlife Refuge).

Key words: Capra aegagrus, Seasonal habitat use, Dareh Anjir Wildlife Refuge, MaxEnt, Maximum Entropy model

INTRODUCTION

Capra aegagrus (wild goat) is a member of the family Bovidae (Ziaie, 2008) and ranges discontinuously from central Afghanistan and southern Pakistan, west through Iran, western Turkmenistan, northern Iraq, the Caucasus region, and as far as southwestern Turkey (Weinber *et al.*, 2008). The species as well as its three subspecies are all listed as vulnerable (A2cde) by the IUCN (IUCN Red list. 2008). The wild goat is widely distributed throughout Iran, including in both mountainous and forested areas of the north and in areas of the central desert (Harrington, 1977; Ziaie, 2008). Illegal hunting, livestock competition, and habitat destruction are known as the main threats to this species. One wild goat population is in habitats of the Dareh Anjir Wildlife Refuge (DWR) located in central Iran. DWR has long been considered as one of the most important game wildlife refuges with wild goat as its prime game animal (Abedini, 2012). Several studies have been carried out on habitat suitability modeling for caprids in Mediterranean areas (Acevedo *et al.*, 2007; Cassinello *et al.*, 2006). However, habitat use of the wild goat throughout its distributional domain is not well understood. This lack of information hinders the conservation of this threatened species. Information on habitat use is a prerequisite for wildlife management decisions, particularly for threatened animals. Therefore, it could be stated that one of important issues in wildlife and species management is having information about habitat and distribution of species. Modeling using MaxEnt method is a method for obtaining this information (Phillips *et al.*, 2006). Veber et al. (2011) used MaxEnt for modeling the habitat of four endangered mussels in Ohio River basin in USA. In this study, 22 variables were used for

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modeling. MaxEnt software predicted the presence points of species which biologists have determined precisely and also predicted some river branches where species did not exist as suitable habitat (Veber *et al.*, 2011). In the study entitled "Where the bears roam in Majella National Park, Italy", MaxEnt model was used for population estimation and evaluation and modeling habitat of Brown Bear (van Gils *et al.*, 2013).

In the present study, Maximum Entropy (MaxEnt) species geographical modeling technique was used to model habitat suitability of Capra aegagrus in DWR, Yazd, Iran to determine how the presence of wild goat is influenced by environmental variables and to develop probabilistic habitat models for winter (cold period), spring (lamb bearing period) and summer (the warm and dehydration season) for the presence of wild goat in DWR.This research attempted to determine the desirable habitats and factors affecting the desirability of the Capra aegagrus habitat in different seasons at DWR using the maximum entropy method.

MATERIALS & METHODS

DWR covers an area of 175302 ha of plains and mountains and Foothills. It is located in Yazd Province (32°102 N to 32°362 N and 54°482 E to 55°322 E).Yazd is located in the Central Iranian Plateau (Abedini, 2012). This area was designated as a reserve by DOE in 2004. Its altitude ranges from 830 to 2293 m above sea level (Fig.1). Mean annual precipitation is 74.9 mm. DWR's maximum rainfall occurs in January, and the months of June, July, August and September are without rainfall. Hot, dry summers and very cold winters, high evaporation and little rainfall are among the prominent features of the region. July is the warmest month and January is the coldest month of the year (Abedini, 2012; CECI-CW, 2009). Mean daily Temperature is19.1°C. Based on the division made by Ambrezh, Dareh Anjir has a dry and cold climate, and based on DE marten, the area has a dry climate (CECI-CW, 2009). There is no permanent stream or lake in DWR, and wildlife uses free water sources such as springs and stone troughs. The main plants of the area are listed inTable 1(CECI-V, 2009).

Aside from wild goat, there are other animals in this area such as: large herbivores such as wild sheep Ovis orientalis and jebeer Gazella bennettii and carnivores such as cheetah Acinonyx jubatus venaticus, wolf Canis lupus, golden jackal Canis aureus, fox Vulpes vulpes, wild cat Felis silvestris, leopard Panthera pardus and raptors such as golden eagle Aquila chrysaetos, Aquila rapax, Falco

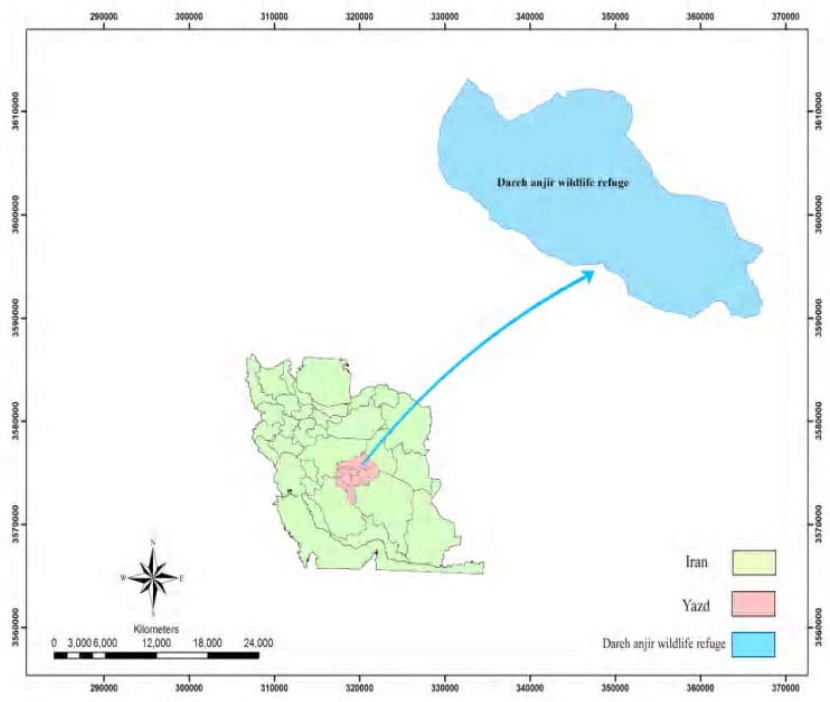

Fig.1. Map of Dare-Anjir Wildlife Refuge and its location in Iran

Table 1.The main plants and conservation value plants of the area

Number	main plants	conservation value plants
1	Artemisia sieberi	Acantholimon scorpius
2	Zygophyllum eurypterum	Amygdalus lycioides
3	Astragalus sp	Astragalus squarrosus
4	Salsola tomentosa	Atraphaxis spinosa
5	Calligonum bungei	Dorema ammoniacum
6	Pteropyrum aucheri	Ferula assa-foetida
7	Acanthophyllum sp	Pycnocycla spinosa
8	Acantholimon sp	Salsola yazdiana
9	Seidlitzia rosmarinus	Zataria multiflora
10	Tamarix sp	Scorzonera intricate

peregrines,… (Abedini, 2012). Population count conducted by the provincial office of DOE in November 2012 resulted in an estimate of 510 wild goats inhabiting the area. Many goats may be harvested each year, and the population seems to be relatively unstable.

Furthermore as we need only presence locations, MaxEnt also appears to be less sensitive than other approaches to the number of presence locations required to develop an accurate model (Elith *et al.*, 2006; Hernandez *et al.*, 2006; Phillips *et al.*,2006) although >30 locations are recommended (Wisz *et al.*, 2007). As with any modeling approach, more locations will likely result in a more precise and accurate model. The reason for MaxEnt's relative insensitivity to sample size relative pertains to its regularization procedure which compensates for over fitting when using only a few locations. The relatively small number of locations required for accurate model construction is a very beneficial aspect of the MaxEnt approach as there is often a lack of reliable locations available for mapping the distribution of many species (Hernandez *et al.*,2006; Pearson *et al.*,2007; Wisz *et al.*, 2007;Phillips *et al.*,2009). The population under study is the Capra aegagrus distribution in the area of DWR. Planning an optimal sampling strategy for habitat desirability modeling is very important. This study was conducted for three seasons in the region. With preliminary field visits, the paths were randomly assigned, and then all the paths were visited to record presence points. By being at the region for 10 days during 9 periods in winter, spring, and summer, 36, 56, 52 instances of presence were respectively recorded by GPS through a variety of ways including direct observation, footprints, and dung. GPS locations of 144 total wild goat-presence points were converted to UTM WGS 84 Zone 40 N projection for subsequent GIS integration. There were 144 presence-only points for winter, spring, and summer were used for making wild goat location shape file. Arc GIS 9.3 software was used for making point shape file of the wild goat presence points .This file was trans formed into.CSV file for using as a dependent variable in MaxEnt program. Thus presence -only data was used as a response variable for prophesying the area that could be potentially occupied by the species in the given set of situations. To model habitat suitability eight (8) variables were selected for their potential importance, based on our studies and from published sources of what would likely have relevance in relation to the species (Farashi *et al.*, 2010; Shams *et al.*, 2010; Mostafavi, 2010; Sarhangzadeh *et al.*,2013).These Topographic variables including elevation, slope, aspect, vegetation, distance to rocky substrate, distance to water source, distance to road and distance to mine were entered in the Maximum Entropy model as predictor habitat variables. The main maps of the study area (DEM, land cover map, road map, etc.) had antecedently been produced for management plans including Management Plan of DWR (CECI-DE, 2009). These maps were used to extract the required habitat variables. Locations of rocky substrates and roads were extracted from land cover and road map of the study area, respectively. (There is no village inside or near the potential distribution of wild goat; roads and mine are considered as the main anthropogenic factor in the study area.) Position of water sources were recorded while fieldworks. DWR is mostly an arid area with few numbers of water sources (constructed water troughs, water stone and few permanent springs).

Projections, grid cell size and alignment, and spatial extent were manipulated to ensure consistency across all data layers using Arc GIS 9.3. All the files in ASCII format were used as continuous predictor variables apart from vegetation ASCII file which was prepared

for input as categorical predictor variables. MaxEnt is a general-purpose algorithm for estimating a target probability distribution by finding the probability distribution of maximum entropy (closest to uniform) (Phillips *et al.*, 2006). The algorithm was chosen for use in this study because it (1) has performed well when compared with other novel methods (Elith *et al.*, 2006; Gibson *et al.*, 2007; Pearson *et al.*, 2007; Hernandez *et al.*, 2008), (2) does not require absence data, and (3) allows for the incorporation of categorical information (that is, vegetation). All analyses were directed using MaxEnt version 3.3.3e; we used maximum entropy modeling of species' geographic distribution (MaxEnt) to predict the probability of wild goat presence in the spring, summer, and winter. We considered two random samplings of presence data for each season in order to have a correct evaluation of the model, test data or evaluating data and training data or educational data. Based on the study and investigations done, the amount of test data was 25%-30% of the presence data, and the amount of training data was 70%-75% of the presence data. In this research, 70% of presence points were randomly used to produce the model, and the remaining 30% were used to evaluate the results of the model for each season. Cross- validation and times ten replication methods were used for random sampling. "cross-validation" has been used in several studies such as Kang et al. (2006) .

After implementing the model, the output parameters generally include:

Cheetah.html: The main output file which contains statistical calculations, maps, model's image and other links of the file.

Cheetah s.asc: including the plan predicted with ascii format.

Cheetah.png: including predicted distribution image.

Plot: including different maps and graphs to print and use in reports.

Perhaps one of the biggest obstacles to be overcome by MaxEnt pertains to model evaluation and subsequent model selection. A model which can be built is not necessarily informative. Several approaches have been used to assess the significance of developed models (Baldwin, 2009).To estimate model performance, we used Receiver Operating characteristic (ROC) curves. This curve is represented as a graph where the vertical axis represents the sensitivity (true positive) and the horizontal axis represents the specificity (false positives).The area under the curve (AUC) made by values of sensitivity and feature is a quantitative indicator showing the efficiency and predictive power of the model. In other words, The main advantage of ROC analysis is that the area under the ROC curve (AUC) provides a single measure of model performance, independent of any choice of threshold (Phillips *et al.*, 2006). For each run, we calculated the AUC, which is the probability that the classifier orders a random positive and random negative point correctly (Phillips *et al.*, 2004). A perfect classifier therefore has an AUC of 1, although the maximum AUC is less than one because of the use of presence- only data (Wiley *et al.*, 2003; Phillips *et al.*,2004). Generally, AUC values greater than 0.7 are considered to be potentially significant, while scores of 0.5 imply a predictive discrimination that is no better than random (Elith *et al.*, 2006).

RESULTS & DISCUSSION

We recorded 144 presence data during a year and used them along with environmental features of different areas to create seasonal models with the MAXENT method.

The model results suggested that the best method for predicting wild goat habitat suitability was in season summer (AUC = 0.953). The values of AUC for all models can be seen in Table 2. AUC values for all models are > 0.85, implying a potentially significant result.

Jackknifing is another result which MaxEnt gives us. It shows the importance of an environmental variable and its impact on model efficacy should be removed or stands alone. According to the jackknife method, the area under the curve (AUC) in spring for the slope variable was greater; this situation may be due to the fact that wild goat presence points are decreasing in low slopes. The area under the curve (AUC) was greater in summer for the variable of distance from water sources; this situation may be due to the fact that the probability of the presence of wild goats decreases as distance from water sources increases. The area under the curve (AUC) was greater for the variable of vegetation in winter, possibly due to the fact that the probably of the presence of wild goats is very dependent on vegetation, considering the cold and dry weather and unfavorable winter feeding conditions. Finally it can be said that it seems the slope variable in spring, the distance from water sources variable in summer, and the vegetation variable (Artemisia sieberi-Zygophyllum eurypterum) in winter have the most useful information .MaxEnt determines the relative contribution of each variable in the model. Based on the results of the maximum entropy algorithm in this research, the contribution of each variable in the three seasons of spring, summer, and winter to modeling is explained in Table 3. The slope variable with the highest relative contribution (46%) in spring, the variable of distance to water source

Table 2. The values of AUC for Test and Training data in each season

Season	AUC-TRAINING	AUC-TEST
Spring	0.929	0.925
Summer	0.953	0.943
Winter	0.949	0.866

Table 3. Relative contribution of the independent variables to the MaxEnt model

Variables	Percent contribution-Spring	Percent contribution-Summer	Percent contribution-Winter
Aspect	8.7	3.3	1.3
Elevation	0.1	0.2	0.7
Mine	1.2	2.8	2.4
Plant community	21.4	19.6	12
Road	0.9	2.1	2.8
Rocky substrate	13.5	6.9	45.1
Slop	46	9.9	34.2
Water resource	8.2	55.3	1.5

with the highest relative contribution (55.3%) in summer, and the variable of distance to rocky substrate with the highest relative contribution (45.1 %) in winter were recognized as the most important influencing parameters in species distribution and were also used in creating the prediction plan for each season.In spring, the slope variable had 46% of the total changes while other variables had contributions between 0.1% and 21.4%. In summer the variable of distance to water sources was 55% of total changes, and other variables contributed between 0.2% and 19.6%. In winter, the variable of distance to rocky substrate alone had 45% of the total changes while others had contributions between 0.7% and 34.2%.

This is a representation of the MaxEnt model for Capra_aegagrus. Warmer colors show areas with better predicted conditions. White dots show the presence locations used for training, while violet dots show test locations. Desirability on the map of habitat desirability varies from zero to one. Places that are very desirable and the presence probability of wild goat is high are presented in red; places where the presence probability of wild goat is zero are presented in blue; and in places presented in green, the presence probability of wild goat varies from 31% to 77% . Habitat and desirability appropriateness Maps were presented for three seasons in Dareh Anjir Wildlife Refuge using MaxEnt. Then the prepared maps were classified again according to the possible threshold level of the observation of the species under study. Based on the investigations and the experts' ideas, places on the map of desirability of habitat for each season were categorized into two classes of desirable and undesirable. For the spring season, those places with a probability of 0% to 26.6% observation of wild goats were classified as undesirable areas; the regions with a probability of 26.6% to 100% were classified as desirable areas. For the summer, the places with a 0% to 29.2% probability of observing wild goats were classified as undesirable areas, and those places with a probability of 29.2% to 100% were classified as desirable. For winter, the places with a 0% to 330.1% probability of observing wild goats were classified as undesirable areas, and those with a 30.1% to 100% probability were classified as desirable (Fig.2). The undesirable class included those areas where the presence probability of wild goats was the least, while the desirable areas included those areas used by wild goats or having the potential to sustain wild goats. As seen in Table 4, the area of desirable and undesirable habitats in each season is explained based on hectares for Dareh Anjir Wildlife Refuge. Wild goats had the most desirable habitat in spring.

Dareh Anjir Wildlife Refuge is one of the usual habitats of wild goat in Iran, so our model can potentially be used in this region for other habitats, although our results should be evaluated in other habitats through reviewing this study. Based on the results obtained from modeling with a maximum entropy algorithm for the species under study in the Dareh Anjir Wildlife Refuge, the factors with the most effective roles in determining and increasing the desirability of the habitat for wild goat in spring, summer, and winter, were slope, distance from water sources, and distance from rocky substrate, respectively (Table 3). Also the resulted logistic regression models revealed the dependence of wild

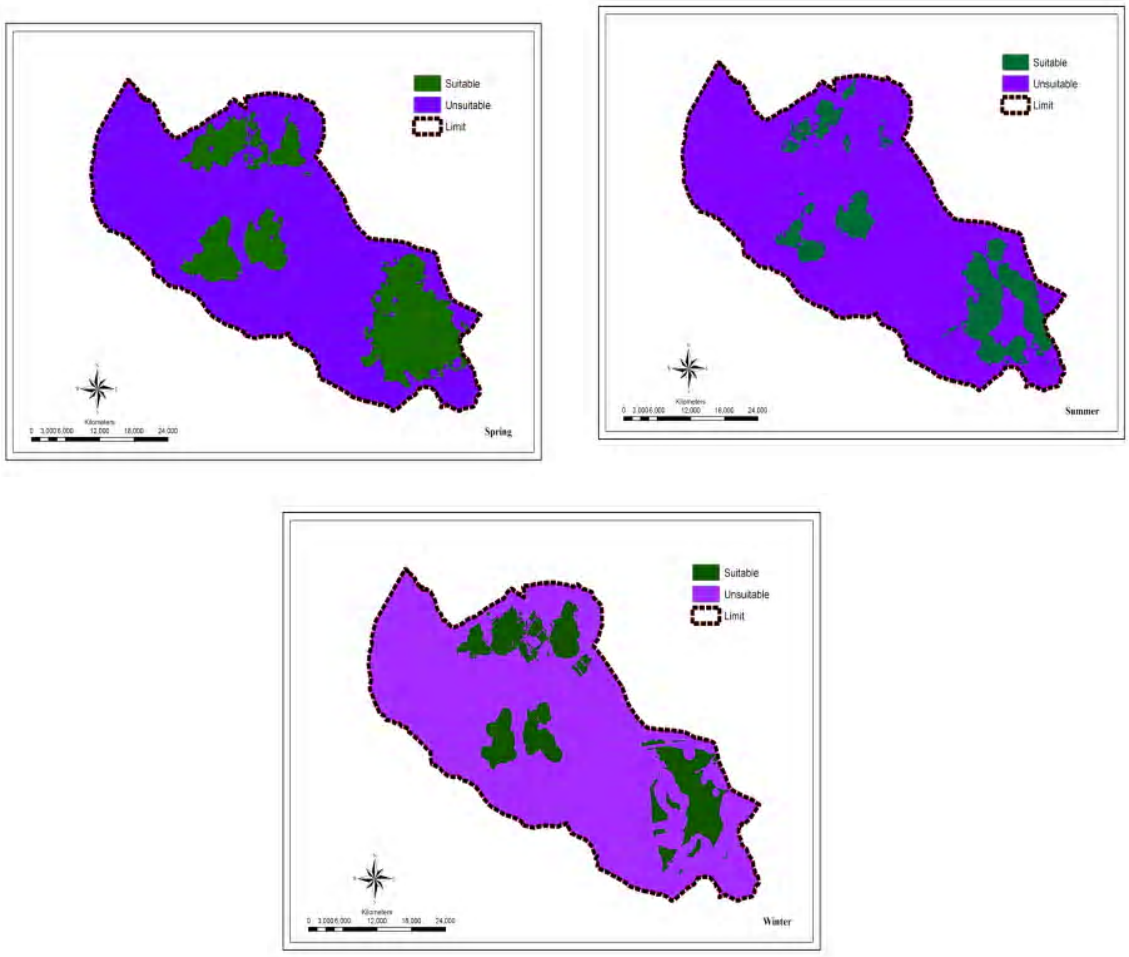

Fig.2. Suitable and Unsuitable habitats for wild goat in different seasons (Dareh Anjir Wildlife Refuge)

Table 4. The area of desirable and undesirable habitat for Dareh Anjir wildlife refuge in spring, summer and winter

Season	Suitable-Ha	Unsuitable-Ha
Spring	41512	133790
Summer	25319	149983
Winter	27822	147480

goat on rocky substrates and steep slopes as was suggested in studies (Genov *et al.*, 2009; Weinberg, 2001; Weinberg *et al.*, 2008). This reflects the anti-predator strategy of wild goat, which is imposed by its morphological characteristics. The relatively short and muscular legs of wild goat support its agility in steep and rugged rocky substrates where it retreats to avoid predators (Harrington, 1977; Ziaie, 2008). The maps of obtained desirability in three seasons indicated that the most desirable habitat in Dareh Anjir Wildlife Refuge is located at the height of 1000 to 2600 meters above sea level and sloped at 0% to 65%. In their 2010 study, Farashi et al. used the ENFA method to estimate the slope and height of the desirable habitat of wild goat in Kolah Ghazi National Park, located in the provinces of Esfahan, at more than 30% slope and an elevation of 1900 to 2300 meters above sea level or more. Based on the predictions made by maximum entropy algorithm, the northern, central, and southeastern parts of Dareh Anjir Wildlife Refuge are more likely to have wild goats. As noted before, the most important factor in this study for determining

Table 5. The area of slope variable in desirable and undesirable habitats in spring

Slope	Suitable-ha	Unsuitable-ha
1: 0-2	23.183388	20370.46875
2: 2-5	1371.6837	65686.26563
3: 5-8	4203.9209	25061.24219
4: 8-12	6827.5073	9945.672852
5: 12-15	3871.6257	3087.254395
6: 15-20	5660.6104	3720.933594
7: 20-30	8338.292	2882.467773
8: 30-65	10192.963	2650.634033
9: +65	1043.2524	189.3309937

habitat desirability of the wild goat in spring was the slope variable. As seen in Table 5, a slope of 30% to 65% has the most area (10,192.963 hectares) of desirable habitat in spring, and the presence probability of wild goats in the region is more than that of other regions, so it has a special importance.

In summer, the most important variable to determine and increase the desirability of the wild goat habitat and predicting desirable areas for the presence of wild goats in the region was the variable of distance from water sources. We could only identify water sources such as springs, wells (Abedi *et al.*, 2014), and stone troughs. The results of the maximum entropy algorithm models showed that water sources, especially in summer, are important in the desirability of the wild goat habitat. Our observations of wild goats frequently moving to water sources proved this idea; therefore it can be considered a factor in areas climatically similar to Dareh Anjir Wildlife Refuge. Wild goats depend on water more in winter and spring than in summer.

131 hectares of water sources are located in desirable regions and 58 hectares are in undesirable regions of the studied area. Thus, the fact that this variable is important to the region's presence probability of wild goats in summer, and keeping in mind the recent years' regional droughts, the application of management measures and improvement in conditions, unfavorable habitats with good water resources can be prioritized and can be led to favorable conditions.

The response curve of the variable of distance from water sources showed that the more distant from water sources, the less the presence probability of wild goats will be (Fig.3).

A comparison of the habitat desirability map with distribution points of water sources indicated that the classes which have the most desirability for wild goats also have the most water sources distribution (Fig.4). This indicates the consistency of the resulting model with the reality of the habitat.

Based on the results obtained from modeling, the variable of distance from rocky substrate was considered the most important factor to increase the desirability of the habitat and predicting desirable regions for wild goat presence in winter. 7424 hectares of rocky substrate are located in desirable regions, and 1243 hectares are in undesirable regions. Due to the harsh winter conditions, the wild goats come to live on the rocky substrate. The response curve of the variable of distance from rocky substrate shows that the farther the distance from rocky substrate is, the less the probability of presence and observation of wild goats will be (Fig.5).

In their 2010 study of the protected region of Haftad Ghole in the province of Markazi, Shams et al. used logistic regression and concluded that the habitats used by wild goat in all seasons are usually steep slopes, rocky substrates, and water sources, on slopes away from the west and in regions away from roads. Also it can be said that from those items which are indicative of the adaptation of the model with reality, the comparison of the most desirable levels habitat with available statistics is obtained from the observation of wild goats during the past years. Based on this fact, most observations in the past years have been made at points which overlap the desirability of habitat in three seasons. So, we reached the conclusion that the current habitat for wild goats in Dareh Anjir Wildlife Refuge is greater than the habitats now used by these species. If the region can be managed properly, it would protect more wild goats than the maximum number ever existed. Our study was done in the Steppe habitat and did not include other habitats (like forest) which are ranges of the geographic distribution of wild goats in Iran. Studying other habitats may produce a range of results which differ from ours. Obtaining more knowledge about the ecology of wild goats and selecting a better characteristic than predictors, may help to improve and develop the model in the future.

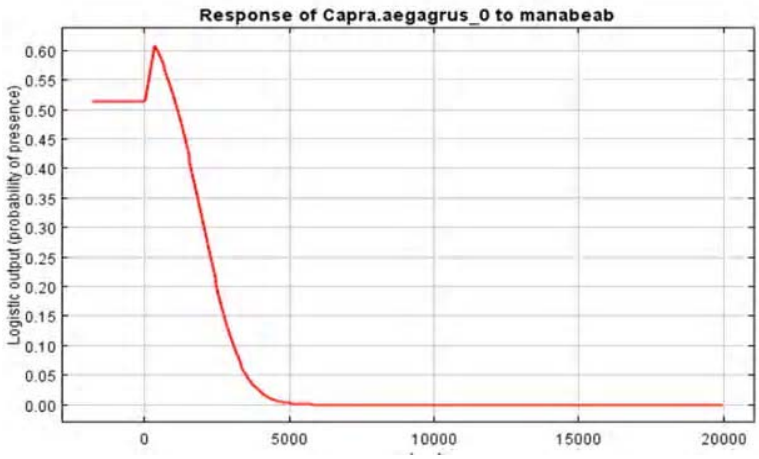

Fig. 3. The Response curve of the variable of distance from water sources in summer

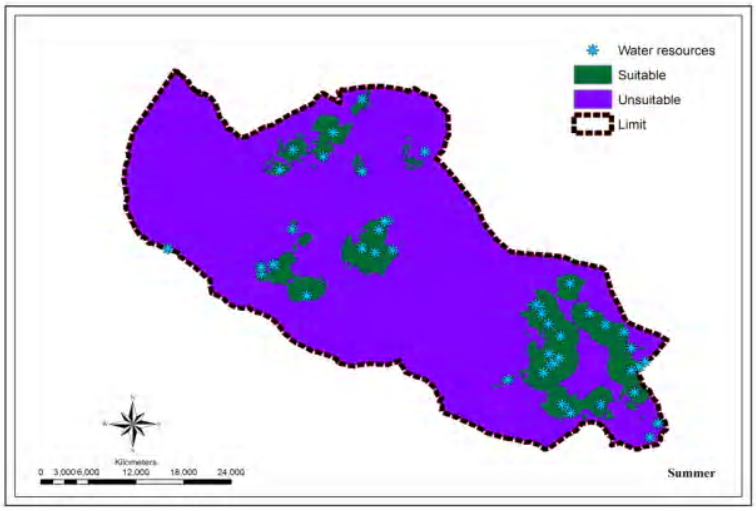

Fig. 4. the map of habitat desirability of wild goat in summer and how the distribution of water source in Dareh Anjir wildlife refuge

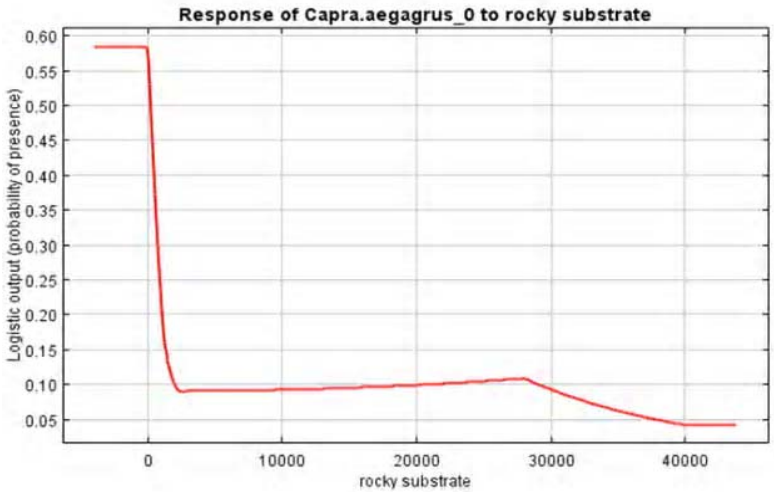

Fig. 5. The Response curve of the variable of distance from rocky substrate in winter

CONCLUSION

Evaluation potential areas for Capra aegagrus can be considered as one of the most important steps toward conservation of the wild goat. It can also help managers and officials to identify and protect more desirable areas. For instance, the northern, central and southeastern habitat regions of Dareh Anjir Wildlife Refuge, when compared with its other areas, seem to have wilder goat protection strategies, and more attention should be paid to them. The patterns of desirable changes of habitat in different seasons should be considered by the region's officials in order to plan more effective wild goat protection strategies. It needs to be said that each season requires its own special, clear-cut plan that considers its features. Spring, which coincides with the lambing of wild goats, is vital for the management and conservation of wild goats. State Environmental Protection Administration reports show that hunters who trap newborn lambs in spring are one of the major threats to wild goat populations. Local people who enter the goats' habitat to gather herbs can be another threatening factor; it is illegal, yet continues to be a problem in the region. Thus in order to better protection of wild goats in spring, the prediction map of distribution could be used to determine the total region under protection. The state office can also increase desirable habitats in Dareh Anjir Wildlife Refuge for wild goats and other species, especially the Asiatic cheetah, by planning and implementing training programs to improve local knowledge of the importance of the region and the species.Since summer is the season of heat and dehydration, one of the controllable variables which affect the desirable habitats of wild goat is its water sources. The simplest way to increase desirable wild goat habitats in the study region is to manage existing water sources and produce more. Finally it is recommended that the desirable habitat modeling be used in Iran's wildlife species recovery projects. Using these models, managers and officials can not only identify the important, controllable variables which have the most effects on the desirable habitats of target species, but also create new populations by identifying desirable habitats and planning more successful projects.

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