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Assessing Regional Habitat Changes for the Persian fallow deer (*Dama dama mesopotamicus*) using Maximum Entropy modeling approach in Khouzestan province, Iran

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ABSTRACT: This study was conducted in Dez and Karkheh regions in southwestern Iran to model habitat suitability of the Persian fallow deer *Dama dama mesopotamicus* and assessing trend of habitat changes since 1989. A total of 22 confirmed presence records of the species were collected from 1988 to 2003. MaxEnt approach was used to develop habitat suitability model with regards to nine environmental variables, including density of farmlands, forests, and disturbed forests, density of livestock, vegetation, residential areas and distance to the forest edge, residential areas, protected areas and frequency of surface water bodies. After validation of the model for all parameters used for 1989, relative developed map was extrapolated to the habitat conditions in 2007. Comparing the habitat suitability maps developed for 1989 and 2007 reveals that area of suitable habitats for the Persian fallow deer has declined by 30% within 18 years. A total of 1000 ha of forests (within suitable habitats for the species) has been degraded. About 100 ha of these habitats were converted to farmlands and less than 0.5 ha was altered to the residential areas. In addition, area of about 1000 ha has lost the suitability without any land use changes. Currently, reintroduction of the Persian fallow deer to the area is under consideration by Department of Environment of Iran. Therefore, results of this study are recommended for choosing reintroduction sites based on the predicted suitable maps to enhance the probability of survival for reintroduced individuals.

Key words: Persian fallow deer, Southwestern Iran, MaxEnt modeling, Habitat change, Dez and Karkheh regions

INTRODUCTION

The Persian fallow deer (*Dama dama mesopotamica)* is classified as Endangered (EN) on the IUCN Red List of Threatened Species (Masseti and Mertzanidou, 2008). The species was previously abundant across western Asia, some parts of the Middle East such as west of Iran and Iraq to the Mediterranean Sea lane, e.g. countries of Syria, Lebanon and Palestine (Chapman & Chapman, 1997). Followed by habitat degradation and poaching of the specimens, its population has decreased dramatically and its dispersal is now restricted to the forests and woodlands existed in surroundings of Dez and Karkheh Rivers in Khuzistan province (Rabiei, 1995). Until 1945, it was thought that the species is extinct. In 1956 a small population of the Persian fallow deer was found in Dez and Karkheh regions. However, in the recent decade no reliable report of the species has been recorded in these regions (DoE unpublished data). Since 1953, a program concerning management of the species' captive population has begun while six deer were translocated from Karkheh region to an enclosure in Dasht-e-naz region located in Sari Township, Northern Iran. Later in 2007 and 2008, about 70 deer were translocated from Ashk Island (in Lake Urmia) and Dasht-e-naz region to two enclosures established in forests and woodlands close to the Dez and Karkheh Rivers (DoE unpublished records). According to the DoE annual wildlife census (unpublished), current population and the number of enclosures for conservation of this species have increased and more than 450 deer exist in a total of 13 enclosures established all over the country. Subsequently, a scientific and research-based planning is critical for improving management of the program and evaluating feasibility of successful reintroduction of a part of deer captive population to its previous and potential habitats. Two captive populations in Dez and Karkheh regions provide an opportunity for

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reintroduction of this species to the natural habitats in the region. For further planning, a good understanding to the Persian fallow deer habitat requirements and identification of available suitable habitats are essential. Habitat suitability models using GIS and multi-variable statistical analysis identify the factors effecting probability of presence of the species and describe the relationship between species and its habitat (Guisan and Zimmerman 2000). Various researchers have used these approaches (e.g. ENFA, MAXENT) to address suitability of habitats of a number of species in Iran such as the wild goat *Capra aegagrus* (Sarhangzadeh *et al*., 2013), wild sheep *Ovis orientalis* (Bashari and Hemami, 2013) and leopard *Panthera pardus* (e.g. Erfanian *et al*., 2012; Sanei *et al*., 2013; Taghdisi *et al*., 2013). However, ecological information (in particular habitat suitability) concerning the Persian fallow deer is still scarce (Heidemann, 1994). Therefore, in this research historical presence points of the Persian fallow deer in Dez and Karkheh protected areas and national parks is investigated. Using these data, we aimed to analyze the relation between environmental factors and species dispersal together with developing the habitat suitability model and relative classifications to the suitable and non-suitable areas. Moreover, understanding the habitat requirements of species could help managers to choose reintroduction sites more properly.

MATERIALS & METHODS

Dez Protected Area and National Park with an area of 21,952 ha is distributed along the Dez River from south of Dezful to north of Ahwaz (i.e. about 80 km) with geographical coordinates of 31° 35´ to 32° 12´ N and 48° 22´ to 48° 51´ E. Karkheh PA and NP with an area of 15,829 ha is distributed along the Karkheh River from Shush to north of Ahwaz for about 100 km with geographical coordinates of 31° 36´ to 32° 20´ N and 48° 09´ to 48° 35´ E (Fig. 1). These regions were designated as protected areas in 1967. However, in order to conserve the Persian fallow deer some parts of these regions were designated as wildlife refuges in 1975 and then national parks in 2011.

Dez and Karkheh PAs and NPs are covered by forests and woodlands which are very rich in fauna and flora. These areas contain 40 mammal species sp., 160 bird species sp., 54 reptiles, 30 fish, 4 amphibians and 320 plant species (Ziaei, 2008). It is worth mentioning that the regionally extinct Persian lion (*Panthera leo persica*) was once inhabiting in this region (Firuz, 2000). Average annual precipitation in Dez and Karkheh regions are 243 and 285 mm/y with average annual temperature of 23° C and 25° C (Annual Meteorological Records of Iran, 2003), respectively. In terms of local communities about 140 villages, with a total population of more than 60,000 people, are located inside and around the study site. Occupation of local communities is mostly farming and animal husbandry (Geographical Organization of Iranian Ministry of Defense, 2011).

Data collection was done from September to December 2012 via field surveys, interviews with knowledgeable people and studying DoE reports. Interviews with in-service and retired wildlife wardens were carried out in order to assess any deer presence report in the region. Relative annual and daily wildlife reports were obtained from provincial DoE of Khouzestan province. A total of 22 deer presence localities were recorded all of which belonged to the years earlier than 2003. Subsequently, field surveys were conducted in Dez and Karkheh PAs and NPs to

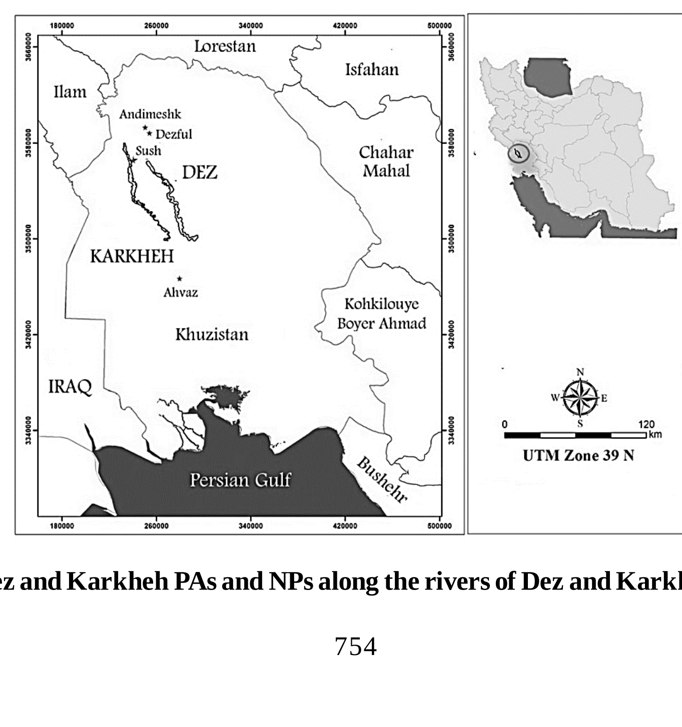

Fig. 1. Location of Dez and Karkheh PAs and NPs along the rivers of Dez and Karkheh in southwest of Iran

record GPS points of assessed presence locations. Geographical coordinates of recorded presence points were saved (in UTM system) as a CSV file to be used for MAXENT modeling.

Considering related literature, studying species behavior, interviews with local experts and knowledgeable wildlife wardens, captive deer populations in Dez and Karkheh regions as well as the characteristics of the study area, a total of 10 environmental variables were selected for habitat suitability modeling of the Persian fallow deer in the study area. These included (1) density of livestock, (2) density of residential areas, (3) distance to residential areas, (4) density of farmlands, (5) vegetation density, (6) density of forests, (7) distance to the forest margins, (8) density of disturbed forests, (9) frequency of surface water bodies, and (10) distance to the borders of protected area. Considering the fact that all recorded presence points belonged to the years from 1988 to 2003 and we failed to obtain any reliable presence record afterwards, habitat variables related to 1989 and 2007 (close to the current condition) were considered. Maps of habitat variables were mostly extracted from vegetation and land-use maps of the years 1989 and 2007. Since dispersal of wildlife in the habitats is related to their home range size (Allouche, *et al*., 2008), home range of the species was considered as 2.9 km^2 for further analysis (Bar-David *et al*., 2005).

To develop the map of livestock density, data concerning location of animal husbandries and number of livestock (inside and around the study site up to 1 km from the site boundaries) in 1986 and 2008 were collected from Khouzestan Veterinary Organization. Arc GIS 9.3 (ESRI, 2010) was used to develop the livestock density map whereas a radius of 3 km (maximum movement of livestock during grazing as calculated by interviewing with stockholders) around each pixel of the study area was considered. In terms of residential areas, geographical borders were extracted from the map of vegetation - land use. Focal statistics command of ArcGIS was used to develop density map of this variable for 1989 and 2007. To develop the maps of distance from residential areas in 1989 and 2007, geographical locations of villages inside and outside of the study site (up to 1 km from the site) were recorded.

Map of density of forest vegetation, average distance from borders of protected area, disturbed forest density, frequency of water bodies and density of farm lands were developed for an area equal to the assessed home range of the Persian fallow deer using the command 'focal statistics' of ArcGIS. To address vegetation density, previously developed index of NDVI (Mohammadi *et al*., in press) was used. In this index, increasing NDVI means increasing the vegetation density which subsequently results in higher habitat suitability. Since the study site is not very large, factors of climate, slope and altitude were excluded from the study. Correlation among variables which may cause skewed statistics and false predictions (Hirzel *et al*., 2002; Patthey, 2003; Scheingross, 2007), was considered. Maps were developed with the pixels of 30 m x 30 m and scale of 1:50000.

Since non-detection of the species does not imply certain absence of the animal (MacKenzie *et al*., 2002), presence only data were used for habitat suitability modeling in 1989 via MAXENT software, version 3.3.3 (Phillipes *et al*., 2006). Subsequently, the developed model was generalized using project function of the model to the conditions of 2007. Area under the curve (AUC) was used to assess performance of the modeling. Percent contribution of the variables together with Jackknife test were used to determine the role of each variable in the modeling process. In conjunction of the use of MAXENT software, suitability threshold that maximizes prediction accuracy of presence and background points was used for classification of habitat suitability in years 1989 and 2007. Maps developed for 1989 and 2007 were overlaid using ArcGIS 9.3 to identify the habitats which have lost their suitability during the time span.

RESULTS & DISCUSSION

A total of 22 presence points for the years from 1988 to 2003 were assessed while we failed to record any reliable report of the Persian fallow deer afterwards. Correlation coefficient of selected variables revealed that there is no strong linear relationship among them (r=0.8). Therefore, all the variables were included in the modeling process. Assessed AUC for the model equals to 0.92 indicating that modeling was performed well (Fig. 2). Jackknife test (Fig. 3) illustrates that the most important variables in the modeling were density of farmlands and forests, NDVI index and distance from the forest edge, while density of residential areas had the least influence in the modeling process. Similarly, evaluation of the percent contribution of each variable to the habitat suitability model (Table 1) indicates that density of the farmlands together with NDVI index have the most contribution to the model performance while the least contribution belongs to the density of residential areas.

Results suggest that MaxEnt modeling could efficiently estimate dispersal of suitable habitats for the species using imperfect but well distributed presence data. This finding is also supported by previous studies of Hernandez ***et al*.** (2006), Phillips *et*

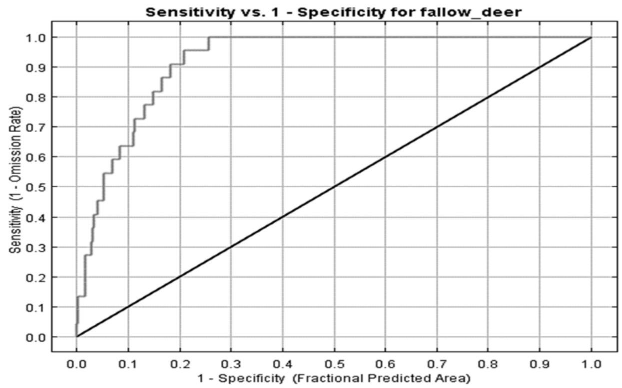

Fig. 2. Area under ROC curve for validation of habitat suitability model. Grey line close to 1, indicates good performance of the model. Grey line near the straight line indicates that the model is not performing better than a random model (Giovanelli *et al*., 2010).

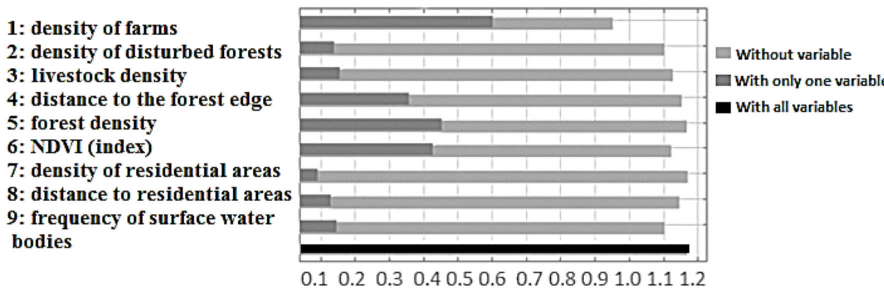

Fig. 3. Jackknife test addressing importance of each variable on habitat suitability model. Light grey lines indicate model performance when variables are excluded from the set of variables and dark grey lines indicate performance of the test when each variable is included separately.

Table 1. Percent contribution of environmental variables in the habitat suitability modeling of the Persian fallow deer

Environmental variables	Percent contribution
Density of farmlands	52.3
NDVI (Index)	22.4
Density of disturbed forests	7.9
Frequency of surface water bodies	6.4
Livestock density	4.3
Distance to the forest edge	3.6
Distance to residential areas	2.5
Density of forests	0.6
Density of residential areas	0.0

al. (2006) and Giovanelli *et al*. (2010) suggesting maxent a useful tool for habitat suitability modeling with low sample size It is worth mentioning that accurate selection of a set of environmental variables that affect the species occurrence is a key to obtain a reliable distribution modeling output (Behdarvand, 2011). Fig. 4 illustrates that increasing density of farmlands by 15% results in dramatic declines of the habitat suitability for the species. However, increase in NDVI index (i.e. vegetation density) has positive impact on habitat suitability for the Persian fallow deer which means that the species prefers dense habitats. Response curves of habitat suitability for ascending frequency of water bodies and density of disturbed forests shows a general decline as presented in Fig. 4. According to the MaxEnt analysis, suitability threshold equals to 0.327 whereas the model has the highest precision for classification of pixels of the map

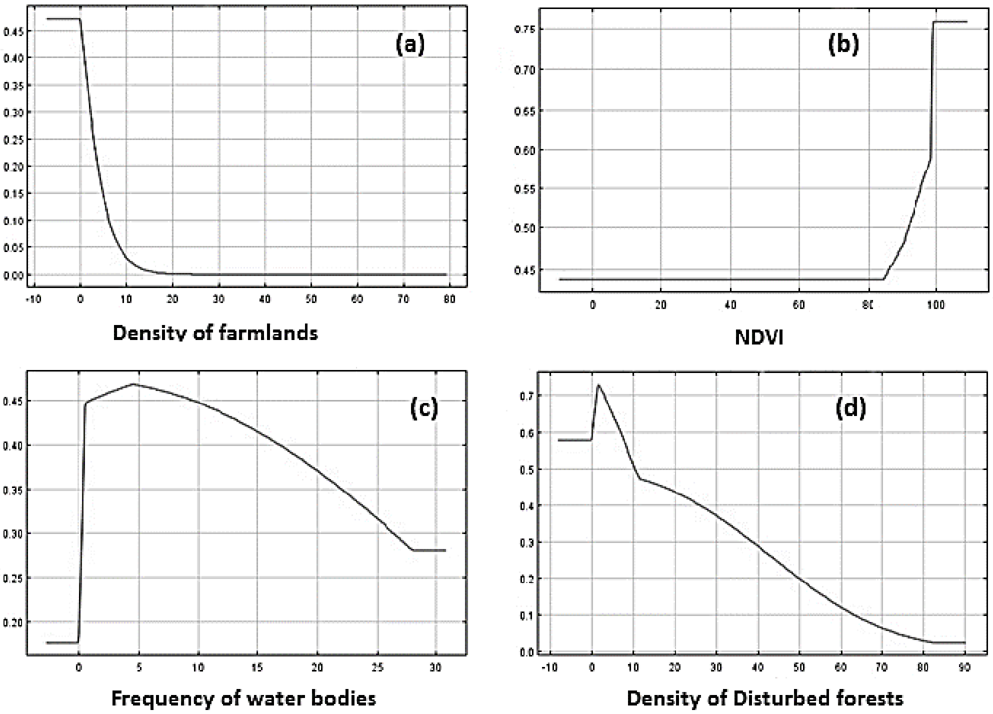

Fig. 4. Response curves of habitat suitability for the Persian fallow deer (vertical axis) to the density of farmlands (a), changes in NDVI index (b), frequency of surface water bodies (c) and density of disturbed forests (d).

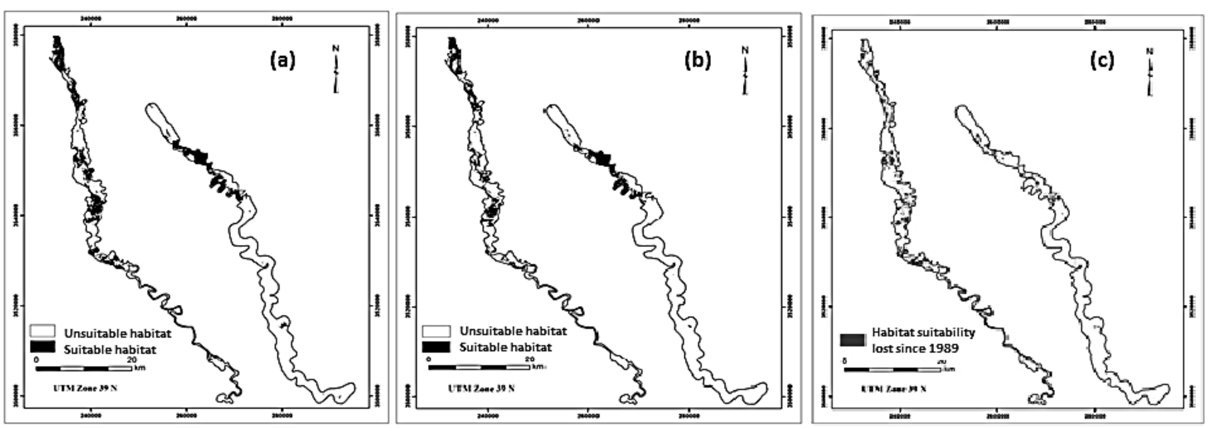

Fig. 5. Habitat suitability classification map of Persian fallow deer in 1989 (a), 2007 (b) and habitats that have lost the suitability (c)

in terms of suitability of the habitats for the Persian fallow deer. Thus, this threshold was used to develop the map of habitat suitability for the Persian fallow deer in 1989 and 2007. Overlaying these two maps (i.e. 1989 and 2007) indicates that the area of suitable habitats decreased by 2,160 ha from 1989 (7739.7 ha) to 2007 (5579.8 ha).

Fig. 5 shows the habitats that lost their suitability during this time span. Overlaying the map of habitat loss with the map of vegetation and land use reveals that from 1989 to 2007 about 1000 ha of forests within suitable habitats have been converted to degraded and sparse forests. Furthermore, 100 ha of these lands were converted to farms and less than 0.5 ha altered to residential areas. However, area of about 1000 ha has lost suitability without any conversion of the land use or vegetation.

It is worth mentioning that in 2007 a total of 5 habitat patches with a total area of 4,300 ha (i.e. 1000 ha, 650 ha, 1250 ha, 600 ha, 800 ha were identified to be larger than the Persian fallow deer home range size. Among these, 3 discrete patches are located in Karkheh PA and NP and 2 patches with an area of 2000 ha were located in Dez PA and NP (Fig. 6). These two patches

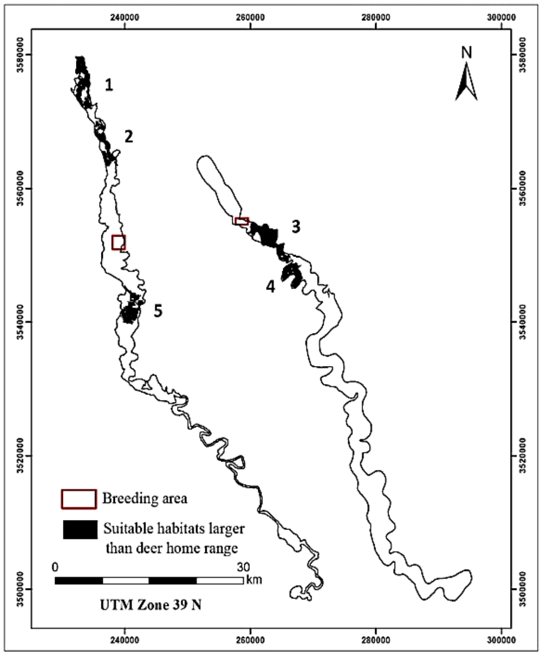

Fig. 6. Location of remained suitable habitat patches with a larger area than the Persian fallow deer home range size (Breeding area was used to breed deers in the study area).

of habitats in Dez PA and NP formed the largest continuous habitat for the Persian fallow deer in the region.

Our findings suggest that increasing density of farmlands result in declines of the habitat suitability for the Persian fallow deer, while increasing density of forests increases the habitat suitability for the species. This could be as a result of the fact that the species is highly dependent to dense vegetation for feeding and refuge. Not surprisingly, increase of frequency of surface water bodies increases the habitat suitability. However, increases in frequency of water bodies by more than 5% causes unsuitability of habitat for the species (Fig. 4-c). In general, increases in density of disturbed forests result in decline of habitat suitability. Increases in habitat suitability when habitat disturbance occurs by few percent could be a result of increases of pasture for grazing in slightly sparse forests (See Fig. 4). This is also supported by reports and observations of local experts and wildlife wardens about behavior of the Persian fallow deer in enclosures. However, when habitat disturbance exceeds 3%, habitat suitability declines dramatically. This could be due to the fact that the species prefers open lands and hills for grazing and forests for refuge and to give birth to the fawns. This is also supported by the studies conducted about habitat selection of the Persian fallow deer using ENFA (Mohammadi, in prep.). Previous studies and documentations about the species also indicate that the Persian fallow deer uses herbaceous plants, branch tips and fruits for feeding. It hides from predators in the thick forests particularly when delivering the fawns (Ziaei, 2008; Hosseinzade rabari *et al.*, 2011).

Results illustrates that suitable habitats have decreased to about 5,580 ha during 18 years from 1989 to 2007 (i.e. 30% decline). This result is comparable to the findings of the study conducted by Madadi *et al.* (2012) indicating 25% decrease in the area of the forests in surrounding of Karkheh River after construction of a dam nearby.

Density of farm lands and livestock as well as human population in the study area is increased by 2, 1.5 and 2.5 times respectively comparing to 3 decades ago (data assessed from Geographical Organization of Iranian Ministry of Defense; Iranian Census Organization – unpublished records). Average annual Debi for Dez and Karkheh Rivers has decreased 6 times comparing to 1970s (data assessed from Energy Ministry of Iran – unpublished records). However, attempts for implementation of water and flood control in Karkheh and Dez Rivers along with construction of a dam resulted in declines of the water fluctuation and soil humidity in lower lands. Detail studies are required to investigate impacts of these factors on vegetation structure of the habitats. Meanwhile, these changes together with decrease of the area of suitable habitats in one hand and dependency of the Persian fallow deer to the forest vegetation for food and refuge in the other hand have led to disappearance of the species in the area for more than a decade.

Since reintroduction of the Persian fallow deer to its original habitat is being considered by DoE managers, the results of this study could be applied for further planning to decrease destructions and restore the habitats for reintroduction of the species captive population to the area. In this regard and considering findings of this research, following issues are recommended to improve habitat suitability for the Persian fallow deer in the region: (1) Enforcement of regulations concerning environmental water rights of Dez and Karkheh Rivers. (2) To conduct further studies in the upper-lands of Dez river whereas more suitable habitats are available comparing to the southern areas. (3) livestock exclusion from the area and (4) to purchase the lands from private land owners inside and around the identified suitable habitat patches in Karkheh and Dez (Fig. 5) to increase habitat safety for the species.

CONCLUSIONS

Our study successfully modelled the habitat association of fallow deer in the past to predict current suitable habitats for species reintroduction. We hope that our research increase the success of further deer management activities. For instance, our results indicated that suitable habitats were turned into unsuitable areas for the Persian fallow deer within 18 years from 1989 to 2007 mostly due to the conversion of the forests to disturbed and degraded forests (50%) and farmlands whereas the issue is more serious in Karkheh region rather than Dez. To re-introduce the species to the region several issues such as private land ownerships in the study area, environmental water rights of Dez and Karkheh Rivers, research and studies on pesticides and plant and animal disease, awareness raising programs for the local communities and livestock exclusion from the area need to be essentially considered.

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REFERENCES

Allouche, O., Steinitz, O., Rotem, D., Rosenfeld, A., Kadmon, R. (2008). Incorporating 30-distance constraints into species distribution models. Journal of Applied Ecology, **45,** 599–609.

Annual Meteorological Records of Iran. (2003). Meteorological Year Book of Iran. (Tehran: Meteorological Organization of Islamic Republic of Iran).

Bar-David, S., Saltz, D. and Dayan, T. (2005). Predicting the spatial dynamics of reintroduced population: the Persian fallow deer. Ecological Applications, **15,** 1833–1846.

Bashari, H. and Hemami, M.R. (2013). A predictive diagnostic model for wild sheep (Ovis orientalis) habitat suitability in Iran. Journal for Nature Conservation, **21,** 319-325.

Behdarvand, N. (2011). Modeling current attacks of wolves to human and livestock in Hamedan. Dissertation, University of Tehran

Chapman, D.I., and Chapman, N.G. (1997). Fallow deer: Their history, distribution and biology. (Machynlleth: Coch-y-bonddu Books).

Erfanian, B., Mirkarimi, S.H., Mahini, A.S. and Rezaei, H.R. (2012). A presence-only habitat suitability model for Persian leopard *Panthera pardus saxicolor* in Golestan National Park, Iran. Wildlife Biology, **19 (2),** 170-178.

ESRI. (2010). ArcGIS Desktop: Release 9.3. Redlands, CA: Environmental System Research Institute.

Firuz, E. (2000). Wildlife of Iran (Vertebrates). (Tehran: University Publication Center).

Geographical Organization of Iranian Ministry of Defense (2011). A guide to the provinces of Iran. (Tehran: Iran Ministry of Defense).

Giovanelli, J.G.R., De Siqueira, M.F., Haddad, C.F.B. and Alexandrino, J. (2010). Modeling a spatially restricted distribution in the Neotropics: how the size of calibration area affects the performance of five presence-only methods. Ecological Modelling, **221,** 215–224.

Guisan, A. and Zimmermann, N.E. (2000). Predictive habitat distribution models in ecology. Ecological Modelling, **135,** 147-186.

Heidemann, G. (1994). Situation of Persian fallow deer (*Cervus dama mesopotamica*) in Iran. Internal report, Institute fur Haustierkunde, Der Christian- Albrechts-Universitat, Kiel, Germany.

Hernandez, P.A., Graham, C.H., Master, L.L. and Albert, D.L. (2006). The effect of sample size and species characteristics on performance of different species distribution modeling methods. Ecography, **29,** 773-785.

Hirzel, A.H., Hausser, J., Chessel, D. and Perrin, N. (2002). Ecological-niche factor analysis: How to compute habitat-suitability maps without absence data? Ecology, **83,** 2027-2036.

Hosseinzade rabari, M. (2011). Estimate feeding carrying capacity of Persian fallow deer in Ashk Island of Lake Urmia. Dissertation. Islamic Azad University, Science and Research branch.

IUCN (2013). IUCN Red List of Threatened Species (Version 2013.2). Retrieved May **29,** 2014 from www.iucnredlist.org.

MacKenzie, D.I., Nichols, J.D., Lachman, G.B., Droege, S., Royle, A. and Langtimm, C.A. (2002). Estimating site occupancy rates when detection probabilities are less than one. Ecology, **83(8),** 2248-2255.

Masseti, M. and Mertzanidou, D. (2008). *Dama dama*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 28 August 2014.

Mohammadi, H., Karami, M., Kiabi, B.H. and Monavari, S.M. (in press). Trend of habitat changes for the Persian fallow deer *Dama dama mesopotamica* in Dez and Karkheh PAs and NPs using RS and GIS. Experimental Animal Biology.

Patthey, P. (2003). Habitat and corridor selection of an expanding red deer (*Cervus elaphus*) population. Dissertation, University of Lausanne.

Phillips, S.J., Anderson, R.P. and Schapire, R.E. (2006). Maximum entropy modeling of species geographic distributions. Ecological Modelling, **190,** 231-259.

Phillips, S.J., Dudlk, M. and Schapire, R.E. (2004). A maximum entropy approach to species distribution modeling. (In proceedings of the 21st international conference on machine learning (655-662). New York: ACM Press.)

Rabiei, A. (1995). Ecology and management of Persian fallow deer. Dissertation. University of Tehran.

Saltz, D. (1996). Minimizing extinction probability due to demographic stochasticity in a reintroduced herd of Persian fallow deer *Dama mesopotamica*. Biological Conservation, **75,** 27-33.

Saltz, D., Zidon, R., Dolev, A., Perelberg, A., King, R. and Berger-Tal, O. (2011). Reintroducing the Persian fallow deer *Dama mesopotamica* in Israel- a chronology. Animal Production Science, **51,** 251-258.

Sanei, A., Gordmardi, E., Jafari, B., Absalan, H. and Zakaria, M. (2013). Persian leopard distribution in relation to human pressures and prey resources in North Khorasan province, Iran (In: F.S. Lai, R. Halis, S.N. Abu Bakar, S. Ramachandran, C.L. Puan (Eds.), proceedings of international forestry graduate students' conference. Malaysia: Universiti Putra Malaysia.)

Sarhangzadeh, J., Yavari, A.R., Hemami, M.R., Jafari, H.R. and Shams-Esfandabad, B. (2013). Habitat suitability modeling for wild goat (*Capra aegagrus*) in a mountainous arid area, central Iran. Caspian Journal of Environmental Science. **11 (1),** 41-51.

Taghdisi, M., Mohammadi, A., Nourani, E., Shokri, S., Rezaie, A. and Kaboli, M. (2013). Diet and habitat use of the endangered Persian Leopard (*Panthera pardus saxicolor*) in northeastern Iran. Turkish Journal of Zoology, **37,** 554-561.

Ziaei, H. (2008). Field guide of Mammals of Iran. (Tehran: Iran wildlife center).