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Habitat distribution modeling of *Halocnemum strobilaceum* and *Artemisia sieberi* species using Maximum Entropy Method (Maxent) in the Qum Province rangelands

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Keywords: Maxent, geostatistics, potential habitat, AUC, Kappa coefficient

Abstract

The objective of this study was to estimate geographical distribution of *Halocnemum strobilaceum* and *Artemisia sieberi* species, finding the most important variables in the distribution of these species, as well as understanding tolerance range of these species to environmental factors in Qum province rangelands. Maps of the environmental variables were constructed using GIS and Geostatistics. Then predictive maps of species distribution using maximum entropy method (Maxent) and presence data species were made. The correspondence of predictive and actual maps was evaluated using Kappa coefficient. As well as, Accuracy of the predictive models was evaluated using the area under the curve (AUC). According to the results, amount of soil gravel factor, the electrical conductivity of first depth and sand content in second depths have the greatest impact on distribution of *Halocnemum strobilaceum* species, whereas lime amount in first soil depth, amount of silt in the first and second depths and acidity of the first soil depth have the greatest role in distribution of *Artemisia sieberi* species. Compliance of the actual and predictive maps for both species was assessed at very satisfactory level (Kappa coefficient was 0.74 and 0.70 for *Halocnemum strobilaceum* and *Artemisia sieberi* species respectively).

Introduction

Predictive modeling of species geographic distributions and habitats identification in different plant species has an important role in the conservation and rehabilitation of rangelands. In recent years, Utilization of predictive modeling of plant geographic distribution species distribution modeling which has been widely used in ecology (Elith et al, 2006; Peterson et al, 2006). Modeling methods that need to presence only data have great importance (Graham et al, 2004). Among these methods the Maximum entropy method can be cited (Phillips et al, 2006).

Maxent is a maximum entropy based machine learning program that estimates the probability distribution for a species' occurrence based on environmental constraints (Phillips et al., 2006). Maxent is an approach for estimating species distribution by presence only data, and environmental variable (continuous or categorical) layers for the study area Maxent which has been found to perform best among many different modeling methods (Elith et al., 2006).

Halocnemum strobilaceum is perennial species in the saline and alkaline rangelands. This species has critical role in forage supplying, soil conservation, preventing erosion and creating a suitable environment for the animals and birds in the rangelands. As well as *Artemisia sieberi* is one of the most important species which has the greatest habitat extent in the steppe rangelands of Iran. The main objective of this study were to assess the geographical distribution of species, finding the most important variables in the habitat distribution for each species and exploring similarities and differences between two species in terms of habitat preference.

The study area

The study area is located in the central part of Qum province in geographic coordinate's 50' 50° 30'' to 50' 54° 30'' E and 34'59° 30'' to 35' 03° 30'' N. Minimum and maximum altitudes in the study area are 796 and 1100 meters above sea level, respectively. Figure (1) shows the general location of the study area.

Methods

Environmental predictor variables

Vegetation sampling (Name of plant species and canopy cover percent) was carried out using random systematic method. The plot size was determined using Minimal Area method from 2 to 25 m^2. The used sample size was determined 60 plots. In order to soil sampling at each habitat, eight holes were drilled and samples were taken from 0-30 and 30-80 depths. Using geostatistical and kriging interpolation method with the same spatial resolution soil digital layers were prepared and stored in GIS. Arc GIS 9.3 and GS^+ Version fifth software were used for mapping soil properties. Principal component analysis (PCA) was used in order to data redaction and reducing the number of input variables in the Maxent model. The area under the receiver operating characteristic function (AUC) was used for evaluation of the discrimination ability (Fielding and Bell, 1997). Also Jackknife analysis was used to determine the importance of variables. We used the freely available MAXENT software.

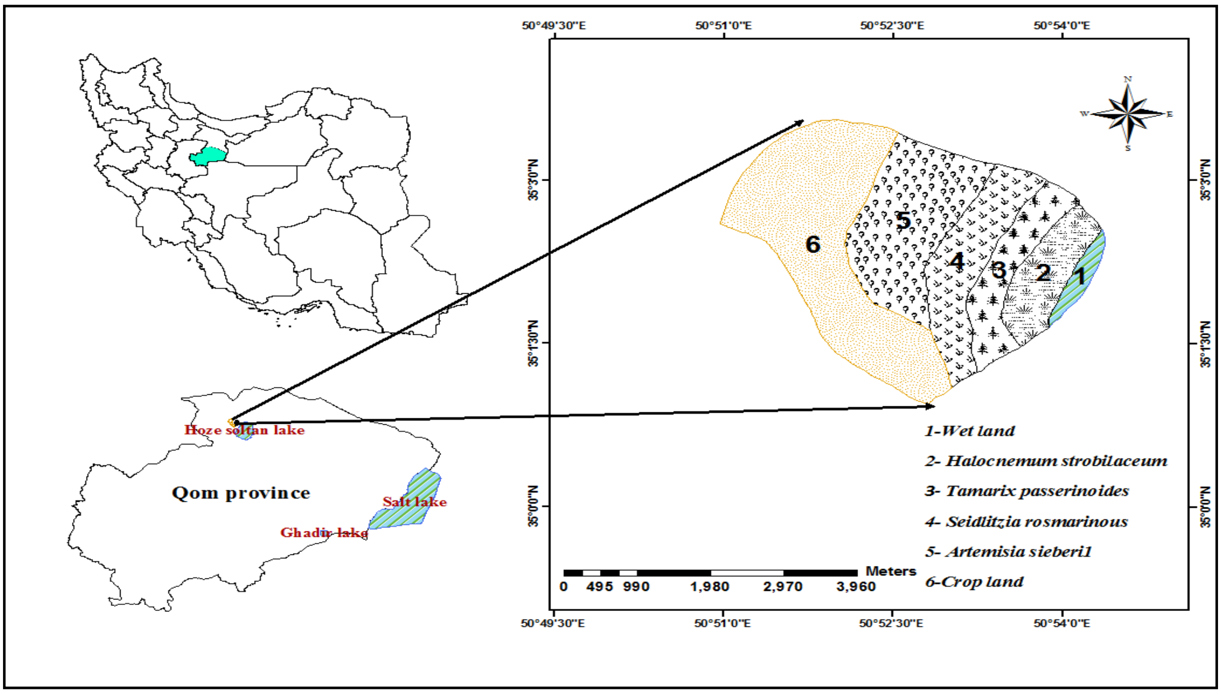

Figure 1. General location and vegetation types map of the study area. The study area is situated in the west Hoze soltan lake of Qum province. The vegetation around the lake is the strip mode.

Results

1. Species distribution maps

Conformity of the species distribution maps of the two species which were derived using layer of environmental variables at each habitat, with actual maps, was determined by measuring the kappa coefficient using Idrisi software. Based on the obtained kappa coefficients, predictive maps for both *Halocnemum strobilaceum* and *Artemisia sieberi* habitats have a very good compliance with actual maps (Table 1).

Table 1. Presence optimal threshold and maps compliance between predictive and actual maps of each habitat in the study area

No.	Habitat	Optimal threshold	Kappa	Level of agreement
1	*Halocnemum strobilaceum*	0.1	0.74	Very good
2	*Artemisia sieberi1*	0.3	0.7	Very good

2. Predictor variable importance

Based on the jackknife operation results (Figure 3), gravel 1 and gravel 2, Ec1 and sand 2 significantly affects habitat distribution of *Halocnemum strobilaceum* when used individually followed by silt1 and gyps2 whereas in the *Artemisia sieberi* habitat, lime, Ph1 and Silt2 were identified as the most important variables. Therefore the mentioned variables have the most useful information for studied species and can provide valuable information about habitat distribution of plant species.

3. Response curves

Response curve analysis of the most important variables in the *Halocnemum strobilaceum* habitat distribution Indicates that areas with 0-5 gravel percent are the most suitable habitats for this species and presence probability of this species by increasing in amount of gravel, significantly reduced. These curves also Indicates that the presence of these habitats are most likely to occur in soils with high electrical conductivity (150 to 200 ds/m); So soils with high salinity can make the suitable habitat for this species. *Artemisia sieberi* response curves also showed that increasing in the first depth lime and silt amount in the first and second soil depths reduce the presence probability of this species but increasing in the soil acidity to 8.5 increases the presence probability of this species. Therefore it can be concluded that the habitat with high levels of first depth lime (from14 to 16%), first and second depth silt approximately 5 to 10 percent and high Ph values (from 8.4 to 8.8), can provide suitable habitat for this species.

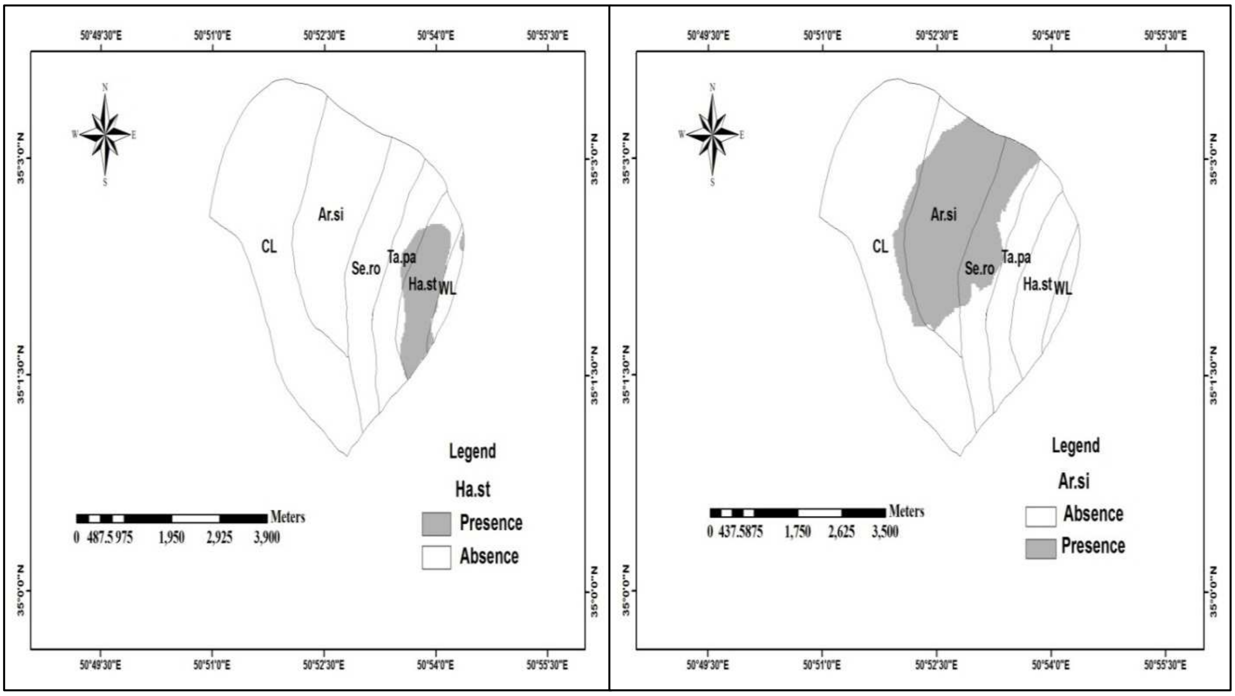

Figure 2.Predictive and actual species distribution maps for *H. strobilaceum* and *A. sieberi* (predictive maps shown darker*)*

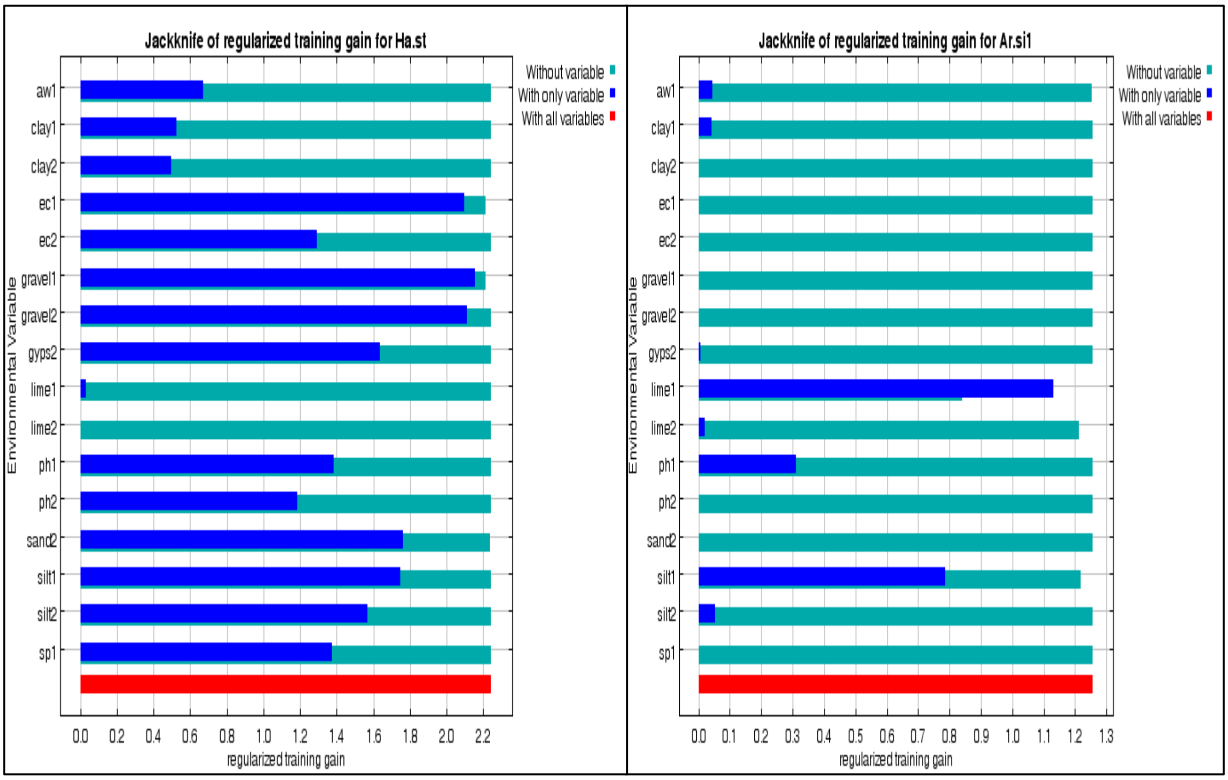

Figure 3. Jackknife results of variable importance

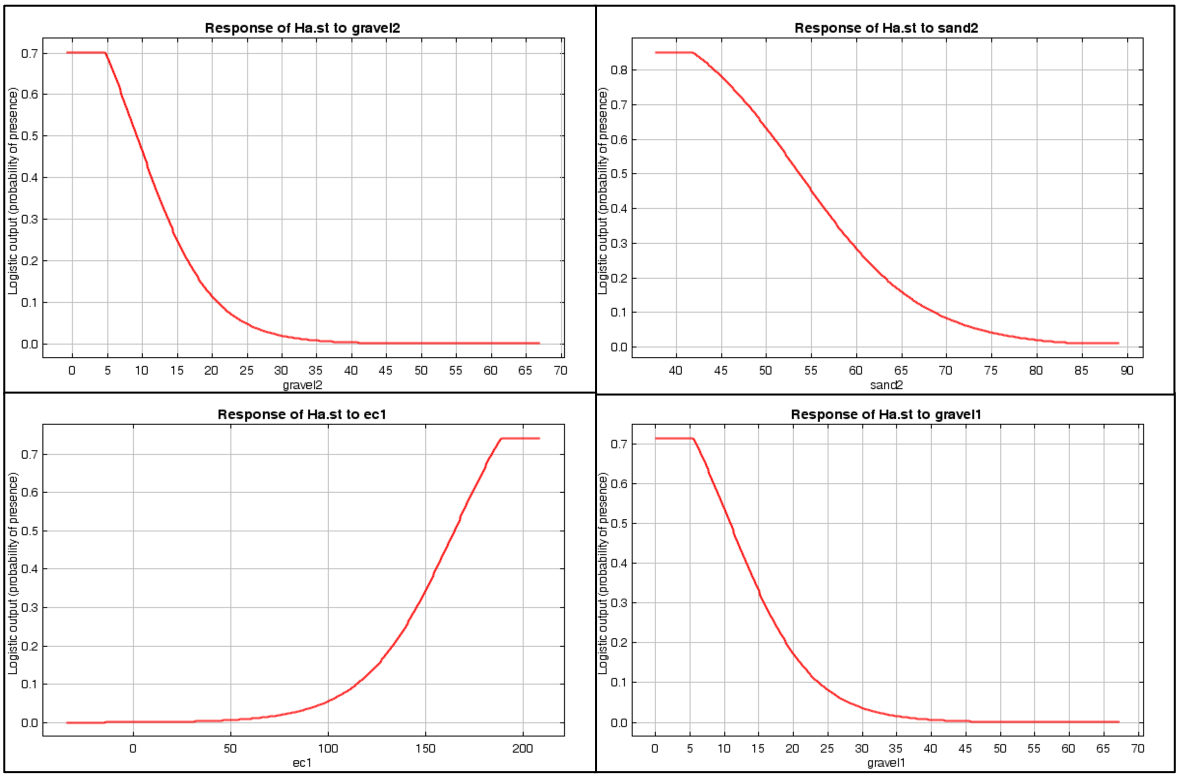

Figure 4. Response curves of the most influential predictors for Halocnemum strobilaceum

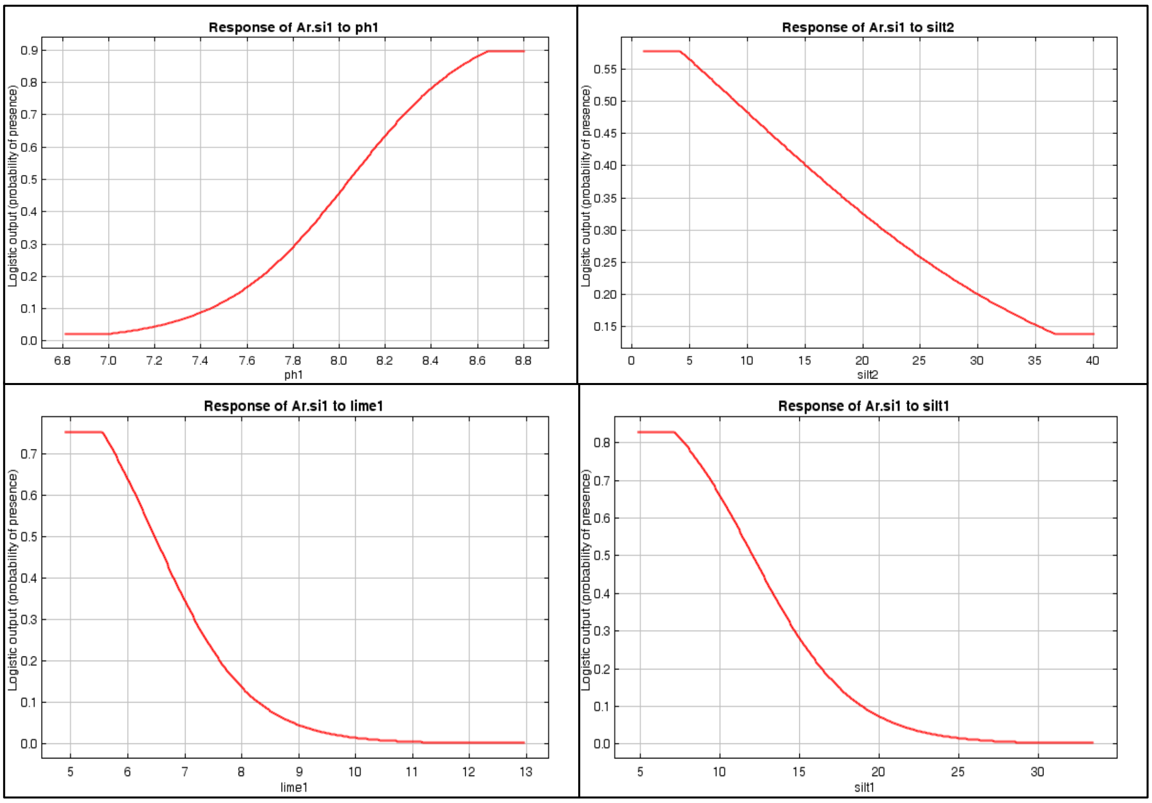

Figure 5. Response curves of the most influential predictors for *A. sieberi*

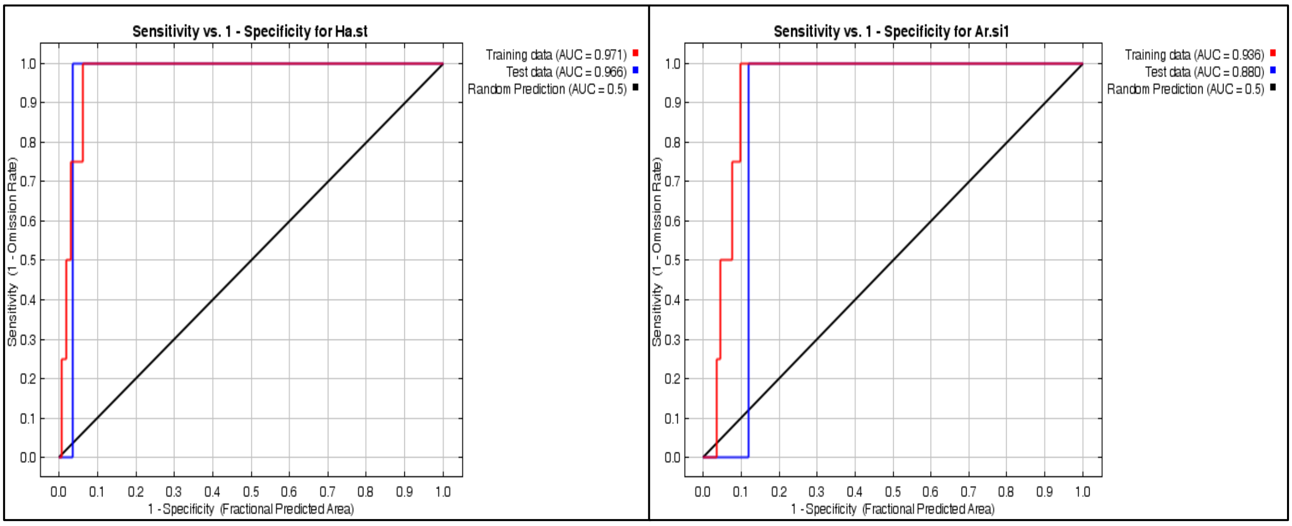

Figure 6. ROC curves of sensitivity vs. specificity

Discussion

The result showed that the electrical conductivity in the Hoze sultan margin is very high, but with distance increasing from the center of playa, decreases soil salinity. On the other hand, soil texture has been coarse and conditions for the species which are less resistant to the salinity have been favorable. These results indicate which vegetation changes in the study area obey from the soil properties gradients. Based on jackknife graphs (Figure 3), increasing in the electrical conductivity has a positive impact on the habitat distribution of the *Halocnemum strobilaceum* and increases habitat suitability for the establishment of this species whereas; gravel amount increasing reduces habitat suitability of this species. This finding is consistent with the results of Zare Chahouki (2012) and Azarnivand et al (2010). The researchers have stated that *H. strobilaceum* species is the most resistant species to salinity. Based on the results these studies this species is able to tolerate a wide range of salinity (1.7 to 147 mg /m/ cm). That is why that this plant species forms pure communities around too salty lakes in arid regions (Tug Gul et al, 2008; Qu et al, 2008). In other words, Soils with high salt and electrical conductivity could be habitat representative of this species (Khalasi et al, 2011). These findings confirm to the results of the present investigation.

According to the results, with getting away from Playa center and thereby salinity reduction and increasing in the gravel and limestone amount soils*, Artemisia sieberi* species has established. Habitat requirements study of this species indicates that the highest presence probability of the *Artemisia sieberi* is in areas with high lime content and accordingly is expressed that *Artemisia sieberi* is Lime-loving plant and its density has an inverse relationship with salinity (Zare chahouki, 2011; Hosseini et al, 2013). Lime effect on plant growth through its effects on acidity as well as reduce availability of micronutrients such as zinc and manganese has been emphasized in several studies (kourori & khoshnavis, 2002; Zare chahouki, 2012).

Interpretation of the maximum entropy results should be performed with caution, since in the maximum entropy method variable importance is determined based on the Maxent algorithm, which is different from the other methods used (Phillips et al, 2006). As well as maximum entropy method is a generative method in contrast to GLM and GAM which are regarded as diagnostic methods, and can provide better predictions when the training data are limited (Ng & Jordan, 2001). Maxent results provide key information about the species tolerance to effective environmental variables which these information could be used in the preservation of susceptible and endangered habitats, so this method is useful in the preventing the invasion of invader species in this habitat, managers can also use the results of this method for optimal management of resources and performing of rehabilitation action in the relevant areas.

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