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Determination of Potential Habitat of Two Rangeland Species in Semi-Desert Area Using GIS (Case Study: Watershed of Kolah Deraz, Qasr-e-Shirin, Iran)

Ali Mahdavi[A], Mojtaba Jamshidifard[B]

[A]Assistant Professor, Department of Forest Sciences, Faculty of Agriculture and Natural Resources, University of Ilam, Iran (Corresponding Author), Email: a_amoli646@yahoo.com
[B]M.Sc. in Combat to Desertification, General Natural Resource Office of Kermanshah, Iran

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Abstract. To determine the potential habitat of two rangeland species of *Salsola rigida* and *Agropyron trichophorum* in Qasr-e-Shirin, Iran, Geographic Information Systems (GIS) and Remote Sensing (RS) techniques were used. At first, several maps (vegetation cover and land uses maps and thematic maps of various organizations) were collected or prepared. For digitizing geology, vegetation and conventional states maps, topographic data layers, soil maps and soil data layers the softwares of ARC/ INFO, ILWIS and TOSCA were used. Land use map of Qasr-e Shirin city was prepared using IRS1 satellite imagery. The current habitats of studied species were determined by visiting the area and limiting it by GPS and marking on map. Three sites for each of species were selected. 10 soil profiles were randomly drilled in depth of 35 cm within each site. The soil parameters such as EC, Texture, pH and organic matter for each sample were measured. The results showed that from the total rangeland area (6270 ha), two locations 1677.3 ha (26%) were fitted for growth of *Salsola rigida* of which 211 ha (3.36%) from this area belongs to original habitats and 1466 ha remained, was belong to the potential habitat. For the second species, the results indicated that two areas totally 1356 ha were habitat of *Agropyron trichophorum* which 167 ha (2.66%) were belonged to the current original habitats and the rest of 1189.8 ha (18.97%) was belonged to the potential habitat for *Agropyron trichophorum*.

Key words: *Salsola rigida*, *Agropyron trichophorum*, Potential habitats, Qasr-e-Shirin, GIS

Introduction

The sustainable management of natural resources requires an exhaustive knowledge of the physical environmental components with particular focus on the relations between these elements and the various plant communities (Mejias *et al*., 2010). As the current spasm of species extinction has become apparent (Debinski *et al*., 1999), land managers and biologists have sought to identify habitats important to the reservation of species diversity. Understanding the potential distribution of rare plant species is a key component in managing and regulating land-use activities (Nock, 2008). Predictive modeling of plant distributions rests on the assumption that correlations exist between the presence and the absence of a species and selected climate, topographic, substrate, and land-cover variables (Nock, 2008). Associations between plants species and their environment (and predictive maps based upon these associations) had significantly improved efforts for plant conservation and management (Elith and Burgman, 2002).

Nowadays, rapidly increasing destruction of natural resources and problem which was caused by desertification seems to be essential to use new techniques to accelerate the identification, control and management of natural resources (Sedighian, 1996; Eshraghi, 1996). Advancements in Geographic Information Systems (GIS) and Remote Sensing (RS) have revolutionized predictive habitat mapping by significantly improving land managers' abilities in order to detail resource inventories, analysis, and management (Vogiatzakis, 2003). Numbers of studies have conducted to evaluate and identify the potential habitat of plant species that we referred to some of them here. Irvani (1999) investigated the potential habitat of three species of *Ferula ovina*, *Cachrys ferulacea* and *Bromus tomentellus* using GIS and RS in Vahregan river watershed of Iran. His results showed that some environmental factors, such as soil texture, depth, limestone and gravel of soils, temperature, slope direction, slope and elevation have influenced on growth and locating of *Bromus tomentellus.* The most important factors were related to soil texture and slope. The survey of prepared maps showed that 19.7% of the area can be considered as a good habitat for *Bromus tomentellus*, 10.4% of the area can be considered as a good habitat for *Ferula ovina* and 3.2% of the area can be considered as a good habitat for *Cachrys ferulacea*. Moradi (1999) had determined the proper habitats for two species of *Calligonum bungei* and *Atriplex lasiantha* in Sistan, Iran using GIS. The results showed that *Atriplex lasiantha* as compared to *Calligonum bungei* was capable of growing in soils with high salinity, low organic matter and light soil texture and tend to grow in acidic soils. Abbasi *et al.* (2009) determined the potential suitable habitat for three industrial and Mediterranean trees species (cypress, black pine and olive) using RS and GIS techniques in forested areas of Armand in Chahar Mahal-Bakhtiari province, Iran. In this study, various maps such as topography, geology, climate, soil, land use, forest cover, irrigation and dry land farming system and rangelands were prepared using TM data. Results showed that approximately 1150, 996 and 5199 ha of the area had suitable potential for habitats of cypress, black pine and olive, respectively. Zaboli *et al.* (2010) determined the potential habitat for two species of *Haloxylon ammodendron* and *Haloxylon aphyllum* in Sistan region using GIS. In this study, the characteristics of *Haloxylon* habitats were investigated and soil sampling was done in order to determine the ecological requirements of two species. The results showed that 3.18% and 3.53% of the area were suitable for growing the *Haloxylon ammodendron* and *Haloxylon aphyllum*, respectively. Gupta and Owais (2000) attempted using GIS techniques to determine the areas that have the potential for planting *Cardamom elettaria* in Ratechaha watershed in Askim at the North and East of India. The results of study showed that 3.39% and 55.21% of the total areas had very good and good potential for cultivation, respectively. Vogiatzakis and Griffiths (2005) had used four variables of elevation, slope, slope aspect and landscape in GIS for prediction of plant communities' distribution in the region of Lefka Ori in Greece. The assessment of the model with field studies showed an overall accuracy rate of 71% as the accuracy for *Crepis cirsium* 100%, for *Herniaria telephium*, 66.7% and lower percent for species of *Peucedanum alyssum* and *Dianthus lomelosia* (63.2 and 62.5%, respectively).

The rangeland ecosystems of the study area (Kolahderaz Qasr-e-Shirin) is destroyed due to the recent droughts and excessive grazing that resulted in soil erosion and loss of vegetation cover and species diversity of this region (General Natural Resource Office of Kermanshah, 2010). Hence, it is essential to adopt a correct way to conserve these ecosystems and trying towards the restoration, rehabilitation and development of rangeland vegetation with resistant species to the condition of the area. In this regard, the indigenous species that is resistant to drought and soil salinity such as *Agropyron* and *Salsola* can be used. Most important reasons for choosing these two species were widely applied in combat desertification and rangelands rehabilitation, fodder and sands stabilization in desert areas of Qasr-e-Shirin. Our study was done on the basis of the following assumption and consideration: the soil properties are the dominant natural environmental factors in the region for determination of potential habitats. Considering mentioned subjects, the main purpose of this study was to determine the potential habitat for two species of *Agropyron trichophorum* and *Salsola rigida* in Kolahderaz watershed of Qasr-e-Shirin using GIS and RS.

Materials and Methods

Study area

Kolahderaz watershed covers an area of 11445 ha located near the city of Qasr-e-Shirin in Kermanshah province. The studied area limited between 45°30'24" to 45°49'12" east longitude and 34°27'15" to 34°38'21" north latitude (Fig. 1). Range of elevation is 813.7 to 347.69 m above sea level in the area. Rainfall is started in the first half of October and ends in early June. Summer is the dry season in the area. Annual rainfall average is 500 mm (Fig. 2). Monthly average maximum and minimum temperature in July and January are 34°C and 9°C respectively, (General Natural Resources Office of Kermanshah Province, 2010).

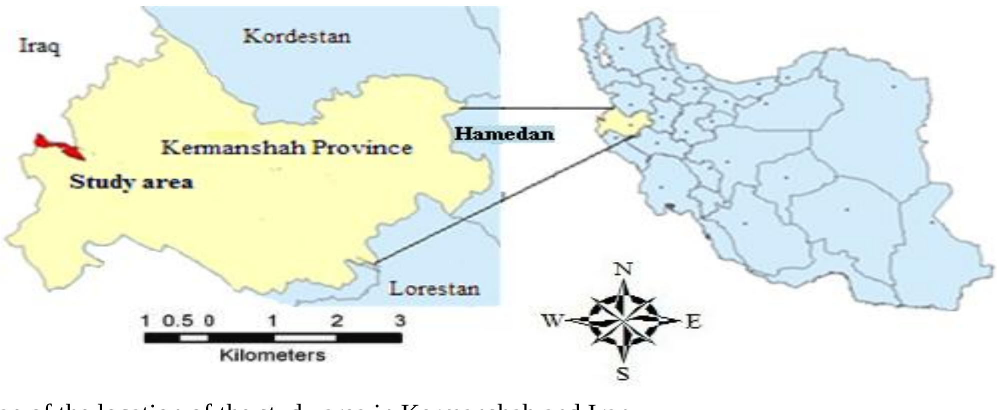

Fig. 1. Map of the location of the study area in Kermanshah and Iran

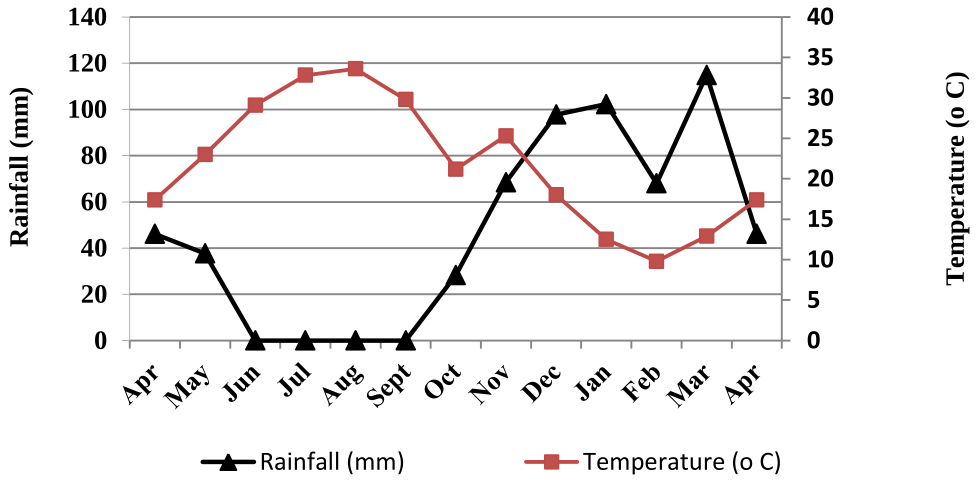

Fig. 2. Omberotermic curve of Qaser-e-Shirin station during 20 years *(*Kermanshah regional meteorological office, 2010*).*

Methodology

Creation of the land use map and determination of present habitats of studied species

The satellite images IRS of the 2011 were used for providing the land uses map of study area. The land uses map was prepared and the area ranges were determined after the field visiting and providing some basic thematic maps from respective organizations (Fig. 3). The present habitats of two species were determined on satellite images and their maps were prepared based on the acquired information from field visits, (Fig. 4). The land use and the current habitats of species maps were created using ARC/ INFO, ILWIS software.

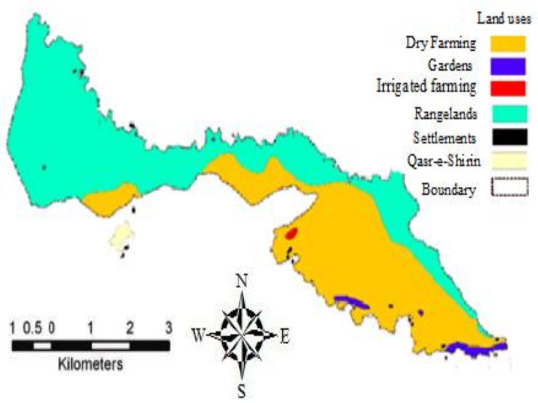

Fig. 3. The land use map of the study area

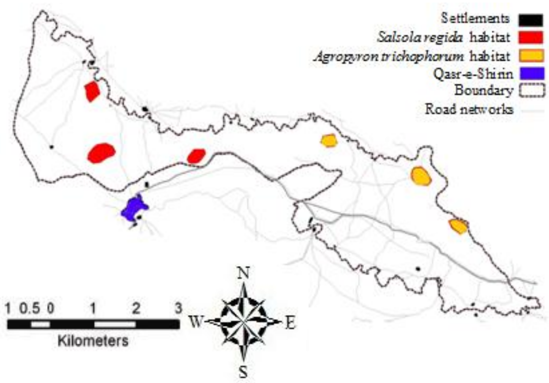

Fig. 4. The map of current habitat of *Salsola regida* and *Agropyron trichophorum* in the study area

Soil sampling

The selection of environmental variables to predict species distributions should include those variables that modulate physical processes and biological response of plant species (Poon and Margules, 2004). The geographical distributions of any plant are limited in the first phase by climatic factors and in the second phase by the soil factors. With regard to this point that the climate and partly physiographic aspects conditions in the study area had the same status, therefore, it seems that the main limiting factor of species in the study area is soil factors. Hence, after identifying the current habitat of the species, soil sampling was done to determine the habitat soil requirements of these two species. Three current sites of both species were selected and 10 profiles in depth of 0-35 cm were randomly drilled in each site and soil samples were taken. Among special features of the soil, the most influential factors in distribution of the studied species that were measured including: soil texture using the particle size and hydrometer methods, electrical conductivity (extraction method and EC apparatus), soil acidity (pH meter tools) and soil organic matter percent (Walkley Black method, Zaboli *et al.*, 2010; Xu *et al.*, 2006).

Creation of various required maps

Required maps of the study area such as vegetation maps, resources and land capabilities map, land use map, Isohyetal curve, Isothermal curve and topography were provided. The ILWIS3.2 software was applied to digitize the maps. The data layers of soil were prepared by the land capability and resources maps. Then the layers of soil texture, EC, pH and soil organic matter were prepared by using these maps, reports and standardizing the data (Figs. 5 to 9). For all polygons of resource and land capability map, the information on various soil parameters was performed based on land units components as separate fields. Each field represents one of the soil factors that were prepared as a separate layer based on land capability maps. In addition, an information layer was prepared for each of the investigated factors of soil. Finally, the suitable habitats for two species on the map were specified by combination of the layers and adjusting with species soil needs. The accuracy of work performance was measured by randomly leaving a part of habitats as control area and didn't consider in the model. After determining appropriate zones of planting for studied species, the control samples were used as the assessment criteria and evaluation of model accuracy in determining suitable habitat (Zaboli *et al.*, 2010).

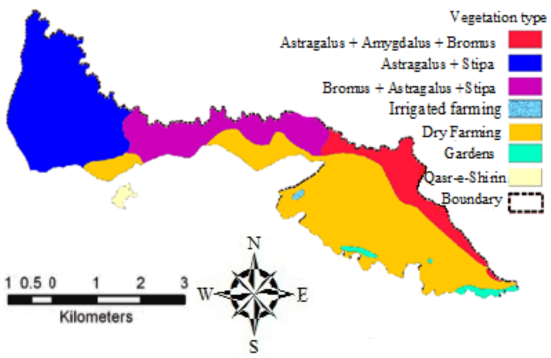

Fig. 5. The map of vegetation type in the study area

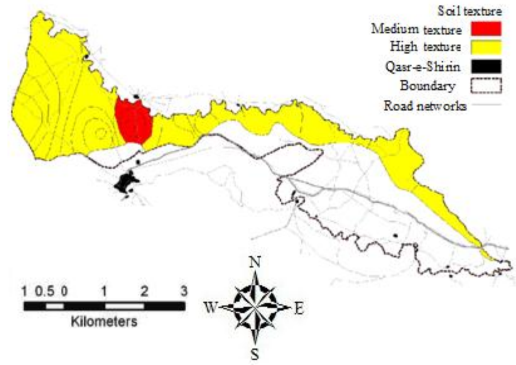

Fig. 6. The map of soil texture in the study area

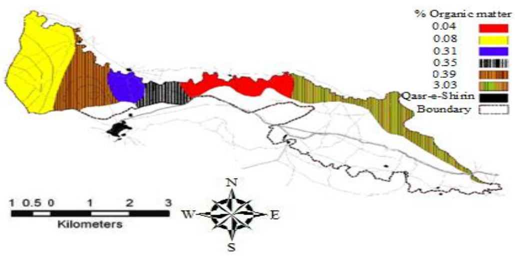

Fig. 7. The map of organic matter percentages of rangeland boundary in the study area

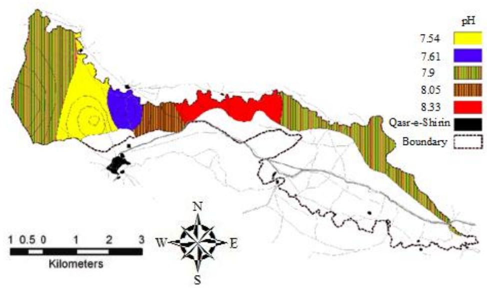

Fig. 8. The map of soil pH of rangeland boundary in the study area

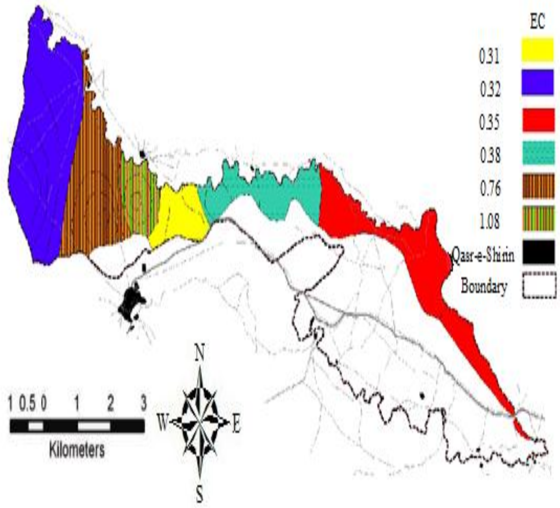

Fig. 9. The map of soil EC of rangeland boundary in the study area

Results

Soil analysis

The results for soil samples analysis are shown in Table 1. As it can be shown, there are differences for some soil characteristics (soil type and texture) between two species. *Salsola regida* in comparison with *Agropyron trichophorum* is growing in a lighter soil type with higher EC values. Comparison of organic matter percentage between soils of two species indicates that the higher OM% is related to *Agropyron trichophorum.* Data on soil properties for *Agropyron trichophorum* and field observations showed that this species is growing in a relatively heavy soil type and in a more degraded area.

Table 1. Soil analysis results of *Salsola rigida* and *Agropyron trichophorum* habitat taken from depth of 35-0cm

Soil Factors	Vegetation Habitat	
	Salsola rigida	*Agropyron trichophorum*
Clay (%)	1.2-9.4	11.4-28.4
Silt (%)	11.6-15.6	51.6-58.28
Sand (%)	75-83.2	13.9-20.2
Organic matter (%)	0.35-0.59	0.44-2.2
EC (dS/m)	0.78-0.31	0.41-0.54
pH	7.4-8.05	7.9-8.15

Determination of the potential habitat for studied species

At this stage, different classified soil data layers for each species were combined based on their ecological requirements using ILWIS software. Then, suitable places (by numerical value of 1) and unsuitable places (with zero values) for each species were determined. Therefore, each layer was converted into a Boolean file. At the end, based on soil test results and investigation of the correlation between ecological characteristics of each species the potential suitable habitats for each studied species were determined (Zaboli *et al*., 2010), (Figs. 10 and 13).

Salsola rigida

The result of soil layers combination showed that 5592 ha (89.18%), 4975 ha (79.3%), 5902 ha (94.1%) and 1677 ha (26.7%) of total studied rangeland area were conditions for *Salsola rigida* in terms of pH, EC, soil texture and organic matter respectively (Figs. 10 to 13).

The results of the integration of all the produced maps showed that there are two appropriate locations for growing *Salsola rigida* that cover 1677.3 ha (26.75%) of the total rangeland area. In addition, the results showed that 211 ha (3.36%) of distinguished area belongs to the current habitat of *Salsola rigida*. Therefore, approximately, 23.39% of the total residual rangeland area (1466 ha) belongs to the potential habitats (Fig. 14).

Agropyron trichophorum

The result of soil layers combination showed that 4665 ha (74.4%), 4225 ha (67.3%), 5902 ha (94.1%) and 3034 ha (48.38%) of total studied rangeland area were suitable conditions for *Agropyron trichophorum* in terms of pH, EC, soil texture and organic matter respectively (Fig.s 10 to 13). The results of the combining of all the produced maps for *Agropyron trichophorum* showed that there are two appropriate places for growing *Agropyron trichophorum* that cover 1356 ha (26.75%) (Fig. 14). The results also showed that 167 ha (2.66%) of this area belongs to the current habitat of *Agropyron trichophorum* and the remained 1189 ha (18.97%) is considering as the potential habitat.

To calculate the overall accuracy for the potential habitat maps of two species, pixel by pixel comparison were made using ground truth. The results show an overall accuracy equal to 95.5% of the obtained maps for both species habitat.

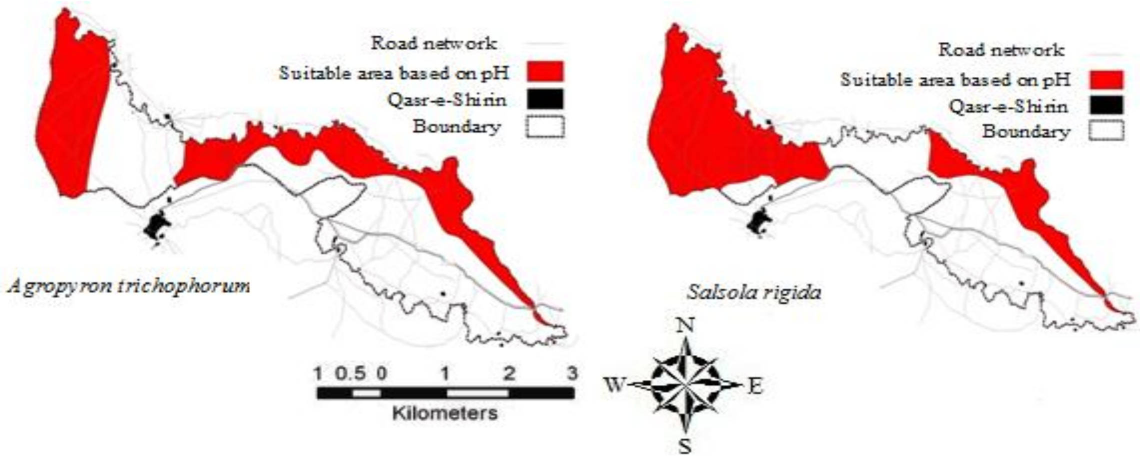

Fig. 10. The map of suitable area for *Agropyron trichophorum* and *Salsola rigida* in terms of pH

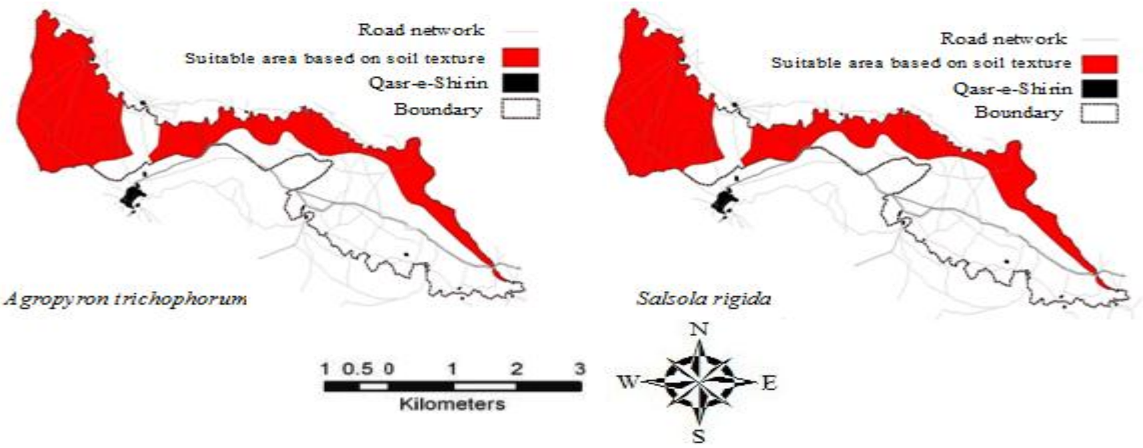

Fig. 11. The map of suitable area for *Agropyron trichophorum* and *Salsola rigida* in terms of soil texture

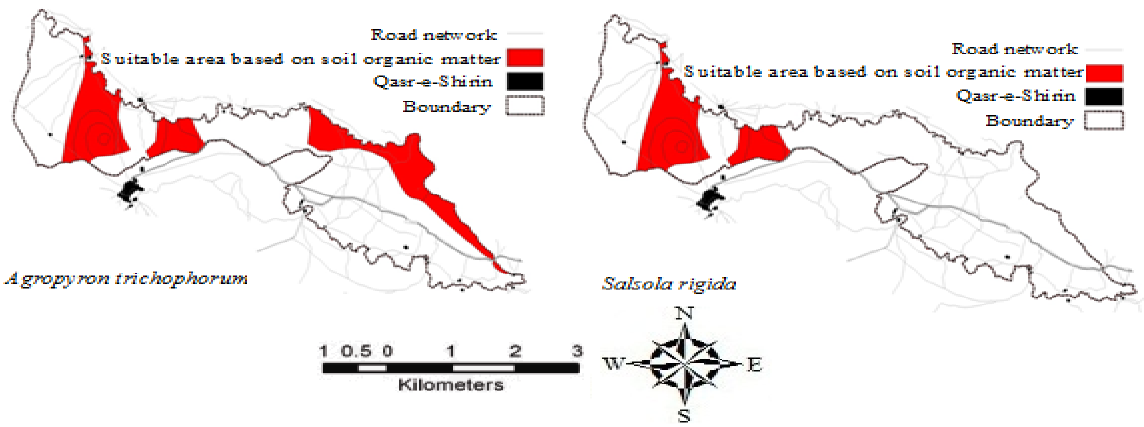

Fig. 12. The map of suitable area for *Agropyron trichophorum* and *Salsola rigida* in terms of soil organic matter

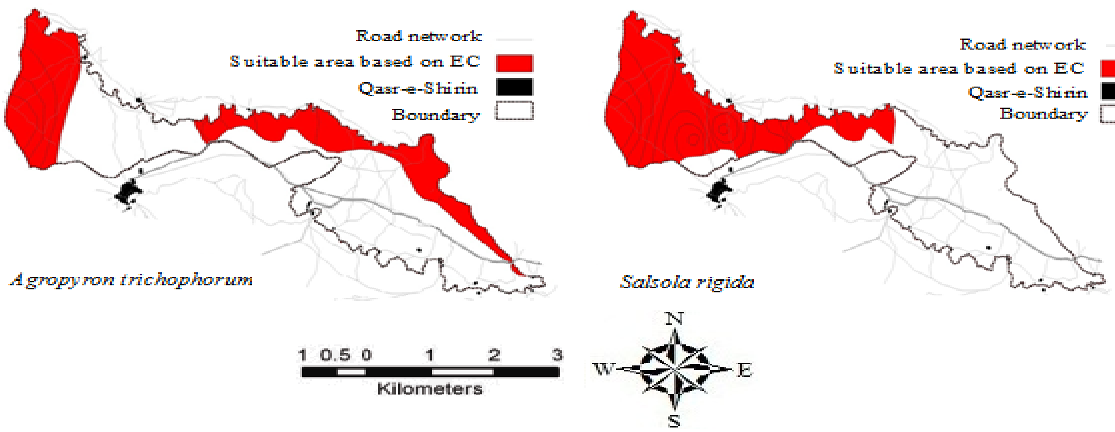

Fig. 13. The map of suitable area for *Agropyron trichophorum* and *Salsola rigida* in terms of EC

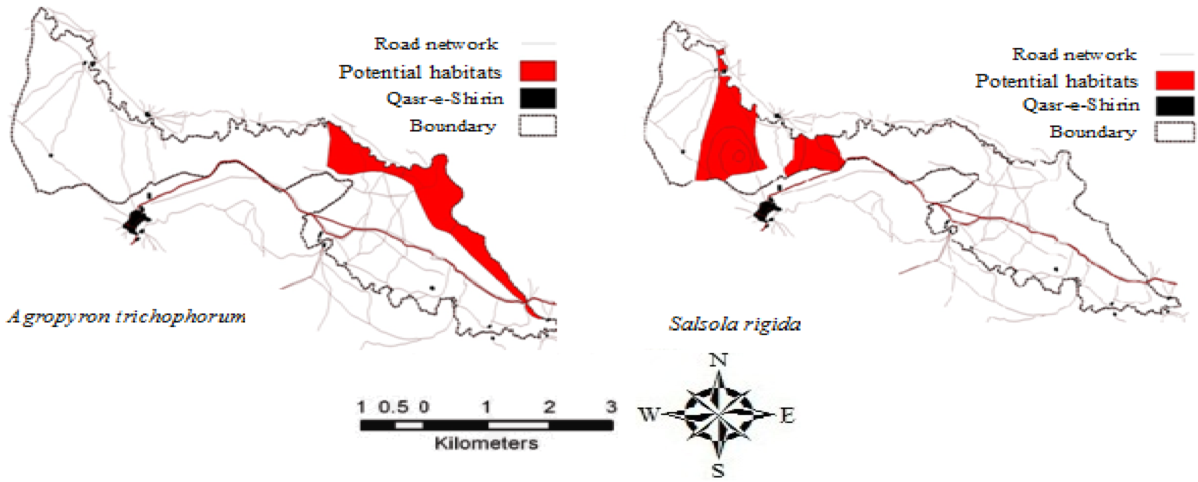

Fig. 14. The map of potential habitats for *Agropyron trichophorum* and *Salsola rigida* in the study area

Discussion

Sustainable land management is crucial for the prevention of land degradation, for the reclamation of degraded land for its productive use, for the reaping of benefits of crucial ecosystem services, and for the protection of biodiversity (Mejias *et al*., 2010). A prerequisite to develop a strategy for the conservation and rehabilitation of rare plant species is an understanding of the habitats in which the populations of the species occur (Wiser *et al*., 1998). The purpose of this study was to identify the potential habitats of these two important species of semi desert area of Qasr-e-Shirin Kolahderaz. Because of the importance of these two studied species in combat desertification in the area and local people using, placement important in order to recover area by this species. The method of evaluation of potential habitats for two species was based on a multi-layered GIS approach, so that, after accessing to the needs of terrestrial species, searching the similar study area in the range of soil conditions were started. So, new habitat areas for species in terms of soil characteristics were determined. The used study approach could be quite valuable in determining potential sites for plant species with specialized habitat requirements. Field evaluation of the habitat provided insight and valuable information on two studied species. The results presented here was close to the hypothesized estimate that this approach would be able predict habitat correctly at 95.5% accuracy for two studied species. GIS was used in this study to digitize and analyze the environmental gradient. Development of

GIS was eased the analysis of environmental gradient over large spatial scales and provides a tool to digitize the gradient. Most of the referred inside and outside studies have used this method to analyzing the distribution of plant species and plant communities and determination of the potential habitat for them along the environmental gradients (Irvani, 1999; Abbasi *et al*., 2009; Franklin, 1995; Austin, 1998). We should consider the importance of environmental factors affecting vegetation growing in desert areas from the perspective of optimal management of these areas. It is important to find the suitable habitats for growing plants to be successful in reformation and rehabilitation in desert and semi-desert areas. In this regard, the relatively new techniques such as GIS and RS can be used to accelerate rehabilitation activities. These methods are reducing the failure possibility in reforming the plans and reducing costs with their acceptable accuracy as a result.

Conclusion

There is an urgent need of plant habitat assessment as an important component in conservation and development planning. It is challenging, however, due to scarcity and lack of synthesis of information on the ecology of plants especially rare plants, lack of effective approaches for habitat assessment at multiple spatial scale, and lack of spatial data for relevant environmental attributes and scales. A regional scale habitat mapping approach should be developed to meet this need using RS and GIS, and soil properties. These potential habitat maps provide effective tools for conservation and development planning as well as monitoring and management of plants (such as rare plant) habitat. Their applications not only help to conserve plant resources through improving reserve, conservation easement, and mitigation designs, but also help to reduce land use conflicts and development cost through improving spatial designs of development projects. It was recommended as follow:

- The produced potential habitat maps were partially validated and need to be further tested with extensive field data.
- The potential habitat maps must be tested precisely in the field to identify methodological defects, incorrect assumptions and faulty input data so that future interactions can be improved.
- A number of potential risks that may affect the accuracy of the method must be considered in future research. Such as: the location of potential habitat may be limited to one region which may result in the perception that the species grow under certain conditions when other areas were simply not examined. Selected environmental variables may not be sufficient to describe all the parameters of species habitat requirements. Finally, errors may be included due to manipulation, inaccuracies in the generation of the environmental layers, or interpolation of lower resolution data.

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تعیین رویشگاه بالقوه دو گونه مرتعی در حوزه نیمه‌بیابانی با استفاده از GIS (مطالعه موردی: حوزۀ کلاه دراز قصرشیرین، ایران)

علی مهدوی[الف]، مجتبی جمشیدی‌فرد[ب]

[الف]استادیار گروه علوم جنگل، دانشکدۀ کشاورزی و منابع طبیعی، دانشگاه ایلام (نگارنده مسؤل)، پست الکترونیک:
a_amoli646@yahoo.com
[ب]کارشناس ارشد بیابان‌زدایی، اداره کل منابع طبیعی استان کرمانشاه

چکیده. برای تعیین رویشگاه بالقوۀ دو گونۀ مرتعی در منطقۀ قصر شیرین ***Salsola rigida*** و ***Agropyron trichophorum*** از تکنیک‌های سامانۀ اطلاعات جغرافیایی و سنجش از دور کمک گرفته شد. برای این منظور، ابتدا نقشه‌های مختلف (نقشه‌های پوشش گیاهی و کاربری‌های اراضی و نقشه‌های موضوعی سازمان‌های مختلف) جمع‌آوری و تهیه شد. از نرم افزارهای مختلف مانند ARC/ INFO, ILWIS و TOSCA برای رقومی کردن نقشه‌های زمین‌شناسی، پوشش گیاهی، سامانه‌های عرفی، لایه‌های اطلاعاتی توپوگرافی، نقشه‌های خاک و لایه‌های اطلاعاتی خاک منطقه استفاده گردید. نقشه کاربری اراضی منطقه قصرشیرین با استفاده از تصاویر ماهواره‌ای IRS1 تهیه شد. رویشگاه‌های فعلی گونه‌های مورد مطالعه با بازدید از منطقه و محدود کردن آن با GPS مشخص گردید و بر روی نقشه پیاده شد. از هر دو گونه ۳ رویشگاه انتخاب و به صورت تصادفی در داخل هر رویشگاه، ۱۰ پروفیل تا عمق ۳۵ سانتی‌متری حفر و نمونه‌های خاک گرفته شد. برای هر نمونه خاک پارامترهایی از قبیل EC، بافت، pH و ماده آلی تعیین گردید. نتایج نشان داد که از ۶۲۷۰ هکتار مساحت کل مراتع در منطقه مورد مطالعه ۲ منطقه با مساحت ۱۶۷۷/۳ هکتار (حدود ۲۶/۷۵٪ از کل مراتع منطقه) برای رویش گونه علف شور ***Salsola rigida*** مناسب است که از این مساحت ۲۱۱ هکتار (۳/۳۶٪) آن متعلق به خود رویشگاه گونه علف شور است و حدود ۱۴۶۶/۳ هکتار (۲۳/۳۹٪) باقیمانده مساحت رویشگاه‌هایی بالقوه می‌باشند. همچنین نتایج نشان داد که دو منطقه با مساحت ۱۳۵۶/۸هکتار (حدود ۲۱/۶۳٪ از کل مراتع منطقه) برای رویش گونه ***Agropyron trichophorum*** مناسب است که از این مساحت ۱۶۷ هکتار (۲/۶۶٪) آن متعلق به رویشگاه فعلی گونه ***Agropyron trichophorum*** است و حدود ۱۱۸۹/۸ هکتار (۱۸/۹۷٪) باقیمانده مساحت رویشگاه‌های بالقوه به حساب می‌آید.

کلمات کلیدی: ***Salsola rigida***، ***Agropyron trichophorum***، رویشگاه بالقوه، قصرشیرین، GIS