PRIORITIZING AREAS FOR CONSERVATION OF ROSACEAE IN IRAN BASED ON THE GEOGRAPHIC DISTRIBUTION ANALYSIS

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In this study we mapped the *Rosaceae* species richness with the point-to-grid richness analysis tool DIVA-GIS, using a 10×10 kilometer grid cell and the circular neighborhood option with the 50 km radius, to identify potential areas for conservation of *Rosaceae*. This analysis is accomplished by 5762 georeferenced observations. The main potential areas for conservation of this family in Iran belong to the Irano-Turanian Region with its two important parts including central Alborz and Zagros Mountains respectively. These areas cover the centre of endemism of the family in Iran. The *Rosaceae* has 91 rare and 70 endemic species. Mazandaran with the highest number of rare species (23) is one of the most important areas for conservation (in central Alborz).

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Key words: Rosaceae; conservation; species richness; DIVA-GIS; grid cell; Iran

اولویت بندی نواحی برای حفاظت تیره رز در ایران بر پایه آنالیز پراکندگی جغرافیایی

مرضیه پیروی، فارغ التحصیل کارشناسی ارشد، بخش زیست شناسی دانشگاه شیراز

در این مطالعه غنای گونه ای تیره رز را به کمک برنامه DIVA-GIS و با استفاده از خانه گرید های ۱۰×۱۰ کیلومتر و محدوده دایره ای همسایه با شعاع ۵۰ کیلومتر برای مشخص کردن نواحی دارای پتانسیل حفاظت برای خانواده رز نقشه برداری گردید. این آنالیز با استفاده از ۵۷۶۲ داده ژئورفرنس شده انجام شد. مناطق اصلی بالقوه جهت حفاظت این خانواده در ایران ناحیه ایرانی-تورانی با دو بخش مهم البرز مرکزی و کوههای زاگرس است. این مناطق بر مناطق بومزادی این خانواده منطبق هستند. تیره رز ۹۱ گونه نادر و ۷۰ گونه بومزاد دارد. استان مازندران (واقع در البرز مرکزی) با بیشترین تعداد گونه نادر (۲۳ گونه) یکی از مهم ترین نواحی برای حفاظت به شمار می آید. ۱۰ خانه گرید ۵۰×۵۰ کیلومتر لازم است تا تمام گونه های این تیره را در بر گیرد.

INTRODUCTION

Plants comprise some 300,000 species, are key structural elements of terrestrial ecosystems, and are the basis of all terrestrial food webs (Kreft & Jetz 2007). Today we are faced with some severe problems such as population pressure and the destruction of ecosystems which lead to genetic erosion and loss of biodiversity (Hodgkin 1997) and also global warming and water shortages that may cause the loss of specific plant species and accessions (International Plant Genetic Resources Institute 1999). It seems that these issues may have very serious consequences for food security and the environment in the future (McNeely and Scherr 2002). The International Union for Conservation of Nature (IUCN) has provided a list of assessing the risk of extinction for species in 1994 (the red list). IUCN is increasingly undertaking national and regional Red List assessments and is collaborating on national Red List projects to incorporate their data into the global IUCN Red List. Also this list has provided in Iran that shows such a high extinction issue. Thus conservation planning, including important plants species and ecosystems is an important issue all over the world. However, we need to pay attention to the socioeconomic components of biodiversity, in such conservation projects to be successful (Brush 2000).

The scientists would be attracted more to study on species, biogeography and biodiversity in biogeographic regionalization and systematic conservation (Chen & Bi 2007). Furthermore, richness is a fundamental measurement of community and regional diversity, underlay many ecological models and conservation strategies (Magurran 1988, Smidt & al.2007).

Plant or animal biodiversity data are captured into databases and make them extremely valuable to be used for setting conservation priorities, increasingly. This function is a funding and staffing priority and is currently being actively promoted through the recently launched South African Biodiversity Information Facility (http://www.sabif.av.za, Robertson & Barker 2006). These databases are comprised of the information which are referred to as collection data (Funk & Richardson 2002) that are being used in biodiversity studies more and more all the time; maybe because of easier access through the internet (Bisby 2000, Graham & al. 2004, Robertson & Barker 2006). The abundance and diversity of *Rosaceae* in a region in Iran suggests it may be an indicator of wider plant diversity patterns within the biome. We can test this by a comprehensive specimen database whereby the result of this test can be used to identify areas of particular conservation priority

Very large-scale studies have been made possible by using of specialist geographical software such as Geographic Information Systems (GIS) and World map. Besides, variables such as species richness can be mapped on a grid in these softwares that could lead to hotspots or centers identified by eye (McAllister & al. 1994, Williams & al. 1994, Long & al. 1996, Crisp & al. 2001). So this approach recognizes areas of species richness (or endemism) by their central hotspots (Crisp & al. 2001) that can be so useful in studies such as conservation priority.

Rosaceae, one of the largest angiosperm lineages, comprises of approximately 3000 species in 100 genera (Kalkman 2004, Lo & Donoghue 2012). The family includes the most important fruit-producing crops such as apples (*Malus spp.*), Pears (*Pyrus spp.*), strawberries (*Fragaria spp.*) and stone fruits (*Prunus*; peaches, plums, apricots, etc), as well as other valuable ornamental plants including roses (*Rosa*). Rose family distribution is cosmopolitan to sub-cosmopolitan, but is diversified, particularly in the northern hemisphere (Judd & al. 1999, Hummer & Janick 2009) and also northern temperate region. So due to the fact that northern forests and also the other regions of Iran provide good situations for this important family, we tried to prioritize the areas for protecting this family in Iran.

In this study, we tried to find the areas with a high concentration of biodiversity, since we can prioritize them for protection that would make it possible to increase the use of conservation resources (Peters & al. 2005). With the goal of identifying the most important areas for conservation of *Rosaceae* disturbed in Iranian environments, we assessed geographic distribution of the family *Rosaceae* by Diva-GIS.

MATERIALS AND METHODS

We gathered different data such as: family, genus and species name; locality; collector name and some other data from different sources like Flora Iranica (Browicz & al. 1969, Zielinski 1982) which is the major taxonomic and nomenclatural reference and also Flora of Iran published by Research Institute of Forests and Rangelands (Khatamsaz 1992). Additional distribution data were also obtained from local Herbaria such as TARI, IRAN, Tabriz, Sanandaj and Kermanshah herbaria and also Akhani herbarium. However most data obtained directly from lables of speciemens in the Shiraz University Herbarium..

In cases where there was taxonomical disagreement between the two sources, we referred to Tropicos (www.Tropicos.org) and IPNI data bases (www.IPNI.org) to select the correct scientific name.

By using of taxonomic keys from various floras (Browicz & al. 1969, Zielinski 1982, Khatamsaz 1992), we also studied herbarium specimens and after identification, the concerned information (distribution data) was added to databases, that involves 1590 records of georefernced database.

The location of data set was georeferenced using Google Earth (http://earth.google.com/) and MapInfo maps that identified towns and road names and their distances. There were some data without coordinate that were excluded from database. A database (in Microsoft Access) with5762 georeferenced data was compiled that was used in analysis.

We found the number of observations and species for each province and then drew a table based on these information (table 1). In this table we found the highest number of observations and species among all provinces and the aggregate of them; furthermore we recorded the province with the highest number of rare species (species which are found 5 times or less).

The species richness plotted on Iran map by using of DIVA-GIS version 5.2 (Hijman & al. 2005) on the basis of grids with 10×10 km cells. By this method, high species richness regions were determined by computing the number of species in each 10×10 km grid cell. This was done for endemic species too. In this study we defined endemism based on the province scales which resulted to finding the provinces with the highest number of endemics.

We used a statistic method to estimate the distribution area for each species named: Circular Area (CA_r). We designed a circular area (CA_{50}) with a radius

Table 1. Number of observations, species, rare species and ratio of observation vs. species per province.

provinces	obs	species	Rare species	Obs/species
Ardabil	153	57	7	2.68
Bushehr	24	6	1	4
Chaharmahal va Bakhtiari	72	33	5	2.18
East Azerbaijan	277	71	11	3.9
Esfehan	196	56	4	3.5
Fars	1436	77	14	18.65
Gilan	391	85	12	4.6
Golestan	196	54	6	3.63
Hamadan	90	35	4	2.57
Hormozgan	39	5	11	7.8
Ilam	6	4	1	1.5
Kerman	127	34	1	3.76
Kermanshah	108	40	5	2.68
Khuzestan	18	10	0	1.28
Kohgiluyeh va Boyer-Ahmad	110	39	3	2.82
Kordestan	131	48	7	2.73
Lorestan	234	49	4	4.78
Markazi	56	26	2	2.15
Mazandaran	715	126	23	5.67
North Korasan	80	36	4	2.22
Qazvin	75	34	1	2.21
Qom	8	7	0	1.14
Khorasan Razavi	107	39	5	2.74
Semnan	87	33	2	2.64
Sistan and Baluchestan	44	9	3	4.89
South Khorasan	11	9	0	1.22
Tehran	469	95	16	4.94
West Azarbaijan	231	61	11	3.77
Yazd	42	15	0	2.8
Zanjan	39	12	0	3.25
Total	5572	-	-	-

50 km to each observation, then the aggregate of all circular areas was calculated for each species. All of them were done by using of Map Info Software. When the circular neighborhood option is chosen for analysis/point-to-grid/main, calculations are made based not on the observations within each grid cells, but rather on the observation found within a circle with its center in the middle of each grid cells and on the specified radius (Bonham-Carter 1994, Cressie 1991, Hatami & Khosravi 2013).

The CA_{50} statistic was plotted against the number of observations to explore differences in abundance between species. A species with a relatively high number of observations per CA_{50} would be abundant within its area of distribution, whereas a low number would indicate that a species was more scattered over the range in which it occurs (Hijmans & Spooner 2001, Mousavi & Khosravi 2010).

To investigate more aspects of species and endemics distribution area, the smallest area (the number of grid cells) determined that is needed to include all species of the family. This supplementary analysis is used to study on optimal reserve selection to conserve maximum species diversity. The species complementarity procedure is based on the algorithm described by Rebelo (Rebelo 1994, Rebelo and Siegfried 1992) and is applied in the DIVA-GIS Software that selects grid cells so as to identify the minimum set of cells that captures a maximum amount of species. The process is iterative, whereby the first iteration is the most species rich and the second is the richest grid cell in species which are not represented in the first iteration and so on, until all species have been represented. We determined the minimum number of grid cells needed to capture all species and mapped the location of the first 10 grid cells. The grid cell size was defined as 50 × 50 km.

RESULTS

The total records that we gained were 5762 georefrenced data; from which 1590 records are concerned with the Shiraz University Herbarium specimens. According to information of the Shiraz University Herbarium data base *Rosaceae* has 35 genera and 253 species in Iran. *Amygdalus* L. is one of the biggest and the most important genus of this family with 27 species in Iran.

To propose strategies for taxa conservation, we need to determine the geographical distribution patterns of them (Lira & al. 2002), so on the base of this fact, 5 main approaches have been taken in this study to define priority conservation areas for the *Rosaceae* family in Iran:

The first approach, distribution of the *Rosaceae* species in Iran provinces defined 3 provinces with high number of observations. These provinces are Fars, Mazandaran and Tehran respectively, which include more than 47 % observation from all 5572 observations. Mazandaran (with 126 species) includes the highest number of species among the other provinces (table 1).

Based on the data bank analysis we identified 91 species in this family as rare (the species which are observed 5 times or less), of which 26 are endemics in Mazandaran province. Besides, Mazandaran with 23 rare species, have the highest number of endemics (table 1). Subsequently we can conclude that Mazandaran can be determined as one of the most important places for conservation. Because it's numerous rare species are probably in NT (Near threatened) level of IUCN risk level, that it means they are expected to be endangered in the near future.

Due to the fact that the provinces are different in shapes and sizes, their number of observation and species are affected. So in the second approach we used the grid based maps generated by using the DIVA-GIS, which showed two hotspots of the observation in Fars and central Alborz (fig. 1). The hotspot of species richness is located in Central Albors too, that includes Tehran and Mazandaran Provinces with 221 species, (fig. 2). As the maps show (fig. 1 & fig. 2), the species richness hotspots coincide with the observation hotspots. So obviously we can consider that Central Alborz can be suggested as one of the conservation priority areas in Iran.

High number of collections has been done in Fars province despite of low species richness. In provinces with high species richness against low observations, like Gilan and Ardebil, more collection would lead to finding more species records.

In the third approach we found that *Rosaceae* have 50 endemics in Iran based on the different floras. Also we identified Central Alborz as an endemism hotspot (fig. 3).

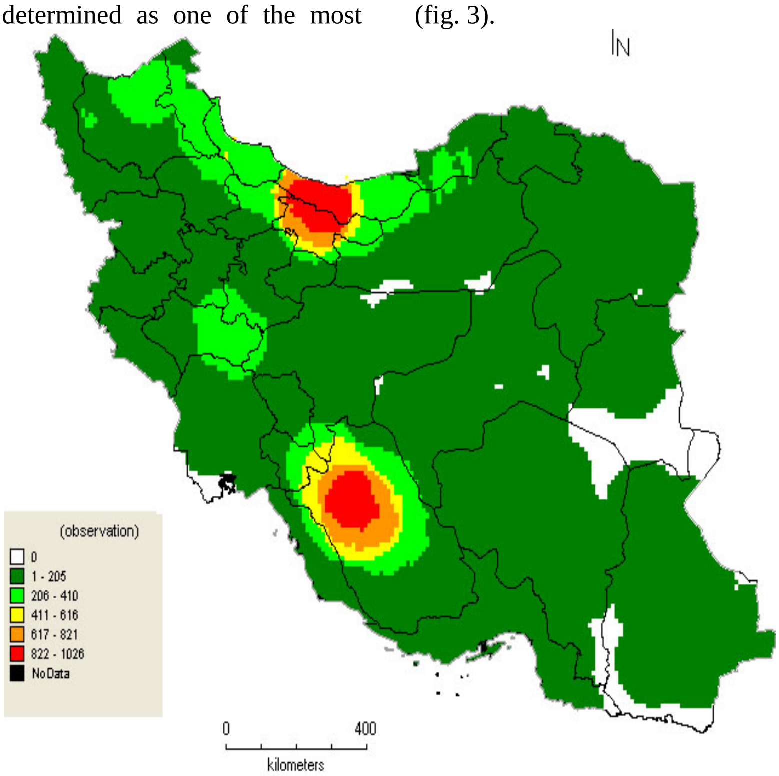

Fig. 1. Number of observations species per 10×10 km grid cell. A circular neighborhood with a radius of 50 km was used to assign observations to a grid cell.

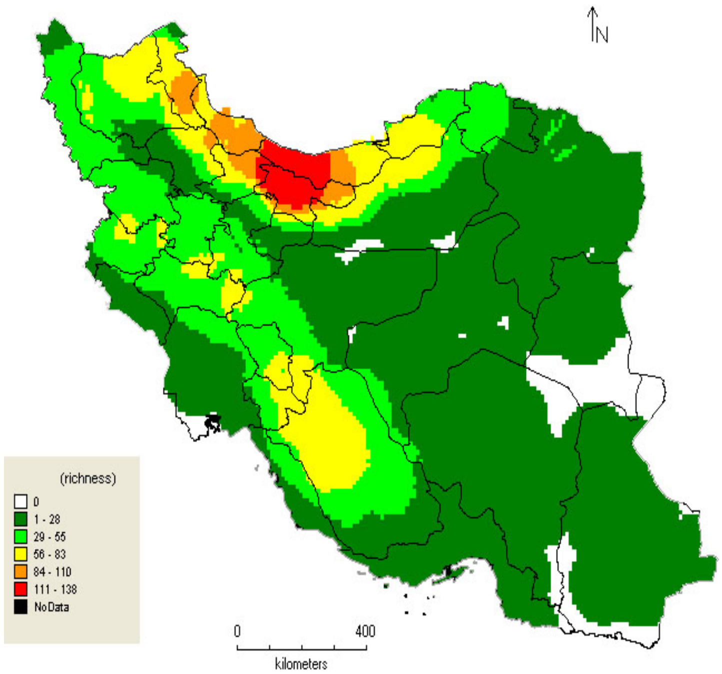

Fig. 2. Number of Rosaceae species (richness) per 10×10 km grid cell. A circular neighborhood with a radius of 50 km was used to assign observations to a grid cell.

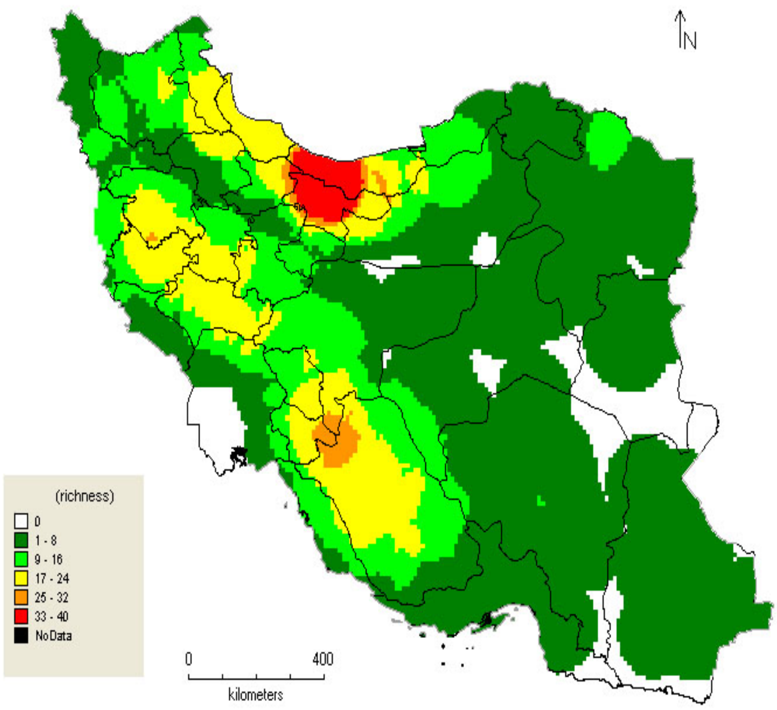

Fig. 3. Number of endemic species per 10×10 km grid cell. A circular neighborhood with a radius of 50 km was used to assign observations to a grid cell.

In approach 4 we used the ratio between circular area (CA_{50}) and number of observation for each species to compare the abundance of the species in their distribution area that had been named RCA_{50} (fig. 5) Low RCA_{50} means, more abundant that species is, for example *Malus floribunda* Siebold ex Van Houtte with low RCA_{50} is the most abundant species among the others. However high RCA_{50} which refers to low observation of a species in its distribution area refers to less abundance of that specific species, i.e. *Amygdalus mozaffarianii* Khatamsaz that is one of the rarest species.

Furthermore, for the total of species the circular area (CA_{50}) average is 69358.81km^2. The amount of CA_{50} is more than average for almost 68.44 percent of the total species (just more than half of the total species), (fig. 4). So it is obvious that some species like *A. mozaffarianii* which have more amounts of RCA_{50} are considered to be in NT or VU (considerable as a species facing a high risk of extinction in nature) status and need to be considered for conservation priority.

Finally approach 5, complementary analysis is a method to show the places with highest biodiversity, and subsequently to prioritize the places for conservation.

On the basis of this analysis only ten 50×50 grid cells are needed to capture all the species of *Rosaceae* (fig. 6). As it is shown in fig. 6 two grid cells located in Central Alborz are enough to capture about 70 percent of all *Rosaceae* species. Most of these grid cells are located in alien zones. These results indicate that for this family, there is an important correlation between total diversity and endemism. Thus the same grid-cells important to protect the *Rosaceae* species are also important to protect the endemic ones. Figure 7 shows ten first grid cells for prioritizing conservation. Obviously the grid cell located in Central Alborz deserves the first priority in conservation and the one located in Fars province gets the second rank. The other grid cells can be considered in the next positions.

DISCUSSION

As a matter of fact we are facing a species extinction crisis currently, so we need to identify areas with priority for conservation. It is necessary to find the most threatened areas of exceptionally high biodiversity and rates of endemism to protect i.e. hotspots (Mittermeier & al. 1998, Myers 1988 Reid 1998 Medail & Quezel 1999).

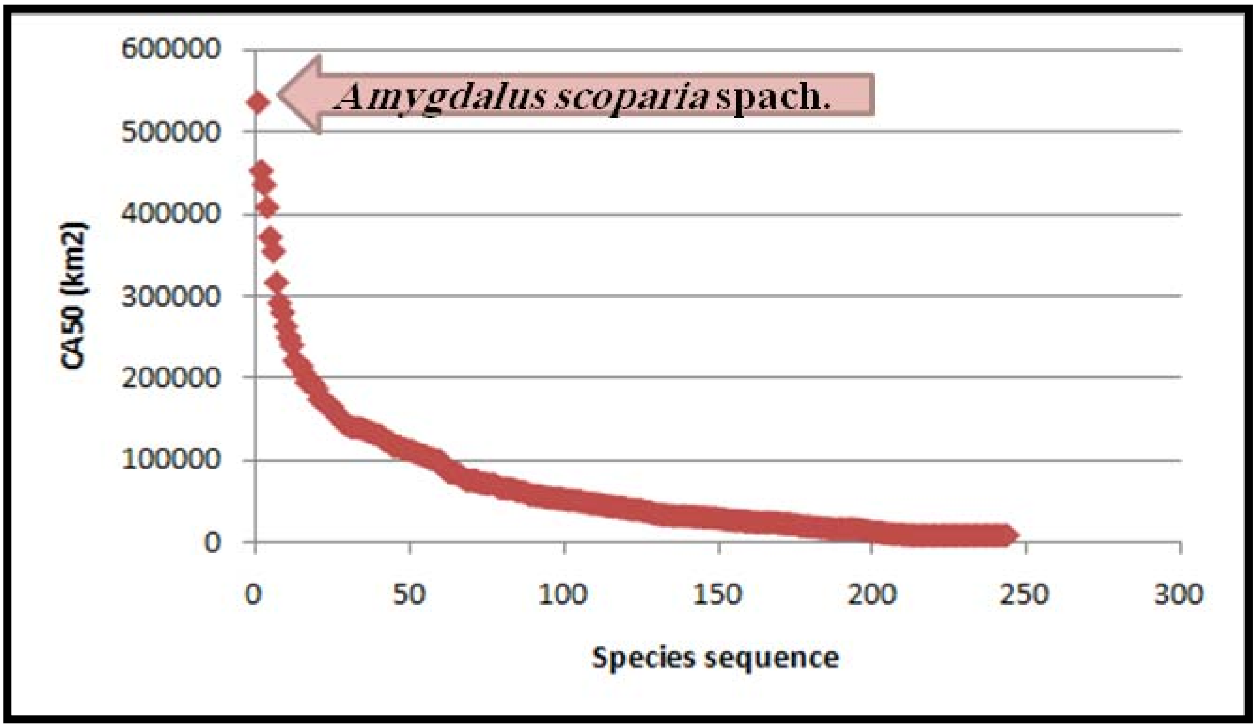

Fig. 4. Circular area CA_{50} of Rosaceae species. A circular area with a 50 km radius was assigned to each observation.

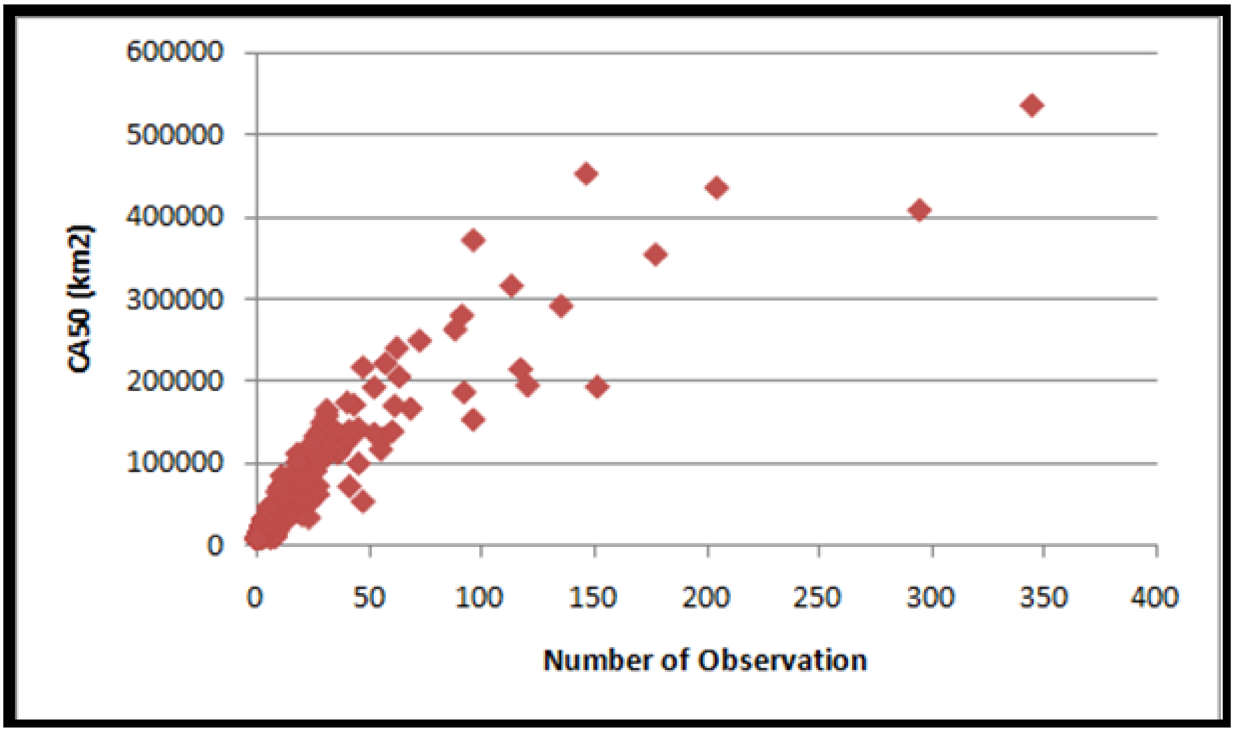

Fig. 5. Circular area (CA_{50}) vs. number of observation of Rosaceae species. Each dot refers to one species. A circular area with a 50 km radius was assigned to each observation.

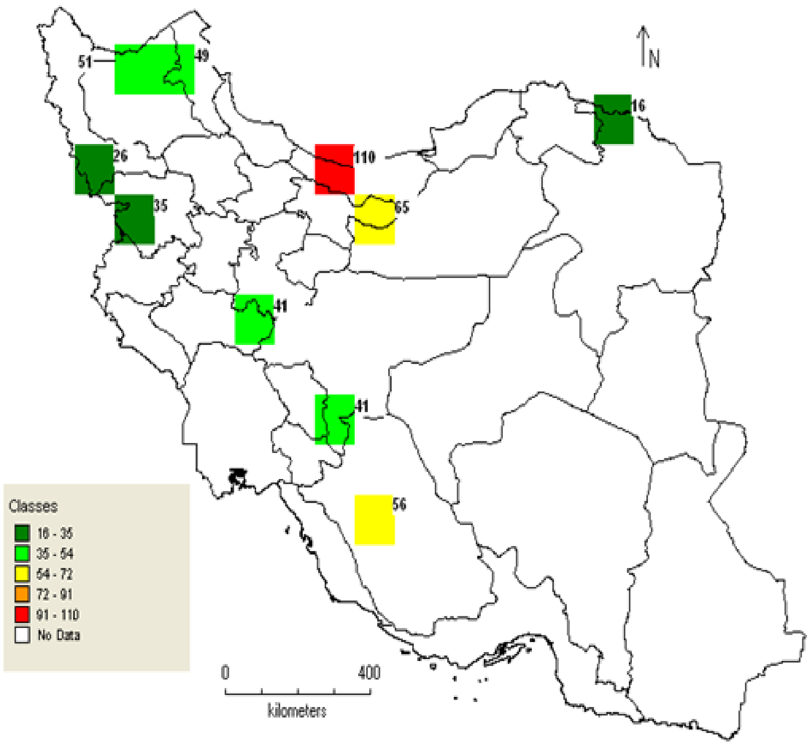

Fig. 6. The location of ten 50×50 grid cells needed to include all of the Rosaceae species.

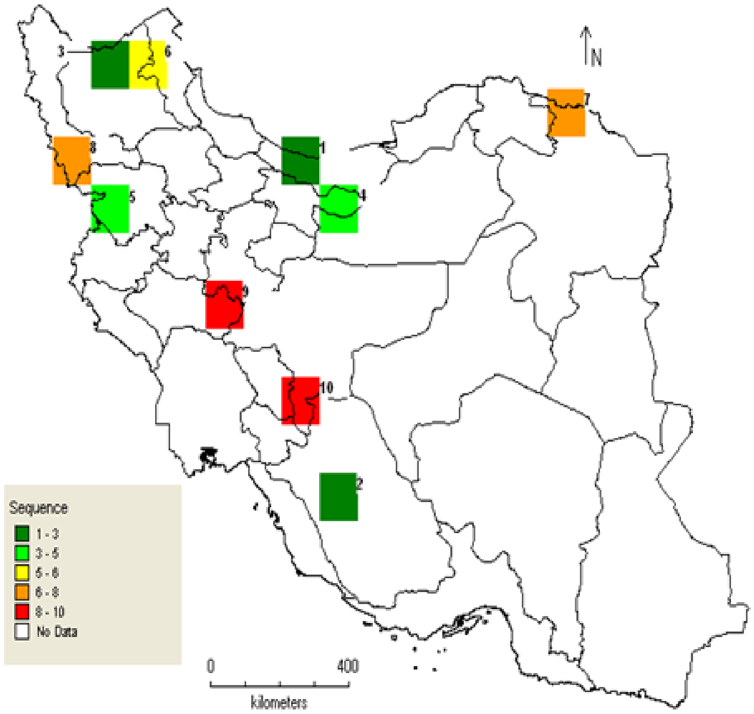

Fig. 7. The location of ten 50×50 grid cells with the mention of the priority of conservation.

Scientists try to prioritize regions for conservation on the basis of their biodiversity value that is among the most important theoretical tasks of conservation biology. They also need to devise some management strategies to protect biodiversity in ecosystems to reach this goal (Meyers & al. 2000, Smidt & al. 2007). Generally we can say that to protect our ecosystem we should prioritize regions, and then set some strategies based on the biodiversity so we need to identify zones with high plant species richness and endemism to define biodiversity hotspot. In this study we proved how some useful tools such as species richness, circular area and complementary analysis can easily and logically identify the conservation priority.

According to the food and agriculture organization (FAO) data base in 2008, Iran ranked third cherry producer worldwide with the total of 225 thousand tons production after Turkey and USA (FAOSTAT, 2008, Shahi-Gharahlar & al. 2011). So we should pay more attention to set conservation strategies for this important crop and other *Rosaceae* species of economic importance.

The herbaceous species of *Rosaceae* grow in temperate forests as understory plants. *Rosaceae* trees may also be minor component of mature mixed deciduous forests (Hummer & Janick 2009). So according to the fact that at high elevation and also on north slopes of the Alborz (Hyrcanian area that covers central Alborz) precipitation (rain and snow) exceeds 1.000 mm a^{-1} (Alex 1985, Noroozi & al. 2008) the humid conditions on the northern side of Alborz result in a Hyrcanian deciduous closed forest. So the *Rosaceae* species are of the most important in this forest, especially by the fact that we have the highest records of *Alchemilla spp., Potentilla spp., Filipendula spp.* and some others from these regions. Noroozi & al. (2008) concluded that *Potentilla* with 19 species is one of the largest alpine genera in Iran.

Furthermore as Hummer & Janick (2009) showed, that the herbaceous *Rosaceae* species also grow in salt or freshwater marshes, these situations are observed all over Iran frequently, especially in Fars province where the Parishan, Bakhtegan and Maharlu Lakes are. Zohary (1973) depicted a general picture of vegetation maps of southern Zagros Mountains and the Lake Maharlu area (fig. 8).This map shows Lake Maharlu is located within the supposed climax area of the *Pistacia-Amygdalus* scrub of Zagros Mountains (Zohary 1973, Djamali & al. 2009). In general *Pistacia-Amygdalus* scrub forms a vegetation belt around the Zagros oak woodland. This belt is broader in the eastern foothills facing the central Iranian Plateau (fig. 8). The idea that in the Maharlu area one of the dominant tree species of this vegetation unit is

Amygdalus scoparia, supports our results (we had the highest record of this species, in Fars province). This is most probable because of the drier and hotter climate conditions and particularly the lower spring rainfall that prevails in the south-east Zagros. The lower elevations around Lake Maharlu are covered by xeromorphic dwarf-shrublands which contains shrubs such as *Cerasus microcarpa*, one of the most frequent species reported from Fars province (Djamali & al. 2009). So it supports that our results (concerning species richness) are not just because of our numerous records from these places, but for the situation and climate of these areas, Lake Maharlu can be one of the most important centers of *Rosaceae* diversity.

Furthermore Noroozi & al. (2008) supported this hypothesis that the proportion of endemism increases with increasing altitude. About 32 % of all Iranian alpine endemic species are restricted to the Alborz (i.e. *Potentilla aucheriana* and *Potentilla multifida*), 46 % restricted to the Zagros, and the taxonomic relationships of most endemic species show that the origin of alpine flora of Iran is Irano-Turanian (see also Klein 1991; Noroozi & al. 2008).

To better assess plant conservation we determined 3 ranks of species richness: central Alborz (Tehran and Mazandaran provinces), Gilan and Ardabil provinces and in third position Zagros Mountains in Fars province.

Coincidence between richest in species and/or endemism grid-cells with some regions that have the most rare species, suggest that these zone are important for conservation, because these areas harbor biodiversity. These areas have high values of ecosystem and species richness in relation to other areas Therefore, the mountainous areas in the Irano-Turanian Region (as the diversity centers) are vital for this family.

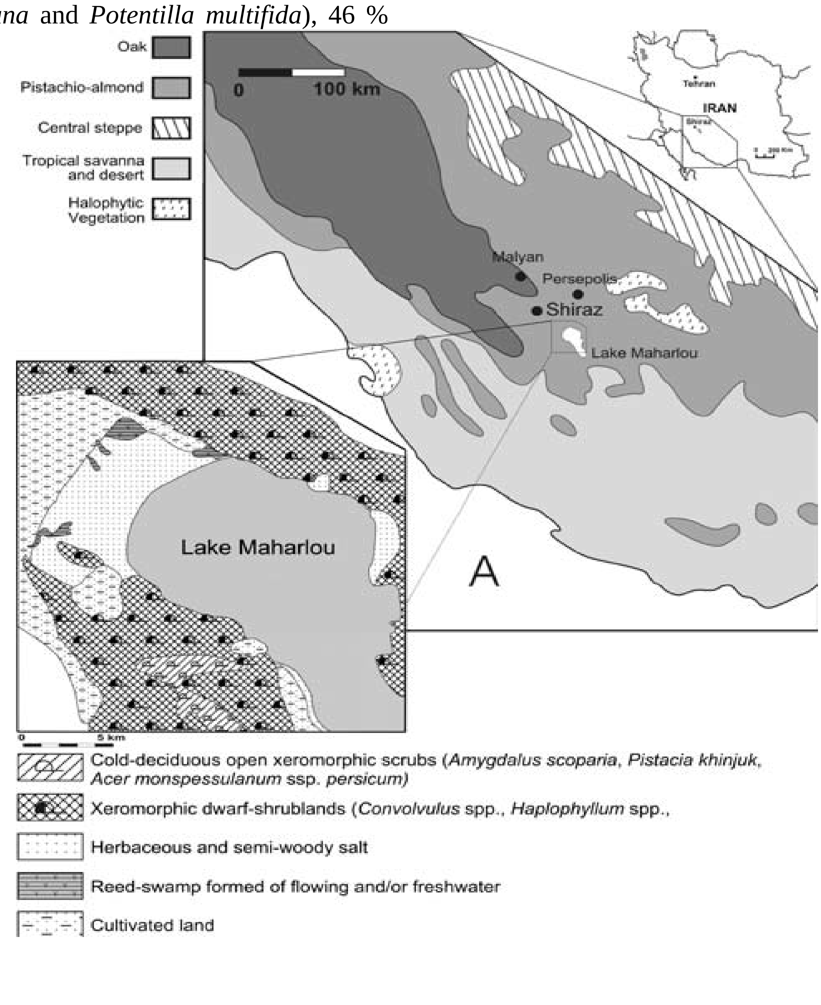

Fig. 8. Regional and detailed vegetation maps of the southern Zagros Mountains (a, simplified from Zohary 1973, Djamali 2009) and the Lake Maharlu area (b, after Carle and Frey 1977, Djamali 2009).

CONCLUSION

As we showed Alborz Mountains with the most species richness and rare species, coincide with the area of endemic hotspot so it should be in the first priority of conservation strategy, because of its important rule in biodiversity.

We also found out Fars province is one of the most important regions to prioritize conservation after central Alborz. Fars province is located in Zagros Mountains and there are lakes in this province that are rich in biodiversity especially for *Rosaceae* species (such as *Amygdalus spp*.). According to the text Maharlu is one of these lakes. But unfortunately due to intensive cultivation, the natural vegetation of the surrounding parts of the lake is replaced by irrigated arable lands which extend in some parts to vicinity of the lake shore. Moreover intensified human activity is most probably the principle cause of a nearly total destruction of the *Pistacia-Amygdalus* scrub in Maharlu area (Djamali & al. 2009). Also some others like Parishan and Bakhtegan Lakes are near to being destroyed completely, because of dam constructions and/or well excavations recently. So their vegetation is endangered seriously. These regions are of the most important zones with high species richness of *Rosaceae* (especially such as *Amygdalus*), they should be recognized as high priority for conservation.

As final point, it should be noted that I did have access to limited herbarium materials, so it is probable that the results change if more data be added to the analysis. Some sources of data used belong to the old collections; their localities may have been disturbed and the flora being extinct at the time of preparing this manuscript.

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