Distribution of Poaceae, Chenopodiceae, Papaveraceae and Fumariaceae Plant Families in Fars, Iran

An Application of GIS in Plant Systematic and Conservation

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Abstract: Several worldwide priority area proposals have been developed, but local considerations are necessary to identify priority areas for conservation within these regions. Then the list of plant species developed to use as conservation characteristics that complemented the Land cover data, as it is supposed that many species would be automatically conserved by protecting their associated land cover types. There is a large amount of species richness due to geological, soil and climatic variation in Fars, Iran and a majority of these species have not been identified. The species were identified using Floras, monographs and available articles. The endemic species and the regions of high species richness of these four families were reported. Results indicated that the four plant families have in total, 126 genera and 265 species, where eight species were endemic. The Poaceae family has 90 genera and 170 species; five of them are endemic. The Chenopodiceae family has 29 genera and 76 species; two of them are endemic. The Papaveraceae family has five genera and 12 species; one species is endemic. The Fumariaceae family has two genera and seven species, without any endemic species. Ninety eight species were recorded for the first time. Overall, the Shiraz town ship has the highest species richness among all twenty townships in the province.
[Jafarpour M, Manohar M. **Distribution of Poaceae, Chenopodiaceae, Papaveraceae and Fumariacea Plant Families in Fars, Iran; An Application of GIS in Plant Systematic and Conservation.** *Life Sci J* 2014;11(6):182-193]. (ISSN:1097-8135). http://www.lifesciencesite.com. 25

Keywords*:* Poacea, Chenopodiaceae, Papaveraceae, Fumariaceae, Species Distribution

1. Introduction

Species distribution models (SDMs) are statistical tools that unite observations of species occurrence or abundance with environmental estimates. They are used to achieve ecological and evolutionary insights and to predict distributions across landscapes. SDMs are now broadly used across terrestrial, freshwater, and marine areas. Species distributions have been modeled for these realms, and across species from many biological groups. One of the key steps in good modeling practice includes gathering relevant data and mapping predictions to geographic space. In this article, it is focused on the basic steps to provide a foundation for next steps to construct modeling of data in future research (Elith & Leathwick, 2009).

Producing predictions of distributions can be achieved using a mix of presence–absence incidence data, professional view and Geographical Information System (GIS) -modeling approaches. Incidence data provides the framework of species distributions but in nearly all cases, there is ‘observer bias’ in terms of sampling (Graham *et al*., 2004) and this is particularly true in sections such as the tropics where sampling has been limited. Therefore there is an important role for refining ranges rooted in specialist estimation of biologists familiar with the species and environments in question, at least in some cases (Ferrier *et al*., 2002; Guralnick & Hill, 2009; J. Pearce *et al*., 2001).

In a world where biodiversity loss occurs year on year, the first and the most basic consideration is to identify and count the number of species in different geological and biological territories. By estimating the numbers of species, it is possible to estimate increasing, stable or decreasing trends for each species. Ecologists distinguish different aspects of biodiversity that must be measured while trying to quantify biodiversity. One of the best indicators for monitoring biodiversity is species richness, which is the number of species in an area (Weber *et al.*, 2004).

In any plant community, some species are considered common, others less common or rare. There is insufficient information for assessment of biodiversity, and the data necessary for the decision makers are more common than not, unavailable, incomplete or unreliable. In addition to that, the data is not always presented in a suitable format for usage by policy makers and managers, increasing the tendency for the data to be wrongly interpreted (F. W. Davis *et al*., 1990; Funk & Richardson, 2002; Sastre & Lobo, 2009). Therefore, the data should be reported in a suitable manner for policymakers in biodiversity fields. This would help policymakers in prioritising decisions for the identification of species and habitats for the protection of (Carver *et al*., 2012; Dawson & Hendee, 2009; J. L. Pearce *et al*., 2008; Sarkar & Margules, 2002).

The distribution map of species is a basic and major foundation for Prioritizing new areas and new species for conservation. The current intensity and scale of human development poses an immediate threat to biodiversity. Our goal was to synthesize distributional data on species and their habitats to identify important areas for decision makers for conservation (J. L. Pearce*, et al.*, 2008).

Inventory is the most common recording approach for a particular species at any given location (at a specific time); this process allows the species to be reviewed by experts for proper identification and finally to understand the biodiversity of the habitat. Inventory allows for the following functions in any specific area - identifying sampling gaps, improving survey design, reducing collecting faults, making richness, restricted range and distribution maps, and choosing priority biodiversity sites for conservation decisions (Funk & Richardson, 2002; Sastre & Lobo, 2009) Major obstacles in using inventory data include the unavailability of these data in a useful format and the hesitation of most systematists to be involved in biodiversity and conservation research(F. W. Davis*, et al.*, 1990; Funk & Richardson, 2002; Margules & Pressey, 2000; Sastre & Lobo, 2009).

Data regarding biodiversity have been dotted in diverse formats in natural history collections, survey reports and the literature. An essential challenge for the biodiversity informatics society is to provide the way to contribute and quickly create these data and the information they supply us to make a simply available, united worldwide map of biodiversity. Such a map would provide raw and abstract data and information on biodiversity and its change across the world at numerous scales(Guralnick & Hill, 2009).

Species occurrences are the basic data used to produce many diverse summary views on biodiversity. One vital result originated from species occurrences are species distribution maps. These maps record where species are present and absent across their full scope and are frequently used to input themselves for additional biodiversity assessments. Recording the present geographic distributions of taxa at a large-scale is a demanding task (Whittaker *et al.*, 2005) and eventually, the confidence in distributional knowledge is a straight purpose of the selected smal size (Hurlbert & Jetz, 2007). Increasing knowledge about species distributions to better determination will help maximize global biological knowledge, progress the systematic foundation for conservation support and permit us to more correctly model changes in species or population distributions that may happen under ecological change conditions(Guralnick & Hill, 2009).

Systematic data can play a crucial role in the identification and classification of organisms, especially to determine sites for protection and conservation. As May pointed out in 1990 “Without taxonomy to give shape to the bricks and systematics to tell us how to put them together, the house of biological science is a meaningless jumble.” As a result of this study, the complete systematic data of four families is provided and is available by request. Distribution models for each selected group were determined by documenting the data from collections currently housed at Shiraz University museum, herbarium, and Eram Botanical Garden. (F. W. Davis*, et al.*, 1990; P. H. Davis *et al.*, 1988; Hedge H, 1997; Zohary & Feinbrun-Dothan, 1966, 1978, 1986).Several comprehensive studies on the benefits of using museum collections in biodiversity assessments have been published (Hortal *et al.*, 2008; Miller, 1993; Ponder *et al.*, 2001).

Most botanists have used hard-copy maps to show basic distribution patterns which can be incomplete and somewhat unreliable for evaluation and measurement on a larger scale in biodiversity. These basic distribution maps are not compiled in digital form. It means that it is difficult or impossible to retrieve the metadata (i.e., the collected data and attributes of the specimen(s) associated with each point on the map), select and combine distribution datasets for various organisms, perform spatial statistics on the distributions, or overlay species distribution map onto maps of soils, climate and other environmental variables (Bletter *et al.*, 2004).

Geographical information system (GIS) approaches for mapping wilderness have been developed which are an example of the application of modern technology for solving current predicaments (Aplet *et al.*, 2000; Carver*, et al.*, 2012). GIS makes it possible to produce digital maps with significant advantages. GIS is one of the most popular methods which have increased indexes and indicators for monitoring and assessment of biodiversity studies(Salem, 2003; Zhang *et al.*, 2008).

GIS approaches for mapping wilderness have been developed to support decision-making for planning, policy and management of wildlife (Carver*, et al.*, 2012). One of the applications of GIS base maps in systematics research in assessing and monitoring biodiversity is generating species distribution maps. In fact, records of species or habitat can be stored in a data set and mapped to show where they are located. This geographic information can be used to target surveys and monitor schemes (Carver*, et al.*, 2012; Dawson & Hendee, 2009; Salem, 2003). The data can be put into GIS in different forms. These forms are known as a spatial or an aspatial data. Spatial data include maps, satellite imagery and aerial photographs. Aspatial data include tables of measurements, species and habitat, attributes, photographs, videos and sound(Salem, 2003; Zhang*, et al.*, 2008) Assessment of biodiversity is based on the range of species data. A range of species is the area occupied by species, and it is used to refer to a distribution area. To determine species range, biologists record geographic location of their observation and collect specimens. These data can be plotted on maps to represent species range. Models of the distribution are constructed to predict where survey efforts can be targeted, as substitutes for surveys of species in analysis of biodiversity on a regional scale (Salem, 2003; Zhang*, et al.*, 2008).

A number of large-scale priority region schemes have been developed, but local considerations are needed to recognize priority areas for conservation within these regions. Then the list of plant species developed to use as conservation attributes that added to the Land cover data, as it is supposed that many species would be automatically conserved by protecting their related land cover types (Smith *et al.*, 2008). The determination of distribution of all plants in Iran is a long-lasting effort because there are 2500 native species from nearly 8200 known species of plants in Iran (Department of Environment, 2000). Therefore, in order to have a comprehensive understanding of the plant diversity distribution, this study has focused on four groups (considered genera and species of wide variety) which included, Chenopodiaceae, Papaveraceae, Poaceae, and Fumariacea in Fars, Iran.

The objectives of this study seek to identify genera and species in four families which are, Chenopodiaceae, Papaveracea, Poaceae and Fumariaceae in the Fars province; and also to report new species. In addition, it is determined the area of distribution of species from four plant families as well as finding the areas which have the greatest species richness and rarity. Finally, it is introduced rare and endemic species in Fars. This article also addresses broader questions, such as the ability of the data to explain the diversity of plants in Fars, Iran and whether the data can be useful.

2. The study area

The Iranian habitat supports almost 8,200 species of plants (a conservative estimate), of which, almost 1,900 are endemic. A great part of Iran is located in the Palaearctic region and it is considered as the main origin of many genetic resources of the world, including many of the original strains of commercially valuable plant species such as wheat, or medicinal and aromatic species (http://www.cbd.int/doc/world/ir/ir-nr-01-en.pdf).

At present, only protected areas afford reliable protection to Iran's biodiversity. In the unprotected areas, biodiversity is decreasing rapidly. In the last 30 years, 1.2 million hectares (40%) of Iran's deciduous temperate forests have been destroyed (Department of Environment, 2000). Rangelands and marginal farmlands are vulnerable to desertification, which is being exacerbated by soil erosion, over-grazing and over-exploitation of marginal farming areas (http://www.cbd.int/doc/world/ir/ir-nr-01-en.pdf)

Protected areas and reserved systems in Iran form the core area for biodiversity conservation. This reserve is not sufficient by itself for long-term conservation and must be harmonized with conservation efforts in other areas and land-uses. In Iran, areas protected by the Department of Environment cover 8.2 million hectares which is about 5% of the land area (http://www.cbd.int/doc/world/ir/ir-nr-01-en.pdf).

The Department of Environment intends to increase this area to 10% of the national land area. Since limited research has been carried out on the topic, the focus of study is on the Fars province which is located in the south west of Iran. Fars is the third largest province in Iran and covers an area of 125,000 square kilometres. This province is bounded to the north by Esfahan, Kohkiluye and Boir- Amad; to the west by Bushehr; and to the east by Yazd and Kerman (Figure 1). Fars is located between latitudes of 27 to 37 degrees and longitudes of 50 to 55 degrees. The Zagros mountain range is northwest of Fars (Fig1). This explains the existence of subterranean resource and offers new insights into the nature of arid environments (http://www.cbd.int/doc/world/ir/ir-nr-01-en.pdf).

3. Materials and Methods

Distribution models for each selected group were determined by documenting the data from collections currently housed in the Shiraz University museum and herbarium, and the Eram Botanical Garden as well as using data and from books by (F. W. Davis*, et al.*, 1990; P. H. Davis*, et al.*, 1988; Hedge H, 1997; Zohary & Feinbrun-Dothan, 1966, 1978, 1986).

The location of every species should be considered in the data set based on the biodiversity survey as following: the place where the species are housed, the museum accession number, numbered rows and columns or alphabetical by family. Some fields, such as the latitude and longitude were used for all species, while other fields were not applicable to all groups (Funk & Richardson, 2002). For example, the field of the subspecies would stay blank for some species in this study; a complete database is available from the authors on request.

The following results were included from rapid summaries of dataset: the total number of species, genera in every family, the number of genus with one species and endemic species and the richest and poorest area from the point of view of species distribution were introduced.

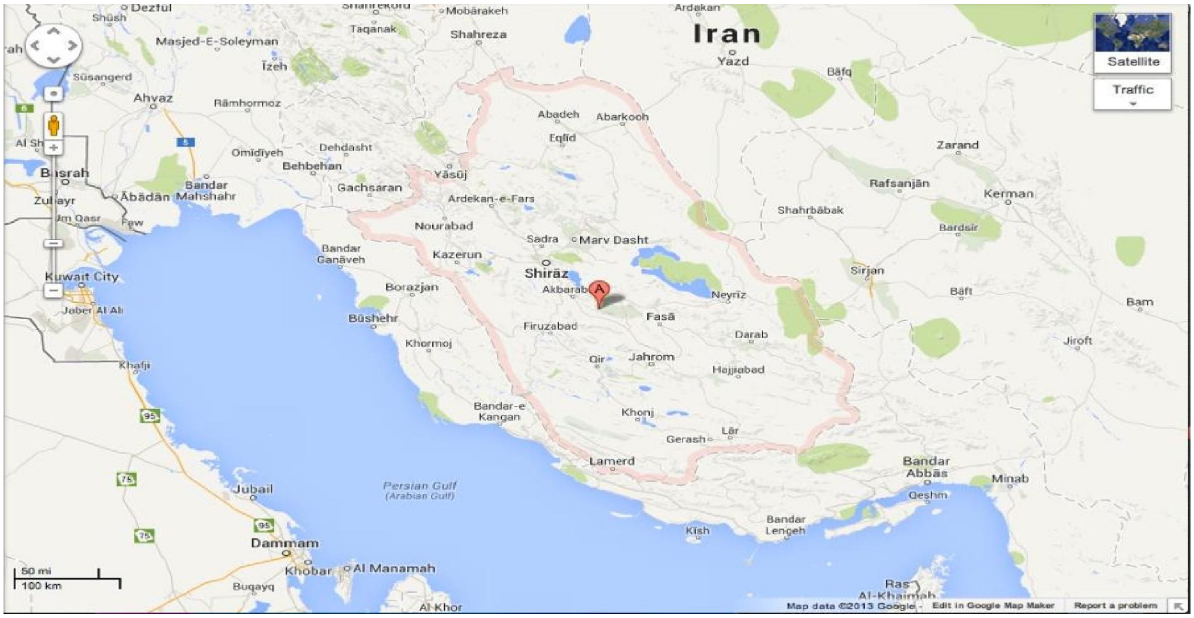

Figure 1- Fars, Iran Google map (https://www.google.com/maps)

GIS applied as the powerful software to link the information of the locations with the created figures on the maps. The longitude and latitude of species location has input into the Mapinfo program for making dot maps. In order to gain this objective, the data set is opened in Mapinfo to convert column to decimal degree trough tools menu of Mapinfo program. Thereafter, the points can be. This species distribution can be illustrated on the map/maps.

4. Results

4. 1. Poaceae family:

4. 1.1 Distribution pattern

The total number of records for the Poaceae family surveyed was 2404; from that, 1881 belonged to specimens of the Herbarium of Shiraz University. The inference from this research shows that this family has 116 genera and 328 species in Iran where 90 genera and 170 species were found in Fars province (Fig 5). Therefore, from these records, 60 species are being reported for the first time. The most diverse genera in the family is the *Bromus* genus with 16 species(Fig 2) , *Agilops* with 10 species (Fig 3) and *Hordium* with 10 species (Fig4) are the most diverse genera of this family, as shown in the distribution maps.

Eleven genera were found to have only one species: *Boisseria, Catapodium, Crithops, Dactylis, Trachynia, Eremapogon, Heteranthelium, Imperata, Lamarkia, Psilurus*. The other genera in the Fars province have one or more than one species in the other locations: Arrhenatherum, *Arundo, Boisseria, Brachypodium Calamagrostis, Catapodium, Chloris, Crithopsis, Crypsi, Cutand, Cymbopogon, Cynodon, Dactylis, Dactyloctenium, Dichanthium, Cynodon, Diplachne, Eremapogon, Gausteridium, Glyceria, Digitaria, Henrardia, Heteranthelium, Hyparrhenia, Imperata, Lamarckia, Lophochloa, Lophochloa, Milium, Nardurus, Parapholis, Paspalum, Phragmitis, Psathyrostachys, Psilurus*.

It is important to mention that Shiraz was found to be the richest area in species with 116 species and Marvdasht with 64 species, while Lamerd and Ghirghazin with only 5 species are the poorest; as depicted in the distribution map of Poacea family (Fig 5).

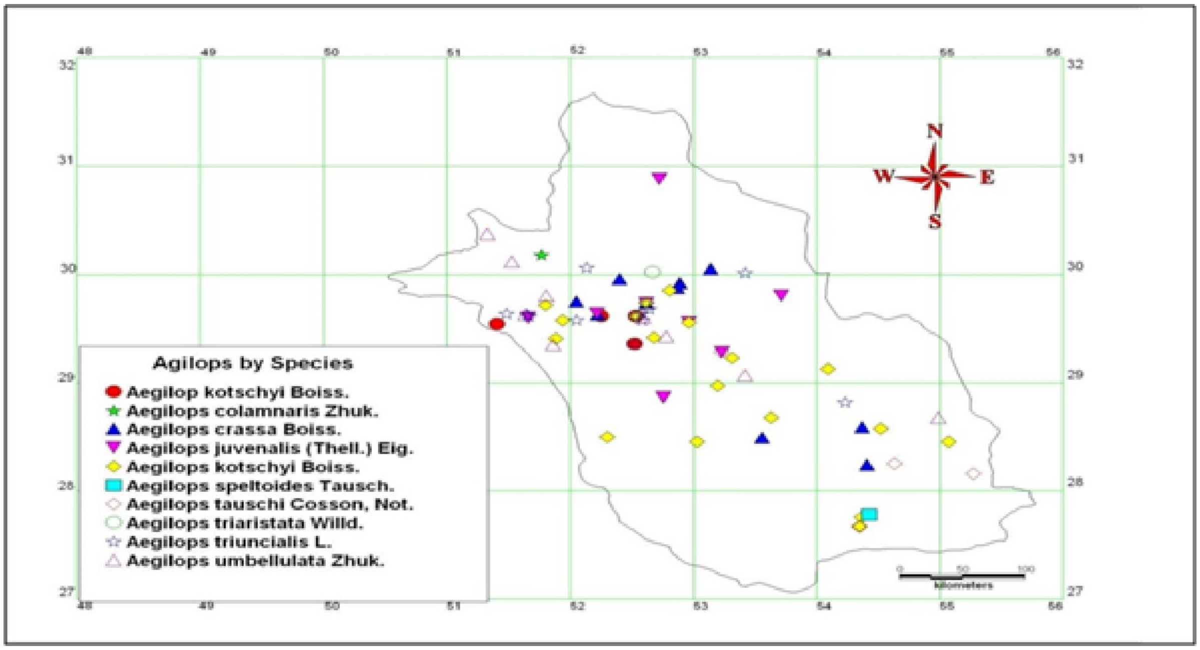

Figure 2- Distribution map of Bromus genus with 16 species

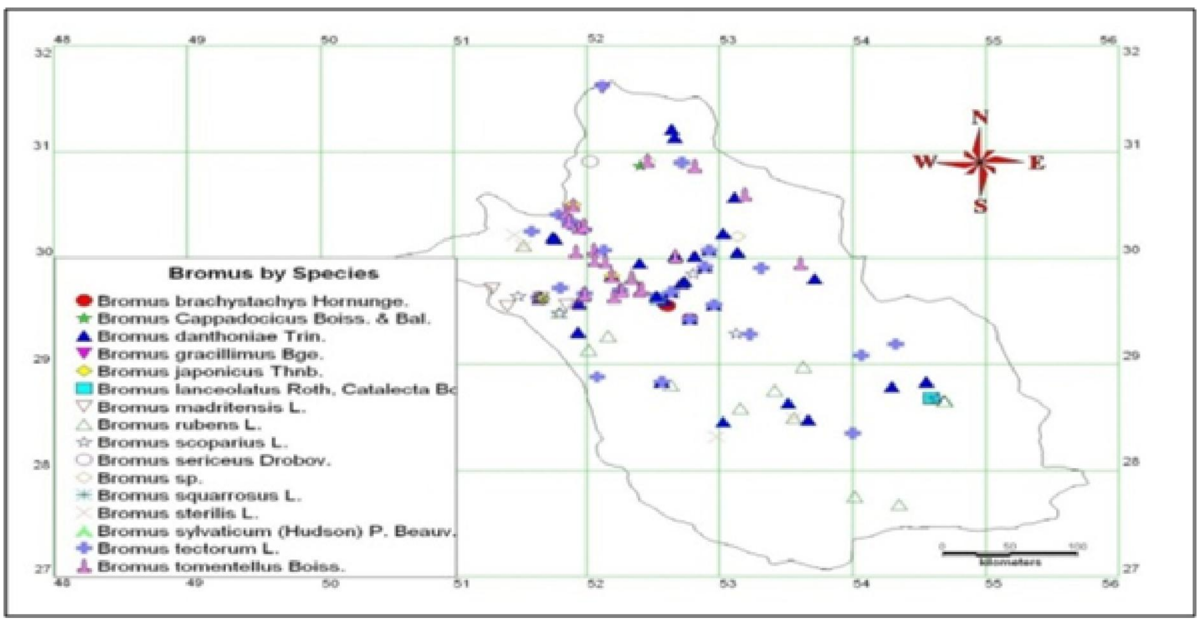

Figure 3- Distribution map of Bromus genus with 16 species

4.1.2 The distribution of endemic species of Poaceae family in Fars province:

Based on findings from the data bank, four species have been reported as endemic. This includes *Agropygon afghanicum* Melderis in Bor., *Agropygon long-aristatum* (Boiss.), *Stipa haussknechtii* Boiss., *Stipa sp.* and solely one species *Stipa Atriseta* Staph ex Bor, Sp. has been Narrow endemic. However, the *Stipa atriseta* Staph ex Bor., *Stipa sp.* species are the only endemic species in Fars province that had been collected from Bamo in Shiraz, Delu in Eghlid_and Kuhchahsiah in Marvdash.

Moreover, most of the numbers of endemic species belong to Shiraz and Eghlid and also the minimum number of endemic species belongs to Darab town with one species (Fig1).

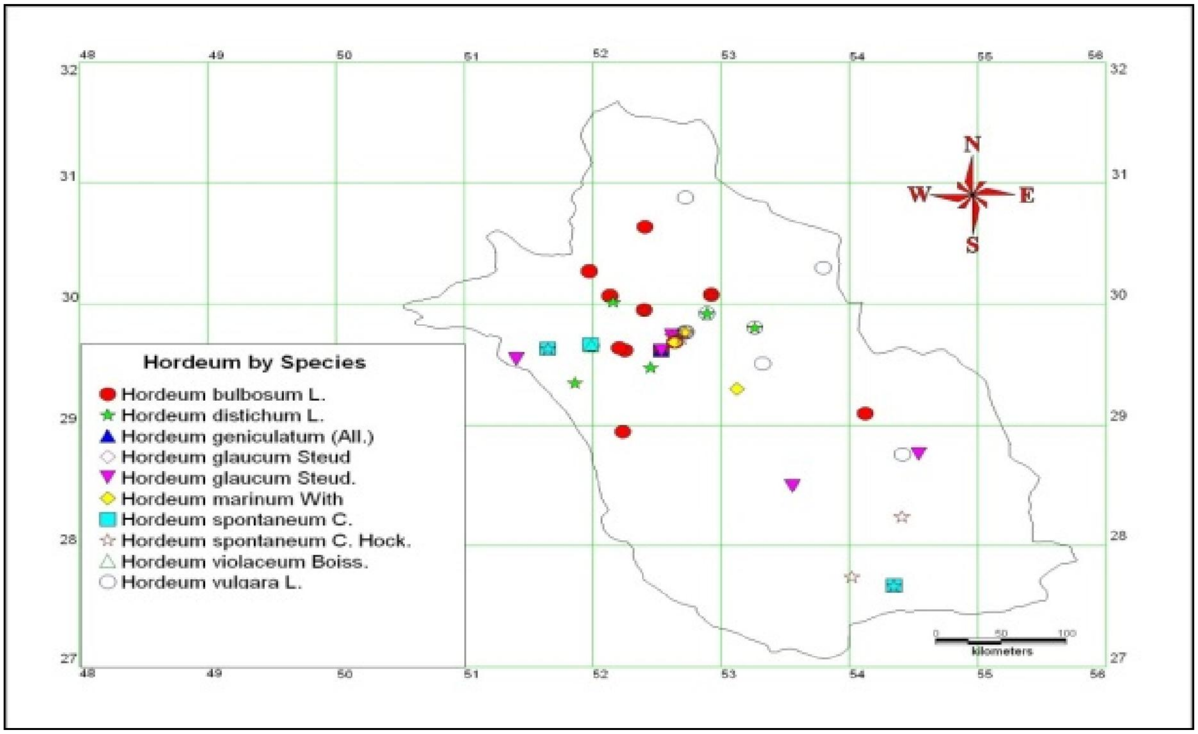

Figure 4- Distribution map of Hordium genus with11 species

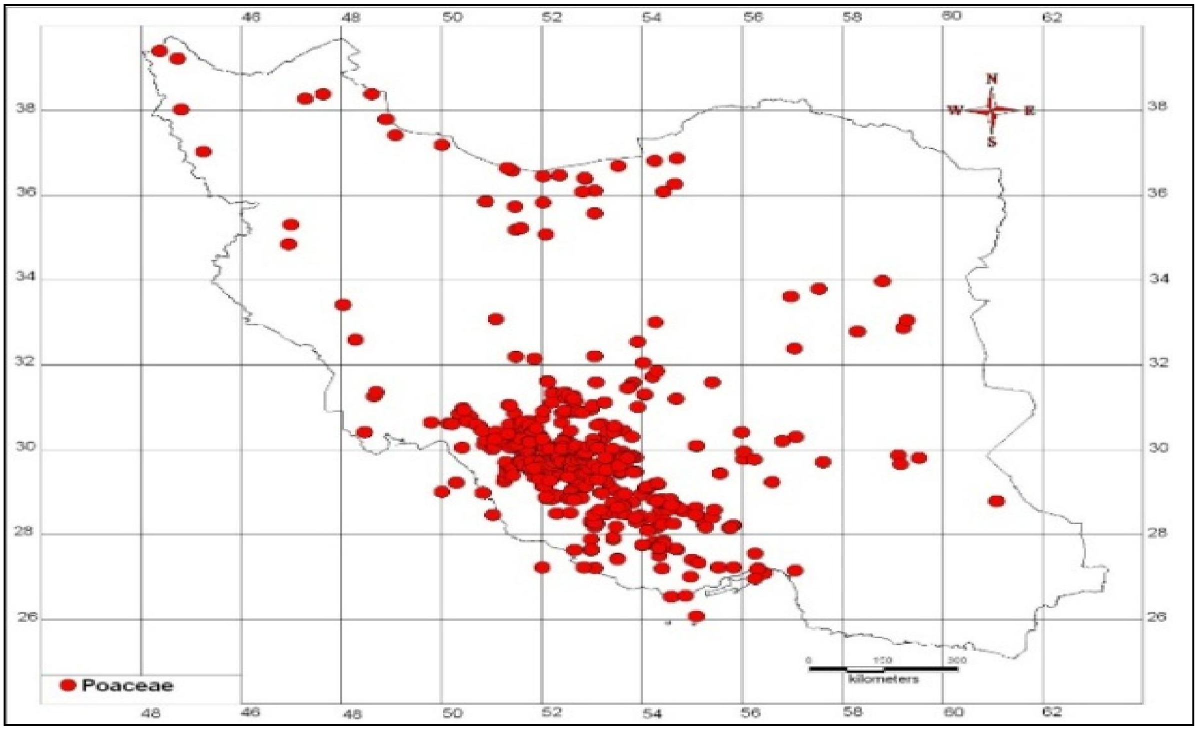

Figure 5- Distribution map of Poacea Family with 170 species

4.2. Chenopodiaceae family:
4.2.1Distribution pattern

The total number of records for the Chenopodiacea family surveyed is 1050, of which 709 belong to specimens of Herbarium of Shiraz University. The result of this research showed that this family has 37 genera and 150 species in Iran, from that, 29 genera and 70 species were found in Fars province. Therefore, from these records, 26 species is reported for the first time. The two largest genera in terms of species richness in this family are the *Salsola* genus with 13 species (Fig 6) and *Atriplex* with 9 species (Fig 7).

The following genera has only one species: *Anthoclamys, Bienertia, Camphorosma, Cornulaca, Gibsonia, Halocnemum, Halostachys, Krascheninnikovia and Panderia*. The other genus reported has one species in Fars province whereas; some of this genus has more than one species in the other locations*: Anthoclamys, Bienertia, Camphorosma, Cornulaca, Girsohnia, Halimione, Halimocnemis, Halostachys, Halocharis, Halocnemum, Halopeplis, Horaninovia, Krascheninnikovia, Noaea, Panderia and Petrosimonia.*

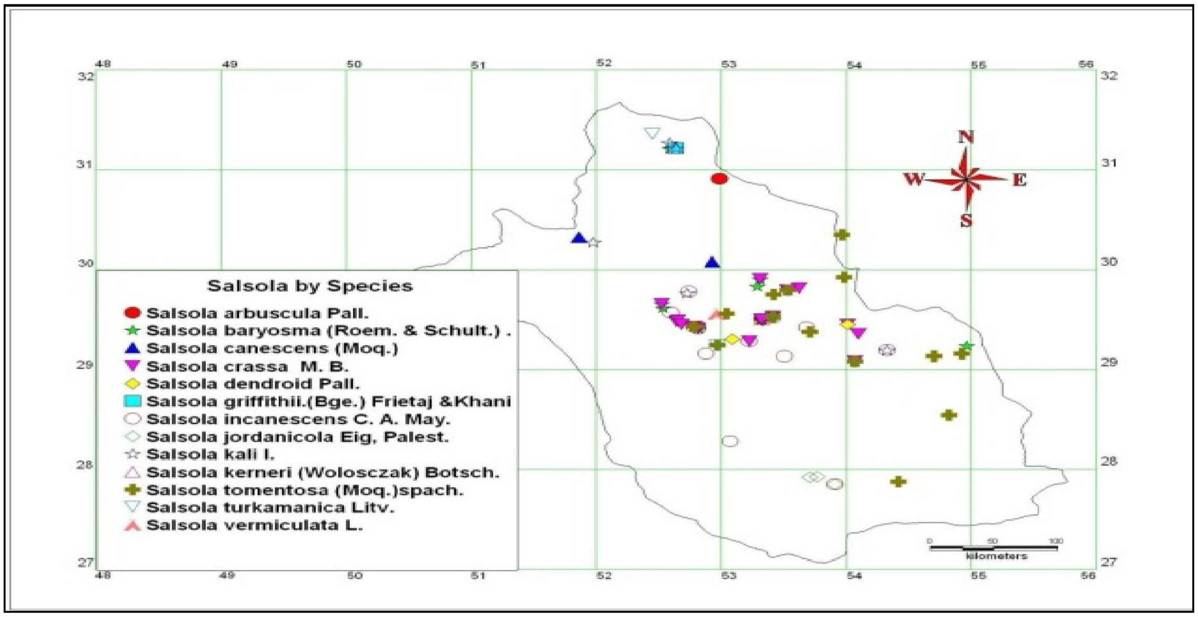

Figure 6- Distribution map of Salsola genus with 13 species

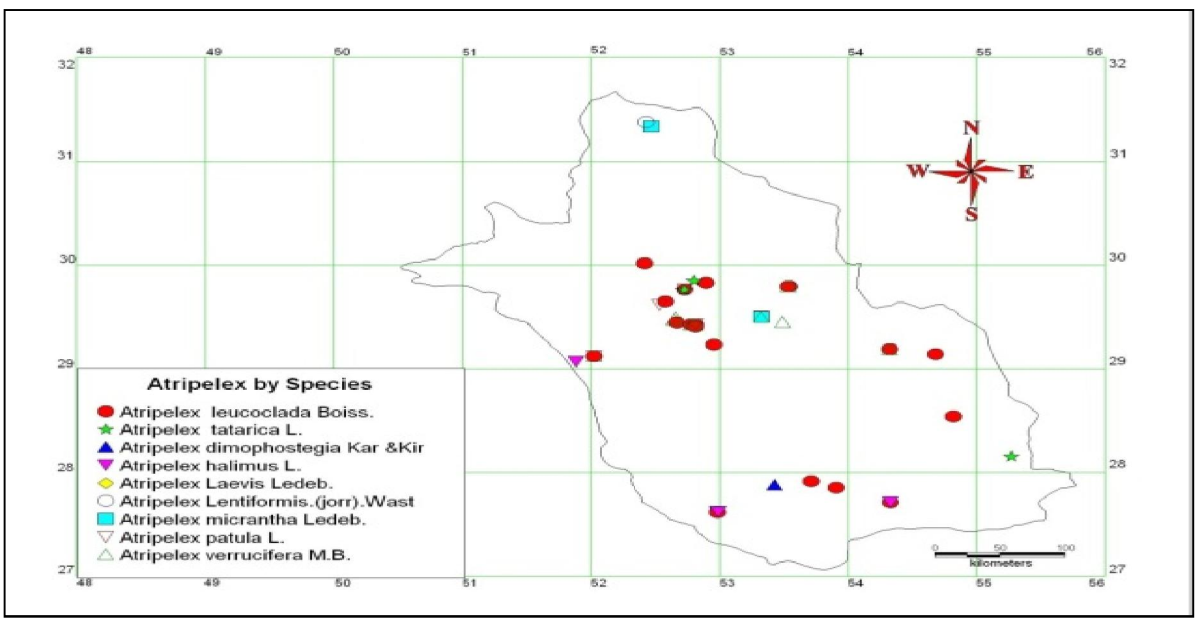

Figure 7- Distribution map of Atriplex genus with 9 species

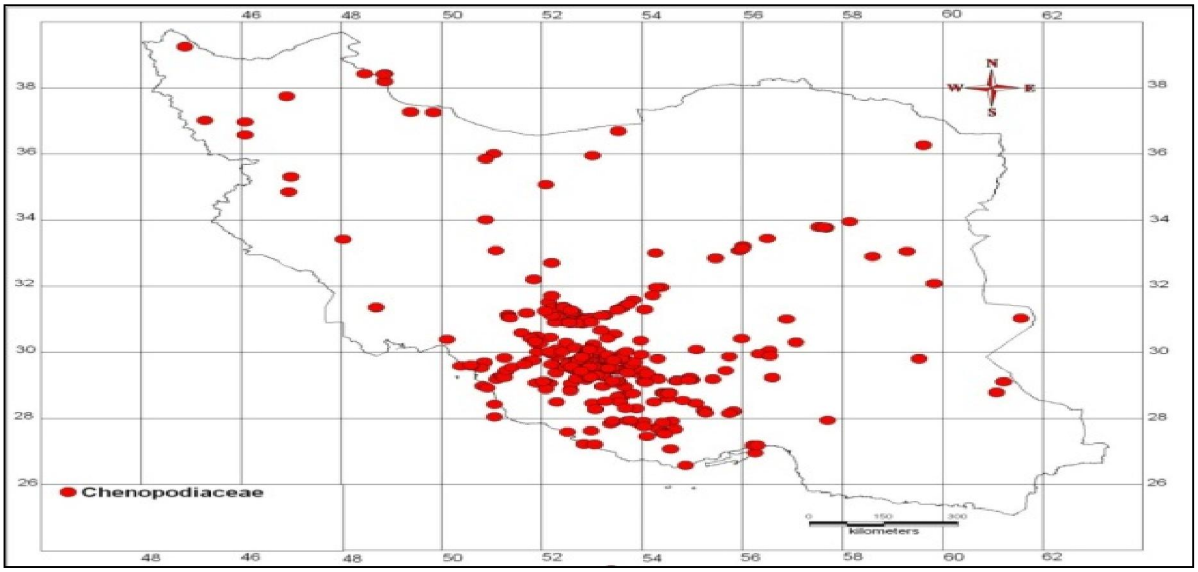

Figure 8- Distribution map of Chenopodiaceae Family with 70 species

4.3. Papaveraceae family

4. 3.1 Distribution pattern

To sum up, Shiraz with 26 species has the greatest floristic richness while Larmerd (Fig 1), with only 2 species, has the poorest floristic richness in the Fars province, as depicted in the distribution map of the Chenopodiaceae family (Fig 8).

The total number of records for the Papaveracea family surveyed is 406, from that, 345 records belong to specimens of Herbarium of Shiraz University. The inference from this research shows that this family has five genera and 38 species in Iran, where, five genara and twelve species were found in the Fars province.

From these records, eight species were reported for the first time.

The *Papaver* genus with ten species is the most diverse genus in Fars, as shown in the distribution map (Fig 9). *Papaver macrostomum* Boiss., *Papaver decaisnei* Hochst & Steud. and *Papaver argemon* L. respectively have the most distribution in the Fars province. *Glacium grandiflorum* Boiss. and *Glacium oxylobum* Boiss., both have the most distribution in Fars province. *Glacium elegans* which has been collected more in the west and northwest of Fars is an imported ornamental species that has already been recorded in Herbarium of Shiraz University. The *Hypecoum pendulum* L. is the only genus in this family with one species.

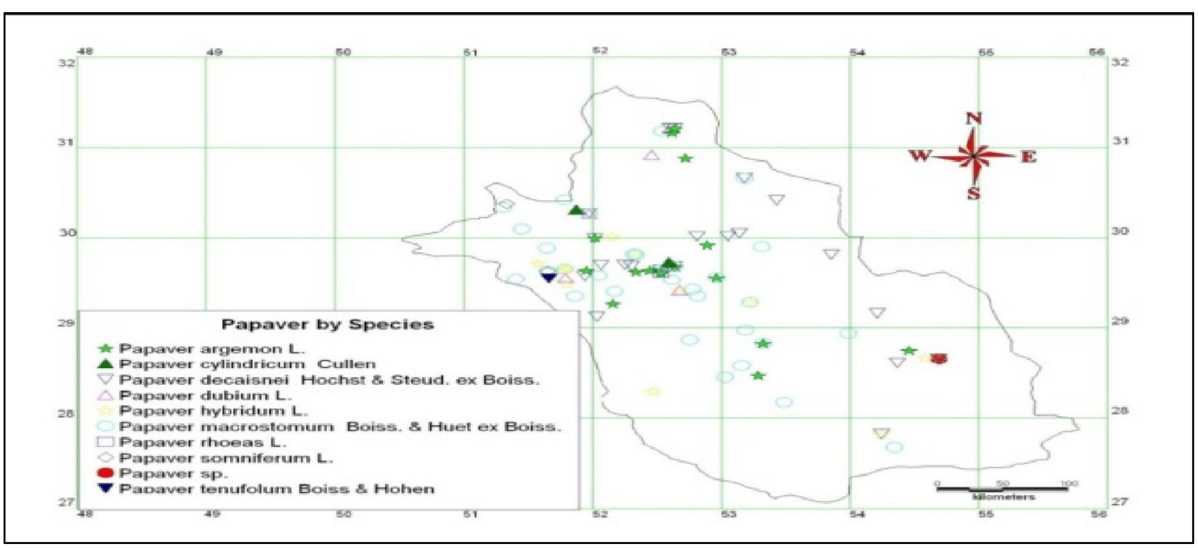

Figure 9- Distribution map of Papaver genus with 10 species

In short, the species distribution in the Fars province include, Shiraz with 17 species, Kazerun with 14 species (greatest floristic richness in the area) and also Lar with only 2 species making it the poorest floristic region in the Fars province (Fig1). The distribution map of Papaveraceae family is depicted below (Fig 10).

4. 3.2 The endemic species of Papaveraceae in Fars Province:

Glaucium haussknechtii Bornm. is the only endemic species of this family in the Fars province.

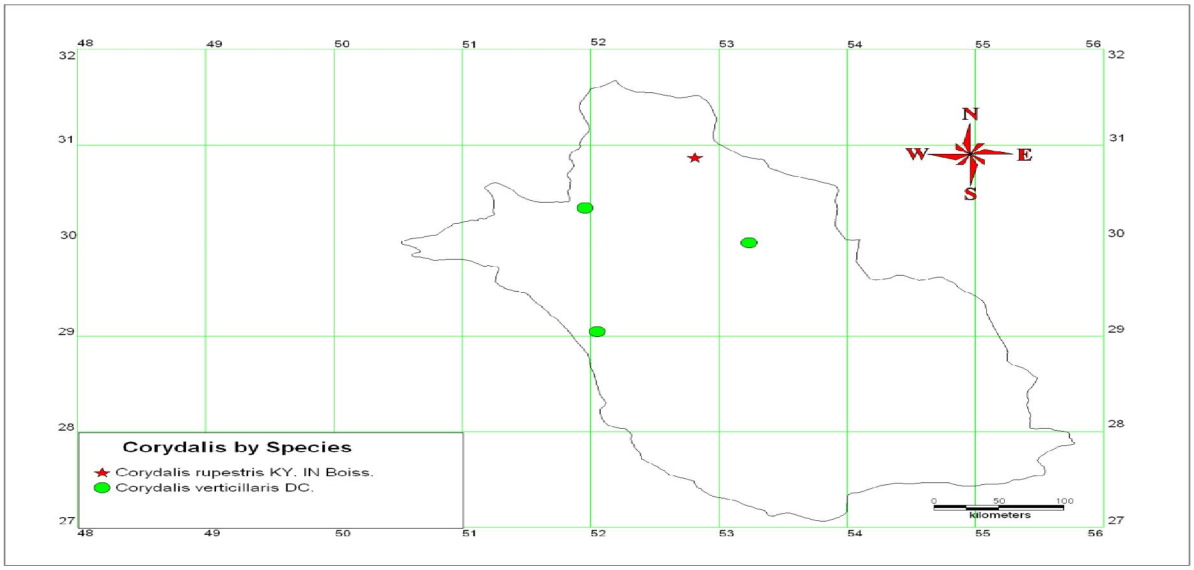

Figure 10- Distribution map of Corydalis genus with 2 species

4.4. Fumariaceae family

The total number of records for the Fumariaceae family surveyed is 139 of which, 70 records belong to the specimens of the Herbarium of Shiraz University. The inference from this research shows that this family has two genera and ten species in Iran, of which two genera (*Corydalis* and *Fumaria*) and seven species were found in the Fars province. Four species were reported for the first time. The distribution map of Fumariaceae family with seven species is depicted (Fig 13). *Corydalis* with two species (Fig 11) and *Fumari*a with five species recorded in Fars. – as shown in the distribution map (Fig 12).

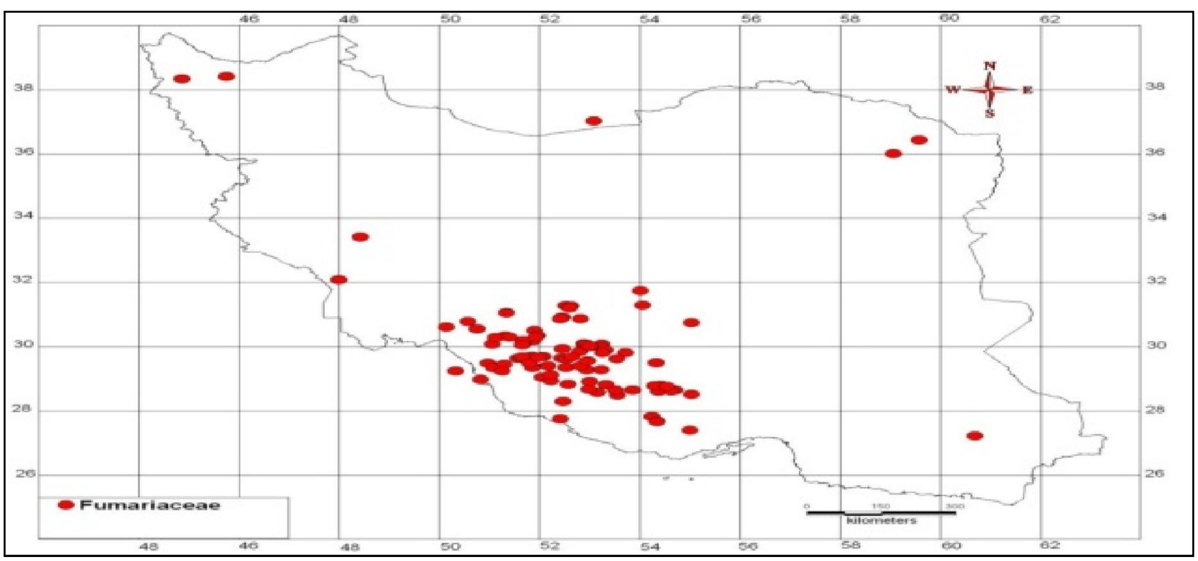

Figure 11- Distribution map of Papaveraceae family with 12 species

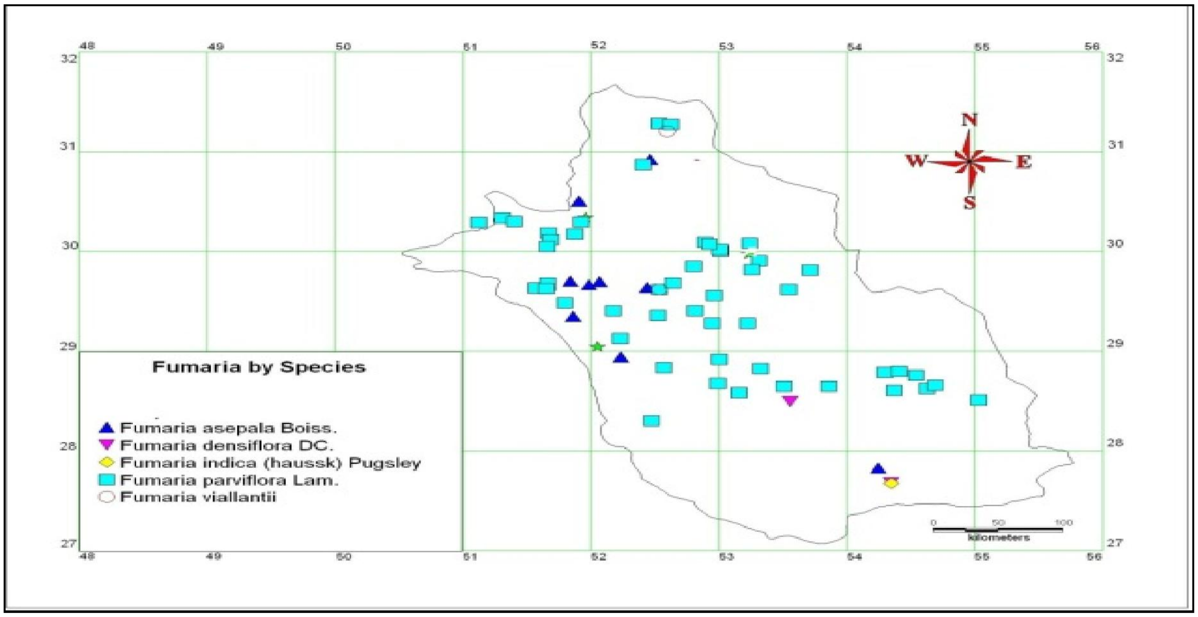

Figure 12- Distribution map of Fumariaceae with 7 species

5. Discussion

The concept of biodiversity holds different meanings depending on where one is. The task of conserving biodiversity includes that places can be prioritized for conservation. Prioritization of these places cannot be efficiently concluded by using only richness as the biodiversity index because richness does not indicate how the diversity of the population is distributed. Thus, it is important to measure biodiversity (Sarkar & Margules, 2002; Sastre & Lobo, 2009).

A number of important factors can influence conservation decisions for area prioritization and biodiversity monitoring. When using collected data for monitoring the biodiversity of an area, one assumes that the species collected represents the diversity. If the area is thoroughly covered and the identifications are correct, the species distribution can be a good index of biodiversity.

Even though some of these assumptions may not be considered true in the case of Fars, collected data provides the only direct evidence of the distribution of a species (Funk & Richardson, 2002; Sastre & Lobo, 2009). Prioritization according to richness maybe inaccurate because of two reasons: firstly, it is well-accepted that the prioritization of the places by richness is usually not an efficient way of targeting diversity. Two (or more) places, for instance, may be rich in the targeted features (e.g. species) and have very similar features. Conserving both may repeat protection of these features which, of course, is advantageous for their security, especially if it is affordable. However, conserving both may add very little to what would be achieved by conserving just one of them and then using limited conservation resources to add some other places with a very different set of features, thus increasing the total number of features that can be conserved (Margules & Pressey, 2000; Williams *et al.*, 1996).

The second reason why the place selection on the basis of richness is unsuccessful is that richness is not the same as diversity. Diversity, including biodiversity, indicates difference and variety whereas richness does not involve this implication (Sarkar & Margules, 2002; Sastre & Lobo, 2009). Species richness and rarity have been the most commonly cited measures of biodiversity (Borchsenius, 1997; Kier *et al.*, 2009). However, various definitions have been proposed for Species Richness (Casazza *et al.*, 2008; Kier*, et al.*, 2009; Williams*, et al.*, 1996). The term species richness is used here to indicate the total number of species in an area. Any measure of the number of species which are rare, endemic, or have a restricted range is difficult to achieve with the existing data.

Although some of the species in this study are restricted range species, without detailed knowledge of the total distribution, it cannot be mentioned whether or not it is endemic. Moreover, there are many areas of Fars-Iran that have not been properly surveyed, and this lack of information makes any description of something as rare, endemic or restricted in range, uncertain(Sastre & Lobo, 2009). Certainly literature searches and expert knowledge are useful for some of the taxa as it is used in this study.

6. Conclusion

In order to investigate the distribution of four families in Fars-Iran, the species of the four families Poacea, Chenopodiaceae, Papaveraceae and Fumariaceae were identified using floras monograph and also based on reviews that were conducted on past researches as the references. Information of each collection from each species including the name of the genera and names of the species, locations of collection, altitude and longitude, date of collection were given to a data set. Species distribution, endemic species, as well as regions of high species richness of these four families were determined based on the dataset. The dataset was created with suitable format which can be used in conservation decision making.

Numerous summaries of created datasets were obtained which showed that the four families above mentioned, had totally 126 genera and 265 species, of which eight species were endemic. The Poaceae family had 90 genera and 170 species, of which, five of them were endemic. The Chenopodiceae family had 29 genera and 70 species, where two of species were endemic. The family Papaveraceae had five genera and 12 species, of which one species was endemic. The Fumariaceae family had two genera and seven species without any endemic species. 98 species from province were recorded for the first time. The city of Shiraz has the highest species richness among the twenty townships in the province.

All these approaches were used to address the research problems of biodiversity to support planning, policy and management in conservation of plant biodiversity of Iran, particularly, in the study area. This paper introduces a strategy in combining plant systematics and ecological studies using GIS, as an approach for estimating the areas with the highest species richness as well as endemic and endangered plants.

Acknowledgement

The authors would like to express their gratitude and appreciation to both Shiraz University Herbarium and Dr. Ahmad Reza Khosravi.

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3/30/2014