# Mapping and Geographic Distribution of *Origanum syriacum* var. *sinaicum* in south Sinai, Egypt

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**Abstract:** Through this research we trying to draw complete a picture of the eco-geographical distribution of *Origanum syriacum* var. *sinaicum* as possible which combining the results of this study with previous studies is an important component of the eco-geographical process. An eco-geographic study is the process of gathering and synthesizing ecological, geographical and taxonomic information about a taxon. The results are predictive and can be used to assist in the formulation of conservation priorities. Here and as result for the eco-geographical study for *Origanum syriacum* var. *sinaicum* as endemic species in Sinai, we found that the species is a specific-habitats-species, grow in a narrow to moderate range of climatic conditions in SKP can give as a good indicator for the reason of endemism in SKP.

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**Key words**: Endemic; *Origanum*; Saint Katherine protectorate; South Sinai; Conservation; Desert plant

## 1. Introduction

An eco-geographic study is the process of obtaining, collating and analyzing different kinds of existing data pertaining to a taxon within a defined region (Maxted *et al.,* 1995). Such a study validated, refined and complemented by subsequent exploration and other fieldwork is generally seen as an essential first step in the development of a comprehensive strategy for the conservation and use of plant genetic resources. Before sensible conservation decisions can be made, a basic understanding of the taxonomy, genetic diversity, geographic distribution, ecological adaptation and ethno-botany of a plant group as well as of the geography, ecology, climate and human communities of the target region is essential endangered species are often sparse (Ferrier *et al.,* 2002; Engler *et al.,* 2004) and clustered making commonly. This kind of analysis will help to explore such key issues as when, where and how to collect germplasm; where genetic reserves might best be placed and how they would need to be monitored and managed; and the relative contribution of ex situ and in situ approaches to an overall conservation strategy.

In order to develop an efficient and effective conservation strategy using complementary in situ and ex situ techniques, we must have a clear understanding of each target species's geographical distribution, its habitat preferences and requirements, its genetics, reproductive biology and taxonomy. The details of the localities where past collection have been made, the so-called passport data, associated with herbarium and germplasm collections, are a key source of information to guide future conservation activities. For example, if the passport data for a particular species indicates that it has previously been found only in the mountainsides of St Katherine Protectorate, then these areas are likely to contain the species today. Looking for it on nearby mangrove swamps in Southern Egypt will be of little use. The ecological, geographic, genetic, reproductive biology and taxonomic data are collectively referred to as eco-geographic data and their analysis is a necessary prerequisite of efficient conservation.

In this study we targeting using, evaluation and analysis the available data about *Origanum syriacum* var. *sinaicum*. For data analysis, we used a multivariate analysis, GIS and descriptive analysis this to ensure the best using and orientation for the information. As result for the available data and analysis, we get good outputs that can help in support any conservation actions for the species, these outputs related with the *Origanum syriacum* var. *sinaicum* diversity Hotspot areas in SKP', species' area protection prioritizing and the status of the species in SKP.

### 1.1. Study area

The Saint Katherine Protectorate extends over virtually the entire mountain massif of southern Sinai, an area of 4350 km$^2$. The protectorate was established in 1996, under the support of the Egyptian Environmental Affairs Agency (EEAA). The protectorate area is described as predominantly smooth-faced granite outcrops from mountains such as Mt. Serbal, Mt. Ras Safsafa, Mt. El-Rahbah,….etc. Mountains consisting of old volcanic rocks are rather common. It includes Egypt's highest peaks, which support a unique assemblage of high-altitude ecosystems with a surprisingly diverse fauna and flora, and a relatively high representation of endemic species. It encompasses the highest percentage of plant species endemism in Egypt. It has about 44% of the total endemic plant species of the country. Within the protectorate there are numerous sites of enormous archaeological, religious and cultural significance, the best known of which are the Monastery of Saint Katherine dating from 330 CE and Mount Sinai or Jebel Musa.

### 1.2. Species overview

*Origanium syricum* L., subsp. sinaicum (Boiss.) Greuter & Burdet., is also have a vernacular local name as "Za'atar" and Bardaqwish.

This species is Perennial herbs, and considers as low under-shrub reach 90 cm. in tall, have much branched-erect stems with broadly ovate leaves. Is endemic species for SKP, grow on saint Katherine areas mountains (Fig. 1). *Origanum syriacum* var. *sinaicum* is belonging to the Labiatea family which encompasses most of the endemic species in Sinai 6 mm (Boulos, 2002).

Figure 1. *Origanum syriacum* var. *sinaicum* inside its natural habitats in SKP

## 2. Methodology

### 2.1. Data collection

125 spatially unique point locations for *Origanium syricum's* current distribution were collected and used in this study. Location data collected in surveys in 2010, for One hundred eighty eight stands which included presence for the species among 26 sites. The collection methods included surveying about one hundred eighty eight stands were selected randomly in the different habitats of SKP. The selection of stands is dependent on the presence of one or more of the globally significant species. Surveys are carried out during spring and summer seasons, i.e. between the end of May and July, 2010. The stand area was surface 25 $m^2$. The habitats of each species were described using 15 quantitative and four qualitative variables at each site. For each stand, we recorded the coordinates and elevation using GPS. Also, slope and topographic position are identified using Clinometers. In each stand, total vegetation cover was recorded using Domin Scale. Number of non-endemic plants was recorded. The growth parameters of the endemic plants (e.g. height, canopy diameter, leaf number/plant and leaf length) are measured, as well as their density in the studied stands. Different threats facing the endemic plants in the studied stands were estimated (e.g. grazing, tourism, cutting, drought, etc.). The study sites are overwhelmingly rocky, and therefore, the soil samples were collected from notches and cervices with true soil. For each site with true soil samples, the soil reaction (pH) and soil conductivity (EC) were measured using pH-meter and Conductivity meter respectively. The percentage of organic matter and concentration of available nitrogen were measured at the laboratory using standard methods **(Allen *et al.*, 1976).**

### 2.2. Input data

We used 19 ‘‘bioclimatic’’ variables, including annual and seasonal aspects of temperature and precipitation that are presumed to be maximally relevant to plant survival and reproduction, has derived and prepared with the help of point-to-grid cells of the climatic data map option of DIVA-GIS, using a grid size of 4 × 4 km cells and superimposed with the species distribution map. We also included elevation, slope, aspect, and compound topographic index driven from ARC GIS (esri). All analyses were conducted at the native 2.5" (~ 4.4 km pixels) spatial resolution of the environmental data sets. Species diversity and richness map was prepared with the help of point-to-grid analysis option of DIVA-GIS, using circular neighbourhood method with a radius of 4 km. A scatter diagram was prepared using MVSP software to understand species distribution along the environmental gradients and different climatic variables.

**2.3. Ecological niche modeling (ENM)**

ENM has been used in numerous applications and subjected to various tests, based on diverse analytical approaches (Csuti, 1996; Miller, 1994). The particular approach to modeling species' ecological niches and predicting geographic distributions is described in detail elsewhere (Peterson *et al.,* 2002). Previous tests of this modeling technique for diverse phenomena in various regions have been published over the world (Irfan-Ullah *et al.,* 2006). The ecological niche of a species can be defined as the set of ecological conditions within which it is able to maintain populations without immigration (Irfan-Ullah *el al.,* 2006). Several approaches have been used to approximate species' ecological niches, of these, one that has seen considerable testing is the BIOCLIM of DIVA-GIS (DIVA 2005). All modeling in this study was carried out on a desktop implementation of DIVA-GIS/BIOCLIM Ecological niche modeling, which it have been used in many important applications, including identifying places where species of special concern might occur, the study of invasive species, and for predicting the effect of climate change on species distribution and extinction. Although there are a large number of different ecological niche modeling approaches, they all use the same principles. Locations from where a species is known to occur are used to extract environmental data from spatial databases. Distribution prediction and the species suitable habitats extracted based on climatic parameters (annual mean temperature, temperature range, monthly diurnal temperature and precipitation), The BIOCLIM model of DIVAGIS uses a set of 15 of the available 24 climatic variables loaded with the program and most of these variables are those that are likely to affect the ecological domain of the species.

These data are employed to describe the apparent ecological niche of the species in question. This description of a niche, in multidimensional ecological space, is then projected onto a map (in geographic space). Otherwise the lowest (most limiting) percentile score across the environmental layers is mapped. The resulting map has values of zero (not suitable) to 50 (highest possible score). The result is a map with a predicted potential distribution of the species. The modeled distribution is derived from observations on the species and climate data. The predicted range map shows area where the species is very likely, less likely, and very unlikely to occur.

**2.4. Multivariate Analysis**

The following 19 ecogeographical variables were used in all multivariate techniques: longitude (Ln), latitude (Lt), altitude (Al), annual rainfall (Rn-A), mean and minimum temperature in January, representing peak winter conditions (mean and minimum winter temperature-Tmean-W, Tmin-W), mean and maximum temperature in August representing peak summer conditions (mean and maximum summer temperature-Tmean-S, Tmax-S), slope direction relative to the north (S-D) and slope rate in percentage (S-R).

**2.5. PCA Analysis**

Principal Component analysis (PCA) of the continuous eco-geographical variables was used to identify a smaller number of principal components to account for most of the eco-geographical variance among 25 sites populated with *Origanum syriacum* var. *sinaicum*. PCA was based on the correlation matrix and presented as biplot ordinations of populated sites (PC scores) and eco-geographical variables (PC factor loading). Actual populated sites were depicted in the ordination by plotting sites' principal component scores using a unique symbol for each cluster of sites. PCA and hierarchical clustering was applied by MSVP v.5.1.

**3. Results**

**3.1. Eco-geographical analysis**

This include 3 divisions, geographical, ecological and climatic attributes analysis. Table (1) includes detailed information for the Geog. and Eco. Variables Range for the specie in level of its micro-habitats, SKP South Sinai region.

**3.1.1. Geographical attributes analysis**

**3.1.1.1. Species distribution and coverage**

A total of 125 locations for *Origanium* were recorded from different 26 sites/wades, which included the following regions: Shiekh Awad, Sherage, Shag Tinia, Wadi Telah, Frea'a, Tale'a El Kalb, Farsh Rommana, Farsh Rommana, Farsh Sala, Abu Towaita, Wadi Tinia, Shag Abu Hamman, Wadi Fara'a, Wadi El Arbein, Abu Gifa, Slybat, Tofaha, Farsh Sefsafa, Farsh Losa, Loger, Rohibet Nada, Wadi Rommana, Ekhdeid, Gabel Ahmar, Shag Mousa, Gragnia, Wadi Tala'a (Maps 1 & 2).

It seems that most of the localities close to the area of saint katherine mountain, as the center of endemism in SKP. The species present among area equal about 50 sq km, in general it take a narrow localized species distribution pattern with some few meta-populations such as Tala El Kalab and Sheik Awad.

**3.1.1.2. The altitude effect**

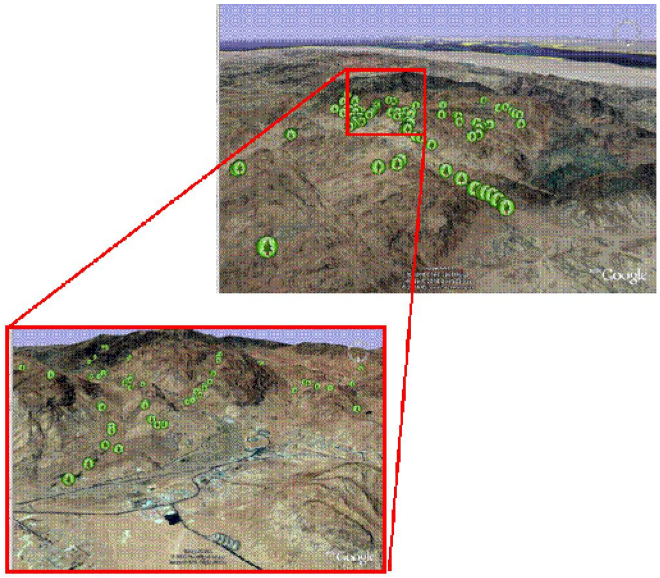
The relationship was further confirmed when the distribution and altitude maps were superimposed.

It was found that *Origanum* had a wide range of distribution between 1193 and 2051 m, the average alt is 1693 m, it mean that the species alt niche length is occupied about 858 m upward, this niche representatives about 41.5% of the total available alt-niche in SKP (min-alt = 500m and max alt = 2560 m) (map 3) (Figs. 2 & 3).

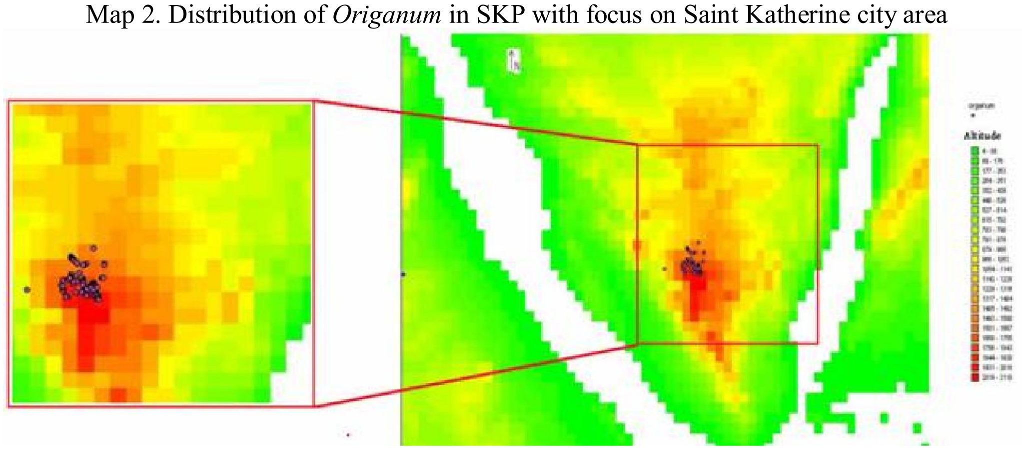
Table 1. Climatic and geographic Conspectus for the *Origanum syriacum* var. *sinaicum* habitats

| V code | Variable | Species Climatic range (SCR) | | | SKP Climatic range (SKPCR) | | | South Sinai Area Climatic range (SSACR) | | | Sp CR /SKP-CR | Sp-CR /SSA-SR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | Range | Min | Max | Range | Min | Max | Range | | |
| 0 | Altitude | 1193 | 2051 | 858 | 500 | 2560 | 2060 | 0 | 2560 | 2560 | 41.65 | 33.52 |
| 1 | Annual Mean_temp | 11 | 16 | 5 | 11 | 20 | 9 | 11 | 24 | 13 | 55.56 | 38.46 |
| 2 | mean monthly temp range | 12 | 12 | 0 | 11.2 | 12.2 | 1 | 10.5 | 12.2 | 1.7 | 0.00 | 0.00 |
| 3 | isothermality | 43 | 44 | 1 | 43 | 44 | 1 | 42.5 | 44.5 | 2 | 100.00 | 50.00 |
| 4 | Temp. Seasonability | 580 | 610 | 30 | 550 | 610 | 60 | 500 | 610 | 110 | 50.00 | 27.27 |
| 5 | Max temp. of warmest month | 25 | 29 | 4 | 25 | 31.5 | 6.5 | 25 | 36 | 11 | 61.54 | 36.36 |
| 6 | Min temp. Of coldest month | -3 | 2 | 5 | -3 | 6 | 9 | -3 | 11 | 14 | 55.56 | 35.71 |
| 7 | temp .annual range | 27 | 28 | 1 | 26 | 28 | 2 | 24 | 28 | 4 | 50.00 | 25.00 |
| 8 | mean temp of wettest month | 4.5 | 9 | 4.5 | 4 | 14 | 10 | 4 | 21 | 17 | 45.00 | 26.47 |
| 9 | mean temp of driest quadrate | 18 | 21 | 3 | 17 | 25 | 8 | 17 | 28 | 11 | 37.50 | 27.27 |
| 10 | mean temp of warmest quadrate | 18 | 22 | 4 | 18 | 27 | 9 | 18 | 30 | 12 | 44.44 | 33.33 |
| 11 | mean temp of coldest quadrate | 4 | 8 | 4 | 3 | 14 | 11 | 3 | 17 | 14 | 36.36 | 28.57 |
| 12 | Annual precipitation | 21 | 80 | 59 | 7 | 80 | 73 | 1 | 80 | 79 | 80.82 | 74.68 |
| 13 | precipitation of wettest month | 4 | 14 | 10 | 2 | 14 | 12 | 1 | 14 | 13 | 83.33 | 76.92 |
| 14 | precipitation of driest month | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| 15 | Precipitation seasonability | 84 | 98 | 14 | 82 | 183 | 101 | 82 | 347 | 265 | 13.86 | 5.28 |
| 16 | precipitation of wettest quadrate | 10 | 40 | 30 | 4 | 40 | 36 | 1 | 40 | 39 | 83.33 | 76.92 |
| 17 | precipitation of driest quadrate | 0 | 2 | 2 | 0 | 2 | 2 | 0 | 2 | 2 | 100.00 | 100.00 |
| 18 | precipitation of warmest quadrate | 0 | 2 | 2 | 0 | 2 | 2 | 0 | 2 | 2 | 100.00 | 100.00 |
| 19 | precipitation of coldest quadrate | 10 | 38 | 28 | 6 | 38 | 32 | 1 | 38 | 37 | 87.50 | 75.68 |
| 20 | min_temp_ann | 5 | 10 | 5 | 5 | 14 | 9 | 5 | 19 | 14 | 55.56 | 35.71 |
| 21 | max_temp_ann | 17 | 22 | 5 | 17 | 25 | 8 | 17 | 29 | 12 | 62.50 | 41.67 |


Map 1. Distribution of *Origanum* in SKP



Map 2. Distribution of *Origanum* in SKP with focus on Saint Katherine city area




Map 3. Altitude map of southern sinai and *Origanum syriacum* var. *sinaicum* species distribution drawn using DIVA-GIS

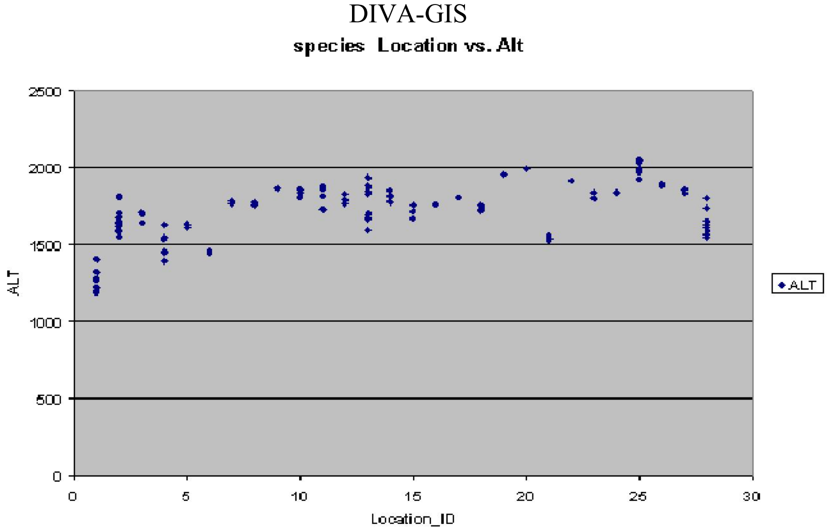



Figure 2. Altitudinal range of *Origanum* in SKP

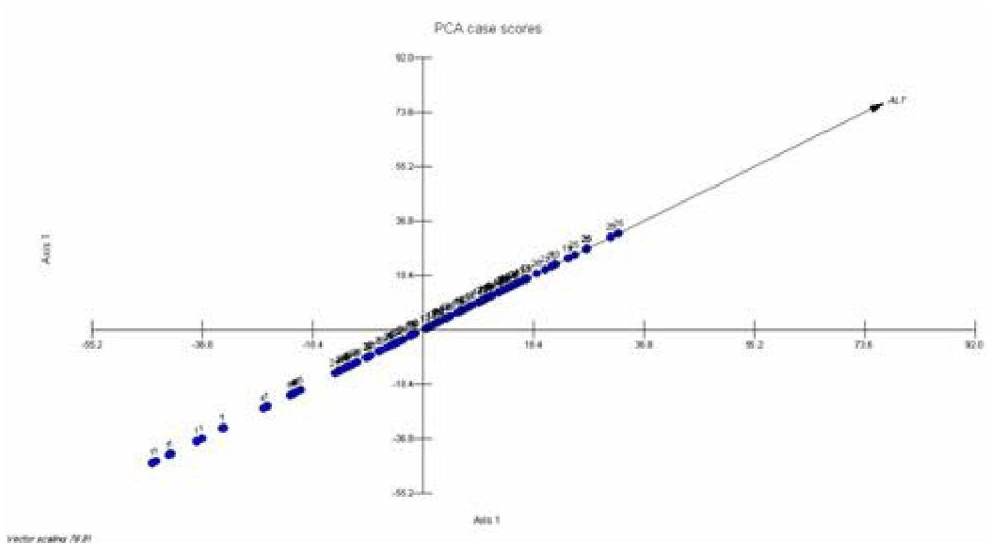



Figure 3. Principal Component analysis (PCA) altitude effect analysis as limiting factor for distribution of *Origanum* in SKP

**3.1.1.3. Aspect effect**

The slope rate of the populated sites is high, which the species founded in slope aspect between 88 and 89.9 degree. Populations are located at Northern (25% of the populations), Northern east (40.7%), Eastern (12.03%), western (4.62%), and northern west slopes (17.59%). This distribution pattern of the populated sites is not significantly different from the division of slope aspects among all survey sites (Table 2) (map 4).

Table 2. Aspect values for the *Origanum* habitats in SKP

| Aspect | Percentage % |
|---|---|
| N | 25 |
| NE | 40.74074 |
| E | 12.03704 |
| W | 4.62963 |
| NW | 17.59259 |

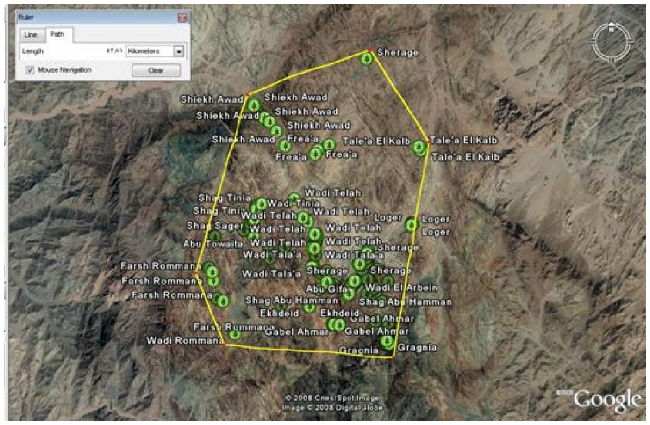

Map 4. Effect of pattern of the altitude aspect in distribution of *Origanum* in SKP

**3.1.2. Ecological attributes analysis**

**3.1.2.1. Population demography**

Most of the *Origanum syriacum* var. *sinaicum* populations were small and plants occurred sporadically in space, as little groups or as individuals. At the micro-site level, *O. syriacum* plants occupied most of high altitude representative different habitats in SKP such as wade bed, terrace, gorge, slope and farsh, the only habitat that there is no presence for *Origanum* is cave habitats. This indicates that this species has a wide range of spatial distribution and presence.

The estimated spatial size of *O. syriacum* estimated based on calculation the area of occupancy AOO and extent of occurrence EOO. Extent of occurrence is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding cases of vagrancy, and Area of occupancy is defined as the area within its 'extent of occurrence' (see point 9 above) which is occupied by a taxon, excluding cases of vagrancy. The measure reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitats. which AOO for *Origanum syriacum* var. *sinaicum* estimated about 31.6 sq km, it represents about 0.63% from total SKP area. And EOO is estimated about 42.8 sq km, it represents about 0.86% from total SKP area (42.8 from 5000 sq km). Population Fragmentation Factor (PFF) = (AOO/EOO)= 0.7 (map 5). This leads to that there were differences between sites. Which PFF values of all sites yielded a ratio lower than 1, and more than 0.5, pointing to a semi patchy distribution of most of *Origanum* population. This indicate more aggregated pattern. This patchy pattern is in accord with the habitat heterogeneity of sites.




Map 5. extent of occurrence of *Origanum syriacum* var. *sinaicum* within SKP

**3.1.2.2. Eco-geographical characters and habitats preference for *Origanum***

The altitude of *Origanum* sites ranges from 1193 m above sea level in Sheikh Awad area to 2051 m in Gabel Ahmar. The average altitude across all the populated sites is 1689 m. the sites is subjected for annual precipitation ranging from 21 to 80 mm. the minimum temperature for these sites is located between 5 to 9 and the maximum temperature from 17 to 21°C.

The survey show there is no specific habitat preference of the species, which based on table (1) this species located into most of the micro-habitats, included Slope, Terraces, Gorge and Farsh, but *Origanum syriacum var. sinaicum* showed much better growth in gorges habitats (Table 3 and Figs. 5 & 6).

**3.1.2.3. Overlapped with other endemic species's Distribution in SKP**

As most of endemic plants in SKP are restricted mostly to higher elevations of SKP mountains and also based on their common growing as companion species inside it habitats depending on Khader 2007, The analysis of species richness and the distribution of endemic plants in the different microhabitats of SKP along an elevation gradient is indicated to that the number of endemic species increased with increasing the altitude from 1200 m to 2200 m (a.s.l.). This pattern of endemic species was associated with increase in the number of non-endemic plants (Fig. 7). This is in part may be due to tremendous geological complexity of the mountains and habitat heterogeneity.

The highest value of species overlap (56%) was recorded between *Phlomis aurea* and *Origanum syriacum* ssp. *sinaicum*. Also, *Origanum syriacum* ssp. *sinaicum* showed higher overlap values with both *Nepeta septemcrenata* (35%) and *Anarrhinum pubescens* (34%) (Fig 8).

The other 5 endemic plants (*Nepeta septemcrenata, Phlomis aurea, Thymus decussatus, Origanum syriacum subsp. sinaicum* and *Anarrhinum pubescens*) are recorded in 5 microhabitats in SKP. The most interesting is the relatively high growth parameters of *Thymus decussatus* in Farsh microhabitat. *Origanum syriacum subsp. sinaicum* showed much better growth in gorges.

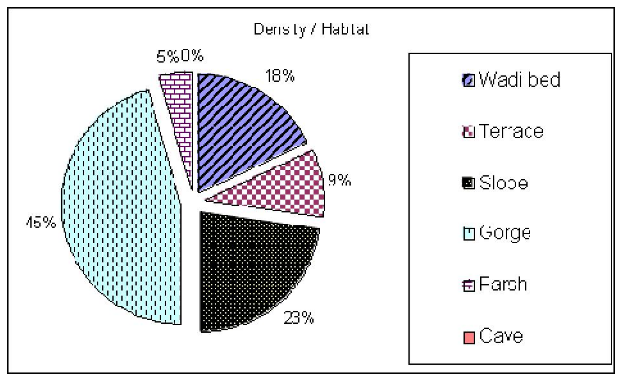



Figure 5. The distribution of the different microhabitat types among populated sampled units. Numbers within pie slices indicate the total populated sample units of each category.

**3.1.2.4. Species Conservation status and measures**

**3.1.2.4.1. Threats**

*Origanum syriacum* in SKP faces many threats, which can be divided into 2 divisions relating with the nature of human inferences for each of them: Human-interferences impacts: These included over-grazing of the domestic animals (Low), over-collection for medicinal uses (high), grazing of feral donkey (moderate) and irresponsible Tourism (moderate).

Natural-interferences impacts: Drought and Climate change (high temperate/low precipitation).

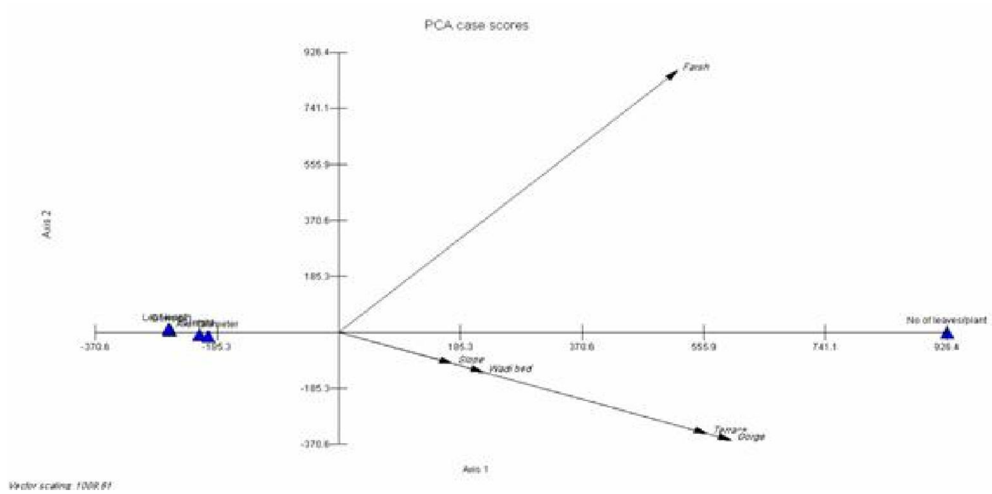



Figure 6. PCA values and analysis for the driver micro-habitats for *Origanum* in SKP

Table 3. Mean values and range (in bracts) of ecological characteristics in the different microhabitats of St. Katherine Protectorate, Southern Sinai

| Parameter | Microhabitats | | | | | |
|---|---|---|---|---|---|---|
| | Wadi bed | Terrace | Slope | Gorge | Farsh | Cave |
| Altitude (m) | **1357** (1190-1900) | **1662** (1453-1928) | **1829** (1634-2300) | **1894** (1594-2037) | **2050** (2025-2233) | **1770** (1700-2100) |
| Soil depth (cm) | > 1 | - | - | - | > 1 | > 1 |
| Soil moisture (%) | - | - | - | - | - | > 50 |
| Soil pH | **7.4** (6.9-8.1) | **7.5** (7.0-8.1) | **7.6** (6.9-8.3) | **7.6** (6.6-8.4) | **7.6** (7.2-8.2) | **6.8** (6.7-7) |
| EC µS/cm | **316** (99-1920) | **312** (107-917) | **589** (103-2900) | **254** (90-1060) | **440** (160-1203) | **1022** (817-2147) |
| Organic matter (%) | **2.00** (0.25-3.41) | **2.54** (0.75-3.12) | **3.01** (0.67-3.46) | **2.35** (0.76-4.73) | **2.32** (1.29-3.96) | **3.57** (2.35-5.01) |
| Nitrogen (ppm) | **102** (62-188) | **92** (67-45) | **101** (59-261) | **105** (80-158) | **96** (79-163) | **102** (82-143) |

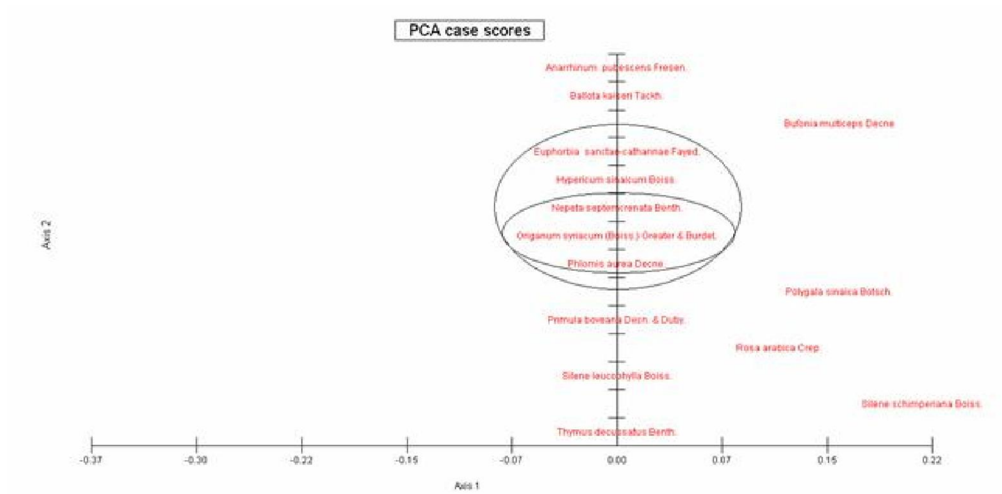



Figure 7. PCA values for the species overlapping inside the *Origanum* micro-habitats in SKP

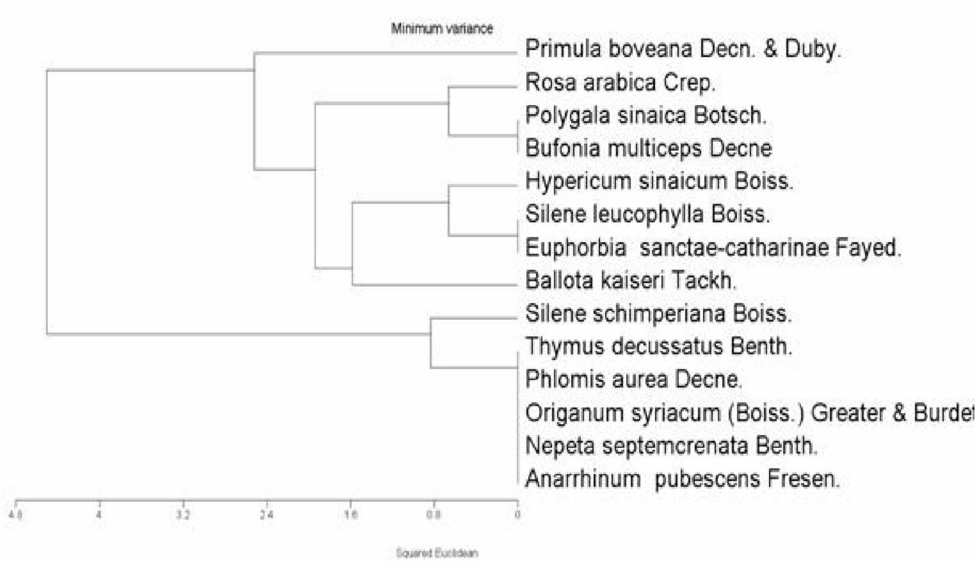



Figure 8. Species correlation within the micro-habitats in SKP

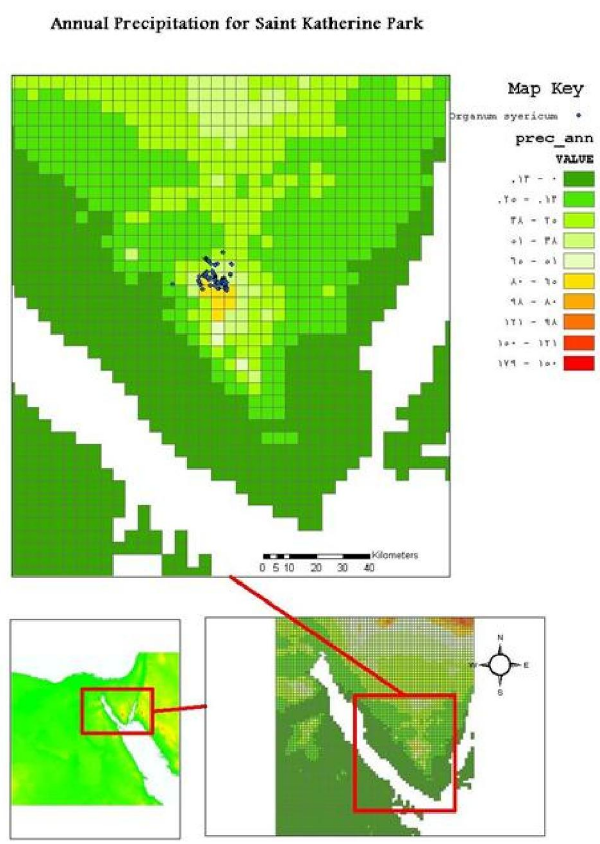
### 3.1.3. Climatic variables analysis

#### 3.1.3.1. Precipitation effect

The superimposed map of BIOCLIM annual precipitation and species distribution indicates that *Origanum syriacum* naturally occurs in the low-rainfall zones (less than 100 mm), A well-distributed rainfall within the range of 51–85 mm is best suited for *Origanum* growth. The annual rainfall in all the collection sites ranged from 13 to 85 mm (map 6).

The scatter diagram of species distribution (Figure 9) prepared with rainfall and altitude shows that the high altitude species are falling in comparatively high-rainfall grids of the BIOCLIM map. As in southern Sinai, that high area especially that northern facing received more precipitation at high altitude areas. Based on this diagram it seem that the species population distribution can be broadly divided into three different zones/groups, controlled completely with correlated and integrated effect from the altitude and the precipitation, which as the altitude been higher as the precipitation increasing. The first group/zone occurs in low altitude correlated with low precipitation, zone, 2 in mid-alt with moderate precipitation and zone 3 in high alt with high precipitation. It is notable that most of the species populations, about 92% grow in zone1 and 2 which seeking high precipitation (Fig. 10).

May be the highly elevation gradient and the dissected terrain in this area results in restricted gene flow over short distances led to isolation of small populations of the species and the terrain and elevation gradient together lead to variable climatic patterns resulting in different selective regimes.




Map 6. Annual Precipitation for SKP

#### 3.1.3.2. Effect of temperature in biogeography of *Origanum syriacum* var. *sinaicum* in SKP

The superimposed map (maps 7 & 8) of BIOCLIM annual Min-temperature, Max-Temperature and species distribution indicates that *Origanum syriacum* naturally occurs in the low-temperature zones range from 5.3–11.8°C at winter and from 17.4-23.4 at summer season. A well-distributed rainfall within the range of 51–85 mm is best suited for *Origanum* growth. The annual rainfall in all the collection sites ranged from 13 to 85 mm (Figs. 11 & 12).

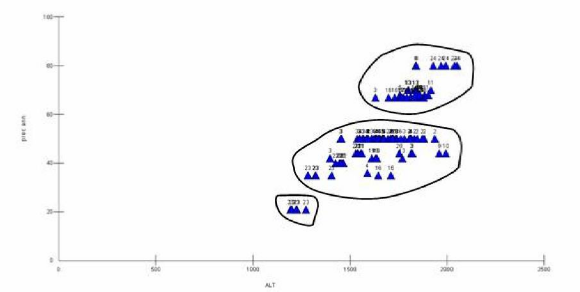


Figure 9. Scatter diagram for species distribution clustering based on the climatic variables

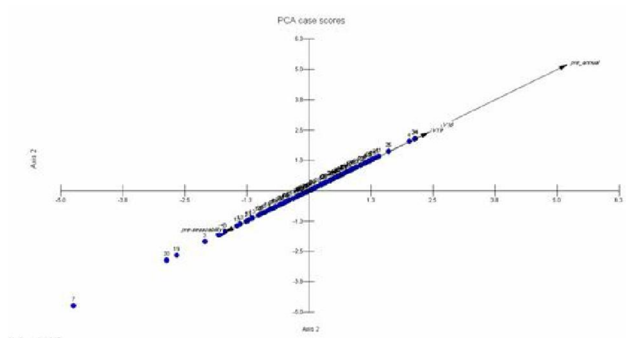


Figure 10. PCA values show the annual precipitation as limiting factor for distribution of the *Origanum* in SKP

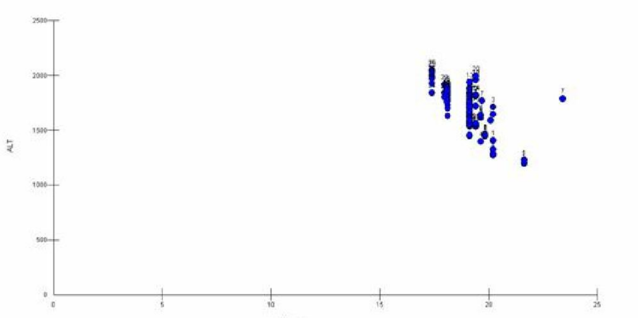


Figure 11. Maximumm temperature as limiting factor in the species distribution in SKP

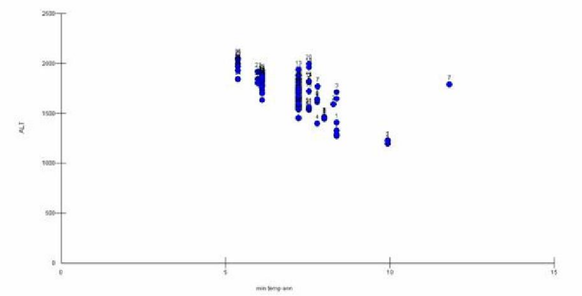


Figure 12. Minimum temperature as limiting factor in the species distribution in SKP

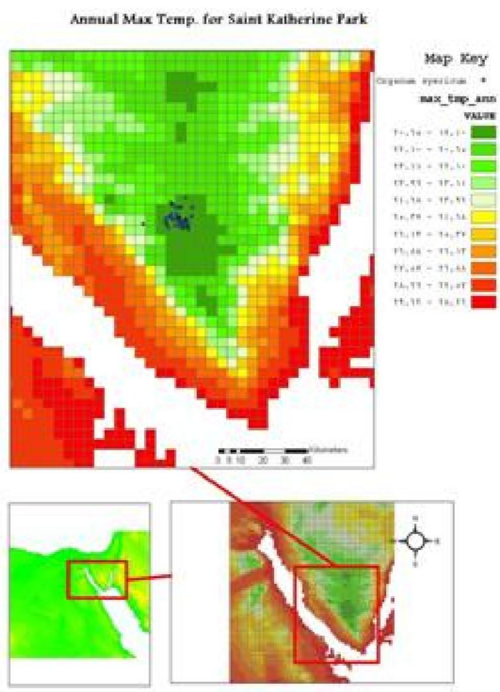
## 4. Discussion

Most conservation decisions are made at finer geographic scales than hotspots or ecoregions (Mace *et al*., 2000). In addition, there is a need to develop and adopt techniques that allow assessment both at finer and larger scales. Therefore, it is necessary to develop scale independent techniques that allow researchers and managers to assess biodiversity patterns within hotspots (Mace *et al.,* 2000). Such techniques need to be procedurally simple for easy replication within or outside protected areas, especially where trained personnel and/or recent baseline data are rare. On large spatial scales, the length of a biotic gradients (climate, topography, soil), available energy, habitat area, historical and chance events, recruitment limitation and extinction-immigration dynamics have been considered as important factors in explaining species richness (Hurtt and Pacala 1995; Wohlgemuth, 1998; Hubbell, 2001; Whittaker *et al*., 2001; Thuillier *et al*., 2006). In addition, the importance of historical factors has recently been emphasized. In this respect, plant species richness is assumed to be high in habitats that have been abundantly available for plants for long periods (Taylor *et al*., 1990; Zobel, 1992; Aarssen and Schamp, 2002).

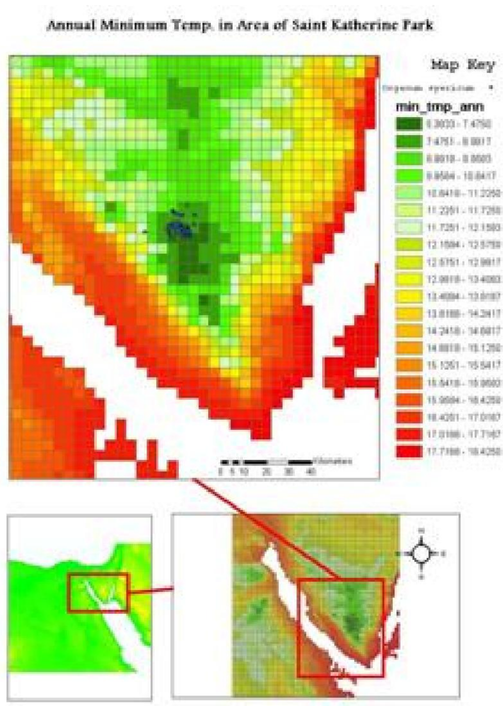
### 4.1. Relation between the species and it environment

#### 4.1.1. Macro-environment of *Origanum syriacum* var. *sinacum* (*Origanum syriacum* var. *sinaicum* as indicator for the origin of SKP as a climatic-island for endemism)

At the macro-environment scale, or the eco-region scale, and by analysis the variables data on a regional scale, we can clearly see that SKP situated among the same range for the area of west Asia and east south Europe. For that this climatic and topographic uniqueness came as representative for overlapping between the Mediterranean and Irano-Turanian flora regions. As shown from the maps below that SKP have the same range of climatic and topographic values that similar for the areas of north-west the med. sea and region of north Iran (Fig 13).




Map 7. Annual MaximumTemperature in SKP




Map 8. Annual Maximum Temperature in SKP

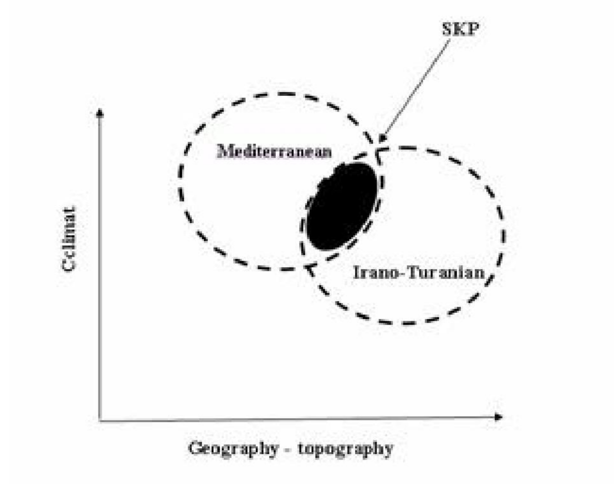



Figure 13. Illustrated shape for SKP as transition zone between the the Mediterranean and Irano-Turanian flora regions

This climatic and topographic conditions with such this overlapping, which can't be found expect in SKP inside Egypt, make SKP as a "transition-isolated region", so as the endemism phenomena return mainly to the physical and ecological isolation over the space and time. Which this isolation make the species exclusive or restricted to a particular area. The isolation is the main reason this because of presence of barriers that prohibit any migration, dispersal or interaction with other communities. The degree of endemism depends on how effectively and for how long an area has been isolated. Here is Saint Katherine the isolation found as result for the extreme unique climatic barriers, topographic (mountain massive) barriers and also which we can call it as "climatic islands of biodiversity" (maps 9, 10, 11 & 12).

#### 4.1.2. Meso–environment (altitude/precipitation) Drivers

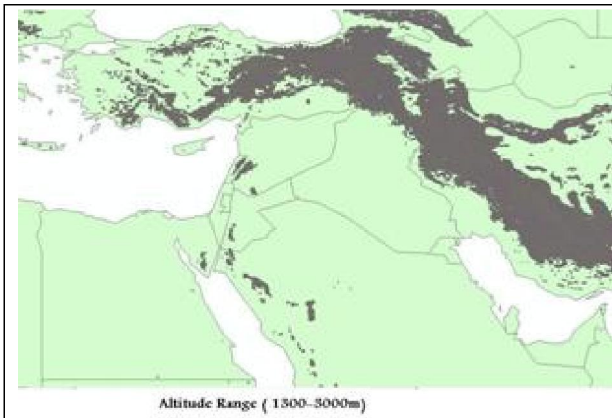
In the meso-scale in SKP, it seem based on the results that the limiting factors in presence, spatial distribution and populations pattern are the altitude and precipitation, which as figure 13 shows there is a 3 well defined zones, clusters for the distribution of the *Origanum syriacum* var. *sinaicum*. Which most of the species found over the mid and high altitude zones, in the same time at moderate to high precipitation degree (Figs 14 & 15).

#### 4.1.3. Micro- environment (micro-habitats role)

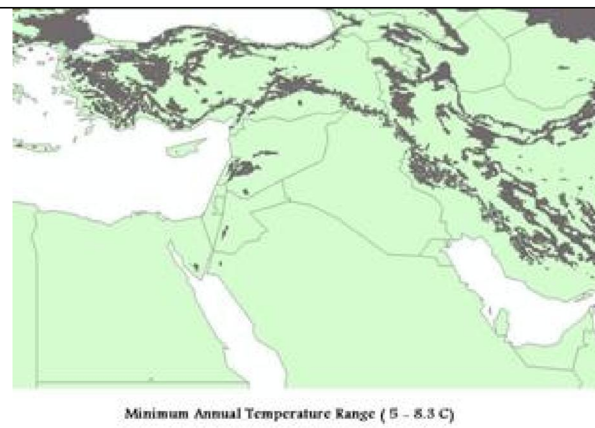
In this very specific scale, we can see the importance and role of the micro-topography and micro-climate, which the direction of sun exposure, mountain slopes degree and aspect degree have distribution pattern of the *Origanum syriacum* var. *sinaicum*. The species is rare and mostly grow in rocky habitats in mountains, the slope aspect for their habitats ranging between 88 and 89.9 degree. The species prefer to grow in semi-shade to no-shade habitats which the populations are located at Northern direction (25% of the populations), Northern east (40.7%), Eastern (12.03%), western (4.62%), and northern west slopes (17.59%). This distribution pattern of the populated sites is not significantly different from the division of slope aspects among all survey sites. Also it grow inside all the habitats expect the shaded-caves. The species prefer acid, neutral and alkaline soils which the PH value rang from 6-8.36. it seem that the nature of soil and its nitrogen content play important role in distribution and growth of the plant which plants can grow in Nitrogen content range from 67 – 163 PPM. Here we can say that presence of absence or degree of distribution of the habitats types limiting factors role in presence, growth and the sure will affect the distribution, presence and absence of the species inside its preferred habitats.

### 4.2. Species Niche-modeling

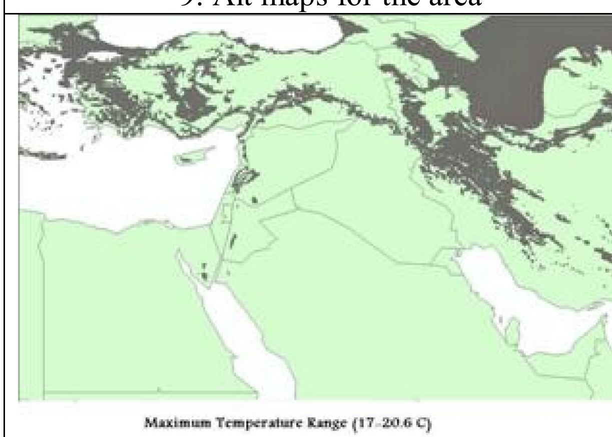
The ecological niche of a species can be defined as the set of ecological conditions within which it is able to maintain populations without immigration (Irfan-Ullah *el al.,* 2006). The particular approach to modeling species' ecological niches and predicting geographic distributions is described in detail elsewhere (Peterson *et al.,* 2002). Previous tests of this modeling technique for diverse phenomena in various regions have been published over the world (Irfan-Ullah *et al.,* 2006). Results indicated that *Origanum syriacum* var. *sinaicum* occupied about 55-60 % of the available niche-range inside SKP, which is marked by a broad physiological-climatic tolerance with overlap, this also mean that this species have a high gene flow and dispersal over a climate gradient and along its habitats that may be indicate that have a low allelopatric speciation (Figs. 16, 17, 18 & 19).



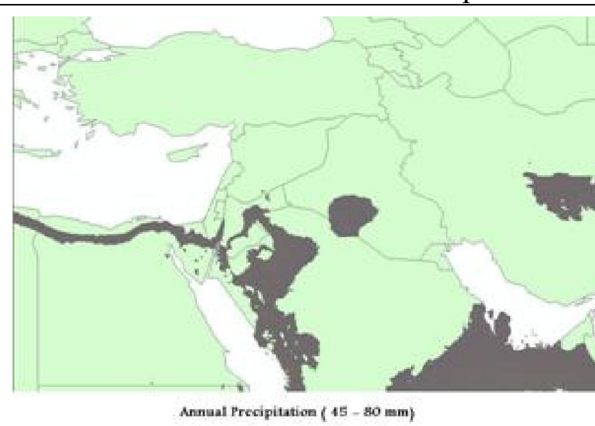

9. Alt maps for the area




10. Minimum annual temp




11. Maximum annual temp.




12. Annual precipitation

Maps 9-12. The climatic variables range for SKP and the similar regions among the same range

One of the simplest means of ecogeographic data analyses for assess the nich of the species is the calculation of the frequency of distribution or number of specimens collected from sites characterised by different biotic and abiotic features e.g. grid squares, climate zones, soil types, aspect, habitat types, etc. The results can be presented in the form of graphs and pie charts. Data arranged in this fashion will help to identify the particular niche occupied by the target taxon. In this way the analysis can be used to indicate areas previously uncollected, where the species is likely to occur. Here is appear the species niche is more restricted to the mid-zones for each variables (Fig 20, 21 & 22).

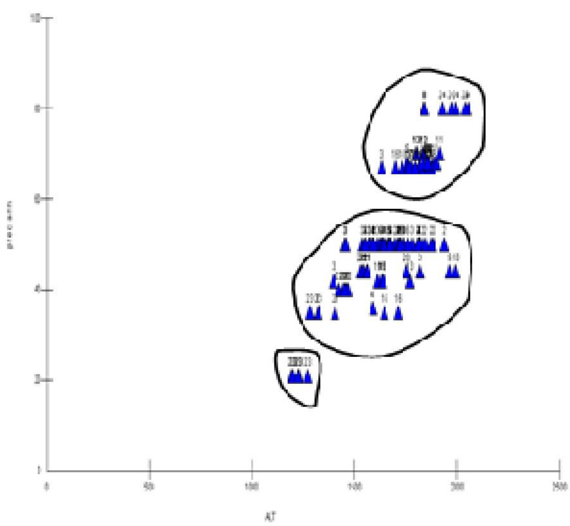


Figure 14. Clustering diagram shows the alt. and the annual precipitation as limiting factors for distribution of the *Origanum* in SKP

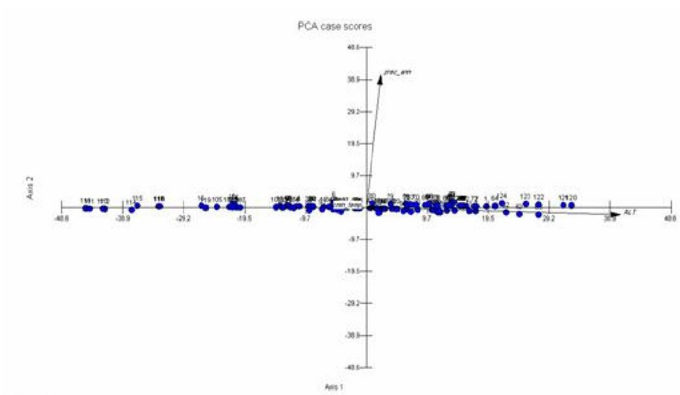



Figure 15. PCA values show the annual precipitation as limiting factor for the *Origanum* niche/distribution

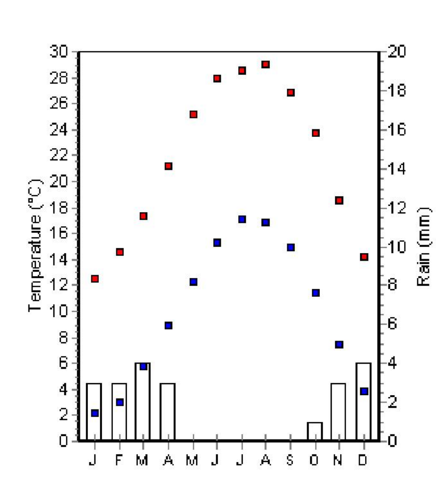



Figure 16. Minimum temperature and rainfall values for the habitats of *Origanum* within the low and high altitudinal regions, respectively in SKP

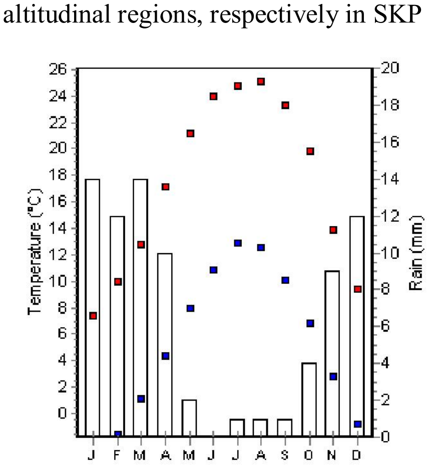



Figure 17. Maximum temperature; and rainfall values for the habitats of *Origanum* within the low and high altitudinal regions respectively in SKP

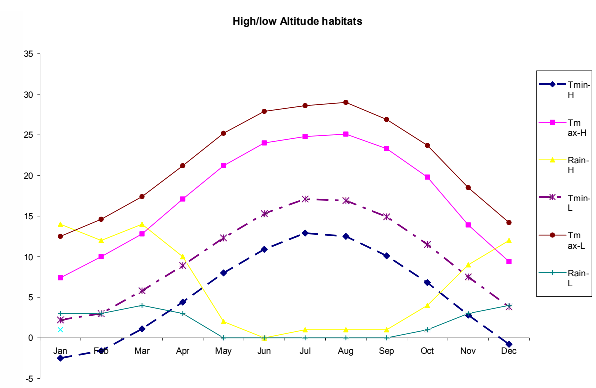



Figure 18. Diagram shown the overlapped between the min and max temperature; and rainfall values for the habitats of *Origanum* within the low and high altitudinal regions

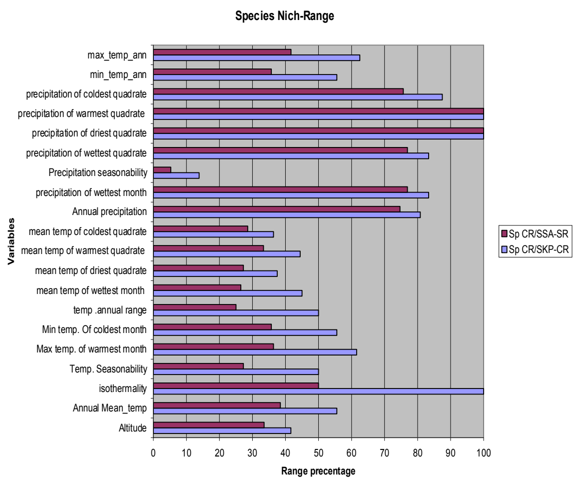



Figure 19. *Origanum* Climatic Niche Range (Sp-CR) comparing for the availability of climatic variables range within SKP (SKP-CR) and South Sinai (SS-CR)

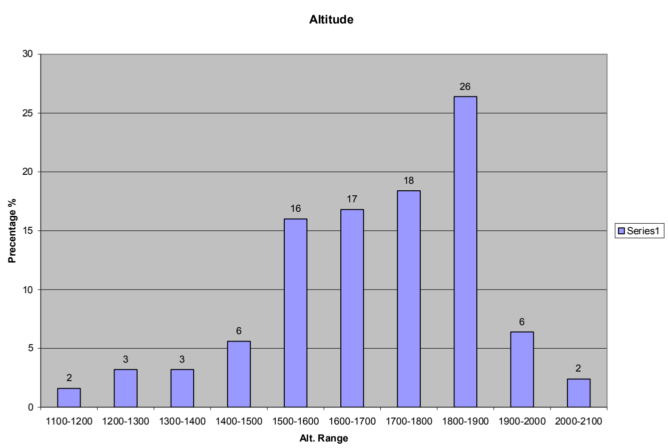



Figure 20. *Origanum* sp. distribution frequency along the available altitude range

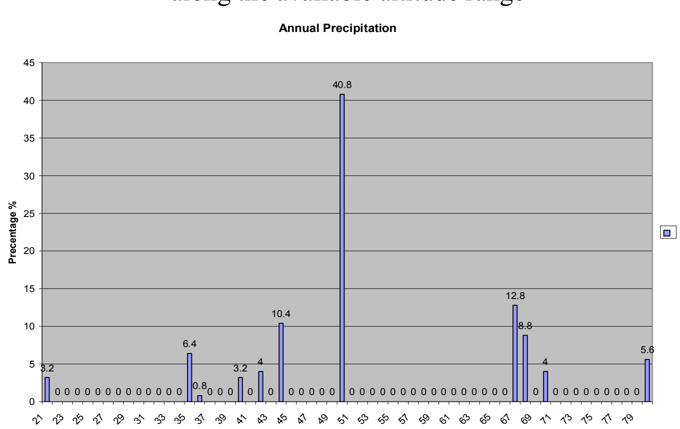



Figure 21. *Origanum* sp distribution frequency along the available annual precipitation range

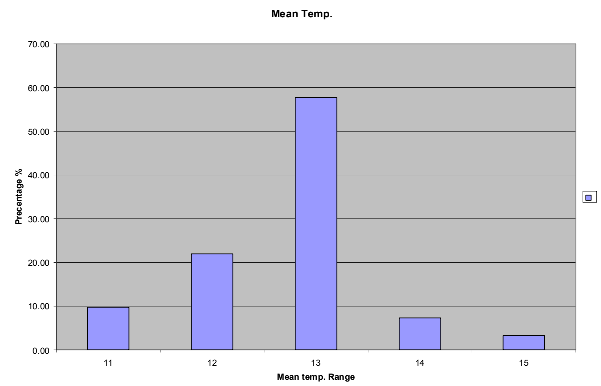



Figure 22. *Origanum* sp distribution frequency along the available Mean Temperature range

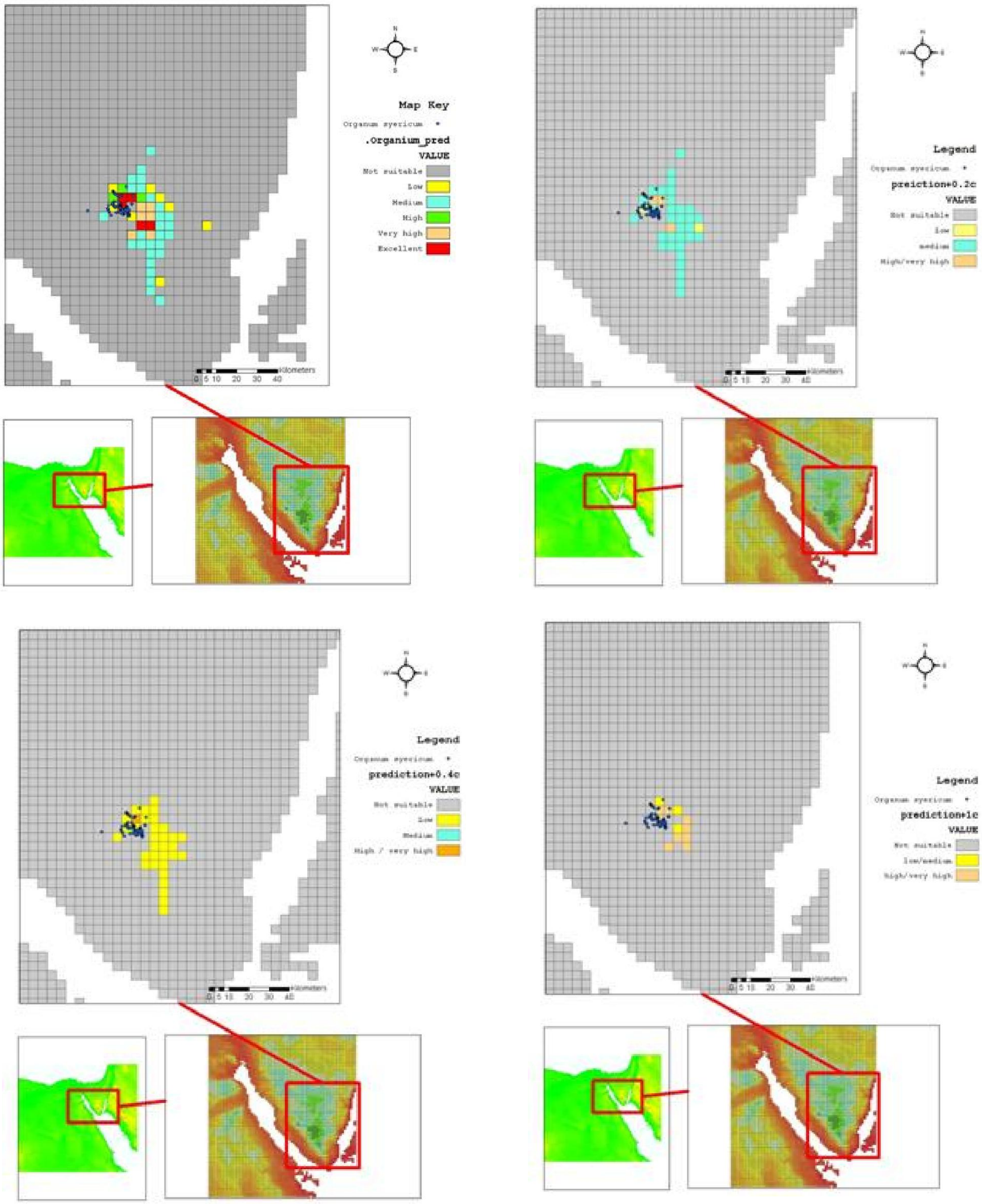
**4.3. Linking eco-geographic pattern and Species prediction**

Using the climatic variables and the species niches climatic factors that driven based on the previous mentioned results, here we can get a prediction map for the *Origanum* distribution in SKP, which using the DIVA-GIS software and the BIOCLIMATE variables the map shown a five ranks for the species predicted distribution which ranging from un-suitable to excellence areas for presence of the species.

Predictions of the distribution of *Origanum syriacum* var. *sinaicum* were good, given current knowledge of the species, the first map shown the prediction of the *Origanum* distribution or the suitable habitats for presence of the species in Egypt. Here this prediction depends on the limited factors such as alt, temp, precipitation. It seem that most of excellent regions for the species distribution is very restricted to area of SK and mousa mountains, while there is a medium and low distribution areas around the main area for the species distribution. To date, this species has been reported only from middle-high elevation of the northern part of SKP, particularly in SK and Mouse mountains areas adjoining the SKP center of endemism. The species has never been documented from other sectors of SKP in the extreme southern parts. But here and based on the prediction and the available variables it seem that there is a low-to-medium potential for presence of the *Origanum syriacum* var. *sinaicum* in the southern area as shown in map (13).

Using the prediction tools under assumption of climate change at different level of temperature increasing such as at + 0.2, 0.4 and 1$^{O}$C we can get scenario for the species predicted distribution at different cases of temperature increasing as shown in maps 2, 3 and 4 , which shown shrinking in the predicted suitable habitats for the species in SKP.

The most notable from these maps that SK and Mousa mountain considers the only suitable habitats for the species under this expected climate change (map 13 a, b, c, d).



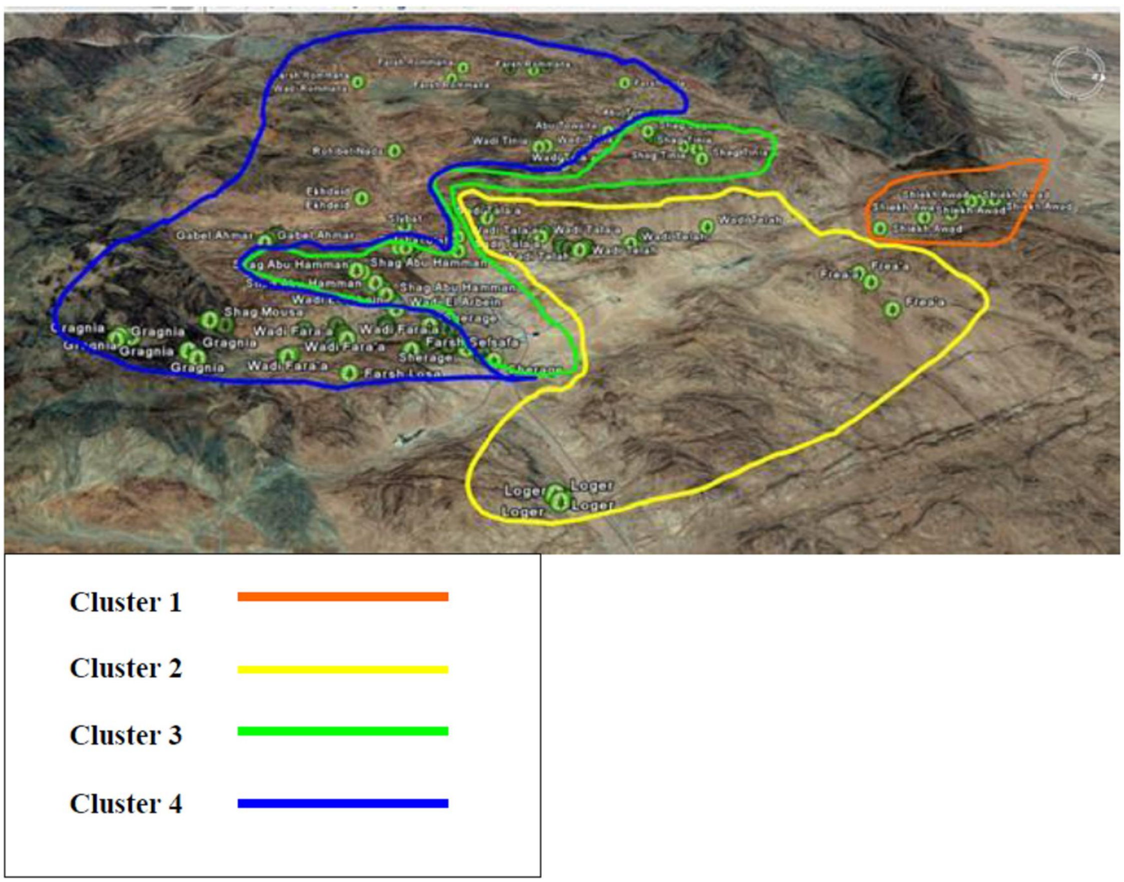

Map 13 a, b, c shown the species distribution prediction under different climate change scenario (at 0.2, 0.4, 1.0 Temperature degree increasing)

From these results we can get some valuable indicators as following:

- Total current suitable habitats at grid cell size 4 x 4 km = 160 sq km are equal about 3.2 % of total SKP area.
- Total predicted suitable habitats in south Sinai = 784 sq km = 15.68 % of total SKP area.
- Total predicted suitable habitats in south Sinai in case of climate change with increasing temp + 0.2$^{o}$C = 592 sq km = 11.84 % of total SKP area.
- Total predicted suitable habitats in south Sinai in case of climate change with increasing temp + 0.4$^{o}$C = 528 sq km = 10.56% of total SKP area.
- Total predicted suitable habitats in south Sinai in case of climate change with increasing temp. + 1$^{o}$C = 192 sq km = 3.84 % of total SKP area.

This means that there is shrinking in the suitable habitats under the mentioned climate change with 24.48% at 0.2$^{o}$C, 32.65% at 0.4$^{o}$C and 75.51% at 1.0$^{o}$C.

From comparing the values of current suitable habitats coverage values (3.2% of total SKP area) and the predicted suitable habitats coverage values (3.84%) it appear that the both values very similar, this may be lead that the current situation of *Origanum syriacum* var. *sinaicum* may be is result of gradually historical climatic effect, especially increasing in temp parallel with decreasing in precipitation, that may be affected the habitats suitability and the distribution converge for the species.




**4.4. Eco-geographic distinctiveness of origanium's populations/ distribution regions**

**4.4.1. *Origanum* distribution areas/population clusters**

By comparing the areas of distribution for the species based on the different climatic and topographic factors, it seem that the species communities found within 4 uniqueness regions (map 14), which we can divided them into four clusters as following:

Cluster 1

| | |
|---|---|
| Sheikh Awad | 1 |

Cluster 1: which only includes Sheikh Awad area that seem it have its unique climatic and topographic conditions, that their mix give this area a special condition different than the other areas.

Cluster 2

| | |
|---|---|
| Wadi Telah | 4 |
| Frea'a | 5 |
| Tale'a El Kalb | 6 |
| Loger | 21 |

Cluster 2: includes 4 wades/areas

Cluster 3
(Overlap between C2+C4)

| | |
|---|---|
| Sherage | 2 |
| Shag Tinia | 3 |
| Shag Abu Hamman | 13 |
| Wadi Alarbein | 15 |
| Shag Serage | 12 |

Cluster 3: includes 4 wades/areas represent overlapped areas between cluster 2 and 4

Cluster 4

| | |
|---|---|
| Farsh Rommana | 7 |
| Farsh Rommana | 8 |
| Farsh Sala | 9 |
| Abu Towaita | 10 |
| Wadi Tinia | 11 |
| Wadi Fara'a | 14 |
| Abu Gifa | 16 |
| Slybat | 17 |
| Tofaha | 18 |
| Farsh Sefsafa | 19 |
| Farsh Losa | 20 |
| Rohibet Nada | 22 |
| Wadi Rommana | 23 |
| Ekhdeid | 24 |
| Gabel Ahmar | 25 |
| Shag Mousa | 26 |
| Gragnia | 27 |

Cluster 4 which includes 17 wades/areas, most of the species distribution areas.

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