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Assessment of the vegetation cover of northern high mountains in Jordan

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Abstract

The vegetation cover of the northern mountains of Jordan was investigated and surveyed. Line transects sampling method as well as walking through methods have been applied in this study. A total area of 15x80 km was studied and divided into grid system, and thus the selected grids have been used for the line transect sampling. The study showed that the natural forest of Aleppo pine, evergreen oak forest, deciduous oak forest, degraded forest and manmade Aleppo pine forest areas are suffering from man interference and continuous encroachment for the uses of agriculture, urbanization, grazing, fire and querying. The available plant species under forest were collected and herbarium specimens are prepared and deposited. Analysis parameters such as density (D), relative density (RD), frequency (F), relative frequency (RF), abundance (A), relative abundance (RA) and the importance value (IV) are studied. The values of the parameters are recorded for all species, but since the number of collected species is more than 500, then these parameters are listed for the highest 20 species to show clear image about the most dominant and the most abundant and other parameters. From the quantitative ecological analysis using various parameters, the species recoded as having the highest values such as *Quercus coccifera, Sarcopoterium spinosum, Asphodelus aestivus, Eryngium creticum, Ononis natrix* and others confirm that the study area falls within a Mediterranean biogeographic zone in Jordan. Based on the obtained results, it is highly recommended thus to exert maximum efforts to conserve such limited forest cover, since Jordan, is classified as a country with dry to semidry ecosystem. In addition some of the rare and endemic recorded species occur only under forest cover, particularly the orchid species.

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Introduction

The Mediterranean (shrub) scrub land vegetation is characterized by low forest with evergreen and deciduous elements occurring under specific environmental conditions of cool moist winter and dry hot summer. This shrub land vegetation is called *maquis* in the Mediterranean region and *matorral* in Chili; *fynbos* in South Africa; and *Chaparral* in California, USA, (Raven *et al.*, 1986). Although such types of vegetation have evolved separately in isolation, yet they are treated and recognized as the same type of Mediterranean vegetation since the prevailing environmental conditions are similar. Although Mediterranean formation in various parts of the word has similar low shrub or short tree vegetation, however, species composition is different in each place.

Mediterranean areas are characterized by showing the highest diversity in terms of number of families and number of species. This is all due to favorable climatic conditions. Differences within the studied sites that belong to the Mediterranean region, attributed to the prevailing bioclimatic conditions, are aggravated by the level of disturbances that these sites have experienced (Al-Eisawi, 1994, 1996). Various reasons threatening the vegetation cover and biodiversity in Jordan. Among these are destruction of habitats, urbanization and recreational activities and tourism, expansion of agricultural projects and, uncontrolled grazing, deforestation and land fragmentation (Taimeh, 1995).

In general the vegetation in any region is a reflection of the prevailing environmental conditions, therefore, some scientists start to study the presence of various vegetation communities and their analysis using satellite and Aerial imagery for wide scale use and for presenting the vegetation as a digital information to connect localities based on coordinated and the precise presence of vegetation or a specific location of one or more species, such studies are known as remote sensing studies. In Europe (Poland) a study of the Tata National Park was carried out to compare ground mapping and different image classification (Zagajewski *et al.*, 2005). A study was carried out in South East Europe (Rhodpe Mountain Bulgaria) to use remote sensing in studying the dynamic changes in the vegetation (Naydenova *et al.*, 2010). The use of remote sensing was applied to monitor the response of wild vegetation after being affected by fire, the study was comparing there different parts in Israel, Spain and USA (Van Leeuwen *et al.*, 2010). In Israel remote sensing methods used to assess temporal and spatial vegetation cover changes in relation to rainfall (Schmidt & Gitelson, 2010). In Japan the special analysis approach of vegetation distribution in urban areas at a regional scale was studied using remote sensing (Kumagai, 2008).

The vegetation cover in Jordan desert was conducted in comparison with satellite imagery to monitor rangeland grazing (Edwards *et al.*, 1996). Recently remote sensing was used to study the vegetation of the mountains in Jordan and to examine the spatial distribution of herbal and medicinal plants using GIS (Al-Bakri *et al.*, 2011)

The vegetation studies in the Mediterranean basin are very wide and variable; a selection of some close related countries as well as studying the vegetation in the high mountains in different places of the world. A review of the forest vegetation of Turkey, and their status past present and future conservation was given in adequate details by (Çolak & Rotherham, 2006). The high mountain vegetation of Turkey was given also by (Parolly, 2004).

Revision and multivariate analysis for the vegetation of the high mountains of Crete was conducted by (Bergmeier, 2002); the floristic composition and vegetation analysis in Hail region north of central Saudi Arabia was evaluated by (El-Ghanim *et al.*, 2010). Vegetation analysis of Wadi Al-Jufair, in Najd, Saudi Arabia has been studied by (Alatar *et al.*, 2012). Another study to analyze the vegetation and floristic diversity of Wadi Al-Noman, Mecca, Saudi Arabia was conducted by Abeddel-Khalik *et al.*, 2013). A recent

study about the flora of Holy Mecca, Saudi Arabia has added 80 more species to the same study area after a year time (Al-Eisawi & Al-Ruzayza, 2015). The vegetation analysis of some desert rangelands in United Arab Emirates has been assessed by (Shaltout *et al.*, 2008).

The road sides' vegetation in the Judean desert was studied by (Holzapfel & Schmidt, 1990). Rock communities and succulent vegetation in northern Yemen (SW Arabia) with ecological, phyto-chrological and evolutionary aspects were analyzed by (Ürlich, 2014).

The characteristics of vegetation and the vertical distribution patterns of the northern slope of Usun mountains in Xinjiang/ China were reported by (Tian *et al.*, 2013); a concise scheme of vegetation boundary terms in subtropical high mountains was brought about by (Chiu, 2014). The role of cushion plants on the diversity at high elevations in the Himalayan Hengduan Mountains was determined by (Chen, 2015).

The characteristics of specific vegetation studies in the Mediterranean basin are conducted by various workers. Characteristics of *Pinus halepensis*, pine forest in southern Siberian Peninsula was studied by (Torres *et al.*, 1999). The characteristics of the plant community organization in the Mediterranean grassland in France were conducted by (Madon *et al.*, 1999). Effect of grazing and topography on long-term vegetation changes in a Mediterranean ecosystem in Israel was studied by (Karmel & Kadmon, 1999).

Studies on the climate and vegetation of the Mediterranean Basin based on geological or palynological studies to trace climate change based on long term and major climate gaps are variable. One of the studies was dealing with the climatic vegetation change and cultural change in the Easter Mediterranean during the Mid-Holocene environ-mental transition (Roberts *et al.*, 2011). A study was dealing with the climate of the Mediterranean basin and Eurasian of the last glacial maximum as reconstructed by inverse vegetation modeling and pollen data (Guiot *et al.*, 1999). A study of vegetation reconstruction in Eastern Jordan was based on pollen records obtained from the Azraq basin in the Eastern Desert, Jordan under the study of late Holocene vegetation in the Azraq Wetland Reserve, Jordan (Woolfenden & Ababneh, 2011). Medicinal plant diversity and vegetation analysis of logged over hill forest of Tekai Tembling Forest reserve in Jerantut, Pahang in Malaysia, was assessed by (Eswani *et al.*, 2010). The vegetation has a direct effect on the richness of biodiversity and thus richness in medicinal plants and ethnobotany and the vegetation structure in the specific study areas (Oran & Al-Eisawi, 2014, Oran 2014, Al-Eisawi, 2015).

In Jordan there are old studies for the vegetation and range lands conduct by FAO or UNESCO. Kasbligil (1956) was one of the first people to write a report about Jordan. Long (1957) wrote a report about the vegetation and range lands in Jordan submitted to FAO (Food and Agriculture Organization). The work of Zohary (1973) and others on the vegetation and bioclimatic regions has laid the basic understanding of the vegetation in the Middle-East (Poore & Robertson, 1964; Zohary, 1962, 1973). In Jordan new studies on the vegetation of Jordan have been conducted, certain studies are based on the assessment of the vegetation in some wild reserves in Jordan (Al-Eisawi & Hatough, 1987, Al-Eisawi, 2014); while some others have a wider view about Jordan in general especially, a new look at the vegetation of Jordan and new vegetation classification for the country (Al-Eisawi, 1985, 1996). However, the vegetation of specific parts of Jordan is related to special studies such as Araba Valley (*Wadi Araba*), (Al-Eisawi, 1983, 2014). Other studies in Jordan are oriented to study the relation between man and mountains, (Al-Eisawi, 2004, Oran, 2004), man and sustainable use of biodiversity in relation to water quality (Al-Eisawi, 2004). The motivation for this study is to complete the series of studies carried out

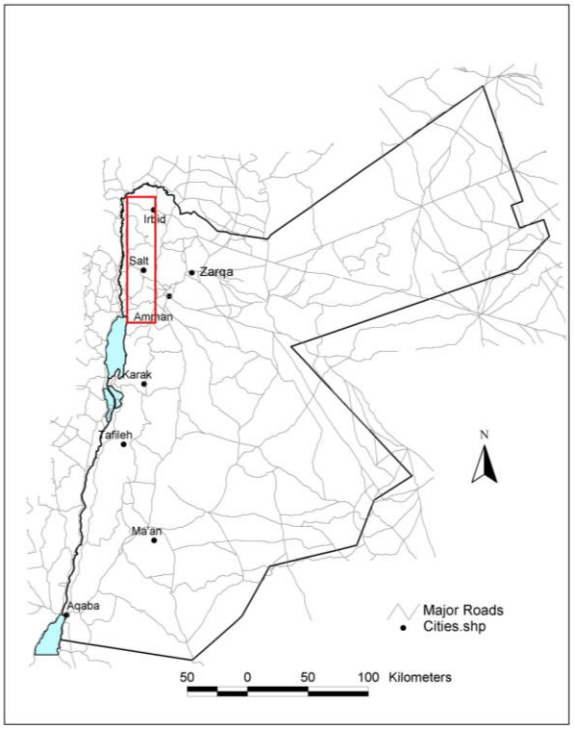
on this critical region, especially ethnobotany and survey of medicinal plants and flora analysis.

The aim of this study is to assess the status of the vegetation in Jordan in terms of types of main forests; the leading species in each type; and the assessment of herbal biodiversity in the forest regions.

Materials and methods

Study area

Jordan is a small country about 90,000 k² with central region of Range Mountain extending from north to south. Dry ecosystem is prevailing in Jordan with almost 80% of the county is desert. Therefore, the forest coverage in Jordan is based on wild and manmade does not exceed 1% of the total area. The major concentration of the forest is concentrated in the northern part, extending to the capital city Amman. Therefore, a stretch of 15 X 80 km large transect was selected.



Map 1. Jordan map showing survey target Area.

The target area (15 X 80) is divided into grids of 5x5 km. Only every other square is selected for surveying. Each selected square (Grid) 25 km² is divided into grids of 1x1km. Within the square of 25 km², again only every other 1km² is surveyed (Map 1).

Squares that are falling in urban areas or cultivated land are excluded even if they are counted among the selected squares for study. The coordinates of the line and the direction are recorded using GPS.

Main valleys (*Wadis*) and water springs found within the study area and accessible are surveyed, whether they fall in the selected squares or not.

Survey method

Route method

When exploring valleys (wadis) and water canals or springs; all observed plant species are recorded along that path. The importance of this method is recording vegetation components and species in accessible valleys, which mostly do not grow under canopy or open areas of forest or none forest vegetation.

Transect method

When exploring open areas of forest vegetation or none forest vegetation line transects method is used for surveying and recoding all species touching the line (Barbour, *et al.,* 1987). A line of 400 m long was used for survey. Mostly the same 400 m are divided into 4 units each 100 for the ease of recording and increasing the recording accuracy.

All names of plant species and their survey parameters such as their repeated number on the line are recorded on ready specially designed sheets. The sheets are then fed to the computer and thus every day additional species are added with their survey parameters.

All plant species recorded are collected and dried and kept in plant pressers, until complete drying; then finally identified and deposited in the Herbarium, Department of Biological Studies, Faculty of Science, University of Jordan, Amman (AMM).

Moreover, these parameters were used to calculate

density (D), relative density (RD), frequency (F), relative frequency (RF), abundance (A), relative abundance (RA), and the importance value (IV) using the formulas as given in the results (Barbour, *et al.,* 1987; Krebs, 1989; Hegazy *et al.,* 1998).

Results

Vegetation in general

The squares included in the studied grids are all falling within the Mediterranean biogeographic region, which is characterized by mostly high altitude ranging from 1100-400 m, with a soil type ranging from clayey loam–salty loam. This soil is known in the Mediterranean as red Terra-Rosa soil to yellowish rendzina or rarely calcareous and sandy soil penetrations (Zohary, 1962). The rainfall in this region ranges between 400-600 mm/year. The vegetation type is reaching its climax in certain places forming typical maquis Mediterranean vegetation ecosystem with 100% total coverage in few patches.

The vegetation is ranging from total coverage to total non-forested land based on the human activity, since this land receives the highest rainfall and considered the most fertile, thus it is often has continuous encroachment regardless of the government care. Accordingly most of the land has been used for agriculture or urbanization uses (Al-Eisawi, 1996, 2004).

In simple terms the limited vegetation, still resembles the lung of breathing and the natural oxygen source for the majority of Jordan.

Forest types

The vegetation cover was found to include four major forest types in Jordan except one that occurs in southern Jordan. These types of forest are:

1 Pine forest
2 Evergreen oak forest
3 Deciduous oak forest
4 Mixed forest
5 Manmade pine forest
6 Degraded Mediterranean forest vegetation

Forest strata and composition

Although the forest height , as previously mentioned is short and not exceeding 8m except in pine forest, however, the strata is made of maximum 3-5 layers;

i. Pine forest

It is made by the clearly dominant wild Aleppo pine *Pinus halepensis* which extends in the Mediterranean basin up to the Iberian Peninsula (Torres, 1999). The following layer is made of the beautiful shrubs of *Arbutus andrachne*, in Europe this species is replaced by *Arbutus unedo*, although some treat the two species as the same. The third layer is shorter shrubs such as *Calycotome villosa* or *Pistacia palaestina* and *Crataegus azarolus*. Some of these species might grow if space permits to be in the second layer size. The fourth layer is made of bushes and low shrubs such as *Cistus creticus, C. salviifolius* and *Phlomis kurdica*. The fifth or the final layer is the herbs layer which is the most important layer since the majority of orchid species occur under these layers (Al-Eisawi, 1986, 1998)

ii. Evergreen oak forest

This kind of forest is forming the majority of natural forest land in northern Jordan. The leading species is the evergreen oak (*Quercus coccifera* = Syn. *Q. calliprinus*) in association with the evergreen stew berry tree (*Arbutus andrachne*) and sometimes wild Palestinian pistachio (*Pistacia palaestina*). All of these often form the highest stratum, followed by shrub layer then a third bush layer and fourth of herbaceous layer. In some more wet places *Phillyrea latifolia* is belonging of the family Oleaceae mimics the evergreen oak and thus becomes as an equal partner in distribution.

The presence of *Phillyrea latifolia* becomes associated with a rare wild pistachio in Jordan the *Pistacia lentiscus*. Often climbers of species such as: *Smilax aspera, Rubia tenuifolia* (Syn. = *R. olivieri*) and *Clematis cirrhosa* or *C. Clematis flammula* become very common in this association.

iii. Deciduous oak forest

It is an open forest in Jordan cannot be as dense as evergreen oak forest although the trees along and wider in growth. The leading species is the deciduous oak *Quercus ithaburensis* as the top layer associated with lower layer of another species of pistachio *Pistacia atalntica*, or *Prunus dulcis* (=Syn. *Amygdalus communis*) and *Crataegus azarolus*. The third layer is small shrubs and bushes then the herbal layers. This kind of forest is very much subjected to animal grazing especially, sheep and goats.

iv. Mixed forest

This type is not truly a mixed forest in a sense where have two or more dominant specie, but it is a species becoming sharing with primary vegetation dominant species such as *Pinus halepensis* is sometimes replaced partially by the evergreen oak *Quercus coccifera* or becomes clearly mixed with it as a secondary element. In some other times at a border of echo-tone deciduous oak becomes mixed with evergreen oak until a clear cut separation is recognized and thus a pure forest type is becoming very clear. Such a thing is very clear in Balka Governorate, Jordan, particularly in Zai Mountains, where at the top Pine forest is very clear followed by at evergreen oak at lower altitude and again at lower altitude followed by deciduous forest. Of course at the echo-tones, a ratio of mixed types occurs between the adjacent vegetation types.

v. Manmade forest

Such forests are made by the Ministry of Agriculture, Department of Forestry and they are totally made by a single species of Aleppo pine. Once an expert enters the forest easily can recognize that it is a manmade forest due to the density, monoculture, the morphology of the tree and most important factor is lack of natural layering and absence of many species occurring in natural pine forest.

vi. Degraded forest

Such forest are most common on the mountainous regions and can be recognized by remnants of forest elements of low shrubs in particular *Crataegus azarolus* and *Prunus dulcis* (=*Amygdalus communis*). Most of this land becomes covered by a leading spiny bush of the species *Sarcopoterium spinosum*. Stages of this type of degraded forest in the Mediterranean are recognized as *Batha* or *Garigue* according to the height of the vegetation.

Conservation Remarks

The majority of the surveyed squares have shown degraded forest ecosystem as the most common type for the surveyed squares in Jordan. In fact, it was observed that the majority of the ecosystem have been almost distorted and in some cases destroyed totally by human activities of the following types:

1 Unusual expansion of urbanization of cities, towns, villages and borders of municipalities.
2 Expansion of cultivated areas.
3 Expansion of quarries.
4 Expansion of industrial areas.
5 The visual increase of roads and farm tracks.
6 The destruction of the limited natural forest land by various human activities, especially cutting of the trees, cultivation within the forest and the most obvious is the overgrazing by the herds of sheep.

It is very unfortunate to say that within a few years the majority of the study area will be almost urbanized, cultivated or used for other human activities.

Urbanization, land reclamation and natural vegetation destruction are most obviously observed activities during the course of this study. Strange enough looking at a forest from far away one feels that it is one block of wild forest elements; unfortunately, close observation and investigation reveals penetration of agriculture and orchard plants within margins or even in the heart of the forest especially in hidden areas and those with difficult access to them. It has been observed that cultivation starts sometimes at the margin or the heart of the forest by clearing few trees and replacing them with few orchard trees especially olives. Later on and every year they expand the area

by few more trees and thus within few years you end up with a proper orchard almost legally owned by the people who made this illegal forest reclamation.

Flora and plant biodiversity richness

Line transect survey results are deposited and arranged in one long sheet, showing presence or the absence of any species in each line as well as the height the number of plants for each species and the total number of species recorded in each line (Appendix 1). Based on the parameters of frequency, relative frequency, abundance, height, density and importance value have been calculated. The total number of species recorded in this study is 554 species including new taxa are recorded for the first time to the flora of Jordan.

Vegetation Analysis

Once the data is ready in the tables of the Microsoft Excel Spread Sheets, various parameters for each species were calculated. Accordingly, the values of frequency, relative frequency, abundance, relative abundance, density, relative density and the importance value index were calculated and listed in tables shown below. Again, since the number of analyzed species is too big to be adapted in one page, results of analysis were transferred into continuous pages using Microsoft Word Office. Analysis and calculations were made using simple Microsoft Excel (Appendix 2).

The abbreviations are:

1: No. of squares of occurrence

2: Total Quadrates Studied

3: Total Individuals

4: Frequency (F)

5: Relative Frequency (RF)

6: Abundance (A)

7: Relative Abundance (RA)

8: Density (D)

9: Relative Density (RD)

10: Importance value index (IVI)

Frequency

This term refers to the degree of dispersion of one species in a given area. It is usually expressed as a percentage of occurrences. Therefore, we can get an idea about the frequency of each species in all the line transects studies as a frequency percentage of a ratio out one hundred such as 21%, 72% and so on.

To calculate the frequency value:

F = Number of transect in which the species occurs (recorded) / Total number of sampled transects X 100

Frequency can be studied on quadrate, line transect, belt transect or others. Each segment of the line transect is taken as equivalent to a quadrate for the purpose of calculation of frequency.

The frequency of a species in terms of dispersion relative to all the species recorded in the study. Thus the relative frequency is determined by the use of the following formula:

R. F. of a species = Number of occurrence of a species / Number of occurrence of all species X 100.

All recorded species have been analyzed for their parameters. But since they are 554 species one cannot list all of the especially when value becomes the same and has no significance. Therefore, only the top twenty species have listed for all parameters as follows.

Table 1. Showing the most frequent 20 species in the study area among all species.

No.	Sp. No.	Species name	Frequency value
1.	91	*Eryngium creticum*	78.3
2.	82	*Echinops polyceras*	61.5
3.	119	*Lagoecia cuminoides*	61.5
4.	39	*Asphodelus aestivus*	58
5.	169	*Quercus coccifera*	56.6
6.	72	*Crataegus aronia*	49.7
7.	153	*Pimpinella cretica*	46.9
8.	150	*Phagnalon rupestre*	44.8
9.	137	*Ononis natrix*	39.2
10.	159	*Pistacia palaestina*	37.8
11.	207	*Teucrium polium*	37.8

No.	Sp. No.	Species name	Frequency value
12.	194	*Senecio vernalis*	36.4
13.	62	*Centaurea iberica*	35.7
14.	212	*Urginea maritima*	35
15.	215	*Varthemia iphionoides*	35
16.	21	*Anagallis arvensis*	33.6
17.	8	*Ajuga chia*	31.5
18.	51	*Ballota undulata*	31.5
19.	148	*Paronychia argentea*	30.8
20.	160	*Plantago afra*	30.8

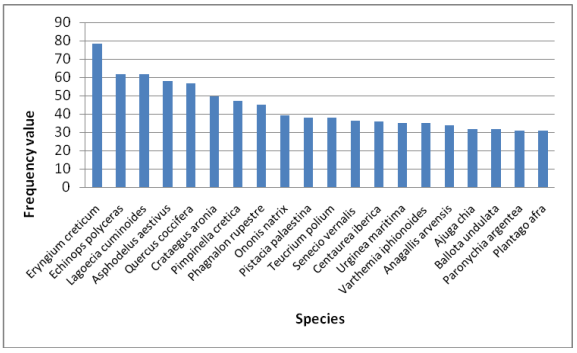


Fig. 1. Showing Frequency value of most frequent 20 species.

Abundance

Abundance is the study of the number of individuals in the community of each species in the unit area. In other words, how many plants of the same species recorded in each line transect. Thus, how many plants are recorded in all sampled transects. Therefore, abundance is calculated as in the following formula:

Abundance = Total number of individuals of a species in all transects / Total number of transects in which the species occurred.

However, the abundance does not give the total picture of the numerical strength of a species in the study area, because, the transect (quadrates) of occurrence are taken into consideration and not all studies transects.

Table 2. Showing the most abundant 20 species among all studied species in the study area.

No.	Sp. No.	Species name	Abundance value
1.	189	*Sarcopoterium spinosum*	72.9
2.	169	*Quercus coccifera*	47.9
3.	163	*Plantago ovata*	43.9
4.	66	*Cistus creticus*	42
5.	39	*Asphodelus aestivus*	36.5
6.	28	*Anthemis bornmuelleri*	34.3
7.	157	*Pinus halepensis*	31.1
8.	154	*Pimpinella eriocarpa*	31
9.	75	*Cyclamen persicum*	28.4
10.	57	*Calendula palaestina*	27.9
11.	27	*Anemone coronaria*	26.4
12.	67	*Cistus salvifolius*	26.4
13.	212	*Urginea maritima*	25.8
14.	21	*Anagallis arvensis*	24.3
15	52	*Bifora testiculata*	23.8
16	137	*Ononis natrix*	23.2
17	61	*Capsella bursa-pastoris*	22.6
18	65	*Cichorium pumilum*	21.8
19	197	*Sinapis arvensis*	21.3
20	170	*Ranunculus asiaticus*	20.7

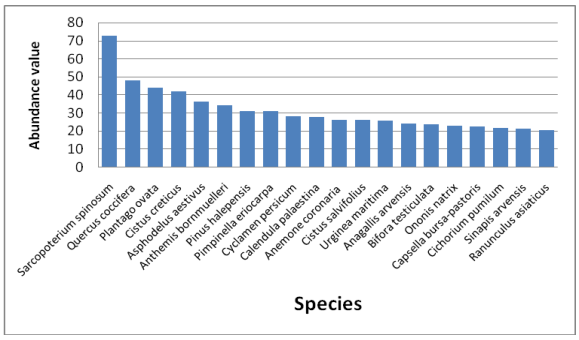


Fig. 2. Showing the abundance value for the 20 most abundant species.

Density

Density is an expression of the numerical strength of a species, where the total number of individuals of each species is divided by the total number of transect (quadrate) studied. Density is calculated as shown in the formula bellow:

Density = Total number of each species in all transect / Total number of transects studied.

While the relative density is calculated as shown in the formula bellow:

Relative Density = Total number of each species in all transect/ Total number of individuals of all species in all transects studied X 100.

Table 3. Showing the highest density of the top 20 species among all species recorded in the study area.

No.	Sp. No.	Species Name	Density value
1.	169	*Quercus coccifera*	27.2
2.	189	*Sarcopoterium spinosum*	21.4
3.	39	*Asphodelus aestivus*	21.2
4.	91	*Eryngium creticum*	11.1
5.	82	*Echinops polyceras*	10.5
6.	119	*Lagoecia cuminoides*	9.56
7.	212	*Urginea maritima*	9.02
8.	137	*Ononis natrix*	9.07
9.	21	*Anagallis arvensis*	8.15
10.	66	*Cistus creticus*	7.34
11.	62	*Centaurea iberica*	7.3
12.	65	*Cichorium pumilum*	6.41
13.	153	*Pimpinella cretica*	6.41
14.	170	*Ranunculus asiaticus*	6.22
15.	75	*Cyclamen persicum*	5.97
16.	27	*Anemone coronaria*	5.92
17.	194	*Senecio vernalis*	5.94
18.	157	*Pinus halepensis*	5.44
19.	163	*Plantago ovata*	4.91
20.	29	*Anthemis palaestina*	5.18

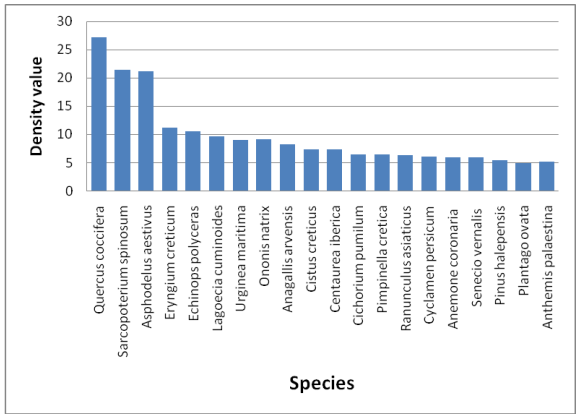


Fig. 3. Showing the density value for the most important 20 species.

Cover

The cover was estimated for all species as a whole. In fact, it was given as an observed value for the studied site. However, the vegetation cover in the whole study area was ranging from 40-100%. In general, the vegetation cover in the study area is found to be the best in the kingdom and most case was more than 60%. This is a reflection of rich ecosystem in terms of forest cove, fertile soil and high rainfall.

Importance of Index Value (IV)

In any community structure, the quantitative value of each parameter of frequency, density, abundance, and cover has its important value. However, the total picture of ecological importance cannot be obtained by any one of them separately.

For example, frequency gives the dispersion of any species in the study area. Density on the other hand gives the numerical strength of a species in the study area. Dominance is reflected by the cover only. Therefore, in order to get an overall picture of the ecological importance of a species with respect to community structure, the percentage value of relative frequency, relative dominance, and relative density should be calculated.

Table (4) show the Importance Value Index (IV) of each species based on calculation of the relative frequency, abundance and density of the all species in the studies area.

Table 4. Showing Importance Value Index of the top 20 species among all studied species. Species number refers to their position the raw data list.

No.	Sp. No.	Species Name	Impor-tance Value Index
1.	169	*Quercus coccifera*	0.16
2.	189	*Sarcopoterium spinosum*	0.14
3.	39	*Asphodelus aestivus*	0.13
4.	91	*Eryngium creticum*	0.09
5.	82	*Echinops polyceras*	0.08
6.	119	*Lagoecia cuminoides*	0.08
7.	137	*Ononis natrix*	0.07
8.	212	*Urginea maritima*	0.07
9.	66	*Cistus creticus*	0.06
10.	21	*Anagallis arvensis*	0.06
11.	62	*Centaurea iberica*	0.06
12.	153	*Pimpinella cretica*	0.06
13.	163	*Plantago ovata*	0.05
14.	65	*Cichorium pumilum*	0.05
15.	75	*Cyclamen persicum*	0.05
16.	170	*Ranunculus asiaticus*	0.05
17.	27	*Anemone coronaria*	0.05
18.	194	*Senecio vernalis*	0.05
19.	157	*Pinus halepensis*	0.05
20.	29	*Anthemis palaestina*	0.05

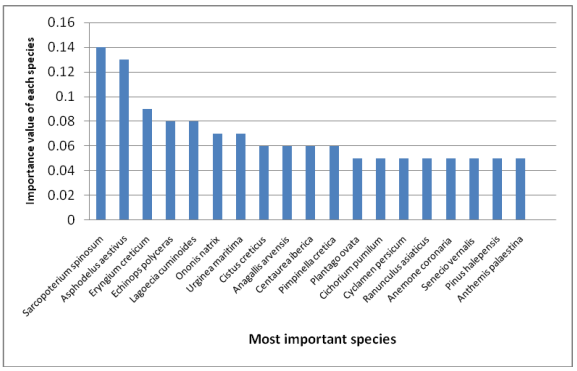


Fig. 4. Showing the importance value of the highest species.

From the quantitative ecological analysis using various parameters, the species recoded as having the highest values such as *Quercus coccifera, Sarcopoterium spinosum, Asphodelus aestivus, Eryngium creticum, Ononis natrix* and others confirm that the study area falls within a Mediterranean biogeographic zone in Jordan. The vegetation type is either forest vegetation dominated *Quercus coccifera* of degraded Mediterranean forest vegetation dominated by *Sarcopoterium spinosum and Asphodelus aestivus*. Most of the studies ecosystem is dry Mediterranean ecosystem with some hydric of fresh water ecosystems as represented by the various valley (*Wadi*) system associated in some cases by running water as in Wadi Rmaimen.

Discussion

The quadrate and line transect methods of varying sizes are used for the purpose of detailed study. By the study of numerous lines or quadrates, knowledge of the structure of vegetation may be obtained. In its simple form the quadrate and line transects are used in counting the individuals of each species to determine their relative abundance and importance. The transect method is usually employed when studying the pattern of changes between different communities and it is therefore laid across the ecotone (an artificial boarder line between two different communities) (Barbour, *et al.,* 1987; Krebs, 1989).

The vegetation of the study area which is the high northern mountains in Jordan fall within five major governorates: Amman (the capital), Balqa, Jarash and Ajlun representing a typical Mediterranean phyto-geographical areas, and very rich ecosystem in terms of vegetation cover and diversified plant species, rich soil and rainfall. Such governorates almost hold 80% of the total population which shows how much human impact is affecting the vegetation zones (Al-Eisawi, 1994).

The vegetation cover in the whole study area as mentioned before was ranging from 40- 100%, which is the best vegetation cover in the whole country and in most case was more than 60%, it is understood from these results that the ecosystem is rich in terms of forest cover, highly fertile soil and rainfall.

During the course of this study it was observed also that almost all peaks of mountains have been sold out, cleared from natural vegetation and a new house with terraces and new cultivation have been initiated. This observation is becoming a new phenomenon in the majority of Jordan especially, in places where forest vegetation and green cover is available. It is becoming nowadays euphoria and fashion to buy and trade with such sites since they are becoming popular places for rich people to initiate fancy houses and palaces. The recent communication systems, where no need for the use of wired telephones after the popularity of mobiles have encouraged people to live in remote places. The water and electricity can be solved for such houses on site by having electric generators and cisterns of water as harvested from rainfall or even imported by water tanks.

Most of the studied sites are not pristine due to the current land use practices exist in many natural areas in Jordan, such as deforestation and grazing, mining, expansion of agricultural areas and urban development.

However, the results showed that some of the natural forests occurring in Jordan are still present no matter

what is the available area. The importance of this is giving the researcher exact idea about the structure, stratification, plant association, leading species and species dominance. Therefore this allows the researchers and scholars to observe species in their natural habitats. Because, destruction of natural forest, will cause the absence of most wild species that require the shade, humidity, the microorganisms and the natural association of both plants and animals. This makes the natural ecosystem different from manmade forest ecosystem as previously mentioned and as other researchers observed (Zohary, 1962; Al-Eisawi, 1996; Çolak & Rotherham, 2006; Oran & Al-Esawi, 2014).

Looking at the parameters of frequency, one cannot say that *Eryngium creticum* and *Echinops polyceras* were the most frequent plants within the study area unless a proper survey is conducted. One might tell if we are looking at a forest, then it is easy to say that *Pinus halepensis* in the most frequent and dominant and the leading species. But if the forest structure changes to mixed forest then a kind of measuring survey is needed to decide which species in the most dominant and most frequent.

This is of course true for other parameters of study, at the time, when we found that *Eryngium creticum* and *Echinops polyceras* the abundance showed different plants *Scarcopoterium spinosum and Quercus cocciofera* to be the most abundant. While in density *Quercus coccifera* and *Sarcopoterium spinosum* became the densest with changing position about the leading first species.

Generally, speaking, the study area showed maximum richness in biodiversity and rare or endemic species. It is therefore, suggested that similar studies should be carried out to stand at the actual status of various ecosystems and as a monitoring routine work (Al-Eisawi, 2014, 2015). However, it is concluded from this ecological survey for the high northern mountains of Jordan, that the studied area is characterized by its species diversity richness, endemic, economic, rare and endangered plant species were recognized as a result of the prevailing Mediterranean environmental conditions. The evergreen and deciduous oak forests as well as pine forests are, also the characteristics of the same Mediterranean area. Most of the phyto-geographical region in Jordan is facing the danger of loss and degradation; therefore more efforts are to be paid for the protection and conservation of the wealthy natural high mountains of the blessing land of Jordan.

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References

Abdel-Khalik K, El-Sheikh M, El-Aidarous A. 2013. Floristic diversity and vegetation analysis of Wadi Al-Noman, Mecca, Saudi Arabia. Turk J Bot **37**, 894-907.

Alatar A, El-Sheikh MA, Thomas J. 2012. Vegetation analysis of Wadi Al-Jufair, a hyper-arid region in Najd, Saudi Arabia. Saudi Journal of Biological Sciences **19**, 357-368.

Al-Bakri1 JT, Al-Eisawi DMH, Damhoureyeh S, Oran S. 2011. GIS-Based Analysis of Spatial Distribution of Medicinal and Herbal Plants in Arid and Semi-Arid Zones in the North-west of Jordan. Annals of Arid Zone **50(2)**, 99-115.

AL-Eisawi DMH, Hatough A. 1987. Ecological Analysis of the Vegetation of Shaumari Reserve in Jordan. Dirasat **XIV(12)**, 81-94.

AL-Eisawi DMH. 1983. Studies on the flora of Jordan. II. On the flora of Wadi Araba (Araba Valley). Candollea **38(1)**, 359-364.

AL-Eisawi DMH. 1985. Vegetation of Jordan. In Hadidi, A. (editor). 1985. Studies in the History and Archaeology of Jordan. II. Ministry of Archaeology. Amman. pp. 45-57.

AL-Eisawi DMH. 1986. The Orchids of Jordan. Kew Bulletin **41(2)**, 359-377.

AL-Eisawi DMH. 1998. Field Guide to Wild Flowers of Jordan and Neighbouring Countries. Jordan Press Foundation "Al Rai". Amman. Pp. 296 with 488 coloured photographs.

Al-Eisawi DMH. 1994. Forests and Man Impact in Jordan. Proceedings of the International Symposium "Man and Mountains, 94". Italy 20-24 June, 1994. pp. 385–398.

Al-Eisawi DMH. 1996. Vegetation of Jordan. Published by UNESCO-Cairo-Office. Regional OFFICE FOR Science and Technology for the Arab States. Cairo. pp. 284.

Al-Eisawi DMH. 2004. Water scarcity in relation to food security and sustainable use of biodiversity in Jordan. Proceedings of the, International FORUM on Food Security under Water Scarcity in the Middle East: Problems and Solutions COMO (Italy) November, 24-27.

Al-Eisawi DMH. 2014. Vegetation community analysis in Mujib Biosphere Reserve, Jordan. Jordan Journal of Natural History **1**, 35-58.

Al-Eisawi DMH. 2015. Medicinal plants in Mujib Biosphere Reserve, Jordan. International Journal of Pharmacy & Therapeutics **6(1)**, 25-32.

Al-Eisawi DMH, Al-Rziaza S. 2015. Flora of Holly Mecca, Saudi Arabia. Accepted in the: International Journal of Biodiversity and Conservation **7(3)**, 173-189.

Barbour M, Burk J, Pitts W. 1987. Terrestrial Plant Ecology. 2ed. edition, Benjamin/Cummings, USA.

Bergmeier E. 2002. The vegetation of the high mountains of Crete- a revision and multivariate analysis. Phytocoenologia **2**, 205-249.

Chen J, Schob C, Zhou Z, Gong Q, Li X, Yang Y, LI Z, Sun H. 2015. Cushion plants can have a positive effect on diversity at high elevations in the Himalayan Hengduan Mountains. Journal of Vegetation Science **doi: 10**.1111/jvs 12275.

Chiu CA, Lee MF, Tzeng HY, Liao MCA. 2014. Concise scheme of vegetation boundry terms in subtropical high mountains. African Journal of Agricultural research **9 (20)**, 1560-1570.

Çolak AH, Rotherham ID. 2006. A review of the forest vegetation of Turkey: its status past and present and its future conservation. Biology and Environment: Proceedings of the Royal Irish Academy **106B(3)**, 343-454.

Edwards M, AL-Eisawi DMH, Millington A. 1996. The use of ERS Atsr-2 Data for monitoring rangeland vegetation in the Eastern Badia, Jordan. University of Leicester. Submitted to the Remote Sensing Society Annual Conference.

El-Ghanim WM, Hassan LM, Galal TM, Badr A. 2010. Floristic composition and vegetation analysis in Hail region north of central Saudi Arabia. Saudi J. Biol Sci **17(2)**, 119-128.

Eswani N, Abd Kudus K, Mazre M, Awang-Noor AG. 2010. Medicinal plant diversity and vegetation analysis of logged over Hill forest of Tekai Tembeling forest reserve, Jerantut, Pahang. Journal of Agricultural Science **2(3),** 189-210.

Guiot J, Torre F, Cheddadi R, Peyron O, Tarsov P, Jolly D, Kaplan JE. 1999. The climate of the Mediterranea basin and of Eurasia of the last glacial maximum as reconstructed by inverse vegetation modeling and pollen data. Ecologia Mediterranea **25(2)**, 193-204.

Higazy AK, El-Demerdash MA, Hosni HA. 1998. Vegetation, species diversity and floristic relations along an altitudinal gradient in south west Saudi Arabia. Journal of Arid Environment **38,** 3-13.

Holzapfel C, Schmidt W. 1990. Roadsides vegetation along transect in the Judean desert. Israel Jornal of Botany **39**, 263-270.

Karmel Y, Kadmon R. 1999. Effects of grazing and topography on long-term vegetation changes in a Mediterranean ecosystem in Israel. Plant Ecology **145**, 243-245.

Kasabligil B. 1956. Report to the Government of The Hashenite Kingdom of Jordan, on an ecological survey of the vegetation in relation to forestry and grazing. Rome. UNESCO/FAO.

Krebs CJ. 1956. Ecological Methodology. Harper and Collins, New York. NY.

Kumagai K. 2008. Analysis of vegetation distribution in urbanareas spatial analysis approach on a regional scale, 2008. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences **XXXVII (B8) Beijinj**, 101-105.

Long G. 1957. The Bioclimatology and Vegetation of East Jordan. Rome, UNISCO/FAO.

Madon O, Gachet S, Barbero M. 1999. Influence of study scale on the characteristics of plants community organization in a Mediterranea grassland (Mont Ventoux, France). Ecologia Mediterranea **25(2)**, 205-214.

Naydenova V, Dimitrov P, Jelev G, Roumenina E. 2010. Analysis of the dynamics of vegetation parameters LAI, EVI and FPAR for forest areas using MODIS data. Remote Sensing for Science, Education, and Natural and Cultural Heritage, **EARSeL**, 357-363.

Oran SA, Al-Eisawi DMH. 2014. Medicinal Plants in the high mountains of northern Jordan. International Journal of Biodiversity and Conservation **6(6)**, 436-443.

Oran SA, Al-Eisawi MMH. 2015. Ethnobotanical survey of the medicinal plants in the northern high mountains of Jordan. **Submitted**.

Oran SA. 1994. Flora of Shoubak Mountain, Socioeconomic and Man Impact. Proceeding of The International Symposium "Man and Mountains 94". Primo Convergo Internazionale Per La Protezione E Lo Sviluppo Dell' Ambiente Montano (BS), Italy 20-24 Guigno 1994. PP. 739-751.

Oran SA. 2014. A list of flowering wild plants in Tafila province. International Journal of Biodiversity and Conservation **6(1)**, 24-40.

Parolly G. 2004. The high mountain vegetation of Turkey - a state of art report, including a first conspectus of the major syntax. Turk J Bot **28**, 39-63.

Poore MED, Robertson JC. 1964. An approach to Rapid Description and mapping of Biological Habits. Sub-commission on Conservation of Terrestrial Biological Communities of the International Biological Program, Jordan. Rome. UNESCO/FAO.

Raven P, Evert R, Erichhorn S. 1986. Biology of Plants. Edt. 4. Worth Publishers, Inc. New York. pp. 775.

Roberts N, Eastwood WJ, Kuzucuoğlu C, Fiorentino G, Caracutta V. 2011. Climate, vegetation and cultural change in the eastern

Mediterranean during the mid-Holocene environmental transition. The Holocene **21(1)**, 147-162.

Schmidt H, Gitelson A. 2010. Temporal and spatial vegetation cover in Israeli transition zone: AVHRR-based assessment of rainfall impact. International Journal of Remote Sensing **21(5)**, 997-1010.

Shaltout KH, El-Keblawy AA, Mousa MT. 2008. Vegetation analysis of some desert rangelands in United Arab Emirates. Middle-East Journal of Scientific Research **3(3)**, 149- 155.

Taimeh AY. 1995. Land resources in Jordan: Policies Toward Better Uses, Preservations and Development. FAO, Mimeographed Report, Amman, Jordan.

Tian ZP, Zhuang LI, LU S, LI WH. 2013. Characteristics of the vegetation and the vertical distribution patterns on the northern slope of the USUN Mountains, XINJIANG. Pak. J. Bot. **45 (4)**, 1123-1134.

Torres JA, Garcia-Funentes A, Salazar C, Cano E, Valle F. 1999. Charaterisation of Pinus halepensis Mill. Pine in southern Iberian Peninsula. Ecologia Mediterranea **25(2)**, 135-146.

Ürlich D. 2002. Rock communities and succulent vegetation in northern Yemen (SW Arabia) – ecological, phytological and evolutionary aspects. Phytoecologia **32(2)**, 205-249.

Van Leeuwen WJD, Casady DG, Neary DG, Bautista S, Allosa JA, Carmel Y, Weittenberg DM, Orr BR. 2010. Monitouring post-wildfire vegetation response with remotely sensed time-series data in Spain, USA and Israel. International Journal of Wildland Fire **19**, 75-93.

Woolfenden BW, Ababneh L. 2011. Late Holocene vegetation in the Azraq Wetland Reserve, Jordan. Quaternary Research **76**, 345–351.

Zagjewski B, Kozlowska A, Krowczynska M, Sobczak M, Wrzesien M. 2005. Mapping high mountain vegetation using hyperspectral data. EARSel_eProceedings **4(1)**, 70- 78.

Zohary M. 1962. Plant Life of Palestine. Ronald Press Co. New York. pp. 262.

Zohary M. 1973. Geobotanical Foundation of the Middle East. Amsterdam. Sweets and Zeitlinger.