Vegetation Community Analysis in Mujib Biosphere Reserve, Jordan

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ABSTRACT

Field surveys of the plants and vegetation of the Mujib Biosphere Reserve in Jordan were carried out between 2005 and 2007. The study covered all areas of the reserve as defined by latitudes 7425000 W to 757000 E and longitudes 3501000 N to 3474500 S (total reserve area = 220 km^2). Plants and their vegetation were sampled both by area plots and line transects. Transect routes were directed from east to west across the reserve and defined as sectors (1-7). These generally included a range of altitudes from 900m down to -400m along the border with the Dead Sea. Various parameters were recorded during the study including the site name, its location (GPS coordinates), principle plant species present, and their life forms together with associated species and soil conditions. Various species were collected, photographed, and later deposited at the Herbarium of the Department of Biological Sciences, Faculty of Science, University of Jordan. From the various plant associations observed, three biogeographic regions were recognised, namely Mediterranean, Irano-Turanian and Tropical (Sudanian). In addition, five plant communities were identified and allocated to named classes as *Artemisia herba-alba; Retama raetam – Salsola vermiculata; Zygophyllum dumosum; hydric vegetation* and *tropical vegetation.* Differences within classes were grouped as sub-classes. The total number of plant species recorded during the survey was 408 which included several new and rare species to the flora of Jordan. An illustrated map showing the distribution of vegetation areas across the reserve is presented.

INTRODUCTION

The Mujib Biosphere Reserve is one of the largest reserves in Jordan. It situated within the mountain range of Jordan that extends with altitudes of 7425000 W to 757000 E and the latitudes of 3501000 N to 3474500 S. The reserve comprises rough terrain composed of a series of mountains, slopes and very deep valley formations with steep with inclinations extending to values in excess of 70% in some cases and often with inclinations ranging from 30 – 50 %. The reserve crosses a series of important wadis (valleys) including Zara, Zgara, Atoun, Wadi Abu Irteimeh, Wadi Um Ghreiba, Wadi Hidan, Wadi Um Zghaib and Wadi Mujib after which the reserve is named.

Mountain ranges in the study area vary in form and altitude. The higest altitude in Faqu' site is about 900 m at the southern borders of the reserve, while in Makawir at the southern border the height is 680 m. Again the mountains vary from 900-680 m in the eastern side and decline to about (- 400) m at the Dead Sea level in the West. Therefore, the reserve covers various stages geographical regions within which there are a series of microclimates. This kind of formation is reflected in the distribution of the flora and vegetation within the reserve, where three biogeographical regions are recognised, the Mediterranean, the Irano-Turanian and the Sub-tropical or Sudanian biogeographic region (Al-Eisawi, 1996) all of which occur within a relatively small area of about 220 km^2.

One of the earliest scientific studies of this region, before the area became a reserve, was a survey of plants carried out from the area of Ad-Daier near Makawer down to the west passing Zara and the Dead Sea (Al-Eisawi, 1983, unpublished work). The plants, which were collected there, are now deposited at the Herbarium of the Department of Biological Sciences, Faculty of Science, University of Jordan. Amman. One of the major references to Jordan is the work of Post, revised and published by Dinsmore (1932-1933) in the 'Flora of Syria Palestine and Sinai'. In his book 'Plant Life of Palestine' Zohary (1962) has covered most of the literatures related to the area until that date. Zohary's (1966-1972) work together with that of Feinbrun-Dothan (1978-1986) in the 'Flora Palaestina' are considered to be

the main references to the flora of Jordan. Zohary (1973) previously wrote the 'Geobotanical Foundation of the Middle East' in which he wrote extensively about the plant biogeographic regions, the major plant groups and formations across the whole area.

A major work related to Jordan and Mujib Biosphere Reserve is that of Al-Eisawi (1982), who published a list of vascular plants in Jordan in which more than 2000 species were recorded. Since then, various papers referring to the flora and biodiversity of Jordan have been published. A revised checklist including 2545 species has been recently published (Al-Eisawi, 2013). A few papers have been specifically concerned with the vegetation of Jordan including that of Al-Eisawi (1985). This latter work became the basis for the publication of a major reference entitled 'Vegetation of Jordan' sponsored by UNESCO (Al-Eisawi, 1996). An illustrated book (Al-Eisawi, 1998) also provides an account of more than 488 species of Jordan. Some of those species are also found in the Mujib Biosphere Reserve.

In 1996, The Royal Society for the Conservation of Nature (RSCN) conducted a survey of the water resources of the Mujib Biosphere Reserve. This was followed by surveys of birds and of mammals (carnivores) within the reserve (Hendig, 1998 and Nassar and Sabol, 1999 respectively). Details of the trapping methods developed during the latter study can be found in (Nassar and Sabol,1999). Nassar & Sabol (1999) studied the geology of Mujib Biosphere Reserve but also included details of location, access, topography, climate and vegetation and previous geological work. In that introductory study of the climate and vegetation, four main vegetation communities were identified with respect to elevation, namely:

i. Sudanian (with Saharo-Arabian) (15% of the total area)
ii. Saharo-Arabian (24.25% of the total area)
iii. Irano-Turanian (38.33% of the total area)
iv. Mediterranean transitional zone within Irano-Turanian (15% of the total area).

In 2000, the Research and Survey Section of the RSCN conducted a vegetation survey of Mujib as part of their Biosphere Reserve, Riverine

and Spring Vegetation Monitoring programme. This was based on a line transect along 2580 m of the River Mujib valley. Every twenty meters a record was made of the plants present across the water path. Species recorded included the following : *Saccharum ravenae (ravennae), Juncus maritimus, Inula crithmoides, Typha domingensis, Phragmites australis, Atriplex halimus, Tamarix sp., Nerium oleander, Blumea bovi, Sinapis arvensis, Ochradenus baccatus, Capparis spinosa (=Capparis cartilaginea)* and *Aaronsohnia factorovskyi.* However, this number of species represents only a relatively small proportion of the total biodiversity and richness of the area surveyed.

The RSCN (2001, 2002) submitted a report to the National Centre for Agricultural Research and Technology Transfer (NCARTT), under the title 'Inventory of Medicinal and Herbal Plants'. In this report a brief description of various areas of Jordan such as Ajloun woodlands, Safawi and Azraq study area, Mujib Biosphere Reserve and Feinan and Wadi Araba Study Area was given. Al-Noubani (2005), studied the distribution of *Teucrium polium* in addition to other elements of the flora of Mujib Biosphere Reserve in her thesis entitled: 'Productivity and Some Aspects of Phytochemical Analysis of *Teucrium polium* L. Grown in Different Environments'. In the study, she also recorded various counts of vascular plants from the sampling sites.

Although scientists (phytosociologists) currently have different views on the nature of the 'plant-community', most ecologists accept the existence of plant communities, which replicate themselves spatially within the two extremes proposed by Clements and Gleason. In practical terms, most plant communities are probably distributed according to a mosaic pattern. However, as human disturbances have become more intense, the boundaries of plant communities have become much sharper than under natural conditions. In some cases, vegetation components have been completely lost due to human impacts. Therefore, the main aims of this study were to re-define the vegetation communities within Mujib Biosphere Reserve and to produce a map of the distribution of these plant communities.

MATERIALS AND METHODS

Vegetation description

The method of description used here was based on the occurrence of species along a defined transect (floristics). Alternative methods based on physiognomic or structural features were considered inappropriate for the area. Where vegetation cover is scarce, as in the Mediterranean or arid or semi-arid desert, the most appropriate method of survey is the line transects method, which was used here. Initial surveys employed both 50m and 100m line transects due to the large areas to be surveyed.

Later, more systematic line transects were used to produce area based samples which could be allocated to a map. This method was used to produce small scale grid samples within a larger grid refernce system of survey. Where the terrain was too difficult to survey fully due to steep slopes or valley formations with rock beds, it was impossible to effect a survey based on a systematic selection of grid system. However, it was decided to make a survey along lines crossing the reserve from east to west to make sure that changes in vegetation with the drop in altitude was recorded.

Accordingly, the reserve was crossed from various parts of the reserve from east to west whenever possible, by walking and the use of a vehicle for ease of access. Various line transects and surveys were therefore completed by such means. The start and end points of each line were marked using a hand held GPS. Plant species along the lines were recorded and plant specimens collected for identification and preservation when necessary. Photographs of the plant communities and surrounding areas were taken, as well as individual plant species where appropriate. Particualr attention was given to hydric vegetation along the wadi formations during the survey.

Physical characteristic of the study area

Soil

Detailed soil surveys of the reserve have not been carried out to date, but from the observations made during this survey, the soils can be divided into one of the following groups:

i. Typical Mediterranean red soil or 'terra rosa'.
ii. Brown greyish clay like soil.
iii. Brown yellowish soil.
iv. Calcareous soil.
v. White chalk soil.
vi. Sandy soil especially, Kurnub (Cretaceous) formations
vii. Saline soil.

Vegetation types in relation to soil conditions were given for each line transect at the ten major sectors.

Temperature

Information related to temperature and rainfalls were extracted from RSCN reports (2001). The mean annual temperature ranged from 12.6 ºC at Fagu' to 29 ºC at Raddas on the Dead Sea. The hottest month was in July at Raddas 39 ºC and 29.6ºC in the eastern mountain side in Fagu'. In the coldest months temperatures were 3.7 ºC at Fagu' and 19 ºC at Raddas at a lower altitude in the west near the Dead Sea.

Rainfall

The rainfall is taken from RSCN (2001) records with an annual rainfall maximum of 326.5 mm in Fagu' and a minimum of 71.5 mm in Raddas. The month with maximum rainfall was recorded in Makawer in January with 83.5 mm, whilst in December it was 17.2 mm in Raddas. The period between June and September recorded no rainfall across all areas of study

RESULTS

A total of seven line transects crossing the reserve from east to west were surveyed. The length of the line transect varied less than 500m up to a few kilometers based on the road accessibility to walking on foot. The length of the line was calculated as a linear distance between the start and end point GPS coordinates of the transect. The start point of each transect was usually decided on the basis of a change in the vegetation structure. At other times the start and end points was sometimes based on the nature of the terrain.

Those areas surveyed were allocated to one of **seven** sectors, namely::

1. Sector 1 Makawir Dead Sea
2. Sector 2 Faqu' – Raddas
3. Sector 3 Al-Batheiah Dead Sea
4. Sector 4 Ad-Dair Makawir – Dead Sea
5. Sector 5 Dead Sea – Main
6. Sector 6 Bat-han, Mujib, Raddas
7. Sector 7 Wadi Shgaig – Dead Sea

Findings according to Sectors

The total number of areas surveyed, as previously mentioned, provides records for the seven major sectors crossing the reserve from east to west. Each sector includes many line transects varyiong from ten to 27 lines. In some cases specific detailed studies were made using parallel line transect for one of the lines up to times measuring various factors such as dominance, abundance, density, coverage, height and other factors to test our observation and recognition. In some other places the plant community was observed initially as an almost pure stand of one species but later became mixed with one or more other species such that the dominant species becomes replaced by another species.

However, the following example Makawer–Dead Sea line shows the details of obtained information in each line within one sector. Looking at the line transects and changing in altitude, a clear change in the plant species and their associated plant communities

is apparent. In this line, the starting point of the survey was 686 m and the end of the sector was 169 m with a declination of about 500 m unit as one reaches almost a stable type of ecosystem. Due to space limitation, it was not possible to put all the raw data collected from all sites. Sample of the vegetation survey for the various sectorts is represented in a similar way for Makawer sector. For all other sectors, actual data have been excluded from the account due to space limitations.

Sector 1 Makawir Dead Sea

Locality No 58/2005	**Line 1 Sector 1 (1/1)**
Locality	Makawir – Dead Sea
Vegetation	Mediterranean- Irano-Turanian vegetation
Dominant species	*Ballota undulata, Varthemia iphionoides, Artemisia herba-alba, Reaumuria hirtella, Noaea mucronata*
Community	*Artemisia herba-alba, Reaumuria hirtella, Noaea mucronata*
Soil	Clay soil, light brown becoming calcareous later on at lower altitudes
Coordinats	0748826 E 3496695 N
Altitude m	686-595
Notes	This line starts from Makawir Station down to the west for about 400 m. The terrain is rocky, rough and mostly covered by pebbles. The vegetation in the upper part is Mediterranean turning into mixed Mediterranean and Irano-Turanian elements. The density of the vegetation is about 35-40 %.
Date	11/10/2005
Collectors	D. Al-Eisawi
Line length	Variable

Coordinates	Starting E	Starting N	Ending E	Ending N	Inclination %	Height cm	Cover %	Altit
L1	0748826	3496695	0748439	3476089	40	40m	37	686-595

Recorded Species			
1.	*Aegilops sp*	25.	*Helianthemum salicifolium*
2.	*Allium desertorum*	26.	*Hippocrepis unisiliquosa*
3.	*Alyssum damascenum*	27.	*Hordeum glaucum*
4.	*Anthemis sp.*	28.	*Ifloga spicata*
5.	*Artemisia herba-alba*	29.	*Minuartia decipiens*
6.	*Ballota undulate*	30.	*Minuartia Formosa*
7.	*Bromus fasciculatus*	31.	*Noaea mucronata*
8.	*Bromus lanceolatus*	32.	*Ononis reclinata*
9.	*Bromus tectorum*	33.	*Onopordum sp*
10.	*Carex pachystylis*	34.	*Papaver argemone*
11.	*Carlina hispanica*	35.	*Paronychia argentea*
12.	*Carrichtera annua*	36.	*Phagnalon rupestre*
13.	*Carthamus tenuis*	37.	*Phlomis brachyodon*
14.	*Catapodium rigidum*	38.	*Plantago coronopus*
15.	*Centaurea hyalolepis*	39.	*Poa bulbosa*
16.	*Colchicum brachyphyllum*	40.	*Roemeria hybrid*
17.	*Crithopsis delileana*	41.	*Rostraria berythaea*
18.	*Crucianella ciliate*	42.	*Salsola vermiculata*
19.	*Cynosurus callitrichus*	43.	*Silene coniflora*
20.	*Daucus subsessilis*	44.	*Taeniathermum crinitum*
21.	*Echinops polyceras*	45.	*Torilis leptophylla*
22.	*Erucaria pinnata*	46.	*Urginea maritime*
23.	*Filago desertorum*	47.	*Varthemia iphionoides*
24.	*Filago pyramidata*	48.	*Verbascum fruticulosum*

Vegetation communities – descriptions

The major (recognisable) vegetation types are allocated to classes whilst variations within classes are called sub-classes, which represent a smaller plant community unit. Specific plant communities can be recognised within each line as part of the major transects profile. Such small communities can often represent a pure stand of one species or an alternative dominance of two to three different species. Since such findings are generalluy of a small scale restricted in size to m^2, they cannot easily be recorded on the map due to the large scale of the study area.

The hydric class can in fact be the frist of three major classes since it is restricted by the presence of water either as a continuous or with intermittent flow. While the tropical class is a deviation from the hydric vegetation and becomes recognised in location with hot springs such as those at Zara, or in habitats characterised by very low altitudes with hot temperature, similar to those wet habitats found along the road of the eastern side of the Dead Sea.

Within the Mujib Reserve, there are five major classes of plant communities and 18 very marked sub-classes, as shown in (Fig. 1). However, it is justified to say that some of the small communities (sub-classes) are often distributed between two major plant cover communities (classes). At other times, the leading species of one community (sub-class) becomes the second or the third most common in other communities. Some species such as *Salsola vermiculata,* and *Urginea maritima* occur in almost all parts of the reserve, while other species such as *Artemisia herba-alba, Teucrium polium, Ononis natrix,* and *Ballota undulata* are largely restricted to the highlands of the reserve, above 600m.

Similarly, the species of *Typha angustifolia, Phragmites australis, Nerium oleander, Arundo donax, Salix alba,* and *Tamarix spp.* are restricted to water availability and forming the major formation of the hydric vegetation. Again, *Moringa peregrina, Phoenix dactylifera, Imperata cylindrica* and *Saccharum spp.* Are only found in hot water springs and very hot wet conditions.

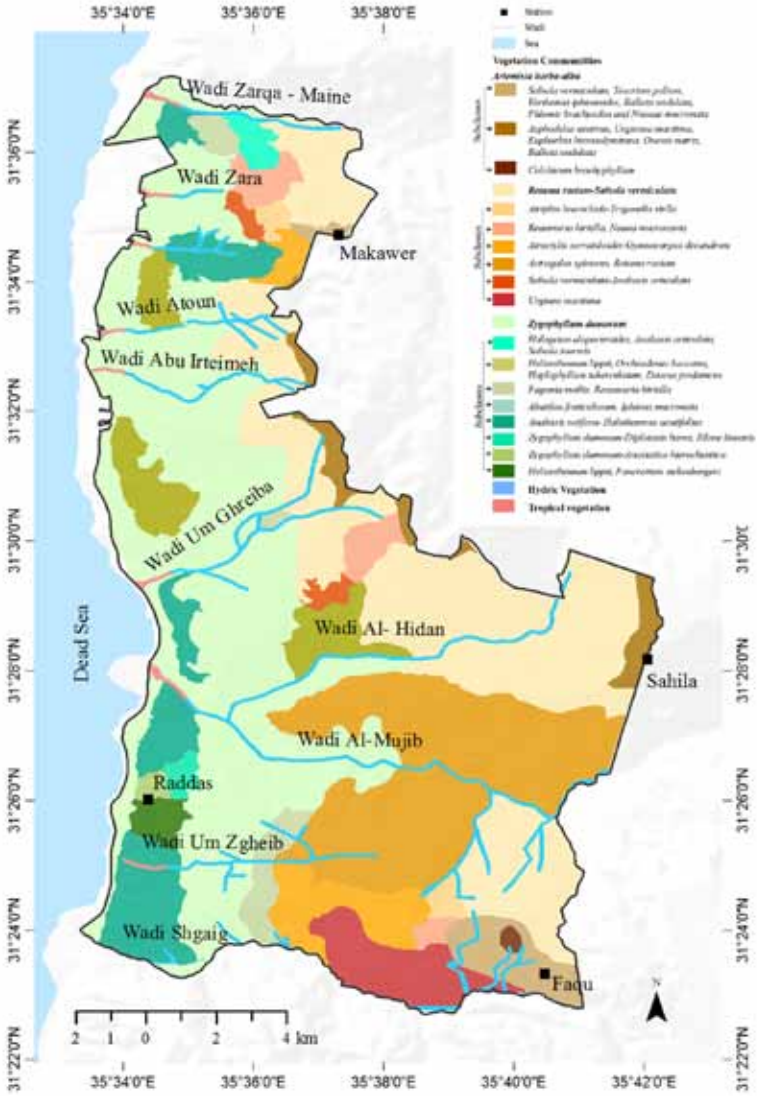

Fig. 1: Vegetation Communities at Mujib Biosphere Reserve

Therefore, it was clear that specific edaphic factors especially, soils type have played an important role in the distribution of other groups of species such as *Reaumuria hirtella* restricted to clay-salty soils. By contrast, *Haplophyllum tuberculatum, Daucus jordanicus, Helianthemum lippii* and *Ochradenus baccatus* are restricted to sandy soils of *Zygophyllum dumosum* class, which always occurs at an altitude of less than 400m.

Class 1. *Artemisia herba-alba* (Plate 1. A)

This type of vegetation is restricted to altitudes above 600 m. However, sometime penetration of one class with another class can be observed in a restricted area due to changes in rock or soil type. This class of vegetation is dominated by *Artemisia herba-alba* in combination with other plant species especially, *Salsola vermiculata, Teucrium polium, Varthemia iphionoides, Ballota undulata, Phlomis brachyodon, Noaea mucronata, Asphodelus aestivus, Urginea maritima, Ononis natrix,* and *Euphorbia hierosolymitana.*

When a new leading species within a restricted area appears even when the leading species of the class is still apparent then a new sub-class is recognised. This vegetation class is usually a Mediterranean type which occurs in the mountainous areas of south Jordan, especially when temperature is cold and rainfall is maximum in the local area, but generally less than that of the northern mountains of Jordan. The vegetation is dominated by perennial herbaceous and woody bushes and very low shrubs, with height ranging from 20 to 60 cm. Soil is usually of limestone origin and mostly of a brownish clay-loam type. This class has some variations of composition in the leading species leading to thesub-divisions:

Subclass: *Asphodelus aestivus, Urginea maritima, Euphorbia hiero solymitana, Ononis natrix* and *Ballota undulata*

Subclass: *Salsola vermiculata, Teucrium polium, Varthemia iphi onoides, Ballota undulata, Phlomis brachyodon,* and *Noaea mucronata*

Subclass: *Asphodelus aestivus, Urginea maritima, Euphorbia hiero solymitana, Ononis natrix* and *Ballota undulata*

Subclass: *Colchicum brachyphyllum*

Class 2. *Retama raetam- Salsola vermiculata* (Plate 1. B, Plate 2. A)

Retama raetam is typical of steppe vegetation, although it might extend its distribution to desert or marginal Mediterranean. It occurs in more humid places or in north facing slopes where the solar radiation is minimal to avoid soil dissection. In fact, *Salsola vermiculata* is a more dominant species in this class, but since *Retama raetam* is much higher plant, the name of class was given as *Retama - Salsola* rather than *Salsola – Retama*. The soil is mostly of soft limestone origin, with often calcareous to yellowish or gravelly features and a thin layer of clay like soil if present.

Salsola vermiculata know locally as *(Hamdh, Hamth)*, is a very important component of the grazing system in the dry ecosystem of Jordan. Wherever it is found it gives a good indication about the importance of the grazing land. As this plant is perennial and grows almost all the year round but especially during summer like most other members of the family Chenopodiaceae. Accordingly, the presence of this plant in most ecosystems of the reserve and at various altitudes is a good indicator of a highly palatable species. In fact, *Salsola vermiculata* was observed in almost all study sectors. This class varied in compostion so it is sub divided into the following subclasses:

Subclass: *Atriplex leucoclada – Trigonella stellata*

Subclass: *Reaumuria hirtella- Noaea mucronata*

Subclass: *Atractylis serratuloides- Gymnocarpos decandrum*

Subclass: *Astragalus spinosus- Retama raetam*

Subclass: *Salsola vermiculata- Anabasis articulata*

Subclass: *Urginea maritime*

Class 3. *Zygophyllum dumosum* (Plate 2. B, Plate 3 A)

This class is a typical low altitude tropical element of vegetation that dominates at the low hillsides of the Dead Sea and Arab Valley in Jordan. The class is characterised by having low woody shrubs of a height ranging from 30-70 cm and rarely more. The leaves are highly succulent, round and delicate flowers and winged pentangular fruits. All vegetative parts are palatable by local grazing animals especially, goats.

This class of vegetation is the leading species starting from about 400m above sea level becoming almost the single species at lower altitudes. If calcareous and lime stone condition change, where *Zygophyllum* is dominant, especially, when humid sand stone is available other members become clearly increasing and leading species such as *Ochradenus baccatus, Helianthemum lippii,* and *Daucus jordanicus.* This class has some variation in its composition and leading species resulting in the following sub-classes:

Subclass: Halogeton alopecuroides, Anabasis articulata, Salsola inermis

Subclass: Helianthemum lippii, Ochradenus baccatus, Haplophyllum tuberculatum and *Daucus jordanicus*

Subclass: Fagonia mollis - Reaumuria hirtella

Subclass: Abutilon fruticulosum - Iphiona mucronata

Subclass: Anabasis setifera- Halothamnus acutifolius

Subclass: Zygophyllum dumosum-Diplotaxis harra and Silene linearis

Subclass: Zygophyllum dumosum - Anastatica hierochuntica

Subclass: Helianthemum lippii - Pancratium sickenbergeri

Class 4. Hydric vegetation (Plate 3. B)

Hydric vegetation is a typical type of vegetation occurring along fresh water canals, wadis, rivers or water springs. Height, thickness and species composition of plant species varies according to the location of the fresh water passage. The altitude of the water passage and ecosystem often affect the occurrence of additional new species

or replacing exsisting species. The best examples of the fresh water ecosystem have been observed in Wadi Shgaig, Wadi Mujib especially at the exit leading to Raddas Station, and at Wadi Al-Batheiah. The vegetation may become very thick and difficult to penetrate due to the tree and high shrub dense formation especially when strong stream of running fresh water is available.

Vegetation components observed are usually the various species of *Tamarix, Nerium oleander, Arundo donax,* and *Phragmites australis.* In association with these dominant species, often, other important hydric elements become apparent such as *Ficus carica, Salix spp. Typha domingensis,* and many other herbaceous plants. This class has some variations of composition and leading species that are subdivided into the *Nerium oleander* and *Arundo donax subclass.*

Class 5. Tropical vegetation (Plate 4. A, B)

This type of vegetation is very much associated in the study area with hot springs, high humidity, low altitudes, and hot conditions. Such specific characteristics of this habitat have created almost a microclimate of hydric tropical vegetation within the study area, where dense vegetation dominated by few tree species. Other components of the vegetation are composed almost entirely of grasses. The trees and shrubs are largely made up of *Moringa peregrina, Phoenix dactylifera, Ziziphus spina-christi, Tamarix species* and by *Capparis deciduas respectively.* The remaining components of this vegetation group consist of often dense 'mats' of *Saccharum ravennae, Imperata cylindrica, Phragmites australis, Arundo donax* and of the fern *Adiantum capillus-veneris* together with the orchid *Epipactis veratrifolia.* Variations in the floral compostion of this class give rise to the sub-classes dominated by species including *Moringa peregrina, Phoenix dactylifera, Ziziphus spina-christi* and *Saccharum.*

DISCUSSIONS

The Mujib reserve contains a wide range and diversity of habitats. Much of this diversity reflects differences in altitude of over 1300m (range -400m to 900m below and above sea level). Additional species richness is generated by the presence of hydric habitats of fresh

water or hot spring, both of which are of particular interest to tourists. The reserve also spans three biogeographic zones within a limited area. This variation is of particular interest to ecologists and biologists with special interests in the variation of plant species, their distribution and evolution. Both the high temperature and altitudinal ranges provide opportunites for changes in slection pressures over relatively short distances.

The presence of these three biogeographic regions within such a limited area has caused a special pressure on the living organisms especially, at the meeting points and borders of zonation of the three regions. Such condition can produce certain plant and animal groups with specific sets of morphologic, genetic and ecological characters that can separate them as new endemic species, subspecies or varieties. Since the terrain is very rough in the Mujib reserve, sufficient time is needed to walk around carefully and safely trough the reserve to be able to observe the variety of species found growing within the boundaries of the reserve. This of course is very critical and true if the surveys are extended to include the various growth seasons and for a longer period. However, field survey and the observations of the vegetation types and species composition and distributions confirm that there are three biogeographic regions within the boundaries of the reserves as follows:

1. Mediterranean

This region in Mujib reserve, starts at the eastern boundaries of the reserve at an altitude of 900 to 600 m or a little less when the microclimate conditions permit the Mediterranean elements to develop which are identified as 'Mediterranean penetration', with an annual rainfall in excess of 250 mm. The Mediterranean region in Jordan is normally characterised by having a forest vegetation or a degraded forest vegetation, with soil types of Terra Rosa (red soil) or Rendzina (yellow soil). Although typical Mediterranean conditions have not been formerly observed within the reserve, Terra Rosa soils has been observed at the eastern borders of the reserve in Makawir and Faqu' areas which seesm to confirm its existence.

Most trees represented in the region consist of remants of a forest climax vegetation with a limited number of *Pistacia atlantica* at the eastern borders of the reserve west of Faqu' and Sarfa. This was the only proper element of forest formation but a very good indicator of degraded forest, which was present at one time within the past century or two. However, the widespread occurrence of *Artemisia herba-alba* in association with *Ballota undulata, Varthemia iphionoides, Eryngium glomeratum, Echinops polyceras* and *Phlomis brachyodon* are typical of a Mediterranean flora. The occurrence of *Artemisia herba-alba* in the Mediterranean region similar to the Mediterranean condition in Tafila, Shuabak, Ras an Nagab and other parts in Southern Jordan is an indication of high, cold, exposed and rather less rainfall typical of Mediterranean conditions. Due to this fact, some people recognise *Artemisia herba-alba* as *Artemisia seiberi,* since *Artemisia herba-alba* is a typical Saharo-Arabian element. *Euphorbia hierosolymitana* was the best example of the Mediterranean penetration within the Irano-Turanian conditions.

2. Irano-Turanian

This region is confined to the area ranging from 600 to 300 m above sea level with a rainfall ranging from betweee 250 and 100 mm. This area has calcareous soils and a vegetation consisting of small shrubs such as *Retama raetam* or *Astragalus spinosus*. The dominant vegetation is usually made of bushes of less than 50 cm height. This area is typical Irano-Turanian region of Jordan.

3. Tropical (Subtropical-Sudanian)

This region may start at an altitude of 400 m as an extension of penetration within the Irano-Turanian territory, but in general typical tropical region is well recognised at an altitude of 200 m above sea level down to - 400 m below sea level. Typical tropical vegetation includes trees and shrubs such as *Acacia sp. Salvadora persica, Maerua crassifolia, Moringa peregrina, Ziziphus spina-christi, Phoenix dactylifera, Balanites aegyptiaca* and *Calotropis procera.* Unfortunately, typical tropical (Sudanian) vegetation falls outside the reserve at the western borders of the reserve, where the majority of such conditions lie within private property. Typical tropical vegetation in Mujib is

characterised by the sudden appearance and dominance of a single species *Zygophyllum dumosum,* which is a low succulent shrub or bush, usually in association with other plants depending on the soil conditions.

Often, within the tropical area, the presence of streams, canals and or hot spring are very important for the presence of specific hydrophilic tropical elements such as *Imperata cylindrical, Saccharum ravennae, Capparis decidua, Moringa peregrina, Adiantum capillus-veneris,* and *Phoenix dactylifera* amongst others.

In addition to the above factors the Mujib Biosphere reserve also contaians at least two endemic plant species, *Iris edomensis* and *Daucus jordanicus* and a few rare species such as *Crocus cartwrightianus, Capparis decidua,* and *Epipactis veratrifolia.* Newly discovered species like *Pancratium parviflorum* are likely to be added to as the reserve as it receives further study. Thus, the reserve is important for its varied ecology and plant biodiversity but also as a venue for ecotourism

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REFERENCES

Al-Eisawi, D. M. H. (1982). List of Jordan Vascular Plants. *Mitt. Bot. Münchin*, 18: 79-182.

Al Eisawi, D. M. H. (1985). Vegetation of Jordan. In Hadidi, A. Studies in the History and Archaeology of Jordan. II. Ministry of Archaeology. Amman. Pp. 45 57.

Al-Eisawi, D. M. H. (1995). Vegetation and Flora of Azraq Reserve. Hashemite Kingdom of Jordan. Azraq Wetland Reserve Project. Amman, Jordan. The World Bank – Global Environment Facility.

Al-Eisawi, D. M. H. (1996). Vegetation of Jordan. Regional Office for

Science and Technology for the Arabian States.UNESCO – Cairo Office. Pp. 284.

Al-Eisawi, D. M. H. (1996). Vegetation of Jordan. Regional Office for Science and Technology for the Arabian States.UNESCO – Cairo Office. Pp. 284.

Al-Eisawi, D. M. H. (1998). Field Guide to the Wild Flowers of Jordan and Neighbouring Countries. Printed by Jordan Press Foundation, Al-Rai. Pp.296.

Al-Eisawi, D. M. H. (2013). Flora of Jordan, Cheklist, Revised Edition, 1. University of Jordan Press. The University of Jordan. Amman. Pp192.

Al-Eisawi, D. M. and Hatough, A. (1987). Ecological Analysis of the Vegetaion of Shaumari Reserve in Jordan. *Dirasat*, XIV (12): 81-94.

Al-Noubani, R. (2005). Productivity and Some Aspects of Phytochemical Analysis of *Teucrium pollium* L. Grown in Different Environments. M. Sc. Thesis, submitted to the Environmental Sciences and Management Programme. Faculty of Graduate Studies, University of Jordan. Pp. 79.

Begon, M., Harper, J. L. and Townsend, C. R. (1990). Ecology: Individuals, Populations and Communities. 2nd ed. Blackwell Scientific. Oxford.

Clements, F. E. (1916). Plant Succession: An Analysis of the Development of Vegetation. Carmegie Inst. Wash.Pub. Pp. 242.

Clements, F. E. (1928). Plant Succession an indicators. H. W. Wilson Co. New York. Pp 453.

Feinbrun-Dothan, N. (1978 & 1986). Flora Palaestina, Vol. 3 & 4. The Israel Academy for Science and Humanities. Jerusalem.

Gleason, H. A. (1917). The structure and Development of the plant association. *Bull. Torrey Bot. Club*, 53: 7-26

Gleason, H. A. (1926). The individualistic concept of plant association. *Ecology*, 8: 299-326.

Gleason, H. A. (1939). The individualistic concept of plant association. Am. *Midland Naturalist*, 21: 92-110.

Hatough, A., AL Eisawi, D. M. and Disi, A. (1986). The effect of Conservation on the wildlife in Jordan. *Environmental Conservation*, 13(4): 331 335.

Hatough, A. and AL Eisawi, D. M. (1988). The Arabian Oryx in *Jordan. Journal of Arid Environments*, 14: 291 300.

Hendig, P. T. (1998). Mujib Nature Reserve, Bird Survey: 2nd Phase. UNDP/ World Bank – Global Environment Facility Project. Amman, Jordan. Pp. 55.

Nassar, K. and Sabol, T. (1999). Mujib Nature Reserve, Carnivores Trapping Project. Royal Society for The Conservation of Nature (RSCN). Amman, Jordan. Pp. 21.

Nassar, K. and Sabol, T. (1999). Mujib Nature Reserve, Geology Report. Royal

Post, G. and Dinsmore (1932-1933). Flora of Syria Palestine and Sinai, 1&2 Vol. American University of Beirut. Beirut. Pp. 928.

RSCN (Society for the Conservation of Nature) (1996). Mujib Nature Reserve, Water Survey. UNDP / World Bank – Global Environment Facility, Project for the Conservation of Mujib Reserve. Amman, Jordan. Pp.116 = Appendices.

RSCN (2000). Wadi Mujib Nature Reserve, Riverine & Spring Vegetation Monitoring. Amman, Jordan. Pp. 21.

RSCN (2001). Inventory of Medicinal and Herbal Plants. Submitted to the National Centre for Agricultural Research and Technology Transfer (INCARTT). Amman, Jordan. Pp. 169.

RSCN (2002). Mujib Nature Reserve, Mujib Raptor Survey. European Commission – Bird Life International for Birds and People in the Jordan Valley. Amman, Jordan. Pp.24.

RSCN. UNDP / World Bank – Global Environment Facility. Amman, Jordan. Pp. 41.

Zohary, M. (1962). Plant Life of Palestine. The Roland Press Company. New York. Pp. 262.

Zohary, M. (1966, 1972). Flora Palaestina, Vol. 1& 2. The Israel Academy for Science and Humanities. Jerusalem.

Zohary, M. (1973). Geobotanical Foundation of the Middle East, 2 Vol. Swets and Zeitlinger.

Plate 1

A: *Artemisia herba-alba* vegetation

B: *Retama raetam* vegetation calss in association with *Urginea maritima*

Plate 2

A: *Astragalus spinosus* class of vegetation subclass *Astragalus spinosus- Retama raetam*

B: *Zygophyllum dumosum class*

Plate 3

A: *Zygophyllum dumosum class*

B: Hydric Vegetation

Plate 4

A: Tropical vegetation, showing a local orchid *Epipactis veratrifolia*

B: Wild Palm