

Marei Hussain Al-Qahtani

# Vertical and Horizontal Distribution of Vegetation Communities and Habitats in Assir Mountains

**Abstract:** Data analysis and reconnaissance surveys showed that from an ecological and geomorphological point of view, the research area could be divided horizontally into two distinct plant communities (mountainous plant community and semi-desert plant community) and vertically into five plant habitat types, namely the toe-slope habitat, foot-slope habitat, mid-slope habitat, shoulder slope habitat and summit slope habitat. The recognised communities and habitat types varied in their environmental features (topography, soil conditions and the degree of animal impacts) and consequently in their vegetation composition. Although the vegetation density in this area is low ( $2.71/100\text{ m}^2$ ), it is considered relatively high compared with other areas in Saudi Arabia. However, great diversities in density and distribution of vegetation were found between slope segments, and also generally between the south-west and north-east parts of the research area. The floristic composition and distribution of main plant groups were found to reflect the condition of soil and the topographical variety in Assir Mountains.

المستخلص: أوضح المسح الاستطلاعي وتحليل البيانات أن بالإمكان تقسيم منطقة الدراسة أفقياً إلى منطقتين نباتيتين هما مجموعة النباتات الجبلية ومجموعة النباتات شبه الصحراوية، وعمودياً إلى خمس مواطن نباتية هي مواطن نباتات أطراف المنحدرات، مواطن نباتات أقدام المنحدرات، مواطن نباتات وسط المنحدرات، مواطن نباتات أكتاف المنحدرات ومواطن نباتات قمم المنحدرات. كما أوضحت الدراسة أن البيئات والمواطن النباتية تختلف في خصائصها البيئية من حيث الطبوغرافيا وحالة التربة وبالتالي اختلافها في التركيب النباتي. ورغم أن الكثافة النباتية في منطقة الدراسة إلى حد ما ضعيفة ( $2.71/100\text{m}^2$ ) إلا أنها تعتبر كثافة عالية نسبياً إذا ما قورنت مع أي منطقة نباتية أخرى في المملكة العربية السعودية. ومع ذلك وجد أن هناك اختلافات كبيرة في كثافة وتوزيع النباتات بين الوحدات الانحدارية وبين شمال شرق وجنوب غرب منطقة الدراسة. كما وجد أن التركيب النباتي وتوزيع المجموعات النباتية الرئيسية يعكس بجلاء الاختلافات في حالة التربة والطبوغرافيا على مرتفعات عسير.

## Introduction.

The Arabian Peninsula is located in the south-west of Asia. Therefore, it encompasses wide parts of two phytogeographical regions that cover many parts of the Middle East and north Africa. These regions are the Sahara-Arabian region and the Sudanian region (Al-Qahtani, 1998).

From the viewpoint of ecologists, phytogeographers and biogeographers, such as Al-Aodat, *et al.* (1985), and according to the

classifications of Eig, (1931,1932,1933), and Takhtajan (1986), the south-western territory of Saudi Arabia, which includes the research area, falls entirely within the east Sudanian region.

The flora and vegetation of the Sudanian region are characterized by hundreds of genera, numerous species and plant communities. The main vegetation types of this region are open woodland, savanna and grassland. The Eritrean-Arabian subregion of the Sudanian, south Arabian province, in the south and south-west of the Arabian peninsula is the richest and the most complex with its latitudinal zonation and species diversity containing about 225 endemic species (Takhtajan, 1986; Zohary, 1973). Also, the same subregion is characterized climatically by a tropical climate with high temperatures in summer and warm temperatures throughout the rest of the year. Precipitation and atmospheric humidity are normally high, with the average rainfall exceeding 400 mm per year. Due to the monsoon, it is evenly

Marei Hussain Al-Qahtani  
Department of Geography  
King Khaled University,  
P. O. Box 9077, Abha,  
Saudi Arabia  
Tel: (965)  
Fax: (965)  
E-mail:

distributed through the rainy season and takes place mainly during the spring months (Al-Qahtani, 1991). High mountains in the area receive rainfall throughout the year but rainfall reaches its peak in the spring season. The subregions in the Arabian peninsula are mainly characterized by temperatures that are high enough to support a tropical vegetation.

Within the study area, ecologists and phytogeographers have indicated in brief comments, that this area is an important part of Saudi Arabia, in terms of the magnitude of its vegetation cover. Some of these studies have described the vegetation of this area as follows.

Brooks & Mandil (1983) studied the "Vegetation Dynamics in Asir Woodlands" and reported the following:

*"In Saudi Arabia, the greatest number of plant species is found in the highlands of the south and south-west where East African vegetation contributes to the character of the region. Forty-four per cent of the flora in southern and south-western Arabia represents Sudanian elements found in the altitudinal zonation of the savanna scrub and the montane woodlands".*

Konig (1988) investigated the "Phytogeography of South-western Saudi Arabia" and described the vegetation in the study area as follows:

*"The vegetation of the study area is climatically influenced and characterized mainly by forest, woodland and xeromorphic woodland communities - in contrast to the central parts of the Arabian peninsula, which are dominated by dwarf-shrub communities, grassland and deserts".*

This study aims to investigate and analyse in detail the perennial vegetation of the research area, in terms of the morphology, ecology and distribution and their relationship with slope habitats. Investigation and analysis of the above points is based on data of vegetation, slope and soil samples that were collected from 300 quadrats from the research area.

### Materials and Methods.

Sixty transects were selected systematically as profile lines along the eastern slopes of Assir mountains. Each transect started from a specific measured point on the lower slope and crossed the facing slope to the edge of the mountains. The distance between transects was 5 km. Each transect was subdivided into five slope units from the ridge to the toe: summit, shoulder, mid-slope, foot-slope, and toe-slope. These units covered all the

physiographic and physiognomic variations of the region. Selection of these units, which can be seen every where, depended on variation of vegetation distribution, slope gradient and form, with soil uniformity. Sample collection sites were established in the centre of each slope unit on each transect. According to ecologists and pedologists, the best time for gathering samples of soil and vegetation is after rain period which stretches from November until the end of May. As a result of this, fieldwork was carried out in the period June to August 1999. The point-centred quarter method, (Kent & Coker, 1992) which is widely used for the sampling of gradient vegetation in forest and woodland ecosystems as well as in sparsely-vegetated areas, was applied at the centre of these units. In other words, this technique was used to measure, investigate and analyse the perennial plants in 300 sites. In each site, slope factors (slope angle, slope gradient and slope length) and vegetation components (height, basal diameter, basal area crown area, absolute density, relative covering value, number of points with particular species, total number of individuals, abundance of species/100 m<sup>2</sup>, absolute dominance, absolute frequency, relative density, relative dominance, relative frequency and importance value) were measured and computed, and soil samples (soil depth, soil moisture, texture class, pH and organic matter) and plants were collected and analysed. This technique has proven to be sufficient and effective in previous investigations of vegetation status and its relationship with slope and soil factors, such as Mueller-Dombois & Ellenberg (1974), Kent & Coker (1992) Martz (1992), Derosé *et al.* (1993), Makhnach (1994) and Simanton *et al.* (1994). Plant species and nomenclature were identified *in situ* in most of the studied sites by the means of the available scientific references on the flora of Saudi Arabia and its surrounding countries, such as Abulfatih (1984, 1987), Al-Qahtani (1991, 1998), Blatter (1907) and Migahid (1980, 1988). The other species were identified via collecting samples from fresh branches and transfer them to the herbarium. The all procedures suggested by Tarzi (1984) were applied in the collecting and preparation of soil samples, which were analysed according to the procedures that were suggested by soil survey staff (1992), and are applied at laboratories of King Saud University and the National Agriculture and Water Research Centre, Saudi Arabia.

## The Study Area.

Assir mountains occupy a unique position in the south-west of Saudi Arabia. In terms of geographical location, Assir mountains lay in the zone between 17° 20' - 20° 45' N latitudes and between 41° 40' - 44° 17' E longitudes (Fig. 1). Geologically, the study area belongs to the greater Afro-Arabian shield which is a part of the Precambrian crystalline plate (Schmidt *et al*, 1973). The elevation of the area above sea level ranges from 1000 m to 3130 m (Al-Shareef, 1984). It contains mountains, escarpments, deep valleys, rolling land and rocky hills (Abulfatih, 1981). The area is distinguished by moderate temperature throughout most months of the year. Although, there is a decrease in temperature in winter, it does not reach freezing point, because this area is influenced by the warm marine wind. The important thing is that this area receives a high rainfall. These rains are distributed throughout the year with peaks in spring and summer (Al-Qahtani, 1998).

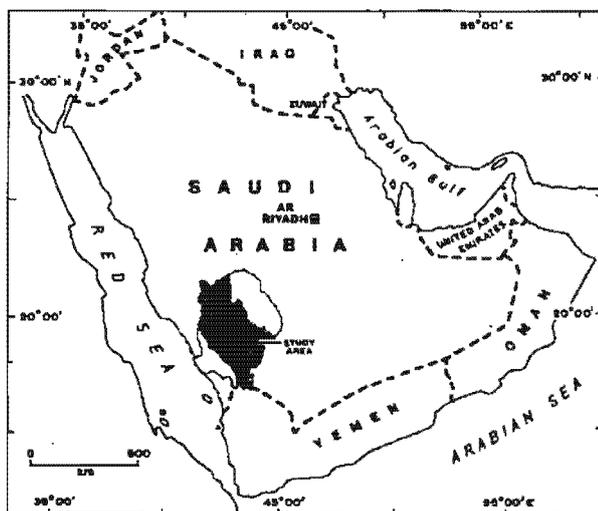


Figure 1: Geographical and Regional Location of the Study Area.

## Results and Discussion.

### 1- Features of Plant Communities and Habitats.

The following discussion and analysis provide quantitative estimates of vegetation structure and distribution of the plant communities and habitats in the research area. They focus particularly on the data collected from the research area, and the reconnaissance surveys.

Data analysis and reconnaissance surveys

showed that from an ecological and geomorphological point of view, the research area could be divided horizontally into two distinct plant communities (mountainous plant community and semi-desert plant community) and vertically into five plant habitat types, namely the toe-slope habitat, foot-slope habitat, mid-slope habitat, shoulder slope habitat and summit slope habitat. The recognised communities and habitat types varied in their environmental features (topography, soil conditions and the degree of animal impacts) and consequently in their vegetation composition. This fact has confirmed what Batanouny (1987) stated, that topography and soil properties, especially the physical attributes and water resources, play an important role in the distribution of the different plant communities in the western mountains of Arabian peninsula. Analysis and discussion of these communities and habitat types are presented below.

### 2- Mountainous Plant Community.

A mountainous plant community is distributed in this area. Its topography and climate are widely different from those of the semi-desert plant community located in the north-east of the research area. This is due to the high altitude (2000-3130 m above sea level) with its consequences for air temperature, and to relatively high rainfall without a prolonged dry period as in the desert and semi-desert plant communities. It contains high mountains, rocky hills, escarpments and rolling lands. Such topography, with its relatively high rainfall and moderate temperature, has created a distinct type of habitat for plant growth. As can be seen from Table 1, 21 perennial species belonging to 12 botanical families were recorded in the mountainous plant community. Most of these species need relatively high moisture levels and a low temperature. Most botanical species found in this community are distinguished by moderate to small sizes. The mean of height, basal diameter, basal area and crown area of the perennial species in this community were calculated to be 1.68 m, 6.50 cm, 80.34 cm<sup>2</sup> and 2.45 m<sup>2</sup> respectively. *Acacia gerrardii* species recorded the greatest height (7.85 m) in the mountainous plant community, whereas *Juniperus procera* species recorded the biggest basal diameter (72 cm) and the greatest crown area (707.14 m<sup>2</sup>). The plant cover value varies from one stand to another, but overall it is better than the plant cover value in the semi-desert plant community. According to Domin's scale, the mean estimation of

plant cover value was counted to be 4.94, which equals about 11 to 25 %.

Quantitative analysis of species in the mountainous plant community, covering absolute density, relative covering value, number of point with species, total number of individuals, abundance of species, absolute dominance, absolute frequency, relative density, relative dominance, relative frequency and importance value is presented in Table 1. The absolute density and relative covering value of perennial species in this community are 3.01/100 m<sup>2</sup> and 32 respectively. These are considered high values, compared with the absolute density and relative covering value in the semi-

desert plant community (2.46/100 m<sup>2</sup> and 13.21 respectively). Absolute dominance values indicate that *Juniperus procera* (217.66 cm<sup>2</sup>/100 m<sup>2</sup>), *Acacia gerrardii* (82.06 cm<sup>2</sup>/100 m<sup>2</sup>), *Acacia negrii* (65.38 cm<sup>2</sup>/100 m<sup>2</sup>), *Dodonaea viscosa* (15 cm<sup>2</sup>/100 m<sup>2</sup>) and *Lycium shawii* (6.82 cm<sup>2</sup>/100 m<sup>2</sup>) are the most dominant in this community. Importance values indicate that *Juniperus procera* (IV = 69.76) *Acacia negrii* (IV = 55.93) *Acacia gerrardii* (IV = 54.4) *Lycium shawii* (IV = 28.34) and *Dodonaea viscosa* (IV = 24.73) are the important perennial species, whereas the other species recorded in south-western mountains are considered to be of less importance.

**Table 1.** Summary of Vegetation Data of Mountainous Plant Community: **NPS** = number of points with species, **TNI** = total number of individuals, **AS** = abundance of species in 100 m<sup>2</sup>, **AD** = absolute dominance (cm<sup>2</sup> / 100 m<sup>2</sup>), **AF** = absolute frequency (percent), **RDE** = relative density, **RDO** = relative dominance, **RF** = relative frequency, **IV** = importance value and **IVR** = importance value rank.

No. of Sampling points = 150  
No. of Species samples = 600

Absolute density (per 100 m<sup>2</sup>) = 3.01  
Relative Covering Value = 32

No	Species	NPS	TNI	AS	AD	AF	RDE	RDO	RF	IV	IVR
1	<i>Acacia gerrardii</i>	38	102	0.512	82.06	25.33	17.01	20.39	17.00	54.40	3
2	<i>Acacia negrii</i>	53	119	0.597	65.38	35.33	19.84	16.25	19.84	55.93	2
3	<i>Lycium shawii</i>	37	80	0.401	6.82	24.67	13.32	1.69	13.33	28.34	4
4	<i>Lycium barbarum</i>	6	13	0.065	0.60	4.00	2.16	0.15	2.17	4.48	9
5	<i>Solanum incanum</i>	5	7	0.035	0.37	3.33	1.16	0.09	1.17	2.42	10
6	<i>Solanum schimperianum</i>	2	4	0.020	0.19	1.33	0.66	0.05	0.67	1.38	12
7	<i>Withania somnifera</i>	1	2	0.010	0.13	0.67	0.33	0.03	0.33	0.69	18
8	<i>Dodonaea viscosa</i>	31	63	0.316	15.00	20.67	10.50	3.73	10.50	24.73	5
9	<i>Kleinia odora</i>	22	53	0.266	3.60	14.67	8.84	0.90	8.83	18.57	7
10	<i>Euryops arabicus</i>	35	59	0.296	5.50	23.33	9.83	1.37	9.83	21.03	6
11	<i>Psiadia arabica</i>	19	27	0.136	1.35	12.67	4.52	0.34	4.50	9.36	8
12	<i>Juniperus procera</i>	30	47	0.236	217.66	20.00	7.84	54.09	7.83	69.76	1
13	<i>Leptadenia pyrotechnica</i>	3	6	0.030	0.51	2.00	1.00	0.13	1.00	2.13	11
14	<i>Calotropis procera</i>	1	1	0.005	0.14	0.67	0.17	0.03	0.17	0.37	20
15	<i>Periploca aphylla</i>	1	2	0.010	0.26	0.67	0.33	0.06	0.33	0.72	17
16	<i>Sageretia thea</i>	3	4	0.020	0.17	2.00	0.66	0.04	0.67	1.37	13
17	<i>Rumex nervosus</i>	2	3	0.015	0.13	1.33	0.50	0.03	0.50	1.03	15
18	<i>Reseda sphenocleoidis</i>	1	3	0.015	0.10	0.67	0.50	0.02	0.50	1.02	16
19	<i>Lavandula dentata</i>	1	1	0.005	0.06	0.67	0.17	0.01	0.17	0.35	21
20	<i>Adenium obesum</i>	1	2	0.010	2.28	0.67	0.33	0.57	0.33	1.23	14
21	<i>Chytia richardiana</i>	2	2	0.010	0.11	1.33	0.33	0.03	0.33	0.69	19
Total			600	3.01	402.42	196.01	100	100	100		

Source: personal field work.

### 3- Semi-Desert Plant Community.

The semi-desert plant community is clearly evident in the north-east of the research area. This part of the research area is located between 1000-2000 m altitude, and links the south-western

highlands with the desert regions to the east. The soil in this part is relatively deep and alkaline, with little organic matter. Values of rainfall in the north-east of the research area are too low to support a perennial vegetation cover (Al-Qahtani, 1998). However, many perennial species have adapted to

this environmental situation and have appeared and are distributed in this region. As can be seen from Table 2, 22 perennial species belonging to 19 genera and 9 botanical families were recorded in the semi-desert plant community. *Phoenix dactylifera* recorded the greatest height (14 m), the biggest basal diameter (149 cm) and the greatest crown area (176.79 m<sup>2</sup>) in the semi-desert plant community. Due to the overgrazing that occurs in this zone, and the low level of rainfall, the plant cover value is very weak in this community. According to Domin's scale, the mean estimation of plant cover value was computed to be 3.59 (or 1-4%). The common species recorded in this community are either spiny or succulent plants which can endure and adapt to low moisture and high temperature. Absolute density and relative covering value of perennial species were calculated to be 2.46/100 m<sup>2</sup> and 13.21 respectively. Comparing the absolute density and relative covering value in this community with the

equivalent values in the mountainous plant community, it is found that the north-eastern part of the research area has less density and relative cover. Values of species abundance showed that *Acacia arabica* (1.283/100 m<sup>2</sup>), *Lycium shawii* (0.381/100 m<sup>2</sup>), *Acacia gerrardii* (0.205/100 m<sup>2</sup>), *Dodonaea viscosa* (0.135/100 m<sup>2</sup>) and *Kleinia odora* (0.107/100 m<sup>2</sup>) are very common species in north-western part of the research area. Absolute dominance values showed that *Juniperus procera* (167.87 cm<sup>2</sup>/100 m<sup>2</sup>), *Phoenix dactylifera* (69.77 cm<sup>2</sup>/100 m<sup>2</sup>), *Acacia arabica* (67.45 cm<sup>2</sup>/100 m<sup>2</sup>) and *Acacia gerrardii* (57.30 cm<sup>2</sup>/100 m<sup>2</sup>) are the most dominant in this community. Importance values have confirmed that *Acacia arabica* (IV = 121.68), *Juniperus procera* (IV = 51.18), *Lycium shawii* (IV = 33.58) and *Acacia gerrardii* (IV = 31.41) are the important perennial species, whereas the other species are of comparatively little importance.

**Table 2.** Summary of Vegetation Data of Semi-desert Plant Community: **NPS** = number of points with species, **TNI** = total number of individuals, **AS** = abundance of species in 100 m<sup>2</sup>, **AD** = absolute dominance (cm<sup>2</sup> / 100 m<sup>2</sup>), **AF** = absolute frequency (percent), **RDE** = relative density, **RDO** = relative dominance, **RF** = relative frequency, **IV** = importance value and **IVR** = importance value rank.

No. of Sampling points = 150 No. of Species samples = 600		Absolute density (per 100 m <sup>2</sup> ) = 2.46 Relative Covering Value = 13.21									
No	Species	NPS	TNI	AS	AD	AF	RDE	RDO	RF	IV	IVR
1	<i>Acacia arabica</i>	92	313	1.283	67.45	61.33	52.15	17.357	52.17	121.68	1
2	<i>Acacia gerrardii</i>	25	50	0.205	57.30	16.67	8.33	14.745	8.33	31.41	4
3	<i>Acacia negrii</i>	1	1	0.004	0.20	0.67	0.16	0.051	0.17	0.38	21
4	<i>Lagonychium farctum</i>	5	7	0.029	0.26	3.33	1.18	0.067	1.17	2.42	11
5	<i>Tephrosia apollinia</i>	1	1	0.004	0.02	0.67	0.16	0.005	0.17	0.34	22
6	<i>Lycium shawii</i>	47	93	0.381	11.13	31.33	15.49	2.864	15.50	33.85	3
7	<i>Lycium barbarum</i>	8	12	0.049	0.44	5.33	1.99	0.113	2.00	4.10	8
8	<i>Solanum incanum</i>	1	2	0.009	0.09	0.67	0.37	0.023	0.33	0.72	17
9	<i>Dodonaea viscosa</i>	17	33	0.135	3.19	11.33	5.49	0.820	5.50	11.81	6
10	<i>Kleinia odora</i>	14	26	0.107	1.98	9.33	4.35	0.509	4.33	9.19	7
11	<i>Euryops arabicus</i>	11	11	0.046	0.64	7.33	1.87	0.165	1.83	3.89	9
12	<i>Psiadia arabica</i>	4	8	0.033	0.28	2.67	1.34	0.072	1.33	2.74	10
13	<i>Juniperus procera</i>	15	24	0.098	167.87	10.00	3.98	43.20	4.00	51.18	2
14	<i>Leptadenia pyrotechnica</i>	2	2	0.008	0.16	1.33	0.33	0.041	0.33	0.70	18
15	<i>Calotropis procera</i>	2	3	0.012	0.37	1.33	0.49	0.095	0.50	1.09	15
16	<i>Sageretia thea</i>	3	2	0.009	0.10	2.00	0.37	0.026	0.33	0.73	16
17	<i>Rhamnus disperma</i>	2	4	0.016	2.72	1.33	0.65	0.700	0.67	2.02	12
18	<i>Phoenix dactylifera</i>	1	1	0.004	69.77	0.67	0.16	17.954	0.17	18.28	5
19	<i>Ziziphus spina-christi</i>	1	1	0.004	3.63	0.67	0.16	0.934	0.17	1.26	13
20	<i>Rumex nervosus</i>	1	1	0.004	0.40	0.67	0.16	0.102	0.17	0.43	20
21	<i>Lavandula dentata</i>	2	2	0.008	0.10	1.33	0.33	0.026	0.33	0.69	19
22	<i>Mentha lavandulacea</i>	2	3	0.012	0.51	1.33	0.49	0.131	0.50	1.12	14
Total			600	2.46	388.61	171.32	100	100	100		

Source: personal field work.

#### 4- Toe-Slope Habitat Type.

Toe-slope zones are comprised of stream sides which are one of the characteristic geomorphologic features of the research area. These streams are formed of a complex network of the research area and its tributaries. The soil of toe-slope zones is formed of materials derived from the surrounding mountains (El-demerdash & Zilay, 1994) and receives more water from surface flow and flood than elsewhere. The results of soil analysis show that these zones have deep soil, high moisture and fertility, compared with the other habitats in the research area.

As listed in Table 3, this habitat is occupied by 21 perennial species. These species are *Acacia arabica*, *Acacia gerrardii*, *Acacia negrii*, *Lycium shawii*, *Lycium barbarum*, *Solanum incanum*, *Solanum schimperianum*, *Withania somnifera*, *Dodonaea viscosa*, *Kleinia odora*, *Euryops arabicus*, *Psiadia arabica*, *Juniperus procera*, *Leptadenia pyrotechnica*, *Calotropis procera*, *Sageretia thea*, *Phoenix dactylifera*, *Ziziphus spina-christi*, *Rumex nervosus*, *Lavandula dentata* and *Mentha lavandulacea*. Mean height (2.33 m), basal diameter (15.43 cm) and crown area (16.40 m<sup>2</sup>) of the perennial species recorded in this habitat indicate that the plants of this habitat are characterised by large size, compared with the other habitats in the research area (Figures, 2 & 3). Abundance values of species indicate that the most common species in this habitat are *Acacia arabica*

(0.70/100 m<sup>2</sup>), *Acacia gerrardii* (0.58/100 m<sup>2</sup>), *Acacia negrii* (0.54/100 m<sup>2</sup>), *Lycium shawii* (0.44/100 m<sup>2</sup>) and *Juniperus procera* (0.27/100 m<sup>2</sup>). The relative covering value of perennial species in the toe-slope habitat (44.01) is consistent with the comment made above regarding the large size of the trees and shrubs of this habitat (see fig. 4). The absolute density of perennial plants in this habitat is 2.95/100 m<sup>2</sup>. This is considered high density, compared with the absolute density in the other habitats of the research area. Absolute dominance values show that *Acacia gerrardii* (190.55 cm<sup>2</sup>/100 m<sup>2</sup>), *Phoenix dactylifera* (174.44 cm<sup>2</sup>/100 m<sup>2</sup>), *Acacia arabica* (70.50 cm<sup>2</sup>/100 m<sup>2</sup>), *Juniperus procera* (61.15 cm<sup>2</sup>/100 m<sup>2</sup>) and *Acacia negrii* (56.62 cm<sup>2</sup>/100 m<sup>2</sup>) are the most dominant in this habitat. Importance values indicate that *Acacia gerrardii* (IV = 72.22), *Acacia arabica* (IV = 59.67), *Acacia negrii* (IV = 46.43), *Lycium shawii* (IV = 31.42) and *Phoenix dactylifera* (IV = 30.95) are the important perennial species. According to the importance value and the rank of importance value, *Lycium barbarum*, *Solanum incanum*, *Solanum schimperianum*, *Withania somnifera*, *Dodonaea viscosa*, *Kleinia odora*, *Euryops arabicus*, *Psiadia arabica*, *Juniperus procera*, *Leptadenia pyrotechnica*, *Calotropis procera*, *Sageretia thea*, *Ziziphus spina-christi*, *Rumex nervosus*, *Lavandula dentata* and *Mentha lavandulacea* are associated with this habitat, but are less important than those mentioned above.

**Table 3.** Summary of Vegetation Data of Toe-slope habitat type: **NPS** = number of points with species, **TNI** = total number of individuals, **AS** = abundance of species in 100 m<sup>2</sup>, **AD** = absolute dominance (cm<sup>2</sup> / 100 m<sup>2</sup>), **AF** = absolute frequency (percent), **RDE** = relative density, **RDO** = relative dominance, **RF** = relative frequency, **IV** = importance value and **IVR** = importance value rank.

No	Species	NPS	TNI	AS	AD	AF	Absolute density (per 100 m <sup>2</sup> ) = 2.95 Relative Covering Value = 44.01				
							RDE	RDO	RF	IV	IVR
1	<i>Acacia arabica</i>	17	57	0.70	70.50	28.33	23.72	12.20	23.75	59.67	2
2	<i>Acacia gerrardii</i>	20	47	0.58	190.55	33.33	19.66	32.98	19.58	72.22	1
3	<i>Acacia negrii</i>	16	44	0.54	56.62	26.67	18.30	9.80	18.33	46.43	3
4	<i>Lycium shawii</i>	19	36	0.44	8.71	31.67	14.91	1.51	15.00	31.42	4
5	<i>Lycium barbarum</i>	3	3	0.04	0.36	5.00	1.36	0.06	1.25	2.67	11
6	<i>Solanum incanum</i>	1	2	0.03	0.33	1.67	1.02	0.06	0.83	1.91	14
7	<i>Solanum schimperianum</i>	1	1	0.01	0.10	1.67	0.34	0.02	0.42	0.78	18
8	<i>Withania somnifera</i>	1	2	0.03	0.38	1.67	1.02	0.07	0.83	2.70	9
9	<i>Dodonaea viscosa</i>	3	5	0.06	0.79	5.00	2.03	0.14	2.08	4.25	8
10	<i>Kleinia odora</i>	2	2	0.03	0.61	3.33	1.02	0.11	0.83	1.96	13
11	<i>Euryops arabicus</i>	4	7	0.09	1.60	6.67	3.05	0.28	2.92	6.25	7
12	<i>Psiadia arabica</i>	3	3	0.04	0.43	5.00	1.36	0.07	1.25	2.68	10

13	<i>Juniperus procera</i>	10	22	0.27	61.15	16.67	9.15	10.58	9.16	28.89	6
14	<i>Leptadenia pyrotechnica</i>	1	1	0.01	0.28	1.67	0.34	0.05	0.42	0.81	17
15	<i>Calotropis procera</i>	1	1	0.01	0.71	1.67	0.34	0.12	0.42	0.88	16
16	<i>Sageretia thea</i>	1	1	0.01	0.13	1.67	0.34	0.02	0.42	0.78	19
17	<i>Phoenix dactylifera</i>	1	1	0.01	174.44	1.67	0.34	30.19	0.42	30.95	5
18	<i>Ziziphus spina-christi</i>	1	1	0.01	9.08	1.67	0.34	1.57	0.42	2.33	12
19	<i>Rumex nervosus</i>	1	1	0.01	0.10	1.67	0.34	0.02	0.42	0.78	20
20	<i>Lavandula dentata</i>	1	1	0.01	0.13	1.67	0.34	0.02	0.42	0.78	21
21	<i>Mentha lavandulacea</i>	1	2	0.02	0.77	1.67	0.68	0.13	0.83	1.64	15

Total 240 2.95 577.77 180.04 100 100 100

Source: personal field work

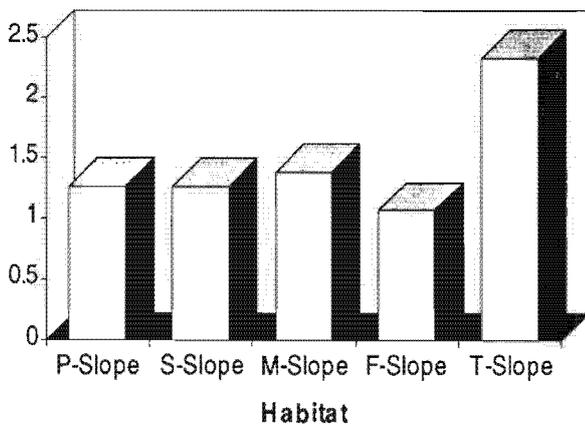


Figure 2: Mean of plant heights of the vegetation habitats in the research area

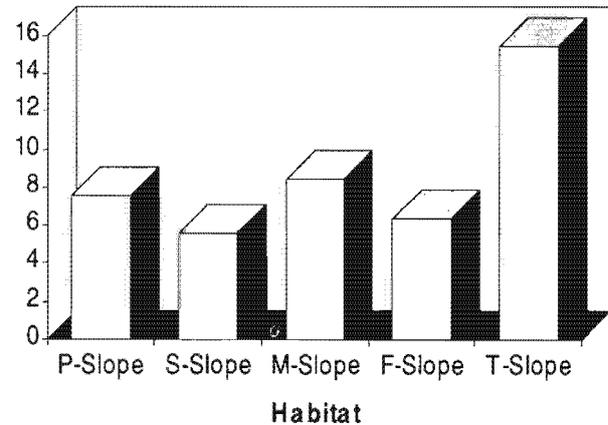


Figure 3: Mean of basal diameter in the vegetation habitats of the research area.

### 5- Foot-Slope Habitat Type.

The pediment or foot-slope is the greatest slope unit in the research area, in terms of its area and low slope angle (mean angle =  $7^{\circ} 43'$ ). These zones connect toe-slope habitat and mid-slope habitat where the slope angle exceeds  $13^{\circ}$ . Although the rainfall in these zones is somewhat scanty, they receive more water from surface flow than elsewhere. Soil properties are deep and moist compared with the other habitats, and the texture class is loamy sand. It is noted that these zones are affected by overgrazing, particularly in the north-east of the research area, due to its their accessibility to livestock (Al-Qahtani, 1998).

In terms of the vegetation, 16 perennial species were recorded in the foot-slope habitat and are listed in Table 4. These botanical species are *Acacia arabica*, *Acacia gerradii*, *Acacia negrii*, *Lagonychium farctum*, *Lycium shawii*, *Lycium barbarum*, *Solanum incanum*, *Solanum schimperianum*, *Dodonaea viscosa*, *Kleinia odora*, *Euryops arabicus*, *Psiadia arabica*, *Sageretia thea*, *Rhamnus disperma* and *Rumex nervosus*. As mentioned above, the impact of grazing, which has

resulted in deterioration of the foot-slope habitat, has affected the plant morphology of this habitat. The trees and shrubs are dispersed and stunted. The absolute density is 2.78/100 m<sup>2</sup> and the mean height is 1.07 m. The relative covering value of perennial species is also low (20.68). Abundance values of species show that the most common species in this habitat are *Acacia arabica*, *Acacia gerradii*, *Lycium shawii*, *Acacia negrii* and *Dodonaea viscosa*. They recorded 0.76/100 m<sup>2</sup>, 0.46/100 m<sup>2</sup>, 0.41/100 m<sup>2</sup>, 0.34/100 m<sup>2</sup> and 0.16/100 m<sup>2</sup> respectively. Absolute dominance values indicate that *Juniperus procera* (110.73 cm<sup>2</sup>/100 m<sup>2</sup>), *Acacia gerradii* (80.33 cm<sup>2</sup>/100 m<sup>2</sup>), *Acacia negrii* (46.12 cm<sup>2</sup>/100 m<sup>2</sup>) and *Acacia arabica* (39.90 cm<sup>2</sup>/100 m<sup>2</sup>) are the most dominant in this habitat. According to importance value, *Acacia arabica* (IV = 68.44), *Acacia gerradii* (IV = 60.61), *Juniperus procera* (IV = 45.50), *Acacia negrii* (IV = 40.05) and *Lycium shawii* (31.35) are the most important perennial species, whereas the other species listed in Table 4 (11 species) are considered common associate species in this habitat, but with less importance.

**Table 4.** Summary of Vegetation Data of Foot-Slope Habitat Type: **NPS** = number of points with species, **TNI** = total number of individuals, **AS** = abundance of species in 100 m<sup>2</sup>, **AD** = absolute dominance (cm<sup>2</sup> / 100 m<sup>2</sup>), **AF** = absolute frequency (percent), **RDE** = relative density, **RDO** = relative dominance, **RF** = relative frequency, **IV** = importance value and **IVR** = importance value rank.

No. of Sampling points = 60		Absolute density (per 100 m <sup>2</sup> ) = 2.78									
No. of Species samples = 240		Relative Covering Value = 20.68									
No	Species	NPS	TNI	AS	AD	AF	RDE	RDO	RF	IV	IVR
1	<i>Acacia arabica</i>	18	66	0.76	39.90	30.00	27.33	13.61	27.50	68.44	1
2	<i>Acacia gerrardii</i>	16	40	0.46	80.33	26.67	16.54	27.41	16.66	60.61	2
3	<i>Acacia negrii</i>	14	29	0.34	46.12	23.33	12.23	15.74	12.08	40.05	4
4	<i>Lagonychium farctum</i>	1	1	0.01	0.07	1.67	0.35	0.02	0.42	0.79	16
5	<i>Lycium shawii</i>	16	35	0.41	5.91	26.67	14.75	2.02	14.58	31.35	5
6	<i>Lycium barbarum</i>	1	1	0.01	0.07	1.67	0.36	0.02	0.42	0.80	15
7	<i>Solanum incanum</i>	2	1	0.01	0.13	3.33	0.36	0.04	0.42	0.82	13
8	<i>Solanum schimperianum</i>	1	1	0.01	0.09	1.67	0.36	0.03	0.42	0.81	14
9	<i>Dodonaea viscosa</i>	7	14	0.16	3.24	11.67	5.76	1.11	5.83	12.70	6
10	<i>Kleinia odora</i>	5	10	0.12	1.96	8.33	4.32	0.67	4.17	9.16	9
11	<i>Euryops arabicus</i>	11	13	0.15	2.21	18.33	5.40	0.75	5.42	11.57	7
12	<i>Psiadia arabica</i>	7	11	0.13	1.06	11.67	4.68	0.36	4.58	9.62	8
13	<i>Juniperus procera</i>	7	9	0.11	110.73	11.67	3.96	37.79	3.75	45.50	3
14	<i>Sageretia thea</i>	4	4	0.05	0.49	6.67	1.80	0.17	1.67	3.64	10
15	<i>Rhamnus disperma</i>	1	2	0.02	0.51	1.67	0.72	0.17	0.83	1.72	12
16	<i>Rumex nervosus</i>	2	3	0.03	0.26	3.33	1.08	0.09	1.25	2.42	11
Total			240	2.78	293.08	188.35	100	100	100		

Source: personal field work.

## 6- Mid-Slope Habitat Type.

The mid-slopes are very complex zones, in terms of topographical structure and botanical composition. The mean slope angle of these zones is 13° 46' and slope forms are mostly straight though in a few places they are concave. The soil is shallow and has moderate moisture (2.38%) while the texture class is loamy sand. As for vegetation of this habitat, 16 perennial species were recorded and listed in Table 5. The body size of plant species in this habitat appear to be small, with a mean height, basal diameter and crown area of 1.39 m, 8.60 cm and 5.07 m<sup>2</sup> respectively. *Juniperus procera* recorded the greatest height (6.80 m) and the biggest basal diameter (100 cm), whereas *Acacia negrii* recorded the greatest crown area (78.29 m<sup>2</sup>) in this habitat. The percentage of plant cover value in this habitat was estimated at each sampling point. According to Domin's scale, the mean estimation was computed to be 4.33. This value equals 11 to 25%. Abundance of species indicated that *Acacia arabica* (0.86/100 m<sup>2</sup>), *Lycium shawii* (0.41/100 m<sup>2</sup>), *Acacia gerrardii* (0.30/100 m<sup>2</sup>), *Dodonaea viscosa* (0.29/100 m<sup>2</sup>), *Kleinia odora* (0.25/100 m<sup>2</sup>), *Acacia negrii* (0.24/100 m<sup>2</sup>), *Euryops arabicus*

(0.19/100 m<sup>2</sup>) and *Juniperus procera* (0.18/100 m<sup>2</sup>) are very common and widespread species in this habitat. *Psiadia arabica*, *Leptadenia pyrotechnica*, *Lycium barbarum*, *Solanum incanum*, *Calotropis procera*, *Lagonychium farctum*, *Rhamnus disperma* and *Mentha lavandulacea* are considered common associate components. Computation of absolute density (2.99/100 m<sup>2</sup>) indicated that the distance between perennial species is low; nevertheless, viewing the plants of this habitat from high stands gives the impression that the absolute density is more than 2.99/100 m<sup>2</sup>. Relative covering value (18.33) confirmed what was mentioned above, that the body sizes of plant species in this habitat are small. Absolute dominance values show that *Juniperus procera* (332.04 cm<sup>2</sup>/100 m<sup>2</sup>), *Acacia arabica* (40.85 cm<sup>2</sup>/100 m<sup>2</sup>), *Acacia gerrardii* (37.95 cm<sup>2</sup>/100 m<sup>2</sup>), *Acacia negrii* (19.20 cm<sup>2</sup>/100 m<sup>2</sup>) and *Dodonaea viscosa* (12.51 cm<sup>2</sup>/100 m<sup>2</sup>) are the most dominant in this habitat. On the other hand, the importance values indicate that *Juniperus procera* (IV = 83.60), *Acacia arabica* (IV = 66.28), *Lycium shawii* (IV = 29.71), *Acacia gerrardii* (IV = 28.19) and *Dodonaea viscosa* (IV = 21.97) are the important perennial species in this habitat.

**Table 5.** Summary of Vegetation Data of Mid-Slope Habitat Type: **NPS** = number of points with species, **TNI** = total number of individuals, **AS** = abundance of species in 100 m<sup>2</sup>, **AD** = absolute dominance (cm<sup>2</sup> / 100 m<sup>2</sup>), **AF** = absolute frequency (percent), **RDE** = relative density, **RDO** = relative dominance, **RF** = relative frequency, **IV** = importance value and **IVR** = importance value rank.

		Absolute density (per 100 m <sup>2</sup> ) = 2.99 Relative Covering Value = 18.33									
No. of Sampling points = 60 No. of Species samples = 240											
No	Species	NPS	TNI	AS	AD	AF	RDE	RDO	RF	IV	IVR
1	<i>Acacia arabica</i>	20	69	0.86	40.85	33.33	28.76	8.77	28.75	66.28	2
2	<i>Acacia gerrardii</i>	10	24	0.30	37.95	16.67	10.04	8.15	10.00	28.19	4
3	<i>Acacia negrii</i>	10	19	0.24	19.20	16.67	8.03	4.12	7.92	20.07	6
4	<i>Lagonychium farctum</i>	1	1	0.01	0.07	1.67	0.33	0.02	0.42	0.77	16
5	<i>Lycium shawii</i>	15	33	0.41	10.45	25.00	13.71	2.25	13.75	29.71	3
6	<i>Lycium barbarum</i>	2	3	0.04	0.50	3.33	1.34	0.11	1.25	2.70	12
7	<i>Solanum incanum</i>	2	3	0.04	0.39	3.33	1.34	0.08	1.25	2.67	13
8	<i>Dodonaea viscosa</i>	13	23	0.29	12.51	21.67	9.70	2.69	9.58	21.97	5
9	<i>Kleinia odora</i>	9	20	0.25	3.69	15.00	8.36	0.79	8.33	17.48	7
10	<i>Euryops arabicus</i>	10	15	0.19	2.27	16.67	6.36	0.49	6.25	13.10	8
11	<i>Psiadia arabica</i>	4	6	0.07	0.62	6.67	2.34	0.13	2.50	4.97	9
12	<i>Juniperus procera</i>	10	15	0.18	332.04	16.67	6.02	71.33	6.25	83.60	1
13	<i>Leptadenia pyrotechnica</i>	2	4	0.05	0.69	3.33	1.67	0.15	1.66	3.48	10
14	<i>Calotropis procera</i>	2	3	0.04	0.66	3.33	1.34	0.14	1.25	2.73	11
15	<i>Rhamnus disperma</i>	1	1	0.01	3.14	1.67	0.33	0.67	0.42	1.42	14
16	<i>Mentha lavandulacea</i>	1	1	0.01	0.50	1.67	0.33	0.11	0.42	0.86	15
Total			240	2.99	465.53	186.68	100	100	100		

Source: personal field work.

## 7- Shoulder Slope Habitat Type.

Although many researchers in geomorphology and environmental science have not regarded the shoulder slope as an independent slope unit and distinct plant habitat, other researchers, such as Martz (1992), and Makhnach (1994) have distinguished this type of slope unit in their studies. The reconnaissance, surveys and data analysis of the present study indicated that this slope unit is a distinct plant habitat in the research area. Comparing this habitat with the other communities and habitats, it has the lowest absolute density (2.59/100 m<sup>2</sup>) and the lowest plant diversity (only 15 perennial species were recorded in the sampling points of this habitat). The soil of this habitat is alkaline and in general its texture is coarse, while its mean moisture is very low (2.33%). The sizes of plant species of this habitat seem to be small. The mean of height, basal diameter and crown area of perennial plants were found to be 1.27 m, 5.59 cm and 7.38 m<sup>2</sup> respectively. *Juniperus procera* recorded the biggest basal diameter (52 cm) and the greatest crown area (707.14 m<sup>2</sup>), whereas *Dodonaea viscosa* recorded the greatest height (7.30 m) in this habitat.

As mentioned above and listed in Table 6, 15 perennial species were recorded in the sampling points of this habitat. The relative covering value of these species was computed to be 20.28, and the

mean vegetation cover value of this habitat was estimated according to Domin's scale to be 4.03, which equals about 4 to 10%. Abundance of species (Table 6) indicated that *Acacia arabica* (0.71/100 m<sup>2</sup>), *Lycium shawii* (0.39/100 m<sup>2</sup>), *Dodonaea viscosa* (0.28/100 m<sup>2</sup>), *Acacia gerrardii* (0.24/100 m<sup>2</sup>), *Kleinia odora* (0.22/100 m<sup>2</sup>), and *Euryops arabicus* (0.18/100 m<sup>2</sup>) are very common species in the shoulder slope habitat. *Juniperus procera* (0.15/100 m<sup>2</sup>), *Acacia negrii* (0.11/100 m<sup>2</sup>), *Psiadia arabica* (0.11/100 m<sup>2</sup>), *Lycium barbarum* (0.10/100 m<sup>2</sup>), *Solanum incanum* (0.03/100 m<sup>2</sup>), *Leptadenia pyrotechnica* (0.03/100 m<sup>2</sup>), *Cluytia richardiana* (0.02/100 m<sup>2</sup>), *Tephrosia apollinia* (0.01/100 m<sup>2</sup>) and *Lavandula dentata* (0.01/100 m<sup>2</sup>) are considered common associate components in this habitat. Absolute dominance value indicated that *Juniperus procera* (74.81 cm<sup>2</sup>/100 m<sup>2</sup>), *Dodonaea viscosa* (19.12 cm<sup>2</sup>/100 m<sup>2</sup>), *Acacia gerrardii* (18.41 cm<sup>2</sup>/100 m<sup>2</sup>), *Acacia arabica* (15.56 cm<sup>2</sup>/100 m<sup>2</sup>), and *Acacia negrii* (13.85 cm<sup>2</sup>/100 m<sup>2</sup>) are the most dominate species in this habitat. According to computing of importance value, *Acacia arabica* (IV = 64.67), *Juniperus procera* (IV = 58.53), *Lycium shawii* (IV = 35.20), *Dodonaea viscosa* (IV = 33.63), and *Acacia gerrardii* (IV = 29.98) are the important perennial species in this habitat. The other species listed in Table 6 are considered important species, but to a much lesser degree.

**Table 6.** Summary of Vegetation Data of Shoulder Slope Habitat Type: **NPS** = number of points with species, **TNI** = total number of individuals, **AS** = abundance of species in 100 m<sup>2</sup>, **AD** = absolute dominance (cm<sup>2</sup> / 100 m<sup>2</sup>), **AF** = absolute frequency (percent), **RDE** = relative density, **RDO** = relative dominance, **RF** = relative frequency, **IV** = importance value and **IVR** = importance value rank.

No. of Sampling points = 60		Absolute density (per 100 m <sup>2</sup> ) = 2.59									
No. of Species samples = 240		Relative Covering Value = 20.28									
No	Species	NPS	TNI	AS	AD	AF	RDE	RDO	RF	IV	IVR
1	<i>Acacia arabica</i>	18	66	0.71	15.56	30.00	27.41	9.76	27.50	64.67	1
2	<i>Acacia gerrardii</i>	9	22	0.24	18.41	15.00	9.26	11.55	9.17	29.98	5
3	<i>Acacia negrii</i>	5	10	0.11	13.85	8.33	4.25	8.69	4.17	17.11	7
4	<i>Tephrosia apollinia</i>	1	1	0.01	0.05	1.67	0.39	0.03	0.42	0.84	15
5	<i>Lycium shawii</i>	17	36	0.39	8.20	28.33	15.06	5.14	15.00	35.20	3
6	<i>Lycium barbarum</i>	4	9	0.10	0.83	6.67	3.86	0.52	3.75	8.13	10
7	<i>Solanum incanum</i>	1	3	0.03	0.32	1.67	1.16	0.20	1.25	2.61	12
8	<i>Dodonaea viscosa</i>	13	26	0.28	19.12	21.67	10.81	11.99	10.83	33.63	4
9	<i>Kleinia odora</i>	9	20	0.22	3.49	15.00	8.49	2.19	8.33	19.01	6
10	<i>Euryops arabicus</i>	8	17	0.18	2.51	13.33	6.95	1.57	7.08	15.60	8
11	<i>Psiadia arabica</i>	6	10	0.11	1.34	10.00	4.25	0.84	4.17	9.26	9
12	<i>Juniperus procera</i>	10	14	0.15	74.81	16.67	5.79	46.91	5.83	58.53	2
13	<i>Leptadenia pyrotechnica</i>	2	3	0.03	0.61	3.33	1.16	0.38	1.25	2.79	11
14	<i>Lavandula dentata</i>	1	1	0.01	0.13	1.67	0.39	0.08	0.42	0.89	14
15	<i>Chuytia richardiana</i>	2	2	0.02	0.23	3.33	0.77	0.15	0.83	1.75	13
Total		240	2.59	159.46	176.67	100	100	100			

Source: personal field work.

### 8- Summit Slope Habitat Type.

In general, this habitat's soil is partly shallow (mean depth = 20.88 cm), alkaline (mean pH = 8.31) and moist (mean moisture = 2.53%) while its texture is coarse (loamy sand) (Al-Qahtani, 1998). The botanical formation of the mountain top habitat differs markedly from the other plant habitats in the area under study. Although the mean ground plant cover of this habitat is weak (4.03 according to Domin's scale), the absolute density of perennial species is very high (6.22/100 m<sup>2</sup>) compared with other habitats in the research area (Fig. 5). The distance between trees and shrubs is small. The greater plant density can be attributed to augmentation of rainfall amount in this habitat, particularly in the south-western mountains, and to its remoteness from human activities, especially from the grazing in the north-east of the research area. The vegetation of this habitat gives the appearance of hats covering the mountain peaks, especially in the south-western mountains.

According to the mean of trees and shrubs height (1.27 m), basal diameter (7.59 cm), crown area (3.76 m<sup>2</sup>) and the relative covering value (38.38), it is possible to say that the sizes of this habitat's species are moderate. *Acacia arabica* recorded the greatest height (6.56 m) and *Juniperus procera* recorded the

biggest basal diameter (62 cm) whereas *Acacia gerrardii* recorded the greatest crown area (68.98 m<sup>2</sup>) in this habitat. As listed in Table 7, 18 perennial species belonging to 10 botanical families and 15 genera were recorded at the tops of slopes. Quantitative analysis (Table 7) of the number of points with species, total number of individual, abundance of species, absolute dominance, absolute frequency, relative density, relative dominance, relative frequency and importance value gave the following results:

According to abundance of species, *Acacia arabica* (1.42/100 m<sup>2</sup>), *Lycium shawii* (0.85/100 m<sup>2</sup>), *Dodonaea viscosa* (0.73/100 m<sup>2</sup>), *Kleinia odora* (0.70/100 m<sup>2</sup>), *Acacia gerrardii* (0.49/100 m<sup>2</sup>), *Euryops arabicus* (0.47/100 m<sup>2</sup>) and *Acacia negrii* (0.46/100 m<sup>2</sup>) are very common species in summit slope habitats, whereas *Juniperus procera* (0.29/100 m<sup>2</sup>), *Lycium barbarum* (0.23/100 m<sup>2</sup>), *Lagonychium farctum* (0.13/100 m<sup>2</sup>), *Psiadia arabica* (0.13/100 m<sup>2</sup>), *Reseda sphenocleoidis* (0.08/100 m<sup>2</sup>), *Solanum schimperianum* (0.05/100 m<sup>2</sup>), *Periploca aphylla* (0.05/100 m<sup>2</sup>), *Adenium obesum* (0.05/100 m<sup>2</sup>), *Sageretia thea* (0.03/100 m<sup>2</sup>), *Rhamnus disperma* (0.03/100 m<sup>2</sup>) and *Lavandula dentata* (0.03/100 m<sup>2</sup>) are considered common associate components. Absolute dominance values show that *Juniperus procera* (209.42 cm<sup>2</sup>/100 m<sup>2</sup>), *Acacia gerrardii*

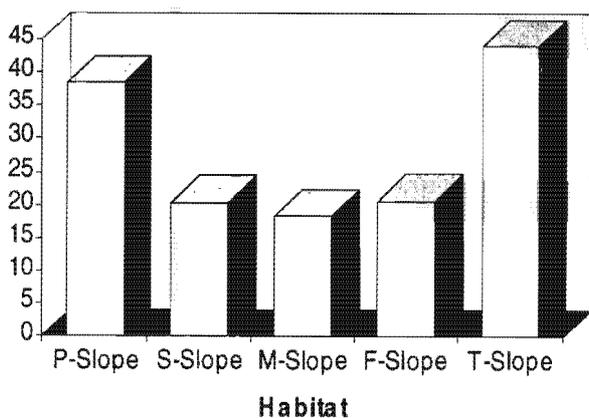
(73.25 cm<sup>2</sup>/100 m<sup>2</sup>), *Acacia arabica* (65.69 cm<sup>2</sup>/100 m<sup>2</sup>), *Acacia negrii* (44.88 cm<sup>2</sup>/100 m<sup>2</sup>) and *Lycium shawii* (32.47 cm<sup>2</sup>/100 m<sup>2</sup>) are the most dominant species in this habitat. Importance values confirmed the importance of *Acacia arabica* (IV = 59.27), *Juniperus procera* (IV = 52.36), *Lycium shawii* (IV

= 34.10), *Acacia gerradii* (IV = 30.88), *Dodonaea viscosa* (IV = 26.92), *Kleinia odora* (IV = 24.57) and *Acacia negrii* (IV = 24.14) in the mountain tops of the area under study. The other perennial species listed in Table 7 are also considered important species in the research area, but to a lesser degree.

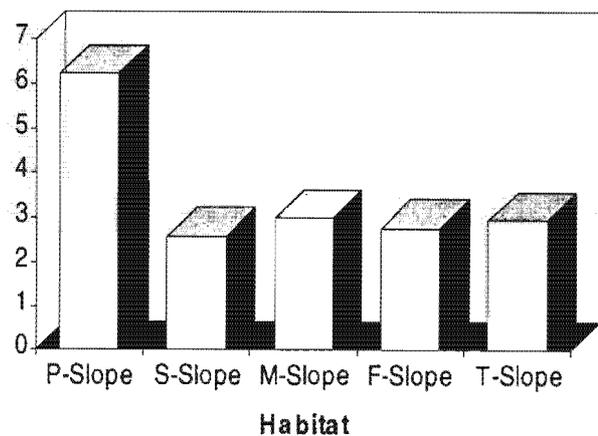
**Table 7.** Summary of Vegetation Data of Summit Slope Habitat Type: **NPS** = number of points with species, **TNI** = total number of individuals, **AS** = abundance of species in 100 m<sup>2</sup>, **AD** = absolute dominance (cm<sup>2</sup> / 100 m<sup>2</sup>), **AF** = absolute frequency (percent), **RDE** = relative density, **RDO** = relative dominance, **RF** = relative frequency, **IV** = importance value and **IVR** = importance value rank.

No. of Sampling points = 60		Absolute density (per 100 m <sup>2</sup> ) = 6.22									
No. of Species samples = 240		Relative Covering Value = 38.38									
No	Species	NPS	TNI	AS	AD	AF	RDE	RDO	RF	IV	IVR
1	<i>Acacia arabica</i>	19	55	1.42	65.69	31.67	22.83	13.52	22.92	59.27	1
2	<i>Acacia gerradii</i>	8	19	0.49	73.25	13.33	7.88	15.08	7.92	30.88	4
3	<i>Acacia negrii</i>	9	18	0.46	44.88	15.00	7.40	9.24	7.50	24.14	7
4	<i>Lagonychium farctum</i>	3	5	0.13	1.33	5.00	2.09	0.27	2.08	4.44	10
5	<i>Lycium shawii</i>	17	33	0.85	32.47	28.33	13.67	6.68	13.75	34.10	3
6	<i>Lycium barbarum</i>	4	9	0.23	2.05	6.67	3.70	0.42	3.75	7.87	9
7	<i>Solanum schimperianum</i>	1	2	0.05	0.47	1.67	0.80	0.10	0.83	1.73	16
8	<i>Dodonaea viscosa</i>	12	28	0.73	17.07	20.00	11.74	3.51	11.67	26.92	5
9	<i>Kleinia odora</i>	11	27	0.70	10.04	18.33	11.25	2.07	11.25	24.57	6
10	<i>Euryops arabicus</i>	12	18	0.47	4.87	20.00	7.56	1.00	7.50	16.06	8
11	<i>Psiadia arabica</i>	3	5	0.13	0.99	5.00	2.09	0.21	2.08	4.38	11
12	<i>Juniperus procera</i>	8	11	0.29	209.42	13.33	4.66	43.12	4.58	52.36	2
13	<i>Periploca aphylla</i>	1	2	0.05	1.30	1.67	0.80	0.27	0.83	1.90	15
14	<i>Sageretia thea</i>	1	1	0.03	0.21	1.67	0.48	0.04	0.42	0.94	18
15	<i>Rhamnus disperma</i>	1	1	0.03	9.43	1.67	0.48	1.94	0.42	2.94	13
16	<i>Reseda sphenocleoidis</i>	1	3	0.08	0.50	1.67	1.29	0.10	1.25	2.64	14
17	<i>Lavandula dentata</i>	1	1	0.03	0.38	1.67	0.48	0.08	0.42	0.98	17
18	<i>Adenium obesum</i>	1	2	0.05	11.39	1.67	0.80	2.35	0.83	3.98	12
Total			240	6.22	485.74	188.35	100	100	100		

Source: personal field work.



**Figure 4.** Relative covering value of perennial vegetation in the research area.



**Figure 5.** Absolute density of perennial vegetation in the botanical habitats in the research area

## Conclusions.

From the foregoing, it emerges that the vegetation of the area under study is associated clearly with numerous environmental parameters, such as topography, altitude, soil condition and moisture amount (Alwelaie *et al.* 1993), as well as other climatic and human factors. These circumstances and factors influence the distribution, establishment, growth and regeneration of the plants (Batanouny, 1987) and have produced different plant shapes inside the research area (Bloom, 1996; El-Demerdash *et al.* 1994). The following paragraphs summarize the main findings of this research

The composition and distribution of vegetation reflect the conditions of the environmental factors in the research area. The soil, topography and climate of the south-western part (or mountainous plant community) differ widely from those of the semi-desert plant community located in the north-eastern part. This is due to the high altitude (2000-3130 m a.s.l) of the former area with its consequences for air temperature, and to relatively high rainfall without a prolonged dry period, as in the semi-desert plant community. The vegetation density in the south-western part (3.01/100 m<sup>2</sup>) is higher than that in the north-eastern part (2.46/100 m<sup>2</sup>). Also, the vegetation density in the upper slope segments, namely summits and shoulders of slopes (4.41/100 m<sup>2</sup>) is higher than that in the lower slope segments, namely toes and feet of slopes (2.87/100 m<sup>2</sup>).

As mentioned earlier, due to the greater precipitation amount on the habitat of peak-slopes the absolute density of this habitat (6.22/100 m<sup>2</sup>) is more than double the absolute density in any other habitat, while the shoulder slope habitat recorded the lowest absolute density (2.59/100 m<sup>2</sup>). The toe-slope habitat, foot-slope habitat, and mid-slope habitat also had a relatively low density (2.95/100 m<sup>2</sup>, 2.78/100 m<sup>2</sup> and 2.99/100 m<sup>2</sup> respectively). As can be seen from Fig. 4, the relative covering values in the toe-slope habitat (44.01) and peak-slope habitat (38.38) are high, compared with other habitats. The augmentation of relative covering value in these two habitats is imputed mostly to individual sizes in toe-slope habitat and the greater plant density in the peak-slope habitat.

The height of plants is one of the important botanical components that comprise the life-form of individuals. As said before and as can be noted from Fig. 2, the individuals of the toe-slope habitat are characterised by large breadth and height. The mean of perennial plant heights in this habitat is 2.33 m, whereas it ranges between 1.07 to 1.39 m in the

other habitats. One of the main reasons why plants in the toe-slope habitat flourish, is the soil conditions; the soil is deeper and more moist than in the other habitats. These conditions enable the individuals to extend their roots faraway to stabilize themselves and to obtain water. In addition, the lower elevation and low wind speed in this habitat has allowed the plants to grow more and achieve greater height (Abulfatih, 1981 & Al-Qahtani, 1998).

Mean basal diameter again confirmed the distinctiveness of toe slope habitat plants. It is considered very high in this habitat (15.43 cm) compared with the mean basal diameter in the other habitats. Probably, the augmentation of mean basal diameter in the toe-slope habitat is related to the concentration in this habitat of *Acacia spp*, which have big stems, as well as to availability of other environmental factors, such as moisture, soil depth and conservation. As can be seen from Fig. 3, the means of plant basal diameters in the other habitats are moderate to small.

From the findings of this research, and the review of available literature on the research area and on Saudi Arabia as a whole, the following recommendations for the conservation and protection of natural vegetation are summarised and offered below:-

- 1- The successful method of conservation (the *hema* system) that was adopted over a very long period of time by the tribes in the Al-Hejaz and Assir regions to protect the trees, shrubs and pastures should be reapplied, with some modifications to be appropriate to the present time (e.g. cancellation of tribal quality).
- 2- Cutting green trees and shrubs should be prevented completely by enforcement of laws prohibiting it. Alternative sources of fuel (e.g. Gas) should be provided by the Government in the markets. If no alternatives are available, the inhabitants of Assir mountains will be forced to obtain fuel from *Acacia arabica*, *Acacia gerrardii*, *Acacia negrii* and *Juniperus procera*.
- 3- Road-building should avoid the areas dense in vegetation. Roads could, however, be established across the valley course sides which are usually bare of vegetation cover.
- 4- Reforestation and planting of trees and shrubs that are well adapted to the environmental conditions of Assir mountains, such as *Tamarix aphylla*, *Olea europaea* and *Acacia negrii* should be encouraged.

## References:

- Abulfatih, H.**, (1981a). Plant Ecology of Dalaghan National Park, Asir Province, Saudi Arabia. *Proceedings of Saudi Biology Society*. **5**: 131-141.
- Abulfatih, H.**, (1981b). Wild Plants of Abha and its Surroundings. *Proceedings of Saudi Biology Society*. **5**: 143-159.
- Abulfatih, H.**, (1984). Elevationally Restricted Flora Elements of the Asir Mountains, Saudi Arabia. *J. of Arid Environment*. **7**: 35-41.
- Abulfatih, H.**, (1984). Wild Plants from Abha and its Surrounding Regions. Saudi House for Publication and Distribution. Saudi Arabia, Jeddah. 125 pp.
- Abulfatih, H.**, (1987). Medical Plants from South-west of Saudi Arabia, (in Arabic and English). Al Thagher press. Khamis Mushayt. 153 pp.
- Al-Aodat, M; Abdullah, A; and Al Sheikh, A.**, (1985). Plant Geography. King Saud University Publication. Al Riyadh. 326 pp.
- Al-Qahtani, M.**, (1991). Effect of Soil Characteristics on Morphology of Wood-plant in Wadi Wad., Saudi Arabia. MA thesis. Department of Geography, King Saud University. 155 pp.
- Al-Qahtani, M.**, (1998). An Assessment of the Relationships Between the Surface Soil Properties and Components of Slope and Vegetation in the Upper Wadi Bishah Basin, Saudi Arabia. PhD thesis (unpublished). Faculty of Science and Environment, Hull University. 35 pp.
- Al-Shareef, A.**, (1994). Geography of Saudi Arabia. (Vol. 1) (in Arabic) Dar Al Marrikh. Al Riyadh, Saudi Arabia: 383 pp.
- Al-Welaie, A; Choudary, S; and Al Wetaid, Y.**, (1993). Vegetation of Some Red Sea Islands of the Kingdom of Saudi Arabia. *J. of Arid Environments*. **24** (3): 287-296.
- Batanouny, K.**, (1987). Current Knowledge of Plant Ecology in the Arabian Gulf Countries. *Catena*, **14**: 291-315.
- Blatter, E.**, (1907). The Flora of Aden. *J. of Bombay-Natural History Society*. **17**: 895-920.
- Bloot, J.**, (1996). Plants of Juniperus species in monkey stomachs. *Okad Newspaper*. Jeddah, No 10946.
- Brooks, W; & Mandil, K.**, (1983). Vegetation Dynamics in the Asir Woodlands of South-western Saudi Arabia. *Journal of Arid Environments*, **6** (4): 357-362.
- Derose, R; Trustrum, N; and Blaschke, P.**, (1993). Post-Deforestation soil loss from steepland hillslopes in Taranaki, New Zealand. *Earth Surface Processes and Landforms*, **18**: 131-144.
- Eig, A.**, (1931-1932). Les elements et les groups phytogeographiques auxiliaires dans la flora palestinienne, 2 pts. Feddes Report., Beih., **63**: 1-201; 120 Tafel.
- Eig, A.**, (1933). A historical-phytosociological essay on Palestinian forests of *Quercus aegilops* L. ssp. *itbaburensis* (Desc.) in past and present. Beih. Bot.cbl. Abt. B., **51**: 225-272.
- El-Demerdash, M; Hejazy, A; and Zilay, A.**, (1994). Distribution of the Plant Communities in Tihamah Coastal Plains of Jizan Region, Saudi Arabia. *J. of Vegetation.*, **112** (2): 141-151.
- El-Demerdash, M; & Zilay, A.**, (1994). An introduction to the Plant Ecology of Tihamah Plain of Jizan Region, Saudi Arabia. *Arab Gulf J. of Scientific Research.*, **12** (2): 285-299.
- Kent, M & Coker, P.**, (1992) *Vegetation Description and Analysis: A Practical Approach*, Belhaven Press, London. 363 pp.
- Konig, P.**, (1988). Phytogeography of South-western Saudi Arabia. *Die Erde.*, **119**: 75-89.
- Makhnash, N.**, (1994). Distribution of Minerals of the Fine-sand fraction in slope soil of Byelarus. *Eurasia Soil Science.*, **26** (8): 57-66.
- Martz, L.**, (1992). The variation of soil erodibility with slope position in a cultivated Canadian Prairie landscape. *Earth Surface Processes and Landforms.*, **17**: 543-556.
- Migahid, A.**, (1980a). Natural vegetation of Saudi Arabia, (in Arabic). *Al Majallah Al Arabiyah (Arabic Journal)*, **5**: 32-43.
- Migahid, A.**, (1980b). Natural vegetation of Saudi Arabia, (in Arabic). *Al Majallah Al Arabiyah (Arabic Journal)*, **6**: 40-47.
- Migahid, A.**, (1988). *Flora of Saudi Arabia*. 3rd ed. (2 vols.) King Saud University Publication. Al Riyadh. Saudi Arabia.
- Mueller-Dombois, D & Ellenberg, H.**, (1974). *Aims and Methods of Vegetation Ecology*. John Wiley and Sons, New York. 547 pp.
- Schmidt, D; Hadley, D; Greenwood, W; Gonzales, L; Coleman, R; and Brown, G.**, (1973). Stratigraphy and tectonism of the southern part of the Precambrian shield of Saudi Arabia. *Dir. Gen. Mineral Resources, Min. Bull.* **8**, 13, Jeddah.
- Simanton, J; Renard, K; Christiansen, C; and Lane, L.**, (1994). Spatial distribution of surface rock fragments along catenas in semi-arid Arizona and Nevada, USA. *Catena*, **23**: 29-42.
- Soil Survey Staff.**, (1992). *Keys to Soil Taxonomy*. Soil Management Support Services Technical Monograph No. **19** (5th ed). Pocahontas Press, Blacksburg, Virginia. 541 pp.
- Takhtajan, A.**, (1986). *Floristic Regions of the world* (Translated by Theodore, J. Crovello). University of California Press, Berkeley, Los Angeles. 208 pp.
- Tarzi, J.**, (1984). *Procedures for Collecting Soil Samples for Different Purposes Under the Condition of the Kingdom of Saudi Arabia*, (in English and Arabic). Ministry of Agriculture and Water, Directorate of Agricultural Research, Al Riyadh, Saudi Arabia. 50 pp.
- Zohary, M.**, (1973). *Geobotanical foundations of the Middle East*, 2 vols. Stuttgart: Gustav Fischer Verlag. 244 pp.

(Received 23/02/2000 In revised form 19/12/2000)