The Vegetation of the State of Qatar as Related to Landform and Soil

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Key Words: Diversity, Landform, Relative importance, Similarity, Qatar, Vegetation.

ABSTRACT

The effect of landform and soil on the vegetation of the State of Qatar is described. Five major landform/soil subdivisions are recognized; depressions, wadis, rocky and conglomerate hammada surfaces, sand dunes and sabkhas. The vegetation was sampled and relative importance, diversity values and similarity indices were estimated. Soils samples were analysed. Depressions have the richest and most diversified plant cover. On the other hand sand dunes have very poor vegetation cover. Sabkhas have simple and less diversified flora. The five landform/soil subdivisions show great differences in diversity and degrees of similarity. Differences in soil physical and chemical properties enhanced by landform variations are probably the major factor involved.

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INTRODUCTION

Since Shreve (1942) called attention to the greater diversity of vegetation on the bajadas of North American deserts than in the valley floors, and the greater site-to-site variations on the bajadas, considerable effort has been directed into studying the effect of landform and soil properties on plant life. Shreve (1951) statement on the role of soil on desert vegetation has been extensively quoted (ref. Kassas and Girgis, 1965; Thalen, 1979; Babikir, 1986). Shreve postulates:

> *" The physical texture of the soil, its depth and the nature of its surface are equally important... The profound influence of the soil upon desert vegetation is to be attributed to its strong control of the amount, availability and continuity of water supply. This fundamental requisite of plant is the most effective single factor in the differentiation of desert communities."*

Several scholars of the Near Eastern and particularly Arabian plant life maintain that landform and soil properties are important in affecting plant life (Vesey - Fitzgerald, 1957; Zohary, 1962, 1973; Kassas and Girgis, 1965; Ayyad, 1973; Halwgay and Halwgay, 1974, 1977; Batanouny, 1973, 1981a; Abul-Faith, 1975; Halwagy *et al.,* 1982; Frey *et al.,* 1985). Poore and Robertson (quoted in Thalen 1979) formulated the effect of landform and soil on vetegation for the desert rangelands of Jordan as follows:

> *"The accumulation of run-off may mean that some parts have effectively many times the mean annual rainfall, other parts have much less. Because a layer of coarse material prevents evaporation from the surface of the soil, gravels usually afford a more favourable environment than sand, sand than silt, and silt than clay. Salinity may also be a problem on heavy soils. The water balance of the vegetation varies therefore with topography and soil texture."*

In their study of the vegetation of the coastal salt marshes of Kuwait, Halwagy and Halwagy (1977) further stressed the importance of topography on plant distribution:

> *"It appears that ground level plays some role in determining plant distribution..... The importance of ground level in connection with plant distribution may be further inferred from the predominance of a certain species within a community or zone of another as a result of variations in microtopography".*

A few attempts were made to correlate landforms to the vegetation of Qatar. Obeid (1975) indicated that the vegetation of the Qatar peninsula closely reflects its geography, geology, topography, soils and climate. Batanouny (1981a, 1981b) stated that despite the modesty of Qatar's relief, it seems to play a major role in affecting plant life and hence plant composition and distribution. In three short accounts the author (Babikir 1984a, 1984b, 1986) studied the vegetation of natural depressions, playas and sand dunes. The present work attempts to apply appropriate quantitative techniques to shed more light on the relationship between landform/soil and plant distribution.

Study Area

The State of Qatar lies in the middle of the western coast of the Arabian Gulf between 24° 27′-26° 10′ N and 50° 45′-51° 40 ′ E with an area of about 11,600 Km^2. The Qatar peninsula is composed of Lower Eocene Limestone and gypsum rocks (Cavelier 1970, De Cardi, 1978). The surface of the Qatar peninsula is of low to moderate relief, with the highest elevation of 103 m above sea level being attained in Southern Qatar where mesa type hills and large barchan sand dunes are found (Johnstone and Wilkinson, 1960; FAO, 1981; Eccleston 1982). The Qatar peninsula landscape is dotted by some 2000 depressions of young colluvial deposits of limestone origin which resulted primarily from structural collapse at depth (Halcrow-Balfour, 1981). In general, however, the peneplaned and eroded nature of the peninsula coupled with a prolonged arid climate provides very few positive topographical features except in the south.

Several attempts were made to divide the country into topographic regions, the most common of which is the north and south one (Cavelier, 1970; Obeid, 1975; FAO, 1981; Eccleston, 1982). In an earlier attempt Johnstone and Wilkinson (1960) divided the Qatar peninsula into three topographic regions : the limestone plateau, the sandy south and the coasts. Diab (1980) divided the peninsula into five topographic regions namely; the coasts, inerior lowlands, rocky outcrops, the western higher areas and the sandy south. Most recently El Shlalda (1986) also divided the country into five similar regions.

For the purpose of the present study, five landform/soil sub-divisions are recognized. These are : the rocky hammadas, wadis, depressions, sabkhas and sand dunes (Fig. 1). These subdivisions differ with regard to their elevation, microclimate, water supply and soil physical and chemical characteristics.

Much of the central part of the peninsula is formed of a plateau which is composed of limestone and dolomites overlain by up to a few centimetres of broken material. The soils of the plateau are shallow lithosols (88.8% of the

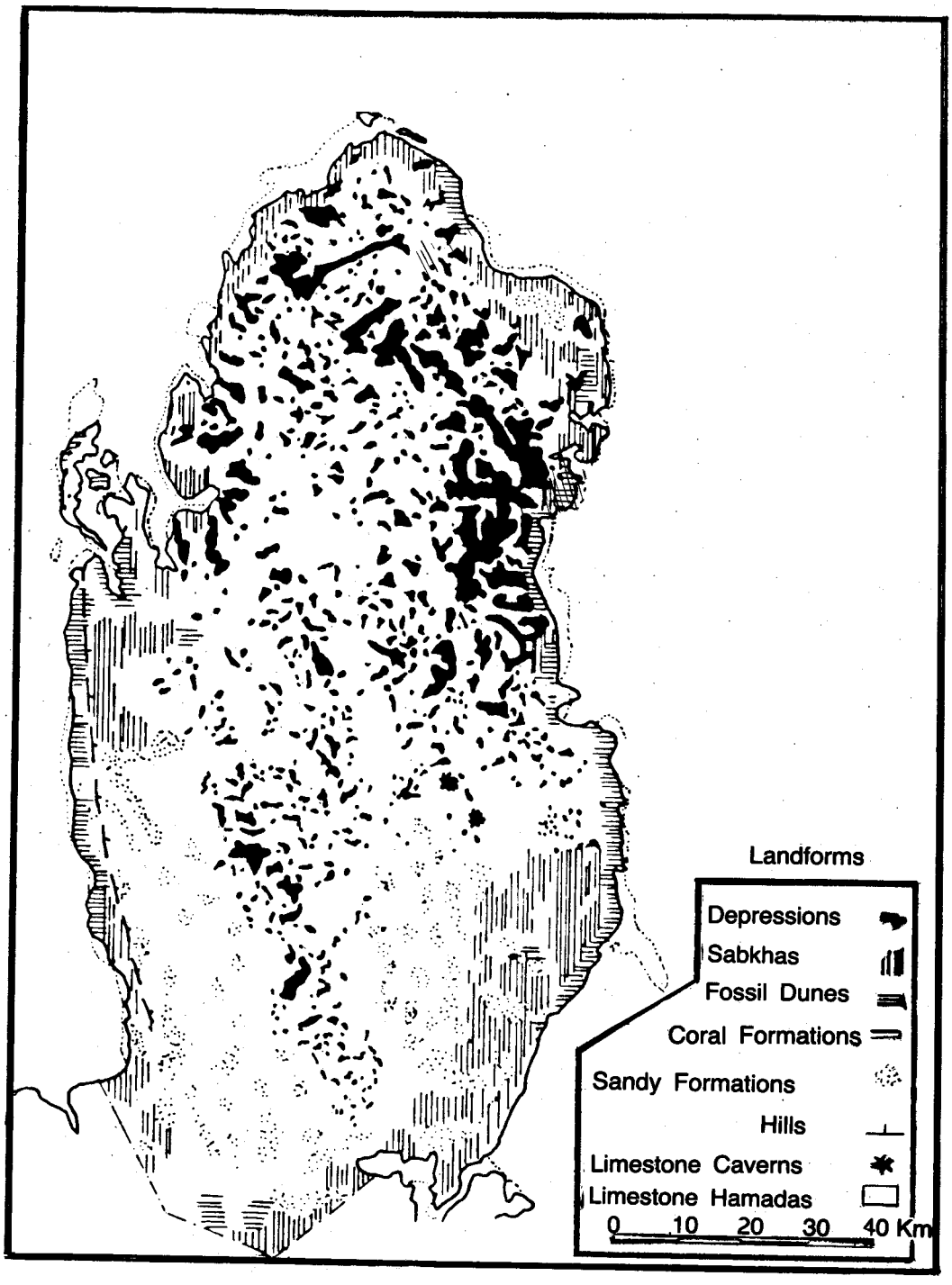

Fig. 1 Landforms of Qatar

country's soils) with rock fragments scattered on the surface, or rocky hills of limestone and sandstone outcrops (Halcrow-Balfour, 1981; FAO, 1981). These are termed here rocky hammadas. Wadis in Qatar represent the relatively deep and long runnels. They occur mainly in south-west Qatar because of the relatively hilly country. In these wadis fine sediments are found which crack after drying or have rolled solid crusts when they are thin (Batanouny, 1981a). Depressions, which are the surface expression of subsurface collapse structure, are infilled with colluvium. In the northern depressions deposits are deep and fine textured, while the southern depressions have shallow, coarser aeolian sand deposits. In general, the depressions soil (2.4% of the soils of Qatar) includes calcareous loam, clay loam, sandy clay loam. Sabkhas, which are the inland or coastal saline flats or playas are widespread in Qatar and they consist of fine silt and calcareous sands with high salt content and a high watertable. Sabkha soils are highly saline and their texture is between calcareous clay loam, sandy clay loam and sandy loam. Extensive dune fields cover a considerable area of south-eastern Qatar. These aeolian sandy soils are characterized by deep profile with clacareous coarse sand to loamy coarse sand and an admixture of desert and marine sand. More details on the nature and composition of the different soil associations are found in the reconnaissance soil survey (UNDP/FAO, 1973), in the FAO technical report No. 2 (FAO, 1974) and in the final FAO report on the water resource of Qatar and their development (FAO, 1981).

Climate and Vegetation

The climate of Qatar is charaterized by high temperatures, hot dry summer winds, high relative humidity for greater part of the year and scanty rainfall (c. 77 mm/year in Doha) which is also irregular and variable in both time and space. As a result, the vegetation is open and is composed of permanent framework of perennials and ephemerals that appear after rains (Obeid, 1975; Batanouny, 1981a). Obeid (1975) recognized six types of plant communities on the basis of soil and water conditions. These community types are: coastal sabkha, coastal sand, rodha depression, sand dune, *Acacia tortilis* and *Ziziphus nummularia.* Batanouny (1981a) using floristic composition and habitat factors recognized eleven glycophytic and nine halophytic plant communities. On the basis of landforms only, however, Batanouny (1981b) recognized six eco-geomorphological systems. These are: rocky hammads, rocky ranges and ridges, depressions, wadis, sand formations and sabkhas.

Methods

Vegetation parameters are analysed using different ecological indices to relate vegetation changes to variations in landforms and soils. The hypothesis to be re-examined here is that; the vegetation of Qatar closely reflects its

landforms and soils. This hypothesis was deduced from the observations of Obeid (1975), Batanouny (1981a, 1981b) and Babikir (1984a, 1984b- 1986).

Plant communities in the five major landform/soil subdivisions were analysed by means of 380 lm^2 quadrats: 120 on the rocky hammadas, 50 on the wadis, 100 on depressions, 60 on sabkhas and 50 on sand dunes. The vegetation parameters included: listing of all species (determinations follow Batanouny, 1981a Arab Organization for Agricultural Development, 1983); the Curtis and McIntosh (1950) importance index as modified by Abul-Fatih (1975) was calculated for each species; diversity within each of the five subdivisions was estimated by means of both the Shannon-Wiener function (Margalef, 1956) and Simpson's index of diversity (cf. Krebs, 1985:523). Krebs (1985) states that the combination of the two measures summarizes most of the biological information on diversity. Finally the degree of species similarly between the five subdivisions was estimated with Krebs index of similarity (Krebs, 1985).

Some soil analysis were also carried out. One soil sample was collected from the top 5-30 cm layer from 10 locations in each of the five landform/soil subdivisions. The soils were analysed for physical and chemical properties at the State of Qatar, Ministry of Industry and Agriculture Soil Laboratory.

Results

Table 1 summarizes the results of the vegetation analysis of the five landform/soil subdivisions.

The rocky hammadas:

Zygophyllum quatarense is the most frequently encountered species with a relative importance value index of 63.2. A few other associates are relatively abundant such as *Helianthemum lippii* and *Hammada elegans.* The common thorny bush *Lycium shawii* attains a relatively high relative importance value 18.4. In the sandy accumulations on the rocky and gravelly areas of the south and west, the perennial shrubs *Motkiopsis ciliata* and *Seidlitzia rosmarinus* and the perennial grass *Panicum turgidum* attain relatively high relative importance value indices. Other important associates are *Fagonia indica, Francoeuria crispa* and the perennial herb *Launea procumbens.* The important annuals are the grasses *Eragrosits barrelieri* and *Stipa capensis.*

Table 1

Relative importance value index of the five landform/soil subdivisions, based on data of 380 1m² random quadrats.

Plant Species	Rocky Hammadas	Wadis	Depressions	Sabkhas	Sand Dunes
Perennials:					
Acacia ehrenbergiana Hayne	5.9	24.6	6.4	—	—
Acacia tortilis (Forssk.) Hayne	1.9	—	7.4	—	—
Aeluropus lagopoides (L.) Trin. ex Thawites	—	—	—	13.05	—
Aerva javonica (Burm. f.) Spreng	5.9	—	—	—	—
Aizoon canariens L.	—	12.5	2.7	—	—
Anabasis setifera Moq.	6.3	—	—	10.39	—
Arthorcnemum glaucum (Del.) Ung. - Sternb.	—	—	—	2.7	—
Capparis spinosa L.	—	—	6.0	—	—
Cistanche phelypaea (L.) Couts	—	—	—	32.9	—
Citrullus colocynthis (L.) Schrad.	—	—	1.9	—	—
Convolvulus prostratus Forssk.	0.6	—	—	—	—
Cornulaca mocacantha Del.	—	—	—	2.7	—
Chrysopogon aucheri (Boiss) Stapf	3.9	—	—	—	—
Cymbopogon parkeri Stapf.	—	—	4.6	—	—
Cyperus conglomeratus var. multiculmis (Boeck) Kuckenth	—	—	—	27.75	31.2
Cyperus laevigatus L.	—	—	—	1.05	—
Dichantium annulatum (Forssk.) Stapf.	—	—	—	1.9	—
Eleusine compressa (Forssk.) Asch. et Schweinf	—	—	13.8	—	—
Fagonia burguieri	3.2	—	—	—	—
Fagonia indica Burm. f.	8.2	—	2.1	—	—
Francoeuria crispa (Forssk.) Cass.	11.8	51	—	—	—
Halocnemon strobiolaceum (Pall.) M. Bieb	—	—	—	5.2	—
Halopeplis perfoliata (Forssk.) Bunge ex Aschers in Schweinf	—	—	—	20.9	—
Hammada elegans (Bunge) Botsche	26.3	—	0.9	6.08	—
Helianthemum lippil (L.) Dum.-Cours	31.5	—	5.6	—	—
Helio tropium bacciferum Forssk.	7.8	—	1.05	—	—
Herniaria hemistemon J. Gay	—	—	2.8	—	—
Indigofera articulata Gouan	5.3	—	—	—	—
Lasiurus hirsutus (Forssk.) Bioss.	—	—	—	—	3.45
Launaea capitata (Spreng.) Dandy	3.45	—	—	—	—
Launaea nudicaulis (Roxb.) Ramayya et Rajagopal	—	—	3.45	—	—
Leptadenia pyrotechnica (Forssk.) Decne.	—	14.8	—	—	—
Limonium axillare (Forssk.) Kuntze	2.6	5.7	—	52.3	5.6
Lycium shawii Roen et Schult	18.4	8.5	5.7	—	—
Moltkiopsis ciliata (Forssk.) Johnst.	18.4	—	—	—	—
Panicum turgidum Forssk.	16.7	19.0	3.6	5.4	46.5
Pennisetum divisum (Gmel.) Henr.	—	5.7	6.9	—	11.6

Plant Species	Rocky Hammadas	Wadis	Depressions	Sabkhas	Sand Dunes
Polycarpaea repens (Forssk.) Aschers et Schwenf	—	—	1.35	—	—
Psoralea plicata Del.	—	—	13.9	—	—
Pulicaria undulata (L.) Kostel	—	—	24.9	—	—
Ochradenus baccatus Del.	—	—	5.6	—	—
Rhanterum epapposum Oliv.	—	—	2.8	0.4	—
Robbairea delileana Milne-Redhead	0.23	—	—	—	—
Salsola baryosma (Roem. et Schult.)	—	—	—	3.4	—
Salsola schweinfurthii Solms - Laub	—	—	—	25.9	—
Salsola vermiculata L.	—	—	—	15.6	—
Salvia aeagyptiaca L.	—	—	9.9	—	—
Seidlitzia rosmarinus Bunge ex Boiss.	15.9	—	—	3.4	—
Sporobolus arabicus Boiss.	3.45	1.9	—	7.8	—
Stipagrostis obtusa (Del.) Nees	1.9	—	—	—	—
Stipagrostis plumosa L.	10.5	—	7.5	—	—
Suaeda vermiculata	—	—	—	3.4	8.37
Teucrium polium L.	1.9	—	—	—	—
Ziziphus nummularia (Burm. f.) Wight et Walk - Aru	—	—	7.5	—	—
Zygophyllum quatarense Hadidi	63.2	13.3	47.4	16.8	3.45
Annuals:					
Anagallis arvensis L.	—	—	2.7	—	—
Anastatica hierochuntica L.	1.95	—	1.35	—	—
Astragalus eremophilus Bois	—	—	1.05	—	—
Astragalus tribuloides Del. var. minutus (Boiss)	1.05	—	—	—	—
Cornulaca aucheri Moq.	1.05	—	—	—	—
Emex spinosus L.	—	—	2.9	—	—
Eragrostis barrelieri Daveau	13.2	—	1.95	—	—
Fagonia ovalifotia Hadidi	0.45	—	2.8	2.7	—
Hippocrepis bicontorata Loisel	—	—	0.9	—	—
Neurada procumbens L.	—	—	3.6	—	—
Plantago amplexicautis Cav.	—	—	1.35	—	—
Rumex vesicarius L.	—	—	—	2.7	—
Schismus barbatus (L.) Thell.	—	—	1.05	—	—
Sclerocephalus arabicus Boiss.	1.05	—	0.9	—	—
Stipa capensis Thumb.	5.9	—	7.7	—	—
Trigonella stellata Forssk.	—	—	2.4	—	—
Tripleurospermum auriculatum (Boiss) Rech.	—	—	1.35	—	—
Zygophyllum simplex L.	0.23	3.1	—	1.05	—
Unidentified species	26.3	—	—	—	—

*Depressions here include only major ones, i.e., rohdas.

Wadis:

Here the tree species *Acacia ehrenbergiana,* the platable grass *Panicum turgidum* and the leafless shrub *Leptadenia phyrotechnica* are the most conspicuous species especially in the south and south-west, and they attain high relative importance values (24.6, 19 and 14.8 respectively). Other important species are *Zygophyllum quaterense, Aizoon canariense* and *Lycium shawii.* Only one annual, *Zygophyllum simplex,* was encountered in the quadrats.

Depressions:[1]

Here quite a number of perennials attain high relative importance values. The bushy composite *Francoeuria crispa* is the most important species, as it attains a relative importance value index of 51. The second most important species is the shrubby perennial *Zygophyllum quatarense* with a relative importance value index (47.4). The Third importance is the perennial grass *Cymbopogon parkeri* with a relative importance value index of 46. Among other important perennials are *Pulicaria undulata, Psoralea plicata, Eleusine compressa* and *Salvia aegyptiaca.* The tree species *Ziziphus nummularia, Acacia tortilis, A. ehrenbergiana* and the spiny shrubs *Capparis spinosa* and *Lycium shawii* are still common components of the vegetation. Other perennials encountered are *Helianthemum lippii, Launaea nudicaulis, Ochradenus baccatus* among others.[2] The largest number of annuals (13) was encountered in depressions. The most important of these are: *Stipa capensis, Neurada procumbens, Emex spinosus* and *Fagonia ovalifolia.*

Sabkhas:

The salt-secreting halophyte *Limonium axillare* is the most encountered perennial with a relative importance value index of 52.3. It is followed in importance by the perennial root parasite *Cistanche phelypaea* which attains a relative imortance value index 32.9. The third in importance is the perennial herb *Cyperus conglomeratus* var. *multiculmis* followed by *Salsola schweinfurthii* which are often encountered in pure stands and they form big phytogenic mounds. The succulent halophytic chenopod *Halopeplis perfoliata* is also a frequently encountered perennial. Other important consultants of the vegetation are *Zygophyllum quatarense, Salsola vermiculata, Aeluropus lagopoides, Anabasis setifera* and *Sporobolus arabicus.* Only three annuals were encountered. These are: *Fagonia ovalifolia, Rumex vesicarius* and *Zygophllum simplex.*

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1. Only deep depressions were examined in this study.

2. Please refer to table 1.

Sand dunes:

Cyperus conglomeratus var. *multiculmis* is the dominant perennial on sand dunes, with a relative importance value index of 31.2. The perennial grass *Panicum turgidum* is the second most important plant species. Other frequently encountered species are *Pennisetum divisum, Saueda vermiculata* and *Limonium axillare.* Only six perennials were encountered in all area sampled and not a single annual was encountered.

Soil:

Table 2 shows that chemical and physical analyses of the soil along the five landform/soil subdivisions were very variable. Data for mechanical analysis reveal that the soils of the rocky hammadas are sandy loams, those of wadis are sandy clay loams, those of depressions are clay loams, while of sabkhas and sand soils are sandy. The pH values are slightly alkaline (they range between 7.74 and 8.58) with no significant difference between the five subdivisions. Soil slainity, however, varies widely between the five subdivisions. While the electric conductance is over 80 M Mhos/cm in sabkhas, it is only 0.9 and 1.7 in depressions and wadis respectively. The percentage of organic carbon is slightly higher in depressions and wadis than in the other three subdivisions. The water holding capacity values are also high in depressions and wadis, while they are low in sabkhas and sand dunes. Chlorides are high on the saline sabkha soils, while hydrogen carbonates are low in all subdivisions.

Discussion and Conclusions

The vegetation of different landform/soil subdivisions in Qatar show a wide range of variation. The five subdivisions show substantial difference in spectrum (38 species in depression and 6 only on sand dunes). They also vary greatly in the diversity values of the flora they support. According to both Shannon and Simpson's diversity indices, depressions support the most diversified plant cover (Table 3). This high diversity is a result of the favourable soil conditions (Table 2). On the other hand wadis and sand dunes have a far lesser diversified plant cover.

Depressions and rocky hammadas have a high species similarity index (39.4). The similarity between plant cover of the rocky hammadas and depressions is due to the widespread distribution of both landforms, as the rocky hammadas are often dotted by depressions. The highest species

Table 2
Soil Physical and Chemical Analysis

Landform	Clay %	Silt %	Sand %	Texture Class	pH	EC M Mhos/ cm/25°	Organic Carbon %	Water Soluble Salts (Meq. HCO_3)	Water Holding Capacity Volumetric Percentage			Water Soluble Salts	
									Field Capacity	Permanent Wilting Point	Available Water	CO_3	Cl
Rocky Hammadas	10.42	8.18	81.4	Sandy loam	7.74	9.45	0.4	1.28	4.4	1.7	2.62	Nil	63
Wadis	24	15	61	Sandy Clay Loam	7.84	1.7	0.6	2.67	19	10	10	Nil	1200
Depressions	40.9	15.1	44	Clay Loam	8.02	0.9	0.73	1.42	19	9	11	Nil	360.13
Sabkhas	2.5	1	96.5	Sand	8.58	83.7	0.09	1.05	1.65	0.58	1.07	0.78	1334
Sand dunes	4.44	1	94.56	Sand	8.29	4.28	0.05	1.09	1.55	1.42	0.13	Nil	17.8

similarity index is attained between wadis and sand dunes, while depressions and sand dunes have the lowest index. This may be explained by the fact that major wadis and sand dunes share the sandy southern part of the country. The rest of the landform/soil pairs have moderate to low species similarity indices (Table 4).

It appears that plant distribution in Qatar is partially determined by plant-soil-water relationships. Similar conclusions have been reached by several author's studying the desert vegetation of the Arabian Peninsula (Vesey-Fitzgerald, 1957, Halwagy and Halwagy, 1974, 1977; Batanouny, 1981a, 1981b; Babikir 1984b, 1986, Frey *et al.* 1985). The vegetation of the rocky hammadas with their limited soil depth and hard calcareous rock fragments is sparse as plant growth is confined to suitable microhabitats, i.e., where reasonable deep soil is accumulated. Some of the characteristic species of the rocky hammadas such as *Helianthemum lippii* and *Hammada elegans* have been reported to dominate similar habitats (Thalen, 1979).

The differences in the physical properties of the soil show that they may have a major effect on plant life. Similar conclusions have been reached by Zohary (1962), Kassas and Girgis (1965), Halwagy and Halwagy (1974, 1977). The sandy soils of sabkhas and sand dunes support the poorest plant cover and they are almost devoid of annuals.[1] At the same time, certain species attain high relative importance value indices only in sand dunes and sabkhas and their growth is more or less confined to such sandy habitats, e.g. *Cyperus conglomeratus* var. *multiculmis* and *Salsola schweinfurthii.* The edaphically restricted flora at sand dune areas has been well reported in the literature (Ayyad, 1973; Pavlik, 1985; Barbour *et al.* 1985; Moreno-Casasola, 1986). It also appears that there is a close interaction between the poor vegetation cover and the continuous sand movement due to the strong N and NW prevailing winds. Batanouny (1973), Frey *et al.* (1985) and Moreno-Casasola (1986) pointed that sand mobility inhibits the growth of any but highly specialized plant species.

1. The year of the study was a dry one.

Table 3
Diversity values (Shannon and Simpson's Indices) for each Landform/ Soil subdivision

Landform/Soil Subdivisions	Shannon Index Hs values	Simpson's Index	Total Number of 1 m^2 Quadrats
Rocky Hammadas	2.26	0.948	120
Wadis	1.02	0.89	50
Depressions	2.34	0.949	100
Sabkhas	1.82	0.93	60
Sand Dunes	0.52	0.63	50

Table 4
Krebs Similarity Index for each pair of the five landform/soil subdivisions

	Rocky Hammadas	Wadis	Depressions	Sabkhas	Sand dunes
Rocky Hammadas	—				
Wadis	34.1	—			
Depressions	39.4	23.5	—		
Sabkhas	35.3	27.8	16.4	—	
Sand dunes	17.6	42.1	13.6	34.5	

On the other hand, depressions support the most diversified flora of all subdivisions. Soil characteristics and water revenue appear to be the responsible factors. The deep clay loams of the depressions have greater water revenue (Table 2).

The salt content of the soil may also be a major determinant of the species composition and distribution. As soils with electric conductance below 4 M Mhos/cm are regarded as having low salt content (Hesse, 1971) therefore only sabkha soils (83.7 M Mhos/cm) are considered very saline. Halophytic vegetation is more or less confined to the sabkhas and the less dynamic coalesced sand dunes of south-eastern Qatar which are subject to constant moistening by salt spray from the sea. Kurschner (1986) reported such spray halophytes in the Sultanate of Oman. Similar observations were reported from

other parts of Arabia by Vesey-Fitzegerald (1957) Halwagy and Halwagy (1977) Thalen (1979) Halwagy *et al.* (1984 and 1985).

Soil moisture content is probably the major physical factor causing vegetation variations between the five landform/soil subdivisions. Water holding capacity of the soil varies widely between the five subdivisions (Table 2). Therefore, the surface niche available to the annual flora in depressions and rocky hammadas may not be available on sand dunes and sabkhas. Luxuriant growth of perennials appear to be associated with the relatively deep layers of sandy clay loams and clay loams of depressions and large wadis.

The brief analysis of the effect of landform and soils on plant composition and distribution in Qatar, has presented some evidence to support the general concept of desert plant habitats and their vegetation: 1) Variations between plant communities may be attributed to the changes in macro- as well as microrelief. 2) Soil properties particularly texture, moisture content and salinity play a major role in determining vegetation composition, frequency, density, cover and diversity.

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