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Evaluation of arid rangelands degradation and productivity in response to variable precipitation and land use changes

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Abstract

Several changes have impacted the ecosystem at northwestern coast of Egypt include transformation from extensive to intensive agro-pastoral systems, increasing the rate of urbanization,and frequent drought periods. This study was carried out at the northwestern coast of Egypt to evaluate changes in vegetation composition and rangeland productivity at Wadi Umm Ashtan in 2004 and 2015 as influenced by changes in land use and variable precipitation. Detail plant survey was conducted in each of the studied years, and the plant life of this Wadi was surveyed, plant cover and other vegetation parameters of each plant species were calculated. Rangeland productivity was evaluated of six different habitat represent the main sections of Wadi Umm Ashtan. Results indicated that tremendous changes have been noticed from spring of 2004 to spring of 2015, average vegetation cover at the different parts of the Wadi declined from about 24 % in 2004 to 15 % in 2015. The Wadi has faced increasing in urban encroachment rate whereas several tourism development and land urbanization projects have been established. As an example of the coastal part of the Wadi, vegetation survey in spring, 2015 of mobile sand dunes habitat indicated that total vegetation cover decreased to 7.3 % compared to about 11% in spring, 2004. Drainage lines habitat was rich in species diversity and several palatable plant species were recorded in this part of the Wadi. Overall, Drought, overgrazing, and different land use changes have negatively impacted vegetation cover at the study area and increased soilerosion.

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Introduction

Egypt is located in the arid and hyper arid region with a total area of about one million km², of which only a small portion, 4 % of total area, is agricultural productive lands and about 96 % is desert lands, about 1.5 % of the total country area can be considered desert rangelands (NAP, 2015). Egyptian desert rangelands are important for food production and ecosystem services for a large portion of Egypt's population. They provide food, shelter, clothes for most of the numeric people living in these extremely arid regions. The common livestock types in the Egyptian deserts including sheep, goats, and camels. Livestock depend mainly on the natural vegetation to provide their nutrient requirements where rangelands are the main feed resource particularly during the rainy season.

There are three major geographic regions that characterize the Egyptian Desert Rangelands. Those three geographic regions are northwest coast of Egypt, northeast coast of Egypt, and the southeast corner of Egypt (The Hala'ib Triangle). The North Western Mediterranean Coastal Belt, which we are dealing with, extends from Alexandria westward to El Sallum for about 500 km, and from the seashore inward for about 15 km, is considered the richest part of Egypt in flowering plants, owing to its relatively high rainfall. In addition, there are about 218 Wadis in the area running from south to north and represent suitable environment for cultivation fruit, vegetables, and growing native plants. The number of plant species in this belt and the different Wadis forms about 55 % of the total number of species that constitutes the Egyptian flora, which is estimated to be 2121 species (Boulos, 1995) out of which 154 species are confined in their distribution in Egypt to it. Most of these species are annual weeds that flourish during the rainy season, giving the area a temporary annualgrassland aspect. During the longer dry period, there are only the characteristic woody shrubs and perennial herbs, that constitute the scrub vegetation of the area, scattered sparsely in parts and grouped in denser more distinct patches in specially favored habitats.

Since Roman times, the region underwent gradual deterioration, its villages and vineyards disappeared though their sites are still recognizable by their old names. The population changed into nomadic Bedouins with their own practices of farming and habits of life, which undoubtedly contributed a great deal to attaining the present condition of degradation of the natural vegetation and the soils of this area.

Their primitive methods of farming of barley, the extensive grazing of the wild plants by large herds of goats and sheep and by camels, and the indiscriminate cutting of woody plants for fuel have depleted the land of its natural wealth of vegetation and led to serious erosion of the soil and hindrance of the soil forming processes.

Deterioration in plant diversity in the North Western coastal zone is primarily observed in the cushion growth form acquired by under-shrubs and shrubs which are the main perennial elements of the natural plant cover. It is further indicated by the dominance of numerous unpalatable plants including spiny shrubs and under-shrubs including,*Zillaspinosa*, *Echinopsspinosissirrtus,*

Astragalusspinosus,Iphionascapra, Fagonia ssp., the wide occurrence of succulent under-shrubs that may form pure stands e. g. *Zygophyllumcoccmenum, Z. album, Anabasis setifera, A. articulata, Hammadaelegans and H. scoparia*. In addition to the considerable areas which covered with crynohalophytes including *Tamarix* and *Atriplex* species. Other unpalatable plants that now cover considerable areas include the fibrous shrub *Thymelaea hirsute*, the soon leafless *Lygosraetam* and medicinal and poisonous plants such as *Hyoscyamusmuticus, Citrulluscolocynthis, Crozophora*, *Cleome* and *Marrubium ssp*.

As part of the Mediterranean region the northwestern coast of Egypt has been highlighted as a hot spot for

climatic changes, which affect agriculture, rangeland livestock production, and ecosystems services (Sherbinin, 2014). The rainfall along the coastal zone is not even;the average annual precipitation ranges between 102 mm at El Sallumand 180 mm at Alexandria, i.e. the amount of rainfall appears higher to the east than to the west.

The amount of rainfall shows steady decrease in the inland direction where it reaches about 50 mm within the southern limit of the defined catchment area of the coastal zone. Recently, it has noted that there is clearly climate variation in the region, where the amount of annual rainfall highly decreased and its distribution is also not suitable for enhancing rangelands productivity.Whereas, the various rangelands types and their productivities are closely associated with edaphic and climatic characteristics Zahran&Girgis (1971); El- Monayeri *et al.* (1979) and Reiad *et al.* (1996). Tremendous reduction at the pastoral grazing lands in the northwestern coast of Egypt has been occurred in the last 60 years due to increasing livestock numbers, rain-fed agriculture expansion, and the large urban development. Livestock herders expanded their cultivated barley fields on rangelands and around their houses resulting in disappearance of rangelands vegetation close to the villages. Vegetation diversity was affected by the human activities in the area including overgrazing, rain-fed cultivation, and urbanization (Ahmed *et al.,* 2003). Most land use changes in the area were induced by climate variation and human activities.

These current changes are highly influencing the plant biodiversity and reducing ecosystem services provided by native rangelands. Environmental studies in the region which address response of plant diversity to overgrazing and variable rainfall are very limited.Moreover, monitoring rangeland vegetation and tracking plant species richens in the northwestern coast of Egypt would be very necessary as the importance of this area as a primary genetic resource for the country.

This kind of research would be very helpful in understanding vegetation response to the various drivers of land use changes. Hence the primary objective of this research was to evaluate changes in vegetation composition and rangeland productivity in 2004 and 2015 at Wadi Umm Ashtan as influenced by changes in land use and variable precipitation.

Material and methods

Description of the study area

This study was carried out at Wadi Umm Ashtan west of Marsa Matrouh city (Fig. 1).

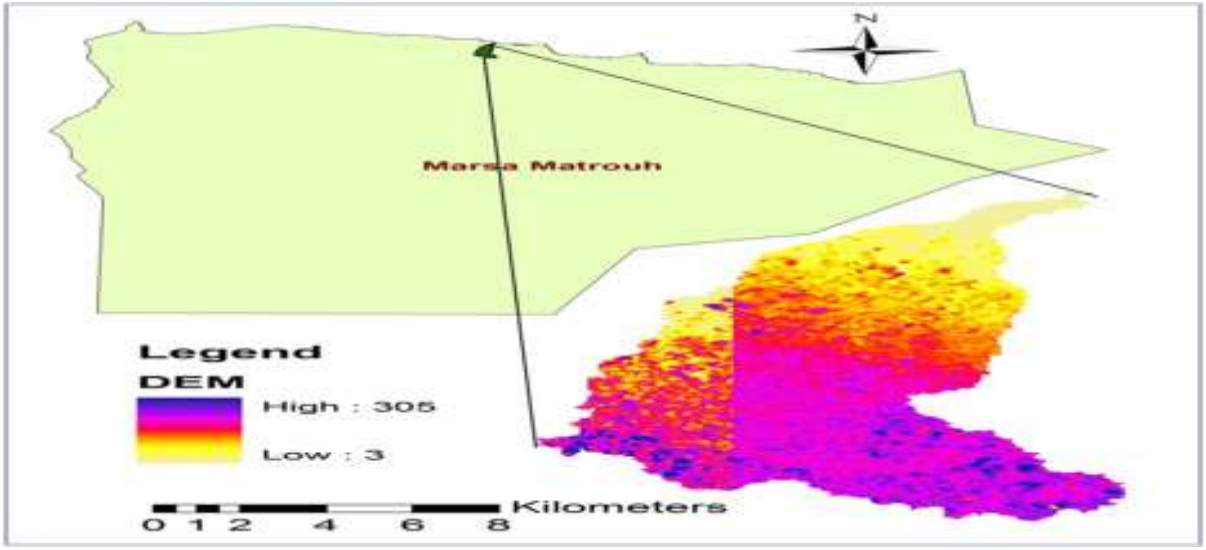

Fig. 1. Location of Wadi Umm Ashtan at Marsa Matrouh Governorate at northwestern Egypt.

Wadi Umm Ashtan comprises three geomorphic units' i.e. coastal plain, pediment, and plateau (Fig. 2). The coastal plain lies to the northern border of the study area. This unit is a band of land parallel to the Mediterranean coast. The coastal plain classified into mobile sand dunes, consolidated coastal sand dunes, saline depressions (wet and dry salt marshes). The piedmont is located to the north of the pediment. This unit exerts slope of 2-3% from south to north, and it is classified to drainage lines and stony desert habitats. The plateau is the largest in acreage with average slope of 0.7-1.0% from south to north. The parent material is considered bare rock habitat.

Wadi Umm Ashtan is one of the broadest and richest Wadis in the western Mediterranean section of Egypt, and receives a large amount of rainfall. The upstream part of the Wadi comprises by stony desert part, slopes which characterized by presence of species well adapted to the gravelly habitat and shallow soil. Sandy desert and drainage line habitat is comprises the biggest part of the Wadi and considered as a catchments area receives the rain fall according to the runoff .This habitat is dense in cover and diverse in vegetation. Species such as: *Varthemiairsute, lygeumspartum, Deverratortousa, Gymnocarposdecendrem, Artemisia herba alba* and *Capparissinaica* were restricted to this habitat. Average annual precipitation and some other climate factors of Marsa Matrouh area in the period from 2004 to 2014 are shown in Table (1). Soil analysis of the six different habitats of Wadi Umm Ashtan is given in Table (2). The first habitat consolidated sand dunes is far from the effect of the wind current and soil texture of this habitat consists mainly of fine sand particle(50%). The second habitat is mobile sand dunes which affected by the wind current and poor in vegetation and sand percentage comprises (87.2%) of the soil texture. The last habitat is the salt crusts which affected by the maritime of the sea; this habitat is characterized by high percentage of salinity and moisture content. Halophytic species include*Halocnemumstrobilecum*, *Arthocemummacrostachyum*, and *Juncusrigidus*; in addition to *Alhagigrogroum* and *Cressiacretica* werepresent in the dry salt marshes.Climate of the study area belongs to the Mediterranean coastal region of Egypt which is warm coastal desert climate. The occasional short rainstorms occur in winter and most of the days are sunny with mild temperature. Generally, the rainy season occurs during the winter and is characterized by great fluctuation in distribution and intensity of rainfall from one year to another. The distribution of main annual rainfall in Egypt shows a maximum rate over the Mediterranean coast with a rapid decrease toward the south. The primary land cover types dominate Wadi Umm Ashtan include sparse rangelands vegetation, dense rangelands vegetation, cultivated barley, urban development, orchard fields, and bare ground desert.

Rangeland vegetation measurements

The plant life in the six different habitats of Wadi Umm Ashtan was surveyed in spring of 2004 and spring of 2015. The 25 list and counting quadrates at each location were used to study the natural vegetation. The size of the quadrates was 20 m^2.The placentation of the quadrates was chosen randomly vertically on the vegetation degrading in nature. The following measurements were determined in order to evaluate the vegetation characteristics.

Plant composition

Plant species and families were fully identified to the families level and named according to Tackholm (1974) updated by Boulos (1995).Plant density (plant/ m^2), plant coverage (%) and plant frequency (%) were calculated according to the following equations as described by Hanson &Churchill (1965) and Mueller-Dombois&Ellenberg (1974).

$$\text{Plant density (plant/ m}^2) = \frac{\text{Number of individual species}}{\text{Total area (100 m}^2)}$$

The importance value for different species was calculated according to Ludwing& Reynolds (1988) by calculating sum of relative density, relative cover and relative frequency for different species by divide the cover, density, and frequency for each plant species

by the total cover, density, and frequency for all species.

Fresh foliage yield

Each plant species in the quadrate was clipped and weighed to determine the fresh forage yield of the different species per unit area (20 m^2) and then counted as (kg/ha.). Also, the whole fresh forage production of all species was estimated.

Dry foliage yield

Samples of fresh foliage for each plant species were taken, and oven dried at 70 C^o till constant weight and then weighed to determine, the percent of dry matter which used to determine dry forage yield for every species and the whole production of dry forage yield (kg / ha).

Results and discussion

Mobile sand dunes habitat

Data in Table (3) shows the vegetation analysis and productivity for the mobile sand dunes habitat of Wadi Umm Ashtan. Six range plants were recorded in this habitat at spring of 2004. These plant species were*Ammophylaarenaria*, *Ononisvaginalis*, *Lotus polyphyllus*, *Zygophyllum album*, *Cakile maritime*, and *Echiumsericeum*. The average heights of these species were 64.3 cm, 7.7 cm, 25.7 cm, 29.5 cm,9 cm, and 10.0 cm, respectively. *Ammophylaarenaria* was the dominantplant species in this habitat, where it recorded the highest cover value of 10.2 % and it also achieved the highest importance value and the highest values of all the other vegetation measurements. *Ammophylaarenaria* attained the highest fresh weight of 50.6 kg/ha with a productivity of 26.8 kg dry matter/ha in this habitat, while *Cakilmaritima* attained the lowest values.

Table 1. Monthly average precipitation (mm) of Marsa Matrouh area from 2004 to 2014.

Month	Year										
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
January	35	53	30	30	66	9	5	42	37.4	35.2	33.4
February	38	15	42	35	31	21	6.5	30	23.5	9.2	12.7
March	4	2	25	15	3	11	1.5	18	15	0.8	8.8
April	5	3	1	9	0	5	10	20	1.4	1	3
May	3	1	1	15	1	0	2.4	4	3.6	12.4	7
June	0	1	0	0	0	0	0	1	0	0	0.6
July	0	0	0	0	0	0	0	0	0.2	0	0
August	0	0	0	0	0	0	0	0	0.2	0	0
September	0	0	0	0.5	0	0	0	3	0	0	0
October	1	3	7	1	12	4	11.4	4	1.7	2	8.5
November	18	16	7	6	3	12	0.2	49	20.4	6.3	12
December	15	27	32	9	31	21	17	2.5	24.4	82	15
Annual	119	121	145	120.5	147	83	54	173.5	127.8	148.9	101

Tremendous changes have been noticed from spring of 2004 to spring of 2015, this part of Wadi Umm Ashtan has faced increasing of urban encroachment rate whereas several tourism development and land urbanization projects have been established. Vegetation survey in spring of 2015of mobile sand dunes habitat at Wadi Umm Ashtan indicated that total vegetation cover decreased to 7.3 % compared to about 11% in spring, 2004. Four plant species were recorded in this habitat at March 2015 i.e. *Ammophylaarenaria*, *Ononisvaginalis*, *Lotus polyphyllus*, and *Zygophyllum album*. The highest plant cover, density, frequency, and importance value wererecorded by *Ammophylaarenaria,* it also gave the highest fresh and dry matter weight (Table, 3). Total fresh and dry matter productivity were 60 kg/ha and 30.4 kg dry matter/ha, respectively in spring of 2015 compared to 85.2 kg/ha and 41 kg dry matter/ha, respectively in 2004.These results reflect the temporal variation in the vegetation cover and

productivity between the two studied years as the result of variable rainfall and land use change in the area. In addition, several studies have shown that human activities and changing of land use lead to rangeland degradation in arid and semi-arid environments (Ayoub, 1998; Oztas*et al.*, 2003; El-Khouly, 2004; Loeser*et al.* 2007).

Table 2. Chemical properties of soils in the different habitats of Wadi Umm Ashtan.

Habitat type	Site	pH	EC mmhos/cm	Cations (meq/L)				Anions (meq/L)		Organic	$CaCo_3$
				Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	So_4^{2-}	Carbon %	%
Mobil sand dune	9	7.9	2.5	9.35	0.54	11.0	7.0	23.5	0.73	0.90	35.0
	10	8.1	2.5	12.17	3.85	4.0	2.4	17.0	0.79	0.96	17.5
Consoledated	11	7.9	1.25	2.44	0.38	15.0	9.0	1.5	0.90	1.26	35.0
sand dune	12	7.0	2.25	1.65	0.23	3.0	2.0	30.0	0.82	0.48	55.0
Salt crusts	4	8.3	55.0	3.7	0.59	80.0	23.0	7.5	0.74	1.58	50.0
	8	7.8	11.5	17	0.51	20.0	10.2	4.5	0.73	0.66	75.0
Drainge	3	8.2	1.0	21.74	0.82	9.0	3.7	16.0	0.92	1.50	15.0
Lines	7	7.7	1.5	2.44	0.23	2.0	1.0	3.0	0.63	1.68	32.5
Slope of	1	7.8	4.5	19.13	1.41	11.0	7.5	11.0	0.79	1.32	20.0
the ridge	2	7.5	1.5	1.7	0.21	21.0	13.6	30.0	0.78	0.96	21.6
Bare rocks	5	7.8	3.0	2.4	0.64	10.0	6.0	5.2	0.91	0.54	12.5
	6	8.0	2.0	22.17	0.64	5.0	2.8	4.0	0.72	1.2	40.0

Table 3. Vegetation Analysis and Rangeland Productivity of the Mobile Sand Dune Habitat of Wadi Umm Ashtan at spring of 2004 and spring of 2015.

Species	Density	Cover %	Frequency	Relative density	Relative cover	Relative frequency	Importance value	Plant height (cm)	Fresh weight (kg/ha)	Productivity (kg dry matter/ha)
Spring, 2004										
Ammophyl aarenaria	459.3	10.2	100	97.5	89.5	37.5	224.5	64.3	50.6	26.8
Lotus polyphyllus	9.3	0.2	66.7	2.0	1.8	25.0	28.8	7.7	6.7	2.8
Ononisvaginalis	1.0	0.5	33.3	0.2	4.4	12.5	17.1	25.7	12.8	7.3
Zygophyllum album	1.3	0.2	33.3	0.3	1.8	12.5	14.6	29.5	14.8	3.9
Cakile maritime	0.3	0.0	33.3	0.1	0.0	12.5	12.6	9.0	0.3	0.2
Echiumsericeum	0.0	0.2	0.0	0.0	1.8	0.0	1.8	10.0	-	-
Spring, 2015										
Ammophyl aarenaria	251	6.3	66.7	97.1	88.7	40.0	225.9	53.1	35.4	18.3
Lotus polyphyllus	5.6	0.3	33.3	2.2	4.2	20.0	26.4	6.1	5.1	2.1
Ononisvaginalis	0.8	0.5	33.3	0.3	0.0	20.0	20.3	20.2	8.3	5.8
Zygophyllum album	1.0	0.2	33.3	0.4	7.0	20.0	27.4	18.3	11.2	4.2
Cakile maritime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Echiumsericeum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Consolidated sand dunes habitat

This habitat is distinguished by the existence of many range plants, which also suffer from overgrazing. Fourteen plant species were recorded in this habitat at spring of 2004 including, *Ononisvaginalis, Helianthemumlippii, Echiochilonfruticosum, Deverratortousa, Eshinopsspinosissimus,Asparagus stipularis and Lygeumspartum* (Table, 4). The average heights of plant species reached 65 cm, and53.6 cm for *Ammophylaarenaria* and *Lygeumspartum*, respectively. *Ammophylaarenaria* attained the highest importance value and plant cover of 71 and 6.84 %, respectively followed by *Ononisvaginalis* with 4.36 % plant cover and 57.3 importance value. While,*Hyoserisradiata*, due to its growth form, recorded the lowest plant height (2.0 cm) value. Also, *A. arenaria* and *L. spartum* attained the highest fresh weight and dry matter productivity of23.3 kg/ha and 14.1 kg/ha, and 16.2 kg/ha and 13.8 kg/ha, respectively in spring 2004.

Table 4. Vegetation Analysis and Rangeland Productivity of the Consolidated Oolitic Sand Dunes Habitat of Wadi Umm Ashtan at spring of 2004 and spring of 2015.

Species	Density	Cover %	Frequency	Relative density	Relative cover	Relative frequency	Importance value	Plant height (cm)	Fresh weight (kg/ha)	Productivity (kg dry matter/ha)
Spring, 2004										
Ammophylaarenaria	144	6.84	100	24.6	35.25	11.1	71.0	65.0	23.3	14.1
Ononisvaginalis	127	4.36	100	21.7	25	11.1	57.3	13.0	3.2	2.6
Helianthemumlippii	130.3	2.74	100	22.2	14.12	11.1	47.4	9.3	3.7	2.9
Lygeumspartum	147	0.58	33.3	25.12	3	3.7	31.8	53.6	16.2	13.8
Echiumsericeum	13.3	1.85	100	2.2	9.53	11.1	22.8	9.0	4.1	2.4
Deverratortousa	4.4	0.21	100	0.68	1.08	11.1	12.4	8.6	2.9	1.8
Echinopsspimosissmus	11.6	0.35	66.7	1.98	1.3	7.3	11.0	12.3	0.5	0.4
Aeleuropuslagopoides	2.7	1.19	33.3	0.46	6.13	3.7	10.3	6.6	-	-
Crucianellamaritimca	1.3	0.78	33.3	0.22	4	3.7	7.9	25.6	-	-
Asparagus stipularis	0.66	0	66.7	0.11	0	7.3	7.4	29.5	0.6	0.5
Hyoseris radiate	0.66	0	66.7	0.11	0	7.3	7.4	2.0	-	-
Echiochilonfruticosum	2.3	0	33.3	0.4	0	3.7	4.1	14.3	0.5	0.3
Teucriumpolium	0.33	0	33.3	0.050	0	3.7	3.8	12.0	-	-
Thymelaea hirsute	0.33	0	33.3	0.050	0	3.7	3.8	11.0	0.3	0.2

Table 4. Cont.

Species	Density	Cover %	Frequency	Relative density	Relative cover	Relative frequency	Importance value	Plant height (cm)	Fresh weight (kg/ha)	Productivity (kg dry matter/ha)
Spring, 2015										
Ammophylaarenaria	85	4.22	100	23.0	43.1	23.1	89.3	48.6	15.3	10.31
Ononisvaginalis	73	2.51	66.7	19.8	25.7	15.4	60.8	8.9	1.8	1.3
Helianthemumlippii	87.1	1.32	33.3	23.6	13.5	7.7	44.8	8.7	2.7	1.5
Lygeumspartum	110.2	0.37	33.3	29.9	3.8	7.7	41.3	51.0	12.3	8.6
Echiumsericeum	5	0.82	66.7	1.4	8.4	15.4	25.1	8.2	3.2	2.0
Deverratortousa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Echinopsspimosissmus	5.7	0.23	33.3	1.5	2.4	7.7	11.6	10.1	0.6	0.4
Aeleuropuslagopoides	1.2	0.31	33.3	0.3	3.2	7.7	11.2	6.1	0.3	0.2
Crucianellamaritimca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Asparagus stipularis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hyoseris radiate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Echiochilonfruticosum	0.8	0.0	33.3	0.2	0.0	7.7	7.9	10.7	0.4	0.2
Teucriumpolium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thymelaea hirsute	1.0	0.0	33.3	0.3	0.0	7.7	8.0	10.0	0.2	0.1

Table 5. Vegetation Analysis and Rangeland Productivity of the Salt Crusts Depression Habitat of Wadi Umm Ashtan at spring of 2004 and spring of 2015.

Species	Density	Cover %	Frequency	Relative density	Relative cover	Relative frequency	Importance value	Plant height (cm)	Fresh weight (kg/ha)	Productivity (kg dry matter/ha)
Spring, 2004										
Halocnemumstrobilaceum	32.3	17.9	100	62.2	44.6	33.3	140.0	17.7	0.7	0.5
Arthrocnemummachrostachyum	11.0	19.6	100	21.2	48.9	33.3	103.4	22.0	84.7	30.2
Juncusrigidus	7.3	1.3	33.3	14.1	3.2	11.1	28.4	113.0	112.3	65.3
Atriplex halimus	1.3	1.3	66.7	2.5	3.2	22.2	27.9	14.0	68.7	30.6
Spring, 2015										
Halocnemumstrobilaceum	20.1	12.1	100	66.3	48.6	42.9	157.8	15.2	0.5	0.3
Arthrocnemummachrostachyum	6.3	11.8	66.7	20.8	47.4	28.6	96.8	21.3	58.3	20.8
Juncusrigidus	3.4	0.5	33.3	11.2	2.0	14.3	27.5	80.3	75.2	42.3
Atriplex halimus	0.5	0.5	33.3	1.7	2.0	14.3	17.9	12.0	35.2	15.8

The same downward trend in vegetation cover and rangeland productivity was mentioned on the consolidated sand dunes habitat as for the mobile sand dunes habitat. Total fresh weight and dry matter production was decreased from 2004 to 2015 by 33.5 % and 36.9 %, respectively.

High reduction of the total vegetation cover was recorded in this habitat as the plant cover decreased from 18.9 % in spring, 2004 to 9.8 % in spring of 2015.Cayrol *et al.*, (2000) and Loeser *et al.,* (2007) reported that both natural and human influences are known to cause massive changes in vegetation cover and dynamics.

Table 6. Vegetation Analysis and Rangeland Productivity of the Drainage LinesHabitat of Wadi Umm Ashtan at spring of 2004 and spring of 2015.

Species	Density	Cover %	Frequency	Relative density	Relative cover	Relative frequency	Importance value	Plant height (cm)	Fresh weight (kg/ha)	Productivity (kg dry matter/ha)
					Spring, 2004					
VarthemiaMontana	31.1	9.04	100	20.23	20	9.09	49.3	43.0	12.1	6.4
Oryzopsismiliacea	34.7	7.17	100	22.57	15.88	9.09	47.5	58.3	7.3	5.7
Lygeumspartum	18.7	11.82	100	12.16	26.19	9.09	47.4	67.6	0.6	0.5
Deverratortousa	36	6.25	100	23.42	13.85	9.09	46.4	36.6	8.5	4.7
Gymnocarposdecander	10.3	1.7	100	6.7	3.7	9.09	19.6	19.0	-	-
Artemisia herba-alba	5.3	2.33	100	3.44	5.16	9.09	17.7	51.0	1.7	1.3
Thymelaeahirsute	3.7	1.87	100	2.9	4.14	9.09	12.6	90.6	17.3	9.8
Thymus capitatus	2.7	0.75	100	1.75	1.66	9.09	12.5	20.0	0.26	0.21
Suaedapruinosa	2.3	2.5	33.3	1.49	5.65	3	10.1	29.0	0.8	0.3
*Centaurea*sp.	5.3	0.24	33.3	3.4	0.05	3	7.0	36.0	-	-
Phlomisfluccosa	0.7	0.3	33.3	0.45	0.69	3	4.1	75.0	-	-
Limoniumpruinosum	0.6	0.21	33.3	0.39	0.47	3	3.6	27.0	1.5	1.1
Noaeamucronata	1.3	0	33.3	0.84	0	3	3.8	12.0	0.4	0.3
Asparagus stipularis	0.3	0	33.3	0.19	0	3	3.2	16.0	0.5	0.3
Atractyliscarduus	0.3	0	33.3	0.19	0	3	3.2	63.0	-	-
Periplocaangustifolia	0.3	0	33.3	0.19	0	3	3.2	84.0	-	-
Reaumuriahirlella	0.1	0	33.3	0.06	0	3	3.1	19.0	0.6	0.4
Capparisorientalis	0	0.45	0	0	1.0	0	1.0	16.0	0.6	0.4
Echiumsericeum	0	0.45	0	0	1.0	0	1.0	13.6	-	-

Table 6. Cont.

Species	Density	Cover %	Frequency	Relative density	Relative cover	Relative frequency	Importance value	Plant height (cm)	Fresh weight (kg/ha)	Productivity (kg dry matter/ha)
						Spring, 2015				
VarthemiaMontana	25.0	7.1	66.7	22.7	25.4	8.7	56.8	38.5	8.9	5.3
Oryzopsismiliacea	31.1	5.3	100	28.2	18.9	13.0	60.2	53.5	5.2	3.1
Lygeumspartum	13.2	8.1	66.7	12.0	28.9	8.7	49.6	54.1	0.3	0.2
Deverratortousa	21.0	3.8	33.3	19.1	13.6	4.3	37.0	41.3	7.8	5.1
Gymnocarposdecander	8.1	0.8	100	7.4	2.9	13.0	23.3	17.1	15.1	9.2
Artemisia herba-alba	3.5	1.3	100	3.2	4.6	13.0	20.9	43.2	1.1	0.7
Thymelaeahirsute	2.7	0.7	100	2.5	2.5	13.0	18.0	80.3	13.1	6.8
Thymus capitatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Suaedapruinosa	1.0	0.5	33.3	0.9	1.8	4.3	7.0	23.1	0.5	0.2
*Centaurea*sp.	3.1	0.1	33.3	2.8	0.4	4.3	7.5	32.1	-	-
Phlomisfluccosa	0.4	0.0	33.3	0.4	0.0	4.3	4.7	81.0	-	-
Limoniumpruinosum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Noaeamucronata	0.8	0.3	66.7	0.7	1.1	8.7	10.5	10.1	0.3	0.2
Asparagus stipularis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Atractyliscarduus	0.2	0.0	33.3	0.2	0.0	4.3	4.5	45.3	-	-
Periplocaangustifolia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Reaumuriahirlella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capparisorientalis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Echiumsericeum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Besides overgrazing or un-controlled grazing, trampling by domestic livestock in semi–arid regions always reduces plant cover that protects the soil and generally results in soil erosion and compaction (Oztas *et al.*, 2003).

Five plant species disappeared and didn't recorded at 2015 survey, these species are *Deverratortousa, Crucianellamaritimca, Asparagus stipularis, Hyoseris radiate, and Teucriumpolium*.

El-Khouly (2004) found that three perennial species in addition to all the annuals plant species were disappeared due to cultivation effect in Siwa Oasis.

Salt crusts habitat

Results of vegetation survey in spring 2004 and spring 2015 are shown in Table (5). It cleared that the number of range plants in this type of habitat is mostly low, especially in the wet salt marshes.

Table 7. Vegetation Analysis and Rangeland Productivity of the Stony DesertHabitat of Wadi Umm Ashtan at spring of 2004 and spring of 2015.

Species	Density	Cover %	Frequency	Relative density	Relative cover	Relative frequency	Importance value	Plant height (cm)	Fresh weight (kg/ha)	Productivity (kg dry matter/ha)
					Spring, 2004					
Deverratortousa	28.3	2.3	100	26.2	14.3	10.3	50.8	13.7	18.2	12.5
Thymelaeahirsute	9.0	4.0	66.7	8.3	24.8	6.9	40.0	53.7	7.4	4.7
VarthemiaMontana	23.0	1.5	66.7	21.3	9.3	6.9	39.5	10.3	5.8	2.7
Asphodelusramosus	16.3	1.0	100	15.1	6.2	10.3	31.6	43.0	-	-
Haloxylonscoparium	6.7	2.3	100	6.2	14.3	10.3	30.8	16.0	10.9	8.1
Noaeamucronata	8.0	0.9	100	7.4	5.6	10.3	23.3	10.0	-	-
Haloxylonsalicornicum	4.0	1.3	100	3.7	8.1	10.3	22.1	15.7	3.2	2.7
Centaureasp.	3.3	2.5	33.3	3.1	15.5	3.4	22.0	17.0	-	-
Lyciumshawii	3.3	0.0	100	3.1	0.0	10.3	13.4	28.0	-	-
Salsolalongifolia	1.0	0.2	66.7	0.9	1.1	6.9	8.9	9.3	-	-
Atractylescarduus	0.7	0.0	66.7	0.6	0.0	6.9	7.5	12.3	-	-
Bellevaliasessiliflora	3.3	0.07	33.3	3.1	0.4	3.4	6.9	5.7	-	-
Reaumuriahirtella	0.3	0.07	33.3	0.3	0.4	3.4	4.1	9.3	-	-
Allium desertarum	0.3	0.01	33.3	0.3	0.1	3.4	3.8	31.0	-	-
Fagoniaarabica	0.3	0.0	33.3	0.3	0.0	3.4	3.7	12.0	-	-
Suaedapruinosa	0.3	0.0	33.3	0.3	0.0	3.4	3.7	16.7	-	-

Table 7. Cont.

Species	Density	Cover %	Frequency	Relative density	Relative cover	Relative frequency	Importance value	Plant height (cm)	Fresh weight (kg/ha)	Productivity (kg dry matter/ha)
					Spring, 2015					
Deverratortousa	18.9	1.4	100	26.8	12.6	13.0	52.5	10.2	13.8	9.2
Thymelaeahirsute	6.1	3.0	66.7	8.7	27.0	8.7	44.4	41.3	5.2	3.1
VarthemiaMontana	19.1	1.1	33.3	27.1	9.9	4.3	41.4	10.8	6.1	3.8
Asphodelusramosus	8.3	0.6	66.7	11.8	5.4	8.7	25.9	35.5	0.0	0.0
Haloxylonscoparium	4.5	1.6	100	6.4	14.4	13.0	33.8	13.7	8.2	5.5
Noaeamucronata	6.0	0.5	66.7	8.5	4.5	8.7	21.7	11.2	-	-
Haloxylonsalicornicum	2.0	0.4	66.7	2.8	3.6	8.7	15.1	12.8	2.5	2.0
Centaureasp.	1.8	1.2	100	2.6	10.8	13.0	26.4	15.3	-	-
Lyciumshawii	1.5	1.2	66.7	2.1	10.8	8.7	21.6	29.1	-	-
Salsolalongifolia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Atractylescarduus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bellevaliasessiliflora	1.8	0.1	33.3	2.6	0.9	4.3	7.8	6.1	-	-
Reaumuriahirtella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Allium desertarum	0.2	0.0	33.3	0.3	0.0	4.3	4.6	26.2	-	-
FagoniaArabica	0.2	0.0	33.3	0.3	0.0	4.3	4.6	8.7	-	-
Suaedapruinosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Most of these species are moderate or low palatable. Among these range species are *Atriplex halimus* (in wet salt marshes), *Juncusrigidus*, *Arthrocnemummachrostachyum*, and *Halocnemumstrobilaceum*. *Juncusrigidus* attained the highest value of height of 113.0 cm in spring, 2004 in this habitat.

The highest value of fresh weight and productivity were attained for *Juncusrigidus*(112.3 and 65.3 kg/ha), while the lowest values were attained for *Haloxylonscoparium* (0.7 and 0.5 kg/ha), respectively. The fresh weights of *A. halimus*, and *Arthrocnemummachrostachyum*were 68.7 kg/ha, and 84.7 kg/ha, respectively, while productivity of these two species was 30.6 kg/ha and 30.2 kg/ha, respectively. In spring of 2015, the same number of species was recorded in this habitat; however, total vegetation cover was declined from 24.1 % in 2004 to 24.9 % in spring of 2015.

Table 8. Vegetation Analysis and Rangeland Productivity of the Bare Rock Habitat of Wadi Umm Ashtan at spring of 2004 and spring of 2015.

Species	Density	Cover %	Frequency	Relative density	Relative cover	Relative frequency	Importance value	Plant height (cm)	Fresh weight (kg/ha)	Productivity (kg dry matter/ha)
					Spring, 2004					
Haloxylonscoparium	23.0	2.8	100	36.0	19.3	15.0	70.6	13.3	5.7	3.5
Lyciumshawii	20.3	2.2	100	31.8	15.2	15.0	62.0	31.7	0.7	0.5
Thymelaea hirsute	1.3	4.9	66.7	2.0	33.8	10.0	45.8	79.0	3.6	2.9
Deverratortousa	4.3	1.8	100	6.7	12.4	15.0	34.1	13.7	1.9	1.1
Asphodelusramosus	8.0	0.6	66.7	12.5	4.1	10.0	27.1	34.3	-	-
Noaeamucronata	4.0	0.7	66.7	6.3	4.8	10.0	21.6	13.7	1.8	1.4
Haloxylonsalicornicum	1.7	0.4	66.7	2.7	2.8	10.0	16.0	13.0	-	-
Allium desertarum	1.0	0.3	66.7	1.7	2.1	10.0	13.8	8.0	0.2	0.1
Asparagus stipularis	0.3	0.3	33.3	0.5	2.1	5.0	7.6	20.7	0.2	0.21
Centaureaeryngioides	0.0	0.5	33.3	0.0	3.4	0.0	3.4	15.3	-	-
					Spring, 2015					
Haloxylonscoparium	15.1	2.1	66.7	34.3	27.3	13.3	74.9	15.1	3.2	1.8
Lyciumshawii	16.3	1.5	100	37.0	19.5	20.0	76.5	23.2	0.5	0.3
Thymelaea hirsute	0.8	3.2	66.7	1.8	41.6	13.3	56.7	61.3	2.3	1.7
Deverratortousa	2.6	0.9	100	5.9	11.7	20.0	37.6	11.2	1.3	0.5
Asphodelusramosus	6.1	0.5	66.7	13.9	6.5	13.3	33.7	26.3	-	-
Noaeamucronata	2.3	1.2	33.3	5.2	15.6	6.7	27.5	9.2	1.4	0.9
Haloxylonsalicornicum	0.6	0.2	33.3	1.4	2.6	6.7	10.6	11.5	-	-
Allium desertarum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Asparagus stipularis	0.2	0.2	33.3	0.5	2.6	6.7	9.7	15.8	0.2	0.1
Centaureaeryngioides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

To assess vegetation loss and soil degradation in an Arctic Salt Marsh,Jefferies and Rockwell (2012) found that the loss of vegetation and changes on soil conditions have resulted in the establishment of an alternative settable state i.e. hyper saline bare sediment and vegetation cover reached to less than 2 % on parts of the studied areas. Other studies also showed that salinity has a negative impact on the plant species diversity (El-Khouly and Fakhry, 1999 and El-Khouly and Khedr, 2000).

Drainage lines habitat

This habitat is rich in range plants, where nineteen range plants were recorded, most of them are highly palatable (Table, 6). These include*Deverratortousa, Artemisia herba-alba, Gymnocarposdecander, Lyciumshawii, Periplocaangustifolia, Atriplex halimus, Noaeamucronata, Suaedapruinosa, Cynodondactylon, Haloxylonsalicornicum, Atractylescarduus* and *Rhamnuslycioides*. Results in Table (6) show that total vegetation cover in spring,

2004 was about 45 % which indicate the high rangeland condition of Wadi Umm Ashtan compared with other parts of northwestern coast of Egypt.

The highest plant cover 11.82 % was recorded by *Lygeumspartum* in 2004.*Thymelaea hirsute* attained the highest value of height (90.6 cm) while *Noaeamucronata*and according to its growth form showed the lowest value (12 cm). Vegetation survey from 2004 showed that the fresh weight and productivity of *Gymnocarposdecander*were the highest in this habitat. Important rangeland plants species were recorded in this habitat and severe overgrazing was occurred in all these valuable genetic resources. However, seven plant species were disappear or didn't show up in spring, 2015 vegetation survey. This part of the Wadi has faced more land use changes in the last 11 years where several farmers started to use subservice water to establish and irrigate small field of vegetable crops. This new land use type leads to increasethe tillage activity in the area. Total vegetation cover decreased to 28 % in spring of 2015, which indicates vegetation degradation in Wadi Umm Ashtan in the last 11 years. Overgrazing and land use change by increasing cultivation activities in this habitat based on subservice water haveremoved the vegetation cover that protects soil from erosion. Connolly *et al.*, (1997) reported that when the percent of vegetation cover is less than 30–40%, runoff and soil loss dramatically increase. In northwestern coast of Egypt, El-Morsy*et al.* (2007) stated that higher averages of plant density, coverage and frequency percentage and foliage productivity were recorded for most perennial and annual species in the un-ploughed sites compared to the ploughed ones.

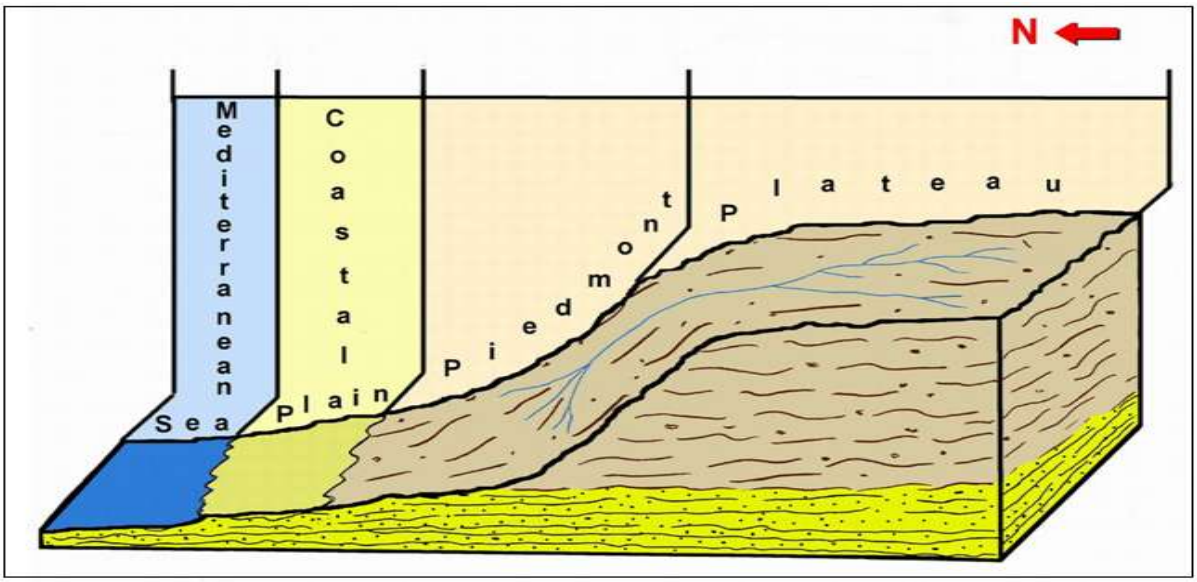

Fig. 2. Geomorphical units of Wadi Umm Ashtan.

Rocky slopes of the plateau(stony desert) habitat

Results presented in Table (7) show the vegetation analysis and rangeland productivity at the rocky slopes of the plateau at Wadi Umm Ashtan in 2004 and 2015. Sixteen range plant species were recorded in this habitat with total vegetation cover of 16.2 % in spring, 2004. *Deverratortousa* had the highest plant density of 28.3 and the highest fresh and dry matter production of 18.2 kg/ha and 12.5 kg/ha, respectively. The highest value of plant height of 53.7 cm was achieved *Thymelaea hirsute* in spring, 2004. In addition, the highest importance value was recorded by *Deverratortousa.*Vegetation analysis from spring of 2015 indicated that total vegetation cover in the desert stony habitat decreased to 11.1 %. Four plant species were not shown on the 2015 vegetation survey indicating the downward trend of species diversity in the study area. Changes in the land use at the coastal

areas and frequent drought have forced the shepherds to graze the high slopes parts of the Wadi resulted in vegetation loss and rangeland degradation.

Bare rock (Table land) habitat

Ten rangeland plant species were recorded in this habitat including, *Noaeamucronata, Lyciumshawii,Thymelaea hirsuteDeverratortousa, Haloxylonsalicormicum, Salsolatetrandra, Gymnocarposdecander* and *Echinopsspinosissmus*(Table, 8). In spring 2004, the two first species were very common whereas other of range species were only common or occasional. Most of the recorded range plants are moderately palatable.*Thymelaeahirsuta* attained the highest average values of height (79 cm), fresh weight (3.6 kg/ha) and productivity (2.9 kg/ha). The highest plant density of 23 was recorded for *Haloxylonsalicormicum*. Vegetation survey in spring 2015 indicated that there were eight plant species in this habitat, where *Allium desertarum* and *Centaureaeryngioides* didn't show up in the survey. Total plant cover, fresh weight, and productivity were 14 %, 14.1 kg/ha, and 9.7 kg/ha, respectively in spring 2004; while these findings were declined in 2015 to 9.8 % for vegetation cover, 8.9 kg/ha for fresh weight, and 5.3 kg/ha for the dry matter productivity.

Conclusion

Vegetation composition of an arid rangeland at northwestern coast of Egypt was surveyed at spring, 2004 and spring, 2015 in order to track changes in vegetation biodiversity in response to drought and land use changes. Results showed that Wadi Umm Ashtan has faced more land use changes in the last 11 years where several farmers started to use subservice water to establish and irrigate small field of vegetable crops. This new land use type leads to increase the tillage activity in the area. Total vegetation cover in the drainage habitat decreased to 28 % in spring of 2015, which indicates vegetation degradation in Wadi Umm Ashtan in the last 11 years. Drought, overgrazing, and land use changes by increasing cultivation activities have removed large portion of the vegetation cover that protects soil from erosion.

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