Ecosystem Services of the Flora of Southern Mediterranean Desert of Egypt

K. Shaltout and Dalia Abd El-Azeem Ahmed

Research

Abstract

The present study aims to evaluate the economic plant species in the Western Mediterranean Desert of Egypt according to the goods and services that they offer and identifying the threat types that govern their gradual change in the study area. Of the 969 species recognized in this region, 548 have at least 1 potential or actual good (56.6% of the total species). Medicinal plants were the most commonly identified, while timber plants were the least. In addition, 338 species (34.9% of the total species) have at least 1 environmental service. Sand accumulators were the most common services, while water purifiers were the least. 411 species (75.0% of the total economic species) suffer from at least 1 type of threat. 267 species suffer from the over-collecting and over-cutting (65.0% of the total threatened species), while 36 species suffer from disturbance by cars or trampling (8.8% of the total threatened species). Physical defenses against threats were noted and sorted into 6 groups of species. Among those, species with hairy leathery leaves and hairy stems were the most represented, while the hidden species were the least common.

Introduction

The Western Mediterranean Desert of Egypt is diversified with the coastal area, wadis, depressions and terrain of varying degrees of accessibility. The area encloses different water sources and varied irrigation schemes. Rainwater is the basis of life and economic activity in the coastal territories, with only moderate contributions from underground water. The range of economic activities is substantial, covering rain fed agriculture, livestock rising, trade, tourism, industry, mining, quarries, petroleum and various services (Batanouny 1999a).

Goods of the natural flora in the ecosystem include species and their parts and products that grow in the wild and are used directly for human benefit (Daily *et al*. 1997). The goods could be classified, among others, into 6 major categories (Shaltout & Al-Sodany 2002): grazing, medicinal, human food, timber, fuel, and other uses (e.g., mats, baskets, chairs, ornamental uses, beach beds, soap manufacture, and oil and dye extraction). For example, trade of medicinal plants is an important source of economic income in the north western coastal region, and has a role in building the economy of community in the region. Local inhabitants have, in some cases, thorough traditional knowledge for managing their natural habitats. The management practices of local inhabitants differ according to the types of habitat. Elderly people have respect for their natural resources. Conversely, the young generation has lost many of these traditional practices. For example, the collection of fuel wood by the old people is focused mainly on the dry and dead plants, while the young generation and people of the surrounding urban settlements do not differentiate between green and dry plants.

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Services of the natural flora are those valuable, ongoing streams of benefits provided by these plants (Turner & Daily 2008). Twelve aspects of services could be described (Heneidy & Bidak 2004): sand accumulation, wind breaking, esthetic concerns, soil fertility, shading, water storage, refuge, salinity tolerance, bank retention, water invading, weed controlling and water purification (phytoremediation).

The present study aims to evaluate the economic uses of the flora of Western Mediterranean Desert of Egypt based on the goods (e.g., medicinal, grazing, human food, timber, fuel and other uses), and services (e.g., sand accumulation, wind breaking, esthetic concerns, soil fertility, shading, water storage, refuge, salinity tolerance, bank retention, water invading, weed controlling and water purification), which they offer, and to assess the threat types that govern their gradual change in the study area (e.g., browsing and over grazing, over collecting and over cutting, clearance for agriculture, habitat loss, disturbance by cars or trampling, and mining and quarrying). It also aims to determine the physical defenses of these economic plants against different kinds of misuses (e.g., species with hairy leathery leaves and hairy stems, species with modified parts for protection, species acquired defensive parts as a result of over grazing, species with sticky latex with unpleasant taste and odor, species with leathery leaves with unpleasant odor, and hidden plants).

Study Area

The western Mediterranean coastal region of Egypt can be distinguished into two main provinces: an eastern province between Alexandria and Ras El-Hekma, and a western province between Ras El-Hekma and Sallum (Figure 1). The landscape of this region is distinguished into a northern coastal plain and a southern tableland (Selim 1969). Generally, the eastern province can be subdivided into two distinct physiographic areas, each with its own particular topographical features (FAO 1970): the area from Alexandria to Alamein which includes three main ridges running parallel to the coast and flat depressions in between (Figure 2), and the area from El-Alamein to Ras El-Hekma, which consists of an irregular succession of alternating low hills and closed depressions, sloping from south to north. There is an almost continuous range of dunes along the coast.

The prevailing climate can be qualified as an arid Mediterranean with mild winters (UNESCO 1977). The distribution of the mean annual rainfall shows that the amount of annual rainfall decreases sharply from about 150 mm near the coast to 80 mm at a distance of 160 km inland, and to 20 mm at a distance of 260 km inland (Figure 3). Most of the rain falls during winter (60% or more from November to February), and the summer is virtually dry. Wind in this region is generally strong and violent; dust storms and pillars are not rare. Dry hot dust-laden winds from the south known as Khamasin blow occasionally for about 50 days during spring and early summer. During winter and early spring, winds blow strongly with an average velocity of about 20-23 km/hour. Wind speed decreases in May and June, but July is windy. The end of summer is characterized by many calm days and the average wind speed drops to 15 km/hour (Shaltout 1983).

The main land uses in the study area are grazing and rain-fed farming (or irrigated by underground and runoff water). The main annual crop is barley (*Hordeum vulgare* L.). Irrigated agriculture of pasture and grain crops and

Figure 1. Study sites in the Western Mediterranean coastal region of Egypt in two main provinces: An eastern province between Alexandria and Ras El-Hekma, and a western province between Ras El-Hekma and Sallum.

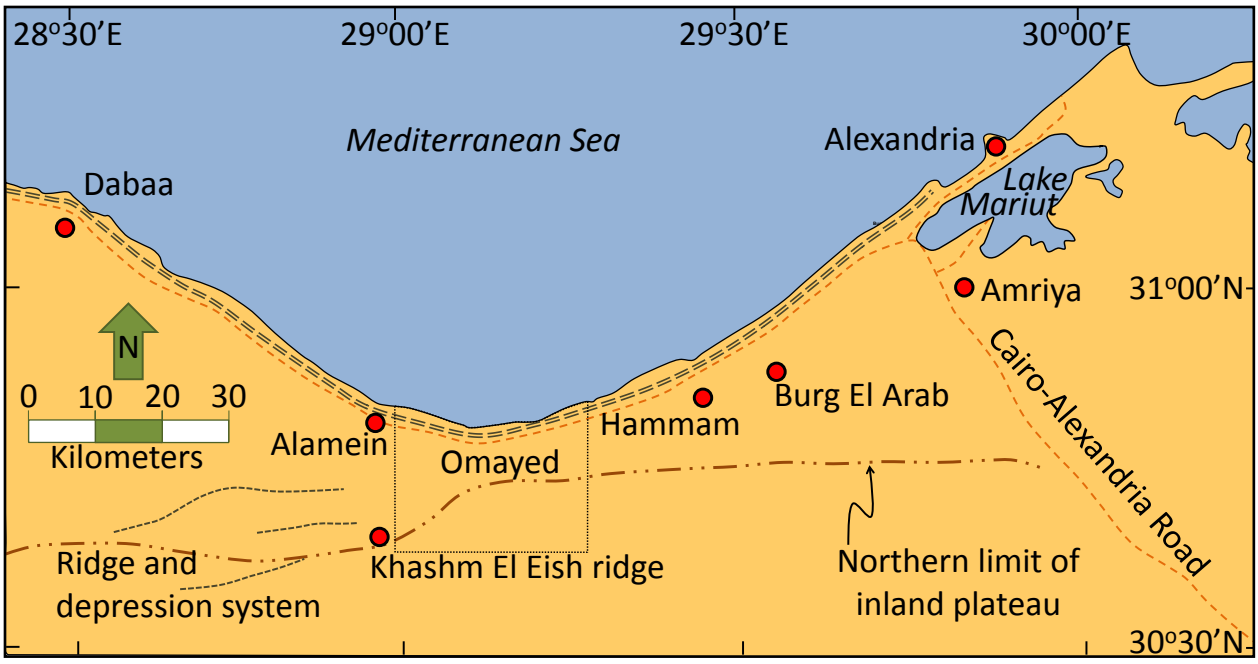

Figure 2. Physiographic system of the eastern part of the north western coastal region of Egypt. (After Ayyad &Le Floc'h 1983)

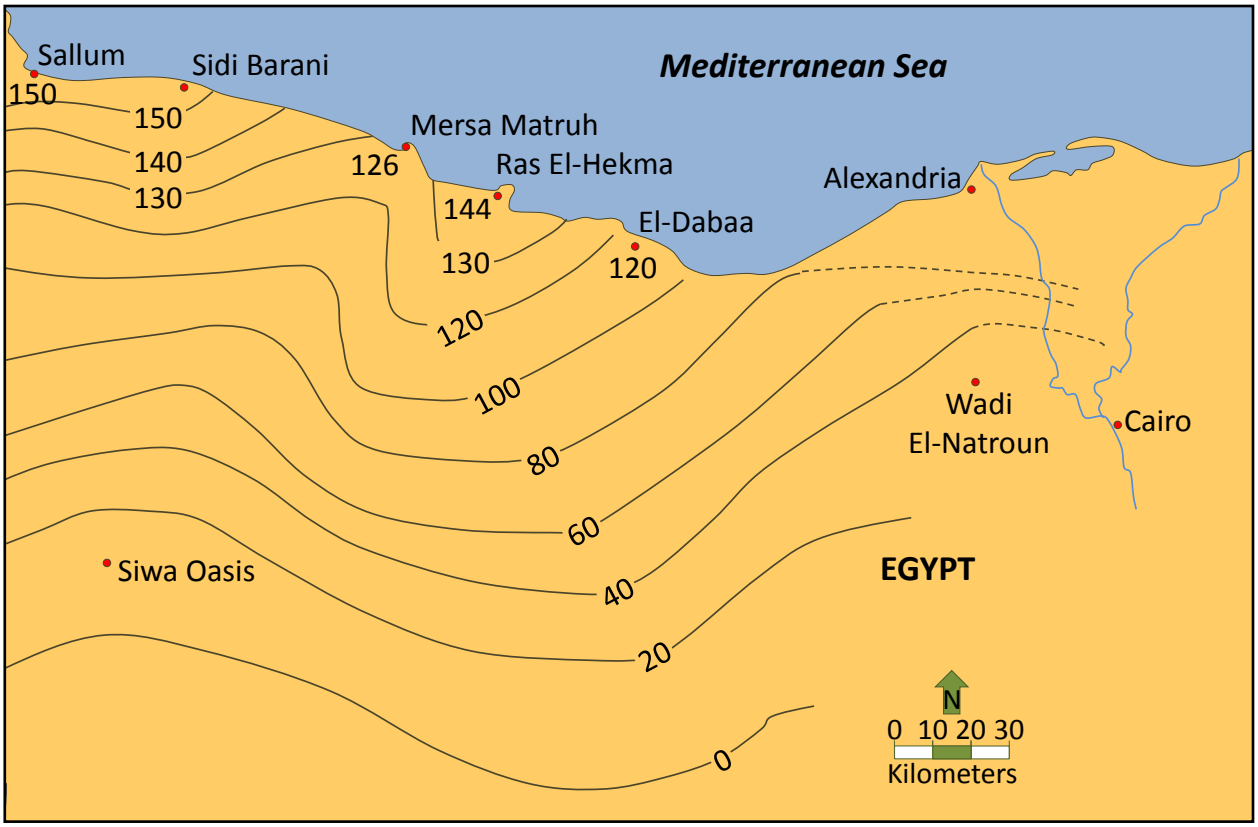

Figure 3. Isohytes of mean annual rainfall (mm) in the Western Mediterranean Desert of Egypt. (After Griffiths 1972)

fruit trees (mainly vines) is spreading after the extension of irrigation canals from the Nile up to 60 km west of Alexandria (Zahran & Willis 2009). Vegetables such as tomatoes, onions, broad beans and watermelons are cultivated mostly in small plots for local consumption. Sheep, goats, camels, donkeys and cattle are found in the study area, but animal production is concerned mainly with sheep and goats. The goats are used largely to supply the Bedouins with meat and milk, about 60-80 liters per location and live weight of 30 kg per goat and 15 kg per kid (Seif El-Nasr & Bidak 2005a).

The changes in land use during the last few decades at Maktala resulted in a decrease of 14.1% of rangelands; while at Omayed it decreased by 2.1%. This may be due to the deterioration of vegetation as well as difficulties in the last few years in transporting the animals to Libya, which is considered the nearest main market for sheep and goats. The observed land use changes were from a structure based on pastoralism to a structure based on multiple uses or on a group of economic activities in which agriculture has an increasing role (El-Kady *et al*. 1995).

Oil and gas fields with their shipping facilities, and gypsum extraction are among land use activities (Kassas 1979). Nowadays, summer resorts and tourist sites occupy the shoreline zone from Burg El-Arab to Mersa Matruh (El-Fahar & Sheded 2002).

Methods

Forty one field trips were conducted to cover different locations in the Western Mediterranean Desert during 3 years from spring 2004 to spring 2007. The main habitats and community types prevailing in each location were determined through visiting different sites. Specimens of the present species were collected from different sites in each location. For the purpose of revealing the natural complexity of the floristic elements in the Western Mediterranean Desert, trips to the same location were done including most of the sampled locations.

Floristic records were prepared as presence/absence of species, type of habitats and plant associations, and local abundance and flowering time of each species. Plants were identified based on the regional references (Boulos 1995, 1999, 2000, 2002, 2005, 2009, Boulos & El-Hadidi 1994, Cope & Hosni 1991, El-Hadidi 2000, El-Hadidi & Fayed 1995, Feinbrun-Dothan 1978, 1986, Täckholm 1974, Zohary 1966, 1972). Life forms were identified following the system of Raunkiaer (1937): (phanerophytes (permanent buds born at height > 25 cm), chamaephytes (permanent buds born above the soil surface till a height < 25 cm), hemicryptophytes (permanent buds born close to the soil surface), cryptophytes (permanent buds born under the soil surface in case of geophytes, in the mud overlain by water in case of helophytes, or in the water in case of hydrophytes), therophytes (the plants finish their life cycle in the form of seeds during a period less than one year) and parasites.

Goods and Services

Goods of the natural flora in the ecosystem include species and their parts and products that grow in the wild and are used directly for human benefit (Daily *et al*. 1997). The potential and actual goods of the recorded species were assessed based on: field observations, information collected from local inhabitants and herbalists. Fifty persons distributed in the study area were interviewed, they are in the age class of 30-50 years old. Their knowledge is due to experience and acquired skills using plant names, locations and methods of collection through their herding trips. Additional information was collected from 14 herb shops distributed in the markets in Matrouh which is the capital of Mersa Matruh governorate. Literature review was used to fill gaps in the collected information (Abdel Razik *et al*. 1996, Ahmed 2003, Al-Eiswi & Takruri 1989, Al-Qura'n 2009, Ayyad 1998, Batanouny 1999b, Belal & Springuel 1996, Boulos 1983, Chevallier 1996, González-Tejero *et al*. 2008, Hadjichambis *et al*. 2008, Heneidy & Bidak 2004, Rizk 1986, Rizk & Al-Nowaihy 1989, Seif El-Nasr & Bidak 2005a, Shaltout 1997, Shaltout & Al-Sodany 2002, Shaltout *et al*. 2010, Wickens 1980). The goods are classified into 6 major categories: grazing, medicinal, human food, timber, fuel and other uses (e.g., mats, baskets, chairs, ornamental uses, beach beds, soap manufacture, and oil and dye extraction).

Services of the natural flora are those valuable, ongoing streams of benefits provided by these plants (Turner & Daily 2008). The services of the recorded species were evaluated based on field observations and reference consultation (Ayyad 1998, Heneidy & Bidak 2004, Seif El-Nasr & Bidak 2005b, Shaltout *et al*. 2010, Simpson 1932, Täckholm 1974, Zahran & Willis 2003). Twelve aspects of services are described: sand accumulation, wind breaking, esthetic concerns (e.g., dry flowers, table, and vase), soil fertility, shading, water storage, refuge (shelters for other organisms and/or hidden plants), salinity tolerance, bank retainers, water invaders, weed controller and water purifiers (phytoremediation).

Threats and Physical Defense

Threats are the direct and indirect causes for ecosystem degradation and species impoverishment. Six types of threat were identified in the study area (see Seif El-Nasr & Bidak 2005c):

1. browsing and over grazing,
2. over collecting and over cutting,
3. clearance for agriculture,
4. habitat loss (industrial/urban growth, coastal development),
5. disturbance by cars or trampling, and
6. mining and quarrying

Recorded species physical defenses were identified by the author in the field and checked with the literature (Boulos 1999, 2000, 2002 and 2005, Feinbrun-Dothan 1978, 1986, Heneidy & Bidak 1999, Shaltout *et al*. 2010 Täckholm 1974, Zohary 1966-1972).

Six groups of physical defense were identified (Heneidy & Bidak 1999): species with hairy leathery leaves and hairy stems, species with modified parts for protection (the defensive parts are spiny organ), species acquired defensive parts as result of over grazing (develop hard woody branches with spine-like terminates), species with sticky latex with unpleasant taste and odor, species with leathery leaves with unpleasant odor, and hidden plants (occur under shrubs and rocks).

Results

Goods and Services

Five hundred and forty eight species in Western Mediterranean Desert (56.6% of the total species) have at least one aspect of potential or actual goods. The goods of the recorded species could be arranged in descend order as follows: medicinal > grazing > human food > other goods > fuel > timber. A synopsis of the common species in the study area is in Appendix 1. The grazed and timber species and those of other goods had the maximum relative value in the sand formations, edible species in the summer resorts, and medicinal and fuel species in Sallum plateau (Table 1). Twenty three out of 55 poisonous species in Egypt were recorded in the study area (41.8% of total poisonous species) with 14 of them also being medicinal plants (Table 2). Two hundred and thirty species have only 1 good (42% of the total economic species), 178 species have 2 (32.5%), 92 species have 3 (16.8%), 32 species have 4 (5.8%), 11 species have 5 (2.0%), and 3 species have 6 goods (0.6%) (Figure 4).

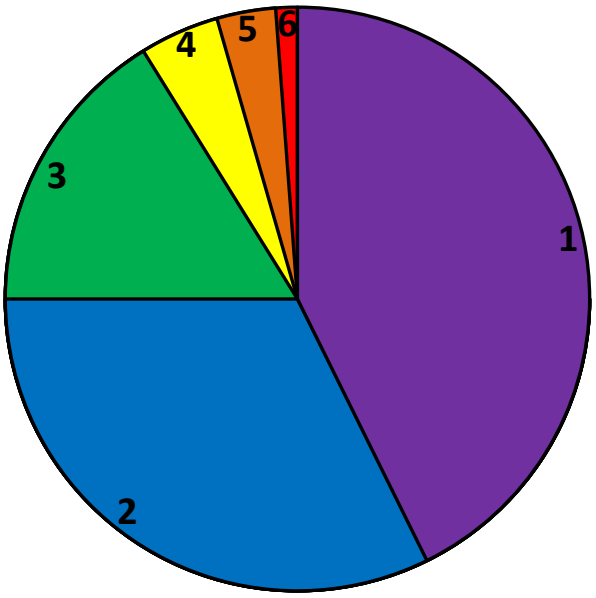

Figure 4. Frequency (%) of recorded species in the Western Mediterranean Desert, Egypt relative to the number of goods (1-6).

Table 1. Goods produced from recorded species in 13 habitats identified in the Western Mediterranean Desert, Egypt. Goods: Medicinal (ME); Grazing (GR); Human food (HF); Fuel (FU); Timber (TI); and Other (OT). Value: Actual (Ac); and Relative percent (Re). The maximum relative values are in red.

Habitat	Total species	ME		GR		HF		FU		TI		OT	
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re
Wadis	255	198	77.6	185	72.5	62	24.3	55	21.6	4	1.6	56	22
Non–saline depressions	207	153	73.9	155	74.9	58	28.0	43	20.8	5	2.4	43	20.8
Inland ridges	202	153	75.7	149	73.8	52	25.7	46	22.8	3	1.5	42	20.8
Coastal dunes	179	138	77.1	145	81.0	39	21.8	50	27.9	5	2.8	46	25.7
Road sides	168	121	72.0	125	74.4	51	30.4	38	22.6	6	3.6	39	23.2
Lake Mariut	150	90	60	99	66.0	53	35.3	19	12.7	3	2.0	36	24
Saline depressions	137	101	73.7	103	75.2	33	24.1	29	21.2	3	2.2	35	25.5
In land plateaus	136	101	74.3	98	72.1	31	22.8	30	22.1	5	3.7	34	25
Cultivated lands	132	97	73.5	98	74.2	42	31.8	27	20.5	2	1.5	28	21.1
Summer resorts	113	66	58.4	72	63.7	42	37.2	12	10.6	1	0.9	18	15.9
Sand formation	59	50	84.8	49	83.1	19	32.2	20	33.9	3	5.1	21	35.6
Salt marshes	46	25	54.3	36	78.3	9	19.6	12	26.1	-	-	15	32.6
Sallum plateau	41	38	92.7	32	78.0	9	22.0	15	36.6	-	-	14	34.1
Total	548	365	66.6	349	63.7	152	27.7	86	15.7	11	2.0	105	19.2

Table 2. Poisonous plants recorded in the Western Mediterranean Desert, Egypt. Medicinal plants (blue)

Family	Species
Euphorbiaceae	
	Chamaesyce hirta (L.) Millsp.
	Euphorbia dendroides L.
	Euphorbia falcata L.
	Euphorbia helioscopia L.
	Euphorbia heterophylla L.
	Euphorbia hierosolymitana Boiss.
	Euphorbia mauritanica L.
	Euphorbia paralias L.
	Euphorbia parvula Delile
	Euphorbia peplis L.
	Euphorbia peplus L.
	Euphorbia prostrata Aiton
	Euphorbia pterococca Brot.
	Euphorbia punctata Delile
	Euphorbia retusa Forssk.
	Euphorbia terracina L.
Ranunculaceae	
	Ranunculus arvensis L.
	Ranunculus asiaticus L.
	Ranunculus muricatus L.
	Ranunculus peltatus Schrank subsp. *fucoides* (Freyn) Muñoz Garm.
	Ranunculus sceleratus L.
Solanaceae	
	Solanum nigrum L.
	Withania somnifera (L.) Dunal

Three hundred and thirty eight species (34.9% of the total species) have at least one environmental service. The services of the recorded species could be arranged in descending order: sand accumulation > windbreaks > esthetic concerns > soil fertility > shade plants > water storage > refuge > salinity tolerance > bank retention > water invading > weed controlling such as smother plants > water purification. Services within habitats vary (Table 3). Sand accumulation, windbreak, and esthetic concerns had the maximum relative number of services in Sallum plateau. Soil fertility was maximal in cultivated lands. Shade and refuge had highest levels in sand formations. Water storage, salinity tolerance and bank retainers had the highest relative number in salt marshes. One hundred and fifty eight species offer only one service (46.7% of the total environmental servicing species), 89 species have 2 services (26.3%), 42 species have 3 services (12.4%) and, 30 species have 4 services (8.9%), 15 species have

Table 3. Services of the recorded species in the 13 habitats identified in the Western Mediterranean Desert, Egypt. Services: Sand accumulation (Sa); Windbreak (Wb); Esthetic concerns (Ec); Soil fertility (Sf); Shading (Sh); Water storage (Ws); Refuge (Re); Salinity tolerant (St); Bank retention (Br); Water invading (Wi); Weed controlling (Wc); and Water purifying (Wp). Actual (Ac); and Relative percent (Re). The maximum relative values are in red.

Habitat	Total species	Sa		Wb		Ec		Sf		Sh		Ws	
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re
Wadis	197	161	81.7	60	30.5	55	27.9	40	20.3	29	14.7	30	15.2
Non–saline depressions	153	136	88.9	47	30.7	41	26.8	25	16.3	22	14.4	29	19
Inland ridges	145	128	88.3	49	33.8	46	31.7	23	15.9	25	17.2	22	15.2
Coastal dunes	143	125	87.4	56	39.2	43	30.1	23	16.1	26	18.2	19	13.3
Road sides	124	98	79	46	37.1	31	25	25	20.2	23	18.6	22	17.7
Inland plateaus	108	91	84.3	34	31.5	28	26	17	15.7	18	16.7	18	16.7
Saline depressions	105	94	89.5	37	35.2	21	20	15	14.3	16	15.2	22	21
Lake Mariut	92	60	65.2	22	23.9	12	13	6	6.5	10	10.9	15	16.3
Cultivated lands	88	74	84.1	22	25	25	28.4	21	23.9	14	15.9	11	12.5
Summer resorts	57	39	68.4	11	19.3	11	19.3	8	14	4	7	6	10.5
Sand formation	51	47	92.2	26	51	16	31.4	4	7.8	15	29.4	15	29.4
Sallum plateau	35	34	97.1	19	54.3	16	45.7	1	2.9	9	25.7	10	28.6
Salt marshes	29	22	75.9	13	44.8	1	3.5	1	3.5	2	6.9	9	31
Total	338	257	76	93	27.5	73	21.6	53	15.7	45	13.3	44	13

Table 3. cont.

Habitat	Total species	Re		St		Br		In		Wc		Wp	
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re
Wadis	197	28	14.2	12	6.1	4	2	2	1	2	1	1	0.5
Non–saline depressions	153	26	17	7	4.6	3	2	-	-	2	1.3	-	-
Inland ridges	145	23	15.9	6	4.1	3	2.1	-	-	-	-	-	-
Coastal dunes	143	22	15.4	11	7.7	3	2.1	1	0.7	3	2.1	2	1.4
Road sides	124	21	16.9	8	6.5	3	2.4	-	-	3	2.4	-	-
Inland plateaus	108	19	17.6	5	4.6	2	1.9	-	-	2	1.9	-	-
Saline depressions	105	19	18.1	13	12.4	5	4.8	-	-	1	1	-	-
Lake Mariut	92	6	6.5	11	12	6	6.5	10	10.9	6	6.5	4	4.3
Cultivated lands	88	12	13.6	2	2.3	-	-	1	1.1	2	2.3	1	1.1
Summer resorts	57	5	8.8	4	7	3	5.3	4	7	5	8.8	1	1.8
Sand formation	51	16	31.4	2	3.9	-	-	-	-	2	3.9	-	-
Sallum plateau	35	9	25.7	3	8.9	1	2.9	-	-	-	-	-	-
Salt marshes	29	5	17.2	13	44.8	3	10.3	1	3.5	1	3.5	-	-
Total	338	40	11.8	23	6.8	11	3.3	11	3.3	8	2.4	4	1.2

5 services (4.4%). Three species have 6 services (0.9%) and only 1 species has 7 services (0.3%) (Figure 5).

Threats and Physical Defense

Four hundred and eleven species (75% of the total economic species), suffer from at least one type of threat. The stresses on the recorded species could be arranged in descending order: over-collecting and over-cutting > habitat loss > browsing and over grazing > clearance for agriculture > mining and quarrying > disturbance by cars or trampling. Threats to plants varied by habitat (Table 4). Browsing and grazing were highest in salt marshes. Over-collecting and over-cutting was highest in cultivated lands. Clearance for agriculture was highest in non-saline depressions. Habitat loss was highest in coastal dunes. Disturbance by cars was obviously highest along road sides. Mining and quarrying were highest threats in the inland plateau. Fifty three species were exposed to only 1 type of threat (12.9% of the total threatened species), 175 species to 2 threats (42.5%), 129 species to 3 threats (31.3%), 41 species to 4 threats (10%), 12 species to 5 threats (2.9%) and only 2 species have 6 types of threat (*Astragalus annularis* Forssk. and *Carduncellus eriocephalus* Boiss.) (Figure 6).

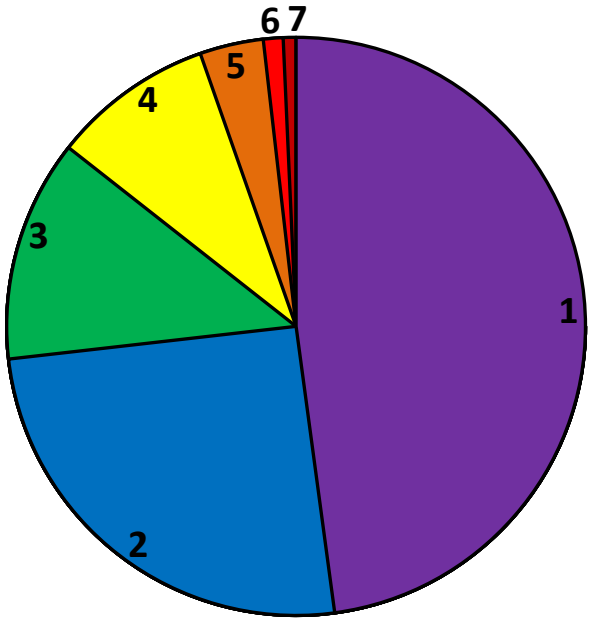

Figure 5. Frequency (%) of recorded species in the Western Mediterranean Desert, Egypt relative to the number of environmental services (1-7).

One hundred and twenty two species have some sort of physical defense (20.8% of the total species) (Table 5, Appendix 1). Group I had the highest relative number of species in wadis (Table 5).

Discussion

Medicinal goods

Local inhabitants in the southern Mediterranean region depend on folk medicine based on plants (Evans 1998, Khutb 1981). The trade of medicinal plants is an important source of economic income in this region. Some collectors receive high incomes through trade with herb dealers and druggists. The plant materials are then resold at higher prices to the consumers (e.g., *Seriphidium*

Table 4. Type of threats of the recorded species in the 13 habitats identified in the Western Mediterranean Desert, Egypt. Threats: Browsing and over grazing (BO); Over-collecting and over-cutting (OC); Clearance for agriculture (CA); Habitat loss (HL); Disturbance by cars or trampling (DT); and Mining and quarrying (MQ). Actual (Ac); and Relative percent (Re). The maximum relative values are in red.

Habitats	Total species	BO		OC		CA		HL		DT		MQ	
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re
Wadis	214	115	53.7	149	69.6	82	38.3	136	63.6	24	11.2	77	36.0
Non–saline depressions	180	95	52.8	115	63.9	81	45.0	113	62.8	20	11.1	82	45.6
Inland ridges	173	100	57.8	119	63.8	60	34.7	113	65.3	19	11.0	74	42.8
Coastal dunes	151	89	58.9	107	70.9	54	35.8	113	74.8	17	11.3	57	37.7
Road sides	140	76	54.3	91	65.0	49	35.0	91	65.0	27	19.3	50	35.7
Inland plateaus	116	66	56.9	83	71.6	41	35.3	69	59.5	13	11.2	73	62.9
Saline depressions	113	67	59.3	78	69.0	50	44.2	72	63.7	13	11.5	43	38.1
Lake Mariut	99	51	51.2	62	62.6	28	28.2	48	48.5	9	9.1	19	19.2
Cultivated lands	96	56	58.3	75	78.1	34	35.4	61	63.5	11	11.5	36	37.5
Summer resorts	71	40	56.3	44	62.0	9	12.7	45	63.4	7	9.9	16	22.5
Sand formation	49	29	59.2	36	73.5	14	28.6	32	65.3	8	16.3	23	46.9
Sallum plateau	38	22	57.9	28	73.7	18	47.4	21	55.3	7	18.4	19	50.0
Salt marshes	36	23	63.9	21	58.3	11	30.6	20	55.6	1	2.8	12	33.3
Total	411	196	47.7	267	65.0	134	32.6	260	63.3	36	8.8	131	31.9

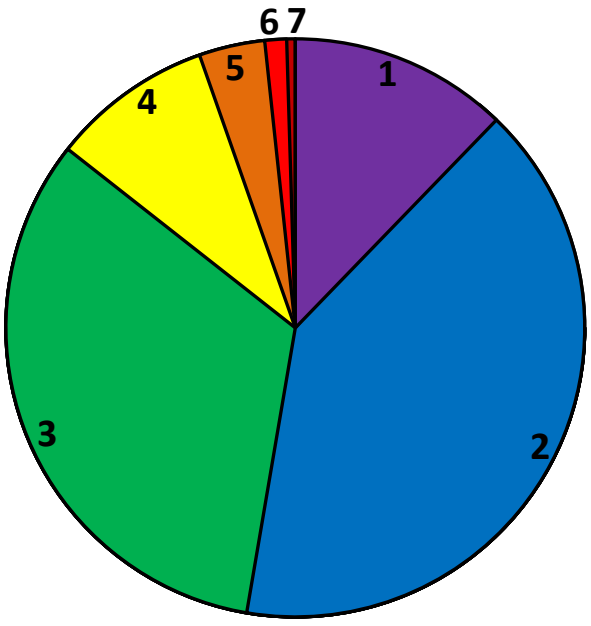

Figure 6. Frequency (%) of recorded species in the Western Mediterranean Desert, Egypt relative to the number of threats (1-7).

herba-alba (Asso) Soják and *Urginea maritima* (L.) Baker). Collecting medicinal plants is an occasional occupation for local people, supplementing regular occupations of farming, herding and trade. This study indicated that 66.6% of the total economic species have medicinal uses.

Eight of the 13 wild pharmaceutical plants in Egypt are present in the study area: *Ammi majus* L., *Ammi visnaga* (L.) Lam., *Citrullus colocynthis* (L.) Schrad., *Datura stramonium* L., *Hyoscyamus muticus* L., *Plantago ovata* Forssk., *Silybum marianum* (L.) Gaertn. and *U. maritima* (Batanouny 1999b). In addition, 14 of the medicinal plants in the study area are poisonous. Of these plants, *Euphorbia helioscopia* L. latex is antiscorbutic, while latex of *Euphorbia peplis* L. is used for chest diseases. A decoction of *Solanum nigrum* L. is used as wash for burns, as a vaginal injection, and a diluted berry infusion is used as a mydiatic eye lotion, as ear drops, and as an external emollient. Roots of *Withania somnifera* (L.) Dunal are used for treatment of rheumatic pains, as a hypotonic and calmative. Dried powdered roots are taken in small doses to treat female sterility. Leaves and fruits are used as a diuretic and antirheumatic (Boulos 1983).

Many other plants identified in this study are used by herbalists. A decoction of *Glaucium corniculatum* (L.) Rudolph aerial parts is used for arthritis (Al-Qura'n 2009). A decoction of *A. visnaga* flowers and seeds is used for kid-

Table 5. Variation in the physical defenses of the recorded species in relation to their habitats in the Western Mediterranean Desert, Egypt. Physical defenses: Hairy leathery leaves and hairy stems (I); Spiny organs (II); Hard woody branches with spine-like terminates (III); Sticky latex with unpleasant taste and odor (IV); Leathery leaves with unpleasant odor (V); and Hidden plants (occur under shrubs and rocks) (VI). Actual (Ac); and Relative percent (Re). The maximum relative values are in red.

Habitat	Total species	I		II		III		IV		V		VI	
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re
Wadis	58	26	44.8	20	34.5	3	5.2	8	13.8	5	8.6	2	3.4
Non–saline depressions	57	21	36.8	20	35.1	4	7.0	8	14.0	6	10.5	3	5.3
Coastal dunes	52	21	40.4	22	42.3	4	7.7	5	9.6	4	7.7	2	3.8
Road sides	50	16	32.0	22	44.0	3	6.0	5	10.0	6	12.0	2	4.0
Inland ridges	49	18	36.7	17	34.7	5	10.2	3	6.1	6	12.2	3	6.1
Inland plateaus	38	12	31.6	14	36.8	6	15.8	3	7.9	4	10.5	1	2.6
Lake Mariut	38	16	42.1	11	28.9	1	2.6	5	13.2	3	7.9	-	-
Summer resorts	37	14	37.8	7	18.9	1	2.7	9	24.3	5	13.5	2	5.4
Cultivated lands	34	13	38.2	13	38.2	1	2.9	3	8.8	3	8.8	3	8.8
Saline depressions	34	9	26.5	16	47.1	3	8.8	3	8.8	4	11.8	2	5.9
Sand formations	15	2	13.3	10	66.7	1	6.7	-	-	1	6.7	1	6.7
Salt marshes	11	4	36.4	5	45.5	2	18.2	1	9.1	-	-	-	-
Sallum plateau	9	2	22.2	4	44.4	-	-	2	22.2	1	11.1	1	11.1
Total	122	49	40.2	36	30.0	7	5.7	20	16.4	12	9.8	6	4.9

ney inflammation and the respiratory system (Hassan *et al*. 2006). Aerial parts of *Adiantum capillus-veneris* L. are used to treat coughs, tumors of spleen and liver, skin and inflammatory diseases (Singh *et al*. 2008). *Urtica urens* L. and *Urtica pilulifera* L. are used as expectorants, purgatives, diuretics, hemostatics, vermifuges and for treatment of eczema, rheumatism, hemorrhoids, hyperthyroidism and cancer (Kavalali *et al*. 2003). *Phragmites australis* (Cav.) Trin. ex Steud. is used for abscesses, arthritis, bronchitis, cancer, cholera, cough, diabetes, dropsy, dysuria, fever, gout, hematuria, hemorrhage, leukemia, nausea, rheumatism, sores, thirst and typhoid (Eid 2009).

Grazing goods

El-Kady (1987) reported that *Echiochilon fruticosum* Desf., *Plantago albicans* L., *Stipa lagascae* Roem. & Schult., *Deverra tortuosa* (Desf.) DC., *Helianthemum lippii* (L.) Dum. Cours., *S. herba-album* and *Gymnocarpos decandrus* Forssk. are palatable to domesticated animals in the study area. Range herbage resources are limited, fluctuating greatly in quantity and quality from year to year. Animal numbers have been allowed to increase, thus range land is deteriorating. Supplementary feed is used by stock owners, particularly to prepare animals for market (FAO 1980). In the study area, 63.7% of the total economic species are grazed and browsed by domestic and wild animals. For example, *P. australis* is considered to be a high quality livestock forage during early growth stages where it is eaten by cattle, goats, sheep and horses; but at maturity it becomes tough and unpalatable and livestock should be fed a protein supplement when grazing this grass (Ayyad 1998, Eid 2009). There are some examples of selective use of different plant organs at different seasons such as the small branches of *Tamarix nilotica* (Ehrenb.) Bunge which are apparently good for camels and goats, while sheep prefer its flowers only (Shaltout & Al-Sodany 2000). Halophytes are fodder for the livestock grazing on natural rangeland, especially for their high water content (60-75%) which can be a subsidiary water source during the dry period. Camels are most important of the livestock that use forage in salt marshes, followed by sheep and goats (Heneidy & Bidak 1996).

Human food goods

Fruits, flowers, vegetative and ground parts of 152 species are eaten by local inhabitants in the study area. For example fresh leaves and young shoots of *Malva parviflora* L. are cooked as a vegetable dish (Shaltout *et al*. 2010). Leaves and young shoots of *Rumex dentatus* L. are eaten raw or cooked, while the fresh leaves and stems of *Beta vulgaris* L. are eaten cooked as a stew/soup mixed with lentils. Fresh young shoots and leaves of *Portulaca oleracea* L. are eaten raw and as a salad or cooked as a vegetable dish (Al-Eiswi & Takruri 1989). The

fleshy young stems of *Sonchus asper* (L.) Hill. and *Sonchus oleraceus* L. are eaten raw. The soft fresh pods of *Vicia sativa* L. are also eaten raw, while the young leaves of *Cichorium endivia* L. subsp. *divaricatum* (Schousb.) P.D. Sell are eaten as a salad or cooked as a vegetable dish (Al-Eiswi & Takruri 1989). The underground parts of *P. australis* and *Typha domingensis* Pers. are sometimes eaten (Shaltout & Al-Sodany 2000), while *D. tortuosa* is eaten as a salad. *Colchicum ritchii* R. Br. is used as one of the numerous ingredients added to a beverage prepared from the rhizomes of *Glossostemon bruguieri* Desf., usually offered as a tonic on birth occasions in Egypt (Seif El-Nasr & Bidak 2005a).

Fuel and timber goods

Woody plants are the main source of fuel for the desert inhabitants. Le Houérou (1974) states that the minimal daily consumption of firewood is 1 kg of dry matter per person. Most of the shrubby species (e.g., *Thymelaea hirsuta* (L.) Endl., *Anabasis articulata* (Forssk.) Moq., *E. fruticosum*, *G. decandrus* and *Lycium europaeum* L.) are cut and harvested. Heneidy & El-Darier (1995) reported that the average amount of fuel wood collected by a household was about 29 kg/day, while the actual quantity used was about 24 kg/day (equal to 8.8 tons/year/household); the excess amount of about 5 kg/day represents a waste that should be controlled. In the present study, 86 woody perennials species (15.7% of the total economic species) are subjected to cutting for fuel. Local inhabitants usually use dry parts only; while travelers, workers or other transients cut green plants when they cannot find dry ones. The wood of *Acacia* trees seems to be the preferred fuel as it produces a strong heat and is slow burning comparing with other woody plants (Shaltout 1997). On the other hand, timber plants are limited all over Egypt. In the area of the present study, only 10 species (1.8% of the total economic species) are suitable as timber. These include *Phoenix dactylifera* L. and *Tamarix* trees (Heneidy & El-Darier 1995).

Other goods from wild plants

Over half of non-agricultural activities consist of processing agro-products and making traditional handicrafts. These are primarily produced by women for household consumption, but are sources of potential sales revenue. Tents and blankets are made exclusively for household use; while carpets, pillows, head covers and necklaces are sometimes sold (Seif El-Nasr & Bidak 2005a). In the present study, 105 species (19.2% of the total economic species) have multiple traditional uses. In northern Egypt, as in many parts of the world, the strong fibrous culms or leaves of *Cyperus alopecuroides* Rottb., *P. australis* and *T. domingensis* are used, in weaving mats, screens and chair-bottoms, in thatching and baskets, and in the construction of barrels and casks. The fine plush afforded by the hairs of female *Typha* flowers was formerly used in stuffing pillows (Sculthorpe 1985). Other species are used for making mats, ropes and baskets (e.g., *Juncus acutus* L. and *Juncus rigidus* Desf.). Some other species have an ornamental value such as *Ipomoea carnea* Jacq., *Glebionis coronaria* (L.) Cass. ex Spach and *Eichhornia crassipes* (Mart.) Solms; and in the manufacture of soap such as *Atriplex vestita* (Thunb.) Aellen var. *appendiculata* Aellen (Shaltout & Al-Sodany 2002).

Forty-five species are multipurpose. These include *Vachellia nilotica* (L.) P. Hurter & Mabb. which has an antifungal effect, is a valuable wood for house-beams, and has bark and leaves used medicinally in colds, opthalmia, diarrhea and hemorrhage (Ismail 2006). The fresh leaves of *A. vestita* are eaten raw or cooked as vegetables. Its roots are cut into narrow pieces used as tooth brushes, and the ash of the plant is rich in alkaline salts used for gastric acidity (Al-Eiswi & Takruri 1989). *Panicum turgidum* Forssk. is used as a vulnerary agent and for removing white spots on the eye. It is a good camel fodder and its grain is eaten by humans. Mats are made from its stiff straw and the plant is used as a thatch for desert shelters (Ayyad 1998). The wood of *P. dactylifera* is used as a tooth brush, and its terminal bud is used for intestinal hemorrhage and diarrhea. Dates are eaten raw and also used internally in medication designed to purge, to regulate the urine (Rizk & Al-Nowaihi 1989).

Phragmites australis has been cultivated and used for many purposes around the world. Ancient Egyptians used its stems as building materials for houses and rafts (Eid 2009). It is also used to make hand-made baskets. Its rhizome is used as a stomachic, antipyretic, and for pulmonary abscesses and food poisoning. Natives of South America used its stems for making arrow shafts, prayer sticks, weaving rods, pipe stems, mats, screens, nets and thatching; they also used the rootstocks and seeds as food. It is also used for lattices and in the construction of adobe huts (Eid 2009). *Sesbania sesban* (L.) Merr. is cultivated for shade and its leaves and young shoots are used as fodder. Its bark yields a useful fiber and the paste of fresh roots is a remedy for scorpion stings (Ayyad 1998).

Environmental services

Three hundred and thirty eight species provide at least one environmental service. Sand accumulators (*Ammophila arenaria* (L.) Link, *Nitraria retusa* (Forssk.) Asch., *Calligonum polygonoides* L. subsp. *comosum* (L' Hér.) Soskov, *Artemisia monosperma* Delile, *P. turgidum*, *Ricinus communis* L. and *Tamarix* trees), are species which deal with drifting sand. Sometimes they make efficient wind breaks that propagate themselves once established, either by seed or by creeping root systems. Some other species are especially useful in dealing with sand in the salt marshes (e.g., *Atriplex portulacoides* L., *Halocnemum strobilaceum* (Pall.) M. Bieb, *Juncus* species and *Zygophyllum album* L.). In the present study sand accumula-

tors had maximum contribution in the Western Mediterranean Desert due to the predominance of sandy soils that characterize this region (Shaltout & El-Ghareeb 1992). Most sand accumulators are phanerophytes and chamaephytes, which mainly inhabit the sand formations and salt marshes; they play an important role in preventing soil erosion, increasing soil deposition and improving drainage of low lands (Seif El-Nasr & Bidak 2005a).

Some of the small trees such as *Salix* and *Acacia* species have a bank holding qualities (i.e., bank retainers). The shade caused by them also keeps down the growth of weeds. Some bank retainers (e.g., *Arthrocnemum macrostachyum* (Moric.) C. Koch, *Suaeda vera* Forssk. ex J. F. Gmel., *Suaeda vermiculata* Forssk. ex. J. F. Gmel, *Suaeda pruinosa* Lange and *Halocnemum strobilaceum* (Pall.) M. Bieb) are suited to salty soil, while only a few (e.g., *Dysphania ambrosioides* (L.) Mosyakin & Clemants and *Panicum repens* L.) prefer agricultural soil. The manner in which they retain the soil differs in the various species (Simpson 1932). In some cases, the individuals have an intricate root system that holds the soil together (e.g., *Pluchea dioscoridis* (L.) DC., *Limbarda crithmoides* (L.) Dumort. and *Suaeda* species). In other cases, species form mats or clumps that prevent the surface of soil from being disturbed (e.g., *Arundo donax* L., *Cynodon dactylon* (L.) Pers., *Dichanthium annulatum* (Forssk.) Stapf and *Imperata cylindrica* (L.) Raeusch.).

Water invaders (sensu Simpson 1932) are land weeds that grow near water, usually with their root systems below water (i.e., helophytes sensu Raunkiaer 1937). The weed invades the water, either from the bank or from more or less shallow water, some are rooted at the normal water level and their stems and branches spread out over the water. Their structure does not permit them to continue spreading by shoots which arise from creeping roots or stems below the water unless the water is slow flowing or shallow (examples in the present study include are *Alternanthera sessilis* (L.) R. Br. ex DC., *Leptochloa fusca* (L.) Kunth., *Echinochloa stagnina* (Retz.) P. Beauv. and *Ludwigia adscendens* (L.) H. Hara subsp. *diffusa* (Forssk.) P.H. Raven). Others spread from submerged creeping root systems, some (e.g., *C. alopecuroides* and *T. domingensis*) only from rather shallow water. In the present study, most water invaders had higher occurrences in Lake Mariut.

The present study includes weed controllers such as *P. australis*, *Saccharum spontaneum* L. subsp. *aegyptiacum* (Willd.) Hack., *A. donax* and *P. dioscoridis*. They have robust growth that prevent the seeds of harmful weeds from getting a hold to crowd out weaker species. Certain species may smother other plants when they are in their young stages (e.g., when a large rosette of *S. marianum* leaves is formed). Quick-growing species forming mats (e.g., *Cyperus laevigatus* L., *Phyla nodiflora* (L.) Greene and *Trifolium resupinatum* L., soon cover a path of bare soil at the water level and stifle any seedling that may germinate.

Water purifiers are those species which had the ability to accumulate wastes from polluted water. Surface water pollution is the result of agro-industrial activities that lead to discharge of waste water into water bodies (Cook 1977, Fayed & Abd El-Shafy 1985). In the present study four species are recognized as purifiers of waste water: E. *crassipes*, *Ceratophyllum demersum* L., *T. domingensis* and *P. australis*. *Eichhornia crassipes* purifies waste water under arid climatic conditions where the mean temperature is always higher than 10 °C. It has a remarkable capacity to withstand effects of pH changes ranging from 3 to 8 in the aquatic environment. This plant adjusts the pH within 2 days except in water rich in iron due to the oxidative stress caused by this element (Jamil *et al*. 1987). Alvarado *et al*. (2008) reported the high arsenic removal efficiency of *E. crassipes* under favorable climatic conditions. It also removes up to 95% of Zinc and 84% of Chromium (Mishra & Tripathi 2009). In addition, *C. demersum* is a useful indicator of water pollution; it can trap macro- and micro–elements and accelerate the removal and biotransformation of herbicides from contaminated water (Zahran & Willis 2003). *Typha domingensis* (Lakshman 1979), among other emergent macrophytes, has considerable potential in purification of municipal waste waters within a reasonably short period. Gallardo-Williams *et al*. (2002) reported its ability of removal lead from contaminated waters.

Phragmites australis has had recent international attention about its capacity for constructing reed wetlands used for phytoremediation of water pollution. It is an ideal candidate for this process because it can form deep roots and hollow rhizomes supporting a great volume of active rhizosphere. Leakage of oxygen from the roots may create oxidized micro- zones that remove organic and suspended solids as well as nitrogen and phosphorus from waste water (Eid *et al*. 2010). Fortunately, the water purifiers in the present study occur in highest concentrations in Lake Mariut, which suffers from heavy loads of chemical pollutants from discharge of untreated domestic sewage and industrial effluents of Alexandria City (Shaltout *et al*. 2005).

Threats

Threats to the world's plants continue to increase as a result of human activities. Among the well-documented threats are habitat loss, invasive species, poor land management, over-collection, and climate change. Most studies suggest that the rate at which plant species are being lost, or at least reduced in numbers, is faster than the speed at which scientists; land managers, policy-makers, and others can, or will, respond. Four hundred and twelve species in the present study (70.2% of the total economic species) suffer from at least 1 type of threat, of which 196 species are subjected to over grazing. This is one of the

main land uses in the study area (Ayyad 1983). Unlike the impact of agriculture, which is very easy to observe even from a long distance (the complete removal of natural vegetation), the impact of grazing is more subtle, but is probably serious. Sheep and goats severely deplete natural vegetation and compete directly with native wildlife for the same food resources. Close examination of areas that appeared in good condition from a distance, revealed that only unpalatable woody perennials remain (e.g., *T. hirusta* and *A. monosperma*), while annuals were heavily grazed. Traditional pastoralism in the past was more limited than today because the human population was much smaller, and summer grazing opportunities were very limited (thus limiting the possibility of maintaining excessively large herds). Nowadays, the use of trucks has enabled local Bedouins to transport their herds from one grazing site to another at high speed, rapidly depleting grazing grounds in large areas. Supplementary food and water transportation by trucks make it possible to take herds to graze marginal habitats in distant localities (Seif El-Nasr & Bidak 2005a).

In the present study, 267 species are exposed to over-collecting and over-cutting by local inhabitants and herbalists. The collection of wild native medicinal plants for commercial trade has no regulation. The most serious aspect of this practice is the targeting of rare and localized plants damaging them further. In the study area, Heneidy (1991) and Heneidy & El-Darier (1995) recorded that human activities, such as clearing and wood cutting of natural vegetation, are more severe than over-grazing. Generally, crop expansion, over-grazing, and firewood collection are the most harmful, and are responsible for 80% of the havoc (Le Houèrou & Gillet 1990). There is an increasing demand by local Bedouin populations for fuel woods, targeting larger woody perennials. The most targeted are species that develop woody branches and roots. This demand is leading to notable degradation of habitats, particularly in localities distant from other sources of energy. The elimination of large woody perennials (which take many years to reach mature sizes) severely reduces the structural complexity of an already highly exposed environment, rapidly accelerating soil movement and erosion, reducing water retention potential and the chances of germination of annuals and smaller plants to become established.

One-hundred and thirty four species identified in the study area are damaged during agriculture processes. Perhaps the most serious threat in this region is the complete destruction of habitats caused by cultivation activities. Traditionally, the local inhabitants cultivated small areas of rainfed winter cereals, olives and figs. Today, with the growth of local populations and the introduction of modern machinery, almost all seemingly cultivable land receiving sufficient rain to grow a crop, is ploughed annually to cultivate winter cereals (mainly barley and wheat). The areas most intensively cultivated are those, which held prime habitats for biodiversity in the past. In general, the economic value of maintaining rangelands versus agriculture reclamation has not been adequately assessed. In the past; camels, donkeys and simple tools were used for plowing, which did not allow for the complete elimination of perennial vegetation or the destruction of areas with thick cover or with rocky substrates; leaving behind a network of natural vegetation patches. Modern machinery, however, indiscriminately and completely removes perennial shrubs, which provide complexity and shelter to wildlife. The processes used flatten the landscape, penetrating through areas previously difficult to cultivate with traditional technology. Plowing is taking place during winter and into early spring, and crops are harvested in late spring to early summer. The land lays barren and completely devoid throughout the rest of the year. This in turn means that grazing pressure is increasing dramatically in any remaining patches of natural habitat, as well as, in marginal areas not suited for cultivation. It is widely accepted that this fragile desert ecosystem is unable to sustain the intensive mono-cropping which causes depletion of soil nutrients and erosion (Seif El-Nasr & Bidak 2005a).

Two hundred and sixty species, in the study area are exposed to habitat loss. The urban expansion and tourism development has consumed large areas of the coastal strip between Alexandria and Mersa Matruh. Almost continuous tourist facilities occupy the coastline between Alexandria and Alamein, with plans to develop the rest of the coast in similar manner. A small portion of the coastal region west of Matruh has also started to be developed in recent years; this has not only led to the complete destruction of the habitats, but also the degradation of vast areas of habitat surrounding them. In addition, 131 species are damaged during the mining and quarrying activities. The rocky ridges parallel to the sand dune belt are subjected to severe quarrying for making limestone bricks. This has caused the eradication of the ridge in many sites resulting in loss of the associated wild life (Batanouny 1999a).

Roles of physical defenses

Relationships between physical defenses and the consumption rate of plants by herbivores are exceptionally complex. Some plants have defensive parts that reduce or avoid consumption by herbivores (Heneidy & Bidak 1999). Such defensive components (e.g., long spines of *Acacia* species) increase significantly more than other structural components (e.g., leaves and twigs), when the risk of damage by herbivores is highest in nutrient-rich habitats (Gowda *et al*. 2003). In the present study 6 groups of the physical defenses were recognized in 122 species. The largest one is the group of plants with hairy-leathery leaves or hairy stems and strong-fragrant odor (49 species including *Pseudognaphalium luteoalbum* (L.) Hilliard & B.L. Burtt, *Lotus halophilus* Boiss. & Spruner and *Plantago lagopus* L.). Some of these species have unpleasant smell and taste. Sometimes these parts re-

duce the palatability and therefore consumption by herbivores. Grime and Blyth (1969) reported that epidermal hairs reduce the palatability of range species or inhibit the passage of food through the gut of animals. In addition, Diaz & Cabido (2009) reported that hairy plants which characterize the Mediterranean region may be drought-tolerance adaptations. Perkins (2010) reported that the hairy plants could help in reflecting more sunlight, reducing detrimental heating of the plant.

The second group includes the plants with modified parts such as spines or spinescent branches and may be considered as grazing-resistant species (e.g., *Alhagi graecorum* Boiss., *S. marianum* and *J. acutus*). The third group has defensive parts in the form of densely woody pointed terminates or short spine-like branches (e.g., *Lycium* species). The defensive parts of this group (mostly shrubs or sub-shrubs) are acquired as a result of herbivores attack, whereas the defensive parts of the second group (plants with modified parts for protection) are already formed in the early stages of the plant life cycle. However, in many cases, the herbivores select or prefer to graze the defensive parts of the young plants; some other animals prefer these parts when the plant becomes mature. For example, the inflorescence of *Echinops spinosus* L. is completely protected by hard spines (involucres) that one cannot touch, while animals graze them and they seem highly palatable especially for camels and goats. This means that these defensive parts are not harmful for particular herbivores because most of mammalian herbivores learn to avoid harmful food based on odor and taste rather than appearance (Heneidy & Bidak 1999).

The fourth group is the plants that have sticky latex with unpleasant taste and odor. They seem to be toxic for livestock, but even some toxic plants, such as *H. muticus*, are grazed when they become dry. This finding is supported by the study of Launchbaugh & Provenza (1993) who recorded that mammalian herbivores can generalize the effect of a toxin from one food to another based on flavor. However, some poisonous species are eaten by livestock (Heneidy & Bidak 1999).

The fifth group has leathery leaves and unpleasant odor that reduces the consumption rate by herbivores and also may affect the palatability of these plants. Examples include *Achillea santolina* L., *Raphanus raphanistrum* L. subsp. *raphanistrum* L. and *Chiliadenus candicans* (Delile) Brullo.

The sixth group consists of hidden species. These do not appear to have any form of defense, but they are weak plants that occur under woody plants or rocks and hence are out of reach by grazing animals. Examples include *Hippocrepis areolata* Desv. and *R. dentatus* subsp. *dentatus*.

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Appendix 1. Goods, services, physical defense and threats of the common species in the Western Mediterranean desert of Egypt. Goods are: Grazing (**G**); Medicinal (**M**); Human food (**H**); Fuel (**F**); Timber (**T**); and Other uses (**O**). Services are: Sand accumulators (**Sa**); Soil fertility (**Sf**); Windbreaks (**Wb**); Bank retainers (**Br**); Shading (**Sh**); Refuge (**Re**); Esthetic concerns (**Ec**); Salinity tolerant (**St**); Weed controllers (**Wc**); Water purifiers (**Wp**); Water storage (**Ws**); and Invaders (**In**). Physical defense are: Species with hairy leathery leaves and hairy stems (**I**); Species with modified parts for protection (spiny organs) (**II**); Species acquired defensive parts as result of over grazing (**III**); Species with sticky latex with unpleasant taste and odor (**IV**); Species with leathery leaves with unpleasant odor (**V**); and Hidden plants (**VI**). Threats are: Browsing and over grazing (**B**); Over collecting and over cutting (**C**); Clearance for agriculture (**A**); Habitat loss (**L**); Disturbance by cars or trampling (**D**); and Mining and quarrying (**Q**).

Scientific name	Goods						Services	Physical defenses	Threats					
	G	M	H	F	T	O			B	C	A	L	D	Q
Phanerophytes														
Vachellia nilotica (L.) P. Hurter & Mabb.	G	M		F	T	O	Sa, Sf, Wb, Br		B	C				
Atriplex vestita (Thunb.) Aellen var. *appendiculata* Aellen	G	M	H			O	Sa, Sh, Wb, Re						D	
Calligonum polygonoides L. subsp. *comosum* (L' Hér.) Soskov	G	M		F	T		Sa, Sh, Wb, Re	III		C	A			Q
Convolvulus lanatus Vahl	G	M		F			Sa, Ec, Sh, Wb, Re	III		C	A			
Lycium europaeum L.	G	M	H	F	T		Sa, Sh, Wb, Sf, Ws, Re	III	B			L		Q
Lycium shawii Roem. & Schult.	G	M	H	F	T		Sa, Sh, Wb, Ws, Re	III	B			L		Q
Nitraria retusa (Forssk.) Asch.		M				O				C	A			
Phoenix dactylifera L.	G	M	H	F	T	O	Ec							
Pluchea dioscoridis (L.) DC.		M				O	Wc	I		C	A		D	
Ricinus communis L.		M	H	F		O	Wb	III		C				
Sesbania sesban (L.) Merr.	G	M		F	T	O	Sh	III	B	C				Q
Tamarix nilotica (Ehrenb.) Bunge				F	T	O	Sa, Wb, Ws, Re			C		L	D	
Thymelaea hirsuta (L.) Endl.	G	M		F		O	Sa, Sh, Wb, Re		B	C	A	L	D	
Chamaephytes														
Anabasis articulata (Forssk.) Moq.	G	M		F		O	Sa, Wb, Sh, Re		B	C	A		D	Q
Arthrocnemum macrostachyum (Moric.) C. Koch	G			F		O	Sa, Sh, Wb, Re, St, Wc, Br		B	C	A			
Atriplex portulacoides L.	G						Sa		B		A			
Chiliadenus candicans (Delile) Brullo	G	M					Sa, Ec	V		C	A	L		
Deverra tortuosa (Desf.) DC.	G	M	H	F		O	Sa, Ec, Wb, Ws, Re							
Dysphania ambrosioides (L.) Mosyakin & Clemants	G						Br, Wc	V	B		A			
Echiochilon fruticosum Desf.	G			F			Sa, Wb, Ec, Re		B	C	A	L	D	
Gymnocarpos decandrus Forssk.	G	M		F			Sa, Sh, Wb, Ws, Re			C	A			
Halocnemum strobilaceum (Pall.) M. Bieb	G	M		F		O	Sa, Wb, Re, Br, St		B	C				
Helianthemum lippii (L.) Dum. Cours.	G	M		F			Sa, Wb, Ec		B	C				Q

Scientific name	Goods						Services	Physical defenses	Threats					
	G	M	H	F	T	O			B	C	A	L	D	Q
Hippocrepis areolata Desv.	G	M					Sa, Sf	VI		C		L		
Ipomoea carnea Jacq.	G		H					III						
Limbarda crithmoides (L.) Dumort.		M					Br			C	A	L		
*Seriphidium herba-al*ba (Asso) Soják	G	M	H	F		O	Sa			C		L		Q
Solanum nigrum L.		M	H				Sa					L		
Suaeda pruinosa Lange	G	M				O	Sa, Wb, Ws, Br							
Suaeda vera Forssk. ex J. F. Gmel.	G	M				O	Sa, Wb, Ws, St, Br					L		
Suaeda vermiculata Forssk. ex. J. F. Gmel	G						Br		B		A			Q
Withania somnifera (L.) Dunal		M						I						
Zygophyllum album L.	G	M				O	Sa, Wb, Ws, St					L		Q
Hemicryptophytes														
Adiantum capillus-veneris L.		M												
Alhagi graecorum Boiss.	G	M	H	F		O	Sa, Wb, Sf	II						
Artemisia monosperma Delile	G	M				O	Sa	I				L	D	
Citrullus colocynthis (L.) Schrad.	G	M					Sa, Sh, Re			C	A	L		Q
Echinops spinosus L.	G	M		F			Sa, Wb, Ws, Re	II	B			L		
Haplophyllum tuberculatum (Forssk.) A. Juss.		M		F		O	Sa, Wb, Ec	IV, V		C	A	L		
Hyoscyamus muticus L.		M				O	Sa, Wb, Ws	IV, V		C		L		
Launaea nudicaulis (L.) Hook. f.	G	M				O	Sa, Ec	VI	B			L		Q
Phyla nodiflora (L.) Greene	G						Wc	I	B					
Plantago albicans L.	G		H											
Silene succulenta Forssk.	G						Ws	I	B		A	L		
Silybum marianum (L.) Gaertn.	G	M	H				Sa, Wb, Ws, Re, Wc	II	B	C				
Stipa lagascae Roem. & Schult.	G								B					Q
Geo-Helophytes														
Ammophila arenaria (L.) Link	G		H	F			Sa, Sh, Wb			C		L		Q
Arundo donax L.	G			F			Wc		B	C		L		
Colchicum ritchii R. Br.		M	H			O	Sa, Ec			C		L		
Cynodon dactylon (L.) Pers.	G	M	H	F			Sa, Sh, Re							
Cyperus alopecuroides Rottb.	G					O	In					L		
Cyperus laevigatus L. var. *laevigatus* L.	G						Wc		B			L	D	Q
Imperata cylindrica (L.) Raeusch.	G	M				O	Sa, Wb							
Juncus acutus L. subsp. *acutus* L.	G	M				O	Sa, Wb, St	II	B	C				
Juncus rigidus Desf.	G	M				O	Wb, St	II	B	C				
Leptochloa fusca (L.) Kunth.							In					L		Q
Panicum repens L.	G	M	H				Br							
Panicum turgidum Forssk.	G	M	H			O	Sa			C		L		

Scientific name	Goods						Services	Physical defenses	Threats					
	G	M	H	F	T	O			B	C	A	L	D	Q
Phragmites australis (Cav.) Trin. ex Steud. subsp. *australis* (Cav.) Trin. ex Steud.	G	M	H	F		O	Sa, Wb, Ws, Wp, In							
Saccharum spontaneum L. subsp. *aegyptiacum* (Willd.) Hack.	G	M					Wc, Sa, Wb			C		L		
Typha domingensis Pers.	G	M	H			O	Sa, Wb, St, Wp		B	C	A	L		
Urginea maritima (L.) Baker		M					Sa, Sh, Ec, Re			C	A	L		
Hydrophytes														
Ceratophyllum demersum L.	G	M					Wp							
Eichhornia crassipes (Mart.) Solms	G					O	Wp							
Ludwigia adscendens (L.) H. Hara subsp. *diffusa* (Forssk.) P.H. Raven							In							
Therophytes														
Achillea santolina L.	G	M		F			Sa, Sh, Ec	V	B			L		
Adonis persica Boiss.	G	M				O	Sa, Ec	V	B	C			D	Q
Althaea ludwigii L.	G						In		B		A			
Ammi majus L.			H											
Ammi visnaga (L.) Lam.	G	M					Sa			C	A	L		
Astragalus annularis Forssk.	G	M					Sa, Sf		B	C	A	L	D	Q
Bassia indica (Wight) A.J. Scott	G	M					Sa, Sh	I	B	C				
Carduncellus eriocephalus Boiss.	G	M					Sa, Sh, Ec	II						
Cichorium endivia L. subsp. *divaricatum* (Schousb.) P.D. Sell		M	H					I	B	C		L		
Datura stramonium L.		M				O	Sa	II	B		A	L		Q
Dichanthium annulatum (Forssk.) Stapf	G						Br							
Echinochloa stagnina (Retz.) P. Beauv.	G						In							
Euphorbia peplis L.		M					Sa	IV		C		L		
Euphorbia helioscopia L.		M					Sa	IV		C		L	D	
Fumaria parviflora Lam.	G	M					Sa				A	L		
Glaucium corniculatum (L.) Rudolph subsp. *corniculatum* (L.) Rudolph		M												
Glebionis coronaria (L.) Cass. ex Spach		M	H			O	Sa, Wb			C	A	L		
Lotus halophilus Boiss. & Spruner var. *halophilus* Boiss. & Spruner	G							I	B		A	L		Q
Malva parviflora L.	G	M	H				Sa							
Plantago lagopus L.		M	H					I						
Plantago ovata Forssk.	G	M				O	Sa		B	C		L		
Portulaca oleracea L.	G	M	H					IV	B	C	A			
Pseudognaphalium luteoalbum (L.) Hilliard & B.L. Burtt		M						I						
Ranunculus sceleratus L.		M						IV		C				
Raphanus raphanistrum L. subsp. *raphanistrum* L.		M	H					V		C				

Scientific name	Goods						Services	Physical defenses	Threats					
	G	M	H	F	T	O			B	C	A	L	D	Q
Rumex dentatus L. subsp, *dentatus* L.	G	M	H					VI	B	C				
Silene villosa Forssk. var. *villosa* Forssk.		M					Sa	I, V		C		L		
Sonchus asper (L.) Hill. subsp. *asper* (L.) Hill.	G		H					IV	B		A			
Trifolium resupinatum L.	G						Wc, Sf		B		A	L		Q
Urtica pilulifera L.			H					I						
Urtica urens L.		M					Sa	I		C				