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Journal of Threatened Taxa

Building evidence for conservation globally

www.threatenedtaxa.org

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

ARTICLE

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26 February 2017 | Vol. 9| No. 2 | Pp. 9777–9785
10.11609/jott.3364.9.2.9777-9785

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Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2017 | 9(2): 9777–9785

Flora richness as an indicator of desert habitat quality in Kuwait

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ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

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Abstract: An assessment of the vegetation in the arid desert habitats of Kuwait was carried out in 2008 and 2009. The richness of vegetation was examined in relation to human activity (e.g., grazing, recreational camping) and impact factors in two open areas (north of SAANR, NS; south of Kabd, SK) were compared with two protected areas (SAANR, Kabd). In total, 420 quadrats were sampled along 84 transects at random locations along off-road vehicle tracks in the study area. The data were classified using two-way indicator species analysis (TWINSPAN) to divide samples into three groups of high internal similarity in terms of plant species presence. Total plant species richness was 20, 35, 2 and 17 species per area in SAANR, Kabd, NS and SK, respectively. Compared to protected areas, open grazed land had markedly fewer species and reduced vegetation cover in the form of grasses, forbs and shrubs. Habitat conditions were especially impoverished in NS, with 99% of samples supporting only one plant species. The low plant diversity in the unprotected open rangelands demonstrates the need for a new strategy to rehabilitate ecological habitats.

Keywords: Biodiversity, camping, desertification, grazing, protected area, rangeland.

Abbreviation: SAANR - Sabah Al-Ahmed Natural Reserve; PA - Protected area; NS - North of Sabah Al-Ahmed Natural Reserve; SK - South of Kabd Scientific Research Station.

Arabic Abstract:

الخلاصة: أجري تقييم الغطاء النباتي في الموائل الصحراوية القاحلة في الكويت في عامي 2008 2009. تم فحص ثراء الغطاء النباتي وعلاقة الأنشطة البشرية (مثل: الرعي، والتخييم الترفيهي) وعوامل تأثيرها في منطقتين مفتوحين (شمال محمية صباح الأحمد الطبيعية، جنوب محمية كبد) مقارنة مع منطقتين محميتين (محمية صباح الأحمد الطبيعية، محمية كبد)، وذلك من خلال أخذ 420 عينة، تم أخذها على طول 84 مقطع عرضي في مواقع عشوائية على جانبي مسار المركبات على الطرق الوعرة في منطقة الدراسة. تم تصنيف البيانات باستخدام مؤشر تحليل الأنواع ثنائي الإتجاه لتقسيم العينات إلى ثلاث مجموعات من التشابه الداخلي العالي من حيث وجود الأنواع النباتية. بلغ ثراء الأنواع النباتية 20، 35، 2 و17 نوعا في محمية صباح الأحمد الطبيعية، محمية كبد، شمال محمية صباح الأحمد الطبيعية وجنوب محمية كبد على التوالي. بالمقارنة مع المنطقتين المحميتين، اتسمت المنطقتين المفتوحتين بقلة الأنواع بشكل ملحوظ وانخفاض الغطاء النباتي في الأعشاب والنباتات ذات الأوراق العريضة والشجيرات. حالة الموائل كانت فقيرة وخاصة في شمال محمية صباح الأحمد الطبيعية، حيث أن 99٪ من العينات احتوت على نوع نباتي واحد فقط. إن انخفاض التنوع النباتي في المراعي المفتوحة غير المحمية يدل على الحاجة إلى استراتيجية جديدة لإعادة تأهيل الموائل البيئية.

DOI: http://doi.org/10.11609/jott.3364.9.2.9777-9785

Editor: Merlin Franco, Curtin University, Malaysia. **Date of publication:** 26 February 2017 (online & print)

Manuscript details: Ms # 3364 | Received 27 April 2016 | Final received 26 January 2017 | Finally accepted 31 January 2017

Citation: Al-Shehabi, Y. & K. Murphy (2017). Flora richness as an indicator of desert habitat quality in Kuwait. *Journal of Threatened Taxa* 9(2): 9777–9785; http://doi.org/10.11609/jott.3364.9.2.9777-9785

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Funding: Self-funded.

Conflict of Interest: The authors declare no competing interests.

For **Author Details** and **Author Contribution:** see end of this article.

Acknowledgements: We wish to thank all our colleagues; Mr. Sham Davande for the help during the studies, and Dr. M. Zafar-ul Islam (Research Coordinator at the National Wildlife Research Center, Taif, Saudi Arabia) for editing the manuscript. Professors Dan Haydon and Pat Monaghan (University of Glasgow) co-supervised the study.

INTRODUCTION

Plant cover is strongly influenced by the geomorphological characteristics, soil and climate of a region. Kuwait mostly comprises a flat, low-lying sandy, arid landscape characterized by four ecological systems: (i) sand dune, (ii) salt marsh and saline depression, (iii) desert plain, and (iv) desert plateau (Daoud & Al-Rawi 1985; El-Shora & Jasim 1996). In this study vegetation was sampled in the desert plain ecosystem which occupies the greater part of the country and contains three main communities: (i) Cyperus Steppe, (ii) Rhanterium Steppe, and (iii) Haloxylon Steppe (Halwagy & Halwagy 1974). The vegetation is categorized by a few grasses and herbs, and short scattered shrubs. Halwagy & Halwagy (1974) described the vegetation of Kuwait "as a poor open scrub of under-shrubs, perennial herbs and ephemerals". They added that tall shrubs are restricted to favourable sites where they grow to 'about a man's height'.

Previous studies on the flora of Kuwait have revealed 374 native and adapted plant species in 55 families, of which 256 (68.4%) are annuals, 34 (9.1%) are shrub, under-shrub and tall shrubs such as *Lycium shawii* (0.3%), and 83 (22.2%) are herbaceous perennials (Boulos & Al-Dosari 1994). Dickson (1955) classified Kuwait vegetation cover into four plant communities, and subsequently five plant communities were recognized in Kuwait (Kernick 1966; Halwagy & Halwagy 1974). More recently, Omar et al. (2001) defined eight dominant plant communities by integrating soil and vegetation information using a GIS study. The original dominant plant species are being replaced by secondary dominant plant species due to overgrazing, quarrying and other ecological disturbances (Omar et al. 2000).

Both the distribution and abundance of dominant perennial shrubs have declined, being replaced by grassy and annual plants, or spiny species (Halwagy & Halwagy 1974; Omar et al. 2000). A rangeland in Kuwait will reach the climax ecosystem when it is mostly occupied by *Rhanterum epapposum* or *Haloxylon salicornicum* perennials (both are small woody shrubs). When growth of *Cyperus conglomeratus* (short thin grassy perennial plant species) dominates an area rangeland is said to reach its mid-level succession stage, which is somewhat palatable for grazing animals. Rangeland reaches a bad condition when there is an abundance of *Cornulaca* species (very spiny leafless plant) and/or annual forbs, while the lowest level stage of succession is bare ground (Omar et al. 2000).

In Kuwait, natural vegetation cover was seriously degraded in large areas of desert habitats by the early 1990s (Khalaf & Al-Ajmi 1993) and became an indicator of land degradation (Al-Awadhi et al. 2003). Natural vegetation covers less than 10% of many land areas in Kuwait (Al-Awadhi et al. 2003). Intensive human activities combined with fragile ecological conditions accelerated environmental degradation. The rate of desertification is approximately 285km^2 per year (Al-Awadhi et al. 2003) and average width of annual sand drift rate is 20m^3 across one meter land width (Khalaf & Al-Ajmi 1993). El-Sheikh and Abbadi (2004) found 139 plant species belonging to 32 families in Sabah Al-Ahmed Natural Reserve (SAANR). SAANR includes rare and endangered plant species (Daoud & Al-Rawi 1985; Bolous & Al-Dosari 1994; El-Sheikh & Abbadi 2004). In addition, it includes one individual of *Acacia pachyceras* which was the only tree species occurring in Kuwait until 85 years ago (Omar et al. 2005).

Objectives

This study aimed to :

(i) identify the richness of plant species in protected and unprotected areas of Kuwaiti desert habitats;

(ii) quantify the habitat quality of protected and unprotected areas; and

(iii) evaluate the effect of human activity factors (e.g., grazing, recreational camping) on desert habitat ecology and its vegetation richness.

METHODS

Study sites

The study sites were located in protected and unprotected areas in northern and western Kuwait and surveyed during December 2008–January 2009. Two protected areas were selected: Sabah Al-Ahmed Natural Reserve (SAANR: 330km^2 in the north), and Kabd Scientific Research Station (Kabd: 40km^2 in the west); similar adjacent open, unprotected areas, labelled "North of Sabah Al-Ahmed Natural Reserve" (NS: 80km^2), "South of Kabd Scientific Research Station" (SK: 40km^2); were studied for comparison with the protected areas (Fig. 1).

The unprotected lands are used as rangeland areas; NS and SK were both characterized by sparse bushy and grassy desert plants. The vegetation was sampled by identifying 84 transects at random locations adjacent to roads in the study area (Images 1 & 2). Random numbers (5–25 m left or right hand) were previously acquired by random number generation, using MS Excel. For

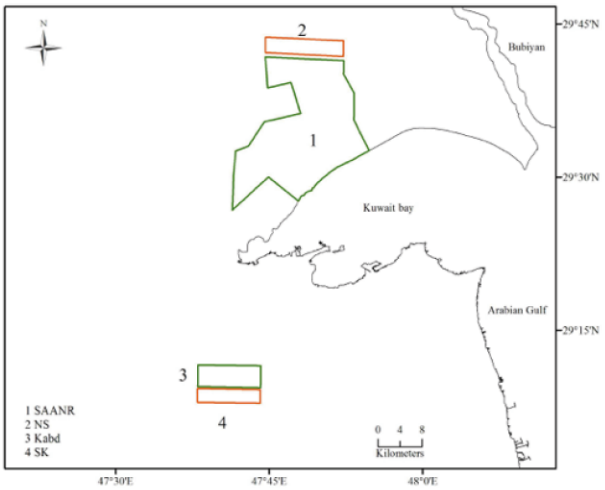

Figure 1. Kuwait Map; 1 - SAANR PA; 2 - NS; 3 - Kabd PA; 4 - SK

each transect, 5 quadrats (1x1 m) were laid out along a transect distance of 5–25 m from either the left or right hand side of the road. Thus there were 105 quadrats in each area, giving a total of 420 quadrats (Image 3). Vegetation data including density and percentage cover were estimated visually within each quadrat.

Statistical Analysis

Species percentage frequency of occurrence within the five quadrats making up each transect sample was calculated. Percentage frequency of plant species per transect sample was as follows: zero (not present in any one out of five quadrats), 20% (present in one out of five quadrats), 40% (present in two out of five quadrats), 60% (present in three out of five quadrats), 80% (present in four out of five quadrats) and 100% (present in all five quadrats). Two-way indicator species analysis (TWINSPAN for Windows 2.3) was used to classify the 84 transects samples. Cut-off levels for the analysis were selected to give 4 pseudo-species: 1(20%F), 2 (40%F), 3 (60%F) and 4 (≥60%F). Otherwise a default analysis was selected.

Image 1. Habitats of unprotected areaa: North of Sabah Al-Ahmed Natural Reserve (NS), South of Kabd Scientific Research Station (SK).

Image 2. Existing roads were used to sample vegetation in each surveyed area

Image 3. Vegetation sampling in unprotected areas NS and SK

RESULTS

In total, 46 plant species from 20 families were identified from the transect sample sites within the study areas (Table 1). Diversity of plant species was very low in unprotected areas in comparison to protected areas (Fig. 2). In unprotected areas (NS and SK) number of individuals (N) was 59 and 325 compared to 842 and 2014 in protected areas (SAANR and Kabd). Compositae and Leguminosae formed the most common families in the studied areas, constituting to 10 (21.7%) and 5 (10.9%) of the total plant species respectively.

Families and species represent the total numbers which were seen within 105 quadrats randomly chosen in each area. SAANR protected area showed richness of species and families more than 10 times that of NS unprotected area, whereas Kabd protected area showed twice the richness of SK unprotected area (Table 2).

SK was totally devoid of shrubs while NS contained only one species of shrub, *Haloxylon salicornicum* (Fig.3). The presence of *Cornulaca aucheri* (a spiny unpalatable plant species) in SK (open area) was an indicator of its poor range land habitat. The most commonly encountered species in SK were annual species which have a short lifespan, and they did not form a stable community. Protected areas were characterized by the presence of stable habitat communities such as Haloxyletum (*Haloxylon salicornicum*) and Stipagrostietum (*Stipagrostis plumosa*). Also, tree species *Lycium shawii* and a shrub species *Rhanterium epapposum* were only seen in protected areas. The former was seen in SAANR while the latter was seen in Kabd. Furthermore, five rare species: *Helianthemum kahiricum*, *Gagea reticulata*, *Allium sindjarensis*. *Rhanterium epapposum*, and *Sclerocephalus arabicus* were seen in protected areas but absent from open areas. *Rhanterium epapposum* was a rare shrub species in open areas and its distribution low.

In addition to rare species, some medicinal species were identified that are of scientific as well as economic value (Abbas & Alsaleh 2002). SAANR and Kabd protected areas both together accounted for 11 medicinal species. Three of these species were seen in open areas: *Haloxylon salicornicum, Plantago boissieri, Moltikiopsis ciliate,* but with lower abundance and usually stunted growth. A grass species, *Stipagrostis plumosa*, was the only common species that was present in open as well as protected areas.

Shrub, grass and herb species represent the total numbers observed within 105 quadrats randomly chosen in each area. Shrub species in SAANR protected area were five times higher than in NS unprotected area. In SK unprotected area, shrub species were absent. Absence of annuals in NS reflects the status of the soil in this habitat (Fig. 4). Its soil is very compacted and not suitable for annual species to grow. Annual species richness in SAANR and Kabd protected areas were 12 and two times higher than NS and SK unprotected areas

Table 1. Plant species occurrence in protected areas and unprotected areas.

Species name	Recorded in
Aeluropus littoralis (Gouan) Parl.	SK
Allium sindjarensis	SAANR, Kabd
Arnebia decumbens (Vent.) Coss. & Kralik	SAANR, SK, Kabd
Asphodelus tenuifolius Cav.	Kabd
Astragalus annularis Forssk.	SAANR, SK, Kabd
Astragalus corrugatus Bertol.	SAANR, Kabd
Astragalus hauarensis Boiss.	Kabd
Astragalus spinosus (Forssk.) Muschl.	SAANR
Brassica tournefortii Gouan	SK, Kabd
Cakile Arabica Velen.	Kabd
Calendula arvensis M. Bieb.	Kabd
Carduus pycnocephalus L.	SK, Kabd
Cornulaca aucheri Moq.	SK
Cressa cretica L.	Kabd
Crucianella membranacea Boiss.	Kabd
Cyperus conglomeratus Rottb.	SK, Kabd
Emex spinosa (L.) Campd.	SAANR
Fagonia bruguieri DC.	SAANR, Kabd
Gagea reticulata (Pall.) Schult. & Schult.f.	Kabd
Gymnarrhena micrantha Desf.	SK
Gymnocarpos sclerocephalus (Decne.) Dahlgren & Thulin	SAANR
Gynandrisis sisyrinchium	SK, Kabd
Haloxylon salicornicum (Moq.) Bunge ex Boiss.	SAANR, NS
Helianthemum kahiricum Delile	SAANR
Ifloga spicata (Forssk.) Sch.Bip.	SAANR, SK, Kabd
Koelpinia linearis Pall.	Kabd
Lappula spinocarpos (Forssk.) Asch. ex Kuntze	SK,Kabd
Launaea capitata (Spreng.) Dandy	SAANR
Launaea mucronata (Forssk.) Muschl.	SAANR
Lomelosia olivieri (Coult.) Greuter & Burdet	Kabd
Lotus halophilus Boiss. & Spruner	SK,Kabd
Lycium shawii Roem. & Schult.	SAANR
Malva parviflora L.	SAANR, Kabd
Moltkiopsis ciliata	SAANR, SK, Kabd
Neurada procumbens L.	SAANR, SK, Kabd
Picris babylonica Hand.-Mazz.	Kabd
Plantago boissieri Hausskn. & Bornm.	SAANR, SK, Kabd
Reseda muricata C. Presl	Kabd
Rhanterium epapposum Oliv.	Kabd
Rumex vesicarius L.	Kabd
Salsola imbricata Forssk.	Kabd
Savignya parviflora (Delile) Webb	Kabd
Schismus barbatus (L.) Thell.	SAANR, SK, Kabd
Senecio glaucus L.	Kabd
Stipagrostis plumosa Munro ex T. Anderson	SAANR, NS, SK, Kabd
Trigonella anguina Delile	Kabd

Table 2. Total plant species richness and Shannon-Wiener index of diversity (H') in protected areas and unprotected areas.

Name	Species richness	Shannon-Wiener Diversity Index (H')
SAANR	20	1.75
NS	2	0.15
Kabd	35	2.30
SK	17	1.81

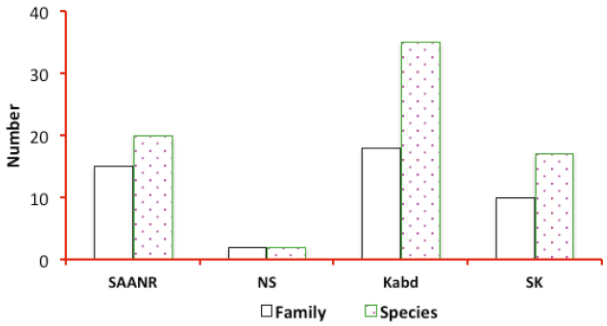

Figure 2. Plant species diversity in unprotected and protected areas.

respectively. Likewise, perennial species richness in SAANR and Kabd protected areas were also four and two times higher than NS and SK unprotected areas, respectively. NS fared the worst, with no annual species and only two perennial plant species. Most perennial plant species were grazed or in bad condition and plying of off-road trucks prevented growth of annual plant species.

One way ANOVA testing showed a significant difference in number of individual plants in a quadrat within these sites: P value <0.0001, F= 68.51, df= 3. Height of vegetation was significantly different between open areas and protected areas. It was very short in both open areas NS (3.4±0.6 cm) and SK (1.5±0.4 cm) in comparison with protected areas SAANR (12.3±1 cm) and Kabd (20±2.2 cm). One way ANOVA testing showed a significant difference in height of plants within these sites: P value <0.0001, F= 36.69, df= 3.

Classifying the sites using TWINSPAN (Fig. 5) produced three main sample-groups: labelled A, B

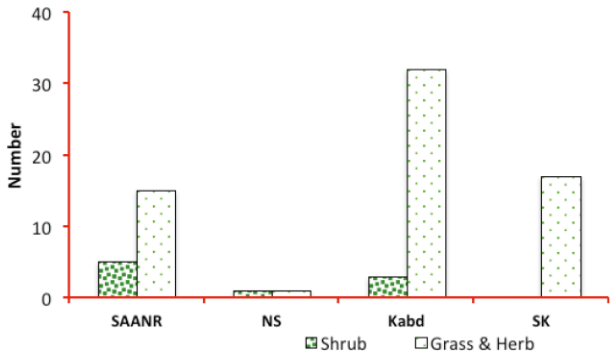

Figure 3. The number of species of shrubs and of grass and herbs in unprotected and protected areas.

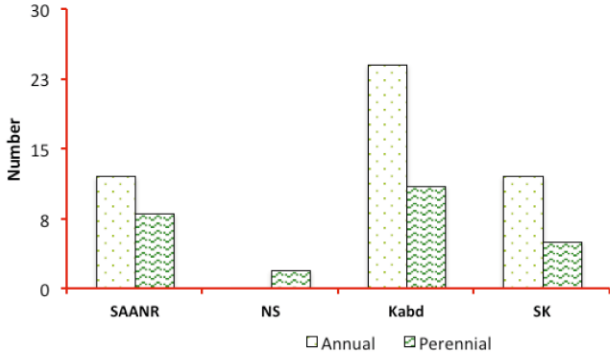

Figure 4. Number of annual and perennial plant species recorded in unprotected and protected areas.

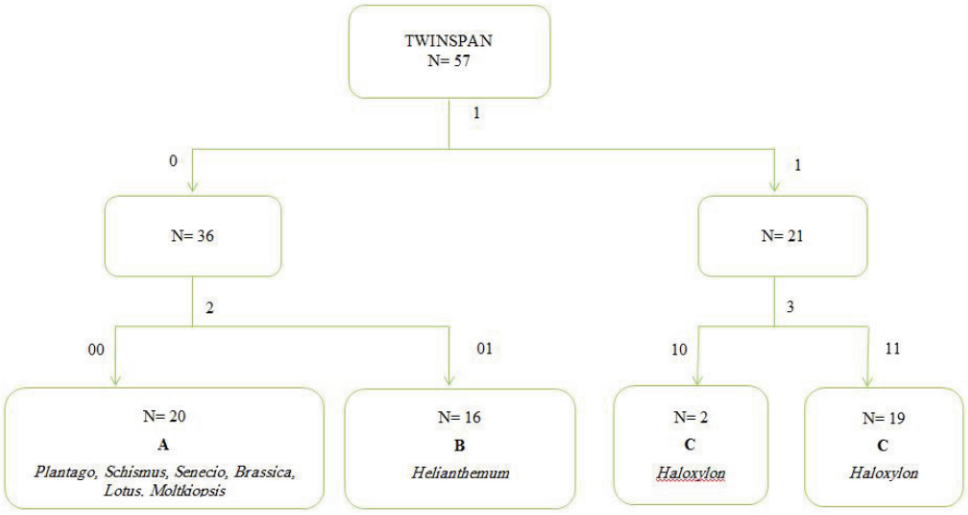

Figure 5. TWINSPAN sample end-groups A–C for the dataset, showing indicator species.

and C. Group C (n = 21 transect samples) was strongly separated from the remainder of the data set at the first hierarchical division (eigenvalue: 0.858), and supported a very species-poor flora, with a maximum of four species in two of the samples, and only one species (the indicator for the sample-group: *Haloxylon*) at nearly all the rest. The majority of the samples were from NS (unprotected), but three were from within the nearby protected SAANR area. This sample group clearly shows close correspondence to the *Haloxylon* plant community known to exist in the area, and appears to be a characteristic feature of heavily disturbed open rangeland vegetation. Groups A (n= 20 transect samples) and B (n= 16 transect samples) separated at the second level of the classification hierarchy, again with a high eigenvalue (0.618) for the division, suggesting a clear separation of the vegetation types represented in samples present in the two groups.

Group B had a diversity intermediate between A and C, and was indicated by *Helianthemum*, which was present at moderate to high abundance in all but one of the transect samples comprising the sample-group. *Stipagrostis* was present at high abundance in 50% of transects making up this group, but *Cyperus* was completely absent, it is likely that this sample group represents a sub-community of the known *Stipagrostis* plant community present in the region. All samples in this group were from the protected SAANR area. Group A had by far the highest plant diversity, and supported a large number of species not found in transects comprising groups B or C (Image 4). It was indicated by the abundant presence of *Plantago*, together with *Schismus*: both plant species were uncommon or absent at other sites. Either one or both of *Cyperus* and *Stipagrostis* were usually present in transects comprising group A, so it is probable that these samples represent a sub-community of the known *Stipagrostis-Cyperus* plant community present in the area. Samples were all from

Image 4. The effect of camping recreational activity on vegetation cover in desert lands of Kuwait.

protected areas, comprising all of the Kabd transects and a number of those collected from SAANR.

DISCUSSION

Floral richness in the study areas was less than expected from previous studies (Boulos & Al-Dosari 1994; Omar et al. 2005). Species richness in Kuwait may however fluctuate significantly from year to year, as is observed in other desert lands. In desert ecology meteorological variables, especially the amount and time of rainfall, triggers germination of annual species (Went 1955; Bowers 1987). Most plants in Kuwait are annual species. Consequently, low average rainfall influenced the floral richness and coverage. Furthermore, the present study was conducted in the early season December to January prior to climax growth of vegetation.

It is clear from the results that floral richness can be used as an indicator of healthy habitats within Kuwait's desert ecosystem. Our results also confirm the findings of Al-Awadi et al. (2003) that vegetation can be used as an indicator of land degradation. Both *Rhanterium epapposum* and *Haloxylon salicornicum* are important dwarf shrubs which help stabilize Kuwaiti desert ecosystems by trapping windblown sand, helping to promote species diversity (Brown & Porembski 1997).

Our results showed a remarkable succession of range land in open areas: NS and SK. Rare and palatable plant species are facing a very high threat of extinction in open areas due to land degradation. In this study *Rhanterium epapposum* was absent in SAANR, which matched the findings of El-Sheikh & Abbadi (2004), although this species is recorded in the SAANR area by others (Boulos & Al-Dosari 1994; Omar et al. 2000). The presence of *Rhanterium epapposum* in Kabd was very low and restricted to limited localized areas. This coincides with the results of Brown (2003), who found its cover to be less than 2%.

Overgrazing depletes the potential ability of habitats to renew their vegetation. Furthermore, off-road driving destroys large areas of open range lands where seeds are unable to germinate due to compacted or disturbed soils. In NS, annual plants were totally absent due to compacted soils as a result of long-term use of land by off-road vehicles. On the other hand, SK has more annual plants than NS. Loose texture of SK soils and presence of some recreation camping fences provide a better chance for annual plants to grow, while the compacted gravel soil texture of NS makes it hard for these plants to germinate and grow.

Plant species in SK were limited and did not offer stable micro habitats. It is difficult to find non-grazed or healthy plant communities in unprotected areas. An overgrazing effect was obvious on vegetation and its species diversity. Overgrazing indicator species such as *Cornulaca aucheri*, *Salsola imbricata* and *Citrullus colocynthis* have been observed in abundance in the south Kabd area. Open areas were characterized by short height, less vegetation cover and fewer plant species in comparison to protected areas. About 60 % of desert land is occupied for this purpose every year in Kuwait (Environment Public Authority 2003) from November to April (Fig. 9). This causes considerable disturbance to plant communities and to other wildlife.

CONCLUSION

Vegetation is a powerful indicator of land degradation in Kuwait, and the richness of plant species is limited by land degradation. The abundance of plant families and species was 2–10 times higher in protected areas versus open areas. The richest open area (SK) contained 50% of total flora species richness, while the worst open area (NS) had less than 10%. This remarkable variance shows the important role of protected areas in preserving Kuwait's desert flora.

Significant difference of vegetation cover and its component species between protected and unprotected areas require decision makers to develop a national strategy to preserve ecosystems. Open areas need some powerful regulations to reduce their degradation. For example the coverage area of *Rhanterium epapposum* has declined from 30% (1974) to 2% (2001) due to excessive grazing and land degradation (Omar & Bhat 2008). Hence, legislation regulating camping, grazing and other damaging human activities should be revised and enforced to conserve open access areas. Premature death of plants will reduce numbers and population recovery (Brown 2001). Extensive degradation will need prolonged and intensive remediation, especially in dry environments and shallow soils (Brown 2003). Consequently, desertification is irreversible without replanting even after 25 years of total protection (Le HoueHrou 1996). Open rangelands demand a new strategy to rehabilitate ecological habitats.

REFERENCES

Abbas, J.A. & F.A. Saleh (2002). *Medicinal Plants of Bahrain*. University of Bahrain, Kingdom of Bahrain, 290pp.

Al-Awadhi, J.M., R.F. Misak & S.A. Omar (2003). Causes and sequences of desertification in Kuwait: a case study of land degradation. Bulletin of Engineering Geology and the Environment 62: 107–115; http://doi.org/10.1007/s10064-002-0175-0

Boulos, L. & M. Al-Dosari (1994). Checklist of the flora of Kuwait. *The Journal of the University of Kuwait* 21: 203–218; http://doi.org/10.1371/journal.pone.0076588

Bowers, M.A. (1987). Precipitation and the relative abundance of desert winter annuals: a six year study in the northern Mojave desert. *Journal of Arid Environments* 12: 141–149.

Brown, G. (2003). Species Richness, Diversity and Biomass Production of Desert Annuals in an ungrazed *Rhanterium epapposum* community over Three Growth Seasons in Kuwait. *Plant Ecology* 165: 53–68; http://doi.org/10.1006/jare.2001.0880

Brown, G. & S. Porembski (1997). The maintenance of species diversity by miniature dunes in a sand-depleted *Haloxylon salicornicum* community in Kuwait. *Journal of Arid Environments* 37: 461–473; http://doi.org/10.1006/jare.1997.0286

Daoud, H.S. & A. Al-Rawi (1985). *The Flora of Kuwait: Dicotyledoneae. Volume 1*. KPI Publishers, London.

Dickson, V. (1955). *The Wild Flowers of Kuwait and Bahrain*. Allen and Unwin, UK, 120pp.

El-Sheikh, M. & G. Abbadi (2004). Biodiversity of plant Communities in the Jal Az-Zor National Park, Kuwait. *Kuwait Journal of Science & Engineering* 31: 77–105.

El-Shora, H. & R. Jasim (1996). *Ecological Science and Desert Plants*. Science Department, Faculty of Fundamental Education, Kuwait, 320pp.

Environment Public Authority (2003). *The Environmental Strategy of the State of Kuwait*. Part I. Al Riyadi Press, Kuwait, 682pp.

Halwagy, R. & M. Halwagy (1974). Ecological studies on the desert of Kuwait. II. The Vegetation. *Journal of The University of Kuwait (Sci.)* 1: 87–95.

Kassas, M. & M. Imam (1954). Habitat and plant communities in the Egyptian Desert. III. The wadi-bed ecosystem. *Journal of Ecology* 42: 424-441.

Kernick M.D. (1966). Plant resources, range ecology and fodder plant introduction. Report to the Government of Kuwait. FAO, TA 181. Memo. 14pp.

Khalaf, F.I. & D. Al-Ajmi (1993). Aeolian processes and sand encroachment problems in Kuwait. *Geomorphology* 6: 111–134; http://doi.org/10.1016/0169-555X(93)90042-Z

Le HoueHrou, H.N. (1996). Climate change, drought and desertification. *Journal of Arid Environments* 34: 133–185; http://doi.org/10.1006/jare.1996.0099

Omar, S.A., Y. Al-Mutawa & S. Zaman (2000). *Vegetation of Kuwait: A Comprehensive Illustrative Guide to the Flora and Ecology of the Desert of Kuwait*. 1st Edition. KISR, Kuwait, 159pp.

Omar, S.A., Y. Al-Mutawa & S. Zaman (2005). *Vegetation of Kuwait: A Comprehensive Illustrative Guide to the Flora and Ecology of the Desert of Kuwait*. 2nd Edition. KISR, Kuwait, 163pp.

Omar, S.A. & N.R. Bhat (2008). Alteration of the *Rhanterium*

epapposum plant community in Kuwait and restoration measures. *International Journal of Environmental Studies* 65(1): 139–155; http://doi.org/10.1080/00207230701823332

Omar, S.A., R. Misak, P. King, S. Shahid, H. Abo-Rizq, G. Grealish & W. Roy (2001). Mapping the vegetation of Kuwait through reconnaissance soil survey. *Journal of Arid Environments* 48: 341–355; http://doi.org/10.1006/jare.2000.0740

Went, F.W. (1955). The ecology of desert plants. *Scientific American* 192: 68–75.

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Author Contribution: YAl-S did the main scientific research paper including the field survey and plant species identification and writing the manuscript. KM was the main supervisor during the analysis and reforming the results of the research and helped me to do the TWINSPAN analysis.

Journal of Threatened Taxa

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ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

February 2017 | Vol. 9 | No. 2 | Pages: 9777–9884
Date of Publication: 26 February 2017 (Online & Print)
DOI: 10.11609/jott.2017.9.2.9777-9884
www.threatenedtaxa.org

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