Journal of Forest Science
Vol. 25, No. 1, pp. 49~55, April 2009

Analysis of Some Desert Ecosystems Vegetation in Abu Dhabi Emirate, United Arab Emirates. Effect of Land Use

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ABSTRACT : The present study analyses the effect of land use on the vegetation of some desert ecosystems in Abu Dhabi, United Arab Emirates (UAE). Three sites were selected to represent different types of land use, inside Umm Al-Banadeq forest, outside the forest and along Abu Dhabi-Al Ain Trucks Road. In total, fifty-two stands were examined; including a matrix of 14 species x 52 stands. Based on species cover data, stands were classified using TWINSPAN and ordinated using DCA. Four vegetation groups were generated at level three of classification. *Zygophyllum mandavillei* was dominant in most vegetation groups; *Heliotropium bacciferum* dominated vegetation groups inhabited the forest. Species richness, species turnover, relative evenness and relative concentration of dominance of forest vegetation groups were 2.8, 5.7, 0.7, and 2.0, respectively. The differences were attributed to both natural variability and forestry-induced changes, including change in land use, drainage and ploughing and shading by trees. Vegetation group inhabited Abu Dhabi-Al Ain Trucks Road, that were dominated by *Haloxylon salicornicum* and *Zygophyllum mandavillei* have high total cover (8.8 m per m^{-1}). Most community and vegetation attributes were significantly higher inside the forest than outside. Human interventions and environmental factors affected species diversity and abundance of these communities.

Keywords : Desert, Land use, UAE, Vegetation

INTRODUCTION

Human impact has been recognized as the most important influence on the composition of the flora and vegetation during the last 5000 years. The world landscapes are now occupied by man-dominated (and in part man-created) floras. Man has been the primary agent in the creation of the new plant communities (Anderson, 1956). The impact has been the dominant factor in the arid environment of the world, particularly, the deserts of Middle East for thousands of years (Zohary, 1983). Studies on vegetation analysis of the United Arab Emirates (UAE) and the effect of land use (e.g. grazing, urbanization and afforestation) seem to be limited.

Vesey-Fitzgerald (1957) reported basic information on the vegetation of the Middle East and the Arabian Peninsula. Satchell (1978) briefly presented notes on the different habitats of the UAE. While El-Ghonemy (1985) described the climate, topography and soil of Al-Ain oasis, and gave a short account of the main plant communities and a detailed description of the monocotyledons taxa of that part of UAE. More recently, Al-Ansari and El-Keblawy (2003) and Mousa (2005) studied the vegetation of selected sites across the UAE. The present study aims at the evaluating the effect of different types of land use and human impact (grazing, afforestation and urbanization) on the vegetation and floral diversity and assess the most suitable conditions that maximize diversity and increase the productivity of rangelands of the westen region of Abu Dhabi Emirate.

MATERIALS AND METHODS

Study area

The study area lies in the western part of Abu Dhabi

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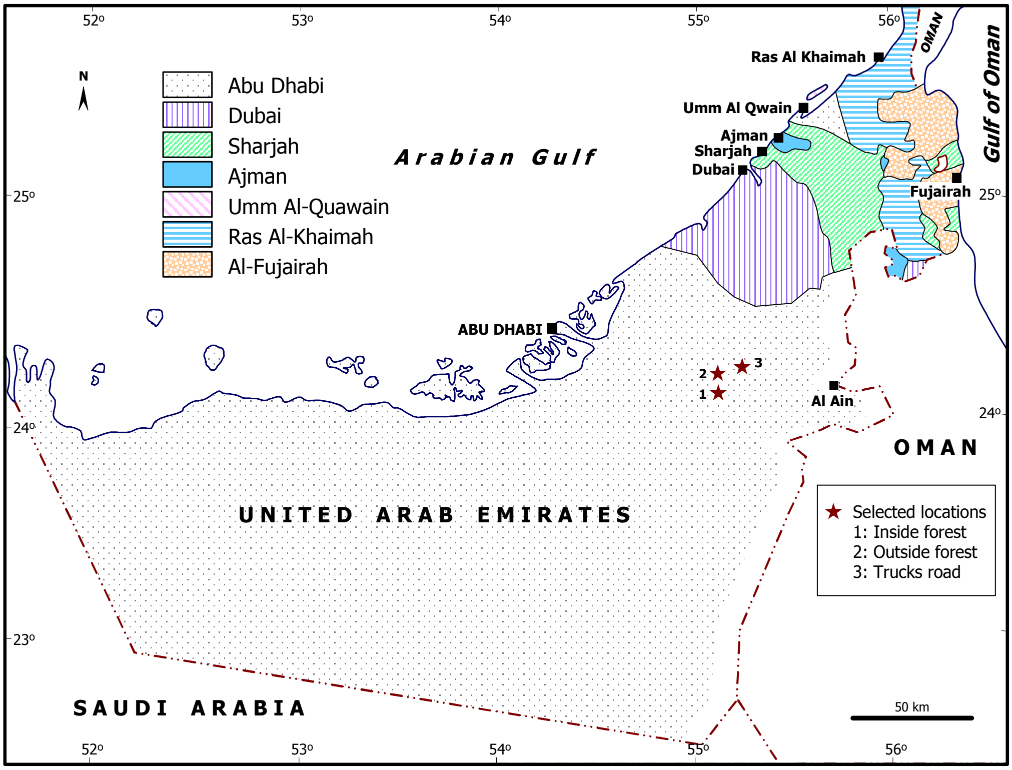

Fig. 1. Map of the United Arab Emirates showing the study area.

Emirate between 23° and 25° latitude and 54° and 56° longitudes (Figure 1). Semi-mobile dunes are the dominant visual feature, with a relatively high water table resulting in evaporative crusts in many depressions, referred to locally as Sabkhas. As along the coastal region, these inland sabkhas may hold surface water for many weeks after winter rains. While the dunes become increasingly stable further north and inland from the coastal lowlands, they remain high in the east (up to Al Hajjar Mountains). Limestone outcrops of the Simsima and Hawasima formations occur in a thin line running north from Al Ain, though many of these are virtually covered with wind-blown sand as at Jebel Mahijir near Al Hair and at Qarn bint Saud. The sands remain fairly well demarcated between the coastal oolitics and the inland Aeolian.

Sampling design

Fifty-two stands were selected in three sites in the study area to represent the main types of human impact and land use, inside Umm Al Banadeq forest (afforestation, protection and drop irrigation), outside the forest (overgrazing) and along Abu Dhabi Al Ain trucks road (urbanization). In each site, list of species was made in each stand indicating the first and second dominant species during the period from summer 2004 to winter 2005. In each stand, presence percentage regarding the duration of the species in habitats was calculated. Species nomenclature was according to Mandaville (1990). The species cover with significant occurrence in the sampled stands was estimated in spring using the line-intercept method (Canfield, 1941). Three to five parallel lines, each of 20 m long, were stretched in each stand. The lengths of the intercept of each species in a stand were measured to the nearest cm. These lengths were then summed and related to the total length of the lines stretched in that stand. The cover was expressed as m $(100\ m)^{-1}$. Estimation was used to calculate the relative cover of species, which in turn was used as a measure for their importance value. Density of the plant populations was measured by quadrate method. Twenty-five randomly located quadrats (1×1 meter each) were laid down in each stand. In each quadrate, the number of individuals per species was counted and the ratio between the total number of individuals and total number of quadrats was calculated as the absolute density per m². Absolute frequency was calculated as the ratio between the total numbers of quadrats in which the species occurred to the total number of quadrats.

Data analysis

TWINSPAN and DECORANA were applied to the matrix of cover estimates of 97 species in 615 stands using the methodology and software reported by Hill (1979a, b). Species richness (SR) of each vegetation group was calculated as the average number of species per stand. Species turnover (ST; beta diversity) was calculated as the ratio between the total number of species recorded in a certain vegetation cluster and its alpha-diversity (Whittaker, 1972). Shannon-Wiener index ($H' = -\sum P_i \log P_i$) and Simpson index ($C = \sum P_i^2$) were calculated for each vegetation group on the basis of relative cover (P_i) of species (Magurran 1988). The variation in vegetation variables in relation to sites were assessed using one-way analysis of variance (ANOVA). The probable environmental significance of the DECORANA axes 1 and 2 were investigated by the simple linear correlation analysis and the forward selection of stepwise multiple regression. Chi-square and ANOVA tests were used to compare population variables in different sites (Nie et al., 2001).

RESULTS

Multivariate analysis

Using TWINSPAN four main vegetation groups were recognized at level three of classification: *Heliotropium bacciferum* (group I), *Heliotropium bacciferum - Zygophyllum mandavillei* (group II) inside the forest, *Haloxylon salicornicum - Zygophyllum mandavillei* (group III) grew along AbuDhabi-Al Ain trucks road and *Zygophyllum mandavillei - Cyperus conglomeratus* (group IV) inside the free grazing area (Figure 2). The ordinations of these groups show clear segregation along DECORANA axes.

Community and vegetation attributes

The number of species was greater inside the forest (12 species) than along trucks road (7 species) (Table 1). Among the recorded species *Cyperus conglomeratus*, *Dipterygium*

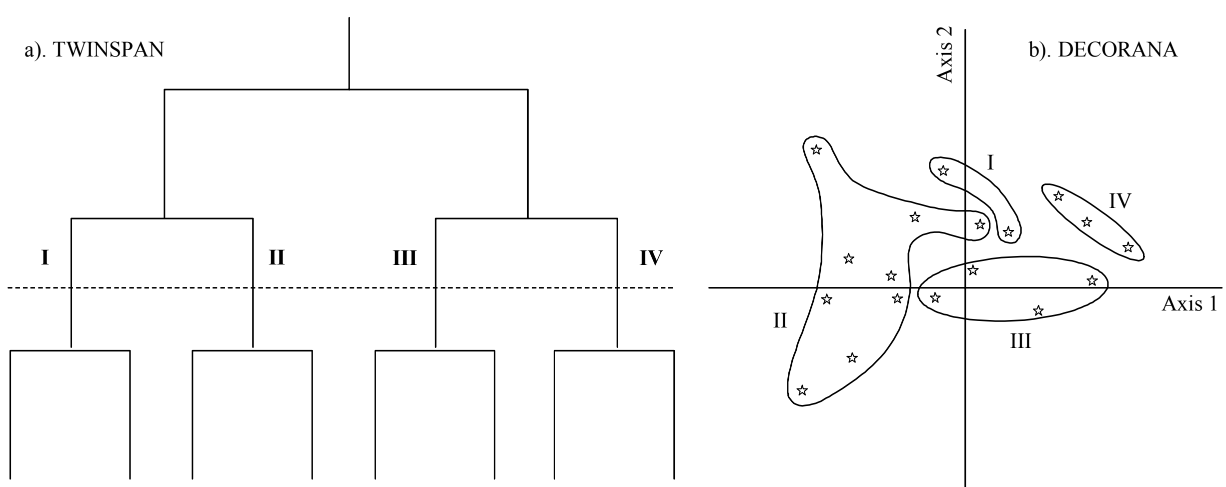

Fig. 2. The relationship between the four vegetation groups segregated after the application of TWINSPAN classification technique (a), and their centroides on the first and second axes of DECORANA (b). *Heliotropium bacciferum* (group I), *Heliotropium bacciferum - Zygophyllum mandavillei* (group II), *Haloxylon salicornicum - Zygophyllum mandavillei* (group III), *Zygophyllum mandavillei - Cyperus conglomeratus* (group IV)

Table 1. Variation in some plant community attributes (mean±stander deviation) of the recorded species inside forest, outside forest and along Abu Dhabi Al Ain trucks road.

Community attributes	Inside forest	Outside forest	Trucks road	F-value
Total species††	12	3	7	81.0***
Species richness‡	2.8±1.4	1.8±0.9	3.2±0.9	3.50*
Species turnover‡	5.7±3.4	2.1±1.0	2.5±0.8	10.50***
Relative evenness‡	0.7±0.5	0.2±0.2	0.9±0.2	9.50***
Relative concentration of dominance‡	2.0±0.9	1.1±0.2	2.2±0.5	6.80**
Total cover (m $(100\ m)^{-1}$)‡	2.1±1.6	7.1±8.2	8.8±5.4	2.20
Total density (indv. $(100\ m^2)^{-1}$)‡	18.6±16.5	30.6±16.2	20.3±16.2	11.30***

††Tested by χ^2.
‡Tested by ANOVA.
*, **, ***: Significant at 5, 1 and 0.1%, respectively.

Table 2. Number (N) and presence (%) of the recorded species inside forest, outside forest and along Abu Dhabi Al Ain trucks road.

Species	Inside forest		Outside forest		Trucks road		p value of χ^2
	N	P (%)	N	P (%)	N	P (%)	
Cyperus conglomeratus	8	26.7	5	50	5	41.7	ns
Dipterygium glaucum	6	20.0	3	30	5	41.7	ns
Zygophyllum mandavillei	19	63.3	10	100	12	100	ns
Heliotropium digynum	10	33.3			2	16.7	
Leptadinea pyrotechnica	1	r†			1	8.3	
Pennisetum divisum	7	23.3			1	8.3	
Aerva javanica	1	r					
Cistanche tubulosa	1	r					
Cornulaca monacantha	1	r					
Fagonia indica	4	13.3					
Heliotropium bacciferum	25	83.3					
Panicum turgidum	1	r					
Haloxylon salicornicum					12	100	

†< 5%.

glaucum and *Zygophyllum mandavillei* were recorded in all sites (Table 2). *Haloxylon salicornicum* was recorded only along trucks road and 6 species recorded only inside the forest: *Aerva javanica*, *Cistanche tubulosa*, *Cornulaca monacantha*, *Fagonia indica*, *Heliotropium bacciferum* and *Panicum turgidum*. Species richness (3.2), relative evenness (0.9) and relative concentration of dominance (2.2) were higher along trucks road than outside the forest (1.8, 0.2 and 1.1 respectively). Total cover was higher along trucks road (8.8%) than inside the forest (2.1%) while total density was higher outside the forest (30.6 $(100\ m^2)^{-1}$) than inside (18.6 $(100\ m^2)^{-1}$). All variations in community attributes due to land use were significant at $p<0.05$ (Table 1).

Species frequency

The overall variation in species number as a result of land use was insignificant. *Heliotropium bacciferum* and *Zygophyllum mandavillei* had the highest frequency inside the forest (83.3 and 63.3%; Table 2). *Zygophyllum mandavillei* had the highest frequency outside the forest (100%).

Haloxylon salicornicum and *Zygophyllum mandavillei* had the highest frequency along trucks road (100%). *Aerva javanica*, *Cistanche tubulosa*, *Cornulaca monacantha*, *Panicum turgidum* and *Leptadinea pyrotechnica* were recorded as rare species, with low frequency percentages (< 5%).

Absolute and relative cover

Results of one way ANOVA showed that variation in cover of two of the three overlapped species due to land use were significant ($p<0.05$). *Cyperus conglomeratus* had more cover (11%) outside forest than inside (2.1%) (Table 3). *Dipterygium glaucum* had more cover outside forest (4.5%) than along trucks road (2.8%). *Zygophyllum mandavillei* had more cover outside forest (6.5%) than inside (1%). *Haloxylon salicornicum* had the highest cover along trucks road (47.4%).

Absolute and relative density

Results of one way ANOVA showed that variation in density of two of the three overlapped species due to land use were significant. *Cyperus conglomeratus* had a higher density (7.2 indv $(100\ m^2)^{-1}$) outside the forest than inside (1.0; Table 4). *Dipterygium glaucum* had a higher density along trucks road (2.2 indv $(100\ m^2)^{-1}$) than inside the forest (1.0) and *Zygophyllum mandavillei* had a higher density outside forest (26.5 indv $(100\ m^2)^{-1}$) than inside (11.9). *Haloxylon salicornicum* had the highest density along trucks road (11.9 indv $(100\ m^2)^{-1}$).

DISCUSSION

The low species diversity inside the forest may be attributed to the effect of protection as well as the hand removal of some of the native flora manually hindered an accurate assessment of diversity. The dominance of *Zygophyllum mandavillei* populations in all sites reflects its capacity to grow at different levels of disturbances. The increase in population and the increasing demand on meat and milk products, coupled with decreasing pastureland, or loss of rain have all worsened the situation. Unfortunately, the degradation has led to serious problem of biodiversity loss. Therefore, overgrazing has decreased the chance of plants growing, to flower and produce enough seeds to spread and germinate from year to year.

Table 3. Absolute (AC: m $(100\ m)^{-1}$) and relative cover (RC: %) of the recorded species inside forest, outside forest and along Abu Dhabi Al Ain trucks road.

Species	Inside forest		Outside forest		Trucks road		F-value
	AC	RC	AC	RC	AC	RC	
Cyperus conglomeratus	0.2	2.1	0.9	11.0	0.3	2.8	3.65*
Dipterygium glaucum	0.3	3.2	0.4	4.5	0.3	2.8	0.38
Zygophyllum mandavillei	1.0	11.9	6.5	84.9	2.9	26.1	6.50**
Heliotropium digynum	0.5	5.7			0.3	2.7	
Leptadinea pyrotechnica	1.7	20.2			1.5	13.3	
Pennisetum divisum	0.3	3.2			0.6	4.9	
Aerva javanica	0.5	6.0					
Cistanche tubulosa	0.1	0.6					
Cornulaca monacantha	1.5	17.9					
Fagonia indica	0.4	4.8					
Heliotropium bacciferum	1.1	12.9					
Panicum turgidum	1.0	11.9					
Haloxylon salicornicum		RC			5.3	47.4	

*, ***:Significant at 5 and 0.1%, respectively.

Table 4 Absolute (AD: indv (100 $m^2)^{-1}$) and relative density (RD: %) of the recorded species inside forest, outside forest and along Abu Dhabi Al Ain trucks road.

Species	Inside forest		Outside forest		Trucks road		F-value
	AD	RD	AD	RD	AD	RD	
Cyperus conglomeratus	1.0	2.0	7.2	20.3	1.8	6.9	3.3*
Dipterygium glaucum	1.0	2.0	1.7	4.7	2.2	8.4	2.9
Zygophyllum mandavillei	11.9	24.0	26.5	74.9	6.3	23.9	8.0***
Heliotropium digynum	2.6	5.2	.		2.0	7.6	
Leptadinea pyrotechnica	1.0	2.0	.		1.0	3.8	
Pennisetum divisum	11.1	22.5	.		1.0	3.8	
Aerva javanica	1.0	2.0	.		.		
Cistanche tubulosa	1.0	2.0	.		.		
Cornulaca monacantha	1.0	2.0	.		.		
Fagonia indica	10.3	20.7	.		.		
Heliotropium bacciferum	6.8	13.6	.		.		
Panicum turgidum	1.0	2.0	.		.		
Haloxylon salicornicum	.		.		11.9	45.5	

*, ***:Significant at 5 and 0.1%, respectively.

As a result species may decline and become rare or even totally disappear. An imbalance in the species dominance and thus in the ecosystem (Thalen, 1979) may be a disastrous outcome. The greater perennial species richness in the quadrats protected from intense grazing in the present study, supports the suggestion by Shaltout et al. (1996) that heavy grazing over extended periods results in the creation of monospecific stands. Shaltout et al. (1996) found that the percent cover, on desert rangelands protected from grazing, increased after only one or two seasons. The difference between percent cover on grazed and protected areas was much greater on sand than on gravel (Oatham et al., 1995). Here, we used both landscape and vegetation classification, to establish the relations between human impact and vegetation. The advantage is to extract useful information on the value of landscape surveying on biodiversity estimation, and to use plant species as indicators of landscape change (El-Kady, 1987). Diverse land unit groups are identified, according to human impact processes and structural landscape variation. These classes of land units correlate with specific plant communities that are recognized from the phytosociological analysis.

CONCLUSION

Desert ecosystems in the western region of Abu Dhabi (UAE) has been subjected to different types of human impacts (e.g. afforestation, grazing and urbanization), leading to the loss of biodiversity. The different land use schemes discussed above have specific associated plant species with little overlap. Afforestation in the UAE, for instance, could be used as conservation attempts for the benefit of many native plant species, provided that human interventions inside these forests are minimized. Overgrazing, on the other hand, destroys the main range plants outside the forest. Along trucks road new communities appeared as a result of protection (fencing along most major roads) and seed dispersal.

ACKNOWLEDGEMENT

The author would thanks Mr. Hamdi Kandil for drawing the figures and his help in typing the manuscript and Mr. Salah el-Shereif for help in field trips and data collection.

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