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Artificial Forest Ecosystems of the UAE Are Hot Spots for Plant Species

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Abstract: Desert and artificial forest ecosystems are important components of the UAE Environment. Additionally, these ecosystems sustain a large number of livestock and wildlife populations. An artificial forest was selected to study some attributes of plant communities. The forest had an area grazed by Arabian Oryx, where the rest was protected from grazing. Soils data showed that soil samples from areas dominated by *Acacia tortillis* and *Prosopis cineraria* had the highest levels of Organic Matter (0.78% and 0.75%, respectively) (not a suitable place to put soil analysis here). While soil samples from areas dominated by *Ziziphus* species recorded the lowest rate of Organic Matter (0.36%). In general terms, grazing resulted in a significant deterioration in species diversity. Shannon-Wiener index value in the protected area (0.67) was greater than in the grazed area (0.46) by 45%. For the chemical analyses and gas production data obtained from the three sampling periods, only four out of the total number of plants has showed high nutritive values.

Key words: Biodiversity % camel % desert % UAE

INTRODUCTION

Various artificial forests are being erected to support wildlife populations in the UAE. These forests could play an important role in relatively sustaining wildlife species that are becoming threatened in the wild. An increased understanding of the impacts of such wildlife species on natural plant communities would facilitate their introduction to the wild, when possible. Overgrazing has been considered as one of the most critical aspects of wildlife as well livestock species impacts on plant diversity in the Arab countries [1]. In a research project funded by the Research Council of UAE University, one investigator [2] assessed the effects of grazing and human disturbances on plant communities in the UAE by comparing some community attributes inside and outside protected sites in two regions of Abu Dhabi Emirate. The protection resulted in significant increases in total number of species, species diversity, species richness and plant density and cover.

Testing the nutritional values of these species is needed if the aim was to sustain wildlife and native livestock species. The indigenous rangeland plants that are adapted to the harsh arid environment represent a valuable genetic and economic resource that may be of great economic value in the future to the UAE and other countries in the region. So far, the natural cycle of regeneration of rangeland vegetation has been disrupted by uncontrolled heavy grazing pressures, particularly during the sensitive periods of the reproductive cycle such as flowering.

The loss of vegetation always results in soil erosion and loss of wildlife habitat and food resources. The indigenous rangeland herbs, shrubs and trees represent a valuable genetic and economic resource that is in danger of being lost. A direct economic consequence is the reduction in the number of animals that can be supported [4]. Other adverse impacts of rangeland degradation are more difficult to quantify. The impact on soil hydrology of the region due to changes in runoff and infiltration characteristics has been considered as a serious threat [5]. Currently some plant, animal or bird species, which are part of the natural ecosystems, have ecological and biodiversity values, but may also have great economic value in the future as a source of adaptation to environmental stresses of heat, drought and salinity.

The objectives of the present component of our study are, therefore, to (1) understand and evaluate desert ecosystems' and artificial forest ecosystems' potential in sustaining wildlife and livestock species through understanding of some plant community characteristics; (3) to examine the extent to which artificial forests can

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contribute to maintaining biodiversity and (4) to evaluate the impact of grazing and artificial forest on some soil chemical characteristics.

MATERIALS AND METHODS

The forest site Um Banadeeg was provided by the forest department as a study site. The study site covers about 560 ha of both planted forest trees and natural vegetation. Three main tree species are present; namely *Prosopis cineraria*, *Acacia tortillis* and *Ziziphus* spina-christi.

Non-tree species that are present include *Cyperus conglomeratus*, *Dipterygium glaucum*, *Fagonia ovalifolia*, *Heliotropium bacciferum*, *Heliotropium digynum*, *Moltkiopsis ciliata*, *Monsonia nivea*, *Panicum turgidum*, *Zygophyllum mandavillei*, *Arnidia hispedesma*, *Cistanche tubulosa*, *Convolvulus* spp., *Dipterygium glaucum*, *Fagonia ovalifolia*, *Heliotropium bacciferum*, *Heliotropium digynum*, *Indigofera argentea*, *Limeum arabicum*, *Neurada procumbens*, *Panicum turgidum* and *Pennisetum divisum*.

About sixty Arabian Oryx are present within an enclosure inside the forest. Permanent 5 by 5 meter-plots were set-up within (26 plots) and outside (27 plots) the grazed area. Plots were located and selectd based on dominant tree species. Vegetation data was recorded in March and October 2004. Data collected included list of all species present within each plot, height, width, length of each individual. The Shannon-wiener index of diversity and species richness were calculated to compare different dates (March vs October 2004), grazing regimes (grazed and ungrazed) and associated tree species.

Soil samples were collected at/near each of the permanent plots. Composite samples of the top 20 cm were collected from under and outside each dominant tree. Samples were stored in bags until analysis was performed. All soil samples were air dried and sieved through a 5-mm mesh to remove large particles. Soil physical characters, such as soil texture and organic matter and chemical characteristics, such as pH, salinity (as estimated by electric conductivity), organic matter, macronutrients and micronutrients, were estimated. Soil texture (i.e., proportions of silt, clay and sand) was estimated using soil hydrometer methods. Organic matter concentration was estimated using loss of mass by soil combustion at 430 degrees C. Soil water extracts were prepared for the determination of electric conductivity (EC) and pH using conductivity and pH meters. N, P, K, Ca, Na and Ca were estimated following the methods reported by Allen [7]. A two-way (dominant tree species and position under tree crown) analysis of varianc.

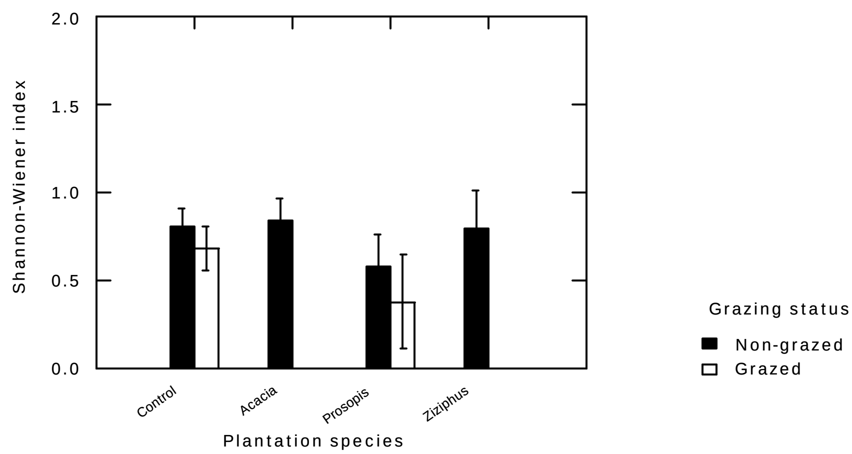
RESULTS

Soil characteristics: For percent Organic Matter, there was a significant effect of dominant tree at $p < 0.05$. Soil samples from areas dominated by *A. tortillis* and *P. cineraria* had the highest levels of OM (0.78 and 0.75%, respectively). While soil samples from areas dominated by *Ziziphus* recorded the lowest rate of OM (0.22%).

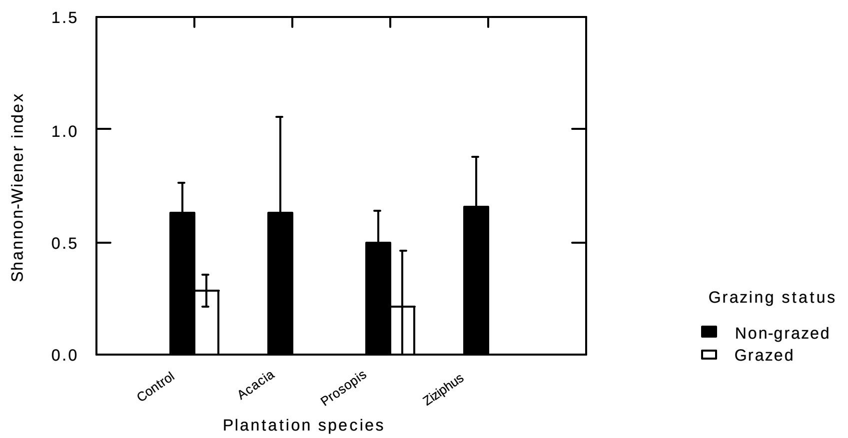
For K, there was a significant effect of dominant tree ($p<0.05$). Soils from *P. cineraria*-dominated areas had the highest levels of K (29.15 ppm). Treeless areas had the lowest levels of K (17.9 ppm).

Fig. 1: Location map of Um Banadeeg forest used to study ecosystem and wildlife population management in the UAE

A: March



B: October



C: Over all the two dates

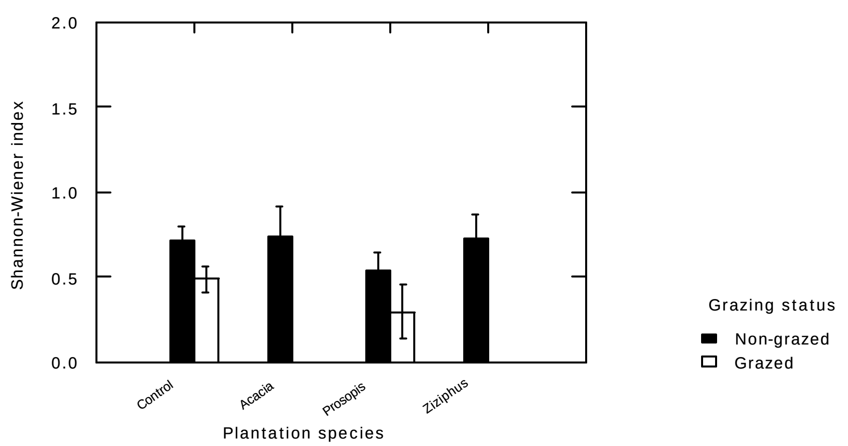


Fig. 2: Effects of Grazing status, date and forest plantation on species diversity as indicated by Shannon-Wiener index

There was a significant interaction between the main effects for percent silt ($p<0.05$). Grazed areas dominated by *P. cineraria* had the highest level of silt (6.02%); while *Ziziphus*-dominated areas had the lowest level of silt (3.64%). Ungrazed treeless areas and those dominated by *Ziziphus* had the highest levels of silt (5.25 and 5.23%, respectively).

There was a significant interaction between the main effects for percent clay ($p<0.05$). Treeless grazed areas had the highest levels of clay (7.36%); while ungrazed areas dominated by *P. cineraria* had the highest percent clay (8.27%). There was no significant effects for all other soils attributes ($p>0.05$).

Effects on species diversity: A three-way ANOVA showed significant effects for grazing status and season on species diversity as indicated by Shannon-Wiener index ($p<0.05$). However, the effect of plantation species and the interaction between the main factors were not significant ($p>0.05$). Generally grazing resulted in a significant deterioration in species diversity. Shannon-Wiener index value in the protected area (0.67) was greater than in the grazed area (0.46) by 45%. This index was significantly greater in March (0.69) than in October (0.44) by 57% (Fig. 2).

Both grazed and protected sites as well as the two dates (Oct and March) were represented in *P. cineraria* plantation and in the non-forested sites. In *P. cineraria* plantation, two-way ANOVA showed insignificant effects for the main factors (i.e., grazing status and date) and their interaction on Shannon-Wiener index ($p>0.05$). In non-forested sites (i.e., control) two-way ANOVA showed significant effect on Shannon-Wiener index for both the date and grazing status ($F = 4.59$ and 4.02 for season and grazing status, respectively, $p<0.05$), but not for their interaction ($F = 0.7$, $p>0.05$). Shannon-Wiener index was greater in the protected than in the grazed site by 32%. This index value was greater in protected than in grazed sites by 122% in October, but by 18.2% in March. Shannon-Wiener index of species diversity was greater in March than in October by 93%. This ranged from 27.8% in the non-grazed sites to 140% in grazed sites (Fig. 2).

In *P. cineraria* plantation, two-way ANOVA showed non-significant effect for both date and grazing status and their interaction ($p>0.05$) on Shannon-Wiener index. Despite the insignificance, this index was greater in the protected than in the grazed site by 82%. It was greater in protected than in grazed sites by 135% in October, but by 53.2% in March. Shannon-Wiener index of species diversity was greater March than in October by 27.7%. This ranged from 16.7% in the non-grazed sites to 79.1% in grazed sites (Fig. 2).

Effects on Species richness: Three-way ANOVA showed insignificant effects for grazing status, date and plantation species on species richness as indicated by number of species per stand ($p>0.05$). Despite the insignificance, the grazing resulted in deterioration of the species richness. Species richness value in protected area (2.81) was greater than in the grazed area (1.25) by 124%. The richness was greater in March (3.06) than in October (2.32) by 32%.

Effects on species frequency and density: Two way ANOVAs showed insignificant effects for the date and grazing status and their interaction on average density and frequency of plant species ($p>0.05$). The only exception was the significant effect of grazing status on the species frequency ($F = 5.51$, $p<0.05$). Unexpectedly, frequency, expressed as a percentage of number of stand in which a species occur per total number of stands, was significantly greater in grazed sites (15.35) than in the protected sites (9.63) by 59%.

Effects on species composition: The total number of species was 16 in the protected sites compared to 10 species in the grazed sites. All species recorded in the grazed sites were present in the protected sites, except *Tribulus* species. On the other hand, 7 species recorded in the protected sites were not present in the grazed sites. These species are *Arnidia hispedesma*, *Cistanche tubulosa*, *Convolvus* species, *Fagonia ovalifolia*, *Neurada procumbens*, *Panicum turgidum* and *Pennisetum divisum*. In addition, *Cyperus conglomerates*, *Heliotropium bacciferum* and *Zygophyllum mandavillei* attained significantly greater frequency and density in the protected than in the grazed sites. *Heliotropium digynum*, however, attained greater frequency and density in the grazed sites. It is interesting to note that some of the species recorded only in the protected sites are palatable plants like *Convolvulus* species, *Fagonia ovalifolia*, *Panicum turgidum* and *Pennisetum divisum* (Table 2).

Nutritional values: Fifteen ground plant samples were collected from, Um Banadeeg, forest. Samples were collected three times during the 2004 (February 26, May 20 and October 14, 2004). Results of the nutritional values are detailed in Tables 3-5.

Crude protein (CP), Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and ash were determined in all samples. Also, gas production technique was run on

Table 1: The effect of grazing and dominant tree species on soil characteristics in an artificial forest site, near Al-Ain, United Arab Emirates

Soil attribute	Dominant tree species	Grazed	Ungrazed
OM (%)	*A. tortillis*	0.78	
	P. cineraria		0.62
	Treeless	0.45	0.36
	Ziziphus spp.	0.51	0.22
EC (mmhos cm^{-1})	*A. tortillis*	5.48	
	P. cineraria	8.87	4.70
	Treeless	5.01	0.72
	Ziziphus spp.	6.77	5.05
pH	*A. tortillis*	8.58	
	P. cineraria	8.48	8.47
	Treeless	8.56	8.43
	Ziziphus spp.	8.63	8.46
P (ppm)	*A. tortillis*	64.44	
	P. cineraria	47.06	38.98
	Treeless	46.26	59.39
	Ziziphus spp.	46.30	70.74
Na (ppm)	*A. tortillis*	260.67	
	P. cineraria	285.47	161.00
	Treeless	165.56	65.39
	Ziziphus spp.	215.63	207.00
K (ppm)	*A. tortillis*	19.33	
	P. cineraria	26.80	31.50
	Treeless	18.00	17.91
	Ziziphus spp.	23.38	26.00
Ca (ppm)	*A. tortillis*	2,891.67	
	P. cineraria	2,728.33	2,831.25
	Treeless	2,830.56	2,882.61
	Ziziphus spp.	2,764.84	2,743.75
N (ppm)	*A. tortillis*	20.84	
	P. cineraria	889.90	30.32
	Treeless	22.28	22.00
	Ziziphus spp.	23.56	47.37
Silt (%)	*A. tortillis*	3.64	
	P. cineraria	4.34	6.02
	Treeless	5.25	4.84
	Ziziphus spp.	5.23	3.64
Clay (%)	*A. tortillis*	8.14	
	P. cineraria	8.27	6.95
	Treeless	6.31	7.36
	Ziziphus spp.	6.05	7.14
Sand (%)	*A. tortillis*	88.22	
	P. cineraria	87.39	87.03
	Treeless	88.44	87.81
	Ziziphus spp.	88.72	89.22

the samples to help determine the nutritive value of the plants. These types of analyses were done on all samples to help us identify the plants with the most nutritive value.

For samples collected on February 26, 2004, results from the chemical analysis and gas production help us eliminate seven plants with low nutritional value. Table 1 shows the chemical analysis (CP, NDF, ADF and Ash) of

Table 2: Effects of grazing on frequency (number of stands in which a species occur/total number of stands, 53) and average density (number/1000 m^2) of different species

	Protected		Grazed	
Species	Frequency	Density	Frequency	Density
Arnebia hispidissima	1.89	1.51	0.00	0.00
Cistanche tubulosa	3.77	3.02	0.00	0.00
Convolvulus spp.	1.89	0.75	0.00	0.00
Cyperus conglomeratus	19.81	38.87	5.66	13.58
Dipterygium glaucum	15.09	16.60	29.25	31.32
Fagonia ovalifolia	4.72	14.72	0.00	0.00
Heliotropium bacciferum	19.81	44.15	5.66	16.23
Heliotropium digynum	8.49	8.30	24.53	38.49
Indigofera argentea	3.77	14.72	7.55	12.83
Limeum arabicum	3.77	3.77	3.77	2.26
Moltkiopsis ciliata	8.49	8.68	1.89	7.55
Monsonia nivea	5.66	18.49	5.66	7.55
Neurada procumbens	3.77	5.28	0.00	0.00
Panicum turgidum	16.98	11.70	0.00	0.00
Pennisetum divisum	1.89	0.75	0.00	0.00
Zygophyllum mandavillei	24.53	122.26	41.51	73.96
Tribulus spp.	0.00	0.00	3.77	1.51

Table 3: Chemical analysis for the various species found in an artificial forest in the UAE (Feb 2004)

#	Sample name	CP %	NDF %	ADF %	Ash %
1	*Leptadenia pyrotechnica*	5.9	66.7	52.4	6.3
2	*Cyperus conglomerates*	5.0	65.7	35.6	9.6
3	*Dipterygium glaucum*	9.4	64.1	46.5	8.3
4	*Pennisetum divisum*	5.3	83.2	44.6	6.4
5	*Panicum turgidum*	4.6	75.2	45.7	11.4
6	*Monsonia nivea*	8.1	45.5	32.5	9.0
7	*Limeum arabicum*	6.4	62.3	45.8	14.6
8	*Heliotropium digynum*	13.2	52.3	38.6	11.9
9	*Rhodes*	8.4	73.3	37.9	12.1

Table 4: Chemical analysis for the various species found in an artificial forest in the UAE (May 2004)

#	Sample name	CP %	NDF %	ADF %	Ash %
1	*Leptadenia pyrotechnica*	6.3	71.8	57	5.9
2	*Cyperus conglomeratus*	3.6	69.4	42.1	12.4
3	*Dipterygium glaucum*	9.5	60.1	43.8	11.2
4	*Pennisetum divisum*	4.1	76.7	39.4	9.5
5	*Panicum turgidum*	3.9	74.3	40.5	10.2
6	*Monsonia nivea*?	NA	NA	NA	Na
7	*Limeum arabicum*	5.6	61.6	45.9	20.7
8	*Heliotropium digynum*	9.3	58.9	42.5	11.5
9	*Rhodes*	8.4	73.3	37.9	12.1

the eight selected plants. In May 20th and October 14th 2004, samples were collected only for the selected eight plants from the previous samples. Results of the chemicals analyses and gas production are shown in Tables 3-5. From the chemical analyses and gas production data obtained from the three sampling periods, only four out of the eight plants have the potential to used all year around as source of natural forage for the Arabian Oryx in Um Banadeeg Forest. The four plants are *Leptadenia pyrotechnica*, *Cyperus conglomeratus*, *Dipterygium glaucum* and *Pennisetum divisum*.

Table 5: Chemical analysis for the various species found in an artificial forest in the UAE (Oct 2004)

#	Sample name	CP %	NDF %	ADF %	Ash %
1	*Leptadenia pyrotechnica*	5.9	63.1	52.1	7.5
2	*Cyperus conglomeratus*	2.7	65.6	44.1	-
3	*Dipterygium glaucum*	6.9	58.6	41.4	9.4
4	*Pennisetum divisum*	3.0	72.1	39.8	11.4
5	*Panicum turgidum*	3.8	69.8	40.2	10.4
6	*Monsonia nivea*	3.8	53.6	40.5	13.9
7	*Limeum arabicum*	6.4	66.1	47.7	9.0
8	*Heliotropium digynum*	8.7	66.5	50.1	7.0
9	*Chloris gayana*	8.4	73.3	37.9	12.1

CONCLUSIONS

Artificial forests could be valuable sites to protect wildlife species in the UAE, because of presence of a better selection of forage species [8]. The role of wildlife and livestock species in minimizing the negative impacts of grazing on desert ecosystems is noteworthy.

In the forest under study, soil samples from areas dominated by A. tortillis and *P. cineraria* had the highest levels of OM (0.78 and 0.75%, respectively). While soil samples from areas dominated by *Ziziphus* recorded the lowest rate of OM (0.22%). Previous studies [8] showed much higher OM content that what is reported here. The differences in age between the forests may be a valid reason for these substantial differences. In any case, any improvement in soil physical characteristics leads, generally, to improved plant growth and hence the added benefits to the wildlife.

As far as grazing impact is concerned, generally grazing resulted in a significant deterioration in species diversity. Shannon-Wiener index value in the protected area was greater than in the grazed area by 45%. This index was significantly greater in March (0.69) than in October by 57%. The total number of species was 16 in the protected sites compared to 10 species in the grazed sites. All species recorded in the grazed sites were present in the protected sites, except *Tribulous* species. On the other hand, 7 species recorded in the protected sites were not present in the grazed sites. In general El-Keblawy and Ksiksi [8] reported higher species diversity where native forest trees were dominant. Artificial forests with exotic species such as Eucalyptus and prosopis juliflora had lower species diversity [8].

An important aspect of the study was to assess the nutritive values of potential plant species available for wildlife feeding. Out of the total number of species analyzed, a short list of four plants was developed. The potentially important species are *Leptadenia pyrotechnica*, *Cyperus conglomeratus*, *Dipterygium glaucum* and *Pennisetum divisum*. Any future attempts for a successful release program of wildlife species such as Arabian Oryx, therefore, is to consider such species as components of the vegetation structure of the habitats.

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