

Floristic diversity of a shrubland in northeastern Mexico

Diversidad florística de un área dominada por arbustos en el Noreste de México

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Abstract. With the objective of ecologically characterize the woody plant communities, twelve sampling sites were randomly selected based on cartographic material and digital ortophotos from the Tamaulipan matorral located in Northeastern Mexico. In each site, the minimum sampling area was determined. Thereafter quadrats of 10 x 10 m were used in variable numbers for the evaluation of the tree and shrub layers, and of 1 m² for the herbaceous layer. In each quadrat, all individuals of any species were registered, measuring its height and crown projection for the determination of density, canopy cover, frequency and importance value for each species. In order to evaluate the overall community a series of ecological indices were used: richness (Margalef), diversity (Shannon-Weiner), equitativity (Shannon), dominance (Simpson) and similarity (Sorensen and Jaccard). A total of 160 taxa pertaining to 46 families were found. The families with a greater number of taxa were the Poaceae, Asteraceae and Cactaceae with 19, 18 and 14 taxa, respectively, followed by the Fabaceae with 9 taxa, and the Euphorbiaceae and Acanthaceae with 8 taxa. The rest of the families mostly presented less than 3 taxa, and 23 of them were represented by a single taxon. The estimation of the diversity according to the Index of Shannon-Weiner (H') showed that in the herbaceous and shrub strata the communities with greater H' were the same than those of greater richness. The greater values of H' varied between 1.23-1.56. The equitativity index showed a large variation in the tree stratum of the study communities, reaching values between 0.20-0.90.

Keywords: Tamaulipan thornscrub; Diversity; Ecological index; Scrubland; Plant communities.

Resumen. Con el objetivo de determinar las características ecológicas de comunidades vegetales maderables, doce sitios fueron aleatoriamente seleccionados en base a material cartográfico y ortofotos digitales correspondientes al matorral tamaulipeco localizado en el noreste de México. En cada sitio, se determinó el área mínima de muestreo sobre la base de cuadrantes de 100 m² (10 x 10 m) donde se evaluaron los estratos arbóreos y arbustivos. Para la evaluación del estrato herbáceo se utilizaron cuadrantes de 1 m² (1 x 1 m). En cada cuadrante todas las plantas fueron identificadas, registrando la altura, proyección de la corona, y la densidad, frecuencia, abundancia y valor de importancia de cada una de las especies. Para poder evaluar el índice de similitud de comunidades vegetales, se usaron una serie de índices ecológicos: índice de riqueza de Margalef, índice de diversidad de Shannon-Wiener, índice de equitatividad, índice de dominancia de Simpson e índice de similitud de Sørensen-Jaccard. Se registraron un total de 160 taxa perteneciendo a 46 familias. Las familias con un número mayor de taxa fueron Poaceae, Asteraceae y Cactaceae con 19, 18 y 14 taxa, respectivamente, seguido por Fabaceae con 9 taxa, Euphorbiaceae y Acanthaceae con 8 taxa cada uno; el resto de las familias presentaron menos de 3 taxa, y 23 de ellas presentaron solo un taxón. En relación a la diversidad florística, los estratos herbáceos y arbustivos mostraron mayor índice de Shannon-Weiner (H') en comparación al estrato arbóreo, y por ende mayor riqueza en especies. El valor de H' varió entre 1,23-1,56; el índice de equitatividad mostró una mayor variación en el estrato arbóreo alcanzando valores entre 0,20-0,90.

Palabras clave: Matorral tamaulipeco; Diversidad; Índice ecológico; Arbustos; Comunidad vegetal.

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INTRODUCTION

Our study was conducted in the coastal plains of the Gulf of Mexico, where vegetation consists of small trees and shrubs, referred to as the “thorny and subinermal matorral”, “Tamaulipan thorny scrub” or “Tamaulipan shrubland”, in most of the territory (Ludwig et al., 1975; Rzedowski, 1978; Foroughbakhch, 2001). The Tamaulipan shrubland occurs extending from the coastal plain of the Gulf of Mexico to the southern rim of Texas State, USA. In these arid and semi-arid zones of northwestern Mexico a great variability in climatic and edaphic conditions causes extremely diverse shrublands in terms of the species composition, height, density and plant associations. The various species occurring in this region can be categorized in several groups based on their ecological adaptations and forestry use. The vegetative associations are composed of almost 60 woody species, and many of them are important in forestry and silvopastoral activities such as the production of timber, posts, firewood, food, medicines, handicrafts, and forage (Berni et al., 1979; Reid et al., 1987; Bainbridge et al., 1990; Alden, 1995).

Woody plants of dryland forests are an economically important forage resource in the rural population (Maydel, 1996). Grazing and fragmentation at a large scale have been practiced for 350 years in these areas. However, the vegetation of this region has been lately undergoing important changes in structure, floristic composition, and a slow (and perhaps irreversible) degradation. This has been the result of diverse human activities such as the selective plant cutting of various genus: *Prosopis*, *Heliopsis*, *Condalia* and *Acacia* (Ffolliott et al., 1982; Pasiecznik et al., 2001; Estrada et al., 2004, 2005).

People have altered the ecological balance over a large surface area because of overexploitation, degradation and elimination of the woody plants from the shrublands to produce wood, timber and charcoal. The result of their activity has been unfortunate for the plant resource sustainability, the elimination of the environmental service that this plant resource offers, and the socioeconomic profits that contribute to the community dwellers. The situation becomes even worse when the incidence of climate disturbances such as drought are considered, which may carry to the desertification of the zone (Burkart, 1976, Eviner, 2003; Fahrng, 2003; Bucur, 2006; Carrillo et al., 2008).

Research on structure and use of matorral lands is increasingly important for the sustained well-being of the rural population, who largely depends on the plant resource. Nevertheless, the literature on structural analysis and development of matorral species is insufficient to elucidate the relationships between vegetation changes and causal factors. The objective of this study was to know the floristic diversity of the shrubby vegetation occurring under the current natural conditions. This will contribute to the implementation of a management program for the sustainable utilization of the vegetal resource present in semiarid zones.

MATERIALS AND METHODS

Study area. This study on the growth and structural vegetation analysis was conducted in a typical semiarid zone of the Gulf of Mexico coastal plain. This is because the vegetation of this area is mostly inhabited by a woodland community dominated by small trees and shrubs, commonly referred to as the “thorny and spiny matorral” or the “tamaulipan thorny scrub” (Rzedowski, 1978). The matorral extends from the Gulf coast to the southern rim of Texas State, USA (Foroughbakhch, 2009). The species present are of shrub type with dominance of deciduous thorny elements, but thorns are lacking in some of them. The overall vegetation is in a transition state between the desert microphyllous scrub, the submountain matorral, the mesquite shrub woodland and the low thorny forest growing at the low altitudes, low plains and hills (Heiseke & Foroughbakhch, 1985).

The investigation was carried out in an area of 65103 km² (23° 10' 27" to 27° 46' 06" North, 98° 26' 24" to 101° 13' 55" West) which included the Rio Grande river hydrological basin (39661 km²), San Fernando-Soto La Marina area (11521.7 km²) and El Salado area (12373 km²).

The climate is in extreme contrasting. The hot and dry climate predominate and, according to the Köpen classification (García, 2004), it is associated to the (1) “B” dry, (2) “Bw” arid or very dry, or (3) “Bs” semi-arid or semi-dry climate. Weather is very hot most of the year, mainly in the plains, but from November to January it is cold. The mean annual temperature is 22.3 °C with a large difference between winter and summer (-2.3 to 41.1 °C). Hails and frosts usually occur every year even after the beginning of the growing season in March. The long-term mean annual precipitation varies from 380 mm (arid zones) to 749 mm (semiarid zones), with two peaks in late May and July – September, and severe drought periods in June and winter. The water budget is unbalanced. The ratio of precipitation to free evaporation is 0.48, and precipitation to potential evaporation is 0.62 (Navar et al., 1999).

The soils of the region are basically stony of Upper Cretaceous siltstone. Commonly, depth of the A horizon is about 30 cm in arid zones, and 40 cm in semiarid zones, with a pH of 7.5 – 8.5 and abundant limestone. The C horizon underneath is about 80 cm deep and contains fissured limestone. In the FAO classification, these soils are classified as rendzine, vertisol, feozem and castañozem with low organic matter content, and low levels of phosphorus and nitrogen (FAO-UNESCO, 1974). Underground water is hard but not saline.

Selection of sampling sites. Sampling sites were delimited based on thematic maps of land use and vegetation, scale 1:50000, and digital ortophotos published by the INEGI (Medina & Natividad, 1998). They were numbered in a progressive form and selected at random to determine the minimum size of the quadrat, according to the species-area curve

(Mueller-Dombois & Ellenberg, 1974; Franco et al., 2001). Twelve of these sites were visited for their correct localization, and the recognition of the existent vegetal communities. On each selected site, a GPS receiver (Global Positioning System) was used to register the geographical coordinates and the elevation above the sea level (Table 1).

Table 1. Sampling sites in northeastern Mexico and their geographical coordinates.

Tabla 1. Sitios de muestreo en el noreste de México y sus coordenadas geográficas.

Sampling sites	Geographic zones	Geographic coordinates UTM		
		East	North	Elevation (m)
1. Plan de oregano (PO)	Great Plains of North America	457694	2883106	152
2. Colorado de Arriba (CA)	Great Plains of North America	400906	2927506	239
3. El Llano (EL)	Great Plains of North America	437024	2854589	193
4. La Barretosa (BA)	Great Plains of North America	451990	2858539	166
5. Emiliano Zapata (EZ)	Great Plains of North America	431651	2937498	164
6. Puente Río Salado (PS)	Great Plains of North America	413460	2982484	146
7. Loma Larga (LL)	Great Plains of North America	448858	2904109	147
8. Los Ébanos (LE)	Great Plains of North America	453517	2824931	196
9. El Álamo (EA)	Great Plains of North America	421068	2929095	195
10. Dulces Nombres (DN)	Gulf Coastal Plains	394236	2844953	351
11. H. San Pedro (SP)	Gulf Coastal Plains	384066	2867217	369
12. Higueras (HI)	Gulf Coastal Plains	398119	2872672	503

Vegetation structure analysis. The minimum area at each site was estimated following Mueller-Dombois & Ellenberg (1974) and Salvador & Álvarez (2004) to obtain a representative botanical composition. The species occurring in each subsample were registered, and the minimum sampling area was determined as the surface where at least 95% of the species of the plant community were present.

A 10 x 10 m quadrat was delimited at random within each study site. The average distance among plots varied according

to the botanical composition and the heterogeneity degree. All the tree, shrub and herbaceous species present within each of the quadrats were identified. Measurements of plant (1) height (m), (2) basal diameter (cm), (3) crown projection area (m²), (4) dominance (absolute and relative), (5) frequency (%) and (6) density (absolute and relative) were obtained (Avery & Burkhart, 2002; Diéguez et al., 2003). The following equations were employed to obtain some of the measured variables (Graf & Sayagues, 2000; Mostacedo & Fredericksen, 2000):

Absolute density = Number of individuals of any given species / Sampling area

Relative density = $\frac{\text{Number of individuals of any given species} \times 100}{\text{Total number of individuals of all species}}$

Absolute dominance of any given species = Mean basal area / tree x N^o of trees of the study species

Relative dominance of any given species = $\frac{\text{Absolute dominance of the study species} \times 100}{\text{Absolute dominance of all species}}$

Relative frequency of any given species = $\frac{\text{Frequency of the study species} \times 100}{\text{Total frequency of all species}}$

The importance value (IV) was calculated for each species according to the following equation:

$$\text{Importance value} = \frac{\text{Rel. Dens.} + \text{Rel. Dom.} + \text{Rel. Frec.}}{3}$$

Diversity and Similarity between communities. The parameters given below (i.e., richness, diversity, dominance and similarity) were estimated as follows:

Richness: The index of Margalef (D_{mg}) was selected to consider the relation between the number of occurring species in the community or stratum (S) and the total number of individuals of all species (N) (Gurevitch et al., 2002):

$$D_{mg} = S - 1 / \ln N$$

Diversity: The index of Shannon-Weinner (H') was chosen to have a measurement of the diversity of species and its proportional abundance in the community (Franco et al., 2001):

$$H' = -\sum [p_i \ln (p_i)]$$

Where: p_i = the proportion of individuals in the i th ($p_i = n_i/N$),
 n = number of individuals of the i th species,
 N = number of individuals of all the species.

Equitativity: It is a measurement of the balance in the abundance of any species in the community. In this case a measurement derived from the index of Shannon-Weiner (H') was used. Calculations were made following Gurevitch et al. (2002):

$$E = H' / \ln S \text{ (see } H' \text{ and } S \text{ above for explanation)}$$

Dominance: The index of Simpson (L) was used to estimate the probability that two individuals taken at random from the community would belong to the same species:

$$L = \sum p_i^2 \text{ (Gurevitch et al., 2002)}$$

Similarity: The similarity between communities was estimated at a general level, and for each one of the evaluated strata. For their estimation, the qualitative indices of Sorensen and Jaccard were used as follows:

$$\text{Jaccard Index: } S_j = a / a + b + c$$

$$\text{Sorensen Index SSD} = 2a / 2a + b + c$$

Where: a = No. of species at both sites; b = No. of species at the second site, and c = No. of species at the first site.

RESULTS

Floristic Composition. A total diversity of 160 taxa pertaining to 46 families was found. The families with greater number of taxa were Poaceae, Asteraceae and Cactaceae with 19, 18 and 14 taxa respectively, followed by Fabaceae with 9 taxa, and Euphorbiaceae and Acanthaceae with 8 taxa in both cases. The rest of the families mostly presented less than 3 taxa, and 23 of them were represented by a single taxon. The most common species present in all sampled communities were *Celtis pallida*, *Opuntia leptocaulis*, *Prosopis glandulosa* and *Ruellia nudiflora*. Other species, also common at the study sites, included *Acacia rigidula*, *Acleisanthes obtuse*, *Castela texana*, *Dyschoriste decumbens*, *Karwinskia humboldtiana*, *Opuntia engelmannii*, *Tridens muticus* and *Ziziphus obtusifolia*.

Density, Canopy Cover and Similarity between Communities. The total number of species in any given community varied from 22 to 75, with a general average of 46.91 species per community. The vegetal stratum with the highest diversity was the herbaceous layer, whereas the tree stratum displayed the lowest diversity.

The average density of individuals per site was 274015.48 individuals/ha (range= 97900 - 466233), where 91% of them corresponded to the herbaceous layer.

The average cover per site was 203, 2%, taking into consideration that overlapping between individuals might oc-

cur between the accumulated cover from the three strata, and even from the interior of each stratum. The maximum vegetation cover was reached in the locality "Dulces Nombres" (Gulf Coastal Plains) with 314, 08%, where vegetation was very dense and uncovered soil surface area was small. On the other hand, the minimum canopy cover was reached in "Plan de Orégano" (108.37%) on the Great Plains of North America; at this location, the plant community had very few tree individuals and large uncovered soil surface areas.

All communities located on the Great Plains of North America showed a greater similarity than those at the Gulf Coastal Plains, with values between 71% ("Plan de Oregano") and 49% ("Loma Larga") (Table 2). Within the Gulf Coastal Plains, "Hacienda San Pedro" showed a similarity in most cases lower than 40%, and "Puente del Río Salado" and "Higueras" in the range from 30 to 50%.

Frequency. In the shrub and arboreal strata there were a total of 62 taxa in the 12 localities, with an average of 21.75 taxa per site. Three species *Celtis pallida*, *Opuntia leptocaulis*, and *Prosopis glandulosa* appeared in all the study communities, and showed the greatest values of frequency (100%). The high frequencies of *Opuntia engelmannii* (91.67%) and *Acacia rigidula*, *Castela texana*, *Karwinskia humboldtiana* and *Ziziphus obtusifolia* were also relevant, and all of them were present in 10 sites (83.33%). The rest of the species exhibited smaller frequencies, and approximately a third of them were hardly present in a single site (Table 3). *Acacia rigidula* was second in the rank, despite occurring in 50% of the localities. The rest of the species presented smaller frequencies and three species (*Acacia farnesiana*, *Cercidium* sp. and *Havardia pallens*) appeared only in one community.

Prosopis glandulosa, a component of the tree stratum, showed quite greater frequency values than those observed for the herbaceous stratum. However, its relative frequency was low in many of the sites, with values generally smaller than 5%, although in the "Hacienda San Pedro" it reached a relative frequency of 20%.

Importance Value (IV). *Prosopis glandulosa* was the species that presented the greatest importance value (IV) in the tree stratum of all communities, with an average of 80%, followed by *Havardia pallens* and *Acacia wrightii*, which showed average values of 21 and 14%, respectively (Table 4). The higher importance value for all strata was obtained by *P. glandulosa* in all communities. Its IV reached 100% in three of the study communities, more than 75% in six communities, and it exceeded 40% in three of the remaining communities. The species with greater IVs after *P. glandulosa* were *H. pallens* (21%), *A. wrightii* (19%) and *A. rigidula* (18%).

Diversity Parameters. Richness (Dmg). Within the shrub stratum, the community with greater richness [according to the index of Margalef (Dmg)] was “Dulces Nombres” with a

Dmg = 5.54, followed by “El Llano” (Dmg = 5.02) and “Los Ebanos” (Dmg = 4.86). The shrub communities with smaller richness were: “Loma Larga” and “Hacienda San Pedro” (Dmg

Table 2. Similarity matrix between communities (considering the three layers) according to the indices of Jaccard and Sorensen.
Tabla 2. Matriz de similitud entre comunidades (considerando los tres estratos) de acuerdo a los índices de Jaccard y Sorensen.

Site	Great Plains of North America							Gulf Coastal Plains					
	PO	CA	EL	BA	EZ	PS	LL	LE	EA	DN	SP	HI	
PO	Shared species	30	19	22	20	17	16	22	25	20	20	8	14
	Jaccard Index %	100	33.93	36.07	33.33	31.48	44.44	55.00	31.25	25.97	27.40	16.67	18.67
	Sorensen Index %	100	50.67	53.01	50.00	47.89	61.54	70.97	47.62	41.24	43.01	28.57	31.46
CA	Shared species		45	30	27	27	16	20	33	36	26	14	20
	Jaccard Index %		100	44.12	39.71	45.76	31.37	35.09	37.93	47.37	31.71	24.56	23.81
	Sorensen Index %		100	61.22	56.84	62.79	47.46	51.95	55.00	64.29	48.15	39.44	38.46
EL	Shared species			53	34	24	16	25	38	34	26	13	24
	Jaccard Index %			100	49.28	34.29	27.12	41.67	42.22	39.53	28.89	19.70	27.27
	Sorensen Index %			100	66.02	51.06	42.67	58.82	59.38	56.67	44.83	32.91	42.86
BA	Shared species				50	25	15	24	37	36	28	15	25
	Jaccard Index %				100	37.88	26.32	41.38	42.05	44.44	32.94	24.59	29.76
	Sorensen Index %				100	54.95	41.67	58.54	59.20	61.54	49.56	39.47	45.87
EZ	Shared species					41	15	16	27	30	24	14	20
	Jaccard Index %					100	31.25	28.07	303.4	38.46	30.00	26.42	25.00
	Sorensen Index %					100	47.62	43.84	46.55	55.56	46.15	41.79	40.00
PS	Shared species						22	16	18	16	12	8	13
	Jaccard Index %						100	42.11	22.78	21.92	16.44	20.00	19.12
	Sorensen Index %						100	53.26	37.11	35.96	28.24	33.33	32.10
LL	Shared species							32	26	22	17	9	18
	Jaccard Index %							100	32.10	28.57	21.79	18.37	24.66
	Sorensen Index %							100	48.60	44.44	35.79	31.03	39.56
LE	Shared species								75	42	37	16	33
	Jaccard Index %								100	42.00	36.63	18.82	32.67
	Sorensen Index %								100	59.15	53.62	31.68	49.21
EA	Shared species									67	31	16	31
	Jaccard Index %									100	31.31	20.78	32.63
	Sorensen Index %									100	47.69	34.41	49.21
DN	Shared species										63	17	27
	Jaccard Index %										100	23.61	28.42
	Sorensen Index %										100	38.20	44.26
SP	Shared species											26	16
	Jaccard Index %											100	23.19
	Sorensen Index %											100	37.65
HI	Shared species												59
	Jaccard Index %												100
	Sorensen Index %												100

PO= Plan de oregano, CA = Colorado de Arriba, EL = El Llano, BA= La Barretosa, EZ= Emiliano Zapata, PS= Puente Río Salado, LL= Loma Larga, LE= Los ébanos, EA= El Alamo, DN= Dulces Nombres, SP= San Pedro, HI= Higueras.

Table 3. Species with higher frequency (%) in the herbaceous, shrub and arboreal strata in the studied communities.
Tabla 3. Especies con mayor frecuencia (%) en los estratos herbáceo, arbustivo y arbóreo en las comunidades estudiadas.

Herb	Freq	Shrub	Freq	Tree	Freq
<i>Opuntia leptocaulis</i>	100.00	<i>Celtis pallida</i>	100.00	<i>Prosopis glandulosa</i>	100.00
<i>Ruellia nudiflora</i>	100.00	<i>Opuntia leptocaulis</i>	100.00	<i>Acacia rigidula</i>	50.00
<i>Dyschoriste decumbens</i>	91.67	<i>Prosopis glandulosa</i>	100.00	<i>Acacia wrightii</i>	33.33
<i>Acleisantes obtusa</i>	83.33	<i>Opuntia engelmannii</i>	91.67	<i>Celtis pallida</i>	33.33
<i>Tridens muticus</i>	83.33	<i>Acacia rigidula</i>	83.33	<i>Bumelia celastrina</i>	16.67
<i>Mammillaria heyderi</i>	75.00	<i>Castela texana</i>	83.33	<i>Condalia hookeri</i>	16.67
<i>Bouteoloua trifida</i>	66.67	<i>Karwinskia humboldtiana</i>	83.33	<i>Porlieria angustifolia</i>	16.67
<i>Makvastrum coromandelianum</i>	66.67	<i>Ziziphus obtusifolia</i>	83.33	<i>Acacia farnesiana</i>	8.33
<i>Rivina humilis</i>	66.67	<i>Acacia wrightii</i>	75.00	<i>Cercidium sp</i>	8.33
<i>Setaria macrostachya</i>	66.67	<i>Porlieria angustifolia</i>	75.00	<i>Havardia pallens</i>	8.33

Freq= Frequency.

Freq = Frecuencia, Herbs= Hierbas, Shrub= arbusto, Tree = árbol.

= 2.73 in both cases), and “Puente Río Salado” (Dmg = 2.00) (Table 5).

Diversity (H'). Those communities with greater H' were the same than those with greater richness in the shrub and herbaceous strata. Within the shrub stratum, the greater values of H' were found in “El Llano” (2.73), “Los Ebanos” (2.69) and “Dulces Nombres” (2.57). The communities with smaller diversity were “Colorados de Abajo” (H'= 2.09) and “Hacienda San Pedro” (H'= 1.85) in the shrub stratum, and “Puente del Río Salado” (H'= 0.70) in the herbaceous stratum (Table 5).

Equitativity (E). The equitativity in the shrubby stratum reached its highest value in the communities “El Llano”, “Loma Larga” and “Higueras”, with a value of E = 0.80. On the other hand, the communities with minor equitativity values were “Colorados de Abajo” (E = 0.72), “Puente del Río Salado” (E = 0.71) and “La Barretosa” (E = 0.70) (Table 5).

Dominance (L). The community with greater dominance in the herbaceous and shrub strata was “Puente del Río Salado” (Great Plains of North America) with values of L = 0.75 and L = 0.25, respectively. It was followed by “Hacienda San Pedro”

Table 4. Species with higher average importance values (IV) in the herb, shrub and arboreal strata from the studied communities.

Tabla 4. Especies con mayores valores de importancia (IV) promedio en los estratos herbáceo, arbustivo y arbóreo de las comunidades estudiadas.

Herbaceous	IV	Shrub	IV	Tree	IV
<i>Ruellia nudiflora</i>	14.30	<i>Opuntia leptocaulis</i>	14.31	<i>Prosopis glandulosa</i>	80.31
<i>Opuntia leptocaulis</i>	8.14	<i>Opuntia engelmannii</i>	10.41	<i>Havardia pallens</i>	20.72
<i>Ruellia sp</i>	7.69	<i>Prosopis glandulosa</i>	9.87	<i>Acacia wrightii</i>	14.00
<i>Calyptracarpus vialis</i>	7.07	<i>Celtis pallid</i>	9.65	<i>Acacia rigidula</i>	11.56
<i>Bouteloua trifida</i>	6.41	<i>Paulothamus spinescens</i>	8.89	<i>Pithecellobium flexicaule</i>	8.51
<i>Oxalis dichondraefolia</i>	6.20	<i>Acacia rigidula</i>	7.56	<i>Celtis pallida</i>	7.97
<i>Tridens muticus</i>	5.83	<i>Ziziphus obtusifolia</i>	7.01	<i>Condalia hookeri</i>	7.39
<i>Lantana camara</i>	5.25	<i>Eupatorium sp</i>	5.76	<i>Bumelia celastrina</i>	6.92
<i>Dyschoriste decumbens</i>	5.11	<i>Karwinskia humboldtiana</i>	5.57	<i>Acacia farnesiana</i>	5.88
<i>Setaria sp</i>	4.92	<i>Castela texana</i>	5.47	<i>Cercidium sp</i>	3.35

For the Shrub and herbaceous strata only those species occurring in at least 25% of the sites were considered. In the tree stratum all species were considered.

IV = Valor de importancia, Shrub = Arbustos, Tree = árbol.

(Gulf Coastal Plains, L = 0.22) in the shrub stratum. The rest of the communities displayed dominance values in the rank of 0.08-0.17, being “El Llano” (L = 0.10) and “Los Ebanos” (L = 0.10) (Great Plains of North America) or “Los Ebanos” (L = 0.08) the communities with the smallest dominance values in the shrub or herbaceous stratum, respectively (Table 5).

DISCUSSION

Comparisons between different ecosystems in semiarid zones are important to determine general trends to find out explanatory variables that could predict changes that may occur after any alteration to the environment due to usual

Table 5. Diversity values obtained in the sampling sites.

Tabla 5. Valores de diversidad obtenidos en los sitios de muestreo.

SITE	Great Plains of North America							Gulf Coastal Plains				
	PO	CA	EL	BA	EZ	PS	LL	LE	EA	DN	SP	HI
Herb Stratum												
N	932	1232	753	399	693	237	358	1340	1375	993	446	810
S	16	35	32	32	30	14	21	56	56	50	19	50
QN	31	50	30	30	25	25	25	30	30	25	30	25
D	30.06	24.64	25.10	13.30	27.72	9.48	14.32	44.67	45.83	39.72	14.87	32.40
Dmg	2.19	4.78	4.68	5.18	4.43	2.38	3.40	7.64	7.61	7.10	2.95	7.32
H'	1.68	2.59	2.11	2.59	2.22	0.70	2.36	2.93	2.82	2.79	2.08	2.86
E	0.61	0.73	0.61	0.75	0.65	0.27	0.78	0.73	0.70	0.71	0.71	0.73
L	0.27	0.11	0.25	0.11	0.16	0.75	0.12	0.08	0.13	0.10	0.16	0.10
Shrub stratum												
N	318	486	393	459	239	149	242	392	442	385	39	184
S	18	18	31	30	21	11	16	30	23	34	11	18
SA	700	1000	600	600	500	500	500	600	600	500	600	500
D*	4542.86	4860.00	6550.00	7650.00	4780.00	2980.00	4840.00	6533.33	7366.67	7700.00	650.00	3680.00
Dmg	2.95	2.75	5.02	4.73	3.65	2.00	2.73	4.86	3.61	5.54	2.73	3.26
H'	2.20	2.09	2.73	2.38	2.36	1.71	2.22	2.69	2.49	2.57	1.85	2.32
E	0.76	0.72	0.80	0.70	0.77	0.71	0.80	0.79	0.79	0.73	0.77	0.80
L	0.16	0.17	0.10	0.13	0.13	0.25	0.14	0.10	0.11	0.14	0.22	0.12
Tree Stratum												
N	10	25	10	19	12	6	16	19	34	78	32	21
S	1	4	3	2	2	1	1	3	7	8	2	4
SA	700	1000	600	600	500	500	500	600	600	500	600	500
D*	142.86	250.00	166.67	316.67	240.00	120.00	320.00	316.67	566.67	1560.00	533.33	420.00
Dmg	0.00	0.93	0.87	0.34	0.40	0.00	0.00	0.68	1.70	1.61	0.29	0.99
H'	0.00	0.82	0.64	0.66	0.29	0.00	0.00	0.54	1.56	1.51	0.14	1.23
E	-	0.59	0.58	0.95	0.41	-	-	0.49	0.80	0.72	0.20	0.89
L	1.00	0.56	0.66	0.53	0.85	1.00	1.00	0.72	0.26	0.29	0.94	0.33

N = number of sampled individuals; S = Number of species; QN = quadrat number (1 m²); D = Density (# individuals/m²); Dmg = Margalef index (Richness); H' = Shanon Weiner's index (Diversity); E = Equitativity of Shannon; L = Simpson's index (Dominance); SA = Sampling area; D* = Density (# individuals/ha); D = Density (# individuals/m²).

PO= Plan de oregano, CA = Colorado de Arriba, EL = El Llano, BA= La Barretosa, EZ= Emiliano Zapata, PS= Puente Río Salado, LL= Loma Larga, LE= Los ébanos, EA= El Alamo, DN= Dulces Nombres, SP= San Pedro, HI= Higueras.

anthropogenic activities in those areas. However, these trait comparisons need to be made in an integrated manner between the different disciplines involved in the study.

The number of total species by community varied enormously from the Great Plains of North America (“Puente del Río Salado”, “Los Ebanos”) to the Gulf Coastal Plains (“Higueras” and “H. San Pedro”). The most common species, considering those present in all the sampled communities, were *Ruellia nudiflora*, *Opuntia leptocaulis*, *Celtis pallida* and *Prosopis glandulosa*. Other species also common in the study sites were *Opuntia engelmannii*, *Dyschoriste decumbens*, *Acacia rigidula*, *Castela texana*, *Karwinskia humboldtiana*, *Ziziphus obtusifolia*, *Acleisanthes obtuse* and *Tridens muticus*.

It is important to emphasize that we detected the presence of two endangered species during the study in compliance with the Official Mexican NOM-059-SEMARNAT-2001 (SEMARNAT, 2002). The species were *Echinocereus poselgeri* (Cactaceae), which has the status “subject to special protection”, and *Manfreda longiflora* (Agavaceae), with “threatened status”. In both cases, deforestation and extensive cattle production are the factors that contribute most to that negative impact, and inflict loss and deterioration of plant habitats. Another relevant factor for survival is the nodricismo required by the species as in the case of *E. poselgeri*. Likewise, the main problem for the establishment of *M. longiflora* is the modification of the habitat, and the succulent character of the plant, which makes it attractive to predators. Similar results were obtained by Velazco-Macias et al. (2011).

In the herbaceous layer, maximum and minimum density values were found in the communities at “El Alamo” and “Puente del Río Salado”, respectively.

Regarding the average cover by site, it was observed a great overlapping between individuals as a result of the accumulated cover from the three strata, and even from the interior of each layer. The maximum vegetation cover was reached in the locality “Dulces Nombres”, community with very dense vegetation and little uncovered surface area. On the other hand, the minimum canopy cover appeared in “Plan de Orégano”, which had a vegetal community with very few trees and large, open uncovered soil surface areas.

According to the indices of Jaccard and Sørensen, the communities with greater similarity were “Plan de Oregano” and “Loma Larga”, “El Llano” and “La Barretosa”, and “Colorados de Arriba” and “El Alamo”. The communities that showed least similarity with those remaining were “Hacienda San Pedro”, “Puente del Río Salado” and “Higueras”, with values in the rank from 30 to 50%.

The general appearance of thornscrub communities is determined by the occurrence of small trees from 3 to 6 m in height present in the shrub and tree strata, which are generally thorny species that vary in density and size (Bainbridge et al., 1990). Humidity plays an important role in determining the exuberance degree and the species associated to the thorn-

scrub and woodland, which affect the density and the insolation degree throughout the depth of the plant layer. It might be observed that the presence of cetaceous species is common under higher insolation conditions, whereas the occurrence of climbing plants associated to different strata is favored under shady vegetation areas.

The physiognomy of the studied sites was dominated by shrub and tree plants. The most outstanding species by its height, density and cover were *H. pallens*, *A. wrightii*, *A. rigidula*, *E. ebano* and *C. pallida*. In all the studied sites, the mesquite populations corresponded to the species *P. glandulosa*. These results are in concordance with those of Jurado & Reid (1989) and Martínez & López (2003).

The most common species in addition to *P. glandulosa* in the tree stratum were *Acacia rigidula*, *Acacia wrightii*, *Celtis pallida*, *Bumelia celastrina* and *Condalia hookeri*.

In the shrub layer, the most common species were *Celtis pallida*, *Opuntia leptocaulis*, *P. glandulosa*, *O. engelmannii*, *Acacia rigidula*, *Castela texana*, *Karwinskia humboldtiana* and *Ziziphus obtusifolia*. In the herbaceous layer, the dominant species were *Ruellia nudiflora*, *Opuntia leptocaulis*, *Dyschoriste decumbens*, *Acleisanthes obtusa*, *Tridens muticus* and *Mammillaria heyderi*.

In general terms, the increase in the number of stems (and consequent enlargement of the crown area) plays an important role in the structure and distribution of thornscrub communities. This criterion was particularly noteworthy in the case of *Prosopis* spp; in most of the studied sites, it was common to observe its presence in disturbed areas due to cutting of trees for the supply of wooden pole fence stands and vegetal charcoal. Growth and proliferation of secondary stems as a consequence of damage or injury to plants of that species has been described elsewhere (e.g., Felker, 1996; Harris et al., 1998). Most woody trees in thornscrub communities are composed of only one stem each in undisturbed areas, but they tend to sprout out several branches after occurrence of any disturbance.

CONCLUSIONS

The physiognomy of the studied sites was dominated by shrub and trees species where *Prosopis glandulosa*, *Acacia* spp., *Bumelia celastrina*, *Celtis pallida* and *Condalia hookeri* were the most outstanding vegetation by its height, density and cover.

We found 160 taxa belonging to 46 families, being the families Poaceae [19], Asteraceae [18], Cactaceae [14], Fabaceae [8] and Euphorbiaceae [8] the most important in number. The total number of species by community varied from 22 (“Puente del Río Salado”) to 75 (“Los Ebanos”) with a general average of 46.91. The vegetal stratum with the highest diversity was the herbaceous layer with 136 taxa (and an average of 34.25 per studied site). The tree stratum displayed the smallest diversity with 13 taxa, and a mean value of 3.17 taxa per site.

The most common species in addition to *P. glandulosa* in

the arboreal stratum were *Acacia rigidula*, *Acacia wrightii*, *Celtis pallida*, *Bumelia celastrina* and *Condalia bookeri*.

In the shrub layer, the most common species were *Celtis pallida*, *Opuntia leptocaulis*, *P. glandulosa*, *O. engelmannii*, *Acacia rigidula*, *Castela texana*, *Karwinskia humboldtiana* and *Ziziphus obtusifolia*. In the herbaceous layer, the dominant species were *Ruellia nudiflora*, *Opuntia leptocaulis*, *Dyschoriste decumbens*, *Acleisanthes obtuse*, *Tridens muticus* and *Mammillaria heyderi*.

The average density of individuals per site considering the three strata was 274015 individuals/ha, where 268400, 413 and 5177 plants/ha belonged to the herbaceous, shrub and tree layers, respectively.

The greatest importance value (IV) was shown by *Ruellia nudiflora* and *Opuntia leptocaulis* in the herbaceous stratum, *P. glandulosa*, *O. leptocaulis* and *O. engelmannii* in the shrub layer, and *P. glandulosa* for the tree layer.

The communities with the greatest floral richness (Dmg = 7.64) and diversity ($H' = 2.93$) were at "Los Ebanos" in the herbaceous layer, "Sweet Names" (Dmg = 5.54, $H' = 2.69$, respectively) in the shrub layer, and "the Alamo" (Dmg = 1.70, $H' = 1.76$, respectively) in the tree stratum.

The communities with greatest similarity values were located at "Plan del Orégano", "Loma Larga", "El Llano", "La Barretosa", "Colorados de Arriba" and "El Alamo", which were situated in the Great Plains of North America. The communities that showed the lowest similarities were at the "Puente del Río Salado", "Hacienda San Pedro" and "Higueras", these last two located in the Gulf Coastal Plains, with values of similarities ranking from 30 to 50% in comparison to the rest of the communities.

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