

## COMPOSITION, STRUCTURE AND DIVERSITY OF SHRUBLANDS IN CENTRAL NUEVO LEON, MEXICO

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**Abstract:** The aim of this study was to carry out a comparative analysis at the plant community level of the five most common types of shrublands (semithorn shrubland, microphyllous desert shrubland, rosetophyllous desert shrubland, piedmont scrub, and tamaulipan thornscrub) in the state of Nuevo Leon (northeastern Mexico). Twenty-five sampling sites (100 m<sup>2</sup> each one) were established in each shrubland type (125 in total) to evaluate the vegetation structure. At each sampling site, we estimated the plant density (N ha<sup>-1</sup>), plant coverage (m<sup>2</sup> ha<sup>-1</sup>), specific richness (*S*), and alpha diversity index (*H'*). One way-analysis of variance was used to compare plant attributes between the plant communities. In the studied five plant communities, a total of 85 vascular plant species were registered, belonging to approximately 65 genera and 28 families. The most representative families were Cactaceae (18 species), Fabaceae (16 species), Asteraceae (six species), and Agavaceae (five species). Analysis of variance showed highly significant differences between the shrublands in terms of the studied plant attributes. The microphyllous desert shrubland showed the lowest plant density (1,868 N ha<sup>-1</sup>) and plant coverage (2,637 m<sup>2</sup> ha<sup>-1</sup>) and the piedmont scrub the highest (4,512 N ha and 17,931 m<sup>2</sup> ha<sup>-1</sup>, respectively). With respect to specific richness and the alpha diversity index, the lowest values (*S* = 3.72 and *H'* = 0.91, respectively) were presented by the microphyllous desert shrubland, whereas the semithorn shrubland exhibited the highest values (*S* = 11.56 and *H'* = 2.15). This study provides valuable information about the composition, structure and diversity of shrublands in the state of Nuevo Leon.

**Key words:** piedmont scrub, tamaulipan thornscrub, xerophytic shrub.

**Resumen:** El objetivo de la presente investigación fue realizar un análisis comparativo de cinco matorrales (matorral subinermes, matorral desértico micrófilo, matorral desértico rosetófilo, matorral submontano, matorral espinoso tamaulipeco), del estado de Nuevo León (noreste de México). Se establecieron 25 sitios de muestreo (100 m<sup>2</sup>; 125 en total), en cada matorral estudiado para evaluar la estructura de la vegetación. En cada sitio de muestreo se evaluó la densidad (N ha<sup>-1</sup>), cobertura de copa (m<sup>2</sup> ha<sup>-1</sup>), riqueza específica (*S*), y la diversidad alfa (*H'*). Se realizó un análisis de varianza para determinar si existían diferencias significativas entre las cinco áreas evaluadas. En los cinco matorrales se registraron 85 especies de plantas vasculares, 65 géneros y 28 familias. Las familias más representativas fueron Cactaceae (18 especies), Fabaceae (16 especies), Asteraceae (seis especies) y Agavaceae (cinco especies). El análisis de varianza mostró diferencias significativas. El matorral desértico micrófilo reveló los valores más bajos en términos de densidad de plantas (1,868 N ha<sup>-1</sup>) y cobertura de copa (2,637 m<sup>2</sup> ha<sup>-1</sup>), mientras que el matorral submontano los más altos (4,512 N ha<sup>-1</sup> y 17,931 m<sup>2</sup> ha<sup>-1</sup>, respectivamente). Respecto a la riqueza específica y la diversidad, las cifras más bajas (*S* = 3.72 y *H'* = 0.91, respectivamente) corresponden al matorral desértico micrófilo, mientras que el matorral subinermes exhibió los valores más altos (*S* = 11.56 y *H'* = 2.15, respectivamente).

**Palabras clave:** matorral submontano, matorral tamaulipeco, matorral xerófilo.

In Mexico, shrublands (xerophytic shrub vegetation, some of which are known as matorral) are the most important floristic communities, as they cover an area of approximately 800,000 km<sup>2</sup>, representing approximately 40% of coun-

try total area (Rzedowski, 1978). The wide range of abiotic conditions in terms of climate and soil types allow shrublands to display different biological forms, species compositions, and floristic diversities (Muller, 1939). According

to the classification of INEGI (2005), fourteen community types are found in Mexico, most of which are widespread in the north of the country. In the state of Nuevo Leon (northeastern Mexico), the following five shrubland community groups are registered: semithorny shrubland (SS), microphyllous desert shrubland (MDS), rosetophyllous desert shrubland (RDS), piedmont scrub (PS), and tamaulipan thornscrub (TT).

In northeastern Mexico, shrublands have provided multiple ecosystem services and have been utilized as sources of forage for livestock and wildlife, fuelwood, charcoal, timber for construction, fence materials and medicinal herbs, in addition to being subjected to agroforestry practices (Reid *et al.*, 1990; Foroughbakhch *et al.*, 2005). Because these shrublands are a natural resource that warrants conservation and proper management measures from an ecological and economic perspective to maintain and even promote these ecosystem services, there is a need to understand their structures and floristic traits at all levels.

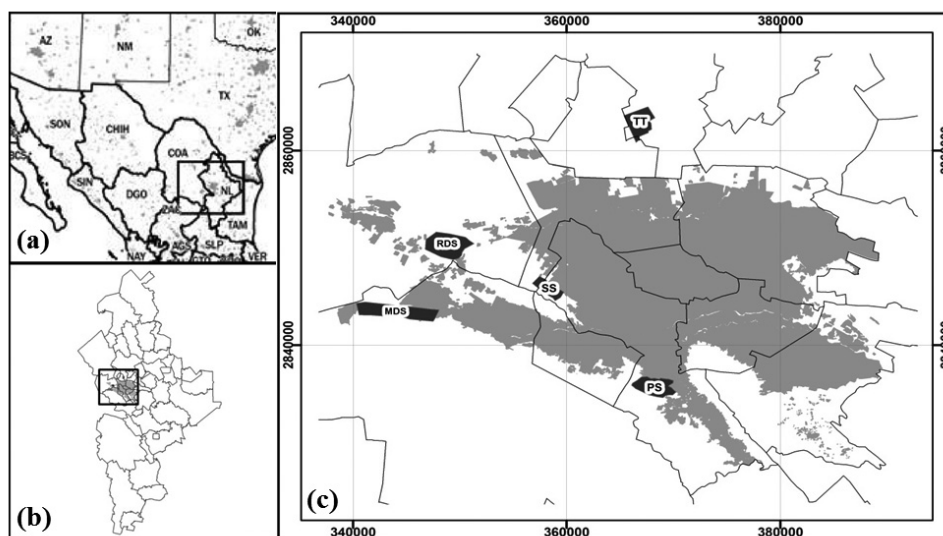
In the state of Nuevo Leon, during the last ten years, a number of studies have been undertaken in different types of shrubland communities. These studies have been focused on the composition (Estrada *et al.*, 2004, 2005, González-Rodríguez *et al.*, 2010), structure (Reid *et al.*, 1990; García-Hernández and Jurado, 2008; Canizales-Velázquez *et al.*, 2009; González-Rodríguez *et al.*, 2010; Molina-Guerra *et al.*, 2013; Jiménez *et al.*, 2012, 2013), distribution (Estrada *et al.*, 2010), and diversity of plant species (Espinoza-Bretado and Nívar, 2005; Alanís *et al.*, 2008; Villarreal-Quintanilla and Estrada-Castillón, 2008; Jiménez-Pérez *et al.*, 2009; Canizales-Velázquez *et al.*, 2009; Estrada *et al.*, 2010, Estrada-Castillón *et al.*, 2012; Jiménez *et al.*, 2013). However,

there have been few studies (Briones and Villarreal, 2001; Encina-Domínguez *et al.*, 2013) aimed at comparing different types of shrublands in terms of their physiognomy, floristic composition, and diversity between highlands (*Altiplano*) and lowlands (*Planicie Costera del Golfo*), and there are no available studies that address and examine the relationships between structural indicator traits and diversity values in the shrublands of northeastern Mexico. Thus, the aim of this study was to conduct a comprehensive and comparative analysis, at the plant community level, of the five most common types of shrublands found in the state of Nuevo Leon with respect to their structure, including their plant density ( $N\ ha^{-1}$ ), plant coverage ( $m^2\ ha^{-1}$ ), specific richness ( $S$ ), and alpha diversity ( $H'$ ).

## Materials and methods

**Study area.** The study was carried out in the shrublands of the center of the state of Nuevo Leon, in northeastern Mexico ( $25^{\circ}\ 58'$  to  $25^{\circ}\ 34'$  N,  $100^{\circ}\ 35'$  to  $100^{\circ}\ 16'$  W), encompassing municipalities of the Monterrey metropolitan area, including Salinas Victoria (tamaulipan thornscrub, TT), Monterrey (semithorny shrubland, SS, and piedmont scrub PS), Garcia (microphyllous desert shrubland, MDS), and Santa Catarina (rosetophyllous desert shrubland, RDS; Figure 1). Table 1 presents some physical and climatic variables as a description of the studied areas.

**Sampling.** In the years 2010 and 2011, 25 sampling plots with sizes of  $100\ m^2$  ( $10 \times 10\ m$ ) were established in each shrubland, resulting in a total of 125 plots for characterizing the vegetation. The distribution of the sampling plots



**Figure 1.** Location of the study sites. A) North of Mexico and south of the USA, B) In the state of Nuevo Leon, northeastern Mexico, and C) In municipalities of the Monterrey metropolitan area, in addition to the areas evaluated. The shaded areas represent urban areas. TT, tamaulipan thornscrub; SS, semithorny shrubland; PS, piedmont scrub; MDS, microphyllous desert shrubland; RDS, rosetophyllous desert shrubland.

**Table 1.** Physical and climatic variables of the evaluated areas (Anonymous, 1981).

Vegetation	Tamaulipan thornscrub	Semithorn shrubland	Microphyllous desert shrubland	Piedmont scrub	Rosetophyllous desert shrubland
Abbreviation	TT	SS	MDS	PS	RDS
Coordinates	25° 54' 48" N 100° 18' 41" O	25° 43' 07" N 100° 24' 28" O	25° 46' 09" N 100° 30' 53" O	25° 36' 18" N 100° 17' 47" O	25° 41' 37" N 100° 34' 06" O
Altitude (meters above sea level)	480	850	930	660	640
Mean annual temperature (°C)	20 to 22	20 to 22	20 to 22	18 to 20	18 to 20
Mean annual precipitation (mm)	400 to 600	300 to 600	300 to 400	400 to 600	125 to 300
Soil type	luvic xerosols	lithosols, rendzinas	luvic lithosols	lithosols, vertisols	regosols, xerosols

was systematic, with a distance of 50 m between them. According to the species-area curve, community SS presented a minimum of 25 sites, while the other communities displayed a fewer sampling plots. For the statistical analysis, we established the same number of sampling plots for each community.

A square shape was used for each plot because this shape made it easier to layout and measure the structural attributes of vegetation in the studied sites (Canizales-Velázquez *et al.*, 2009). In each sampling plot, an inventory of all of the woody species was performed, including measurements such as determination of the plant coverage ( $m^2$ ) and stem diameter (cm) at 10 cm above the soil surface ( $d_{0.10} \geq 1$  cm), which represents a standard measurement used for woody species in TT (Alanís *et al.*, 2008; Jiménez-Pérez *et al.*, 2009).

**Analysis.** The absolute abundance and dominant species were calculated. The absolute abundance ( $A$ ) is defined as  $A_i = N_i S^{-1}$ , where  $A_i$  is the absolute abundance of species  $i$ ;  $N_i$  is the number of individuals of species  $i$ ; and  $S$  is the sampled area (ha). To estimate dominance ( $D$ ), the plant coverage ( $m^2 ha^{-1}$ ) of each individual was determined. The absolute dominance is estimated as  $D_i = Ab_i S^{-1}$ , where  $D_i$  is the absolute dominance of species  $i$ ;  $Ab_i$  is the plant coverage of species  $i$ ; and  $S$  is the sampled area (ha) (Mueller-Dombois and Ellemberg, 1974; Mostacedo and Fredericksen, 2000). Species richness ( $S$ ) was quantified as the total number of species at each site. The index of diversity was assessed for each site as follows (Shannon, 1948):

$$H' = - \sum_{i=1}^s p_i * \ln(p_i)$$

$$p_i = n_i / N$$

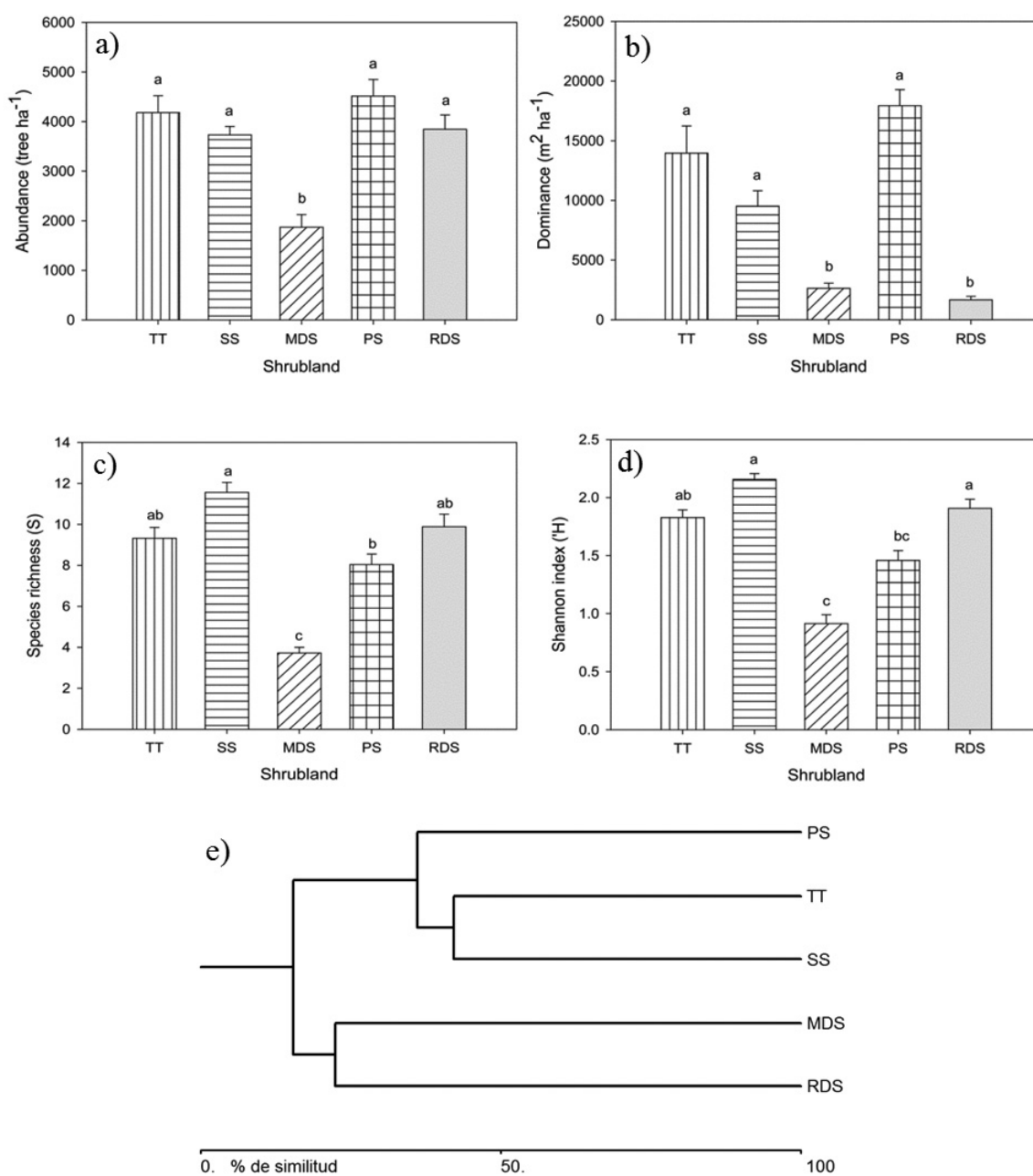
where  $H'$  is the Shannon index of diversity;  $\ln$  is the natural logarithm;  $p_i$  is the proportion of species  $i$ ;  $n_i$  is the number of individuals of species  $i$ ; and  $N$  is the total number of individuals.

Statistical analyses of density, plant coverage, species richness, and diversity were performed following the assumptions of a normal distribution and equality of variances using the one-way ANOVA, or failing that, an equivalent nonparametric test, the Kruskal-Wallis test, under the null hypothesis of equal means or medians. When differences were observed, complementary tests, such as Tukey and Nemenyi ranges (Wheater and Cook, 2005), were used for multiple comparisons. The floristic composition of the scrubs was explored through Bray-Curtis ordination analysis of (Bray and Curtis, 1957). The results are presented in a dendrogram, thereby revealing the similarity among the evaluated scrubs. Statistical analyses were performed using the software package BioDiversity Professional Version 2 (McAleece, *et al.*, 1997).

## Results

A total of 85 plant species were registered in the five studied communities, which belonged to 65 genera and 28 families (Appendix 1). The most representative families were Cactaceae (18 species) and Fabaceae (16 species), followed by Asteraceae (six species) and Agavaceae (five species). RDS showed the greatest number of plant species (48), followed by PS, SS, and TT, with 34, 33, and 30 species, respectively. These four scrub plant communities exhibited a similar number of families (between 18 and 19). The MDS community displayed the lowest number of plant species (15) and families (9). Two of the recorded plant species (*Echinocereus poselgeri* and *Lophophora williamsii*, Cactaceae) are considered protected under the official norm list (NOM-059-SEMARNAT-2010) of the Mexican government for species with a protected status (SEMARNAT, 2010).

The abundance of scrub showed highly significant differences among communities ( $F = 13.015$ ,  $df = 4$ ,  $P < 0.001$ ; Figure 2A). The MDS plant community was the type of scrub presenting the lowest abundance ( $1,868 N ha^{-1}$ ), while the other four plant communities showed similar abundances, with values ranging from 3,732 (SS) to 4,512  $N ha^{-1}$  (PS).



**Figure 2.** A) Abundance (tree ha<sup>-1</sup>) of the evaluated communities, B) Dominance (m<sup>2</sup> ha<sup>-1</sup>) of the evaluated communities, C) Species richness ( $S$ ) of the evaluated communities, D) Shannon index ( $H'$ ) of the evaluated communities; E) Dendrogram of the similarity matrix according to Bray-Curtis ordination for the evaluated vegetation. TT, tamaulipan thornscrub; SS, semithorn shrubland; PS, piedmont scrub; MDS, microphyllous desert shrubland; RDS, rosetophyllous desert shrubland. Means ( $\pm$  standard error,  $n = 25$ ) followed by different letters (a, b, c) show significant differences at  $P = 0.05$ .

Significant differences in the dominant species present were observed among the five studied scrub types ( $\chi^2 = 88.46$ ,  $df = 4$ ,  $P < 0.001$ ; Figure 2B). The desert plant communities exhibited lower plant coverage values than the other community types, but similar values were obtained between them (1,671 and 2,637 m<sup>2</sup> ha<sup>-1</sup> for RDS and MDS, respectively). In contrast, scrub communities SS, TT, and PS displayed higher, comparable values of 9,523, 13,960,

and 17,931 m<sup>2</sup> ha<sup>-1</sup>, respectively, but these values were significantly different. Plant species richness ( $S$ ) differed significantly ( $\chi^2 = 61.88$ ,  $df = 4$ ,  $P < 0.001$ ) among the evaluated areas (Figure 2C). The scrub type that presented the lowest richness values was MDS ( $S = 3.72$ ), followed by PS ( $S = 8.04$ ). In contrast, plant communities RDS ( $S = 8.50$ ), TT ( $S = 9.32$ ), and SS ( $S = 11.56$ ) showed higher and similar richness values.



The Shannon diversity values also differed ( $\chi^2 = 71.64$ ,  $df = 4$ ,  $P < 0.001$ ) among the evaluated areas (Figure 2D). Scrub communities MDS and PS exhibited the lowest Shannon diversities, presenting values of 0.91 nats and 1.46 nats, respectively, while plant communities RDS and SS attained higher Shannon diversity values of 1.90 nats and 2.15 nats, respectively.

A large number of species (44, representing 51.8% of the total species present) were recorded only in one specific type of shrubland, and up to 14 were observed in only two different types. Thus, the plant communities showed lower similarity compared with the plant composition. The scrub types that displayed the highest similarities were TT and SS, presenting a value of 42%, followed by PS with SS and TT, with 36%, and MDS with RDS, with 22% (Figure 2E).

## Discussion

The species richness (85) registered in the present study area was higher compared with a previous study conducted in piedmont scrub, which recorded 52 species (Canizales-Velázquez *et al.*, 2009), and a study conducted in tamaulipan thornscrub, identifying 27 plant species (Jiménez-Pérez *et al.*, 2009). In this study, RDS was the community that showed the highest plant diversity, due to the frequent presence of cactus species, two of which are under the special protection risk category (Appendix 1). Other reports have shown that plants belonging to the Agavaceae and Cactaceae families are important components of the rosetophyllous vegetation (Rzedowski, 1978; Martorell and Ezcurra, 2002).

Among all of the plant families registered in this study, the Fabaceae played a particularly important role within the floristic composition of the scrub, particularly in TT and PS, which agrees with previous studies in this region (Canizales-Velázquez *et al.*, 2009; Jiménez-Pérez *et al.*, 2009; González-Rodríguez *et al.*, 2010). However, our findings disagree with observations reported by Huerta-Martínez and García-Moya (2004) in that in the PS plant community, the most representative family was Cactaceae, with 18 species, followed by the Fabaceae, with nine species. The MDS vegetation showed a similar number of Cactaceae and Fabaceae species, which presented three species each; these findings disagree with those of Huerta-Martínez and García-Moya (2004) who documented a large number (33) of cactus species in MDS. An explanation for this difference is that by Huerta-Martínez and García-Moya (2004) evaluated an area with edaphic and altitudinal variations, which caused a high species richness. With respect to the RDS vegetation, 17 plant species belonging to Cactaceae were found, which agrees with studies conducted by Huerta-Martínez and García-Moya (2004) and Carmona-Lara *et al.* (2008).

*Celtis pallida* was the only species identified in all five types of shrublands, while *Guaiaacum angustifolium* and

*Echinocereus stramineus* were absent only from PS; *Leucophyllum frutescens*, *Karwinskia humboldtiana*, *Forestiera angustifolia*, and *Opuntia engelmannii* were absent only from MDS; and *Cordia boissieri* was absent only from RDS. These generalist species contrast with most of the recorded species (44 out of 85), which are specific to a unique type of shrubland. As mentioned previously, this situation is the main factor conditioning the low similarity values between these five shrubland communities in northeast Mexico.

**Abundance and dominant of species.** The MDS community showed minimum abundance and was significantly different from the other studied scrublands. The most abundant species were *Gutierrezia sarothrae* (146 N ha<sup>-1</sup>), *Prosopis glandulosa* (92 N ha<sup>-1</sup>), *Castela erecta* subsp. *texana* (75 N ha<sup>-1</sup>), and *Agave lecheguilla* (56 N ha<sup>-1</sup>). According to the results reported by Huerta-Martínez and García-Moya (2004), only *P. glandulosa* was registered as a representative species for this community. In contrast, the remaining plant communities were composed of large number of individuals, with higher abundance and similarity being observed among these communities.

With respect to dominance, it was clear that vegetation types such as TT, PS, and SS showed a higher dominance value with respect to the other plant communities, due in part to the tree and shrub species they harbor, such as *Celtis* spp., *Cordia boissieri*, *Acacia* spp., *Havardia pallens*, and *Zanthoxylum fagara*, among others. In contrast, the shrublands with lower dominance are characterized by an abundance of smaller species, particularly the RDS plant community (1,671 m<sup>2</sup> ha<sup>-1</sup>), which displayed the lowest dominance value among the five studied plant communities. RDS showed the greatest number of species belonging to the Cactaceae and Agavaceae, as it was composed of numerous cactus species with rosette-like leaves, with or without thorns, which were generally acaulescent. Carmona-Lara *et al.* (2008) documented 30 cactus species in a region of the municipality of Garcia, Nuevo Leon, within the Sierra Corral de Los Bandidos Natural Protected Area in Mexico; in this study, 15 cactus species were registered, 13 of which were recorded in the natural protected area. Following the RDS plant vegetation type in terms of dominance, a value of 2,637 m<sup>2</sup> ha<sup>-1</sup> was observed for the MDS. Hernández *et al.* (1998) documented a lower dominance value (1,500 m<sup>2</sup> ha<sup>-1</sup>) compared with the present study. These differences are related to lower plant diversity, which suggests that the MDS plant vegetation type is composed of smaller number of species that are consequently the dominant species. In this study, MDS showed the lowest plant species richness.

**Species diversity and richness.** The MDS community showed 15 plant species and a Shannon diversity index of 0.91 nats, thus representing the community with the lowest species richness and diversity values. These results are in

agreement with the findings of Huerta-Martínez and García-Moya (2004), who registered the lowest diversity index value ( $H' = 1.07$  nats) but the highest plant richness (37 species) in MDS plant community. These results showed that the MDS plant community presented the lowest diversity value due to its lower species richness and higher abundance. In contrast, the highest richness was observed in the RDS community, where 48 species were recorded, followed by the PS and SS communities, with 34 and 33 plant species, respectively. These results are in agreement with the observations made by Huerta-Martínez and García-Moya (2004), who recognized the highest plant richness in this type of vegetation. In a study carried out by Carmona-Lara *et al.* (2008), 45 and 18 species were recorded in two RDS research sites, while Estrada *et al.* (2005) reported values in the north of Nuevo Leon state of approximately 48 and 52 species for PS and SS, respectively, which were higher than the values obtained in the present study. In another study, Canizales-Velázquez *et al.* (2009) registered a richness value of 52 species for a PS plant community. This value is slightly higher than the value observed in the present work; in regard to the plant richness of TT, this community presented the highest richness value (30 species) among the five studied communities. Jiménez-Pérez *et al.* (2009) reported richness values of 24 and 19 plant species in a study conducted at two sites harboring TT vegetation. These differences could be attributed to previous intense management practices, which diminished the number of species (Pausas and Austin, 2001, Alanís *et al.*, 2013). These results showed that these shrublands exhibit high species richness, as Fabaceae was a representative group in the three communities with a large number of species. In agreement with other studies, this family was the most representative in the Center of Nuevo Leon state (Estrada *et al.*, 2004). The RDS plant community showed the highest species richness due to the presence of a large number of species from the Cactaceae.

The SS plant community showed the highest diversity value (2.15 nats), followed by RDS (1.90). In a study conducted by Huerta-Martínez and García-Moya (2004), the PS vegetation type was found to show the highest diversity index ( $H' = 1.88$  nats), followed by RDS ( $H' = 1.83$  nats). It should be noted that the results observed by these authors in PS and MDS are similar to the findings of this study. For the northwest region of Nuevo Leon, Carmona-Lara *et al.* (2008) reported diversity index values between 2.86 nats and 2.36 nats in RDS. With respect to the PS vegetation type, it showed a diversity index of 1.46 nats, which was much lower than the index of 3.0 nats documented by Canizales-Velázquez *et al.* (2009). Accordingly, these authors also found a higher richness with respect to the present study. A diversity index value of 1.80 nats was observed in the present study in a TT community, whereas Jiménez-Pérez *et al.* (2009) documented diversity index values in the range of 2.10 to 2.24 in abandoned land areas with a history of

farming and grazing. Studies conducted by González-Rodríguez *et al.* (2010) at three sites that had not undergone any apparent land use change in northeastern Nuevo Leon revealed diversity index values in the range of 2.4 to 2.8. These results showed that TT plant community presents the highest diversity value, associated with a high species richness due to the lack of predominance of one or more species.

As observed by Huerta-Martínez and García-Moya (2004), as well as Villarreal-Quintanilla and Encina-Domínguez (2005), the RDS plant community type is listed as the type of shrubland with the greatest number of plant species in the official norm list (NOM-059-SEMARNAT-2010) of the Mexican government for taxa at risk, with two species. MDS presents just one plant species in this list. In contrast, in a natural protected area of Nuevo Leon state next to the study area, Carmona-Lara *et al.* (2008) observed eight species comprised in the official norm list, all of which belonged to the Cactaceae.

According to Mas and Pérez-Vega (2005), xerophytic shrublands account for approximately 11% of the total surface area (58,129 km<sup>2</sup>) of the National System of Natural Protected Areas. Thus, approximately 6,394 km<sup>2</sup> of these lands belong to some category of natural protected area in Mexico. These lands encompass approximately 6.9% of the surface area of the RDS vegetation type (7,341 km<sup>2</sup>) in the National System of Natural Protected Areas. Which also encompass 5.6% of the MDS surface area (11,548 km<sup>2</sup>) and 5.3% of the PS surface area (1,471 km<sup>2</sup>) in the National System of Natural Protected Areas. The percentage is calculated with respect to the total area of each vegetation type.

This situation reflects the great value of conserving these types of plant communities based on the threatened species found within them and the low dominance observed in natural protected areas. Moreover, these communities are characterized by high vulnerability and fragility of their vegetation due to the serious decrease in their surface area in the last decade, even though their plant communities have been extensively used for various purposes, such as animal feed resources consumed by range livestock and wildlife, charcoal, fuelwood, timber for construction, fiber, fence materials, foodstuffs, and medicinal herbs (Alanís and Foroughbakhch, 2008). The most important threats to these plant communities types are activities leading to land use changes, which have resulted in habitat loss and fragmentation, a diminished cover and composition of vegetation, and growth of urban areas due to human activities.

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**Appendix 1.** Checklist of the plant species and densities (N ha<sup>-1</sup>) registered in the study area. RDS, rosetophyllous desert shrubland; SS, semithorn shrubland; MDS, microphyllous desert shrubland; PS, piedmont scrub; TT, tamaulipan thornscrub. SP: Special Protection. Nomenclature: Tropicos (2014).

Plant species	RDS	SS	MDS	PS	TT	NOM-059
<b>Agavaceae</b>						
<i>Agave americana</i> L.	35					
<i>Agave lechuguilla</i> Torr.	253	13	56			
<i>Agave striata</i> Zucc.	24					
<i>Dasyilirion texanum</i> Scheele	22					
<i>Yucca filifera</i> Chabaud	1	27			4	
<b>Amaranthaceae</b>						
<i>Atriplex canescens</i> (Pursh) Nutt.	12					
<b>Anacardiaceae</b>						
<i>Rhus microphylla</i> Engelm.				24		
<b>Asteraceae</b>						
<i>Artemisia ludoviciana</i> Nutt.	7					
<i>Gutierrezia microcephala</i> (DC.) A.Gray	52		146			
<i>Gymnosperma glutinosum</i> (Spreng.) Less.	1	49			130	
<i>Parthenium argentatum</i> A.Gray			35			
<i>Parthenium incanum</i> Kunth	3					
<i>Viguiera stenoloba</i> S.F.Blake	15					
<b>Berberidaceae</b>						
<i>Berberis trifoliolata</i> Moric.	16				57	
<b>Boraginaceae</b>						
<i>Cordia boissieri</i> A.DC.		67	2	55	154	
<i>Ehretia anacua</i> (Teran & Berl.) I.M.Johnston		5		24		
<b>Cactaceae</b>						
<i>Coryphantha compacta</i> (Engelm.) Orcutt	1					
<i>Coryphantha difficilis</i> (Quehl) Orcutt	6					
<i>Coryphantha neglecta</i> L.Bremer	22				2	
<i>Cylindropuntia imbricata</i> (Haw.) F.M.Knuth	1					
<i>Cylindropuntia leptocaulis</i> (DC.) F.M.Knuth.	23		7		21	
<i>Echinocactus horizonthalonius</i> Lem.	5					
<i>Echinocereus enneacanthus</i> Engelm.	12					
<i>Echinocereus pectinatus</i> (Scheidw.) Engelm.	22					
<i>Echinocereus stramineus</i> (Engelm.) F.Seitz	2	1	6		2	
<i>Echinocereus poselgeri</i> Lem.			7			SP
<i>Ferocactus haematacanthus</i> (Muehlenpf.) Britton & Rose	2					SP
<i>Lophophora williamsii</i> (Lem. ex Salm-Dyck) J.M.Coult.	24					SP
<i>Mammillaria melanocentra</i> Poselger	1					SP
<i>Mammillaria pottsii</i> Scheer ex Salm-Dyck	43					
<i>Neolloydia conoidea</i> (DC.) Britton & Rose	1					
<i>Opuntia engelmannii</i> Salm-Dyck	7	13		14	18	
<i>Sclerocactus scheeri</i> (Salm-Dyck) N.P.Taylor	3					
<i>Thelocactus bicolor</i> (Galeotti) Britton & Rose	5					SP

Plant species	RDS	SS	MDS	PS	TT	NOM-059
<b>Celastraceae</b>						
<i>Mortonia greggii</i> A.Gray	34					
<b>Ebenaceae</b>						
<i>Diospyros texana</i> Scheele		26		74		
<i>Diospyros virginiana</i> L.				2		
<b>Ephedraceae</b>						
<i>Ephedra antisyphilitica</i> Berland. Ex C.A.Mey.	4					
<b>Euphorbiaceae</b>						
<i>Bernardia myricifolia</i> (Scheele) Watts	6	90		13		
<i>Croton torreyanus</i> Müll.Arg.		73		8	6	
<i>Jatropha dioica</i> Sesse	18					
<b>Fabaceae</b>						
<i>Acacia berlandieri</i> Benth.	32	30		6		
<i>Acacia farnesiana</i> (L.) Willd.			4	24	1	
<i>Acacia greggii</i> A.Gray	24	9			1	
<i>Acacia rigidula</i> Benth.		111		517	2	
<i>Caesalpinia mexicana</i> A.Gray		5		51	4	
<i>Calliandra conferta</i> Benth	37					
<i>Cercidium macrum</i> I.M.Johnst.			2		16	
<i>Ebenopsis ebano</i> (Berl.) Britton & Rose		3				
<i>Eysenhardtia polystachya</i> (Ortega) Sarg.		60			8	
<i>Eysenhardtia texana</i> Scheele	3			5		
<i>Leucaena</i> sp.				4		
<i>Mimosa malacophylla</i> A.Gray		6		6		
<i>Havardia pallens</i> (Benth.) Britton & Rose		5		16	35	
<i>Prosopis glandulosa</i> Torr.	26	1	92			
<i>Prosopis leavigata</i> Torr.					3	
<i>Sophora secundiflora</i> (Ortega) DC.	13	8		3		
<b>Fagaceae</b>						
<i>Quercus polymorpha</i> Schltldl. & Cham.				31		
<b>Fouquieriaceae</b>						
<i>Fouquieria splendens</i> Engelm.		11				
<b>Koeberliniaceae</b>						
<i>Koeberlinia spinosa</i> Zucc.	1		2		2	
<b>Lythraceae</b>						
<i>Heimia salicifolia</i> (Kunth) Link				2		
<b>Lauraceae</b>						
<i>Litsea novoleontis</i> Bartlett				20		
<b>Oleaceae</b>						
<i>Forestiera angustifolia</i> Torr.	6	17		32	8	
<i>Fraxinus americana</i> L.				4		
<b>Pinaceae</b>						
<i>Pinus catarinae</i> Passiini	6					

## COMPOSITION, STRUCTURE AND DIVERSITY OF SHRUBLANDS

Plant species	RDS	SS	MDS	PS	TT	NOM-059
<b>Rhamnaceae</b>						
<i>Karwinskia humboldtiana</i> (Willd. ex Roem. & Schult.) Zucc.	4	17		8	26	
<i>Condalia hookeri</i> M.C.Johnst.	18	26		4		
<b>Rubiaceae</b>						
<i>Randia laetevirens</i> Standl.		3		12		
<b>Rutaceae</b>						
<i>Zanthoxylum fagara</i> (L.) Sarg.		53		127	95	
<b>Salicaceae</b>						
<i>Neopringlea integrifolia</i> (Hemsl.) S.Watson		11			2	
<b>Sapindaceae</b>						
<i>Sapindus saponaria</i> L.				2		
<b>Sapotaceae</b>						
<i>Bumelia lanuginosa</i> (Michx.) Pers.		6		12		
<b>Scrophulariaceae</b>						
<i>Leucophyllum frutescens</i> (Berland.) I.M.Johnst.	30	102		9	136	
<b>Simaroubaceae</b>						
<i>Castela texana</i> (Torr. & A.Gray) Rose			75		26	
<b>Solanaceae</b>						
<i>Capsicum annuum</i> L.					1	
<i>Solanum erianthum</i> D.Don				2		
<b>Ulmaceae</b>						
<i>Celtis leavigata</i> Willd.		11		10	55	
<i>Celtis pallida</i> Torr.	1	10	1	6	63	
<i>Ulmus crassifolia</i> Nutt.				8		
<b>Verbenaceae</b>						
<i>Aloysia</i> sp.					18	
<i>Lantana camara</i> L.		44		2	118	
<b>Zygophyllaceae</b>						
<i>Guaiaacum angustifolia</i> Engelm.	48	10	12		31	
<i>Larrea tridentata</i> (Sessé & Moc. ex DC.) Coville	29		1			
<b>Without identification</b>						
sp. 1		7				
sp. 2		3				
<b>Total</b>	961	933	448	1,137	1,045	5