CHARACTERIZATION OF THORN-SCRUB WOODLAND COMMUNITIES AT THE CHAPARRAL WILDLIFE MANAGEMENT AREA IN THE SOUTH TEXAS PLAINS, DIMMIT AND LA SALLE COUNTIES, TEXAS

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ABSTRACT

The composition of semiarid grasslands in southwestern North America has changed during the past 150 years with woody species increasing in density and cover. This brush encroachment involves mostly native species, many of which are woody members of the Fabaceae (legume family) that have increased in importance because of changes in local biotic and/or abiotic factors. At the Chaparral Wildlife Management Area, Dimmit and La Salle counties, Texas, thorn-scrub woodland communities are common. In some, *Prosopis glandulosa* (honey mesquite) is the most important species, however, other thorny woody legume species are prominent, and sometimes dominate the community. Common taxa are *Senegalia berlandieri* [=*Acacia berlandieri* (guajillo, fern acacia)], *S. greggii* [=*Acacia greggii* (catclaw acacia)], *S. roemeriana* [=*Acacia roemeriana* (Roemer's acacia)], *Vachellia bravoensis* [=*Acacia schaffneri* var. *bravoensis* (twisted acacia)], *V. farnesiana* [=*Acacia farnesiana* (huisache)], and *V. rigidula* [=*Acacia rigidula* (blackbrush)]. In the communities studied, thorny woody legume species had importance values between 87 and 157 (possible 200). Between 11 and 20 woody and succulent species were present in these communities with a total of 28 species recorded.

KEY WORDS: *Acacia s.l.*, *Prosopis glandulosa*, South Texas Plains, thorn-scrub woodlands.

The composition and structure of semi-arid grasslands in southwestern North America has changed during the past 150 years (Van Auken 2000). Although some changes are the result of the invasion of exotic species, most changes involve dramatic increases of native woody taxa that were historically present in low densities (Johnston 1963, Archer et al. 1988, Archer 1989).

The flat, deep soils of much of the South Texas Plains once supported an open savanna with a ground layer of short grasses and forbs in which *Prosopis glandulosa* (honey mesquite), along with lesser numbers of other shrubs and trees, which were clustered or scattered. This region also contained a mosaic of rocky, broken uplands that were dominated by relatively dense brushy vegetation. This open savanna has changed to brushy thorn-scrub woodland within the last 150 years apparently due to anthropogenic forces (Correll and Johnston 1970, Van Auken 2000, Ruthven 2001).

The change to thorn-scrub woodland was primarily the result of overgrazing by domestic livestock and fire suppression (Archer et al. 1988, Ruthven et al. 2000, Ruthven 2001). Honey mesquite was the pioneer woody species involved in this transition to thorn-scrub woodland, and is currently the common dominant throughout the southwestern United States and adjacent Mexico (Ruthven 2001). Species representing two genera of thorny legumes (*Senegalia* and *Vachellia*) were also major components of these thorn-scrub woodlands.

The genera *Senegalia* and *Vachellia* are segregates of the genus *Acacia* (*sensu lato*). Based on morphological and genetic evidence, it is evident that the genus *Acacia s.l.* is polyphyletic. Also, there has been an accumulation of data, derived from molecular studies, that has lead to a better understanding of probable relationships within the genus *Acacia s.l.*, as well as the position of the genus within the Mimosoideae. These studies confirmed that the genus *Acacia s.l.* should be separated into as many as five genera, including *Senegalia*

(Seigler et al. 2006) and *Vachellia* (Seigler and Ebinger 2005). The common species of these two genera in Texas include *Senegalia berlandieri* [=*Acacia berlandieri* (guajillo, fern acacia)], *S. greggii* [=*Acacia greggii* (catclaw acacia)], *S. roemeriana* [=*Acacia roemeriana* (Roemer's acacia)], *Vachellia bravoensis* [=*Acacia schaffneri* var. *bravoensis* (twisted acacia)], *V. farnesiana* [=*Acacia farnesiana* (huisache)], and *V. rigidula* [=*Acacia rigidula* (blackbrush)]. These well-armed species are common throughout the arid and semi-arid environments of the South Texas Plains (Isely 1998), and along with *Prosopis glandulosa* are important sources of animal fodder, fuel, and timber (Fagg and Stewart 1994).

Thorn-scrub woodlands are common at the Chaparral Wildlife Management Area (CWMA), located in the northern part of the South Texas Plains ecological region. The importance and distribution of honey mesquite and other thorny legumes is determined by various biotic and abiotic factors, such as climate, moisture, edaphic conditions, present and past grazing pressures, and fire. The objective of this study was to examine the structure and composition of thorn-scrub woodland communities to understand better the importance, distribution, and habitat preferences of thorny legume species.

STUDY AREA

The study area was on the Chaparral Wildlife Management Area (28^{o}20'N, 99^{o}25'W) in the northern half of the South Texas Plains (Ruthven et al. 2000, Ruthven 2001). Located in Dimmit and La Salle counties, 12 km west of Artesia Wells, CWMA is deer-proof fenced and about 6,150 ha in size. Purchased in 1969 by the Texas Parks and Wildlife Department, it serves as a research and demonstration area. The area around CWMA is rangeland, most holdings being large cattle ranches.

Hot summers and mild winters characterize the climate of CWMA. The average daily minimum winter (January) temperature is 5^{o}C, the average daily maximum summer (July) temperature is 37^{o}C, the growing season is 249 to 365 days, and the average annual precipitation (1951 to 1978) is 55 cm (Stevens and Arriaga 1985). The precipitation patterns are bimodal with peaks occurring in late spring (May and June), and early fall (September and October). Short-term periods of drought are common and rainfall can be highly variable between locations (Norwine and Bingham 1985). An all-time low record of 7.16 cm fell during 1917 in Cotulla, a small town 25 km northeast of CWMA (Correll and Johnston 1970).

Soils of CWMA are dominated by Duval very fine, sandy loams, gently sloping and Duval loamy fine sands, 0 to 5% slope (Gabriel et al. 1994, Stevens and Arriaga 1985). The soil surface layer is reddish brown, slightly acid, very friable, and 0 to 40 cm thick. Also present are shallow limestone ridges (calcareous rises) where soils are mildly to moderately alkaline and have a caliche layer near the surface. Topography is level to gently rolling with an average elevation of 175 m above mean sea level.

Domestic livestock have grazed the CWMA since the 18th century (Lehmann 1969). Sheep production dominated from about 1750 to 1870 when cattle became the major livestock. Before 1969, grazing was continuous on the entire area. From 1969 to 1984 a four-pasture rest-rotation system was employed. Cattle were absent from the study area from 1984 to 1989. Grazing resumed in 1990, and, until 2002, CWMA utilized a high intensity, low frequency rotational grazing system. Stocking rates averaged one Animal Unit per 12 ha (Ruthven 2001). A prescribed burn program was initiated at the CWMA in 1997, but none of the sites examined in the present study has been burned (Ruthven, personal communication). Most of the CWMA was chained in 1948 (Ruthven, personal communication). Chaining involves the use of two large tractors with a very heavy linked chain connected at each end to one of the tractors. The chain is pulled across the site, disrupting and pulling out much of the vegetation (Lehmann 1984).

METHODS

During the summer of 2001, five thorn-scrub woodland communities were studied at the CWMA. These sites were selected based on the recommendations of CWMA site personnel who located sites where the vegetation was mature and least disturbed. All sites were upland, nearly level areas, where minimal disturbance, other than grazing, was observed. At four of the sites (1, 2, 3, and 4), a single line transect was randomly established near the center of the long axis of each community. At 30 m intervals along the length of the transect, circular plots 0.03 ha in size were located (a minimum of 10 plots) and all woody plants and succulents greater than 0.4 m tall were identified and their height and average crown diameter determined to the nearest dm. As *Senegalia roemeriana* was found only in one small area, the entire community was examined (Site 5). This site (50 m x 50 m in size) was divided into subplots to facilitate sampling, and all woody plants greater than 0.4 m tall were measured and identified as described above. Data from the plots were used to determine density, average cover, relative density, relative cover, and importance value (IV) for each species at each site. The IV is calculated as the sum of the relative density and relative cover. Sorensen's Index of Similarity (ISs) was used to determine the degree of similarity between the study sites: ISs = 2C/(A+B) x 100 (Mueller-Dombois and Ellenberg 1974).

At each study site, soil samples (n = 16) were taken, both under shrub and tree canopies and in open areas between shrub clusters. All samples were analyzed by the Texas Agricultural Extension Service, Soil Testing Laboratory, College Station, Texas for pH, salinity, and macro-nutrients (ppm in available form). A random sample from each site was analyzed for soil texture. Significant differences between sites for pH and the various macro-nutrients was tested with procGLM ($p < 0.05$) using SAS (1986).

RESULTS

The number of woody and succulent species recorded for the five thorn-scrub woodland sites ranged from 11 to 20 with 28 different species recorded, six being thorny species of legumes (Tables 1 thru 5). Of the 28 species encountered, seven occurred on each of the five sites: *Celtis pallida* (spiny hackberry), *Condalia hookeri* (brazil), *Diospyros texana* (Texas persimmon), *Forestiera angustifolia* (narrowleaf forestiera), *Opuntia engelmannii* (prickly pear), *O. leptocaulis* (tasajillo), and *Prosopis glandulosa.* *Opuntia engelmannii*, *O. leptocaulis,* and *Prosopis glandulosa* were common species in most of the communities and had high densities, covers, and IV's. *Prosopis glandulosa* was the dominant species with the highest IV on two sites (2 and 5) and was second at site 3, whereas one of the two species of *Opuntia* ranked third or higher on all sites. The remaining species listed above were recorded for all sites; though they were sometimes common, they never dominated the community, always ranking fourth or lower in IV. For woody vegetation of all five sites, the Sorensen

Index of Similarity ranged from 51.6 to 84.8 (Table 6), but was usually greater than 66 indicating that sites were very similar (Mueller-Dombois and Ellenberg 1974).

Though one or two species of the genus *Senegalia* and/or *Vachellia* were among the top three species at each study site, they commonly shared dominance with *Prosopis glandulosa*, and/or a species of *Opuntia*. *Vachellia rigidula* was found on three sites, ranking first in IV on site 4 and third on site 1 (Tables 1, 4, and 5). *Vachellia bravoensis* occurred on four sites, ranking third or lower in IV on all sites (Tables 1, 2, 3, and 5). Other thorny legume species were restricted to one or two sites. *Senegalia roemeriana* was second in IV on site 5 (Table 5), *S. greggii* ranked first on site 1 (Table 1), and *S. berlandieri* occurred on two sites, ranking second on site 4, and was uncommon on site 1 (Tables 1, 4).

On all study sites, the soil texture was relatively uniform, being sandy loams with 61 to 75% sand, 12 to 20% silt, and 11 to 19% clay, and none were saline (Table 7). Soils of sites 1, 2, 3, and 5 were mildly to strongly acidic, mostly low to very low in available nitrates, phosphorus, and sodium, but with moderate to high amounts of available potassium, magnesium, sulfur, and calcium (Table 7). Soils of site 4, in contrast, were from a calcareous ridge (cuestas). Soil pH here was mildly to moderately alkaline with high available phosphorous and magnesium, all being significantly different ($p < 0.0001$) from other sites; whereas the level of available sodium was significantly lower ($p < 0.0001$). Although all sites had relatively high levels of available calcium, site 4, was significantly higher ($P < 0.0001$).

DISCUSSION

The thorn-scrub vegetation of CWMA and surrounding area was representative of that associated with the South Texas Plains (South Texas Brush Country or Tamaulipan Brushlands). In much of this rangeland, *Prosopis glandulosa* was the dominant species, with about 10 to 15 other woody or succulent, mostly thorny species, varying in abundance and composition. At the CWMA, honey mesquite was usually the dominant woody species, but, on some sites, other woody legumes were dominant or co-dominant (Johnston 1963, Correll and Johnston 1970).

Honey mesquite-dominated woodland with various species of *Senegalia* and *Vachellia* as co-dominants was the most common plant community on the CWMA. This woodland community, where dominant trees were more than 3 m tall and formed a 26-60 percent canopy, would be equivalent to the Deciduous Woodland, Mesquite-Huisache Series (*Prosopis glandulosa-Vachellia farnesiana*) of Diamond et al. (1987) with other thorny legume species replacing huisache. At three study sites, mesquite was dominant with *Vachellia bravoensis* (Tables 2, 3), or *Senegalia roemeriana* (Table 5) as co-dominants.

Vachellia bravoensis, a large shrub only rarely exceeding 3 m in height, was common at the CWMA. Except for the *Vachellia rigidula/Senegalia berlandieri* community on the calcareous crestas, *V. bravoensis* ranked third to sixth in IV on all sites. S*enegalia roemeriana*, in contrast, was rare at CWMA. We found this species at just one site, where, along with *Prosopis glandulosa*, it dominated the community in a small area less than 75 m across (Table 5). At this site, soil pH was nearly neutral (6.5), and available calcium was relatively high (1101 ppm) (Table 7). Isely (1998) did not report *Senegalia roemeriana* for the South Texas Plains. Correll and Johnston (1970) list the distribution of this species as farther north and west in Texas, being frequent in the Trans Pecos, and infrequent on caliche cuestas in the southern part of the Edwards Plateau.

Vachellia rigidula and *Senegalia berlandieri* dominated limestone ridges and caliche cuestas of the CWMA. This community, in which the dominants were shrubs or small trees 0.5 to 3 m tall, and formed 26 percent of more of the total canopy, would be equivalent to the Deciduous Shrubland, Blackbrush Series (*Vachellia rigidula*) of Diamond et al. (1987). *Vachellia rigidula* appeared to be fairly site specific at the CWMA, ranking first in IV on the calcareous ridge (Site 4) and third in IV on the dry ridge that supported the *Senegalia greggii/Opuntia/Vachellia rigidula* community (Site 1). This species appears to be well adapted to dry sites with high levels of available calcium. *Senegalia berlandieri*, in contrast, was a component of disturbed habitats at CWMA, often along roadsides, in arroyos, and other disturbed areas, but was an important stand component on the limestone ridge (Site 4). This species is common throughout southern and western Texas and is exceedingly abundant on limestone ridges and caliche cuestas (Correll and Johnston 1970, Isely 1998). At this site, the alkaline soils (pH of 8.0) and extremely high concentration of available calcium appear beneficial to this species. *Senegalia berlandieri* and *Vachellia rigidula*, act as nurse trees, and facilitate the recruitment of woody and succulent species (Jurena and Van Auken 1998).

Senegalia greggii had a restricted distribution at CWMA (Site 1) being common only on a dry sandy ridge. At this location catclaw acacia was the dominant member of the community, accounting for one-third of the total IV. This community, which is probably maintained by fire, grazing, and sandy soil, should be classified as the Catclaw Acacia Series, Deciduous Scrubland (*Senegalia greggii*). The woody vegetation at this site was short with only a few individuals being more than 2 m tall (Table 1). Canopy cover was estimated at 25 to 30 percent, and the scattered woody shrubs were mostly small and compact. No individuals of *S. greggii* were more than 2 m tall, and most were less than 1 m tall. Many were in clumps 1-2 m in diameter; the numerous, upright, bushy stems being connected by underground roots or stems.

Of the thorny species of woody legume species found at the CWMA, *Vachellia farnesiana* (huisache) was not common. This species was rare along roadsides and near arroyos, mostly in heavily disturbed habitats. *Vachellia farnesiana* is common throughout the South Texas Plains, but usually in more mesic habitats (Correll and Johnston 1970), where it is a co-dominant of the Deciduous Woodland, Mesquite-Huisache Series of Diamond et al (1987).

Though some of the acacia species at CWMA have distinct habitat preferences, the reasons for their continued importance, and the continued prevalence of thorn-scrub woodland communities they dominate is not entirely clear. Most information suggests that overgrazing and fire suppression were the primary causes of this encroachment (Van Auken 2000). When much of the South Texas Plains was covered with open savanna containing a dense groundcover of grasses and forbs, wildfires were frequent and of sufficient intensity to prevent encroachment by native woody species. However, overgrazing by livestock reduced the fuel load. At the same time, fire suppression allowed for a significant decrease in fire frequency creating ideal conditions for the rapid explosion of native invaders.

ACKNOWLEDGEMENTS

We wish to acknowledge support of this work by a grant from the International Arid Lands Consortium (O1R005), a grant from the National Science Foundation (NSF DEB 04-15803), and to thank The Texas Parks and Wildlife Department, and in particular D. C. Ruthven, J. F. Gallagher, and D. R. Synatzske of the Chaparral Wildlife Management Area for their assistance with the project. We also appreciate the critical review of the manuscript by Dr. Sean Jenkins, Ecologist, Western Illinois University, Macomb, Illinois; William McClain, Adjunct Research Associate in Botany, Illinois State Museum, Springfield, Illinois; and Dr. Chip Ruthven, Project Leader, Matador Wildlife Management Area, Paducah, Texas.

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Table 1. Density (#/ha) by height classes (m), mean crown cover (m^2), relative frequency, relative crown cover, and importance value (IV) of the species encountered at the *Senegalia greggii/Opuntia/Vachellia rigidula* Site (site 1) 28°N 20’ 22”, 99°W 22’ 46”, Chaparral Wildlife Management Area, Texas.

Species	Density (#/ha) by height class (m)					Mean	Rel. Den.	Rel. Cover	IV
	0.4-1	1-2	2-3	3+	Total	Cover			
Senegalia greggii	480	130	--	--	610	1.62	36.7	31.9	68.6
Opuntia engelmannii	170	77	--	--	247	1.71	14.8	13.7	28.5
Vachellia rigidula	30	147	10	3	190	2.61	11.5	16.0	27.5
Opuntia leptocaulis	157	63	--	--	220	0.74	13.2	5.2	18.4
Vachellia bravoensis	87	43	--	--	130	1.88	7.8	7.9	15.7
Condalia hookeri	7	27	13	3	50	5.75	3.0	9.3	12.3
Colubrina texensis	13	43	--	--	56	2.40	3.4	4.4	7.8
Prosopis glandulosa	13	13	--	3	29	2.41	1.8	2.3	4.1
Celtis pallida	30	13	--	--	43	0.96	2.6	1.3	3.9
Forestiera angustifolia	--	7	3	--	10	6.77	0.6	2.2	2.8
Zanthoxylum fagara	7	13	--	--	20	1.99	1.2	1.3	2.5
Diospyros texana	3	13	3	3	22	1.26	1.4	0.9	2.3
Senegalia berlandieri	--	--	3	3	6	5.41	0.4	1.2	1.6
Karwinskia humboldtiana	--	10	--	--	10	1.21	0.6	0.4	1.0
Bumelia celastrina	--	--	3	--	3	7.07	0.2	0.8	1.0
Lycium berlandieri	--	7	--	--	7	2.34	0.4	0.5	0.9
Schaefferia cuneifolia	--	3	--	--	3	5.31	0.2	0.6	0.8
Ziziphus obtusifolia	3	--	--	--	3	0.95	0.2	0.1	0.3
Totals	1000	609	35	15	1659	52.39	100.0	100.0	200.0

Table 2. Density (#/ha) by height classes (m), mean crown cover (m^2), relative frequency, relative crown cover, and importance value (IV) of the species encountered at the *Prosopis glandulosa /Opuntia/Vachellia bravoensis* Site (site 2) 28°N 18' 09", 99°W 21' 40", Chaparral Wildlife Management Area, Texas.

Species	Density (#/ha) by height class (m)					Mean Cover	Rel. Den.	Rel. Cover	IV
	0.4-1	1-2	2-3	3+	Total				
Prosopis glandulosa	90	83	43	243	459	15.16	30.6	58.4	89.0
Opuntia engelmannii	326	103	7	--	436	5.42	29.0	19.8	48.8
Vachellia bravoensis	87	137	33	17	274	3.36	18.2	7.7	25.9
Ziziphus obtusifolia	37	130	47	3	217	5.08	14.4	9.2	23.6
Colubrina texensis	23	37	3	--	63	4.09	4.2	2.2	6.4
Aloysia gratissima	3	27	--	--	30	2.18	2.0	0.6	2.6
Diospyros texana	--	--	--	7	7	13.89	0.4	0.8	1.2
Condalia hookeri	--	--	--	3	3	30.19	0.2	0.8	1.0
Celtis pallida	--	--	3	3	6	7.24	0.4	0.4	0.8
Opuntia leptocaulis	--	7	--	--	7	1.06	0.4	0.1	0.5
Forestiera angustifolia	--	3	--	--	3	0.13	0.2	--	0.2
Totals	566	527	136	276	1505	87.80	100.0	100.0	200.0

Table 3. Density (#/ha) by height classes (m), mean crown cover (m^2), relative frequency, relative crown cover, and importance value (IV) of the species encountered at the *Opuntia/Prosopis glandulosa/Vachellia bravoensis* Site (site 3) 28°N 18' 05", 99°W 21' 29", Chaparral Wildlife Management Area, Texas.

Species	Density (#/ha) by height class (m)					Mean Cover	Rel. Den.	Rel. Cover	IV
	0.4-1	1-2	2-3	3+	Total				
Opuntia engelmannii	480	205	--	--	685	4.26	32.6	23.4	56.0
Prosopis glandulosa	70	55	5	110	240	21.52	11.4	41.3	52.7
Vachellia bravoensis	115	205	30	5	355	3.67	16.9	10.4	27.3
Aloysia gratissima	25	150	70	5	250	3.35	11.9	6.7	18.6
Colubrina texensis	110	145	--	--	255	2.78	12.1	5.7	17.8
Bumelia celastrina	10	25	20	30	85	7.54	4.1	5.1	9.2
Diospyros texana	10	10	15	15	50	6.37	2.4	2.5	4.9
Forestiera angustifolia	70	5	--	--	75	0.34	3.6	0.2	3.8
Celtis pallida	10	15	5	5	35	5.54	1.7	1.6	3.3
Ziziphus obtusifolia	5	20	--	--	25	9.65	1.2	1.9	3.1
Zanthoxylum fagara	--	--	5	5	10	12.58	0.5	1.0	1.5
Opuntia leptocaulis	20	--	--	--	20	0.24	1.0	0.1	1.1
Schaefferia cuneifolia	--	5	--	--	5	1.33	0.2	0.1	0.3
Condalia hookeri	--	5	--	--	5	0.79	0.2	--	0.2
Lycium berlandieri	5	--	--	--	5	0.39	0.2	--	0.2
Totals	930	845	150	175	2100	80.35	100.0	100.0	200.0

Table 4. Density values at the *Vachellia rigidula/Senegalia berlandieri* Site (site 4) 28°N 18’ 56”, 99°W 20’ 44”, Chaparral Wildlife Management Area, Texas.

Species	Density (#/ha) by height class (m)					Mean Cover	Rel. Den.	Rel. Cover	IV
	0.4-1	1-2	2-3	3+	Total				
Vachellia rigidula	190	285	120	60	655	4.20	20.2	26.6	46.8
Senegalia berlandieri	55	105	110	90	360	9.55	11.1	33.2	44.3
Opuntia engelmannii	335	100	--	--	435	3.17	13.4	13.3	26.7
Porlieria angustifolia	510	70	--	--	580	0.64	17.9	3.6	21.5
Schaefferia cuneifolia	380	20	--	--	400	0.64	12.3	2.4	14.7
Lycium berlandieri	45	120	25	--	190	3.03	5.8	5.6	11.4
Prosopis glandulosa	10	--	15	15	40	18.51	1.2	7.2	8.4
Ziziphus obtusifolia	40	75	5	--	120	2.64	3.7	3.1	6.8
Opuntia leptocaulis	120	30	--	--	150	0.90	4.6	1.3	5.9
Forestiera angustifolia	90	45	--	--	135	0.76	4.2	1.0	5.2
Karwinskia humboldtiana	25	15	--	--	40	1.72	1.2	0.7	1.9
Ephedra antisyphilitica	25	10	--	--	35	1.17	1.1	0.4	1.5
Celtis pallida	20	15	--	--	35	1.21	1.1	0.4	1.5
Leucophyllum frutescens	5	15	5	--	25	2.11	0.8	0.5	1.3
Koeberlinia spinosa	10	--	--	--	10	4.42	0.3	0.4	0.7
Zanthoxylum fagara	--	5	--	5	10	1.16	0.3	0.1	0.4
Diospyros texana	5	--	--	--	5	2.01	0.2	0.1	0.3
Condalia hookeri	--	5	--	--	5	1.13	0.2	0.1	0.3
Bumelia celastrina	--	5	--	--	5	0.50	0.2	--	0.2
Eysenhardtia texana	5	--	--	--	5	0.28	0.2	--	0.2
Totals	1870	920	280	170	3240	59.75	100.0	100.0	200.0

Table 5. Density (#/ha) by height classes (m), mean crown cover (m^2), relative frequency, relative crown cover, and importance value (IV) of the species at the */Prosopis glandulosa/Senegalia roemeriana* Site (site 5) 28°N 19' 14", 99°W 24' 50", Chaparral Wildlife Management Area, Texas.

Species	Density (#/ha) by height class (m)					Mean Cover	Rel. Den.	Rel. Cover	IV
	.4-1	1-2	2-3	3+	Total				
Prosopis glandulosa	36	44	40	84	204	11.83	9.4	35.0	44.4
Senegalia roemeriana	100	124	48	28	300	2.83	13.9	12.3	26.2
Opuntia leptocaulis	264	112	--	--	376	1.04	17.4	5.7	23.1
Opuntia engelmannii	108	64	12	--	184	3.13	8.5	8.4	16.9
Condalia hookeri	8	48	32	40	128	5.95	5.9	11.0	16.9
Vachellia bravoensis	64	100	20	--	184	2.75	8.5	7.4	15.9
Gymnosperma glutinosum	108	68	--	--	176	0.49	8.2	1.3	9.5
Celtis pallida	12	28	28	8	76	3.90	3.5	4.3	7.8
Aloysia gratissima	--	48	36	--	84	1.85	3.9	2.3	6.2
Karwinskia humboldtiana	28	52	8	--	88	1.57	4.1	2.0	6.1
Lantana horrida	64	20	--	--	84	1.53	3.9	1.9	5.8
Colubrina texensis	16	28	8	--	52	4.31	2.4	3.2	5.6
Lycium berlandieri	16	52	--	--	68	1.42	3.1	1.4	4.5
Schaefferia cuneifolia	12	12	20	--	44	1.71	2.1	1.1	3.2
Forestiera angustifolia	28	20	--	--	48	0.89	2.2	0.6	2.8
Diospyros texana	--	4	12	4	20	5.53	0.9	1.6	2.5
Condalia spathulata	8	16	--	--	24	0.87	1.1	0.3	1.4
Porlieria angustifolia	16	--	--	--	16	0.23	0.8	0.1	0.9
Vachellia rigidula	--	--	4	--	4	2.01	0.2	0.1	0.3
Totals	888	840	268	164	2160	53.84	100.0	100.0	200.0

Table 6. Similarity Index of the five study sites where thorny woody legume species were common, Chaparral Wildlife Management Area, Dimmit and La Salle counties, Texas.

	Site 1	*Site 2*	*Site 3*	*Site 4*
Site 2	69.0			
Site 3	84.8	84.6		
Site 4	78.9	51.6	68.6	
Site 5	70.3	66.7	70.6	61.5

Table 7. Soil texture (% sand, silt, clay), salinity, pH, and macro-nutrients (ppm) of the soils on the study sites where thorny woody legume species were common, Chaparral Wildlife Management Area, Dimmit and La Salle counties, Texas. For pH and macro-nutrients, the range is given with the average value given beneath in parentheses. Different letters indicates significant difference between sites.

	Site 1 (n=15)	Site 2 (n=14)	Site 3 (n=13)	Site 4 (n=18)	Site 5 (n=2)
Texture					
Sand	75%	71%	71%	61%	77%
Silt	12%	12%	16%	20%	8%
Clay	13%	17%	13%	19%	15%
Salinity	none	none	none	none	none
pH	5.1-6.9 (6.1)a	4.6-6.2 (5.3)b	4.5-6.6 (5.2)b	7.7-8.3 (8.0)c	6.3-6.6 (6.5)a
Nitrate-N	4-6 (5.0)a	5-23 (8.6)b	5-9 (6.2)ab	4-9 (5.6)a	5 (5.0)a
Phosphate	1-5 (2.7)a	1-10 (5.6)a	3-8 (5.3)a	5-24 (16.8)b	2-3 (2.5)a
Potassium	151-320 (230.3)a	226-462 (323.9)b	205-364 (266.5)a	198-361 (287.7)ab	301-358 (329.5)ab
Calcium	660-1323 (925.5)a	469-1497 (721.9)a	495-1428 (784.8)a	3515-23291 (13886.8)b	981-1221 (1101.0)a
Magnesium	91-192 (134.6)ab	84-225 (144.5)a	76-145 (107.2)b	146-413 (242.4)c	141-178 (159.5)a
Sodium	99-271 (198,5)a	98-255 (214.9)a	106-258 (189.5)a	32-235 (82.9)b	217-250 (233.5)a
Sulfur	8-26 (18.7)ac	6-29 (22.2)abc	8-30 (18.8)ac	14-47 (26.8)bc	22-24 (23.0)c