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# Shrub species richness beneath honey mesquite on root-plowed rangeland

KELLEY M. STEWART, JEFFREY P. BONNER, GEORGE R. PALMER, S. FRANK PATTEN, AND TIMOTHY E. FULBRIGHT

*Authors are graduate research fellows, Caesar Kleberg Wildlife Research Institute, Campus Box 156, Texas A & M University-Kingsville, Kingsville, Tex. 78363; research assistant, Caesar Kleberg Wildlife Research Institute, Campus Box 156, Texas A&M University, Kingsville, Tex. 78363; and professor, Caesar Kleberg Wildlife Research Institute, Campus Box 156, Texas A & M University-Kingsville, Kingsville, Tex. 78363.*

## Abstract

**Root-plowed rangeland in southern Texas is often dominated by fabaceous shrubs. We tested the hypothesis that the shrub community present 40 years after rootplowing does not exhibit successional trends toward the mixed-brush species community that existed before rootplowing. Twenty shrub clusters, each organized around a central honey mesquite individual, were selected within a control site and a root-plowed (35-40 years ago) site at each of 3 locations. Number of all woody plants species including cacti *Opuntia* spp. and *Yucca* spp. beneath the nuclear honey mesquite was determined. Shrub species richness within clusters increased with increasing central honey mesquite basal diameter on control and root-plowed sites. Species richness/honey mesquite in root-plowed (2 ± 0.5 species, ± SE) sites was lower than species richness/honey mesquite >200 mm in diameter on control sites (7 ±0.4 species/honey mesquite). Honey mesquite seedlings (1-60 mm basal stem diameter) composed 39 ± 14% of the shrubs beneath honey mesquite canopies on root-plowed sites compared to ≤3% of the woody plants present on untreated sites. Honey mesquite may continue to dominate root-plowed sites for some time, since honey mesquite was the major subordinate shrub species on root-plowed sites.**

**Key Words: brush control, *Prosopis glandulosa*, species richness, succession**

Vegetation in the south Texas Plains has apparently shifted from grass- to woody-plant domination during the last 150 years (Archer 1995). Archer et al. (1988) proposed that this shift in dominance occurred through initial colonization of grassland by honey mesquite (*Prosopis glandulosa* Torr.) followed by establishment of subordinate shrubs beneath honey mesquite canopies. Subordinate shrub establishment resulted in formation of shrub clusters scattered within the grassland matrix with each cluster organized beneath a honey mesquite nucleus. Presumably, on many sites in south Texas these clusters expanded and ultimately coalesced, forming continuous shrubland, whereas a physiognomy consisting of discrete clusters within a grassland matrix remains extant on other sites, particularly on sandier soils.

Shrub cluster development follows a well-defined chronosequence (Archer 1989). Archer et al. (1988) reported that the first species to occur under honey mesquite canopies were prickly pear (*Opuntia lindheimeri* Engelm.) and colima (*Zanthoxylum fagara* (L.) Sarg.) followed by granjeno (*Celtis pallida* Torr.), brasil (*Condalia hookeri* M.C. Johnston), and Texas persimmon (*Diospyros texana* Scheele). Desert yaupon (*Schaefferia cuneifolia* Fray) and lotebush (*Ziziphus obtusifolia* Gray) were estimated to appear when clusters were 36–45 years old, whereas wolfberry (*Lycium berlandieri* Dunal) was the last species to appear.

Many landowners in southern Texas have attempted to convert thornscrub communities to grassland by plowing woody plants with large rootplows pulled by crawler tractors. Honey mesquite and other fabaceous shrubs reestablish following rootplowing (Fulbright and Beasom 1987, Ruthven et al. 1993). Based on traditional (Clementsian) successional theory, the process of shrub cluster development beneath honey mesquite following drastic disturbance (rootplowing) should be similar to that on untreated sites. An alternative hypothesis, based on state-and-transition models of succession (Westoby et al. 1989, Friedel 1991), is that the fabaceous shrub-dominated community present 40 years after rootplowing represents a new stable state that does not exhibit successional trends toward the mixed-brush species community that existed before rootplowing.

Predictions based on traditional successional theory and on Archer's (1989) chronosequence of cluster development are that (1) subordinate shrub species richness increases with increasing honey mesquite diameter on root-plowed and control (untreated) sites; (2) subordinate shrub species richness and percent composition is similar beneath honey mesquite individuals of similar size on root-plowed and control (untreated) areas, but lower for honey mesquite individuals on root-plowed sites than for larger (and presumably older) honey mesquite individuals on control sites; and (3) similarity between shrub clusters on root-plowed and control sites is greater for honey mesquite plants in the same size class than for larger honey mesquites on control sites. The reverse

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of these predictions should be true if the fabaceous shrub-dominated community represents a stable state.

## Materials and Methods

The study was conducted on the 7,300-ha Maltsberger Ranch in LaSalle County, Texas in April 1995. The ranch is located on the Duval-Brystal-Webb association of soils in the south Texas plains (Gabriel et al. 1994). Soils of the Duval series are fine-loamy, mixed, hyperthermic Aridic Haplustalfs; those of the Brystal series are fine-loamy, mixed, hyperthermic Aridic Paleustalfs; and soils of the Webb series are fine, montmorillonitic, hyperthermic Paleustalfs. Climate in the region is characterized by hot summers and mild winters with annual precipitation averaging 55 cm.

Three areas were selected for study, each consisting of a control treatment and a root-plowed treatment, with the latter root-plowed 35–40 years ago (1955–1959). Areas were ≥2 km apart. Buffelgrass (*Cenchrus ciliaris* L.) and blue panic (*Panicum antidotale* Retz.) were planted in the root-plowed areas after treatment. Cattle grazed the sites immediately following root plowing, and no fences were erected to separate the control from the treated areas.

We used a randomized, complete-block design with 3 blocks, each containing a control and a root-plowed treatment. Twenty shrub clusters organized around a central honey mesquite individual were randomly selected within each treatment and block by determining whether or not to sample each honey mesquite encountered along a transect by coin toss. Stem diameter of the nuclear honey mesquite within each cluster was measured. Number of all woody plants, *Opuntia* spp., and *Yucca* spp. beneath the nuclear honey mesquite was recorded. Percent composition by species was calculated as the number of individuals of a species in an experimental unit (treatment, block combination) divided by the total number of individuals of all species beneath the 20 honey mesquite individuals × 100. Honey mesquite stem diameters exceeding 200 mm did not occur in the root-plowed treatment, therefore we divided shrub clusters in control plots into 2 classes: (1) honey mesquite stem diameters of 0-200 mm and (2) honey mesquite stem diameters >200 mm for comparison of treatment means for percent composition of species and similarity indices. Within each block, Jaccard's Index of Similarity (Mueller-Dombois and Ellenberg 1974) between subordinate species beneath honey mesquite within rootplowed sites and subordinate species beneath 0-200-mm-diameter honey mesquite individuals was calculated with species presence-absence data. Jaccard's Similarity Index was used because it is a consistent measure of similarity when using presence-absence data (Janson and Vegelius 1981). Jaccard's Similarity Index was also calculated between subordinate species beneath honey mesquite within rootplowed sites and subordinate species beneath honey mesquite individuals >200 mm in diameter.

A regression analysis was performed to test for a linear relationship between honey mesquite stem diameter and subordinate shrub species richness in root-plowed and untreated sites. A paired *t*-test was used to compare similarity index values between shrub clusters in root-plowed sites and shrub clusters within each central honey mesquite diameter class in control sites. Analysis of variance was used to determine if differences in species richness and composition differed among shrub clusters in root-plowed sites, shrub clusters beneath 0-200 mm diameter honey mesquite individuals in control sites, and shrub clusters beneath >200 mm diameter honey mesquite individuals in control sites. A Tukey's mean separation test was used at the 0.05 level of significance when *F*-values were significant. Percentage data were arcsin transformed for analysis of variance.

## Results and Discussion

Shrub species richness increased with increasing honey mesquite diameter on control (untreated) ($P < 0.01$, $n = 60$) and root-plowed sites ($P < 0.01$, $n = 60$) (Fig. 1). Subordinate species richness was similar among root-plowed (2 ± 0.5 species/honey mesquite, $\bar{x}$ ± SE, $n = 3$) and 0-200-mm-diameter honey mesquite individuals (3 ± 0.3 species/honey mesquite) on control sites, but was significantly lower ($P < 0.05$, Tukey's test, minimum significant difference = 2) beneath honey mesquite individuals in root-

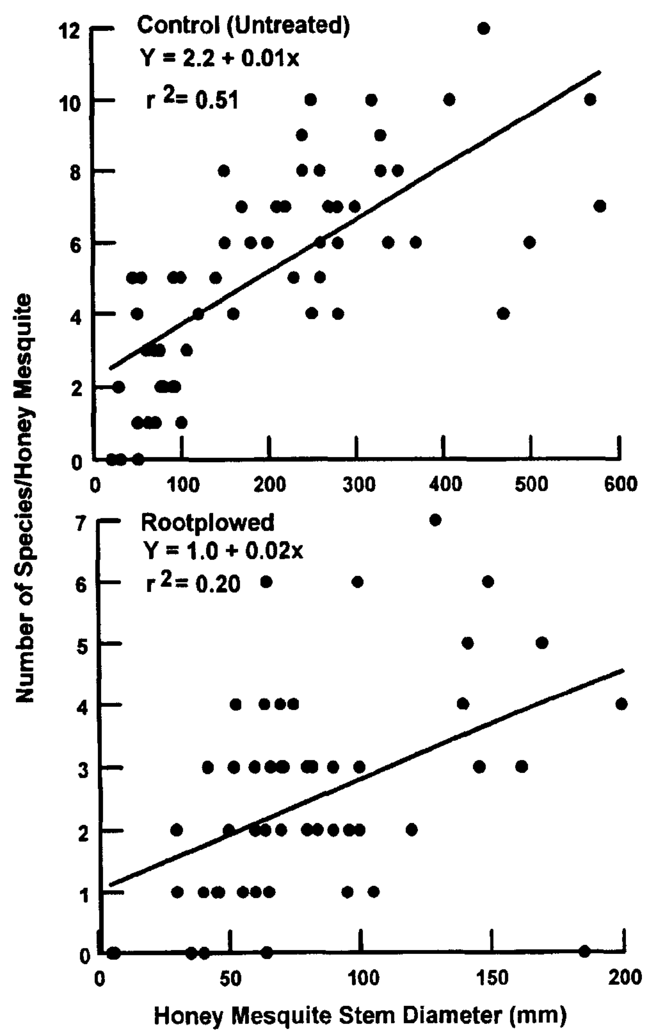


**Fig. 1. Relationship between honey mesquite stem diameter and number of subordinate shrub species and cacti beneath mesqute canopies on sites rootplowed during 1955-1959 and control (untreated) sites, April 1995, La Salle County, Tex.**

Table 1. Subordinate shrub and cacti species presence (P) or absence (A) beneath mesquites on sites rootplowed between 1955 and 1959) or beneath mesquites with stem diameters 0–200 mm or >200 mm on control sites, April 1995, La Salle County, Tex.

| Common name | Scientific name | Root-plowed | Control | |
|---|---|---|---|---|
| | | | 0–200 | >200 |
| **Species of open habitats**[1] | | | | |
| Blackbrush | *Acacia rigidula* Benth. | P | P | P |
| Twisted acacia | *Acacia schaffneri* Herm. | P | P | P |
| Castela | *Castela texana* (T.&G.) Rose | A | P | P |
| Hogplum | *Colubrina texensis* Gray | A | A | P |
| Tx. paloverde | *Parkinsonia texana* Wats. | P | A | A |
| Honey mesquite | *Prosopis glandulosa* Torr. | P | P | P |
| Yucca | *Yucca treculeana* Carr. | P | A | A |
| **Species of early stages of cluster development**[1] | | | | |
| Prickly pear | *Opuntia lindheimeri* Engelm. | P | P | P |
| **Species of intermediate stages of cluster development**[1] | | | | |
| Granjeno | *Celtis pallida* Torr. | P | P | P |
| Brasil | *Condalia hookeri* M.C. Johnston | P | A | P |
| Tx. persimmon | *Diospyros texana* Scheele | P | P | P |
| Tasajillo | *Opuntia leptocaulis* DC. | P | P | P |
| **Species of later stages of cluster development**[1] | | | | |
| Coma | *Bumelia celastrina* H.B.K. | A | P | P |
| Ephedra | *Ephedra antisyphilitica* Berl. | A | A | P |
| Elbowbush | *Forestiera angustifolia* Torr. | A | P | P |
| Wolfberry | *Lycium berlandieri* Dunal | P | A | P |
| Desert yaupon | *Schaefferia cuneifolia* Gray | P | P | P |
| Lotebush | *Ziziphus obutsifolia* Gray | P | P | P |
| **Species not categorized in the literature** | | | | |
| Guajillo | *Acacia berlandieri* Benth. | A | P | P |
| Whitebrush | *Aloysia gratissima* Troncoso | P | P | P |
| Pitaya | *Echinocereus enneacanthus* Eng. | P | P | P |
| Guayacan | *Guaiacum angustifolium* Engelm. | P | P | P |
| Allthorn | *Koeberlinia spinosa* Zucc. | A | A | P |
| Cenizo | *Leucophyllum frutescens* Johnston | A | A | P |
| Nipple cactus | *Mammillaria heyderi* Muelenpf. | A | P | P |

[1] From Whittaker et al. (1979), Archer et al. (1988), Everitt and Drawe (1993), and Archer (1996, personal communication).

plowed sites than beneath honey mesquite individuals >200 mm in diameter on control sites (7 ± 0.4 species/honey mesquite). Honey mesquites on root-plowed sites averaged 14 ± 2 ($n$ = 3) individual shrubs in their understory on control sites, compared to 6 ± 2 shrubs/honey mesquite on root-plowed sites.

We observed differences between treatments in presence and absence of woody plant species encountered (Table 1). Five of the 17 species observed beneath honey mesquites with stem diameters 0-200 mm on the control sites were not present in root-plowed areas. However, 4 of the 16 species observed on root-plowed sites were not recorded beneath honey mesquites with stem diameters 0-200 mm on the untreated sites. Two of these 4 species, Texas paloverde (*Parkinsonia texana*) and Yucca (*Yucca treculeana*) are characteristic of open habitats and 2, brasil and wolfberry, were recorded beneath larger honey mesquites on control sites. Half of the subordinate shrub species that occur in later stages in the chronosequence of shrub cluster development described by Archer et al. (1988) were absent from root-plowed sites. A total of 23 species occurred beneath honey mesquites with stem diameters >200 mm on control sites. Honey mesquite was the major shrub species beneath nuclear honey mesquite canopies on root-plowed sites, whereas honey mesquite composed only a small portion of the shrub species present on control sites (Fig. 2).

Low Jaccard's Index values between shrub clusters on root-plowed sites and shrub clusters beneath nuclear honey mesquites on control sites indicated that the subordinate shrub species composition was dissimilar between root-plowed and control sites. Mean ($n$ = 3) similarity index was 50 ± 3 for similarity between shrub clusters on root-plowed sites and shrub clusters beneath honey mesquites with 0–200 mm stem diameters on control sites. The mean index value was 52 ± 4 for similarity between subordinate shrubs on root-plowed sites and subordinate shrubs beneath honey mesquites with >200 mm stem diameters on control sites. These mean similarity index values did not differ significantly ($t$ = 0.57, $P$ = 0.62, 2 df). These results countered our prediction that similarity between shrub clusters beneath honey mesquites with similar stem diameters on root-plowed and control sites would be greater than similarity between shrub clusters beneath honey mesquites on root-plowed sites and shrub clusters beneath larger (>200 mm) honey mesquites on control sites.

Our data supported predictions that subordinate shrub species richness should increase with increasing honey mesquite diameter on root-plowed and control sites, and should be greater for subor-

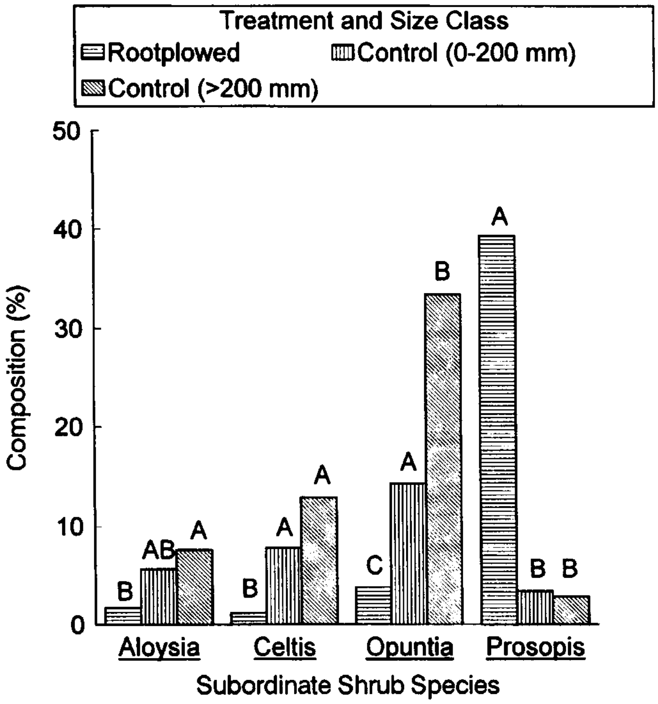


**Fig. 2. Percent composition of 4 subordinate shrub and cacti species beneath honey mesquite canopies on sites rootplowed during 1955-1959 and control (untreated) sites. The *Opuntia* was tasajillo. For a shrub or cactus species, means associated with the same letter are not significantly different (P ≥0.05).**

dinate shrubs under larger honey mesquite individuals on control sites. However, our data did not support predictions regarding subordinate species composition and similarity between shrub clusters on rootplowed and control sites. Based on our results, we conclude that the process of shrub community establishment in root-plowed sites does not follow the chronosequence for undisturbed sites as described by Archer et al. (1988) and Archer (1989).

Honey mesquite seedlings (1–60 mm basal diameter) dominate the understory on root-plowed sites on the Maltsberger Ranch. Archer et al. (1988) reported that honey mesquite seedlings were absent from shrub clusters and few honey mesquite seedlings were encountered in our control sites. Bush and Van Auken (1990) suggested that herbaceous competition along with reduced light levels prevent honey mesquite seedling establishment beneath canopies. Further research is needed to determine why honey mesquite seedlings were abundant beneath honey mesquite canopies on root-plowed sites.

Dominance of honey mesquite on root-plowed sites may be prolonged, since honey mesquite seedlings composed 39 ± 14% of the shrubs beneath honey mesquite canopies on root-plowed sites. Fulbright and Guthery (1996) developed a computer simulation model which predicted that subordinate shrub species richness on sites on the Maltsberger Ranch would not return to pretreatment levels for 150 to 200 years. Further, it appears that the state-and-transition model wherein rootplowing has acted as a drastic disturbance pushing community composition across a threshold to a new, perhaps stable (and depauperate) state is a more appropriate model of vegetation dynamics for these sites than the Clementsian community replacement model.

Maintaining biological diversity is a priority in the scientific community and in public policy (Cairns and Lackey 1992). However, government agencies and programs currently encourage and subsidize rootplowing of south Texas rangeland to increase forage for livestock. Because this and other studies (Fulbright and Beasom 1987, Ruthven et al. 1993) have documented that rootplowing reduces woody species richness of thornscrub communities, the practice should not be encouraged if woody species diversity of south Texas thornscrub is to be preserved.

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