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Plant and Small Vertebrate Composition and Diversity 36–39 Years After Root Plowing

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Abstract

Root plowing is a common management practice to reduce woody vegetation and increase herbaceous forage for livestock on rangelands. Our objective was to test the hypotheses that four decades after sites are root plowed they have 1) lower plant species diversity, less heterogeneity, greater percent canopy cover of exotic grasses; and 2) lower abundance and diversity of amphibians, reptiles, and small mammals, compared to sites that were not disturbed by root plowing. Pairs of 4-ha sites were selected for sampling: in each pair of sites, one was root plowed in 1965 and another was not disturbed by root plowing (untreated). We estimated canopy cover of woody and herbaceous vegetation during summer 2003 and canopy cover of herbaceous vegetation during spring 2004. We trapped small mammals and herpetofauna in pitfall traps during late spring and summer 2001–2004. Species diversity and richness of woody plants were less on root-plowed than on untreated sites; however, herbaceous plant and animal species did not differ greatly between treatments. Evenness of woody vegetation was less on root-plowed sites, in part because woody legumes were more abundant. Abundance of small mammals and herpetofauna varied with annual rainfall more than it varied with root plowing. Although structural differences existed between vegetation communities, secondary succession of vegetation reestablishing after root plowing appears to be leading to convergence in plant and small animal species composition with untreated sites.

Key Words: amphibians, brush management, *Prosopis glandulosa*, reptiles, rodents, woody plants

INTRODUCTION

Mechanized brush management was conducted on thousands of hectares in southern Texas during the 20th century to remove woody plants and increase grass production for livestock (Archer et al. 2011). Conversion of woody plant communities to herbaceous vegetation is temporary in the absence of additional intervention to remove reestablishing woody vegetation. Woody vegetation reestablishes within treated areas and becomes dominant within one or two decades following root plowing (Archer et al. 2011). Root plows consist of large, V-shaped blades pulled by crawler tractors that sever roots of woody plants below the soil surface, resulting in high woody plant mortality (Forgason and Fulbright 2003). When diverse shrub communities in southern Texas are root plowed, the woody plant community that reestablishes following treatment on upland sites is dominated by woody legumes and is less species-rich than the original shrub community (Ruthven et al. 1993).

Root plowing can also alter composition and diversity of the herbaceous plant community. Forb canopy cover was twice as high 16–18 yr after root plowing than on untreated sites in southern Texas (Ruthven et al. 1993). In Argentina and in Arizona, however, herbaceous vegetation canopy cover was similar on root-plowed and untreated sites 12–16 yr after treatment (Roundy and Jordan 1988; Allegretti et al. 1997). Disturbance by mechanical treatments can facilitate invasion and spread of exotic grasses such as buffelgrass (*Pennisetum ciliare* [L.] Link) (Franklin et al. 2006; Johnson and Fulbright 2008). Invasion by exotic grasses following brush management can reduce abundance of native grasses and forbs and populations of small vertebrates (Germano et al. 2001; Sands et al. 2009).

Landscapes that have been root plowed are more homogeneous than landscapes that have not been disturbed by root plowing >30 yr after treatment (Nolte et al. 1994). Habitat heterogeneity and plant diversity are often positively correlated with animal species diversity (Hawkins and Porter 2003; Tews et al. 2004). Reduced animal diversity compared to untreated sites, therefore, is a possible consequence of increased homogeneity and reduced plant diversity of formerly root-plowed sites (Tews et al. 2004; Fuhlendorf et al. 2006).

Long-term effects of root plowing and woody plant recolonization on the diversity of herbaceous plants, small mammals, and herpetofauna on southern Texas rangelands are unknown. Our objective was to compare plant species diversity and habitat heterogeneity, canopy cover of exotic grasses, and abundance and diversity of amphibians, small mammals, and

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reptiles between root-plowed and adjacent sites not disturbed by root plowing (hereafter referred to as "untreated").

METHODS

The study was conducted on the 6 154-ha Chaparral Wildlife Management Area (lat 28°20′N, long 99°25′W) in the western south Texas Plains, USA (Gould and Kapadia 1975; Scifres 1980; Hatch et al. 1990). The study site was purchased by the State of Texas in 1969 and is administered by the Wildlife Division of the Texas Parks and Wildlife Department. Vegetation is dominated by honey mesquite (*Prosopis glandulosa* Torr.)/mixed brush and blackbrush acacia (*Acacia rigidula* Benth.)/guajillo (*Acacia berlandieri* Benth.) communities (McLendon 1991). Prominent herbaceous species included Lehmann lovegrass (*Eragrostis lehmanniana* Nees), fringed signalgrass (*Urochloa ciliatissima* [Buckley] R. Webster), hairy grama (*Bouteloua hirsuta* Lag.), Croton (*Croton* L. sp.), Rio Grande tickseed (*Coreopsis nuecensoides* E. B. Sm.), dozedaisy (*Aphanostephus* DC sp.), and partridge pea (*Chamaecrista fasciculata* [Michx.] Greene) (Ruthven et al. 2000; Ruthven and Synatzske 2002).

Climate of the area is characterized by hot summers and mild winters with a growing season ranging from 249 to 365 d (Stevens and Arriaga 1985). Precipitation patterns are bimodal, with peaks occurring in late spring (May–June) and early autumn (September–October). Mean annual precipitation (1989–1999) is 540 mm (Ruthven and Synatzske 2002). Rainfall during the study was monitored with a weather station on the Chaparral Wildlife Management Area. Soils are sandy loams, and topography consists of gently rolling hills interspersed with ephemeral drainage systems (Nolte et al. 1994).

The study area has been grazed by domestic livestock since the 18th century (Lehmann 1969). Cattle have been the major species of livestock since about 1870, whereas sheep were grazed from 1750 to 1870. Grazing strategies have varied from continuous grazing to various rotational grazing systems (Ruthven et al. 2000).

Experimental Design

We collected data within five pairs of 4-ha (200 × 200 m) sites; each pair consisted of a 4-ha root-plowed site and a nearby 4-ha untreated site. These sites were about four-fold larger than the average home range size of common small mammals in our study area. For example, in a study in southern Texas, Merriam's pocket mouse (*Perognathus merriami* Allen) moved a maximum distance of 46 m; the home range of hispid cotton rats (*Sigmidon hispidus* Say and Ord) was 1 ha for males and 0.5 ha for females (Chapman and Packard 1974; Gaines et al. 2004). Stickel and Stickel (1949) reported that the home range of the northern pygmy mouse (*Baiomys taylori* Thomas) was 0.07 ha. Male and female southern plains woodrats (*Neotoma micropus* Baird) have home ranges of 0.19 and 0.02 ha, respectively (Conditt and Ribble 1997).

Root-plowed and untreated sites were paired based on soil properties. The experimental design included three replications. Three 4-ha sites were randomly selected inside a 150-ha area that was root plowed in 1965; these were paired with three untreated sites with similar soils. We considered the three 4-ha sites within the 150-ha root-plowed area to be subsamples of one replication. They ranged from 483 to 965 m apart. The second replication was a pair of sites consisting of an untreated 4-ha site paired with a 4-ha site with similar soils within a 24-ha area root plowed in 1965. The third replication was a pair of sites consisting of an untreated 4-ha site paired with a 4-ha site in a 32-ha area root plowed in 1965. The minimum distance between untreated and root-plowed sites within each replication was 481 m and the maximum distance apart was 1 236 m.

Vegetation Sampling

We randomly placed fourteen 20-m-long transects within each 4-ha root-plowed site and each 4-ha untreated site within each of the three replications. We used the line-intercept method to visually estimate percent canopy cover of woody plants, cacti, and suffrutescent shrubs along each transect during late summer 2003 (Canfield 1941). Suffrutescent shrubs included leatherstem (*Jatropha dioica* Cerv.), Lantana (*Lantana* L. spp.), and awnless bushsunflower (*Simsia calva* [Engelm. & A. Gray] A. Gray). Woody plant density was estimated by counting individual plants in a 1 × 20 m belt along each transect. We placed four 20 × 50 cm frames at randomly selected points along each of the 14 transects for a total of 56 frames within each 4-ha site. Herbaceous plant percent canopy cover (grasses, forbs, and sedges), percent bare ground, and litter were visually estimated during late summer (July–August) 2003 and early spring (March–April) 2004 (Barbour et al. 1999).

Woody and herbaceous plant species diversity was quantified with Shannon's index (Pielou 1975). Density of woody plant species was used to estimate species richness (species $\cdot$ 280 m^{-2}), Shannon's index, and evenness. Percent canopy cover was used in calculations of species richness (species $\cdot$ 5.6 m^{-2}), Shannon's index, and evenness for herbaceous plants. Beta diversity for woody and herbaceous plants was estimated by calculating the mean of the Jaccard's similarity index values computed for all possible pairs of the 14 transects within each 4-ha root-plowed site and each 4-ha untreated site (Nolte and Fulbright 1997; Balvanera et al. 2002). The number of species within each transect was based on canopy cover estimates.

Herpetofauna and Small Mammals

We trapped herpetofauna and small mammals with drift fence arrays installed at the center of each 4-ha site (Gibbons and Semlitsch 1981; Simpson et al. 1996). Arrays consisted of three 7.6 × 0.305 m lengths of metal flashing that radiated out at 120° angles from a central point (Ruthven et al. 2002). We placed the bottom edge of each array < 10 mm below the soil surface. We buried a plastic container level with the soil surface, one at the center of each array and at the end of each arm of the array. We placed 137 × 137 × 13 mm coverboards in the bottom of each bucket to provide protection from inclement weather and predators. Twenty-five millimeters of soil were also placed in the bottom of buckets to provide added protection for burrowing species. Arrays were monitored twice daily during 2-wk sampling periods corresponding to the peak activity of animals in late spring and summer 2001 through 2004 (Ruthven et al. 2002).

We also sampled small mammals using Sherman traps (Simpson et al. 1996). We established a 11 × 11 grid with 10-m spacing between traps on each pair of 4-ha treatment sites during summer 2004. Traps were baited with rolled oats and peanut butter. Trapping was conducted for consecutive 5-d sampling periods and we trapped both treatments within a pair during the same time period. Small mammals and herpetofauna (except snakes) were individually marked by toe clipping before release. We used mean daily captures per 4-ha site as an estimate of relative abundance. We defined species richness as the number of different species captured within each sampling period and calculated Shannon's and evenness indices based on the proportions of each species captured (Nolte and Fulbright 1997). The study was approved by the Texas A&M University–Kingsville Animal Care and Use Committee (approval number 2003-6-4).

Statistical Analyses

We examined treatment-based differences in characteristics of the woody and herbaceous vegetation, herpetofauna, and small mammals using analysis of variance (ANOVA). We included replication as a random effect to account for variation among the three replications (Littell et al. 1996). For woody plants, we examined differences in total woody plant canopy cover, total density (plants $\cdot$ 280 m^{-2}), species richness (mean number of plant species $\cdot$ 280 m^{-2}), Shannon's index, evenness, and beta diversity index. For herbaceous plants, we considered total percent canopy cover, species richness (number of plant species $\cdot$ 5.6 m^{-2}), Shannon's index, evenness, and beta diversity. We also examined differences in percent litter and bare ground. For small mammals and herpetofauna, we examined differences in abundance of the most abundant species, species richness, Shannon's index, and evenness by treatment and sampling date.

We used stepwise discriminant analysis to identify woody and herbaceous plant species that distinguished between root-plowed and untreated sites (McGarigal and Cushman 2000). We considered absolute canopy cover and density of woody plants, canopy cover and density of the eight woody plant species with the greatest canopy cover or density, and canopy cover of the eight herbaceous plant species with the greatest canopy cover for selection and retained variables if $P < 0.10$.

During early autumn 2003 a wildfire burned two untreated sites and one root-plowed site. We analyzed data with and without these plots to determine if the fire affected treatment comparisons during 2004. Results did not differ significantly ($P > 0.05$) when the burned sites were excluded; therefore, results reported herein are based on all pairs of treatments.

RESULTS

Vegetation

Canopy cover, density, and species richness of woody and herbaceous vegetation were similar in untreated and root-plowed sites (Table 1). For woody plants, species richness, Shannon's index, and evenness were 33%, 30%, and 22% lower, respectively, on root-plowed sites compared to untreated sites. Differences between treatments were not as pronounced for herbaceous vegetation; however, Shannon's index was 16% lower on root-plowed sites in August 2003 and beta diversity was 9% lower on root-plowed sites in March 2004.

Percent canopy cover and density of spiny hackberry (*Celtis ehrenbergiana* [Klotzch] Liebm.) and Brazilian bluewood (*Condalia hookeri* M. C. Johnst.), percent canopy cover of honey mesquite, density of Texas pricklypear (*Opuntia engelmannii* [Salm-Dyck ex Engelm.); and canopy cover of hairy grama and dotseed plantain (*Plantago erecta* Morris) helped to discriminate between vegetation on untreated and root-plowed sites (Tables 2 and 3). Root-plowed sites were dominated by honey mesquite and had more than twice the canopy cover and almost four times greater density of honey mesquite than untreated sites (Table 2). Canopy cover of Texas pricklypear was slightly greater on untreated sites; however, density of Texas pricklypear was more than two times greater on root-plowed than on untreated sites. Brazilian bluewood was four times less dense on root-plowed sites. Canopy cover of hairy grama was three times greater on untreated sites, whereas cover of dotseed plantain was more than three times greater on root-plowed sites (Table 3).

Small Mammals, Reptiles, and Amphibians

Nine species of small mammals were captured both on treated and on untreated sites. Twenty-seven species of herpetofauna were captured on undisturbed sites compared to 24 species on root-plowed sites. The three species not captured on root-plowed sites were Texas tortoise (*Gopherus berlandieri* Stejneger), common king snake (*Lampropeltis getulus* Cope), and milk snake (*Lampropeltis triangulum* Stejneger and Barbour). Species richness, Shannon's index, and evenness of small mammals and herpetofauna were similar in untreated and root-plowed sites during all sampling periods (Table 4). Hispid cotton rats were slightly more abundant on root-plowed sites than on untreated sites. Abundance of other species of small mammals was similar on untreated and root-plowed sites.

Great Plains narrowmouth toads (*Gastrophryne olivacea* Smith) and Texas spotted whiptails (*Cnemidophorus gularis* Baird and Girard) were the most abundant species of herpetofauna in our study area (Table 4). Abundance of herpetofauna was similar on undisturbed and root-plowed sites.

Variation in abundance of herpetofauna and small mammals among years paralleled variation in rainfall. Rainfall during 2001, 2002, 2003, and 2004 totaled 455, 678, 831, and 625 mm, respectively. Total relative abundance of small mammals captured in pitfall traps was higher during 2003 than in other years. More than twice as many total herpetofauna were captured per day in 2003 than in 2001 and 2004 (LS means, $P < 0.009$); more herpetofauna were captured in 2003 than in 2002 but differences in abundance were not statistically significant (LS means, $P = 0.135$) between 2002 and 2003.

DISCUSSION

Woody plant communities present almost four decades following root plowing were less species-rich and diverse than untreated communities, in part because species composition of

Table 1. Means and standard errors (SE), test statistics, and *P* values for characteristics of the woody (July 2003) and herbaceous (August 2003, March 2004) plants in untreated and root-plowed sites ($n=3$ replications) on Chaparral Wildlife Management Area, Dimmit and La Salle Counties, Texas, USA.

Vegetation parameter	Untreated		Root plowed			
	Mean	SE	Mean	SE	$F_{1,2\ df}$	*P*
Woody plants						
Canopy cover (%)	86	12	95	4	1.2	0.393
Density (plants · ha^{-1})	4 448	593	4 643	251	0.3	0.627
Species richness (species · 280 m^{-2})	15	1	10	1	168.0	< 0.001
Shannon index	2.3	< 0.1	1.6	0.1	46.1	0.021
Evenness	0.9	< 0.1	0.7	< 0.1	23.4	0.040
Beta diversity	0.6	< 0.1	0.5	< 0.1	3.6	0.198
Herbaceous plants: August 2003						
Canopy cover (%)	67	2	70	5	0.2	0.673
Species richness (species · 5.6 m^{-2})	22	1.5	20	0.6	1. 5	0.351
Shannon index	2.5	< 0.1	2.1	0.2	9.3	0.093
Evenness	0.8	< 0.1	0.7	< 0.1	4.7	0.163
Beta diversity	0.6	< 0.1	0.6	< 0.1	0.04	0.861
Herbaceous plants: March 2004						
Canopy cover (%)	72	2.5	77	3.8	2.3	0.272
Species richness	20	1.6	19	1.0	0.2	0.716
Shannon index	2.5	< 0.1	2.3	0.2	1.1	0.414
Evenness	0.8	< 0.1	0.8	< 0.1	1.8	0.309
Beta diversity	0.7	< 0.1	0.6	< 0.1	1 652.9	< 0.001
Canopy cover (%)	86	12	95	4	1.2	0.393

treated sites was skewed toward woody legumes, including honey mesquite. Composition of the herbaceous plant community recovered within four decades following disturbance from root plowing and were similar to untreated sites. Buffelgrass and Lehmann's lovegrass, both nonnative C_4 grasses, invaded in the absence of disturbance from root plowing; canopy cover of these two grasses was similar in root-plowed sites and untreated sites (Table 3). Our results concur with those of Gonzalez and Dodd (1979), who found that buffelgrass became dominant within 3 yr in both undisturbed sites and root-plowed sites where they planted the grass. Similarly, researchers in the Sonoran Desert reported that disturbance by livestock grazing or by fire is not necessary for spread of Lehmann's lovegrass (Anable et al. 1992; Geiger and McPherson 2005).

Species richness and diversity of small mammals, reptiles, and amphibians appeared unaffected by the less diverse woody plant communities that characterized root-plowed sites compared to untreated sites four decades following treatment. Recovery of the herbaceous vegetation might be more important for the composition and diversity of the small mammal and herpetofauna communities than recovery of woody plant communities following disturbance from root plowing. Hispid cotton rats were more abundant on root-

Table 2. Means and standard errors (SE) for canopy cover (%) of selected woody plant species and absolute woody canopy cover (%) and density (plants · ha^{-1}) on untreated and root-plowed sites ($n=3$ replications), Chaparral Wildlife Management Area, Dimmit and La Salle Counties, Texas, USA, 2003. We present test statistics and *P* values for species that discriminated between root-plowed and control sites based on stepwise discriminant analysis.

Plant species	Canopy cover (%)						Density (plants · ha^{-1})					
	Untreated		Root plowed				Untreated		Root plowed			
	Mean	SE	Mean	SE	F	*P*	Mean	SE	Mean	SE	F	*P*
Schaffner's wattle (*Acacia schaffneri* [S. Watson] F. J. Herm.)	4	1	6	2	—	—	183	41	226	101	4.3	0.085
Whitebrush (*Aloysia gratissima* [Gillies & Hook.] Troncoso)	5	2	3	1	—	—	198	74	147	65	—	—
Spiny hackberry (*Celtis ehrenbergiana*)	5	< 1	2	< 1	18.0	0.050	214	41	44	14	36.8	0.026
Texas hogplum (*Colubrina texensis* [Torr. & A. Gray] A. Gray)	10	2	4	2	—	—	417	43	282	128	—	—
Brazilian bluewood (*Condalia hookeri*)	6	< 1	2	< 1	67.7	0.012	131	43	32	21	29.4	0.032
Texas pricklypear (*Opuntia engelmannii*)	9	4	10	2	—	—	794	55	1 714	496	10.4	0.084
Honey mesquite (*Prosopis glandulosa*)	23	3	58	2	72.6	0.014	290	51	1 064	380	—	—
Lime pricklyash (*Zanthoxylum fagara* [L.] Sarg.)	3	3	< 1	< 1	—	—	95	95	28	28	—	—
Absolute woody cover	54	4	73	3	—	—	—	—	—	—	—	—

Table 3. Means and standard errors (SE) for canopy cover (%) of selected herbaceous plant species, and cover (%) of litter and bare ground on untreated and root-plowed sites ($n=3$ replications) on Chaparral Wildlife Management Area, Dimmit and La Salle Counties, Texas, USA, 2003–2004. We present test statistics and *P* values for species that discriminated between root-plowed and control sites based on stepwise discriminant analysis.

	Untreated		Root plowed			
Sampling date and species	Mean	SE	Mean	SE	F	*P*
August 2003						
Purple threeawn (*Aristida purpurea*)	6	1	2	2	—	—
Hairy grama (*Bouteloua hirsuta*)	6	1	2	1	8.7	0.042
Hooded windmill grass (*Chloris cucullata* Bisch.)	4	1	8	4	—	—
Lehmann's lovegrass (*Eragrostis lehmanniana*)	10	1	12	5	—	—
Red lovegrass (*Eragrostis secundiflora* J. Presl)	3	<1	4	2	—	—
Buffelgrass (*Pennisetum ciliare*)	3	1	8	5	—	—
Texas bristlegrass (*Setaria texana* W. H. P. Emery)	7	2	6	2	—	—
Fringed signalgrass (*Urochloa ciliatissima*)	12	2	13	5	—	—
Litter	21	1	22	4	—	—
Bare ground	14	1	10	1	—	—
March 2004						
Riddell's dozedaisy (*Aphanostephus riddellii* Torr. & A. Gray)	7	1	7	3	—	—
Hooded windmillgrass	3	1	7	1	—	—
Rio Grande tickseed (*Coreopsis nuecensoides*)	10	2	4	2	—	—
Lehmann's lovegrass	7	3	7	1	—	—
Texas toadflax (*Nuttallanthus texanus* [Scheele] D. A. Sutton)	6	3	5	4	—	—
Buffelgrass	3	3	7	4	—	—
Dotseed plantain (*Plantago erecta* Morris)	4	1	15	2	45.4	0.003
Texas bristlegrass	3	1	3	2	—	—
Litter	18	4	16	5	—	—
Bare ground	12	2	8	2	—	—

plowed sites, but the difference between treatments was extremely small. Greater abundance of hispid cotton rats on root-plowed sites was also reported by Guthery et al. (1979). They attributed greater hispid cotton rat abundance to greater standing crop of herbaceous vegetation on root-plowed versus untreated sites; however, it is unclear why hispid cotton rat abundance was greater on root-plowed sites in our study. In our study, there was slightly less bare ground on root-plowed sites, but the difference between treatments was not statistically significant. Great Plains narrowmouth toad, the most abundant amphibian in the study area, is a habitat generalist, occurring across a broad range of environments (Anderson et al. 1999). Similar to our results, prescribed burning and herbicide application to control woody plants did not reduce abundance of the species in studies conducted in Oklahoma and Texas (Jones et al. 2000; Ruthven et al. 2008).

Abundance of small mammals, amphibians, and reptiles varied more over time than between treatments. Rodent population dynamics in semiarid environments are commonly tied to variation in precipitation patterns, and populations can increase dramatically during periods of increased rainfall (Whitford 1976; Thibault et al. 2010). Greater abundance of small mammals during 2003 probably resulted from above-average rainfall during 2002 and 2003. Total abundance of herpetofauna was greater during the 2 yr with highest rainfall (2002 and 2003), in part because the most abundant species, Great Plains narrowmouth toad, breeds following rainfall events (Anderson et al. 1999; Dayton and Fitzgerald 2006).

Severe disturbance in semiarid environments can result in alternative stable states that differ in vegetation composition from undisturbed sites and do not exhibit succession trends back to the vegetation composition on undisturbed sites (Briske et al. 2005; Suding and Hobbs 2009). This did not appear to be the case on our study sites. Rather than a transition to a new stable state, we hypothesize that vegetation composition eventually converges on root-plowed and untreated sites in a manner similar to that predicted by traditional, directional models of succession. Honey mesquite is one of the first woody plant species to colonize following root plowing of rangeland on upland sites in southern Texas (Fulbright and Beasom 1987; Stewart et al. 1997). Honey mesquite functions as a nurse plant for subordinate shrub species characteristic of mature mixed brush communities such as spiny hackberry (Archer et al. 1988; Franco-Pizaña et al. 1995, 1996). We predict that honey mesquite facilitates establishment of subordinate shrub species on root-plowed sites, eventually resulting in plant communities compositionally similar to those on untreated sites. In support of this idea, Fulbright and Guthery (1995) developed a simulation model that predicted that shrub communities reestablishing on root-plowed sites will return to a species composition similar to the original community in about 150 yr. Composition and diversity of herbaceous vegetation and animal communities also appear to recover to be similar to sites undisturbed by root plowing, given sufficient time. Other researchers have also suggested that traditional directional models of vegetation dynamics better explain vegetation change in similar ecosystems such as central Texas savannas

Table 4. Means and standard errors (SE) for selected small mammal species and herpetofauna abundance on untreated and root-plowed sites ($n=3$ replications) on Chaparral Wildlife Management Area, Dimmit and La Salle Counties, Texas, USA, 2001–2004.

	Untreated		Root plowed			
Functional group and species	Mean	SE	Mean	SE	F	*P*
Small mammals: pitfall traps						
Northern pygmy mouse (*Baiomys taylori*)[1]	<0.1	<0.1	<0.1	<0.1	0.79	0.469
Desert shrew (*Notiosorex crawfordi* Coues)[1]	<0.1	<0.1	<0.1	<0.1	2.75	0.239
Merriam's pocket mouse (*Perognathus merriami*)	0.3	1	0.2	1	4.14	0.179
Total captured per day	0.3	1	0.3	1	1.99	0.294
Species richness (species per sampling period)	2	0.2	3	0.2	2.23	0.274
Shannon index	0.4	0.1	0.7	0.1	6.95	0.119
Evenness	0.7	0.1	0.7	0.1	0.94	0.434
Small mammals: Sherman traps						
Southern plains woodrat (*Neotoma micropus*)	1	0.3	1	0.5	0.73	0.483
Hispid pocket mouse (*Chaetodipus hispidus* Baird)	0.4	0.2	0.2	0.1	2.77	0.238
White-footed mouse (*Peromyscus leucopus* Rafinesque)	0.2	0.2	0.3	0.2	0.31	0.635
Hispid cotton rat (*Sigmodon hispidus*)	11	2	12	2	8.89	0.096
Total captured per day	12	3	13	2	1.37	0.363
Species richness (species per sampling period)	4	0.1	4	0.8	0.00	1.000
Shannon index	0.5	0.1	0.5	0.2	0.00	0.956
Evenness	0.4	0.1	0.4	0.1	1.49	0.340
Herpetofauna: pitfall traps						
Frogs and toads						
Great Plains narrowmouth toad (*Gastrophryne olivacea*)	0.5	<0.1	0.9	1.2	5.1	0.151
Other frogs and toads[2]	<0.1	0.01	0.1	0.3	2.2	0.280
Lizards						
Texas spotted whiptail (*Cnemidophorus gularis*)	0.4	<0.1	0.4	<0.1	1.6	0.336
Other lizards[3]	<0.1	<0.1	<0.1	<0.1	<0.1	0.880
Snakes[1]	<0.1	<0.1	<0.1	<0.1	0.2	0.734
Total captured per day	1	0.1	1.4	0.3	5.2	0.150
Species richness (species per sampling period)	7	0.6	8	0.7	1.1	0.400
Shannon index	1.3	0.1	1.2	0.1	1.5	0.341
Evenness	0.7	<0.1	0.6	<0.1	2.2	0.281

[1] An average of only one animal per month or fewer were captured on each treatment.

[2] An average of only two animals per month or fewer were captured on each treatment.

[3] An average of only three animals per month were captured on each treatment.

than state-and-transition models of vegetation dynamics (Fowler and Simmons 2009).

IMPLICATIONS

A concern regarding use of root plowing to manage woody plants is that it can cause permanent changes in vegetation structure and composition that are undesirable for wildlife. Based on our long-term (> three decades) data, root plowing should be avoided if land managers wish to maintain woody plant species richness and diversity. Effects of root plowing, however, do not appear to be a conservation concern for small vertebrate communities on the Chaparral Wildlife Management Area in Texas.

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