Long-term effects of root plowing on vegetation in the eastern south Texas plains.

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Abstract

The long-term effects of root plowing in plant communities in south Texas are not clearly understood. Our objective was to compare plant species composition and diversity on root-plowed rangelands and untreated rangelands. Two rangeland sites that were root plowed during 1973-74 and 2 sites of native, untreated brush were selected on the Santa Gertrudis Division of the King Ranch, Kleberg and Jim Wells counties, Texas. Woody plant canopy cover was estimated with the line intercept method, and density was estimated with 20-x 1-m plots during 1990. Herbaceous canopy cover was estimated with 20 x 50-cm quadrats. Percent grass, litter, and bare ground coverage were similar on root-plowed and untreated rangelands. Woody plant species and diversity averaged 19 ± 2 species/treatment ($\bar{x} \pm SE$) and 2.56 ± 0.15 on untreated areas compared to 7 ± 1 species/treatment and 1.18 ± 0.01 on root-plowed areas. Forb canopy coverage on root-plowed sites was about twice that of untreated sites. Huisache (*Acacia smallii* Ilse) canopy cover and density were both more than 7-fold greater on root-plowed sites than on untreated sites. Browse species preferred by white-tailed deer (*Odocoileus virginianus* Raf.), such as colima [*Zanthoxylum fagara* (L.) Sarg.] and guajillo (*Acacia berlandieri* Benth.), were absent on root-plowed sites.

Key Words: browse, brush, brush management, range improvement, wildlife habitat

Mechanical brush management became prevalent following World War II with development of heavy equipment such as the root plow in 1949 (Fisher et al. 1973), which has been used throughout the southwestern United States to manipulate woody vegetation (Allison and Rechenstien 1956, Carlton et al. 1973). Woody plants reestablish within 2 to 20 years following mechanical brush management, depending upon the type of treatment, woody plant species, and environmental conditions following treatment. In the thornscrub woodland of the western South Texas Plains, herbaceous plant diversity increased during the first 2 years following mechanical brush management (Bozzo et al. 1992). Woody plant diversity of similar communities was lower than that of the original communities 25 to 32 years following root plowing and roller chopping (Fulbright and Beasom 1987) and 7 years following repeated shredding (Fulbright 1987). Root plowing reduced the abundance of highly preferred white-tailed deer browse plants in the western South Texas Plains (Fulbright and Beasom 1987). Long-term reductions in shrub species diversity following root plowing have also been reported in the more mesic

Texas coastal prairies (Mutz et al. 1978).

There is concern among conservation and environmental groups that range management practices decrease diversity (Lewis et al. 1988). A priority for range research relevant to concerns of biological diversity is a determination of the role of human perturbations on changes in species composition of vegetation communities (McMinn 1991). Long-term changes in woody or herbaceous plant composition may be detrimental to certain wildlife species. Our objective was to determine the long-term effects of root plowing on the composition of herbaceous and woody plant communities in the eastern South Texas Plains.

Materials and Methods

The study area was on the King Ranch (27° 35' N, 98° 0' W) in the eastern South Texas Plains (Gould 1975, Scifres 1980, Hatch et al. 1990). Climate is characterized by hot summers and mild winters with an average daily minimum winter (January) temperature of 8° C and an average daily maximum summer (July) temperature of 36° C, and a growing season of about 290 days (Minzenmayer 1979, D. Largo, NAS Kingsville, pers. commun., 1992). Precipitation peaks occur in late spring (May-June) and early fall (September-October). The 30-year (1962-1991) and 10-year (1982-1991) annual precipitation averaged across the 4 study sites were 68 cm and 61 cm, respectively (P. Lieck, King Ranch Inc., pers. commun. 1992). Annual precipitation during the past 10 years averaged 4 cm greater in the root-plowed sites.

Two separate sites, one 1,282 ha in size and one 870 ha, were root plowed during 1973-1974 (R.H. Thompson, King Ranch Inc., pers. commun., 1992). Untreated sites, one 1,140 ha and one 679 ha, consisted of undisturbed brush with small areas that were chained during 1976. Chaining in south Texas brushlands reportedly does not significantly reduce woody plant diversity (Scifres et al. 1976).

Root-plowed and untreated sites were within a 5.8-km radius of each other and were on the Czar-Delfina-Orelia soil association (State Soil Survey Staff 1977). Soils of the Czar-Delfina-Orelia association consist of loamy sands, fine sandy loams, and sandy clay loams. The study area was not mapped by soil series and the composition of each site relative to soil series was unknown (State Soil Survey Staff 1977). The Czar series are fine-loamy, mixed, hyperthermic Pachic Argiustolls; the Delfina series are fine-loamy, mixed, hyperthermic Aquic Paleustalfs; and the Orelia series are fine-loamy, mixed, hyperthermic Cumulic Haplustolls. Topography was nearly level to gently sloping and elevation ranged between 30 and 50 m (R.W. Schmidt, SCS, pers. commun., 1992).

Plant communities belonged to the Mesquite (*Prosopis glandulosa* L.)-Granjeno (*Celtis pallida* Torr.) association (McLendon 1991). Within this association were 2 primary communities, the

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Mesquite-Colima [*Zanthoxylum fagara* (L.) Sarg.] / Granjeno community, in which colima and bluewood brasil (*Condalia hookeri* M.C. Johnston) are the subdominants, and the Mesquite-Granjeno/Hog-plum [*Colubrina texana* (T. & G.) Gray] community, in which hog-plum is the subdominant. Prominent herbaceous species included multi-flowered false rhodesgrass [*Chloris pluriflora* (Fourn.) Clayton], hooded windmillgrass (*Chloris cucullata* Bisch.), Texas virginsbower (*Clematis drummondii* T. & G.), orange zexmenia (*Wedelia hispida* Jacq.) and bundle flower (*Desmanthus* sp. Willd.).

The study area has been grazed by domestic livestock since the 18th century (Lea 1957, Lehmann 1969). Cattle were the major form of livestock since about 1870, whereas sheep were grazed from about 1750–1870. Recent grazing by cattle was yearlong and stocking rates, averaging 7.4 ha/AU, were similar for all 4 study sites during 1990 and 1991 (T.J. Haegelin, King Ranch, Inc., pers. commun. 1992).

Twenty-five transects ranging from 72 to 351 m long were randomly located within each study site, and four 20-m lines were randomly placed along and perpendicular to each transect (100/site). Woody plant canopy coverage was estimated during late summer and early fall 1990 by the line-intercept method (Canfield 1941). Woody plant density and frequency were estimated by counting individual plants in 100 20-x 1.5-m plots in each site. Woody species diversity was quantified with Shannon's Index (Pielou 1975). Woody plant density and frequency were used to calculate the index. Herbaceous canopy cover was visually estimated during early fall 1990 (September–October) and early spring 1991 (March–April) in 20-x 50-cm quadrats placed at 2-m intervals along a randomly placed line on each transect (250/site) (Daubenmire and Daubenmire 1968). Species frequency data were used to calculate Shannon's Index. Sample sizes were determined by the Stein 2-staged sample test (Steel and Torrie 1980). Similarity indices were calculated with plant frequency data for both woody and herbaceous species by Motyka's version of Sorensen's similarity index (Chambers and Brown 1983). Scientific and common names of all plants are from Hatch et al. (1990).

Woody plant parameters were analyzed by a 1-way analysis of variance with treatment as the main effect (SAS Institute, Inc. 1987). Herbaceous canopy cover estimates were compared with a 2-way analysis of variance, with treatment and season as the main effects and a treatment by season interaction.

Results

Woody species, diversity, and evenness were greater on untreated areas (19 ± 2 species/treatment [$\bar{x} \pm SE$], $P = 0.051$; 2.56 ± 0.15 , $P = 0.085$; 0.78 ± 0.02 , $P = 0.061$, respectively) than on root-plowed areas (7 ± 1 species/treatment, 1.18 ± 0.01 , 0.61 ± 0.04) (Table 1). Important deer browse species absent on root-plowed areas included guajillo, blackbrush (*Acacia rigidula* Benth.), colima, coma (*Bumelia celastrina* Kunth in H.B.K. LA), desert yaupon (*Schaefferia cuneifolia* Gray), palo verde [*Parkinsonia texana* (Gray) S. Wats.], and guayacan (*Guaiacum angustifolia* Engelm.). Huisache comprised $10 \pm 3\%$ of the woody plant canopy on untreated areas, compared to $72 \pm 1\%$ of the woody canopy coverage on root-plowed areas. Mesquite ($P = 0.046$), granjeno ($P = 0.038$), and Texas persimmon ($P = 0.057$) canopy cover were greater on untreated areas. Huisache density was 740% greater ($P = 0.048$) on root-plowed areas than on untreated areas (Table 2). Lotebush [*Ziziphus obtusifolia* (T. & G.) Gray] density was greater ($P = 0.079$) on untreated areas than on root-plowed areas. Similarity indices between root-plowed sites were $IS_{mo} = 0.90$, between untreated sites $IS_{mo} = 0.65$, and between treatments $IS_{mo} = 0.49$.

Overall herbaceous plant canopy coverage estimates averaged $49 \pm 6\%$ on untreated areas and $81 \pm 0\%$ on root-plowed areas

Table 1. Woody plant canopy cover (%) of root-plowed ($n = 2$) and untreated ($n = 2$) areas on the Santa Gertrudis Division of the King Ranch, Kleberg and Jim Wells Counties, Texas, 1990.

Species	Untreated		Root plowed	
	$\bar{x}$	Range	$\bar{x}$	Range
	---- (%) ----		---- (%) ----	
Honey mesquite	59	52–67	23	20–26
Huisache	10	7–13	72	71–73
Granjeno	7	7–7	2	1–3
Hog-plum	2	1–3	3	2–3
Texas persimmon	4	3–5	Tr	
Colima	4	4–4		
Whitebrush	3	<1–5		
Bluewood brasil	2	1–4	<1	
Blackbrush	2	<1–3		
Guajillo	1	0–3		
Lotebush	1	1–2	Tr	
Desert yaupon	1	1–1		
Paloverde	1	<1–1		
Shrubby blue sage	1	<1–1		
Coma	<1	<0–1		
Wolfberry	<1		Tr	
Catclaw acacia	<1			
Twisted acacia	<1			
Coyotillo	<1			
Goatbush	<1			
Guayacan	<1			
Cedar elm	<1			
Texas ebony	<1			
Hackberry	<1			
Total canopy coverage	38	38–38	32	28–35

Table 2. Woody plant density (plants ha⁻¹) on root-plowed ($n = 2$) and untreated ($n = 2$) areas on the Santa Gertrudis Division of the King Ranch, Kleberg and Jim Wells Counties, Texas, 1990.

Species	Untreated		Root plowed	
	$\bar{x}$	Range	$\bar{x}$	Range
	-- (plants/ha) --		-- (plants/ha) --	
Honey mesquite	285	250–320	184	170–197
Huisache	82	43–120	607	493–720
Granjeno	258	173–343	100	83–117
Hog-plum	154	60–247	112	76–147
Texas persimmon	50	33–67	3	0–5
Colima	244	157–330		
Whitebrush	100	3–197		
Bluewood brasil	45	13–77	9	7–10
Blackbrush	79	17–140		
Guajillo	10	0–20		
Lotebush	42	30–53	3	3–3
Desert yaupon	23	13–33		
Paloverde	2	0–3		
Shrubby blue sage	67	53–80		
Coma	2	0–3		
Wolfberry	7	7–7	4	0–7
Catclaw acacia	22	<1–43		
Twisted acacia	2	0–3		
Coyotillo	4	0–7		
Goatbush	2	0–3		
Guayacan	8	3–13		
Cedar elm	1	0–2		
Texas ebony	<1			
Hackberry	1	0–2		
Total density	1,204	1,346–1,630	1,025	862–1,176

(Table 3). Forb cover was significantly ($P = 0.048$) greater on root-plowed areas ($39 \pm 1\%$) than on untreated areas ($20 \pm 4\%$). Herbaceous plant richness was similar between treatments in both

Table 3. Visual estimates of foliar cover (%) of forbs, grass, litter, and bare ground at the Santa Gertrudis Division of the King Ranch, Kleberg and Jim Wells Counties, Texas (Fall 1990, Spring 1991), as affected by root plowing and season, ($n = 2$ /treatment/season).

	Forb	Grass	Litter	Bare ground
	----- (%) -----			
Fall 1990				
Root plowed	38	43	43	40
Untreated	16	27	38	53
Spring 1991				
Root plowed	40	41	38	37
Untreated	24	31	38	45
ANOVA P-value				
Treatment	0.0478	0.0888	0.6324	0.2267
Season	0.4991	0.8717	0.5617	0.5340
TRT*Season	0.7294	0.6328	0.6324	0.7511

fall and spring, with 139 and 155 species on root-plowed sites and 115 and 147 species on untreated sites. Species diversity was also similar between treatments, measuring 3.82 and 4.01 on root-plowed sites and 3.93 and 4.13 on untreated sites in spring and fall. Similarity between root-plowed sites was $IS_{mo} = 0.60$ in Fall 1990 and $IS_{mo} = 0.55$ in Spring 1991. Similarities between untreated sites were $IS_{mo} = 0.41$ (Fall 1990) and $IS_{mo} = 0.52$ (Spring 1991), and between treatment indices were $IS_{mo} = 0.42$ (Fall 1990) and $IS_{mo} = 0.41$ (Spring 1991).

Averaged across sampling dates, grass canopy cover was 45% greater on root-plowed areas (Table 3). Dominant grasses that were more frequent ($P < 0.05$) on root-plowed areas included Kleberg bluestem [*Diachanthium annulatum* (Forssk.) Staph.], bermudagrass [*Cynodon dactylon* (L.) Rich.], sandbur (*Cenchrus incertus* L.), threeawn (*Aristida* spp. L.), fall witchgrass (*Digitaria cognata* Fabr.), and panicum (*Panicum* spp.). Although not dominant, buffelgrass (*Cenchrus ciliaris* L.), which is highly rated as a pasture grass, was more frequent ($P \leq 0.0001$) on root-plowed ($9 \pm 0\%$) than on untreated ($4 \pm 0\%$) areas. Hooded windmillgrass was common on both treatments.

Dominant forbs that were more frequent on root-plowed areas include croton (*Croton* sp.), palafoxia (*Palafoxia* sp.), slender verbena (*Verbena officinale* L.), and anemone (*Anemone* sp.) (Table 5). Broomweed (*Xanthocephalum* sp.) percent frequency was greater on untreated areas than on root-plowed areas. Forbs that were frequent in spring on both treatments included lazy daisy (*Aphanostephus riddellii* L.), pepperweed (*Lepidium* sp.), and woodsorrel (*Oxalis* sp.). Frequency of snoutbean (*Rhynchosia*

Table 4. Frequency (%) of dominant (frequency $\geq 10\%$) grasses on root-plowed ($n = 4$) and untreated ($n = 4$) areas at the Santa Gertrudis Division of the King Ranch, Kleberg and Jim Wells Counties, Texas (September--October 1990, March--April 1991).

	Root plowed		Untreated		P-value
	$\bar{x}$	SE	$\bar{x}$	SE	
	----- (%) -----				
Threeawn	13	1	4	2	0.0081
Sandbur	12	2	2	1	0.0010
Hooded wind-millgrass	11	3	15	2	0.4263
False rhodesgrass	5	2	30	14	0.1344
Bermudagrass	19	3	4	2	0.0067
Kleberg bluestem	47	4	12	3	0.0004
Fall witchgrass	16	3	5	1	0.0108
Lovegrass	14	6	5	2	0.1935
Panicgrass ¹	12	2	1	0	0.0472

¹Spring only ($n = 2$)

Table 5. Frequency (%) of dominant (frequency $\geq 10\%$) forbs on root-plowed ($n = 4$) and untreated ($n = 4$) areas at the Santa Gertrudis Division of the King Ranch, Kleberg and Jim Wells Counties, Texas (September--October 1990, March--April 1991).

	Root plowed		Untreated		P-value
	$\bar{x}$	SE	$\bar{x}$	SE	
	----- (%) -----				
Ragweed ¹	22	13	3	0	0.2830
Anemone ¹	11	1	0	0	0.0082
Lazy daisy ¹	13	11	13	1	0.9753
Croton	28	2	2	0	≤ 0.0001
Tropic croton ²	9	4	11	9	0.8254
Silky evolvulus	8	3	12	2	0.3592
Pepperweed ¹	43	8	20	1	0.1109
Woodsorrel ¹	31	3	21	7	0.3273
Palafoxia	15	1	3	2	0.0007
Plantain ¹	25	6	4	0	0.0688
Ruellia	11	5	12	3	0.8085
Slender verbena	21	4	7	3	0.0319
Broomweed	2	1	12	1	0.0007

¹Spring only ($n = 2$)

²Fall only ($n = 2$)

spp.), preferred by white-tailed deer, was also greater ($P = 0.001$) on root-plowed ($7 \pm 1\%$) than on untreated (0%) areas.

Discussion and Conclusions

Huisache occurs primarily in the Texas coastal prairie and eastern South Texas Plains (Scifres et al. 1982). Based on our results and those of Mutz et al. (1978), we conclude that root plowing in these regions may result in development of a depauperate woody plant community dominated by huisache on rangeland that formerly supported a species-rich community dominated by mesquite. Twisted acacia (*Acacia schaffneri* S. Wats.) increases in abundance westward into the South Texas Plains with a concomitant decrease in huisache (Mutz et al. 1978, Scifres et al. 1982). In the more arid western South Texas Plains, twisted acacia and mesquite dominate root-plowed areas (Fulbright and Beasom 1987). The long-term reductions of preferred deer browse species such as guajillo, blackbrush, colima, bluewood brasil, guayacan, coma, and desert yaupon in the eastern South Texas Plains were consistent with reports in other regions (Mutz et al. 1978, Fulbright and Beasom 1987). The changes in the woody plant community following root plowing were also similar to short-term observations in the Texas coastal prairie (Box 1964) and South Texas Plains (Davis and Winkler 1968).

The abundance of Kleberg bluestem on the root-plowed areas can be attributed to reseeding following treatment. The dominance of sandbur on the root-plowed areas may have resulted from its adaptability to invade cleared, reseeded ranges (Gould 1978). The increase of bermudagrass on the root-plowed areas relative to the untreated areas may have also resulted from its proclivity to invade disturbed areas (Gould 1975). The apparent decrease in broomweed on the root-plowed areas could be due to increased competition with grasses and other forbs. Greater canopy cover of herbaceous vegetation 16 to 18 years after root plowing was similar to the short-term observations of Drawe (1977) on the Texas coastal prairies. Double chaining and raking in south Texas (Scifres et al. 1976) and double chaining in central Texas (Rollins and Bryant 1986) also resulted in increased herbaceous coverage.

Short-term impacts of root plowing rangeland are well documented (Powell 1968, Davis and Winkler 1968, Urness 1974, Guthery et al. 1979); however, the long-term impacts of the shift from diverse thornscrub to a less diverse (woody) community on ecosystem productivity and wildlife populations are unknown and need

further investigation. Lower browse diversity on root-plowed sites was apparently not detrimental to white-tailed deer in the eastern South Texas Plains, presumably because of great forb abundance and utilization by white-tailed deer (Ruthven 1992). However, during dry, hot summers in the western South Texas Plains, deer diets are primarily browse (Varner and Blankenship 1987). Thus, further research on the long-term effects of root plowing on white-tailed deer are needed in more xeric environments such as the western South Texas Plains where lower annual precipitation may result in low forb availability. The effects of root plowing on the diversity of the vertebrate and invertebrate communities also need to be addressed.

Appendix Table 1. Scientific names of brush, forb, and grass species.

Scientific name	Common name
Browse	
<i>Acacia greggii</i> Gray	Catclaw acacia
<i>Aloysia gratissima</i> (Gill & Hook) Troncoso	Whitebrush
<i>Diospyros texana</i> L.	Texas persimmon
<i>Castela texana</i> Turpin	Goatbush
<i>Celtis laevigata</i> Willd.	Hackberry
<i>Karwinskia humboldtiana</i> (Schult.) Zucc.	Coyotillo
<i>Lycium carolinianum</i> Walt.	Wolfberry
<i>Pithecellobium flexicaule</i> (Benth.) Coult.	Texas ebony
<i>Salvia ballotiflora</i> Benth.	Shrubby blue sage
<i>Ulmus crassifolia</i> L.	Cedar elm
Forbs	
<i>Ambrosia</i> sp. L.	Ragweed
<i>Aphanostephus riddellii</i> T. & G.	Lazy daisy
<i>Croton glandulosa</i> L.	Tropic croton
<i>Evolvulus sericeus</i> Sw.	Slender evolvulus
<i>Lepidium</i> sp. L.	Pepperweed
<i>Oxalis</i> sp. L.	Woodsorrel
<i>Plantago</i> sp. L.	Plantain
<i>Ruellia</i> spp. L.	Ruellia
<i>Xanthoxylum</i> sp.	Broomweed
Grasses	
<i>Eragrostis</i> spp. Wolf	Lovegrass

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