Response of Herbaceous Vegetation to Winter Burns in the Western South Texas Plains: An Observation

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ABSTRACT

Prescribed fire is becoming a more widely utilized habitat management practice in southern Texas. We examined the effects of winter burns on the abundance and diversity of forbs and grasses on three rangeland sites during the first and second growing seasons postburn in the western South Texas Plains. Forb and grass cover, density, and frequency were estimated in 50, 7.9-x 19.7-in quadrats. Forb and grass species richness and diversity were similar among treatments and growing seasons. Forb cover was greater on burned sites during the first growing season. Burning increased densities of three-seed croton (*Croton lindheimerianus*), rough buttonweed (*Diodia teres*), and spreading sida (*Sida abutifolia*) during the first growing season. Densities of three-seed croton and rough buttonweed were similar among treatments during the second growing season, while increased densities of spreading sida persisted into the second growing season postburn. Most grasses were unaffected by burning. Date of burn influenced herbaceous vegetation response with greatest forb densities on early winter burns and highest grass densities on mid-winter burns. Even with less than optimum growing conditions burning can increase abundance of annual and perennial forbs.

KEYWORDS: prescribed fire, South Texas, herbaceous vegetation, diversity, species abundance

The Rio Grande Plains of South Texas is the southern-most extension of the Great Plains Grasslands. Fire, along with other climatic variables such as drought, presumably maintained the honey mesquite (*Prosopis glandulosa*) savannas and interspersed grasslands of pristine South Texas (Scifres and Hamilton 1993). Frequency of fire appeared to be highly variable and ranged from 5-30 years (Wright and Bailey 1982). Following European settlement, suppression of fire combined with heavy livestock grazing has lead to the current thorn woodlands common throughout southern Texas (Archer et al. 1988, Archer 1994).

Beginning in the mid-twentieth century, South Texas landowners began to convert these thorn woodlands back to grasslands to enhance rangelands for livestock production. Mechanical treatments such as root plowing were commonly utilized methods for achieving this goal. Mechanical brush manipulation practices can significantly reduce woody plant cover while increasing herbaceous vegetation (Scifres et al. 1976, Bozzo et al. 1992). However, once treated rangelands are revegetated by woody species, woody plant diversity can be dramatically reduced (Fulbright and Beasom 1987, Ruthven et al. 1993).

Land ownership and land use practices in South Texas have changed in recent years. The size of individual landholdings has decreased and revenue derived from those properties has become increasingly dependent on wildlife rather than traditional livestock operations. Many wildlife management programs are directed towards game species such as white-tailed deer (*Odocoileus virgininaus*) and northern bobwhite *(Colinus virginianus*). Woody vegetation is a primary component of white-tailed deer diet in South Texas (Drawe 1968, Taylor et al. 1997). In order to maintain woody plant diversity and increase herbaceous vegetation, rangeland managers are beginning to utilize prescribed fire to enhance wildlife habitat. In the southeastern United States, prescribed fire has long been utilized to manage habitat for northern bobwhite by removing decadent growth and debris, recycling nutrients, and stimulating germination of beneficial forb species (Landers and Mueller 1992). Prescribed burning in eastern portions of the Rio Grande Plains can reduce brush cover while maintaining woody plant diversity (Box and White 1969). Prescribed burning in southern Texas has also been shown to increase herbaceous vegetation preferred by wildlife (Box and White 1969, Hansmire et. al 1988, Ruthven et. al, 2000); however, these studies have only investigated herbaceous vegetation response during the first growing season postburn. In addition, little information is available on the effects of fire in the more xeric areas of the western Rio Grande Plains.

Our objective was to determine the effects of fire on the diversity and density of herbaceous vegetation during the first and second growing seasons post-treatment in the western Rio Grande Plains. We hypothesize that prescribe burning South Texas rangelands during the dormant season will enhance germination and establishment of important seed producing annual forbs such as croton (*Croton* spp.) and partridge pea (*Chamaecrista fasciculata*), increase perennial forbs, and increase grass cover.

METHODS

The study area was on the 15,200 acre Chaparral Wildlife Management Area (28° 20' N, 99° 25' W) in the western South Texas Plains (Gould 1975, Scifres 1980, Hatch et al. 1990). The study site was purchased by the state of Texas in 1969, and is managed by the Wildlife Division of the Texas Parks and Wildlife Department (TPWD). Climate is characterized by hot summers and mild winters with an average daily minimum winter (January) temperature of 41° F and an average daily maximum summer (July) temperature of 99° F, with a growing season of 249 to 365 days depending on freezing temperatures (Stevens and Arriaga 1985). Precipitation patterns are bimodal with peaks occurring in late spring (May-June) and early fall (September-October). The 11-year (1989-1999) average is 21 inches (TPWD, unpubl. data).

Three sites subjected to prescribed burns were paired with three untreated sites utilizing a randomized block design. Burned sites were located within larger areas that had been burned. Rangeland fire in southern Texas typically produces a mosaic of burned and nonburned areas as a result of uneven fuel loads (Box and White, 1969). All study sites received 100% coverage by burns. Study sites were burned during winter 1997-1998, with burning dates of 9 December 1997, 9 January 1998, and 3 February 1998. Study sites were approximately 4 acres in size. Burning conditions were similar, with an average relative humidity of 29 ± 4% ($\bar{x}$ ± SE), temperature of 77 ± 2° F, and wind speed of 5 ± 2 mph. Wind direction was variable. Soil moisture was not recorded; however, based on precipitation prior to burns soil moisture was considered low.

Because of variable wind speed and direction during all burns and uneven fuel loads, rate of spread and flame height were highly variable and were not recorded. Fuel loads were not measured as they varied within study sites. Optimum fuel loads for burning in western portions of South Texas are ≥ 1,800 lb/ac (TPWD, unpubl. data) and based on visual estimations study sites met or exceeded these levels. All burns were ignited as head fires with drip torches.

Soils were similar among treatments and consisted of Duval fine sandy loam, gently undulating, Duval loamy fine sand, 0-5% slopes, and Dilley fine sandy loam, gently undulating (Stevens and Arriaga 1985, Gabriel et al. 1994). The Duval series are fine-loamy, mixed, hyperthermic Aridic Haplustalfs and the Dilley series are loamy, mixed, hyperthermic shallow Ustalfic Haplargids. Topography is nearly level to gently sloping and elevation ranges between 580 and 610 feet.

Plant communities belonged to the Mesquite-Granjeno (*Celtis pallida*) association (McLendon l99l). Within this association were 2 primary communities, the Mesquite-Colima (*Zanthoxylum fagara*)/Granjeno community, in which colima and bluewood brasil (*Condalia hookeri*) are the subdominants, and the Mesquite-Granjeno/Hog-plum (*Colubrina texana*) community, in which hog plum is the subdominant. Prominent herbaceous species included Lehmann lovegrass (*Eragrostis lehmanniana*), an introduced perennial, hooded windmillgrass (*Chloris cucullata*), hairy grama (*Bouteloua hirsuta*), partridge pea, and croton.

Domestic livestock have grazed the study area since the 18th century (Lehmann 1969). Cattle have been the major species of livestock since about 1870, whereas sheep were grazed from about 1750 to 1870. Grazing strategies have varied from continuous grazing to various rotational grazing systems (Ruthven et al. 2000). Since 1990, the study area has been grazed utilizing stocker class cattle under a high intensity, low frequency grazing system during the period October through April. Stocking rates were considered low to moderate, and average 30 acres/animal unit/year. Grazing has little affect on the response of forbs to prescribed fire (Ruthven et al. 2000).

Canopy cover of grasses, forbs, litter, and bare ground was visually estimated during late spring and early summer 1998-99 (June-July) in 50, 7.9-x 19.7-in quadrats randomly placed in each study site (Daubenmire 1959). Grass and forb density and frequency were estimated by counting individual plants in quadrats in each site. Grass and forb species diversity was quantified with Shannon's Index (Pielou 1975). Species frequency data were used to calculate the index. Scientific names of plants follow Jones et al. (1997) and common names are from Hatch et al. (1990).

Response of annual forbs and perennial grasses can vary depending on the timing of winter burns (Hansmire et al. 1988), with forbs being more common on sites burned in early winter (December) than late winter (February) and grasses being more productive following late winter than early winter burns. To assess the potential impacts of burning date, total forb and grass densities and dominant annual and perennial forb and perennial grass densities were compared among burning dates. We realize the implications of pseudoreplication (Hurlbert 1984); however, Wester (1992) suggests that pseudoreplication is a matter of scale and that statistical analyses of single treatment studies in which samples are taken within a relatively small area can be useful in assessing treatment impacts. Although conclusions of these analyses are limited to the study site and may not be extrapolated to other populations, they may be helpful in explaining potential effects of temporal factors on the results of this study.

RESULTS AND DISCUSSION

Forb and grass species richness and diversity were similar among treatments and growing seasons (Table 1). There was an interaction with grass diversity being greatest on burned sites during the first growing season and greatest on nonburned areas during the second growing season. Forb species evenness was greatest during the first growing season on both treatments.

Table 1. Herbaceous species richness, diversity, and evenness on burned (n=3) and untreated (n=3) areas during the first (1998) and second (1999) growing seasons following treatment at the Chaparral Wildlife Management Area, Dimmit and LaSalle Counties, Texas, June- July 1998-1999.

	1998				1999			
	Burned		Untreated		Burned		Untreated	
Class/Index	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI
Grasses and Sedges								
Richness	15	7–23	13	11–14	13	8–16	13	10–17
Diversity	2.16	1.86–2.47	2.06	2.00–2.12	2.06	1.90–2.21	2.15	1.87–2.43
Evenness	0.81	0.71–0.92	0.82	0.80–0.84	0.81	0.73–0.89	0.83	0.81–0.86
Forbs								
Richness	15	7–23	14	4–23	15	10–20	15	11–18
Diversity	2.35	1.63–3.07	2.19	1.28–3.10	2.03	1.35–2.72	2.09	1.60–2.58
Evenness	0.88	0.80–0.96	0.84	0.68–1.00	0.75	0.58–0.93	0.78	0.62–0.94

Total forb cover was greater on burned (13 ± 10%, $\bar{x}$ ± 95% CI) than nontreated (4 ± 3%) sites during the first growing season following treatment application. During the second growing season forb cover was similar between burned and nontreated sites (18 ± 14% and 15 ± 20%, respectively). Grass cover did not differ among burned and nonburned treatments or during the first and second growing seasons (59 ± 18% vs. 57 ± 29% and 74 ± 13% vs. 73 ± 23%, respectively). Burning reduced litter during the first growing season following treatment (24 ± 7% vs. 54 ± 27%) and litter accumulation was similar among burned and nonburned sites by the second growing season (30 ± 10% and 36 ± 5%, correspondingly). Bare ground increased on burned sites during the first growing season (62 ± 19% vs. 28 ± 2%) and was similar on burned and nonburned sites by the second growing season (47 ± 20% and 40 ± 17%, respectively). Red lovegrass (*Eragrostis secundiflora*) had greater cover values on burned sites during the first growing season but were similar among treatments during the second growing season (Table 2). Cover values for thin paspalum (*Paspalum setaceum*) did not vary among burned and nonburned sites during the first growing season but were greater on nonburned sites during the second growing season.

Table 2. Foliar cover (%) of common (frequency ≥ 5%) grasses and sedges on burned (n=3) and untreated (n=3) areas during the first (1998) and second (1999) growing seasons following treatment at the Chaparral Wildlife Management area, Dimmit and LaSalle Counties, Texas, June-July 1998-1999.

	1998				1999			
	Burned		Untreated		Burned		Untreated	
Class/Species	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI
Grasses and Sedges								
Aristida purpurea	4	1–7	9	-4–22	3	0–6	3	-3–8
Boutloua hirsuta	19	-26–65	20	-21–62	19	-5–43	23	-20–66
Chloris cucullata	1	0–2	1	-2–4	1	0–2	1	-1–3
Cyperus retroflexus	0	0–0	0	0–0	1	-1–4	1	0–3

Table 2. (Cont'd.)

	1998				1999			
	Burned		Untreated		Burned		Untreated	
Class/Species	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI
Grasses and Sedges (cont.)								
Digitaria cognata	2	-1–4	1	-3–6	2	-4–8	2	-1–6
Eragrostis lehmanniana	18	-8–44	20	-11–51	31	-6–67	17	-14–48
Eragrostis secundiflora	6	1–10	2	-1–5	8	-6–23	7	-3–17
Eragrostis sessilispica	9	-2–19	5	-3–12	1	-2–4	2	-4–7
Paspalum setaceum	2	-5–9	1	-1–3	6	6–7	14	4–24
Setaria firmulum	0	-1–2	1	-1–3	2	-5–9	2	-1–4
Urochloa ciliatissima	2	-2–7	5	-7–17	6	6–7	6	-11–24

Total grass density was similar between burned and nonburned sites and varied by season with greatest density during the second growing season (38 ± 34 plants/yd^2 vs. 47 ± 22 and 74 ± 43 vs. 69 ± 22, respectively). Densities of individual grass species were similar among treatments (Table 3). Oneflower flatsedge (*Cyperus retroflexus*), red lovegrass, tumble lovegrass (*Eragrostis sessilispica*), and purple threeawn (*Aristida purpurea*) varied by growing season, with the former three species having greater densities during the second growing season and the latter decreasing in density from the first to second growing season. Total forb densities were similar among burned and nonburned sites and varied by season with highest densities during the second growing season (19 ± 30 vs. 11 ± 13 and 41 ± 47 vs 24 ± 26, correspondingly). Densities of three-seed croton (*Croton lindheimerianus*), rough buttonweed (*Diodia teres*), and spreading sida (*Sida abutifolia*) were greater on burned areas (Table 3). Three-seed croton densities were greatest during the first growing season. Densities of silky evolvulus (*Evolvulus alsinoides*) and spreading sida were highest during the second growing season. Three-seed croton demonstrated an interaction with greatest densities on burned sites during the first growing season.

Table 3. Density (plants/yd^2) of common (frequency ≥ 5%) grasses, sedges, and forbs on burned (n=3) and untreated (n=3) areas during the first (1998) and second (1999) growing seasons following treatment at the Chaparral Wildlife Management Area, Dimmit and LaSalle Counties, Texas, June-July 1998-1999.

	1998				1999			
	Burned		Untreated		Burned		Untreated	
Class/Species	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI
Grasses and Sedges								
Aristida purpurea	1.3	0.0–3.0	2.8	0.4–5.3	0.9	-0.4–2.2	0.4	-0.6–1.3
Boutloua hirsuta	10.5	-12.1–33.1	10.7	-4.4–25.7	13.0	-9.4–35.3	22.4	-24.7–69.5
Chloris cucullata	0.9	0.1–1.8	0.6	0.0–1.2	0.5	0.2–1.2	0.9	0.3–1.5
Cyperus retroflexus	0.1	-0.2–0.3	0.0	0.0–0.0	2.2	-2.5–6.9	2.0	0.6–3.5
Digitaria cognata	1.8	-1.5–5.1	1.3	-2.8–5.3	1.1	-1.4–3.7	1.6	0.7–2.4
Eragrostis lehmanniana	8.4	1.4–15.3	14.0	-26.2–54.2	22.4	-6.6–51.3	9.7	-4.4–23.9
Eragrostis secundiflora	3.6	-1.7–9.0	1.6	-0.5–3.8	8.0	-4.4–20.5	6.9	-3.3–17.1
Eragrostis sessilispica	2.2	1.3–3.0	1.9	-1.1–4.9	0.5	-0.7–1.8	0.3	-0.6–1.1
Paspalum setaceum	1.8	-2.9–6.5	1.7	-3.3–6.7	4.7	0.4–9.0	7.5	4.5–10.6
Setaria firmulum	0.3	-0.6–1.1	0.3	-0.4–1.0	0.5	-1.6–2.6	1.1	-0.9–3.1
Urochloa ciliatissima	5.0	-9.2–19.3	10.1	-13.9–34.1	16.5	-0.8–33.7	13.4	0.1–26.8
Forbs								
Aphanostephus skirrhobasis	0.2	-0.4–0.8	2.5	-6.5–11.6	0.1	-0.2–0.3	0.0	0.0–0.0
Chamaecrista fasciculata	1.2	-2.2–4.6	2.5	-0.9–5.9	4.3	-2.6–11.2	3.6	-1.5–8.6
Coreopsis nuecensis	0.9	-2.9–4.6	0.0	0.0–0.0	0.0	0.0–0.0	0.0	0.0–0.0
Croton capitatus	2.8	-6.9–12.6	0.0	0.0–0.0	0.0	0.0–0.0	0.0	0.0–0.0

Table 3. (Cont'd.)

	1998				1999			
	Burned		Untreated		Burned		Untreated	
Class/Species	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI
Forbs (cont.)								
Croton lindheimerianus	2.6	-1.4–6.6	0.0	0.0–0.0	0.2	-0.2–0.6	0.1	-0.2–0.3
Dalea nana	0.5	-0.1–1.2	0.6	-0.7–1.9	2.1	-4.4–8.6	0.9	-0.7–2.6
Diodia teres	5.0	-5.5–15.4	0.2	-0.2–0.6	0.9	-0.2–1.9	0.5	-1.8–2.9
Evolvulus alsinoides	1.6	0.6–2.7	0.7	-0.9–2.4	15.6	-15.5–46.7	10.8	-15.9–37.5
Lesqurella argyraea	0.0	0.0–0.0	0.2	0.0–0.5	0.7	-1.0–2.3	0.4	-0.6–1.4
Porttulaca pilosa	0.0	0.0–0.0	0.0	0.0–0.0	10.7	-35.0–56.5	2.6	-6.3–11.6
Sida abutifolia	0.5	-0.7–1.8	0.3	-0.1–0.7	2.1	0.6–3.5	0.9	-0.8–2.5

Percent frequency of grasses was similar among treatments (Table 4). Growing season trends for oneflower flatsedge, red lovegrass, and purple threeawn followed those for density estimates. Tumble lovegrass was more commonly encountered during the first growing season on both treatments. Hooded windmillgrass exhibited an interaction, being more common on burned sites during the first growing season and more frequently encountered on nonburned areas during the second growing season. Three-seed croton was more common on burned sites (Table 4).

Table 4. Percent Frequency of common (frequency ≥ 5%) grasses, sedges, and forbs on burned (n=3) and untreated (n=3) areas during the first (1998) and second (1999) growing seasons following treatment at the Chaparral Wildlife Management Area, Dimmit and LaSalle Counties, Texas, June-July 1998-1999.

	1998				1999			
	Burned		Untreated		Burned		Untreated	
Class/Species	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI
Grasses and Sedges								
Aristida purpurea	13	1–26	30	2–58	9	-3–22	5	-7–16
Boutloua hirsuta	53	-35–142	59	-1–119	61	8–115	62	-30–154
Chloris cucullata	8	3–13	6	1–11	5	0–11	9	2–17
Cyperus retroflexus	1	-2–4	0	0–0	21	-19–61	18	5–31
Digitaria cognata	12	-6–30	10	-16–36	9	-11–29	15	12–18
Eragrostis lehmanniana	56	31–81	56	-26–138	75	50–101	49	-17–115
Eragrostis secundiflora	25	-8–57	16	-6–38	43	10–75	29	12–47
Eragrostis sessilispica	22	13–31	19	-14–52	3	-5–10	3	-7–14
Paspalum setaceum	12	-14–38	14	-21–49	25	2–49	45	42–48
Setaria firmulum	1	-2–4	4	-5–13	5	-18–28	7	-8–23
Urochloa ciliatissima	27	-12–65	31	-17–80	60	17–103	37	9–66
Forbs								
Aphanostephus skirrhobasis	3	-5–10	11	-18–39	1	-2–4	0	0–0
Chamaecrista fasciculata	11	-18–40	21	-3–44	33	-17–82	32	-16–80
Coreopsis nuecensis	6	-20–32	0	0–0	0	0–0	0	0–0
Croton capitatus	11	-16–39	0	0–0	0	0–0	0	0–0
Croton lindheimerianus	20	-2–42	0	0–0	2	-3–7	1	-2–4
Dalea nana	5	0–11	7	-8–21	16	-27–59	7	-5–20
Diodia teres	16	-17–49	2	-3–7	5	3–8	3	-11–18
Evolvulus alsinoides	15	2–27	7	-8–21	61	24–99	41	-10–92
Lesqurella argyraea	0	0–0	3	0–6	8	-12–28	5	-8–17
Portulaca pilosa	0	0–0	0	0–0	14	-42–70	10	-25–45
Sida abutifolia	4	-6–14	4	-1–9	20	7–33	9	-8–27

Silky evolvulus and spreading sida were more commonly encountered during the second growing season. Three-seed croton demonstrated an interaction occurring with greater frequency on burned sites during the first growing season.

Total forb densities varied among burning dates in the following order December (40 ± 10) > January (18 ± 10) = February (12 ± 4). Croton, rough bottonweed, and partridge pea were the most common annual forbs encountered on burn sites during the first growing season and varied among burning dates (Table 5). Densities of the perennial forb, silky evolvulus, were similar between burning dates. Grass densities varied between burning dates in the following order January (62 ± 8) > December (37 ± 8) = February (36 ± 6). Lehmann lovegrass, hairy grama, red lovegrass, and fringed signalgrass (*Urochloa ciliatissima*) were the dominant grasses on burn sites during the first growing season and varied among burning dates (Table 5).

Table 5. Density (plants/yd^2) of dominant (frequency ≥ 25%) grasses and dominant (frequency ≥ 10%) annual and perennial forbs on burned plots (n=50) by date of burn at the Chaparral Wildlife Management Area, Dimmit and LaSalle Counties, Texas, June-July 1998.

	December		January		February	
Class/Species	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI
Grasses						
Boutloua hirsuta	5.8	3.1–8.6	21.3	17.4–25.2	4.8	1.9–7.8
Eragrostis lehmanniana	11.5	7.4–15.6	5.8	3.4–8.3	8.2	6.0–10.3
Eragrostis secundiflora	1.7	0.3–3.1	3.3	1.4–5.3	6.0	3.2–8.8
Urochloa ciliatissima	1.5	0.4–2.6	11.8	5.8–17.8	2.0	0.9–3.1
Annual Forbs						
Chamaecrista fasciculata	0.5	-0.1–1.1	0.3	-0.3–1.0	2.8	1.2–4.4
Croton spp.	12.0	7.0–17.0	1.8	0.4–3.3	2.8	1.4–4.3
Diodia teres	8.7	3.3–14.0	6.2	0.9–11.4	0.3	-0.1–0.8
Perennial Forbs						
Evolvulus alsinoides	1.8	0.1–3.5	2.0	0.8–3.2	1.2	0.4–2.0

Our results indicate that dormant season prescribed fire on South Texas rangelands can increase densities of important seed producing annuals such as croton during the first growing season following burning. The increases of annual forbs on burned sites during the first growing season were similar to those reported along the transition zone between the South Texas Plains and the Gulf Coast Prairies (Box and White 1969, Hansmire et al. 1988). Ruthven et al. (2000) also reported increases in annuals following winter burns in the western South Texas Plains; however densities were dramatically higher than those reported in our study. For instance, croton densities were two-fold greater on burned sites and prairie sunflower (*Helianthus petiolaris*), which was seldom encountered in our study (≤ 3% frequency, ≤ 0.4 plants/yd^2), was 15-times greater on burned sites when compared to our study. These differences may be a result of varying precipitation patterns. Results reported by Ruthven et al. (2000) were from burns conducted in mid- to late winter 1997 in which spring (February-June) precipitation (17.7 in) was 177% of normal and May-June rainfall (10.8 in) was 234% above average. In 1998, spring rainfall (5.1 in) was 49% below normal and May-June precipitation (0.4 in) was 91% below the long-term average. Forb increases during the second growing season on both treatments can also be attributed to precipitation, as spring 1999 precipitation (9.94 in) was 1% below normal and May-June rainfall (6.71 in) was 146% above average compared to 1998. Partridge pea was the most common annual forb encountered and the lack of treatment effects was similar to that previously reported on the study area (Ruthven et al. 2000). This important forb typically increases following winter and spring burns in the southeastern United States (Czuhai and Cushwa 1968, Lewis and Harshbarger 1976). Moisture conditions at the time of burns may have affected germination of partridge pea. Moist heat, which can be common under prescribed burning conditions in the southeastern United States, stimulates germination of partridge pea while dry heat does not increase germination (Cushwa et al. 1968). Controlled laboratory experiments simulating heat produced by prescribed fire have shown no increase in germination of partridge pea seed following exposure to heat of < 600°F (Mitchell and Dabbert 2000). Typical burning conditions on South Texas rangelands are dry with low relative humidity and moderate winds, which are necessary to carry fire through patchy and variable fuel loads. With the exception of spreading sida which increased following burning, perennial forbs appeared to be unaffected by burning. The varied response by perennials to dormant season fire was similar to other studies (Hansmire et al.1988; Ruthven et al. 2000). Ruthven et al. (2000) reported increases of important perennial forbs such as erect dayflower (*Commelia erecta*) and beach groundcherry (*Physalis cinerascens*), which were seldom (≤ 3% frequency, ≤ 0.4 plants/yd^2) encountered in this study. Effect of burning date on forbs, especially annuals such as croton and buttonweed was similar to that reported in eastern portions of the South Texas plains (Hansmire et al. 1988). Our study sites burned in January and February, as opposed to earlier burns, may have dampened the overall increase of forbs in response to burning.

Although burning increased annual forbs during the first growing season postburn, these benefits did not persist into the second growing season. It is unclear whether increases in forb densities in the first growing season result in an increase in availability of seeds for use by wildlife and future forb production. It does appear that additional disturbance is necessary to stimulate a significant increase in germination of annual forbs. The extension of the positive response of some perennials into the second growing season on burned sites is similar to that reported on comparable study sites (TPWD, unpubl. data). Increases in perennials may be explained by the release of nutrients into the soil (Scifres and Hamilton 1993).

Winter burns generally increase overall grass abundance (Box and White 1969; Hansmire et al. 1988), which was not the case in this study, as most grasses appeared unaffected by burning. Individual grass species' response to dormant season burning can be highly variable (Towne and Owensby 1984, Hansmire et al. 1988). Red lovegrass was the only species that responded to burning with an increase in cover. Burning followed by below average precipitation can result in decreases of grass densities (Reynolds and Bohning 1956). Dry conditions following burns may have negated any positive responses by grasses to burning. As with forbs, overall increases in grass during the second growing season may be a result of increased rainfall. In contrast to greatest grass abundance following late winter burns reported by Hansmire et al. (1988), grass densities were higher following application of mid-winter (January) fire.

Invasion of sandy South Texas rangelands by Lehmann lovegrass is a growing concern. This introduced perennial is an aggressive invader that can displace native grasses and quickly become the predominant grass species (Anable et al. 1992). Although hot fires can kill Lehmann lovegrass (Cable 1965), burning may increase germination of Lehmann lovegrass seed (Ruyle et al. 1988). By the second growing season postburn, Lehmann lovegrass densities were not significantly greater on burned than nonburned sites. Burning during December favored Lehmann lovegrass compared to mid- and late winter burning dates. Extended monitoring beyond the second growing season postburn may be necessary to determine the full effects of burning on this species.

MANAGEMENT IMPLICATIONS

Even with less than optimum growing conditions winter burns can increase abundance of annual and perennial forbs. If enhancing annual forbs is a primary goal, then conducting burns during early winter on a biennial schedule may be beneficial. However, grass production must be taken into consideration, as grasses are the primary fine fuels needed to conduct prescribed burns in much of southern Texas. Proper grazing management is crucial in producing adequate fuel loads for burning. The grazing strategy on the study site appears to allow for ample fuel buildups necessary to successfully conduct burns. Multiple prescribed fires have successfully been applied to rangeland sites on the study area over two to four year periods. Short-term periods of drought and highly variable rainfall are typical of the South Texas Plains (Norwine and Bingham 1985). This coupled with the semiarid (annual precipitation $\leq$ 21 in.) nature of western portions of the South Texas Plains may not provide adequate fuel loads on a regular basis to conduct burning on an alternating year schedule. Realistically, burning may be achieved on a three to four year cycle. We concur with Hansmire et al. (1988) that conducting prescribed fires in January may maximize increases in both forbs and grasses. Mid-winter burning may also inhibit Lehmann lovegrass. It is clear that climatic and temporal factors can dramatically affect the impacts of prescribed burning. Further study into these factors and long-term effects of multiple burns on herbaceous and woody vegetation, as well as wildlife, are warranted.

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