Response of Herbaceous Vegetation to Aeration of a Blackbrush-Guajillo Community

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ABSTRACT

Herbaceous vegetation productivity was compared on blackbrush (*Acacia rigidula*)-guajillo (*Acacia berlandieri*) dominated rangeland sites following mechanical aeration and on adjacent untreated areas. Herbaceous plant biomass was estimated by clipping vegetation in 10.8 ft^2 plots. Grass and forb diversity was greater on aerated sites. Grass biomass was more than 4-fold greater on aerated sites than untreated sites. There were no differences in biomass of individual grass and forb species between treatments, with the exception of sida (*Sida spp.*) which produced greater yields on aerated plots. When grasses were combined into preferential rating classes, grasses of fair forage value produced greater biomass on aerated sites. Beneficial native grasses produced greater biomass and were more commonly encountered on aerated sites. Bristlegrasses (*Setaria spp.*) were more common on aerated sites. Invasive, introduced species such as Lehmann lovegrass (*Eragrostis lehmanniana*) showed no treatment effects. When pooled, forbs preferred by white-tailed deer (*Odocoileus virginianus*) and cattle such as erect dayflower (*Commelina erecta*) and Dillens oxalis (*Oxalis dillenii*) were more common on treated than untreated sites. Grass productivity appears to be adequate to allow the use of prescribed burning as a maintenance tool. To determine the long-term implications of brush management activities, further investigation into the effects of maintenance treatments combined with livestock grazing on herbaceous and woody vegetation is warranted.

KEYWORDS: aeration, herbaceous vegetation, productivity, maintenance treatment

The overgrazing of domestic livestock has caused the Rio Grande Plains of south Texas to change from a grassland savanna to a dense thorn woodland (Archer et al., 1988; Archer, 1994). With the development of heavy equipment such as the root plow and roller chopper, ranchers have a tool that could be utilized to effectively manage woody vegetation (Allison and Rechenthin, 1956) and enhance herbaceous vegetation productivity

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(Scifres et al., 1976; Drawe, 1977; Bozzo et al., 1992). A major problem with mechanical treatments is that woody vegetation can reinvade treated rangelands in a relatively short time period (Welch et al., 1985). In addition, the diversity of reestablished woody plants can be dramatically reduced, especially on root plowed rangelands (Fulbright and Beasom, 1987; Ruthven et al., 1993). Other mechanical treatments have less of an impact on woody plant diversity (Scifres et al., 1976; Fulbright, 1987; Fulbright and Beasom 1987).

The rapid response of woody vegetation to mechanical treatments indicates the necessity for maintenance treatments to sustain the benefits of increased herbaceous yields. Prescribed burning is a follow-up treatment tool that is effective in reducing brush cover, maintaining woody plant diversity, and enhancing herbaceous productivity (Box and White, 1969).

In recent history, land ownership and land use practices in south Texas have changed. The size of individual land holdings has decreased and many new landowners are from urban rather than rural backgrounds. For many new landowners, recreational hunting is the primary use of the land. In fact, many traditional ranchers are realizing that income derived from wildlife related enterprises can exceed that of livestock production. Hunting opportunities for species such as white-tailed deer can command prices > $3,500.00 (Payne et al., 1987).

With the increased interest in wildlife management, land managers are utilizing brush management to enhance wildlife habitat. Mechanical top removal methods have been shown to increase crude protein, phosphorous, and potassium content of browse species preferred by white-tailed deer (Everitt, 1983; Fulbright et al., 1991). Mechanical aeration is a top-removal method that has gained popularity in south Texas within the last 10 years (J. Burnside pers. comm.). Aerators differ from roller choppers in that the blades along the chopper drum are toothed and set at an angle across the face of the drum. The effects of aeration on vegetation and soil properties are not well documented, especially in xeric environments such as the western Rio Grande Plains.

Vegetation communities in the western Rio Grande Plains are mostly dominated by two woody species, honey mesquite (*Prosopis glandulosa*) and blackbrush. Blackbrush dominated communities can form dense stands of woody vegetation with little or no herbaceous vegetation (McLendon, 1991). Under pristine conditions, these communities were dominated by grasses including multiflowered false rhodesgrass (*Trichloris pluriflora*), plains bristlegrass (*Setaria macrostachya*), and tanglehead (*Heteropogon contortus*) and forbs such as awnless bush sunflower (*Simsia calva*), bundleflower (*Desmanthus spp.*), and orange zexmenia (*Wedelia texana*) (Gabriel et al., 1994). Under optimum conditions, herbaceous yields can exceed 3,600 lb/ac.

Because of potential productivity, dense stands of blackbrush dominated rangeland may be ideal locations to conduct mechanical brush treatments. The objectives of this study were to determine the response of herbaceous vegetation to aeration and determine if any increases in herbaceous yields are substantial enough to permit the use of prescribed burning as a follow-up maintenance treatment.

METHODS

The study area was the 15,200 acre Chaparral Wildlife Management Area (WMA) in the western South Texas Plains (Gould, 1975; Scifres, 1980; Hatch et al., 1990). The Chaparral WMA has been managed by the Wildlife Division of the Texas Parks and Wildlife Department since 1969 and serves as a research and demonstration area for the

South Texas Plains ecoregion. Climate is characterized by hot summers and mild winters with an average daily minimum winter (January) temperature of 45° F and an average daily maximum summer (July) temperature of 100° F (Texas Parks and Wildlife Department, unpubl. data). Average annual precipitation is 22 inches with peaks occurring in late spring (May to June) and early fall (September to October).

Three sites, ranging in size from 3.0 to 5.7 ac., were aerated utilizing a Lawson, double/tandum 12 ft. x 30 in. drum aerator pulled by a D7 bulldozer during early-August 1998. Control plots, which were similar in size to treated plots, were established on untreated areas adjacent to aerated sites.

Soils were similar between treatments and consisted of Duval fine sandy loam, Dilley fine sandy loam, Brystal very fine sandy loam, Caid very fine sandy loam, Webb very fine sandy loam, and Goldfinch very gravelly sandy loam (Gabriel et al., 1994). The Duval series are fine-loamy, mixed, hyperthermic Aridic Haplustalfs; Dilley series are loamy, mixed, hyperthermic shallow Ustalfic Haplargids; Brystal series are fine-loamy, mixed, hyperthermic Ustollic Paleustalfs; Caid series are fine-loamy, mixed, hyperthermic Ustollic Paleustolls; Webb series are fine, montmorillonitic, hyperthermic Aridic Paleustalfs; and Goldfinch series are loamy-skeletal, mixed hyperthermic, shallow Ustalfic Haplargids. Topography is nearly level to gently sloping and elevation ranges between 580 and 610 ft.

The study area had 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 about 1750 to 1870. Grazing strategies have varied from continuous grazing to various rotational grazing systems (Ruthven et al., 2000). Under the current high-intensity, low-frequency grazing system, aerated and control sites were grazed at a density of one animal unit (two steers $\leq$ 500 lb = one animal unit) per 3.26 ac. during the period 22 February 1999 through 15 March 1999.

Plant communities on all sites were characteristic of the blackbrush/guajillo-prickly pear (*Opuntia engelmannii*) community within the blackbrush-twisted acacia (*Acacia schaffneri*) association (McLendon, 1991). Woody vegetation canopy cover was > 50% (Texas Parks and Wildlife Department, unpubl. data). Prominent herbaceous species included sixweeks grama (*Bouteloua barbata*), hooded windmillgrass (*Chloris cucullata*), Texas bristlegrass (*Setaria texana*), pink pappusgrass (*Pappophorum bicolor*), Halls panicum (*Panicum hallii*), slender evolvulus (*Evolvulus alsinoides*), Dillens oxalis, and sida. Scientific names follow Jones et al. (1997). Common names follow Hatch et al. (1990).

Transects were established through the center of each site in late-June and early-July 1999. Ten 10.8 ft^2 frames were placed at random locations along each transect. Current year's growth of grasses and forbs was clipped down to ground level within frames. Vegetation was sorted into paper bags by species. Samples were air-dried. Dry samples were weighed to the nearest 0.02 oz. Grass and forb diversity was quantified with Shannon's Index (Pielou, 1975) utilizing frequency data. Data were analyzed by a 1-way analysis of variance with treatment as the main effect.

RESULTS AND DISCUSSION

Grass species richness and diversity were greater on aerated sites (17 ± 1 species/treatment [$\bar{x}$ ± SE], P = 0.0056; 2.63 ± 0.04, P = 0.0012, respectively) than on untreated sites (10 ± 1 species/treatment, 2.18 ± 0.04). Overall grass yields were greater on aerated sites (2,173 lb/ac ± 463, P = 0.0257) than on untreated sites (445 lb/ac ± 169).

Species productivity was similar between treatments (Table 1). When pooled into preference ratings of good, fair, and poor grazing value (Gould, 1978), grasses of fair grazing value produced greater yields on aerated sites (Table 2). When preferred native grasses, based on Gould (1978) and Everitt et al. (1981), were pooled, natives produced greater biomass on aerated sites (Table 2). Favored natives were also more frequently encountered on aerated than untreated sites (80 ± 6% and 40 ± 12%, P = 0.0363, respectively). Dominant grasses that were more frequent (P < 0.05) on aerated areas include Texas bristlegrass and hooded windmillgrass (Table 3). When pooled, bristlegrasses (Texas bristlegrass, plains bristlegrass [*Setaria macrostachya*], knotgrass [*Setaria firmula*], and [*Setaria ramiseta*]) were more commonly encountered on aerated plots (70 ± 6% compared to 27 ± 3%, P = 0.0028).

Table 1. Productivity (lb/ac) of dominant (frequency ≥ 30%) grasses and sedges and dominant (frequency ≥ 15%) forbs on aerated (n=3) and untreated (n=3) areas at the Chaparral Wildlife Management Area, LaSalle County, Texas, June-July 1999.

	Aerated		Untreated		
Class/Species	$\bar{x}$	SE	$\bar{x}$	SE	P-value
Grasses and Sedges					
Aristida purpurea	401	205	151	89	0.3164
Boutloua barbata	71	36	53	27	0.6398
Chloris cucullata	169	71	36	18	0.1442
Cyperus retroflexus	45	18	9	9	0.1313
Digitaria californica	401	205	143	89	0.3164
Erogrostis lehmanniana	276	107	116	116	0.3799
Panicum hallii	426	285	36	18	0.2373
Pappophorum bicolor	730	419	249	125	0.3308
Setaria texana	534	187	125	27	0.0902
Forbs					
Abutilon fruticosum	18	9	2	2	0.1983
Amphiachyris dracunculoides	53	53	1	1	0.3328
Commelina erecta	62	36	6	6	0.2361
Evolvulus alsinoides	27	9	45	45	0.6139
Oxalis dillenii	5	2	2	0	0.1367
Sida spp.	18	4	3	<1	0.0253

Forb species richness and diversity were greater on aerated sites (17 ± 2 species/treatment, P = 0.0224; 2.62 ± 0.12, P = 0.0433, respectively) than on untreated sites (10 ± 1 and 2.17 ± 0.09). Total forb productivity was similar between treatments, with 98 lb/ac ± 46 produced on aerated sites compared to 27 lb/ac ± 9 on control areas. Sida had greater yields on aerated sites (Table 1). Pelotazo (*Abutilon fruticosum*) was more frequently encountered on aerated sites (Table 3). Forbs were pooled into forage groups utilized by white-tailed deer, quail, and cattle (Everitt et al., 1999). Forbs preferred by white-tailed deer and cattle were more commonly encountered on aerated sites (Table 4).

Table 2. Productivity (lb/ac) of grasses of good, fair, and poor grazing value (Gould, 1978) and preferred native grasses (Gould, 1978; Everitt et al., 1981) on aerated (n=3) and untreated (n=3) sites on the Chaparral Wildlife Management Area, LaSalle County, Texas, June-July 1999.

	Aerated		Untreated		
Class/Species	$\bar{x}$	SE	$\bar{x}$	SE	P-value
Good	392	294	169	169	0.5418
Leptochloa dubia					
Pennisetum ciliare					
Setaria macrostachya					
Fair	1,006	303	143	53	0.0505
Chloris cucullata					
Digitaria californica					
Panicum hallii					
Pappophorum bicolor					
Paspalum setaceum					
Sporobolus cryptandrus					
Urochloa ciliatissima					
Poor	107	9	80	36	0.5123
Aristida purpurea					
Bouteloua barbata					
Cenchrus spinifex					
Eragrostis secundiflora					
Preferred Native (includes sedges)	579	178	71	53	0.0498
Cyperus retroflexus					
Leptochloa dubia					
Panicum hallii					
Setaria firmula					
Setaria macrostachya					

Our results indicate that mechanical aeration is an effective tool to increase herbaceous diversity and productivity of blackbrush-guajillo communities, especially species preferred by wildlife and livestock, without increasing undesirable and invasive species such as Lehmann lovegrass. Increases in overall grass yield were similar to aerated sites of mixed brush in the eastern Rio Grande Plains (Texas Agricultural Experiment Station, unpubl. data). In the eastern Rio Grande Plains, Texas bristlegrass on clay loam soils increased following aeration; however, Texas bristlegrass was not a common component of the herbaceous plant community on sandy loam soils. Texas bristlegrass appears to be an important element of the herbaceous community on sandy loam soils in the western Rio Grande Plains, and increases reported in this study were similar to responses on clay loam soils in the eastern Rio Grande Plains. Few data are available on the value of Texas bristlegrass as forage. Bristlegrasses are generally considered to be fair to good forage

species for both livestock and wildlife (Gould, 1978). As Texas bristlegrass is a dominant species throughout much of southern Texas, research into the utilization of Texas bristlegrass by wildlife and livestock is needed. Increases of hooded windmillgrass in this study were also similar to those on aerated sites in the eastern Rio Grande Plains. Herbaceous plant responses were similar to other mechanical treatments reported from the Rio Grande Plains (Scifres et al., 1976; Drawe, 1977; Bozzo et al., 1992).

Table 3. Frequency (%) of dominant (frequency ≥ 30%) grasses and sedges and dominant (frequency ≥ 15%) forbs on aerated (n=3) and untreated (n=3) areas at the Chaparral Wildlife Management Area, LaSalle County, Texas, June-July 1999.

	Aerated		Untreated		
Class/Species	$\bar{x}$	SE	$\bar{x}$	SE	P-value
Grasses and Sedges					
Aristida purpurea	47	20	17	3	0.2181
Boutloua barbata	40	21	33	9	0.7827
Chloris cucullata	50	6	23	7	0.0390
Cyperus retroflexus	60	6	20	15	0.0705
Digitaria californica	33	18	7	3	0.2116
Erogrostis lehmanniana	33	12	3	3	0.0739
Panicum hallii	37	9	23	12	0.4216
Pappophorum bicolor	40	15	27	15	0.5614
Setaria texana	53	3	23	3	0.0031
Forbs					
Abutilon fruticosum	27	3	3	3	0.0078
Amphiachyris dracunculoides	20	6	7	7	0.2051
Commelina erecta	17	7	3	3	0.1481
Evolvulus alsinoides	20	12	13	9	0.6702
Oxalis dillenii	40	10	17	7	0.1242
Sida spp.	50	12	23	3	0.0907

Timing of aeration treatments may have affected herbaceous responses. Previous studies of mechanical top-removal methods in south Texas (Scifres et al., 1976; Bozzo et al., 1992) and central Texas (Rollins and Bryant, 1986) showed increases in herbaceous vegetation following treatments conducted in early- to mid-summer. In north central Texas, Mathis et al. (1971) reported decreases of grasses following root plowing in early spring. Mid-summer is typically hot and dry in south Texas. During the period of May through July 1998, 0.8 inches of precipitation were recorded at the study site.

Prescribed fire is a cost-effective method for controlling woody vegetation and enhancing herbaceous vegetation productivity (White and Hanselka, 1989). In south Texas, fuel loads are the most limiting factor for the use of prescribed fire as a management tool. Optimum herbaceous fuel loads for conducting prescribed burns in the western Rio Grande Plains are greater than 1,800 lb/ac (D. Ruthven, unpubl. data). Increases in grass productivity following aeration appear to be adequate to provide fuel loads to conduct prescribed burns. However, based on individual plots, available grass fuel loads were highly variable, ranging

from 0-5,740 lb/ac. This uneven fuel load is typical of most south Texas rangelands and may result in a mosaic of burned and nonburned areas. Additional mechanical treatments may be necessary before fire can be utilized as a successful maintenance tool.

Table 4. Frequency (%) of forbs utilized by white-tailed deer, quail, and cattle (Everitt et al., 1999) on aerated (n=3) and untreated (n=3) sites on the Chaparral Wildlife Management Area, LaSalle County, Texas, June-July 1999.

	Aerated		Untreated		
Class/Species	$\bar{x}$	SE	$\bar{x}$	SE	P-value
Deer	93	3	53	7	0.0058
Abutilon fruticosum					
Acleisanthes obtusa					
Ambrosia psilostachya					
Aphanostephus ssp.					
Argythamnia humilis					
Commelina erecta					
Cooperia drummondii					
Dyssodia tenuiloba					
Evolvulus alsinoides					
Hybanthus verticillatus					
Lepidium virginicum					
Melampodium cinereum					
Oxalis dillenii					
Palafoxia texana					
Parthenium confertum					
Sida spp.					
Sphaeralcea pedatifida					
Quail	53	3	33	7	0.0550
Abutilon psilostachya					
Ambrosia cumanensis					
Argythamnia humilis					
Commelina erecta					
Evolvulus alsinoides					
Hybanthus verticillatus					
Lepidium virginicum					
Cattle	83	7	47	3	0.0079
Argythamnia humilis					
Commelina erecta					
Hybanthus verticillatus					
Lepidium virginicum					
Oxalis dillenii					
Palafoxia texana					
Sida spp.					

Livestock grazing may have affected herbaceous response on aerated plots. Although high-intensity low-frequency grazing systems may enhance herbaceous productivity under optimum environmental conditions (Heitschmidt et al. 1982), they have been shown to reduce the abundance of forbs that are important components of white-tailed deer diets (Cohen et al. 1989). Although forbs and grasses preferred by livestock and wildlife increased on aerated sites, grazing may have resulted in smaller increases than aeration alone. Increased availability of grasses on aerated areas concentrates livestock (D. Ruthven, unpubl. data). In turn, hoof action and deposition of nitrogen rich waste products may stimulate germination and growth of herbaceous plants. How various high-intensity low-frequency grazing strategies affect herbaceous vegetation in this ecosystem is not clear and warrant further investigation.

Aeration did not appear to significantly affect Lehmann lovegrass (Table 1, Table 3). Lehmann lovegrass is an introduced perennial that has been planted throughout the southwestern United States to control erosion and increase forage production (Cable 1971). However, it is generally considered unpalatable for livestock. On southern Arizona rangelands, this aggressive invader has been shown to out compete native grasses and quickly become the predominant grass species (Anable et al., 1992). Areas dominated by Lehmann lovegrass have been shown to have lower wildlife diversity than areas dominated by a mixture of native grasses (Brock et al. 1986). Lehmann lovegrass now dominates herbaceous communities on many sandy range sites in south Texas. Lack of an increase in Lehmann lovegrass may be attributed to the soil disturbance of the aeration treatment. Lehmann lovegrass germinates from very shallow depths (Cox and Martin, 1984), and aeration treatments may cover seeds at a depth that will not permit successful germination. The fact that prescribed burning may increase Lehmann lovegrass germination (Ruyle et al. 1988) may preclude its use as a maintenance treatment if controlling Lehmann lovegrass is a concern. Grazing ruminants may also disseminate Lehmann lovegrass seed (Fredrickson et al. 1997). Diets of cattle on the study area, a site of high Lehmann lovegrass infestation, are dominated by lovegrasses (R. Kazmaier, unpubl. data). However, utilization of prescribed burning, which may increase palatability of Lehmann lovegrass, followed by livestock grazing may provide a measure of control.

It is clear, as shown by this and other studies, that most mechanical brush management methods are effective means to stimulate production of herbaceous vegetation in the short-term. A perennial problem is that most treated rangelands continue to be overgrazed and lack follow-up maintenance treatments, which may result in the establishment of depauperate woody plant communities with low herbaceous productivity. It is likely that a complex interaction between mechanical treatments, maintenance treatments, and herbivory exists. Further investigation is needed to assess the long-term response of herbaceous vegetation to mechanical treatments, as well as the impacts of maintenance treatments, such as prescribed burning and various grazing regimes, on herbaceous and woody vegetation.

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