USE OF PRESCRIBED FIRE AND CATTLE GRAZING TO CONTROL GUINEAGRASS

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ABSTRACT

Guineagrass (*Urochloa maxima*) is one of several species of exotic grasses that have infested rangelands in South Texas. This grass was originally introduced to improve cattle grazing productivity. However, during the past 50 y, a number of negative consequences of this introduction have occurred, including reduction of wildlife habitat quality, loss of riparian integrity, and a decrease in rangeland economic value. Exotic invasive grasses such as guineagrass can provide forage for domestic animals; however, such plants displace valuable native plants essential to wildlife and may form extensive monocultures. Prescribed burning can be used to remove old dry matter and improve forage palatability, and because cattle prefer guineagrass, it can be intensively grazed to reduce health and competitive ability. We therefore conducted summer- (June) and winter-season (February) prescribed burns in two pastures with six grazing enclosures established to compare grazing effects on burned and unburned areas. We monitored plant composition, density, cover, nonstructural carbohydrates, and nitrogen monthly for 7 mo post-burning for summer-burned and 4 mo for winter-burned sites. Guineagrass density decreased following summer prescribed burning, and native plant species richness increased. Native plant species richness in the summer burning–grazing treatment increased from 1 to 4.3 species/0.25 m^2, an increase of 330%. Ten important forbs used by white-tailed deer (*Odocoileus virginianus*) and six used by northern bobwhite (*Colinus virginianus*) were newly recorded or increased 1 y after application of the burning treatments. Cattle and white-tailed deer preferred burned areas.

keywords: competition, guineagrass, intensive grazing, invasion, invasive species, *Odocoileus virginanus,* prescribed burning, species richness, Texas, *Urochloa maxima,* white-tailed deer.

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INTRODUCTION

Exotic plant species are currently second only to loss of habitat as the largest threat to conservation of biodiversity (Zalba et al. 2000, Keane and Crawley 2002). Negative effects on ecological processes due to invasive plants include changes in hydrological processes, erosion potential, sedimentation, energy flow, nutrient cycling, regeneration of native plants, and fire regimes (Masters and Sheley 2001). Guineagrass is one of several species of exotic grasses that have infested rangelands in South Texas. These grasses were originally introduced to improve cattle grazing productivity. Exotic invasive grasses provide forage for domestic animals; however, such plants displace valuable native plants essential to wildlife and may form extensive monocultures. Negative consequences of invasive plants include reduction of wildlife habitat quality, loss of riparian integrity, and a decrease in rangeland economic value (Masters and Sheley 2001).

Fire has increasingly gained acceptance as a management tool (Wright and Bailey 1982). In the case of invasive species such as guineagrass and other forages, one of the most important effects of prescribed fire is the removal of old growth and stimulation of regrowth. Guineagrass regrowth is thus very palatable for cattle compared to native plant species regrowth; therefore, grazing pressure would be higher on guineagrass, favoring the growth and reestablishment of native species in an area invaded by guineagrass. In addition to the effect of fire on cattle preference for guineagrass, white-tailed deer (*Odocoileus virginianus*) also prefer sprouts of many brush species (Fulbright and Ortega 2006) and forbs that occur in burned areas; therefore, concentration of white-tailed deer is expected in burned areas. Intensive grazing is a well-known strategy for managing invasive introduced grasses; however, most of the published information discusses combinations of factors to balance defoliation intensity and plant reserves to achieve persistence and maximum forage productivity (Marachin et al. 1981, Jones 1986, Canudas-Lara 1988). Grazing strategies can be used to deplete carbohydrate reserves, reduce tillering and meristem tissue development, and kill undesirable invasive plants.

Our study objective was to evaluate the effect of the combination of intensive cattle grazing and prescribed burning on the survival of guineagrass and to quantify the effect of these practices on reestablishment of the native plant community and preference of white-tailed deer for burned areas.

MATERIALS AND METHODS

Study Site

We conducted this project in the Rio Grande Sand Plains (Blair 1950) of South Texas in Willacy County, where two 100- and 200-ha pastures were used at Tecolote Ranch. The climate was subtropical humid with

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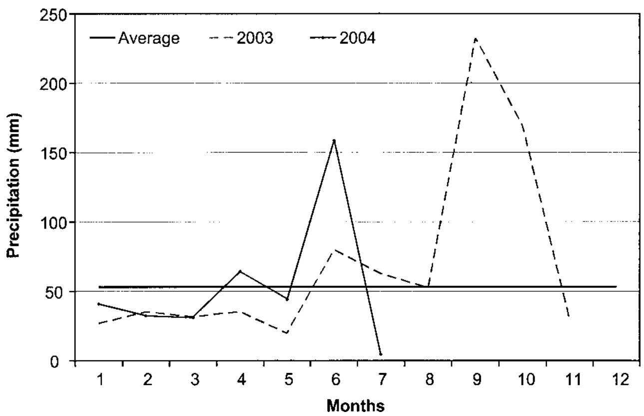

Fig. 1. Monthly rainfall at Tecolote Ranch, near Raymondville, Texas, during 2003 and from January to July 2004.

hot, dry summers and mild winters, with a frost-free season of >300 d. Mean monthly temperatures ranged from 15°C in the winter to 29°C in the summer, but summer temperatures exceeding 35°C were typical. Precipitation was erratic, with 6–8 mo of the year relatively dry, and mean annual rainfall of 650 mm. Rainfall during 2003 and 2004 was unusually high compared to the long-term average. During the months of September and October 2003, rainfall was 233 and 169 mm compared with the long-term average of 137 and 80 mm, respectively (Ramirez 2005) (Figure 1). Scifres and Hamilton (1993) classified the vegetation as a scrubland complex with summer green arborescent, green thorn scrub, and dry–mesic summer green components. The mesquite (*Prosopis glandulosa*)–granjeno (*Celtis ehrenbergiana*) association was the major scrubland association. Study site soils were predominantly sandy (Delfina loamy fine sand and Nueces fine sand) and varied from alkaline to slightly acid (Pendleton and Carter 1974, Nelle 1982). Two guineagrass-dominated pastures mixed with native vegetation with similar guineagrass density were selected for the burning and grazing treatments. Prior to the study, pastures were grazed with a low cattle stocking rate (1 animal unit/14 ha).

Treatments

Eight treatments with three replications resulting from the combination of two seasons (summer and winter) and two factors were evaluated: prescribed burning (burning and no burning) and intensive grazing (grazing or no grazing). The following treatments were applied in summer (June) and winter (February): burning–grazing, burning–no grazing, no burning–grazing, and no burning–no grazing. The experimental site was closed to grazing to accumulate at least 2,000 kg/ha of fine fuel before the application of the burning treatments. Prior to burn application, a double sampling technique (Frame 1981) was used to estimate fine fuel accumulation to ensure at least 2,000 kg/ha was available. Prescribed burning was applied in June 2003 (summer) and February 2004 (winter). Electric fencing was used to protect the no-grazing treatments. Each plot of the no-grazing treatments was about 0.5 ha. After burning, pastures including intensive grazing were grazed whenever guineagrass reached 30 cm in height and at the end of the growing season when the grass began flowering. Cattle were removed from pastures after consumption of 75% of guineagrass standing biomass, which was determined by sampling biomass before grazing using a double sampling technique (Frame 1981) for the pasture and estimating the time cattle would need to consume 75% of the standing biomass.

Field Measurements and Laboratory Analysis

Pre-treatment data to determine density, basal cover, and foliar cover of guineagrass and native plant species foliar cover and species richness were collected, using a 25 × 50-cm Daubenmire frame (Chambers and Brown 1983). We monitored guineagrass density, foliar cover, plant species richness, total nonstructural carbohydrates, and nitrogen in stem bases monthly for 7 mo post-burning for summer burns and 4 mo for winter-burned sites to identify plant response to treatments. Two plots per treatment were used and 15 sampling points were established in each plot.

Total nonstructural carbohydrate concentration levels in stem bases was measured monthly to monitor plant reserves by acid hydrolysis as described by Murphy (1958) and by Kjeldahl procedure (Kjeldahl 1883) for nitrogen from December 2003 to June 2004. Samples were collected and immediately placed on ice and transported to the Lehmann Research Laboratory of the Animal and Wildlife Sciences Department at Texas A&M University-Kingsville in Kingsville, Texas, for chemical analysis. Upon return to the laboratory, plant samples were dried in a forced-air oven at 60°C for 3 d. Subsequent to drying, soil was removed from samples and the roots were dissected from basal crown and stem bases. The stem bases, including the lower 2–2.5 cm of stem, and basal crown were dissected from the rest of the plant shoot and root material, ground in a Willey mill to pass through a 0.5-mm screen, and stored in amber vials until analysis.

A cattle survey was conducted to measure cattle preference between burned and non-burned areas. Number of animals observed in the burned and non-burned areas was recorded 2 times/d (at 0800 and 1800) 2 d every month. To evaluate white-tailed deer preference for burned and non-burned areas, deer spotlighting surveys were conducted on the winter-burned and non-burned areas every month. The same 3-mi (4,827-m) transects were used each month to record deer presence in the burned and non-burned plots. The summer-burned area was not surveyed because the size and distribution of burned areas were not sufficient to separate differences between burned and unburned areas.

Statistical Analysis

Data were analyzed using a randomized complete block design with a factorial arrangement of treatments. Main effects and interactions were considered significant at $\alpha < 0.05$. When significant main effects

Table 1. Guineagrass mean foliar cover under different combinations of prescribed burning and intensive grazing at Tecolote Ranch, Raymondville, Texas, 2003–2004.

	Season			
	Summer (Jun)		Winter (Feb)	
Treatment[a]	% cover	SE	% cover	SE
BG	53	1	79	6
BNG	18	1	98	1
NBG	63	9	58	11
NBNG	56	11	85	8

[a] Treatment: BG, burning–grazing; BNG, burning–no grazing; NBG, no burning–grazing; NBNG, no burning–no grazing.

or interaction effects were found, we assessed difference among treatment means using Duncan's test procedure at $\alpha = 0.05$. Cattle preferences during the trial were analyzed by comparing burned and non-burned areas with analysis of variance. White-tailed deer habitat use was compared by regression analysis. All statistical analyses were done with STATISTICA™ software (StatSoft 2004).

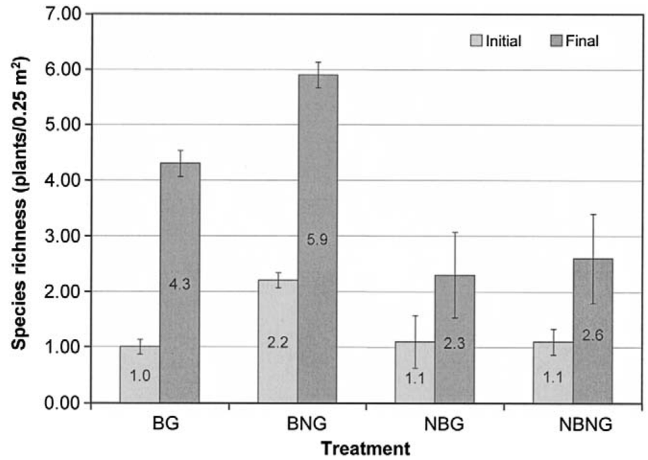

Fig. 2. Final native plant species richness (plants/0.25 m^2) 12 mo after summer prescribed burning and subsequent intensive grazing in a guineagrass-dominated pasture at Tecolote Ranch near Raymondville, Texas, 2003–2004. Treatments: BG, burning–grazing; BNG, burning–no grazing; NBG, no burning–grazing; NBNG, no burning–no grazing.

RESULTS

Pre-treatment Data

Pre-treatment average vegetation data were analyzed for guineagrass density (80,000 plants/ha), guineagrass basal cover (12%), guineagrass foliar cover (70%), and native plant species foliar cover (15%) and species richness (1.1 species/0.25 m^2). We detected no significant differences ($P > 0.05$) among treatments for any of these parameters.

Guineagrass Density

Prescribed burning reduced ($F = 6.863$, $P = 0.058$) guineagrass density in summer-burned areas, with an average of 58,667 plants/ha (SE = 11,366, $n = 2$) compared to 93,333 plants/ha (SE = 10,442, $n = 2$) in non-burned areas. Grazing did not affect ($F = 0.379$, $P = 0.542$) guineagrass density in summer- or winter-burned areas. Prescribed burning increased ($F = 4.452$, $P = 0.043$) guineagrass density in the winter-burned areas, with an average of 115,556 plants/ha (SE = 7,499, $n = 9$) in burned areas compared to 94,222 plants/ha (SE = 11,769, $n = 9$) in non-burned areas.

Guineagrass Foliar Cover

In summer-burned areas, mean guineagrass foliar cover was 18% (SE = 1.7%, $n = 2$; $P = 0.005$) in the burning–no grazing treatment compared to 53% in the burning–grazing (SE = 1.2%, $n = 2$), 63% in the no burning–grazing (SE = 8.9%, $n = 2$), and 56% in the no burning–no grazing (SE = 11.1%, $n = 2$) treatments (Table 1). Guineagrass foliar cover decreased from 38% to 17% in the burning–no grazing treatment by the end of study ($P > 0.05$). In winter-burned areas, guineagrass foliar cover was affected by both burning ($F = 4.679$, $P = 0.038$) and grazing ($F = 6.289$, $P = 0.017$). Guineagrass foliar cover was lower in non-burned areas, with an average of 71% (SE = 10.3%, $n = 9$) compared to 89% (SE = 5.2%, $n = 9$) for prescribed burn treatments. Guineagrass foliar cover was lower in grazing treatment areas, with an average of 68% (SE = 9%, $n = 9$) compared to 92% (SE = 6.3%, $n = 9$) for no-grazing treatments.

Native Plant Species Richness

Sixty-four plant species occurred in the sampling plots where at least one treatment (burning or grazing) was applied. Higher native plant species richness was observed in summer-burned areas compared to winter-burned. Plant species richness in the summer burning–grazing treatment increased 330% from 1.0 to 4.3 species/0.25 m^2, increased 150% from 2.2 to 5.9 species/0.25 m^2 in the burning–no grazing treatment, increased 109% from 1.1 to 2.3 species/0.25 m^2 in the no burning–grazing treatment, and increased 136% from 1.1 to 2.6 species/0.25 m^2 in the no burning–no grazing treatment (Figure 2). Plant species richness differed ($F = 22.086$, $P = 0.009$) among burning treatments and was lower in no-burning areas, with an average of 2.5 (SE = 0.5, $n = 2$) compared to 5.2 species/0.25 m^2 (SE = 0.5, $n = 2$) for burning treatments. Species richness was not affected ($F = 2.7$, $P = 0.175$) by grazing. When data were analyzed to determine the percentage change of species richness between the beginning and end of the study, the interaction between prescribed burning and grazing was significant ($F = 9.56$, $P = 0.036$). Ten forbs used as food by white-tailed deer were newly recorded or increased cover after 1 y in the burning treatments (Table 2). Six important food plants for northern bobwhite (*Colinus virginianus*) were observed in burned treatments (Table 2) but were not found in unburned areas.

In the winter-burned areas by the end of the study, plant species richness ranged from 0 to 2.3 ± 0.84 species/0.25 m^2. Species richness was different ($F =$

Table 2. Native plants used by white-tailed deer and northern bobwhite in burned areas of guineagrass-dominated pastures 1 y after prescribed burning, Tecolote Ranch near Raymondville, Texas, 2004.

Animal species	Plant species: Scientific name	Plant species: Common name
White-tailed deer	*Aphanostephus skirrhobasis*	Lazy daisy
	Callirhoe digitata	Winecup
	Commelina erecta	Dayflower
	Desmanthus virgatus	Desmanthus
	Lesquerella argyraea	Silver bladderpod
	Oxalis dillenii	Woodsorrel
	Chamaesyce glyptosperma	Ridgeseed spurge
	Plantago rhodosperma	Redseed plantain
	Rhynchosia americana	American snoutbean
	Verbena officinalis	Verbena
Northern bobwhite	*Chamaecrista fasciculata*	Partridge pea
	Commelina erecta	Dayflower
	Coreopsis nuecensoides	Coreopsis
	Digitaria arenicola	Witchgrass
	Setaria parviflora	Bristlegrass
	Sporobolus indicus	Smutgrass

9.603, $P = 0.004$) among burning treatments. Richness was lower in burning treatments, with an average of 0.1 species/0.25 m^2 (SE = 0.08 species/0.25 m^2, n = 9) compared to 1.8 species/0.25 m^2 (SE = 0.75 species/0.25 m^2, n = 9) for no-burning treatments. Species richness was not affected by grazing ($F = 1.685$, $P = 0.204$).

Total Nonstructural Carbohydrates and Nitrogen

No significant ($P > 0.05$) differences were found among treatments for total nonstructural carbohydrates or nitrogen in the summer- or winter-burned and no-burned areas. No difference ($P > 0.01$) was found for total nonstructural carbohydrates or nitrogen between the summer- or winter-burned areas.

Cattle and White-tailed Deer Preference

Initially (February 2004), white-tailed deer presence was higher ($P = 0.033$) in the no-burning area, with 19 animals versus 5 animals/3-mi (4,827-m) transect in the burned area. During the next 4 mo, deer presence in no-burning areas gradually decreased ($y = 14.5 - 1.63x$, where x = time in months after burning) and finally just 2 deer were observed. The opposite ($P = 0.008$) behavior was observed in the burned areas, where the presence of deer increased to 14 deer ($y = 4.93 + 1.07x$, where x = time in months after burning; $R^2 = 63.9$). Cattle highly preferred burned areas ($P = 0.001$), with an average of 44.5 animals (SE = 2.7 animals, n = 26) compared to an average of 32.5 animals (SE = 2.4 animals, n = 26) in non-burned areas.

DISCUSSION

In general, summer burns had a more dramatic effect on guineagrass in terms of density, cover, and native plant species richness compared to winter burns. Summer prescribed burning reduced guineagrass density independently of the grazing treatment. These results agree with those of Skovlin (1971), who indicated that guineagrass is susceptible to hot fires. However, in that study, no change was observed when post-treatment guineagrass density was compared to pre-treatment density. In our study, grazing did not significantly affect guineagrass density, in contrast to several studies that indicate high grazing pressure, in general, reduces grass density (Watkin and Clements 1978, Santillan 1983, Valentine 1990).

Native plant species richness, an index to reestablishment of the native plant community, was higher on summer-burned areas compared with areas burned in winter. Species richness in the burning–no grazing treatment increased 150% from 2.2 to 5.9 species/0.25 m^2, and in the burning–grazing areas increased 330% from 1.0 to 4.3 species/0.25 m^2. This result contrasts with that of Drawe and Kattner (1978), who indicated that percent composition of grasses and forbs was not significantly affected by early summer prescribed burning when combined with mowing. In our study, summer burns appeared to improve species richness, perhaps because of a significant reduction of guineagrass foliar cover. In a similar fashion, Santillan (1983) found a short rest period improved legume yields and development after heavy grazing when associated with guineagrass and elephant grass (*Pennisetum purpureum*)—this was due to reduction of grass competition for light. However, Davison and Brown (1985) reported that ‘‘Gatton’’ panicgrass (guineagrass, i.e., *Panicum maximum*) can compete versus legumes after 4 y of heavy grazing pressure, due to legume yield reduction after 4 y. Others have reported that after 3 y of grazing, species richness improved compared with control areas (California Agricultural Technology Institute 2004).

Comparison between grazing and no-grazing plots in winter-burned areas showed a 22% decrease on guineagrass foliar cover, and that extra space was occupied by a 7% increase in native species cover and a 15% increase in bare ground. Different results were reported by Duval and Linnartz (1967), who stated that bare ground did not change 1 y after burning and grazing, but an increase in total herbage yield and species richness was recorded in following years.

White-tailed deer and cattle habitat use was influenced by prescribed burning. A higher concentration of cattle in the burned areas was recorded throughout the study. New regrowth and nutritious forage on burned and frequently grazed areas maintained higher cattle densities. This result agrees with those of Ralphs et al. (1995), Howery et al. (1998), and Villalba and Provenza (1999), who reported livestock preference was highly influenced by forage quality, which is usually higher on grass regrowth. White-tailed deer use decreased immediately after burning, probably because of decreased food sources (Davis 1990). Forbs and brush are the main components of deer diet and are highly affected by fire; however, recovery is slower than that of grasses (Payne and Bryant 1998). One month after burning, deer numbers gradually increased in burned areas and decreased in unburned areas. The increase in native plant species richness and the nutritious regrowth of brush species in the burned areas positively affected the preference of white-tailed deer for burned sites.

Our study results were possibly affected by two factors: 1) rainfall pattern during the period of study, and 2) time needed to achieve grazing effect on the plant community. Two months after summer prescribed burning, heavy rain fell on the study area (Figure 1), 233 mm during September and 169 mm during October 2003. The average precipitation for these months is 137 mm and 80 mm for September and October, respectively, which was 70% and 111% higher than the average, respectively (Ramirez 2005). This unusually high rainfall may have allowed guineagrass to grow and recover from the grazing treatment, increasing mineralization and deposition of ash and atmospheric nitrogen (USGS 1999, Sadras and Baldock 2003). Sadras and Baldock (2003) reported that frequent rainfall events can mineralize >70 kg N/ha when seasonal precipitation exceeds 300 mm, which we observed in this study. USGS (1999) also reported that 30 mm of rainfall can deposit 168 g N/ha directly from the atmosphere in the South Texas Coastal Bend area. This suggests that, in this study, guineagrass could have received >70 kg N/ha. Increases in biomass production of guineagrass have been reported by the Food and Agriculture Organization (2003) as a result of nitrogen fertilization. Middleton and McCosker (1975) reported biomass production of guineagrass of 60 t of dry matter/ha when 300 kg of N was applied in North Queensland, Australia. Secondly, plant longevity can be reduced by heavy grazing but usually after a period of time, the grazing effect over grass persistence occurs after 3 y of intensive grazing (Jones 1986). Jones (1986) also reported African brittlegrass (*Setaria sphacelata*) density dropped from 59,000 to 17,000 plants/ha after 2 y and to 9,000 plants/ha after 8 y. Some other studies report reduction of panicgrasses only after long periods (more than 3 y) under high grazing pressure (Duval and Linnartz 1967). In our study, intensive grazing was applied for only 1 y and this time period appears to be insufficient to reduce guineagrass density.

MANAGEMENT IMPLICATIONS

The application of prescribed burning and subsequent intensive grazing during the summer altered plant species composition on pastures dominated by guineagrass. Guineagrass density decreased with summer prescribed fire. The percent change in plant species richness by the end of the study was higher in the burning–grazing treatment during the summer; but a longer period of time is required to assess the desired effect of grazing and burning on guineagrass density. This initial study suggests burning and grazing can lead to an increase in native plant species, even when extremely wet years apparently masked the effect of grazing on guineagrass density and high precipitation positively affected guineagrass survival. Cattle preferred burned areas probably because of increased guineagrass forage quality. The increase in native plant species richness and the nutritious browse available after burning may have caused the high preference of white-tailed deer for burned areas.

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