Prescribed Burning and Grazing for Prairie Chicken Habitat Manipulation in the Texas Coastal Prairie[1]

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THERE are many ecological factors affecting grasslands and associated biotic communities; among these are fire and grazing, which man can and does control. Fire and grazing can be destructive forces in biotic communities if improperly used. However, when properly utilized they may be useful management tools to manipulate native vegetation for the benefit of wildlife, as well as of other interests of man.

Effects of fire and grazing on quality of prairie chicken habitat in the Texas Coastal Prairie were studied from 1967 to 1970 on the

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This paper discusses the results of that study and other supporting evidence toward establishing a sound ecological base for using fire and grazing as tools in prairie chicken habitat manipulation and management. Particular attention is given to prairie chicken response to prescribed burning and grazing, availability of potential foods, and certain vegetative attributes contributing to habitat quality.

Fire, in the past, may have played an important ecological role in maintaining the Coastal Prairie habitat of Attwater's prairie chicken (*Tympanuchus cupido attwateri*). There is historical evidence that fires occurred frequently over much of the Texas Coastal Prairie (Berlandier 1829; Ilkin 1841; Smith 1895; Bray 1901; Cook 1908). Paralleling the history of fire in this region during the late 1800's and early 1900's is a history of prairie chicken abundance (Lehmann 1941; 1965).

METHODS

The influence of fire and livestock grazing on Coastal Prairie rangeland and Attwater's prairie chicken habitat was studied using prescribed burns, a permanent grazing exclosure, and temporary grazing exclosures. Prescribed burns were carried out on Katy fine sandy loam, a soil representative of much of the Coastal Prairie. Prescribed burning was conducted in a grazed pasture and in a 110-acre permanent grazing exclosure. The exclosure had a 3-year history of total protection from grazing preceding the first burning treatments.

The grazed pastures were moderately grazed in a rotational system throughout this study. Temporary exclosures were constructed to permit comparison among prescribed treatments for three conditions of grazing following prescribed burning on the Katy soil: (1) post-burn deferment, prior to and throughout the growing season, (2) post-burn grazing, including continuous or frequent periodic grazing, and (3) post-burn grazing + deferment, which involved grazing to early summer, followed by deferment the remainder of the year.

A randomized block design with two replicates was used on both grazed and ungrazed areas. Each block of burning replications included an unburned control plot. All study plots were approximately one-half acre (100 × 300 ft) in size with adjoining burned areas ranging up to approximately 3 acres in size.

Burning treatments were carried out on three dates: 4 October 1968 (fall); 4 January 1969 (winter); and 11 March 1969 (spring). Larger supporting burns were carried out on 12 December 1969.

RESULTS AND DISCUSSION

Prairie Chicken Response

Prairie chicken response to prescribed burning and grazing is a direct indication of the positive or negative values of habitat manipulation by these means. In some instances prairie chickens responded markedly to prescribed burning and grazing treatments in this study, while in other instances the response was less pronounced.

The major response of prairie chickens to prescribed burning was on the ungrazed, Katy fine sandy loam in the permanent exclosure. There were no records of prairie chilken activity in this exclosure during the year preceding the first prescribed burns. During the next 2 years, birds were observed utilizing the burned areas in winter, spring, and summer. All observed activities including booming, roosting, loafing, and feeding were on or immediately adjacent to the burns. During March and April 1970, active booming by 5–10 males took place on an area burned in December 1969.

Prairie chicken nests were located in the exclosure in spring 1970. The nests were located on areas burned the previous years (fall 1968 and spring 1969). The nests were approximately 400 yards from the recently burned area where active booming had occurred in March and April. Vegetation in the immediate vicinity of nests was dense to moderately dense, about 18 inches tall, and composed primarily of tall and mid grasses and a few forbs. The major species was Indiangrass (*Sorghastrum nutans*). Other species included little bluestem (*Andropogon scoparius*), meadow dropseed (*Sporobolus asper*), paspalums (*Paspalum* sp.), dicanthelium panicum (*Panicum oligosanthes*), winter bentgrass (*Agrostis hiemalis*), western ragweed (*Ambrosia psilostachya*), winecup (*Callirhoe involucrata*), blackeyedsusan (*Rudbeckia* sp.), wild petunia (*Ruellia* sp.), and gaura (*Gaura parviflora*). The nests were surrounded and covered by a canopy of predominantly current season's grass growth, with small amounts of standing past season's growth.

Based on the positive responses of prairie chickens following prescribed burning, it appears that fire may be a useful tool in maintaining desirable prairie chicken habitat where grazing is restricted or totally excluded in Coastal Prairie grsslands.

Prescribed burning with grazing did not significantly increase prairie chicken activity, although birds did use the prescribed burn complex. Prairie chicken activities, including feeding, loafing, booming, nesting, and brooding, were prevalent in moderately grazed, unburned areas of Katy fine sandy loam. Prairie chicken response to systematic grazing management indicated that desirable habitat also can be maintained by grazing alone, provided that frequency and intensity of grazing are closely controlled. Grazing can be complemented by prescribed burning, either to increase the intensity of grazing in certain areas or to manipulate distribution of grazing.

Increased prairie chicken activities in response to prescribed burning, grazing, or other types of habitat manipulation are believed to be related to changes in habitat factors such as availability of food supplies and life-form characteristics of vegetation (Hamerstrom, et al. 1957; Jones 1963; Kobriger 1965; Brown 1968; and Anderson 1969).

It appeared that the effects of prescribed burning on habitat quality strongly influenced the distribution and activity of Attwater's prairie chickens on ungrazed, Coastal Prairie grassland. However, under grazing, prescribed burning did not appear to significantly influence prairie chicken activity.

Potential Food Supplies

Potential food supplies in the habitat were classed into three categories: (1) vegetative, (2) seed, and (3) insect. These broad classes of "potential foods" serve only as a general index to availability of foods and not to specific food items of Attwater's prairie chicken. Specific food items do occur, in varying amounts, within the broad classes.

Following a prescribed burn, blackened ash remains on the area for several days to a week, depending upon weather conditions. Under conditions of wet soil and a heavy mulch cover at the time of burning, some green shoots of grasses may remain after a burn. In general, greenup usually occurs within 1 or 2 weeks. The first greenup is from new shoot growth of perennial species, followed later by annual grasses and forbs. Similar observations have been reported by Aldous (1934) and Kelting (1957).

On ungrazed areas, vegetation develops rapidly following a burn, and succulent green foods become readily available in increased amounts, especially in the forb class. This is in strong contrast to the slow vegetation development on unburned areas under protection from grazing (Figs. 1 and 2). Current vegetative growth on burned and unburned control plots by mid-spring was represented by 74–82 percent grass, 16–23 percent forb, and 2–5 percent sedge. The fall-burned plots had the highest green herbage yield among treatments for each herbage class and for total yield (Fig. 1). Following in decreasing order of total yields were the winter-burned, the spring-burned, and the unburned control plots. This order prevailed for all classes, except sedge, for which the yield from the spring-burned plots was slightly higher than for the winter-burned plots.

The fall burn appeared the most favorable for producing an abundance of vegetative foods and potential foods in the grass and forb classes. The low availability of vegetative foods of all classes on the spring-burned plots was expected, due to the short growth period after the early March burn.

Potential vegetative foods produced by early spring on the December 1969 burned and unburned control areas were measured in early spring 1970. The green grass yield was 331 lb/acre by mid-March (Fig. 2). The unburned control yielded 396 lb/acre at this time. This difference was not significant. However, a highly significant difference in forb yields ($P < .01$) existed between the burned and the control areas. The burned area yielded 478 lb/acre, while the unburned area yielded only 183 lb/acre. Sedges on the burned area produced 44 lb/acre, while only 5 lb/acre were produced on the unburned control area. Total production of green vegetative materials was significantly greater ($P < .05$) on the burned area, with 853 lb/acre, than on the unburned control, with 584 lb/acre.

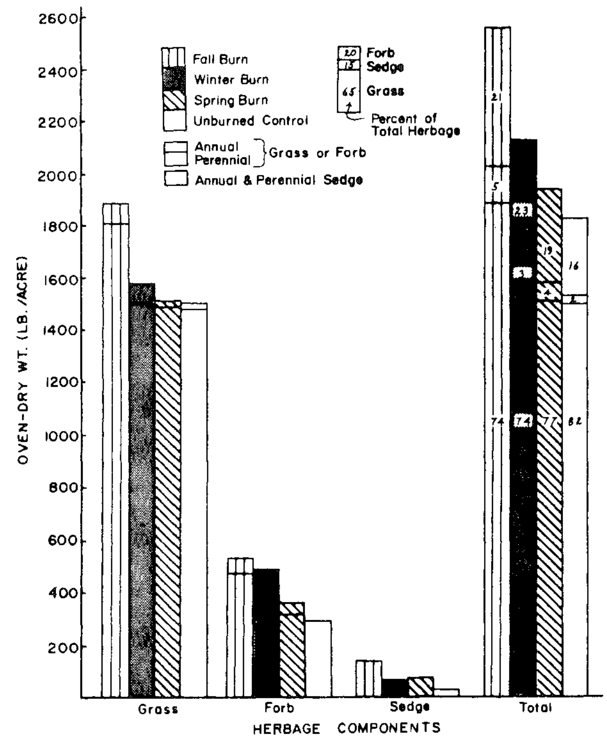

FIG. 1. Availability of potential vegetative foods, by mid-spring 1969, on three prescribed burn areas and unburned control areas on ungrazed, Katy fine sandy loam.

Under grazing, vegetation response and development on unburned areas were similar in many respects to that on the burned areas (Figs. 3, 4, and 5). Availability of potential vegetative foods by mid-spring under conditions of post-burn deferment was represented by 69–76 percent grass, 11–15 percent forb, and 9–20 percent sedge (Fig. 3). The total green herbage under post-burn deferment was greatest on the winter-burned plots, followed in decreasing order by the unburned control, the fall-burned, and the spring-burned plots. Similar trends prevailed for the grass herbage class, but the forb and sedge classes deviated slightly.

Availability of potential vegetative foods with post-burn grazing was influenced by periodic grazing between burn dates and mid-spring

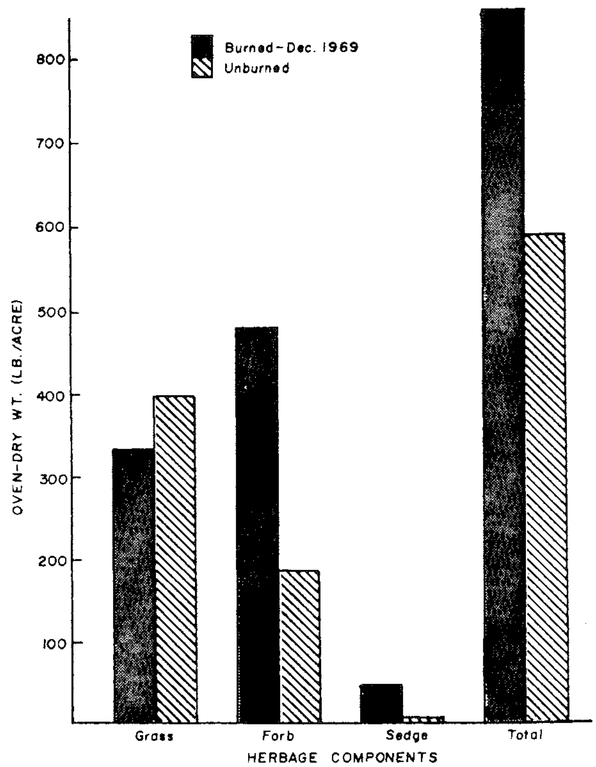

FIG. 2. Availability of potential vegetative foods, by early spring 1970, on a prescribed winter burn area and an unburned control area on ungrazed, Katy fine sandy loam.

sampling dates (Fig. 4). Under post-burn grazing cattle were observed to concentrate heavily on the burned areas soon after greenup. The earlier burned plots were susceptible to longer periods of concentrated grazing use. Total green herbage was most abundant on the unburned control plots and least abundant on the spring-burned plots. The same trend occurred for grasses, which contributed 51–80 percent of the total yield. Forbs accounted for 13–25 percent of total herbage. The highest forb yield occurred on the fall-burned plots, while the lowest forb yield occurred on the winter-burned plots. Sedges produced 7–24 percent of the total vegetative yield.

On the December 1969 burned area the availability of green veg-

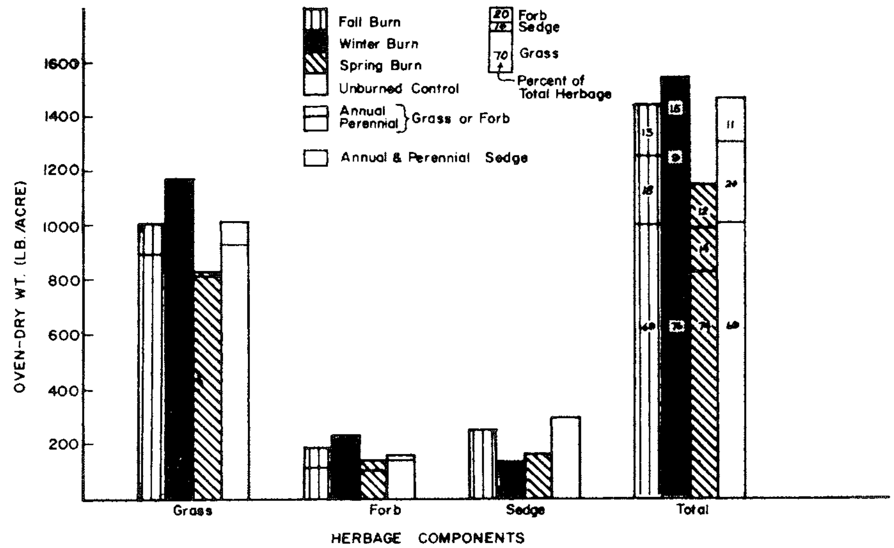

FIG. 3. Availability of potential vegetative foods, by mid-spring 1969, on three prescribed burn areas and unburned control areas on grazed, Katy fine sandy loam with post-burn deferment.

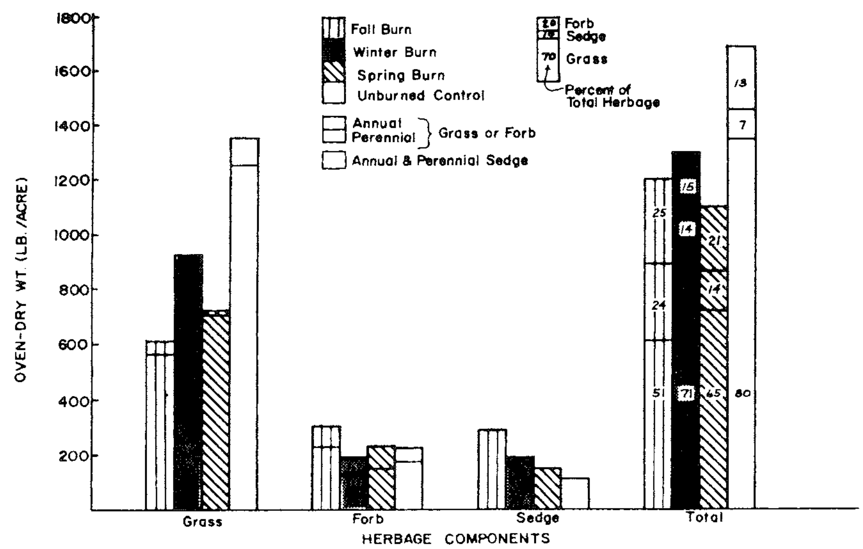

FIG. 4. Availability of potential vegetative foods, by mid-spring 1969, on three prescribed burn areas and unburned control areas on Katy fine sandy loam with post-burn grazing.

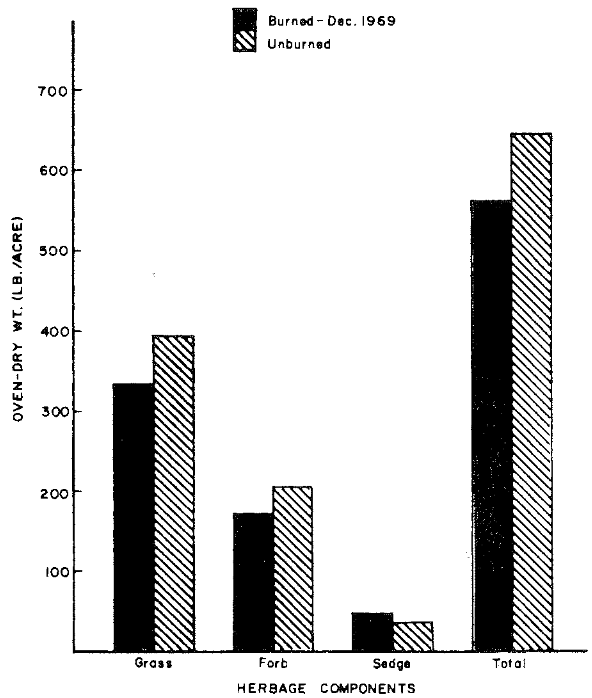

FIG. 5. Availability of potential vegetative foods, by early spring 1970, on a prescribed winter burn area and an unburned control area on grazed, Katy fine sandy loam.

etative materials was not significantly different from the unburned control plots for any herbage class or for total herbage (Fig. 5) Total herbage yield ranged from 560 lb/acre on the burned area to 642 lb/acre on the control.

Almost all green vegetative materials on the burns of both grazed and ungrazed areas were readily available or accessible to prairie chickens for food. A similar situation prevailed on the grazed, unburned control plots. However, on the ungrazed, unburned control plots, much of the current growth of vegetative materials was not readily accessible, due to excessive accumulations of mulch.

Seeds, another important component of prairie chicken diets, were collected in spring 1970, using stratified random sampling to include occasional small sandy mounds and non-mound areas in proportion to occurrence on the Katy soil. These samples contained seeds produced during the first full growing season following the prescribed burns, as well as any residual seeds.

Seeds had slightly higher yields on seasonally burned areas than on unburned control plots in the ungrazed area (Fig. 6). Seed supplies were not significantly affected by prescribed burning on the non-mound areas of ungrazed, Katy fine sandy loam, regardless of date of burning (Fig. 6). However, seeds were most abundant on the fall-burned plots, followed in decreasing order by winter-burned, unburned control, and spring-burned plots. On the mounds, however, seed supplies were significantly greater ($P < .05$) on the spring-burned plots than on fall-burned plots, but not significantly different from winter-burned or unburned control plots.

Under grazing, seed yields were significantly greater on spring-burned plots than on fall-burned and winter-burned plots and somewhat greater than on unburned control areas (Fig. 7). Availability of seed on grazed, Katy fine sandy loam under three post-burn grazing conditions is shown in Figure 7. Differences among means of all graz-

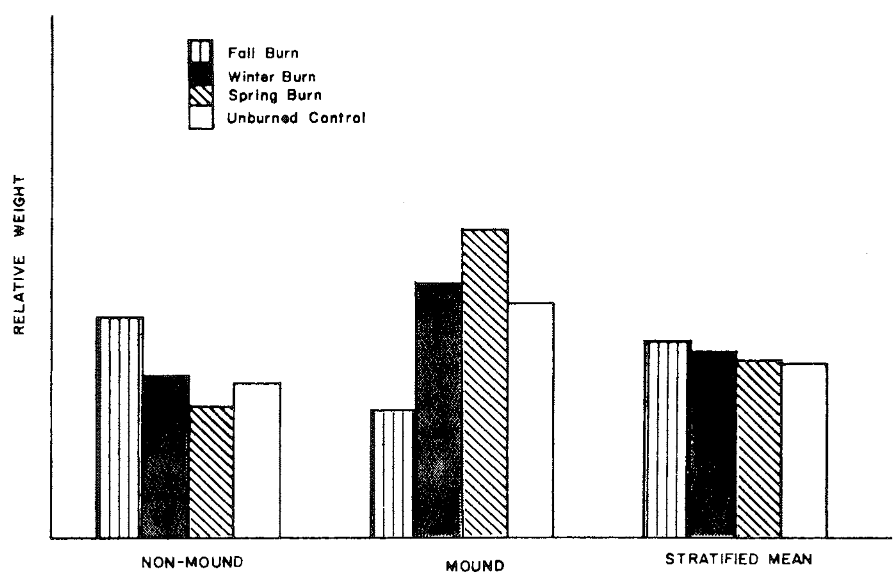

Fig. 6. Relative availability of potential seed foods on three prescribed burn areas and unburned control areas on ungrazed, Katy fine sandy loam.

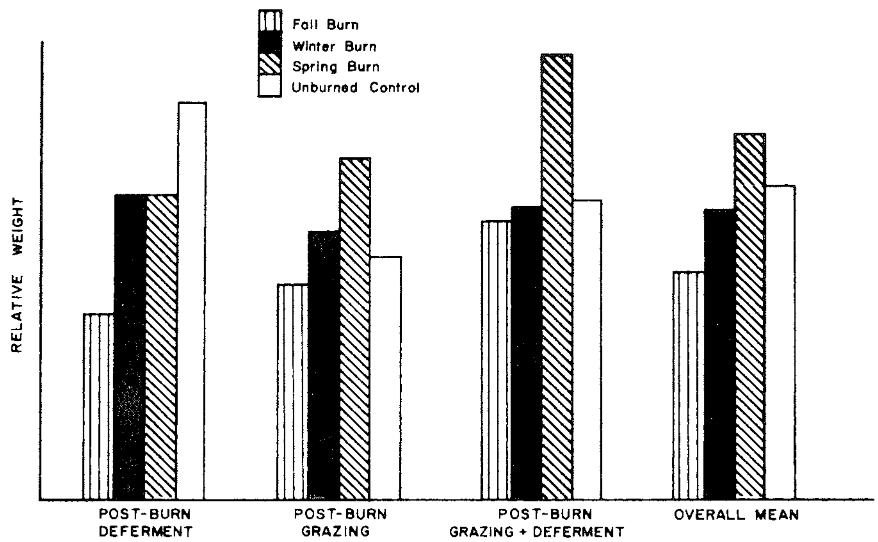

FIG. 7. Relative availability of potential seed foods on three prescribed burn areas and unburned control areas on Katy fine sandy loam with three post-burn grazing conditions.

ing treatments were significant ($P < .05$) between fall-burned and spring-burned plots and between fall-burned and control plots.

Insects and other small arthropods were likewise more abundant on burned than on control plots in the ungrazed area during the summer brood period (Fig. 8). Stoddard (1963) also found that insects were usually most numerous on recently burned areas. Such areas were heavily used as brood range by turkey and quail.

The insect order, Orthoptera, accounted for 82–89 percent of the total weight of the eight orders of insects and spiders important as potential prairie chicken foods (Fig. 8). Therefore, this order is considered separately from the other six orders of insects. The orders Hemiptera, Homoptera, Coleoptera, Lepidoptera, Diptera, and Hymenoptera are grouped as "other insects" and contributed less than 8 percent of the total weight. The spider order, Araneida, also was separated, and it contributed up to 10 percent of the total weight.

Relative weights of Orthoptera were similar among the three prescribed burn treatments (Fig. 8). The unburned control plots produced significantly less ($P < .05$) than either winter or spring-

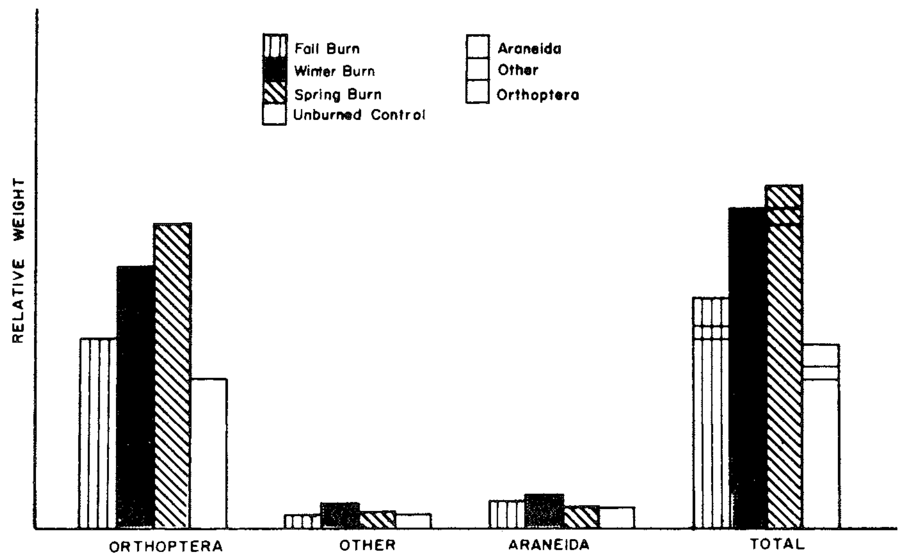

FIG. 8. Relative availability of potential insect foods, during the summer brood period, on three prescribed burn areas and unburned control areas on ungrazed, Katy fine sandy loam.

burned plots while producing only slightly less than the fall-burned plots in the ungrazed area. The winter-burned plots produced significantly greater ($P < .05$) amounts of "other insects", while yields among fall-burned, spring-burned, and unburned control plots were similar. Amounts of Araneida were similar among the burned plots, but only the winter-burned plots yielded significantly greater ($P < .05$) amounts of Araneida than the unburned control plots.

Total weight of potential insect foods was significantly greater ($P < .05$) on the spring-burned plots than on either fall-burned or unburned control plots. It also was slightly more than on the winter-burned plots.

Potential insect foods were compared among prescribed treatments under the same grazing conditions used for vegetative and seed foods (Fig. 9). The spring-burned plots with post-burn deferment produced the greatest weight of Orthoptera and the greatest total insect weight. The fall-burned plots were lowest in production of both groups. Weights of "other insects" were similar on all treatments under post-burn deferment. Araneida weights were highest on the fall-burned plots and lowest on the winter-burned plots.

Orthoptera weights and total weights of insects and spiders, with post-burn grazing, were highest on the winter-burned plots, followed in decreasing order by the unburned control, fall-burned, and spring-burned plots. "Other insects" had higher weights on the winter- and fall-burned plots. Weights of Araneida were similar for winter-burned, spring-burned, and control plots but lower on fall-burned plots.

Orthoptera weights were greatest on the winter-burned plots and least on the unburned control plots with post-burn grazing + deferment. The fall-burned area produced the most "other insects", while the greater weights of Araneida were produced on the spring- and fall-burned plots. Total insect and spider weights were similar and in greater amounts on winter- and fall-burned areas.

Vegetative Attributes

Physical and ecological changes influence the quality of a plant community as potential prairie chicken habitat and subsequently the

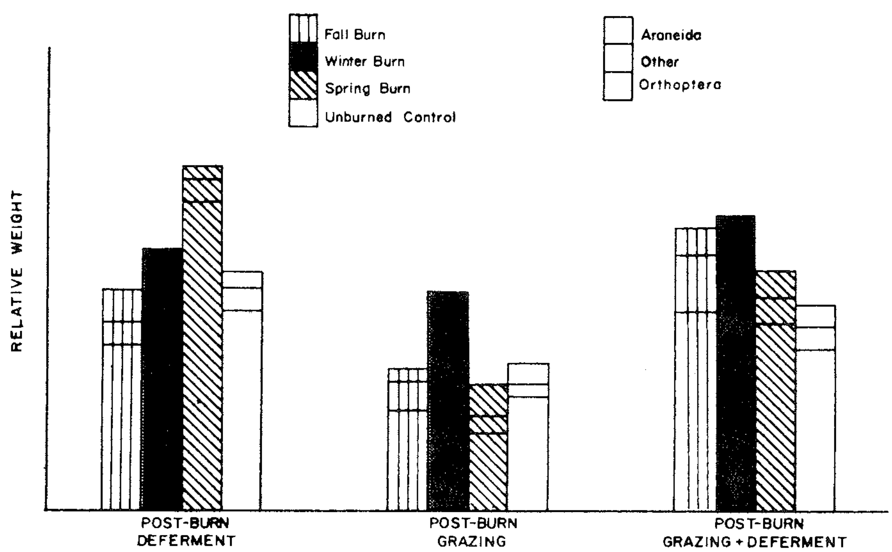

Fig. 9. Relative availability of potential insect foods, during the summer brood period, on three prescribed burn areas and unburned control areas on Katy fine sandy loam with three post burn grazing conditions.

use of such areas by Attwater's prairie chickens for nesting, brooding, feeding, resting, booming, and other essential activities. Certain vegetative attributes such as density, mulch accumulation, height, canopy coverage, grass:forb ratios, and availability of nesting cover contribute to the quality of various habitat components essential in the life cycle of Attwater's prairie chicken. These vegetative attributes were influenced by prescribed burning in both ungrazed and grazed situations.

Total density of vegetation is generally considered to have a strong influence on the degree and type of use by prairie chickens (Hamerstrom, et al. 1957; Jones 1963). Absolute densities of vegetation were increased by all burning treatments and under both grazed and ungrazed conditions of this study (Tables 1 and 2). Vegetation densi-

TABLE 1. ABSOLUTE DENSITY (SHOOTS/FT^2) OF VEGETATION ON THREE PRESCRIBED BURN AREAS AND UNBURNED CONTROL AREAS ON UNGRAZED, KATY FINE SANDY LOAM.

Herbage class	Prescribed treatment				
	Fall burn	Winter burn	Spring burn	Unburned control	
Grasses	34_a	35_a	35_a	15_b	*
Forbs	6_{ab}	9_a	7_{ab}	3_b	*
Sedges & rushes	3_a	3_a	2_a	2_a	NS
Total	43_a	47_a	44_a	20_b	*

* Values having different letter subscripts are significantly different ($P < .05$).
NS Not significant.

ties for all treatments, including unburned controls, on grazed areas, were markedly greater than on the ungrazed area (Tables 1 and 2). Densities were generally quite similar among burn dates and seldom varied significantly. Ehrenreich and Aikman (1963) also reported an increase in vegetation density following burning on native tall grass prairie in Iowa.

Density results should not be misinterpreted regarding habitat quality. Although densities of current vegetative shoots were significantly increased, excessive residue accumulations were significantly decreased (Tables 3 and 4), and an overall improvement in habitat quality occurred, especially on the ungrazed area. Evans (1968)

TABLE 2. ABSOLUTE DENSITY (SHOOTS/FT[2]) OF VEGETATION ON THREE PRESCRIBED BURN AREAS AND UNBURNED CONTROL AREAS ON GRAZED, KATY FINE SANDY LOAM WITH POST-BURN DEFERMENT, POST-BURN GRAZING, AND POST-BURN GRAZING + DEFERMENT.

Herbage class	Prescribed treatment				
	Fall burn	Winter burn	Spring burn	Unburned control	
	Post-burn deferment				
Grasses	46_a	46_a	46_a	34_a	NS
Forbs	10_a	20_a	15_a	7_a	NS
Sedges & rushes	11_a	9_a	9_a	9_a	NS
Total	67_a	75_a	70_a	50_a	NS
	Post-burn grazing				
Grasses	49_{ab}	49_{ab}	52_a	32_b	*
Forbs	9_{ab}	14_a	15_a	3_b	*
Sedges & rushes	9_a	6_{ab}	5_b	3_b	*
Total	67_a	69_a	72_a	38_b	*
	Post-burn grazing + deferment				
Grasses	53_a	37_b	38_b	29_c	*
Forbs	11_a	14_a	7_a	3_a	NS
Sedges & rushes	9_a	11_a	12_a	4_a	NS
Total	73_a	62_a	57_{ab}	36_b	*

* Values having different letter subscripts are significantly different ($P < .05$).
NS Not significant.

pointed out that light to moderate grazing prevents excessive accumulations of mulch that can reduce the value of an area as habitat.

The ungrazed, Katy fine sandy loam, with total protection from grazing and fire since March, 1965, had heavy accumulations of mulch just prior to prescribed burning. The abundance of fuel resulted in extremely hot burns; however, small amounts of mulch remained on the wet soil surface following each burn.

Mulch yields and depth accumulations were determined during the summer following prescribed burns. There were no significant differences among burn dates, but mulch yield on the unburned control was significantly greater ($P < .01$) than on each of the burned areas (Table 3).

Mulch yields on grazed, Katy fine sandy loam followed the same general trend observed under the ungrazed treatments (Table 4). Highly significant differences ($P < .01$) existed between the control

TABLE 3. MULCH YIELDS (LB./ACRE) AND DEPTH ACCUMULATIONS (INCHES) BY MID-SUMMER OF THREE PRESCRIBED BURN AREAS AN UNBURNED CONTROL AREAS ON UNGRAZED, KATY FINE SANDY LOAM.

Type of measurement	Fall burn	Winter burn	Spring burn	Unburned control
Weight	$1{,}257_a$	$1{,}919_a$	$1{,}848_a$	$7{,}148_b$**
Depth	0.67	0.67	0.55	4.89

** Values having different letter subscripts are significantly different ($P < .01$).

plots and each of the burn plots. There were no real differences in mulch yields among burn plots. The unburned control plots yielded 5,548 lb/acre, while the burned plots yielded an average of 1,347 lb/acre.

Height of vegetation is one of the major criterion used to describe the physiognomy of prairie chicken habitat (Jones 1960; 1963; Brown 1968). The system of life-form classification is based on height of dominant categories of vegetation, without regard to plant species. On both ungrazed and grazed areas, all seasonal burns reduced overall vegetation heights by the end of the post-burn growing season (Tables 5 and 6). Grass and forb heights were similar for most prescribed treatments on the ungrazed area. In grazed areas, with post-burn deferment and post-burn grazing, both mean and maximum heights of forbs were considerably greater than grass heights. However, grass cover was more dense and continuous, while forb cover was sparse and broken or intermittent among the grass plants. Under post-burn grazing + deferment, the trend was reversed, and grasses were taller than forbs. A similar situation occurred under total protection from grazing. In general, heights were adequate for prairie chicken cover, except for excessively short vegetation on post-burn grazed areas.

TABLE 4. MULCH YIELDS (LB./ACRE) AND DEPTH ACCUMULATIONS (INCHES) BY MID-SUMMER ON THREE PRESCRIBED BURN AREAS AND UNBURNED CONTROL AREAS ON GRAZED, KATY FINE SANDY LOAM.

Type of measurement	Fall burn	Winter burn	Spring burn	Unburned control
Weight	$1{,}535_a$	$1{,}210_a$	$1{,}295_a$	$5{,}548_b$**
Depth	0.83	0.59	0.55	2.80

** Values having different letter subscripts are significantly different ($P < .01$).

TABLE 5. MAXIMUM AND MEAN HEIGHTS (INCHES) OF VEGETATION AT THE END OF THE FIRST POST-BURN GROWING SEASON ON THREE PRESCRIBED BURN AREAS AND UNBURNED CONTROL AREAS ON UNGRAZED, KATY FINE SANDY LOAM.

Height class	Prescribed treatment							
	Fall burn		Winter burn		Spring burn		Unburned control	
	Grass	Forb	Grass	Forb	Grass	Forb	Grass	Forb
Maximum height	11.03	11.03	12.21	10.24	10.52	12.06	15.76	14.62
Mean height	9.29	9.77	10.05	8.75	9.53	9.34	12.93	13.00

The most critical period in the life cycle of the prairie chicken is during nesting and brooding (Lehmann 1941; Schwartz, 1945; Baker 1953; Hamerstrom, et al. 1957; Jones 1963; Evans 1968). In general, medium-dense stands of tall-grasses and mid-grasses with admixtures of forbs provide the most desirable nesting and brood cover. Relatively open stands of vegetation with paths or trails and small openings of reduced cover facilitate movement and feeding activity of young broods. Thus, an abundance of nesting cover, alone, does not necessarily constitute the most desirable habitat for this critical period.

TABLE 6. MAXIMUM AND MEAN HEIGHTS (INCHES) OF VEGETATION AT THE END OF THE FIRST POST-BURN GROWING SEASON ON THREE PRESCRIBED BURN AREAS AND UNBURNED CONTROL AREAS ON GRAZED, KATY FINE SANDY LOAM UNDER THREE POST-BURN GRAZING CONDITIONS.

Height class	Prescribed treatment							
	Fall burn		Winter burn		Spring burn		Unburned control	
	Grass	Forb	Grass	Forb	Grass	Forb	Grass	Forb
Post-Burn deferment								
Maximum height	14.78	26.40	16.55	24.23	13.20	27.78	15.96	27.58
Mean height	10.36	19.82	10.20	18.56	10.80	17.96	13.24	18.91
Post-burn grazing								
Maximum height	6.70	15.44	6.78	12.41	13.20	28.78	15.96	27.58
Mean height	5.00	12.53	5.28	10.60	5.00	7.17	6.82	10.01
Post-burn grazing + deferment								
Maximum height	8.87	7.09	10.24	8.67	11.03	8.18	11.62	7.13
Mean height	7.45	7.01	8.75	8.43	9.18	8.59	9.89	6.93

Sufficient cover associated with some openings appears to be a more optimum situation for successful nesting and brooding activities. In ungrazed areas, all dates of prescribed burning improved the quality of nesting and brood habitat. Likewise, nesting and brood habitat were enhanced in burned, grazed areas which were deferred throughout or during the latter half of the post-burn growing season.

Prescribed fall-, winter-, or spring-burned areas generally will not have sufficient regrowth by the next nesting season to provide adequate nesting cover. However, by the second season improved nesting habitat will be evident. Either fall-, winter-, or spring-burned areas may be utilized during the first post-burn growing season for vital activities, such as booming, feeding, loafing, and roosting. Vegetation on the burned areas progressively develops through its various phenological stages to provide adequate habitat for these activities. Jones (1963) reported that phenology of vegetation appeared to be a major factor governing use of different segments of habitat in any given period. Fall and early winter burns insure a short plant life-form for booming and subsequent brood range. Later winter and early spring burns would provide diversity of plant life-forms and habitat for vital activities of nesting, feeding, loafing, escape, and roosting in subsequent seasons and years.

It appears that desirable prairie chicken habitat also might be maintained through grazing alone, provided that frequency and intensity of grazing are closely controlled. With grazing alone, excessive residue accumulations can be prevented and important habitat characteristics can be controlled. Baker (1953) and Evans (1968) also recognized certain beneficial effects of light to moderate grazing on prairie chicken habitat.

SUMMARY AND CONCLUSIONS

Prescribed burning and systematic grazing management both offer strong possibilities for prairie chicken habitat manipulation in the Coastal Prairie. Prescribed burning appears to be a useful management tool for maintaining high quality prairie chicken habitat where grazing is greatly restricted or totally excluded. Grazing alone appears to be a suitable alternative to manipulating Coastal Prairie ranges

for the benefit of Attwater's prairie chicken and may be done in conjunction with efficient range livestock production.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Aldous, A. E. 1934. Effects of burning on Kansas bluestem pastures. Kansas Agric. Exp. Sta. Tech. Bull. 38. 65 p.

Anderson, R. K. 1969. Prairie chicken responses to changing booming ground cover type and height. J. Wildl. Manag. 33:636–643.

Baker, M. F. 1953. Prairie chickens of Kansas. Univ. of Kansas Museum Nat. Hist. and State Biol. Survey of Kansas Misc. Pub. 5. 68 p.

Berlandier, J. P. 1829. Jean Paul Berlandier in Texas. Diary of an expedition to Texas. Translated and edited by Jack Inglis, Texas A&M Univ., 1965. 353 p.

Bray, W. L. 1901. The ecological relations of the vegetation of western Texas. Bot. Gaz. 32:99–123, 195–217, 262–291.

Brown, D. L. 1968. Prairie chicken range appraisal. Texas Parks and Wildlife Dep. Job Progress Rep. Project No. W-92-R-4, Oak-Prairie Game Management Survey, June 1, 1966–May 31, 1967. 12 p.

Cook, O. F. 1908. Changes of vegetation on the South Texas prairies. United States Dep. Agric., Bur. Plant Ind. Circ. No. 14. 7 p.

Ehrenreich, J. H., and J. M. Aikman. 1963. An ecological study of the effect of certain management practices on native prairie in Iowa. Ecol. Monogr. 33:113-130.

Evans, K. E. 1968. Characteristics and habitat requirements of the greater prairie chicken and sharp-tailed grouse—a review of the literature. Cons. Res. Rep. No. 12, United States Dep. Agric., Forest Service. 32 p.

Hamerstrom, F. N., Jr., O. E. Mattson, and F. Hamerstrom. 1957. A guide to prairie chicken management. Pittman Robertson Proj. 79-R. Tech. Wildl. Bull. No. 15. Game Manage. Div., Wisconsin Conserv. Dep., Madison, Wisconsin. 128 p.

Ilkin, A. 1841. Texas: its history, topography, agriculture, commerce, and general statistics. Rep. Texian Press, Austin. 100 p.

Jones, R. E. 1960. The life-form concept applied to prairie chicken habitat in Oklahoma. Proc. 1959. Oklahoma Acad. Sci. 40:134–136.

Jones, R. E. 1963. Identification and analysis of lesser and greater prairie chicken habitat. J. Wildl. Manage. 27:757–778.

Kelting, R. W. 1957. Winter burning in central Oklahoma grassland. Ecology 38:520–522.

Kobriger, G. D. 1965. Status, movements, habitats, and foods of prairie grouse on a sandhills refuge. J. Wildl. Manag. 29:788–800.

Lehmann, V. W. 1941. Attwater's prairie chicken, its life history and management. United States Dep. Interior, Fish and Wildl. Serv. North American Fauna 57. 65 p.

Lehmann, V. W. 1965. Fire in the range of Attwater's prairie chicken. Proc. Tall Timbers Fire Ecol. Conf. no. 4, p. 163–175.

Schwartz, C. W. 1945. The ecology of the prairie chicken in Missouri. Univ. Missouri Studies 20. 99 p.

Smith, J. G. 1895. Grazing problems in the Southwest and how to meet them. United States Dep. Agric. Div. Agros. Bull. 16. 46 p.

Stoddard, H. L., Sr. 1963. Maintenance and increase of the eastern wild turkey on private lands of the Coastal Plain of the deep southeast. Bull. Tall Timbers Res. Sta., Tallahassee, Fla. no. 3, 49 p.