Response of Birds, Small Mammals, and Vegetation to Burning Sacaton Grasslands in Southeastern Arizona

CARL E. BOCK AND JANE H. BOCK

Highlight: We studied the impact of fire on an ungrazed sacaton grassland community at The Research Ranch in southeastern Arizona. Two summer burns were followed through two post-fire growing seasons. A winter burn was studied through one post-fire growing season. Burning reduced the height and extent of sacaton grass (*Sporobolus wrightii*) itself, and stimulated growth of other grasses and forbs. Summer fires created more bare ground and encouraged a greater number and variety of annuals than the winter fire. The fires had the effect of reducing total small-mammal populations and greatly increasing bird populations. These results were more dramatic on the areas which burned in early summer than on the winter-burned plot. Raptors and most game birds, particularly mourning doves, were most abundant on one-year-old burns. Seed-eating birds (Fringillidae) preferred burned over unburned areas. Cotton rat (*Sigmodon hispidus*) populations were greatly reduced by the fires, while populations of seed-eating pocket mice (*Perognathus*) and kangaroo rats (*Dipodomys*) increased, especially on the summer burns. Sacaton grasslands recover rapidly even from summer burning, at least in the absence of livestock. Results of this study suggest that fire is beneficial to the indigenous plants and wildlife of sacaton communities, as long as a mosaic of different aged stands is maintained.

In 1929, H. S. Swarth conducted a faunal analysis of southern Arizona. He wrote (1929): "East of the Santa Rita Mountains . . . there are illimitable stretches of rolling hills or gently sloping plains covered with grass and almost nothing else. In some low-lying swales the shorter prairie ('grama') grass is replaced by growth of 'sacaton,' a coarse bunch grass eight to ten feet high." Sacaton grasslands (*Sporobolus wrightii*) reach their greatest development in southeastern Arizona (Kearney and Peebles 1960), although the combined effects of overgrazing, drought, trampling, and erosion have drastically reduced this component of the desert grassland in historic time (Humphrey 1958).

Sacaton is a coarse grass which is readily eaten by livestock only as new spring growth. As a result many ranchers burn sacaton stands to remove old vegetation. Most controlled burning is done in winter or early spring, when temperatures are low and growth has not yet begun, and when as a result little grass will be killed (Humphrey 1970; W. H. Brophy, pers. comm.). On the other hand, most "natural" fires in desert grasslands are likely to occur in May and June—the hottest and driest times of the year, when lightning storms begin in anticipation of the summer rainy season.

In mid-May and mid-June, 1975, two wildfires of approximately 150 and 350 ha occurred on The Research Ranch, a 3,200-ha preserve in Santa Cruz Co., southeastern Arizona. These fires burned through extensive stands of sacaton grass which had been ungrazed since 1969 (Fig. 1). In February,

Fig. 1. *Unburned sacaton grassland on The Research Ranch, southeastern Arizona. The area has been ungrazed since 1969. Photograph taken September, 1977, by T. Elias.*

1976, a third fire of about 100 ha combusted some additional sacaton, including one of our "control" study areas established in August, 1975, for an investigation of the first two burns. The purpose of this study was to determine the effects of these fires on the vegetation, birds, and small mammals of sacaton grassland. The Research Ranch provided a unique opportunity to compare vegetation and wildlife populations in burned and adjacent unburned sacaton communities without the usual complications of cattle grazing and trampling, or other unnatural manipulations.

Methods

Study Areas

Permanent study sites were established on the two summer burns and on adjacent unburned (control) areas in August, 1975. Bird

transects, rodent traplines, and vegetation sampling were carried out on these study areas. In February, 1976, one of the control sites became the winter burn study area, following a third fire. As a result of the timing of the three burns, we have data through two post-fire growing seasons for the summer (1975) burns, but for only one post-fire growing season on the winter (1976) burn.

Data Collection

In January, 1976, a weather station provided by the U.S. Forest Service was established at ranch headquarters. Data collected from a rain gauge and recording hygrothermograph permitted analysis of an annual climatic cycle. Vegetation composition was determined by running line transects (Kershaw 1964) along established routes on burned and unburned study sites. The sampling interval was 0.5 m; sample sizes are indicated in Table 1. All vegetation intercepted by a

Table 1. Cover, expressed as percent of points sampled.

Category	Control (n=900)	Summer burns		Winter burn (n=600)
		1st year (n=600)	2nd year (n=600)	
Forbs	45	72	72	59
Sacaton	74	35	70	50
Other grasses	19	14	29	57
Dead vegetation	1	6	0	0
Bare ground	1	13	7	1

vertical line at each point sampled was identified and recorded. The categories "dead vegetation" (both standing and on the soil surface) and "bare ground" were recorded only when no living plants were present. Vegetation was sampled in late August and September of 1975 and 1976, following the peaks of summer growth (Cable 1975). Mean maximum height of vegetation was compared by measuring the height of the tallest plant at the first 200 points sampled in each habitat. Monthly live-trapping censuses were made from September, 1975, through January, 1976, and from July through December, 1976. Each trapline was 300 m long, with 20 stations set at 15-m intervals, two traps per station. Traplines were run for three consecutive nights (= 120 trap-nights per census). Large folding Sherman live-traps were used, baited with peanut butter. Walking bird censuses of about 1 hour duration were conducted along prescribed 500-m routes on each study site. No attempt was made to determine actual densities of bird populations, but results indicate relative abundances. Censuses were made three or four times per month from September, 1975, through January, 1976, and from July to December, 1976. Control (unburned) plot census results were combined for 1975 and 1976 since control area bird populations were comparable in the 2 years.

Statistical Analysis

The hypothesis being tested was that fire has a significant effect on vegetation composition and wildlife utilization of sacaton grassland. Chi-square tests for goodness of fit were used to test the null hypothesis that vegetation would be the same on all study sites, given equal numbers of points sampled. Expected frequencies were calculated by dividing the total combined numbers of plants recorded on unburned, first-year summer burned, second-year summer burned, and winter burned transects in proportion to the sampling effort made in each of the four habitats. If such four-cell goodness of fit tests showed that a species or category of species (e.g., forbs) was not randomly distributed through the various habitats, then a series of two-cell tests was run to determine which habitats differed significantly from one another. This is a weak statistical procedure, since probabilities become high that spuriously significant scores will result (Roscoe 1969). For this reason two and four-cell tests were considered significant only when probability levels were $\leq$ .005. T-tests were used to compare single pairs of means, as in the case of the 1975 mammal trapping results. Analysis of variance and Scheffé tests (Roscoe 1969) were used when it was desirable to make multiple comparisons of pairs of means. This was the case in analyzing maximum plant heights, the 1976 mammal trapping results, and all of
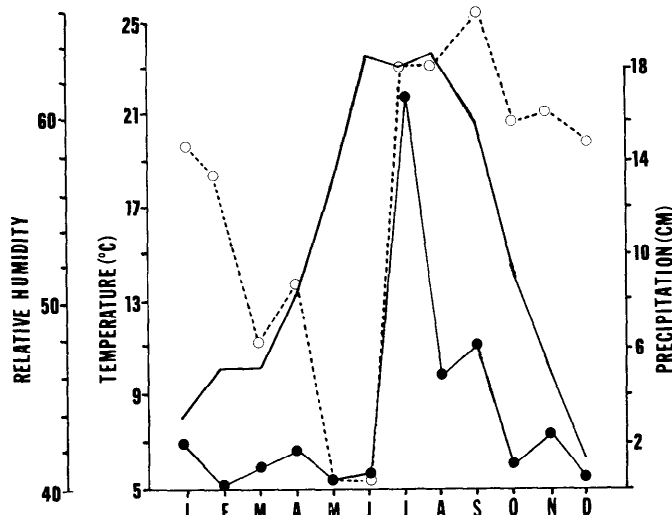

Fig. 2. *Weather data for The Research Ranch in 1976. Temperatures and relative humidities are the means of daily maximum and minimum values. Solid line = temp.; open circle and dotted line = relative humidity; closed circles and solid line = precipitation.*

the bird census data. The Scheffé test is a conservative but "mathematically defensible" (Roscoe 1969) approach to the problem of multiple comparisons in the analysis of variance.

Results

Climatic Data

Figure 2 shows the annual cycles of relative humidity, temperature, and precipitation at The Research Ranch in 1976. While we have no data for 1975, it is safe to say that the same general pattern occurred. Figure 2 is important because it shows that the winter burn (February, 1976) took place when temperatures were low and relative humidity high. By contrast, the May and June, 1975, burns occurred during the hottest and driest months of the year. While we have no data on the actual intensities of the three fires, it seems likely that the summer burns would have been much more severe than the winter burn as a result of these differences in temperature and moisture regime. Also, the winter burn would have recovered somewhat even in its first year as a result of winter precipitation prior to its major period of re-growth during the summer rains.

Vegetation

Forbs were significantly more common, collectively, on both summer and winter burned plots than in unburned habitats (Table 1). This difference persisted through two post-fire growing seasons on the summer burns. Occurrence of forbs on the summer burned plots was greater than on the winter burned area, but two-cell Chi-square tests did not quite meet the critical value used in all of the vegetation comparisons (see Methods). In this case Chi-square = 7.74; 0.01 > p > 0.005. Forbs more common on the burns included, especially, species of *Amaranthus, Ipomaea, Bidens, Convolvulus, Solidago, Portulaca, Chenopodium,* and *Ambrosia.*

Sacaton cover was significantly reduced through one post-fire growing season as a result of both summer and winter burns, but recovery was virtually complete on the summer burned plots (in terms of percent occurrence) after two growing seasons. The summer fires reduced sacaton cover to a significantly greater degree than did the winter burn. Other grasses (mostly *Panicum obtusum*) were significantly more abundant on the winter burned plot than in any other habitat, although the

summer fires also resulted in a significant increase in grasses other than sacaton after two growing seasons (Table 1). Finally, dead vegetation and bare ground were significantly more common on the first-year summer burned plots than in any other habitat. Bare ground was significantly reduced after a second growing season on the summer burned plots, but still was significantly greater than on winter burn or control areas.

All mean maximum heights of sacaton were significantly different from one another ($p < 0.01$), except for the winter burn versus second-year summer burned plots (Table 2).

Table 2. **Mean maximum height of vegetation. Data are for the tallest plant at the first 200 points sampled in each habitat.**

Category	Mean (cm)	Standard deviation
Control	171.9	41.5
Summer burn		
First year	39.3	28.5
Second year	93.2	45.6
Winter burn	88.6	41.9

Small Mammals

Peromyscus sp. (including *maniculatus* and *leucopus*) were the only common rodents on the control area (Table 3). Burned plots supported much smaller populations of *S. hispidus,* but more heteromyid rodents (*Perognathus* and *Dipodomys*). Numbers of *Peromyscus* were unaffected by the fires.

Table 3. **Number of small mammals captured, expressed as the mean number trapped per monthly census (= 120 trap-nights).**

	1975		1976		
Species	Control (n=9)	Summer burn (n=10)	Control (n=6)	Summer burn (n=10)	Winter burn (n=6)
Perognathus hispidus	0.4	4.9	0.3	3.4	3.3
Dipodomys merriami	0	4.0	0.2	3.4	0
Reithrodontomys megalotis	0	0.2	0	0	0
Peromyscus sp.[1]	23.9	23.9	9.7	4.4	10.8
Onychomys torridus	0.1	1.7	0	0.7	0
Neotoma albigula	0.7	0	2.0	0.2	0.2
Sigmodon hispidus	59.6	6.7	29.8	1.9	8.7
Total mammals	84.7	41.4	42.0	14.0	23.0

[1] Includes *P. maniculatus* and *P. leucopus,* not distinguished during live-trapping.

Meaningful comparisons of small-mammal populations between the first and second year after burning were not possible because captures on the control areas declined significantly over this period (Table 3). The following statistically significant within-year differences were found (see Table 3): (1) in 1975, the first-year summer burned areas supported significantly fewer total rodents ($p<0.001$), fewer *Sigmodon* ($p<0.001$), and more combined heteromyid rodents (*Dipodomys* and *Perognathus,* $p<0.05$) than control areas; (2) in 1976, the second-year summer burned plots supported fewer total rodents ($p<0.05$), fewer *Sigmodon* ($p<0.05$), fewer *Neotoma* ($p<0.05$), and more combined heteromyid rodents ($p<0.05$) than the remaining control area; (3) in 1976, the first-year winter burn supported fewer *Sigmodon* ($p<0.05$) and fewer *Neotoma* ($p<0.05$) than the control area.

Bird Populations

Because many of the winter birds lived in flocks, there were large variations in results from one bird census to the next. These variations minimized the number of statistically significant differences between means, and may have obscured some biologically-real distinctions between habitats. However, the following significant differences ($p < 0.05$) were found (Table 4):

1. The control plot supported fewer total birds than either the first-year or second-year summer burned plots; the first-year summer burned plot averaged significantly more total birds per census than the winter burn area.

2. Raptors (Falconiformes) were significantly more abundant, collectively, on the first-year summer burn than in any other area.

3. Fringillidae (seed-eating songbirds) were more abundant on the first- and second-year summer burns than on the control areas. The winter burn appeared to be intermediate in this regard, and it was not significantly different from either the control or summer burned plots.

4. Total doves and quail were significantly more common on the first-year summer burn than in any other habitat, and this also was true individually for the commonest species, the mourning dove. White-winged doves were more abundant on the first-year summer burn than on either the control or second-year summer burned plots.

Discussion and Conclusions

Results of this study show that wildfires can drastically alter the composition of sacaton plant communities, at least through one post-fire growing season. The effects of fire were to decrease the height and extent of sacaton grass itself, and to stimulate the growth of other grasses and forbs. The hot summer fires had a greater effect than the winter burn, especially in creating bare ground and increasing the number and variety of annual forbs. After two post-fire growing seasons the sacaton grass largely had recovered on the summer burned plots, but abundance of forbs remained high. These results appear to be typical of the effects of fire in many different grassland communities (see review by Vogl 1974).

The fires we studied had the effect of reducing total rodent populations and increasing combined bird populations in sacaton grassland (Tables 3 and 4). Again, these effects were much more striking on the areas which burned in May and June than on the winter burned plot. Two-year-old summer burned plots continued to differ more from the control area than did the winter burn after only one post-fire growing season. We found in an earlier study at The Research Ranch (Bock et al. 1976) that fire in upland (*Bouteloua*) grassland sites also increased birds in relation to small mammals. Bendell's (1974) review indicates this to be true of fires generally.

Cotton rat (*Sigmodon hispidus*) populations were greatly reduced by sacaton fires, while pocket mice (*Perognathus*) and kangaroo rats (*Dipodomys*) increased, especially on the summer burns. This change in mammal community composition may be attributed to the food habits of these animals. Cotton rats feed largely on green vegetation, whereas the other species are chiefly seed predators (Baker 1971). The increase in weedy forbs on the burns would favor the pocket mice and kangaroo rats. Increase in variety and abundance of seeds probably also accounted for the large populations of seed-eating birds (Fringillidae, Table 4) which occupied the burned areas.

The first-year summer burned plots supported far more raptors and gamebirds than any other sacaton stands we censused (Table 4). The birds of prey undoubtedly preferred to hunt over these relatively open areas because of the ease of prey

Table 4. Mean numbers of birds counted per census.

Species	Summer burns Control (n=51)	1st year (n=32)	2nd year (n=35)	Winter burn (n=19)	Species	Summer burns Control (n=51)	1st year (n=32)	2nd year (n=35)	Winter burn (n=19)
Turkey vulture (Cathartes aura)	0.08	0.22			Loggerhead shrike (Lanius ludovicianus)	0.24	0.03	0.17	
Cooper's hawk (Accipiter cooperii)			0.03		Yellowthroat (Geothlypis trichas)	1.86			
Red-tailed hawk (Buteo jamaicensis)	0.14	0.16	0.03	0.05	Eastern meadowlark (Sturnella magna)	0.67	2.72	1.63	0.26
Swainson's hawk (B. swainsoni)		0.09			Blue grosbeak (Passerina caerulea)	0.82	0.03	0.06	0.47
Harrier (Circus cyaneus)	0.12	0.69	0.23	0.11	House finch (Carpodacus mexicanus)	0.10	1.53	0.09	1.37
Kestrel (Falco sparverius)	0.04	0.25	0.11	0.05	Pine siskin (Spinus pinus)				0.84
Falconiformes subtotal	0.39	1.41	0.40	0.21	American goldfinch (S. tristis)				1.21
Scaled quail (Callipepla squamata)	0.78	1.53	0.11		Green-tailed towhee (Pipilo chlorurus)	0.10		0.06	0.05
Harlequin quail (Cyrtonyx montezumae)	2.29	1.25	2.40	0.79	Brown towhee (P. fuscus)	0.45	0.16	0.20	0.26
White-winged dove (Zenaida asiatica)	0.14	1.38	0.20	0.37	Lark bunting (Calamospiza melanocorys)		0.44		
Mourning dove (Zenaidura macroura)	1.55	37.06	11.40	2.74	Savannah sparrow (Passerculus sandwichensis)	0.47	2.72	4.20	2.26
Gamebird subtotal	4.75	41.20	14.11	3.90	Vesper sparrow (Pooecetes gramineus)	2.63	14.78	14.91	7.11
Poor-will (Phalaenoptilus nuttallii)	0.02				Lark sparrow (Chondestes grammacus)	0.22	0.28	0.40	0.26
Common nighthawk (Chordeiles minor)			0.09		Rufous-crowned sparrow (Aimophila ruficeps)	0.06		0.14	0.11
Black-chinned hummingbird (Archilocus alexandri)			0.11	0.11	Botteri's sparrow (A. botterii)	1.31	0.03	1.11	1.05
Western kingbird (Tyrannus verticalis)		0.19			Cassin's sparrow (A. cassinii)	0.14	2.09	2.51	0.68
Cassin's kingbird (T. vociferans)	0.45	0.94	0.83	0.37	Chipping sparrow (Spizella passerina)	0.39	0.25	0.11	1.89
Ash-throated flycatcher (Myiarchus cinerascens)	0.08				Brewer's sparrow (S. breweri)		0.88	0.49	
Black phoebe (Sayornis nigricans)	0.04				White-crowned sparrow (Zonotrichia leucophrys)	0.92	1.44	0.60	0.63
Say's phoebe (S. saya)	0.12	0.28			White-throated sparrow (Z. albicollis)				0.11
Horned lark (Eremophila alpestris)		0.09	7.74		Unknown sparrow[1]	1.71	4.41	4.83	3.37
Barn swallow (Hirundo rustica)	0.16	0.25	0.17	0.05	Fringillidae subtotal	9.35	29.03	29.71	21.67
					Total birds	18.14	76.50	54.96	26.57

[1] Most probably Vesper and Savannah sparrows.

detection. Many workers have shown the importance of various weed seeds in the diet of mourning doves (e.g., Dillon 1961; Griffing and Davis 1974). Also, Leopold (1972) has noted that "doves have such small weak legs and feet that they cannot scramble through thick weeds or grass but must move about on essentially bare ground." Clearly a hot summer fire which opens the sacaton community and stimulates growth of forbs will be highly beneficial to dove populations; our results show this to be the case to a striking degree.

Humphrey (1970) recommended that sacaton grass be burned in late winter or early spring to provide maximum young growth for cattle forage, and to minimize permanent fire damage. The results of our work suggest that summer burning (before the onset of the summer rains) may be beneficial to certain bird and mammal populations. A hot early-summer fire does kill some sacaton, but this opens the habitat and stimulates the growth of weedy plants essential as food to many species of birds and mammals. At the same time, mature stands of sacaton provide essential cover for other species, such as the Botteri's sparrow (Table 4). In our opinion, ideal sacaton management would create a mosaic of stands in various stages of post-fire suc-

cession. This undoubtedly would be the state of sacaton grassland under "natural" conditions.

Vogl (1974) has noted the differing opinions concerning the effects of fire on grassland ecosystems. These opinions range from complete condemnation to unqualified praise. Hastings and Turner (1965) and Humphrey (1974) also have discussed the controversy surrounding the role of fire in the maintenance of southwestern grasslands. Vogl (op. cit.) pointed out that the combined effects of fire and grazing can be entirely different from the results of fire alone, and that few studies have been conducted in ungrazed habitats because such areas are difficult or impossible to find. We have conducted a study of the effects of fire on a *large ungrazed* (since 1969) sacaton grassland community at The Research Ranch. It appears that hot early-summer burns are beneficial to plants and wildlife, as long as a mosaic of different aged stands is maintained. It seems intuitively obvious that heavy grazing and trampling following a severe burn could result in something very different—permanent loss of plant cover, erosion, and ultimate destruction of the sacaton community. This may explain why sacaton grasslands are disappearing from the Southwest.

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