Seasonal burning and mowing impacts on *Sporobolus wrightii* grasslands

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Abstract

Land managers have recommended burning or mowing big sacaton *(Sporobolus wrightii)* grassland in either fall or winter for 100 years. The greatest potential for natural fire would have occurred when lightning strike frequency peaked in summer. The objective of this study was to determine how burning and mowing in fall (October), summer (July) and winter (February) influences big sacaton forage quantity and quality. Plants defoliated in fall produced leaves within 215 to 245 days, those defoliated in summer within 3 days, and those in winter within 20 days. Green and dead forage that accumulated after the burning and mowing in the same seasons were similar, but differences occurred among seasons. Green and dead forage following summer treatments were similar to that on untreated areas within 2 or 3 summer growing seasons, but were reduced on fall and winter treatments. Crude protein in green forage was 3 to 5% greater in treated plants than in untreated plants for 6 weeks after treatment, but forage quality increases were temporary. Burning or mowing at any season removes green forage available to livestock and reduces the amount of green forage that may accumulate for at least 2 summer growing seasons.

Key Words: big sacaton, riparian grasslands, southeastern Arizona

Native perennial grasses growing on upland semidesert grasslands of the southwestern United States and northern Mexico are dormant in fall, winter, and spring (Humphrey 1960). In contrast, big sacaton *(Sporobolus wrightii)*, a robust perennial bunchgrass that grows in lowland areas where flood waters accumulate, produces small quantities of green forage when other grasses are dormant (Cox 1984).

In the past, lactating cows were forced to graze big sacaton grasslands when upland grasses were dormant, because few other green forage sources were available (Griffiths 1901). The small quantities of green forage were difficult for grazing animals to obtain since dead forage limited utilization (Haferkamp 1982). Land managers eliminated dead forage by either burning or mowing in fall or winter (Griffiths et al. 1915) and treatments applied in these seasons were and are currently thought to stimulate new growth and enhance forage quality (Humphrey 1958). Studies designed to evaluate treatment and season effects on big sacaton forage quantity and quality do not exist, although, both practices have been applied in the 2 seasons for 100 years.

Big sacaton grows rapidly from late July to mid-September when summer rainfall peaks and daytime temperatures range from 25 to 30° C (Cox 1984, 1985). Prior to the summer rainfall peak the majority of the big sacaton phytomass is dead, daytime temperatures exceed 35° C, and lightning frequency peaks (Osborn 1983, Cox and Morton 1986). Therefore, lightning-caused fires have been most common in early summer (Hastings and Turner 1965).

The objectives of this study were to (1) determine how burning or mowing big sacaton in either winter, summer, or fall affects forage quantity and quality, and (2) discuss the results in relation to various management strategies.

Methods and Materials

Site Description

In January 1980, an experiment was initiated in a big sacaton grassland about 80 km south of Tucson, (31°47′ N. Lat., 110°37′ W. Long.). Soil at the site is a Pima silty clay loam, with a sandy subsoil (thermic Typic Haplustolls) (Richardson et al. 1979). The soil, developed from recent alluvium that weathered from mixed rocks, is moderately alkaline, slightly calcareous and greater than 2 m deep. Elevation is about 1,370 m and average annual precipitation is 400 mm (Sellers and Hill 1974). Approximately 60% of the annual precipitation comes as rain between July and September, and 40% comes as either rain or snow from October to April. Day-time temperatures average 30° C in summer and night-time temperatures are often below 0° C in winter.

A 2-ha study site was fenced within a 500-ha big sacaton pasture. The pasture was lightly grazed by cattle and horses in either fall, winter, or spring between 1976 and 1980, and moderately grazed by

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cows and calves in winter between 1935 and 1975. From about 1885 to 1934, the pasture was unfenced and grazed yearlong.

Charcoal scars on cottonwood *(Populus deltoides)* and mesquite *(Prosopis juliflora)* trees within the pasture indicate the occurrence of fires. Relatives and associates of previous owners acknowledge the occurrence of lightning fires in the summers of 1920, 1935, and 1950 and either fall or winter control burns at 5 to 10-year intervals between 1935 and 1975.

Presampling

Ten, 0.3 by 2.9-m sampling areas were randomly located in 15 by 15-m plots, and all forage harvested at the soil surface. Forage in each sampling area was weighed, dried at 105° C for 48 h, and reweighed. Forage dry weight (fuel load) and fine fuel water content (expressed as a % of dry weight) were averaged by plot.

Defoliation Treatments

Plots were either burned with a headfire or mowed to a 5-cm stubble height in winter (February 6), summer (July 10), and fall (October 2) 1980, 1981, and 1982. The time from ignition to total forage consumption or shredding of all above-ground forage was recorded by plot. During each treatment wind speed and air temperature were recorded at 10-s intervals and averaged by plot.

Forage Sampling

Twenty, 0.3 by 2.9-m sampling areas were randomly selected for sampling at 6-week intervals for 3 years after treatment. Big sacaton plants in 4 sampling areas were harvested at the soil surface and separated into green and dead forage; no area was resampled during the experiment. Separated samples were weighed in the field and a modified weight-estimate technique used to estimate both green and dead forage in 16 sampling areas (Pechanec and Pickford 1937). Separated samples were dried in a forced-air oven at 40° C for 48 h and weighed. Regression techniques were used to estimate dry weights from estimated field weights (Campbell and Cassady 1949). These values were used to calculate green and dead forage.

Forage Quality

Green and dead forage samples were composited by plot into either a total green or total dead sample, and each ground to pass through a 1-mm screen. Samples were thoroughly mixed and 3 subsamples digested and analyzed for total nitrogen using a Technicon[1] digestor and a continuous flow auto-analyzer (Schuman et al. 1973). Total nitrogen was multiplied by 6.25 and expressed as crude protein.

Design and Statistical Analysis

Treatments were arranged in a split block design with 3 replications. The 3 years were randomized as blocks within a replication and the 7 treatments were randomized within years. Therefore, years are main plots and treatments are subplots.

At some sampling dates green and dead forage amounts from untreated plots were from 5 to 1,000 times greater than for treated plots. When these conditions existed, the population variances (treated versus untreated) were tested for homogeneity. If the 2 populations had a common variance, the data were pooled and subjected to analysis of variance; when population variances differed ($P \leq 0.05$), data from untreated plots were analyzed separately from treated plots. When year, treatment, or year by treatment interactions were significant ($P \leq 0.05$) means were separated by a Least Significant Difference test (Steel and Torrie 1960).

In big sacaton grasslands green forage accumulates and dead forage decomposes in late August (Cox 1984). Forage quantities are dependent upon summer rainfall and are highly variable among years (Cox 1985). Therefore, year by treatment comparisons are presented only for the 21 August sampling dates which occurred 1, 2, and 3 years following fall burning and mowing.

Results and Discussion

Above-ground big sacaton phytomass (green plus dead forage) was highly variable among years and seasons, and varied from 2,800 to approximately 5,000 kg/ha (Table 1). Green forage was less than 15% of the big sacaton phytomass in winter and summer. Fuel water content varied from 10 to 30%, and treatment times averaged 68 and 267 s, respectively, for burning and mowing. Green forage averaged 55% of the phytomass in fall, fuel water content averaged 48%, and treatment times averaged 163 and 438 s, respectively for burning and mowing.

Quantity and Quality of Green Forage

Big sacaton leaves began to appear within 20 days on plants defoliated in winter and within 3 days on plants defoliated in summer. Burning or mowing in either winter or summer appeared to stimulate green leaf production, and a lush carpet of green leaves was present from April to August on winter-defoliated plots and from July to August on summer-defoliated plots. Green forage availability on 21 August (24 weeks after winter defoliation and 6 weeks after summer defoliation) for the 3 treatment years (Fig. 1), however, was consistently greater ($P \leq 0.05$) on untreated plots, intermediate on winter-defoliated plots, and less on summer-defoliated plots.

Burning or mowing at any season removes big sacaton phytomass and exposes the crown, but fall defoliations leave the crown exposed in winter when night-time temperatures are frequently below 0° C (Cox 1984). Fall defoliations (1) remove the small quantities of green forage available to livestock in fall and winter and (2) reduce green forage availability in early spring (Fig. 1). The result is the complete loss of the grazing resource for 215 to 245 days after fall defoliation.

Observations made during this 6-year study suggest that big sacaton initiates leaf production in summer and winter. Summer growth occurs from May to August, and few leaves remain green during fall and winter. Most summer leaves become dormant in

[1]Mention of a commercial product is for the reader's convenience and does not imply endorsement by the USDA-Agricultural Research Service.

Table 1. Fuel characteristics, environmental conditions, and forage removal time when burning and mowing big sacaton during 3 seasons in 1980, 1981 and 1982 in southeastern Arizona.

Season		Fuel loam	Fuel water content	Removal time		Wind speed	Air temperature
				Burn	Mow		
		-kg/ha-	-%-	-s-		-km/hr-	-°C-
Winter	1980	3,945	10	60	300	10	18
	1981	2,975	30	80	250	10	10
	1982	4,055	10	50	275	10	10
Summer	1980	5,095	25	80	250	14	30
	1981	2,800	20	65	275	15	30
	1982	3,985	20	70	250	8	29
Fall	1980	3,475	45	180	500	10	20
	1981	4,700	55	145	450	10	25
	1982	3,750	45	165	365	8	19

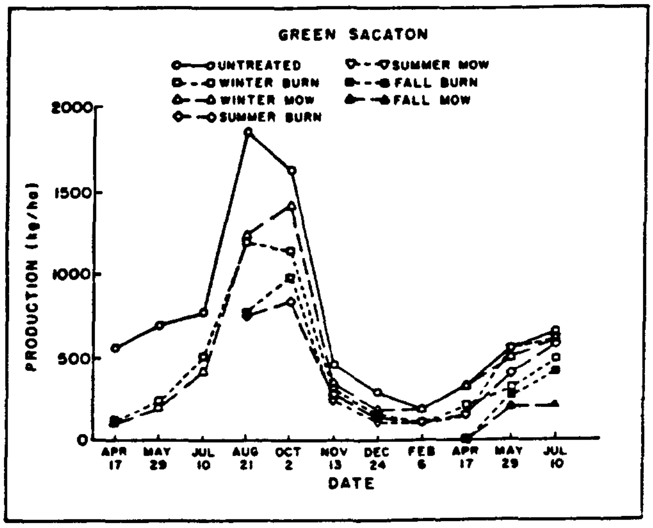

Fig. 1. *Green big sacaton forage following burning or mowing in either winter, summer, or fall during 1980, 1981, and 1982 at a riparian site in southeastern Arizona.*

September and October when the sheaths elongate and roll into a cylinder. During winter a new leaf develops within the rolled sheath, and in early spring (March to April) leaves expand and the dead sheath shatters. Fall defoliations remove summer leaves which provide green forage during fall and winter, inhibit winter leaf formation and development, and green big sacaton forage production remains at zero for 7 to 8 months.

In the first and second summer growing season after treatment, big sacaton green forage accumulated more rapidly on summer than on winter- or fall-defoliated plots (Table 2), but differences

Table 2. Big sacaton green forage at the peak of the summer growing season (21 August) one, two, and three years after treatment.

Number of growing[1] seasons after treatment	Season and treatment	Treatment year 1980	1981	1982	LSD
		kg/ha			
1	Winter burning	735	615	400	2
	Winter mowing	765	560	650	
	Summer burning	865	770	700	205
	Summer mowing	915	790	760	
	Fall burning	725	665	260	
	Fall mowing	665	660	575	
	Untreated	1,900	2,600	1,695	535
2	Winter burning	850	745	690	
	Winter mowing	840	780	550	
	Summer burning	925	935	850	
	Summer mowing	995	965	830	240
	Fall burning	805	755	575	
	Fall mowing	895	655	715	
	Untreated	1,365	1,720	1,705	150
3	Winter burning	615	595	695	
	Winter mowing	735	655	620	
	Summer burning	1,590	1,450	1,375	
	Summer mowing	1,440	2,000	1,530	525
	Fall burning	745	890	790	
	Fall mowing	840	990	630	
	Untreated	1,650	1,845	2,000	

[1]Data were collected in August, one, two and three growing seasons following October (Fall) treatments.
[2]When a bracket includes only the treatments, the variances between treated and untreated means were not homogeneous. Therefore, a separate ANOVA was used for each set. Means in each set that differ more than the given Least Significant Difference value are significantly different at $P \leq 0.05$.

among seasons and treatments occurred infrequently. By the third summer growing season, green forage on summer-defoliated plots was usually greater than on winter and fall-defoliated plots, and generally equivalent to untreated plots. The accelerated growth on summer-defoliated plots supports the hypothesis that summer defoliations, whether by burning or mowing, have the least negative impact on future plant production. Recommended winter and especially fall defoliations (Griffiths 1901, Humphrey 1958), have a detrimental effect on plant production for at least 3 summer growing seasons.

Burning and mowing at any season removes green big sacaton forage available to livestock and reduces the amount of green forage for at least the next 2 years (Table 2). These results are from measurements taken in summers when rainfall was either above, below, or equal to the long-term average (Sellers and Hill 1974, Cox 1984, Cox and Morton 1986). These data do not agree with the prevailing belief that green big sacaton forage production is stimulated by removing dead forage (Humphrey 1958).

Big sacaton green forage quality temporarily improves after burning or mowing in each of the 3 seasons (Fig. 2). Crude protein

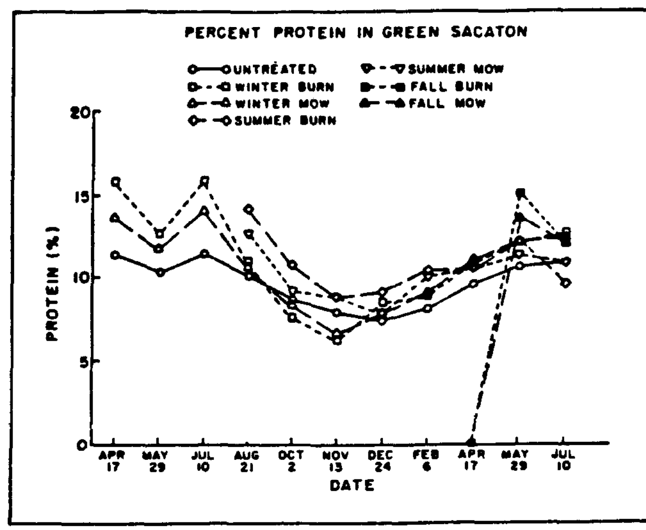

Fig. 2. *Crude protein content of green big sacaton forage following burning or mowing in either winter, summer or fall during 1980, 1981 and 1982 at a riparian site in southeastern Arizona.*

content of green forage was greatest on burned, intermediate on mowed, and least on untreated plots when measured 6 weeks after winter, summer, and fall defoliations. Differences among treatments did not occur after 6 weeks. Green forage availability and quality improves after either burning (Bock and Bock 1978) or mowing (Haferkamp 1982), and daily gains of steers grazing green forage only can be expected to exceed those of steers grazing green plus dead forage (Cox and Morton 1986).

Quantity and Quality of Dead Forage

Green forage that accumulates in summer following winter or summer defoliation becomes dead forage in fall. Dead forage quantities declined gradually during the second spring and early summer (Fig. 3). The remaining dead forage disappears following the summer rains and active plant growth in late July and August (Table 3). On fall-defoliated plots the transfer of green to dead forage occurs aftr the first summer growing season measurement, thus, no dead forage was recorded on 21 August.

In the second and third summer growing season, big sacaton dead seed stalks accumulated more rapidly on summer-defoliated plots than on winter and fall-defoliated plots. Therefore, dead forage quantities on summer-defoliated plots exceeded those on winter and fall-defoliated plots (Table 3), but differences were not always significant. Dead forage is not an ideal forage resource

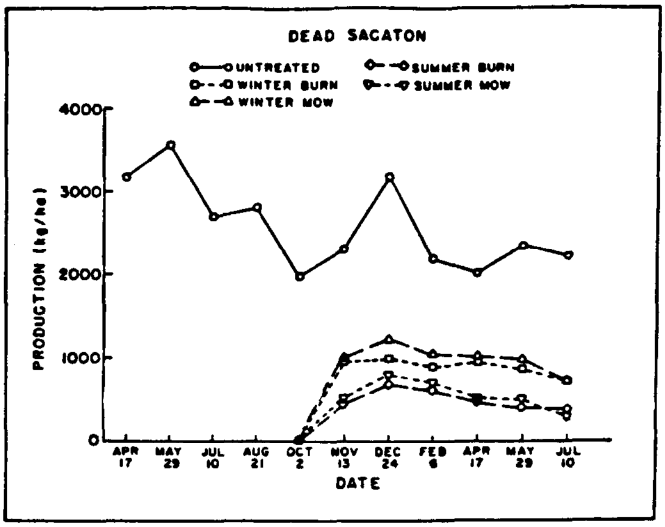

Fig. 3. *Dead big sacaton forage following burning or mowing in either winter, summer, or fall during 1980, 1981, and 1982 at a riparian site in southeastern Arizona. Dead forage accumulations on fall treatments occurred after the second 10 July sampling date.*

Table 3. Big sacaton dead forage at the peak of the summer growing season (21 Ausust), one, two, and three years after treatment.

Number of growing[1] seasons after treatment	Season and treatment	Treatment year 1980	1981	1982	LSD
		kg/ha			[2]
1	Winter burning	0	0	0	
	Winter mowing	0	0	0	
	Summer burning	0	0	0	
	Summer mowing	0	0	0	
	Fall burning	0	0	0	
	Fall mowing	0	0	0	
	Untreated	3,080	1,000	2,300	780
2	Winter burning	1,220	320	145	
	Winter mowing	1,365	335	220	
	Summer burning	1,935	1,180	1,020	
	Summer mowing	1,465	1,575	1,395	685
	Fall burning	650	445	100	
	Fall mowing	685	400	185	
	Untreated	2,710	1,975	1,635	
3	Winter burning	1,650	1,145	1,430	
	Winter mowing	1,640	1,345	1,037	
	Summer burning	2,035	1,665	1,840	
	Summer mowing	2,035	1,850	1,920	735
	Fall burning	570	690	850	
	Fall mowing	640	945	705	
	Untreated	1,980	1,290	1,970	

[1]Data were collected in August, one, two and three growing seasons following October (fall) treatments.
[2]When a bracket includes only the treatments, the variance between treated and untreated means were not homogeneous. Therefore, a separate ANOVA was used for each data set. Means in each set that differ more than the given Least Significant Difference Value are significantly different at $P \leq 0.05$.

because crude protein content annually varies from 3 to 6% (data not shown), but its removal influences pasture stocking rate. Cox and Morton (1986) and have shown that winter defoliations (burning or mowing) cause a three-fold decrease in summer stocking rates, while daily steer gains on defoliated pastures were only one-third greater than on an untreated pastures.

Management Implications

Before 1880, big sacaton existed in pure stands along the riparian channels and tributaries within the North American semidesert grassland (Griffiths 1901). These grasslands acted as a continuous dam which naturally spread floodwaters from nearby uplands and more distant mountainous areas (Renard et al. 1985), trapped sediments which leveled valley floors (Hubbell and Gardner 1950), and contributed to the formation of shallow water tables and perennial streams (Cooke and Reeves 1976).

Big sacaton currently occupies less than 5% of its original area of distribution (Humphrey 1960) because the processes which supplied additional soil moisture were disrupted by channel formation (Cooke and Reeves 1976). Under current conditions, winter and fall defoliations should be discontinued.

Big sacaton plants defoliated in summer may be expected to recover to pretreatment levels within 2 or 3 years. In summer, livestock prefer upland grasses to the regrowth of either burned or mowed big sacaton; even though green forage is abundant, available, and nutritious (Cox 1985, Haferkamp 1982). If fencing is using to separate big sacaton grasslands from upland grasslands, cattle will graze untreated big sacaton and gain from 0.50 to 0.75 kg/day in summer (USDA-ARS, unpublished data). Without fencing, cattle overgraze uplands and gain from 0.40 to 0.45 kg/day when forced to graze big sacaton (Cox and Morton 1986).

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