Fertilizing and Burning Flint Hills Bluestem

CLENTON E. OWENSBY AND ED F. SMITH

Abstract

Burned and unburned Kansas Flint Hills range was fertilized in early May with 0, 40, and 80 lb N/acre/year and grazed from May 1 to October 1. Fertilizing with 40 lb N/acre increased carrying capacity per pound of nitrogen applied more than 80 lb N/acre did. Maintenance of good quality range was favored by burning and 0 and 40 lb N/acre compared to not burning and the same fertilizer rates. Eighty lb N/acre produced poor quality range whether burned or not. Individual steer gains were highest on burned pastures with 0 and 40 lb N/acre compared to unburned pasture at those same rates or pastures with 80 lb N/acre whether burned or not. Increased carrying capacity on fertilized pastures compared to unfertilized gave higher gains/acre.

Nitrogen is apparently the most limiting factor in herbage production of Kansas Flint Hills range (Owensby et al. 1970). Range fertilized at 50 lb/acre of nitrogen has produced twice the herbage of unfertilized plots (Mader 1956; Moser and Anderson 1964). Changes in stand composition toward cool-season grasses and weedy forbs have been the major deterrent to nitrogen fertilization of Flint Hills grasslands.

Anderson et al. (1970) indicated that cool-season grasses and weedy forbs were reduced by late spring burning. Gay and Dwyer (1965) in a one-year study on ungrazed Oklahoma True Prairie found that fire and nitrogen in combination produced 0.8 ton/acre and 1.0 ton/acre more herbage at 50 and 100 lb N/acre, respectively, than burned, unfertilized True Prairie. No fertilizer response was obtained from unburned, fertilized areas.

We studied the effects of no burning and late spring burning with 0, 40, and 80 lb N/acre on herbage production, stand composition, basai cover, and steer gains on bluestem range.

Materials and Methods

Study Area

The study area was four 60-acre and two 44-acre pastures on the Kansas State University Experimental Range Unit (Donaldson Pastures) in the northern Kansas Flint Hills near Manhattan, Kans. Big bluestem (*Andropogon gerardi* Vitman), little bluestem (*Andropogon scoparius* Michx.), and Indiangrass [*Sorghastrum nutans* (L.) Nash] were the major dominants. Kentucky bluegrass (*Poa pratensis* L.) and sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.], along with numerous perennial grasses, forbs, and woody species, constituted the remainder of the plant community. Soils were transitional udic ustolls to udolls. Range sites varied from deep, well-drained sites to rocky to clayey areas. Principal range sites common to all pastures were loamy upland and breaks (Anderson and Fly 1955).

Treatments

Nitrogen was aerially applied as urea in 1972 and as ammonium nitrate in 1973, 1974, and 1975 during early May to burned ar unburned pastures stocked at various rates with yearling steers (Tab 1). Burning was the last week in April.

Table 1. Nitrogen and burning treatments and stocking rates on six Fli Hills bluestem pastures, 1972-1975.

	N-rate (lb/acre)	Stocking rates, steers (acres/animal unit) 1972	1973	1974	1975
Burned (late April)	0	5.0	5.0	5.0	5.0
	40	3.3	3.3	3.3	3.3
	80	2.2	2.2	2.8	2.8
Not burned	0	5.0	5.0	5.0	5.0
	40	3.3	3.3	3.3	3.3
	80	2.2	2.2	2.8	2.8

Plant Census

Basal cover and % composition were determined by the modifie step-point system (Owensby 1973). Three sets of 500 points we taken in each pasture along lines forming a grid of the entire pastur Analysis of variance was run on the change in basal cover ar composition from pretreatment levels by certain species and groups c species for loamy upland and breaks range sites.

Herbage Production

Herbage remaining at growing season's end was harvested fro fifteen 1/10,000th-acre plots randomly located on loamy upland an breaks range sites in each pasture. Herbage was separated int perennial grass and forb-brush components, dried, and reported a pounds of dry matter per acre. Because cages tend to distort tot herbage yield estimates (Owensby 1969), steer days per acre plus th herbage remaining after grazing were used to estimate total herbag production in each pasture.

Cattle

Steers, approximately 14 months old and individually identified grazed the pastures from May 2 to October 3, 154 days. All wer gathered the first of each month, penned overnight without feed c water, and weighed the next morning.

Statistical Analyses

Analyses of variance were run using subsamples to estimate th error variance since the experiment was not replicated. Though nc completely valid statistically, those analyses indicate probable dif ferences.

Results and Discussion

Herbage Yield

Perennial Grass Component

At the end of the growing season, more perennial gras remained after grazing on unburned than on burned pasture (Table 2). On unburned pastures more perennial grass remaine on the breaks than on loamy upland range sites, but on burne pastures amounts remaining were the same for both range sites

Authors are research range scientist, Department of Agronomy, and research animal scientist, Department of Animal Science and Industry, Kansas State University, Manhattan, 66506.

This report is Contribution No. 78-20-j, Department of Agronomy and Department of Animal Science and Industry, KAES, Kansas State University, Manhattan, 66506.
Manuscript received December 12, 1977.

Table 2. Perennial grass (lb D.M./acre) remaining on grazed loamy upland and breaks range sites at season's end (1972-74 avg.).

	N, lb/A		
	0	40	80
Not burned			
loamy upland	2067	1567	1509
breaks	2910	2499	2382
Burned			
loamy upland	1489	1836	1069
breaks	1477	1751	1121

LSD .05 = 482

On unburned pastures less perennial grass remained on fertilized pastures than on the unfertilized; on the burned pastures 0 and 80 lb/acre of nitrogen left comparable amounts, both less than where 40 lb/acre was applied.

Forb-brush Component

Forb-brush herbage remaining at growing season's end on grazed loamy upland and breaks range sites was the same regardless of N-rate on unburned pastures, but less remained on burned pastures at the 0 and 40 lb N-rates than on unburned pastures at the same N-rates (Table 3). Forb-brush amounts remaining on the 80-lb, N-rate, burned pasture were comparable to those of the unburned pastures. The 80-lb N-rate pasture did not burn well, which likely accounted for its similarity with unburned pastures in amount of forb-brush remaining.

Table 3. Forb-brush (lb D.M./acre) remaining at season's end on grazed loamy upland and breaks range sites (1972-74 avg.).

	N, lb/A		
	0	40	80
Not burned			
loamy upland	582	533	546
breaks	462	584	485
Burned			
loamy upland	289	268	555
breaks	155	343	634

LSD .05 = 225

Steer Days Plus Remaining Herbage

Higher stocking rates on fertilized pastures produced more steer days/acre (Table 4). After the first 2 years of the study, stocking rates on the 80-lb, N rate pastures were reduced because too little herbage remained at season's end to maintain vigor of the dominants. A combination of steer days/acre and herbage production indicated that the 80-lb N-rate was not desirable since the 40 lb N/acre gave results nearly as good. Burning and 40 lb/A of nitrogen appeared to be the best for increasing stocking rate and maintaining herbage production.

Plant Census

Plant census is reported as the change in percentage composition and basal cover of the major components of loamy upland

Table 4. Steer days/acre on burned and not burned pastures with indicated nitrogen rates (1972-1975).

N, lb/A	1972-73	1974-75
0	45.5	45.5
40	68.2	68.2
80	107.1	83.3

and breaks range site from pretreatment (1971) to posttreatment (1975).

Basal Cover

Big bluestem, Indiangrass, and Kentucky bluegrass exhibited greatest differences in basal cover changes among treatments (Fig. 1). Big bluestem and Indiangrass basal cover increased on burned pastures with 0 and 40 lb N/acre during the 4-year period, but decreased on the unburned pastures with the same fertilization rates. On pastures with 80 lb N/acre big bluestem and Indiangrass basal cover decreased whether burned or unburned. Apparently, burning favored those warm-season, sod-forming grasses. The 80 lb N-rate pastures were probably stocked too heavily, which likely reduced vigor of palatable, preferred species.

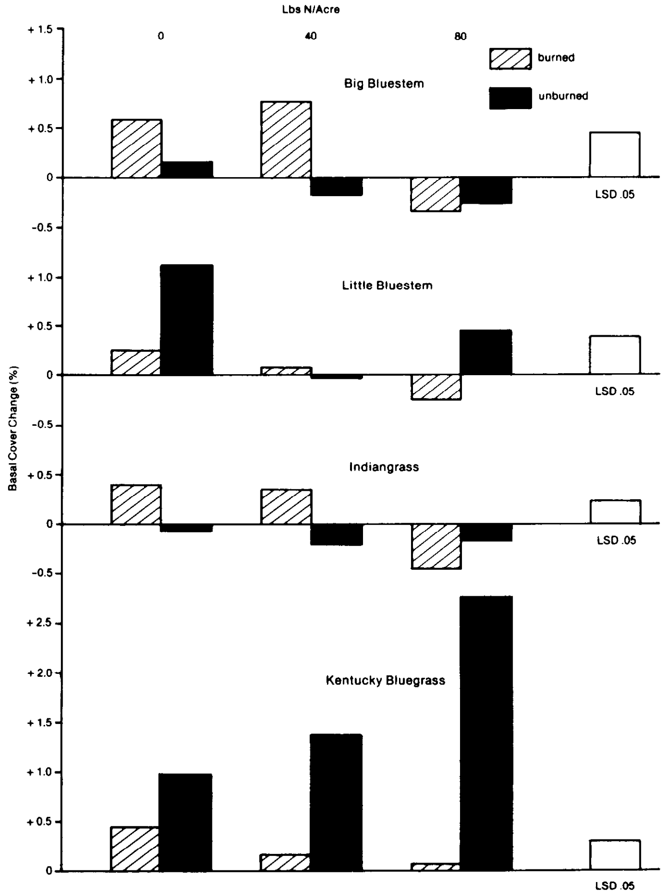

Fig. 1. *Changes in basal cover (%) of different grasses from pretreatment levels (1971) to post-treatment levels (1975) under indicated nitrogen and burning treatments (avg. of loamy upland and breaks range sites).*

Kentucky bluegrass basal cover increased as nitrogen rate increased on unburned pastures (Fig. 1). On burned pastures the basal cover changes were less and decreased as fertilizer rate increased. Greatest increases in Kentucky bluegrass basal cover came on loamy upland range sites (Table 5).

Basal cover of grass-like plants (mostly sedges) increased more as nitrogen rate increased (Table 5). Like Kentucky bluegrass, grass-like plants were mostly cool-season and began growth earlier than the warm-season perennial grass dominants and thus were favored by nitrogen application.

Composition Percentages

The major warm-season perennial grass dominants (big bluestem, Indiangrass, and little bluestem) decreased in relative amount of the total basal cover from 1971-1975 regardless of

Table 5. Changes in basal cover (%) Kentucky bluegrass and grass-like plants for indicated nitrogen treatments on loamy upland and breaks range sites (avg. of burned and unburned treatments). 1971 was pretreatment level.

	N, lb/A		
	0	40	80
Kentucky bluegrass			
loamy upland			
1971	0.16	0.22	0.11
1975	1.26	1.47	2.35
Change	+1.10	+1.25	+2.24
breaks			
1971	0.07	0.06	0.08
1975	0.37	0.33	0.64
Change	+0.30	+0.27	+0.56
LSD $_{.05}$=0.30*			
*Grass-like plants			
1971	0.22	0.18	0.22
1975	0.84	1.03	0.73
Change	+0.62	+0.85	+0.51
LSD $_{.05}$+0.20*			

*LSD applies only to the change in basal cover.

treatment (Fig. 2). Big bluestem and Indiangrass composition % were reduced more on unburned pastures than on burned for pastures with 0 and 40 lb N/acre. Pastures with 80 lb N/acre had more reduction in big bluestem basal cover and less reduction in Indiangrass basal cover on unburned than burned range. Overall burning was detrimental to composition % of little bluestem.

Kentucky bluegrass composition % increased on unburned pastures as nitrogen rate increased, but did not change on burned pastures. Loamy upland had greater increases in composition % of Kentucky bluegrass than did breaks range sites (Table 6).

Plant Census Summary

Basal cover of the desirable warm-season perennial grasses generally increased under burning and fertilizing with 0 and 40 lb N/acre more than under unburned treatments. At the 80 lb N-rate desirable warm-season species decreased in basal cover on both burned and unburned pastures, and remained relatively constant on unburned pastures at the 0 and 40 lb N-rate. Basal cover of less desirable grasses and forbs increased much more at all nitrogen rates on unburned pastures than burned. Apparently, without fire, fertilizing at the 40 lb N-rate did not maintain a high quality stand. Fertilizing with 80 lb N/acre did not maintain high quality stands whether burned or unburned.

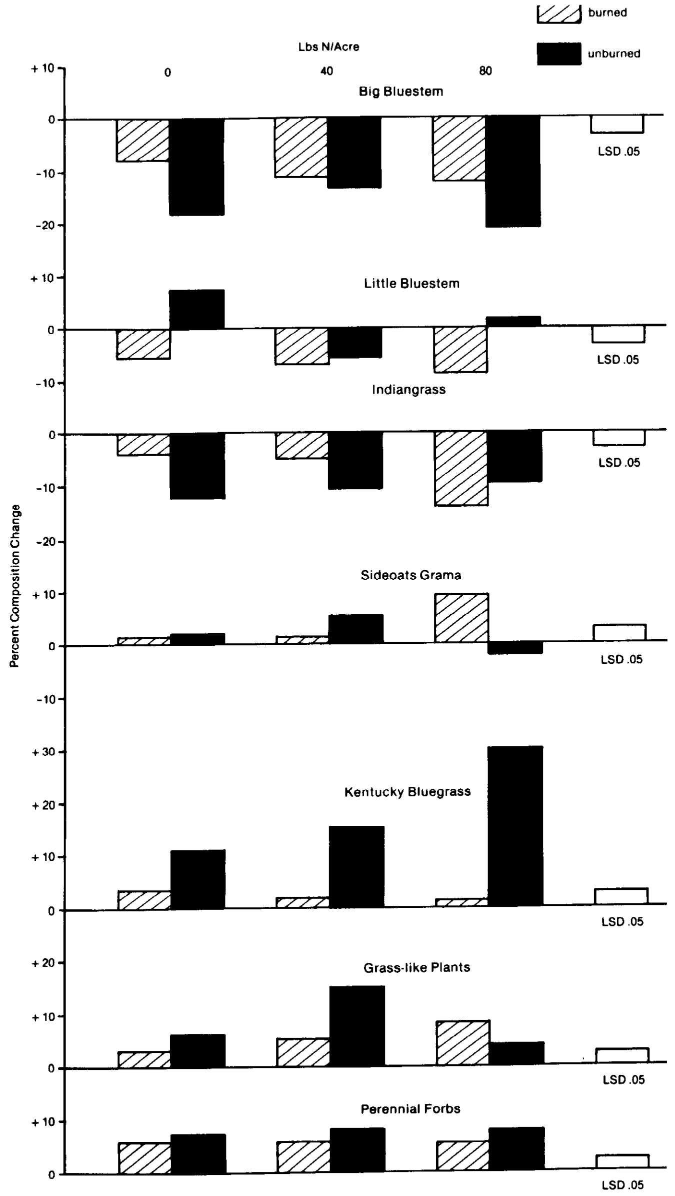

Fig. 2. *Changes in composition percentages (% of total basal cover) of different grasses from pretreatment levels (1971) to post-treatment levels (1975) under indicated nitrogen and burning treatments (avg. of loamy upland and breaks range sites).*

Table 6. Changes in percent composition (% of total basal cover) of Kentucky bluegrass under indicated nitrogen treatments on loamy upland and breaks range sites (avg. of burned and unburned (treatments). 1971 was the pretreatment level.

	N, lb/A		
	0	40	80
Kentucky bluegrass			
loamy upland			
1971	4.3	5.2	2.9
1975	15.6	16.0	25.6
Change	+11.3	+10.8	+22.7
breaks			
1971	1.7	1.3	1.8
1975	4.2	6.6	9.8
Change	+2.5	+5.3	+8.0
LSD $_{.05}$=2.7*			

*LSD applies only to the change in % composition.

Composition percentages of desirable species in the stand decreased more on unburned pastures, particularly at the 80 lb N-rate, than on burned ones. On burned pastures undesirable species increased slightly in composition %, but on unburned pastures increases were large. Burning and fertilizing with 40 lb N/acre seemed to improve maintenance of good quality range. Fertilizing with 80 lb N/acre failed to maintain good quality range whether burned or not.

Previous work on grazed and ungrazed areas with late spring burning in Flint Hills bluestem range showed similar vegetative responses to those reported here. Late spring burning favored warm-season perennial grasses and reduced cool-season grasses and perennial forbs compared to not burning (Anderson et al. 1970; McMurphy and Anderson 1965; Aldous 1934). Earlier research on nitrogen fertilization of ungrazed Flint Hills bluestem range indicated that cool-season grasses and perennial forbs were favored by adding nitrogen, and warm-season perennial grasses were reduced compared to unfertilized areas (Owensby et al. 1970; Mader 1956; Moser and Anderson 1964). Results agree with the findings in this study.

Steer Performance

Gain per Steer

Individual steer gain was generally greater on burned pastures than on unburned, probably because forage quality was higher. Allen et al. (1976) reported that nitrogen free extract was increased and cell wall constituents decreased for big and little bluestem on burned pastures compared with unburned ones. Anderson et al. (1970) reported higher gain per steer on late spring burned Flint Hills bluestem range than unburned. On unfertilized pastures, gain per steer was greater on burned pastures than on unburned 2 of the 4 years and the same the other 2 years (Table 7).

Table 7. Average steer gains (lb/steer) from late spring-burned and unburned bluestem pasture fertilized as indicated.

		Pounds of gain/steer, May 2-Oct. 3, 154 days		
		Nitrogen, lb/A		
Year	Treatment	0	40	80
1972	Burned	183^{ghi}	217^{ij}	195^{h}
	Unburned	135^{cde}	152^{ef}	116^{b}
1973	Burned	160^{fg}	154^{ef}	128^{bcd}
	Unburned	137^{cdef}	120^{bc}	101^{a}
1974	Burned	261^{k}	230^{j}	185^{h}
	Unburned	197^{hi}	154^{ef}	154^{ef}
1975	Burned	181^{gh}	178^{gh}	146^{def}
	Unburned	179^{gh}	147^{def}	137^{cdef}

ab . . k Means with different superscripts differ significantly (P≤.05).

On pastures fertilized with 40 lb N/acre gain per steer was higher on burned pastures than unburned each year. Individual steer gain on the unfertilized, burned pastures was lower in 1972, greater in 1974, and similar in 1973 and 1975 to gains on pastures fertilized with 40 lb N/acre. Individual steer gain was greater in the unburned, unfertilized pasture than on unburned pastures with 40 lb N/acre in 1974 and 1975 and similar in 1972 and 1973.

Steers gained less on the unburned pasture with 80 lb N/acre than on burned ones fertilized at the same rate every year except 1975. Three of the four years, steers gained less on burned pastures with 80 lb N/acre than they did on pastures with 0 and 40 lb N/acre. In 1972, individual steer gain was similar for burned pastures with 0 and 80 lb N/acre, and less than that on the burned pastures with 40 lb N/acre. During the first 2 years of the study, steers on the unburned pasture with 80 lb N/acre gained less individually than those on pastures with 0 and 40 lb N/acre. The last 2 years, the unburned pasture with 80 lb N/acre had gain per steer similar to that on the unburned pasture wth 40 lb N/acre; both were less than gain per steer on the unburned pasture without nitrogen.

Apparently, failure of steers to gain as well on pastures with 80 lb N/acre was due partly to overstocking and reduced forage selectivity by steers. Table 2 shows less forage remained on pastures with 80 lb N/acre at the end of the growing season than on other pastures.

Gain per Acre

Gain per acre on fertilized, unburned pastures was not significantly greater than on the unburned, unfertilized one. Since pastures receiving additional nitrogen were stocked at a higher rate (Table 1) to use additional forage, more gain per acre would be expected unless individual steer gain was greatly reduced. That happened on the unburned pasture with 80 lb N/acre, where in each of the 4 years individual animal gains were reduced. In 2 of the 4 years, gain per steer was lower on the unburned pasture with 40 lb N/acre than on the unburned, unfertilized pasture (Fig. 3). Allen et al. (1976) reported big and little bluestem were similar in most nutritive components whether on an unburned pasture with 40 lb N/acre or on an unburned, unfertilized pasture. Possibly, changes in botanical composition in the fertilized, unburned pastures compared to changes on the unburned, unfertilized one were responsible for the reduced animal performance.

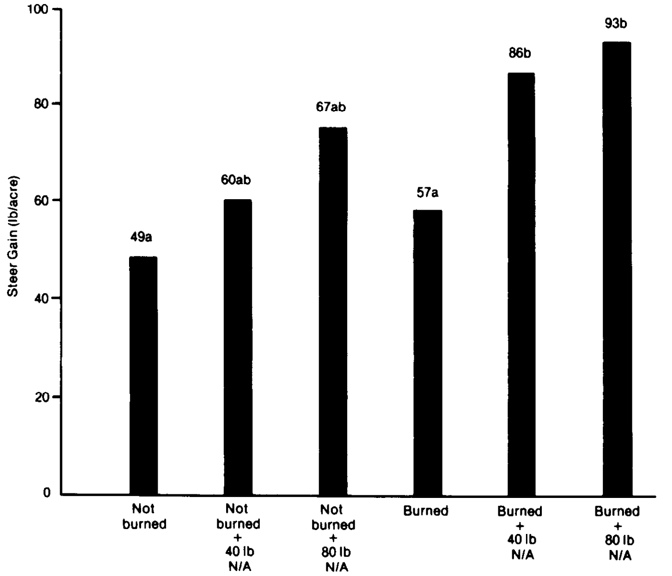

Fig. 3. *Gain per acre by steers on bluestem pasture, May 1 to Oct. 3, 1972-75. Numbers with different letters differ significantly (P>.05). Numbers are pounds gain per acre.*

On burned pastures, gain per acre was greater on fertilized than on the unfertilized one. Pastures with 40 and 80 lb N/acre had similar gain per acre even though stocking rate was greater on the 80 lb N-rate pasture than the 40 lb N-rate one. Again, the reduced gain per head on pastures with 80 lb N/acre was responsible for the similarity in gain per acre between pastures with 40 and 80 lb N/acre.

Conclusions

1. Fertilizing with 40 lb N/acre increased carrying capacity per pound of nitrogen applied more than did fertilizing with 80 lb N/acre, both compared with no fertilization.
2. Maintenance of good quality range was favored by burning and 0 and 40 lb N/acre compared with not burning and the same fertilizer rates. Eighty lb N/acre produced poor quality range whether burned or not.
3. Kentucky bluegrass and perennial forbs increased more on unburned pastures than on burned, with the greatest increases under nitrogen fertilization.
4. Individual steer gains were highest on burned pastures with 0 and 40 lb N/acre compared to unburned pastures at those same rates or pastures with 80 lb N/acre whether burned or not.
5. Forty lb N/acre applied to late spring-burned bluestem pasture seems to represent the best combination of the treatments tested.

6. Even though stocking rate and nitrogen fertilization rates are confounded, making it difficult to determine cause and effect relationships, the research does indicate which of the treatments applied gave the most favorable results.

Literature Cited

Aldous, A.E. 1934. Effect of burning on Kansas bluestem pastures. Kansas Agr. Exp. Sta. Bull. 38. 65 p.

Allen, Leland J., Ed F. Smith, Robert R. Schalles, Benny E. Brent, Leniel H. Harbers, and Clenton E. Owensby. 1976. Effects of range burning and nitrogen fertilization on the nutritive value of bluestem. J. Range Manage. 29:306-308.

Anderson, Kling L., and C.L. Fly. 1955. Vegetation-soil relationships in Flint Hills bluestem pastures. J. Range Manage. 8:163-169.

Anderson, Kling L., Ed F. Smith, and Clenton E. Owensby. 1970. Burning bluestem range. J. Range Manage. 23:81-92.

Gay, Charles W., and Don D. Dwyer. 1965. Effect of one year's nitrogen fertilization on native vegetation under clipping and burning. J. Range Manage. 18:273-276.

Mader, E.L. 1956. The influence of certain fertilizer treatments on the native vegetation of Kansas prairie. PhD Diss. Univ. of Nebraska, Lincoln. 116 p.

Moser, L.E., and K.L. Anderson. 1964. Nitrogen and phosphorus fertilization of bluestem range. Trans. Kansas Acad. Sci. 67:613-616.

Owensby, Clenton E. 1969. Effect of cages on herbage yield in True Prairie vegetation. J. Range Manage. 22:131-133.

Owensby, Clenton E. 1973. Modified step-point system for botanical composition and basal cover estimates. J. Range Manage. 26:302-303.

Owensby, Clenton E., Robert M. Hyde, and Kling L. Anderson. 1970. Effect of clipping and supplemental nitrogen and water on loamy upland bluetem range. J. Range Manage. 23:341-346.

McMurphy, W.E., and Kling L. Anderson. 1965. Burning bluestem range. J. Range Manage. 18:265-269.