# Effects of Fire on True Prairie Grasslands[1]

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THE bluestem pasture region of eastern Kansas, about 4 million acres, is one of the largest remaining tracts of true prairie in the United States. It is often called the "Flint Hills or the Bluestem Pasture Region." Oblong, it extends about 200 miles, and varying in width, from the Nebraska line into northern Oklahoma between the 96th and 97th meridians. Most of it remains as prairie because shallow rocky soil and steep slopes defy cultivation. Annual rainfall varies from 30 inches in the northern part to 38 inches in the south, and the growing season ranges from an average of 170 days in the north to 190 days in the south.

Table 1 lists some of the principal species of plants currently in the region and referred to here. Big and little bluestem make up 40 to 60 percent of the total plant population. Indiangrass, sideoats grama, blue grama, hairy grama, buffalograss and Kentucky bluegrass may constitute up to 10 percent or less of the plant population.

## HISTORY

Chase County is in the center of the Kansas bluestem pasture region. Malin (1942) reporting on early settlement of Chase County stated that it was settled in small farms by those interested in the

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TABLE 1. SCIENTIFIC AND COMMON NAMES OF PRINCIPAL PLANTS REFERRED TO IN THIS PAPER.

| | |
|---|---|
| Grasses: | |
| *Andropogon gerardi* Vitman | Big Bluestem |
| *Andropogon scoparius* Michx. | Little Bluestem |
| *Sorghastrum nutans* (L.) Nash | Indiangrass |
| *Bouteloua curtipendula* (Michx.) Torr. | Sideoats Grama |
| *Bouteloua gracilis* (H. B. K.) Lag ex Steud. | Blue Grama |
| *Bolteloua histuta* Lag. | Hairy Grama |
| *Buchloe dactyloides* (Nutt.) Engelm. | Buffalograss |
| *Poa pratensis* L. | Kentucky Bluegrass |
| Woody Plants: | |
| *Rhus glabra* L. | Smooth Sumac |
| *Symphoricarpos orbiculatus* Moench | Buckbrush |
| *Ulmus americana* L. | American Elm |
| *Juniperus virginiana* L. | Eastern Redcedar |
| *Quercus macrocarpa* Michx. | Bur Oak |
| *Quercus prinoides* Willd. | Chinquapin Oak |
| *Cornus drummondii* | Roughleaf Dogwood |

highly productive land along the streams. *The Chase County Leader* of 7 June 1872 reported: "The divides between the valleys are excellent grazing grounds for cattle and sheep and will always be open to the stock-raiser without cost." This free grass lasted until the early 1880's when, within 2 years, it was all fenced.

Although there are still many farmers and small pasture owners in the area, the grassland areas are dominated by large holdings owned by absentee landlords. In 1959 2 percent of the operators managed 41 percent of the grassland in Chase County (Kollmorgen and Simonett 1965).

The Kansas bluestem area has a unique history of cattle production. From earliest settlement it was used as a summer grazing area for transient herds of cattle moving from southwestern to eastern markets. The cattle arrived in April and were sent to market later in the summer.

It was observed that cattle preferred to graze burned areas and went to areas covered with mature vegetation from the previous growing season less frequently. Cattle moving into and from the area and absentee landlords created lease-pasture operators. They leased from owners and took cattle for summer grazing. Their fees were for receiving and caring for cattle on the grass and shipping them at the end of the growing season. Leases usually stated acreage per animal and that the pastures be burned. Those conditions still prevail in a large part of the area. Cattle come in younger now (1 year or slightly older) and remain on the grass longer, 1 May to 1 October. Calf producing cows are increasing in the area. They stay on the grass the year around, using the mature grass during the winter, so burning may decline (Fig. 1). Acreage guarantees for the summer are usually 4 for heavier animals, and about 7 acres for a cow and calf.

The excellent stand of true prairie grasses that remains may be due to some extent to the unique leasing requirements that began in early days and still are largely maintained. Renters pressured for liberal acreages and required burning for acceptable performance of their cattle. The burning forced pasture operators to be somewhat liberal on acreage to have grass enough for next spring to carry a fire (Fig. 2).

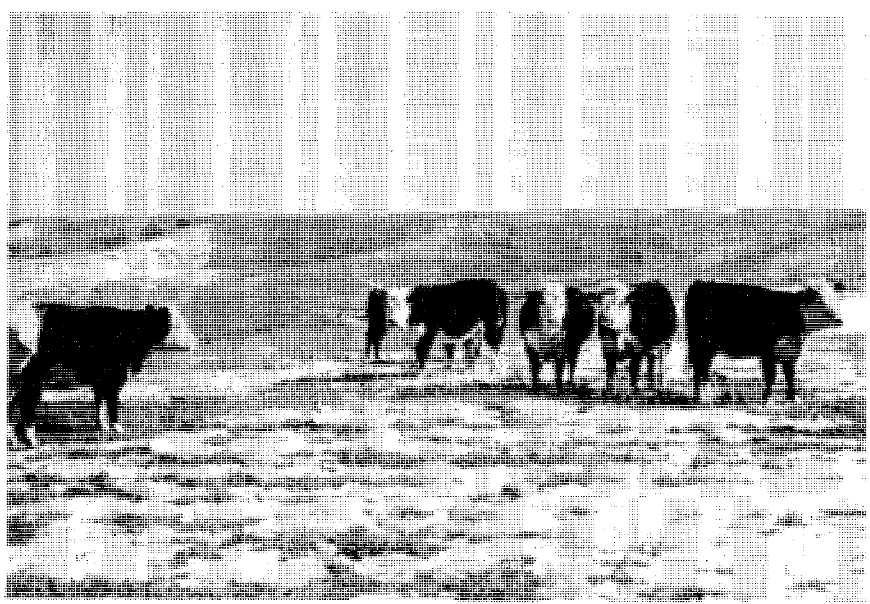

FIG. 1. Young cows on winter bluestem pasture.

Both liberal grazing acreage and fires worked to maintain the true prairie vegetation. Some pasture areas have been burned, usually annually for nearly 100 years.

## VEGETATION

**Big bluestem:**—From 1918 to 1921 Hensel (1923) burned an area in March or early April each year and reported big bluestem decreased, but increased on an unburned control area. Aldous (1934) burned plots once yearly and once each 2 years from 1928–1933 in late fall (1 Dec.), early spring (20 Mar.), mid spring (10 April) or late spring (5 May). Plots burned in late spring increased in big bluestem and coarser grasses. McMurphy and Anderson (1965) reported an increase of big bluestem under late and mid spring burning with no change under early spring burning or no burning (Table 2). Anderson et al. (1970) studying early, mid, and late spring burned, grazed pastures, reported that burning, especially late spring burning, favored big bluestem.

FIG. 2. Grass remaining from previous grazing season being removed by fire.

The preponderence of evidence shows that in the Flint Hills area of Kansas, mid and late spring burnings tend to increase big bluestem plants.

**Little bluestem:**—Spring burning increased little bluestem 48 percent while not burning decreased it 60 percent (Hensel 1923).

TABLE 2. BIG BLUESTEM PERCENTAGES OF TOTAL PLANT POPULATIONS ON ORDINARY UPLAND RANGE SITES IN GRAZED PASTURES.

| Year | Time of Burning | | | Unburned |
|---|---|---|---|---|
| | Mar 20 | Apr 10 | May 1 | |
| 1950 | 26 | 23 | 21 | 19 |
| 1951 | 28 | 22 | 25 | 18 |
| 1952 | 24 | 26 | 25 | 17 |
| 1953 | 24 | 24 | 20 | 17 |
| 1954 | 23 | 23 | 23 | 18 |
| 1955 | 22 | 26 | 28 | 17 |
| 1956 | 32 | 34 | 32 | 18 |
| 1957 | 28 | 26 | 27 | 18 |
| 1958 | 25 | 29 | 34 | 16 |
| 1959 | 34 | 41 | 42 | 22 |
| 1960 | 26 | 33 | 34 | 19 |
| 1961 | 27 | 32 | 36 | 18 |

Adapted from McMurphy and Anderson (1965)

Aldous (1934) reported little bluestem was favored by fall burning, but when McMurphy and Anderson (1965) studied some of the same plots, 30 fall burnings in 36 years significantly decreased little bluestem. In their grazed pastures the unburned consistently had a higher percentage of little bluestem than the burned. Early spring burning decreased little bluestem basal cover (Anderson et al. 1970). Ehrenreich and Aikman (1963) burning on various dates, found seedstalk production increased by burning.

Effects of burning on the little bluestem population are not clear. It responds about as well to nonburning as to any burning treatment. Certainly burning doesn't favor little bluestem as much as it does big bluestem.

**Indiangrass:**—No consistent differences were observed by Aldous (1934) in regard to burning or not burning Indiangrass. It increased or maintained itself under nonburning and all burning treatments except that 1 December burning reduced it.

McMurphy and Anderson (1965) continued the Aldous plots and reported that burning before 1 May reduced Indiangrass. Anderson et al. (1970) found basal cover greater under mid and late spring burning than under early spring or no burning. The percentage of Indiangrass was lowest on the early spring burned pasture.

It seems that fall and early spring burning reduce Indiangrass, whereas late spring burning maintains it or increases it compared to nonburning.

**Sideoats grama:**—Aldous (1934) found that sideoats grama increased or maintained itself in all plot treatments, nonburning, fall burning, and early mid, and late spring burning. No significant difference in composition was found by McMurphy and Anderson (1963) in the Aldous plots although they labeled sideoats grama the dominant increaser in the early spring burned pasture. Anderson et al. (1970) reported sideoats grama remarkably stable under nonburning and early, mid, and late spring burning; however, it increased more under early spring burning than under nonburning or late spring burning.

Results show the percentage of sideoats grama remained about the same under nonburning and all burning treatments except that it tended to increase under early spring burning.

**Kentucky bluegrass:**—All of the research reviewed shows that burning reduced Kentucky bluegrass. Anderson et al. (1970) reported 11 percent Kentucky bluegrass in an unburned pasture and 0.5 percent or less under different spring burning treatments. As it was actively growing when burnings were carried out, it should have been more susceptible to injury than native grasses that were dormant or just beginning to grow when spring burned.

**Woody species:**—Bragg (1971) reported major woody species most likely to increase in the bluestem grasslands in the Geary County area of Kansas as American elm, eastern redcedar, bur and chinquapin oak, smooth sumac, roughleaf dogwood and buckbrush. He concluded, ". . . it appears that fire is the best available treatment to maintain presettlement amounts of woody species coverage on the Geary County, Kansas, tall-grass or bluestem prairie."

Blan (1970) reported that fire killed 63 percent of the redcedars in a 237 acre pasture averaging 88 cedars per acre (Fig. 3).

Table 3 shows late spring burning may be used to eliminate or

TABLE 3. EFFECT OF ANNUAL BURNING IN ERADICATING BUCKBRUSH (1927–1933)

| | | Burned | | |
|---|---|---|---|---|
| | Unburned | Dec. 1 | Apr. 10 | May 5 |
| No. of stems (1926) | 300 | 370 | 480 | 104 |
| No. of stems (1933) | 628 | 140 | 133 | 0 |

Adapted from Aldous (1934)

reduce buckbrush. In late spring buckbrush has started to grow, is leafed out, and is susceptible to fire injury probably in the same manner that Kentucky bluegrass is affected. There must be enough old grass present to carry the fire through the buckbrush if the intention is to reduce or eliminate it by late spring burning.

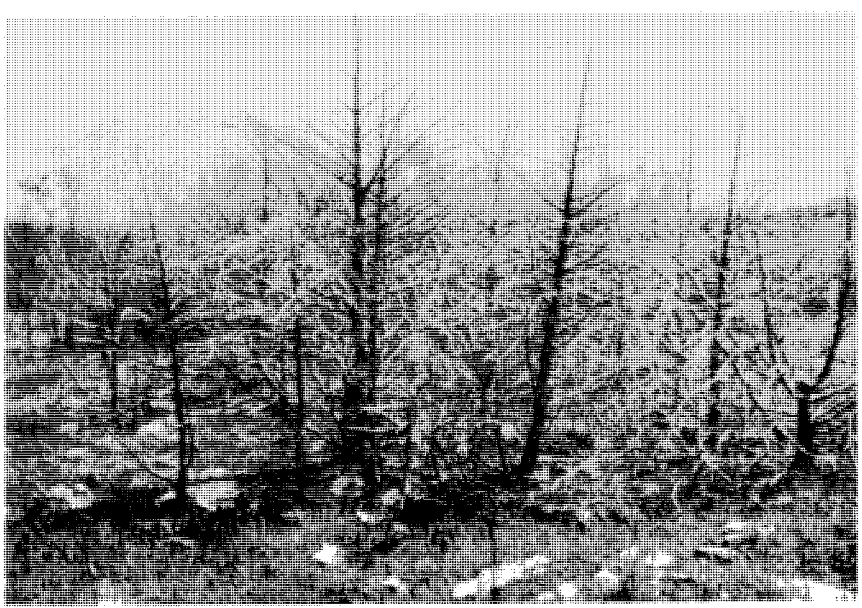

FIG. 3. Eastern redcedar on the true prairie killed by fire.

FIG. 4. Smooth sumac growing on true prairie site burned annually in early spring for 20 years.

Smooth sumac begins to grow later in the spring than buckbrush so fire is not effective in eliminating it from a pasture. Late spring burning will prevent it from growing tall. A stand of sumac on a pasture burned annually in early spring for 20 years still persists with many plants (perhaps increasing) but they are only 12 to 18 inches high (Fig. 4).

A contributing factor to vegetative change other than fire may have been increased grazing pressure wherever forage production was reduced by burning.

## FORAGE PRODUCTION

Hensel (1923) found about the same quantity of hay produced on spring burned as on unburned plots. He clipped and removed herbage.

Aldous (1934) returned clippings to the plots and raked unburned plots before burning. He stated protection from burning, clipping, and grazing animals greatly reduced the density of the vegetation. Grass yield was greatest under nonburning; late spring burning reduced yield only slightly in one series of plots on a neighboring ranch but about a third on plots at the University. Fall and early spring burning reduced yields.

Equal forage yields on nonburned and late spring burned, grazed pastures were reported from ordinary upland range sites by Owensby and Anderson (1967). Early and midspring burning reduced yields. Forage yields on limestone break sites were reduced significantly only by early spring burning.

Hulbert (1969), working with a nearly pure, undisturbed stand of big bluestem at Junction City, Kansas, produced more forage by burning 9 April or clipping than by not burning. Yields were increased by burning in Missouri (Kurera et al. 1967) in Wisconsin (Curtis and Partch 1950) on protected prairie sites.

Farther west and south of the Kansas true prairie in a lower rainfall area at Guthrie, Oklahoma, Elwell (1941) reported lower forage yields after burning.

At Manhattan, Kansas, forage production on true native prairie burned in late spring is about equal to production under nonburning. Burning in the fall or early spring reduced forage production, perhaps through moisture lost by evaporation and run off. Rainfall differences, litter accumulation, and plot management are factors that influence yields from burned pastures in different areas.

## SOIL TEMPERATURE

Hensel (1923) reported that heat of combustion from burning was confined to the immediate ground surface. The soil temperature 1 and 3 inches deep during 2 months after burnings was significantly higher. Aldous (1934) measured temperatures to 7 inches deep, with results similar to Hensel's. Hulbert (1969) found soil temperatures at 10 and 20 cm higher on denuded plots from April to September.

Burning increases the soil temperature, which probably starts vegetation growth earlier and may increase moisture loss.

## SOIL MOISTURE

Aldous (1934) reported moisture content of soil on an unburned plot higher than on any burned plot. Among the burned plots, soil moisture was highest in those burned in late spring, followed by mid spring, and lowest in those burned in fall and early spring. Under favorable moisture conditions, differences were small with no deficiency of moisture. In a dry year, 1933, differences were greater and only unburned plots did not fire or have drooping leaves.

Anderson (1965) determined moisture in the Aldous plots and reported that burning reduced soil moisture; among burning treatments reduction was greatest under fall burning; least, under late spring burning.

On grazed pastures on ordinary upland soil, moisture was highest in mid and late spring burned pasture and lowest in early spring burned and nonburned pasture (Anderson et al. 1970).

Hulbert (1969) and Ehrenreich and Aikman (1963) report lower soil moisture on denuded or burned areas than on undisturbed plots.

Most studies show that fall and early spring burning reduce soil moisture, likely from greater losses by evaporation and runoff. Usually other burning dates also reduced soil moisture, with least reduction from late spring burning.

## STARTING GROWTH IN THE SPRING

Burning stimulated early growth in the spring; a fall burned plot had a 69 percent higher plant population in April than a nonburned plot (Aldous 1934). The plots burned in fall and early spring continued to have a higher plant population until early in June when moisture, rather than temperature, became the controlling factor. Kurera and Ehrenreich (1962), Ehrenreich and Aikman (1963), and Hulbert (1969) all reported earlier growth on spring burned plots than on unburned areas.

## SOIL FERTILITY

Burning had no effect on nitrogen or organic matter in the soil, according to Aldous (1934). Neither nitrogen nor organic matter change was detected by Ehrenreich and Aikman (1963). They found pH and phosphorus in the surface soil increased by burning, the extent varying with quantity of organic matter burned.

Wyrill (1970) sampled the Aldous plots which had been under study since 1926, and grazed pastures studied since 1950 and reported that winter burning of ungrazed plots caused increased pH, organic matter, Ca, Mg, and K and decreased N, while late spring burning only reduced N. Changes from early and mid-spring burning generally ranged between the two extremes. Under grazing, late spring burning reduced N, P, K, and organic matter, and increased pH and Mg; had no effect on Ca.

Additional research is needed for a better understanding of long time effects of fire on chemical properties of prairie soil.

## CATTLE PERFORMANCE

Observation indicates that cattle prefer areas that have been burned. Plants on burned pasture had higher moisture contents and cattle preferred to graze burned pastures early in the summer, according to Aldous (1934).

Three important factors affecting cattle performance are intake of forage and quantity and availability of nutrients in the forage consumed.

Mid- and late-spring burning significantly increased gain compared with nonburning (Table 4), the primary increase coming early in the

TABLE 4. EFFECT OF BURNING ON AVERAGE MONTHLY STEER GAINS (LB/DAY) 1 APRIL TO 1 OCTOBER (16-YEAR SUMMARY 1950–65).

| | May | June | July | Aug. | Sept. | Av. |
|---|---|---|---|---|---|---|
| Unburned | 1.83 | 1.74 | 1.59 | 1.24 | 1.44 | 1.53[a] |
| Early spring burned | 2.42 | 1.90 | 1.56 | 1.13 | 1.23 | 1.57[ab] |
| Mid spring burned | 2.50 | 2.01 | 1.64 | 1.28 | 1.19 | 1.64[bc] |
| Late spring burned | 2.36 | 2.06 | 1.75 | 1.28 | 1.28 | 1.70[c] |

Two means not bearing a common superscript differ significantly (P .05).

growing season. Late-spring burning significantly increased gain 12 of 16 summer seasons, only in 1953, 1961, 1962, and 1964 were unburned pastures equal or superior. Late-spring burning also increased steer gains over early-spring burning. Weight gain obtained with early-spring burning was essentially equal to that obtained with no burning. Early-spring burning gave higher gains than not burning early in the season but lower gains late in the growing season.

Increased weight gain from late- and mid-spring burning may be from increased nutritive value of plants. Smith and Young (1959) found that mid-spring burning increased protein and ash contents of little bluestem, and Hall et al. (1952) reported that on a coastal plain forest site some species increased in protein and phosphorous contents under early-spring burning. More nitrogen was present in Kaw big bluestem after burning (Owensby et al. 1970). Comparing digestibility of forages from unburned and midspring burned (1–15 April) pastures, Smith et al. (1960) found dry matter and crude fiber digestibility higher in forage from the burned area.

Increase in palatability of forage on burned areas has been so well established that Duvall and Whitaker (1964) have used it as a basis for rotation burning. The portion not burned was lightly used or naturally deferred by grazing animals, so fences were not needed.

The increased nutritive value and palatability of forage on burned areas helps explain why animals gained more with mid- and late-spring burning. Forage production being lower under early-spring burning and range condition declining with each year's burning likely explain why early-spring burning did not benefit animal performance.

## SUMMARY

This paper is primarily a review of some of the research in Kansas on burning true prairie grasslands, beginning with H. L. Hensel in 1918 and conducted by many persons since then.

Mid- and late-spring burning increased number of big bluestem plants according to most evidence. Table 2 shows what can be expected under grazing conditions. The effect of burning on the little bluestem population is not clear, likely because such management factors as returning clipped forage to plots or not, date of clipping, and clipping or grazing. Little bluestem seemed to respond about as well most of the time to nonburning as to any burning treatment.

Fall- and early-spring burning reduced populations of Indiangrass while late-spring burning maintained or increased it compared with nonburning. Sideoats grama remained about the same under most treatments with a tendency to increase under early spring burning. Burning significantly decreased Kentucky bluegrass.

Some woody species can be prevented from increasing by annual burning provided they are not too large, adequate fuel is present, and they are in an unprotected area. Included are American elm, redcedar, bur and chinquapin oak, and rough leaf dogwood. Redcedar is especially susceptible to fire. Buckbrush can be controlled by repeated late spring burning. Smooth sumac plants are stunted by burning but they persist and may increase in number.

Forage production was about the same at Manhattan, Kansas, on late spring burned and nonburned areas. Fall-, early-, and mid-spring burning reduced yields. Yields were increased by burning east and north of Kansas in some higher rainfall areas of the prairie. Yields were reduced in a lower rainfall area southwest of Kansas.

Burning increased soil temperature, which encouraged early plant growth. Usually soil moisture content of burned plots was reduced least by late spring burning. The combination of higher temperatures, exposure to evaporation and runoff, and growing plants demand for water under fall- and early spring burning probably helped reduce soil moisture, especially during dry periods.

Increased gains by steers grazing mid- and late-spring burned pastures compared with gains on early spring burned and nonburned pastures may result partially from increases in nutritive value of the plants. Forage from the mid-spring burned area was higher in protein, and both dry matter and crude fiber of mid-spring burned areas were more digestible than from the nonburned pasture.

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