Burning Flint Hills Range[1]

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Highlight

Late spring burning on May 1 was less detrimental than burning in fall or in early or mid-spring. Late spring burning, however, reduced infiltration rate, soil moisture, and forage yield, as compared with unburned range. Advantages of late spring burning over not burning were an increase in big bluestem, control of Kentucky bluegrass and other less desirable plants, and more rapid beef gains.

Burning has played an important role in the past management of Flint Hills range and still is common in that area. Old arguments against burning have been concerned with reduction of forage yield and water runoff (Elwell et al., 1941). It has been the purpose of this study to investigate the effects of burning bluestem range at various winter and spring dates on soil moisture from small plot studies and on range condition under stocking at a moderate rate with cattle.

One of the first studies of range burning in the Flint Hills was that of Hensel (1923) who found no difference in forage production due to burning. Aldous (1934) reported more soil moisture in unburned than in burned plots and noted that time of burning may affect soil moisture. Further studies by Hanks and Anderson (1957) verified that soil in winter burned plots contained less moisture than soil in any other treatment. They were fortunate in having sampled before a 4.47-inch rain which came in an intense storm in late September. Subsequent sampling showed that unburned plots retained 83% of that precipitation, the burned ones only 37 to 46%. That was five months after burning, with a full season's top growth present. Subsequent investigations showed infiltration rates on unburned plots to be about 4.5 in/hr for the first 70 minutes, decreasing to about 1.4 in/hr at 100 minutes. Infiltration rates on the burned plots were less than 3.00 in/hr at 30 minutes, 2.75 at 70 minutes, and 1.70 in/hr at 100 minutes. Decreased infiltration rates resulted from burning regardless of time of burning, and the effect continued all season.

Bieber and Anderson (1961) concluded that early burnings reduced soil moisture content but that differences in soil moisture between unburned plots and those burned extremely late in the spring were not significant.

Aldous (1934) found that burned plots had higher soil temperatures in the spring than unburned ones, and that apparently stimulated earlier growth. It tended to increase forage yields early in the growth period, but after mid-June the unburned plots had more forage than the burned ones. Effects of the higher soil temperature and earlier plant growth on soil moisture were not discussed.

Perhaps the strongest argument for burning has been increased steer gains from burned pastures (Smith et al., 1963), although that argument may not be valid in a long-range program.

Methods

The experiments were conducted near Manhattan, Kansas, in the True Prairie described by Herbel and Anderson (1959). The major grasses were big bluestem *(Andropogon gerardi* Vitman), little bluestem *(Andropogon scoparius* Michx.), indiangrass *(Sorghastrum nutans* (L.) Nash), switchgrass *(Panicum virgatum* L.) Kentucky bluegrass *(Poa pratensis* L.), *and* sideoats grama *(Bouteloua curtipendula* (Michx.) Torr.).

Aldous (1934) had initiated studies in 1928 on two sets of five plots, one set burned annually and one biennially. The treatments were winter burned (about December 1), early-spring burned (about March 20), mid-spring burned (about April 10), late-spring burned (about May 1), and unburned. The soil, a silty clay loam on a nearly level ridge top, was classified as an Ordinary Upland range site. The experiments were continued until wartime labor shortages forced their suspension in 1944. Treatments were resumed in 1950, all plots being burned annually to give two replications of each treatment. The plots have been protected from grazing from the beginning of the experiment.

In 1959 one aluminum access tube was installed in each plot and soil moisture readings were taken at intervals throughout the season with a neutron moisture gauge. Results that year were reported by Bieber and Anderson (1961). One more aluminum access tube was installed in each plot early in 1960 to permit two observations per plot. Precipitation in 1960 and 1961 was above the 32-inch mean.

In 1950 three 44-acre pastures were fenced for a burning-grazing trial in which burning has been done on the same dates as the early, mid, and late spring burned Aldous plots. They were compared with an unburned pasture of 60 acres. Yearling steers were placed in the pastures May 1 each year and removed about

[1] *Contribution No. 917, Department of Agronomy, Kansas Agricultural Experiment Station, Manhattan.*

October 1. A moderate stocking rate of 5.0 acres per animal unit was used, and livestock gains are reported by Smith et al. (1963).

Range sites in the pastures were described by Anderson and Fly (1955). The major range site was Ordinary Upland, but Limestone Breaks and a small amount of Claypan also occurred. Information reported here is from the Ordinary Upland site.

Botanical composition measuring basal area was taken in the ungrazed Aldous plots and the grazed pastures using the randomized line transect described by Anderson (1942).

Results and Discussion

Soil Moisture. — As many as 1500 individual soil moisture readings were taken in both 1960 and 1961 with a neutron gauge. Results are summarized in Table 1. Total moisture in the entire 5-foot soil profile was greatest in the check plots and significantly less for each earlier date of burning except early and mid spring burned plots. Within the soil profile greatest reductions in moisture content occurred in the fourth and fifth feet of the winter burned treatment. All burnings reduced soil moisture, but late spring burning reduced it least.

Average moisture does not explain why forage yields seem to be affected by burning in some seasons and not in others. The effect, timing, and location of moisture differences within the soil profile vary with each season.

Table 1. Average soil moisture in inches of water per foot of soil in the Aldous ungrazed plots for 1960-1961.

Soil Depth Feet	Time of Burning Dec 1	Mar 20	Apr 10	May 1	Check
First	4.00b	3.91c	4.01b	4.06a	4.08a
Second	3.65e	3.75d	3.80c	4.00b	4.09a
Third	3.44e	3.54d	3.69c	3.77b	3.95a
Fourth	3.21d	3.74b	3.66c	3.74b	4.07a
Fifth	2.72e	3.70c	3.59d	3.85b	3.90a
Entire 5 feet	3.41d	3.73c	3.75c	3.89b	4.02a

[1]Means within each foot of soil followed by the same letter are not significantly different at the .05 level.

Infiltration Rate. — Precipitation during the first three months of 1960 came as 45 inches of snow. Soil moisture readings were taken as soon as the snow had melted and the ground had become firm. At that time, all plots had over 4 inches of water per foot of soil in the surface 3 feet. However, the fourth and fifth feet of the soil profile in the winter burned plots had 3.23 and 2.67 inches of water, respectively, while all other plots had over 4.00 inches of water per foot at those depths. The plots were small (33 x 66 feet), and snow was drifted uniformly over all plots. The snow melted rapidly in March, and more water ran off winter burned plots than off others. Soil moisture in the fifth foot of the winter burned plots did not change throughout the 1960 growing season and apparently contributed very little to plant growth.

In 1961 the third foot (Fig. 1) of the soil profile provided a good insight into moisture differences which apparently were influenced by differential infiltration rates. In January only the check had had its soil moisture replenished, followed in February by the late burned plots. By March all except the winter burned plots had had their soil moisture restored in the third foot. The fifth foot of the winter burned treatment failed that entire season to develop the moisture reserve attained by the other plots. It is the failure to replenish moisture in the lower part of the soil profile that can influence plant-water relationships during dry seasons. Moisture storage at lower depths greatly prolongs growth activities when upper soil moisture becomes depleted.

Soil Moisture Utilization. — A definite pattern of water removal from the soil developed in 1961. Previously extreme fluctuations in the first and second feet made it difficult to evaluate data (Bieber and Anderson, 1961). Data from the mid-spring burned plots (Fig. 2) serve as an example of soil moisture use. Precipitation that summer was be-

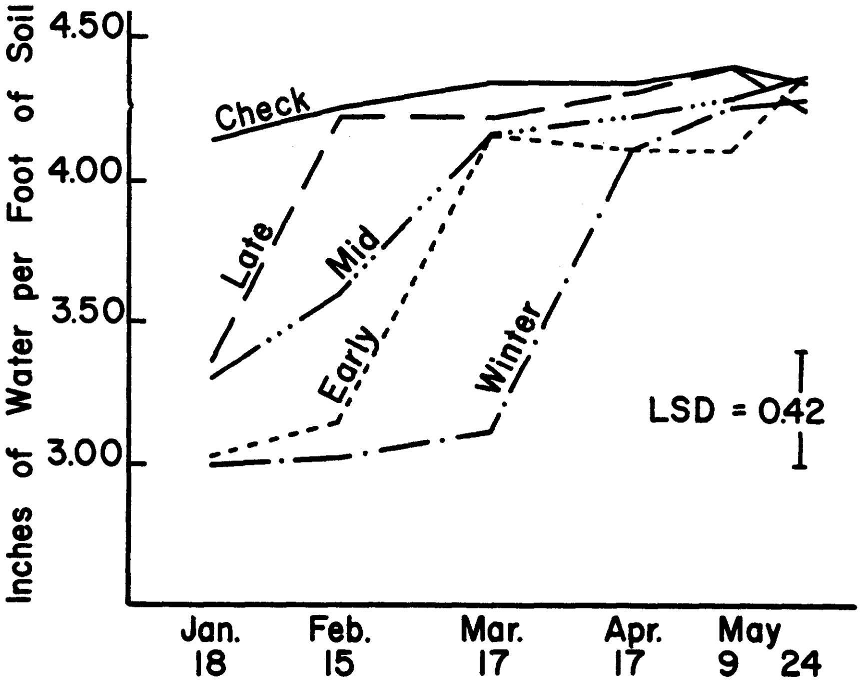

Figure 1. Soil moisture replenishment in 1961; third foot of the soil profile.

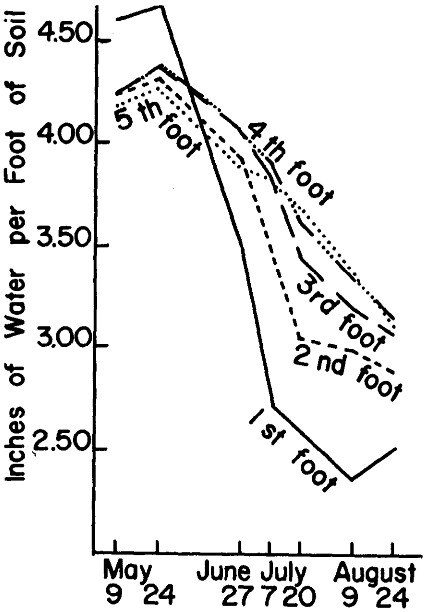

Figure 2. Soil moisture removal.

low average and much of it fell in light showers. Clark (1940) found that grasses were able to intercept as much as 50% of a 0.5-inch rain in a 30-minute period. Therefore, the effectiveness of small rains is reduced.

Moisture was removed more rapidly from near the surface than from deeper levels. As moisture near the surface became depleted, water from deeper levels was used more rapidly. In previous years frequent rains would replenish moisture in the surface soil, and this moisture would then be removed quickly by growing plants (Bieber and Anderson, 1961).

That pattern of soil moisture use probably helps explain the lack of annual plants in excellent range. An annual plant would have to possess rapidly growing roots to remain in soil with alternately adequate and inadequate moisture for growth in the upper profile.

Since plants take moisture from the upper soil profile first, a deficit in the lower soil horizon may be relatively unimportant in seasons of adequate, timely precipitation which keeps soil moisture replenished in the upper soil profile. Burning might also have a limited influence in a dry growing season preceded by enough precipitation for soil moisture storage throughout the soil profile in all treatments.

Forage Production.—The long-term forage yield average through 1960 has been summarized by McMurphy and Anderson (1963). Forage production in lb/acre of forage from these plots in 1960 was as follows: check, 3960; late-spring burned, 3449; mid-spring burned, 3536; early-spring burned, 2770; and winter burned, 2667. The unburned check produced significantly more than early spring or winter burned plots. In 1961 no significant differences occurred in forage production, which ranged from a low of 2401 pounds from winter burned to a high of 3224 lb/acre from the late spring burned plots.

Forage production from the grazed pastures has followed the same general long-time trend, the unburned pasture producing the greatest, and the early-spring burned one the smallest yield.

Vegetation.—Persistence of the desirable forage species in the ungrazed Aldous plots after 30 burnings in 36 years bears testimony to the indestructability of prairie by fire; however, the botanical composition of the plots has been influenced by fire (Table 2). In the first few years of the experiment little bluestem increased in the burned plots (Aldous, 1934), but that trend has now disappeared. Big bluestem has become the dominant species in the winter burned and late-spring burned treatments. Burning earlier than May 1 was detrimental to indiangrass, but prairie junegrass *(Koeleria cristata* (L.) Beauv.) was favored by winter burning. Late spring burning appeared to reduce the forb population, and all burnings were detrimental to Kentucky bluegrass.

The grazed pastures showed the same general trend in botanical composition changes as the ungrazed plots except that the early-spring burned one has been reduced in range condition. Big bluestem, a very palatable grass, increased in the mid and late-spring burned pastures (Table 3). During the drought of the 1950's density of the vegetation dropped to about one-third that of the predrought level. Even the number of big bluestem plants per line declined, but less than total vegetation. Therefore, the percentage of big bluestem increased near the end of the drought, and when good soil moisture returned, big bluestem quickly moved into unoccupied areas and increased in actual number as well as percentage.

Table 2. Botanical composition[1] of the ungrazed Aldous plots in percentage of total plant population, 1957-1961 mean.

	Time of Burning				
Species	Dec 1	Mar 20	Apr 10	May 1	Check
Big bluestem	45.4a	29.7b	26.5b	43.6a	13.8c
Little bluestem	12.3c	30.0ab	38.4a	26.7b	34.7ab
Indiangrass	1.9d	3.6c	8.1b	16.9a	17.3a
Prairie junegrass	8.6a	3.7b	1.2c	0.4d	0.5d
Grass Decreasers[2]	67.7c	70.2bc	75.3b	87.1a	68.5c
Sideoats grama	11.8a	8.8a	11.6a	6.9a	9.8a
Kentucky bluegrass	0.3b	0.3b	0.1b	0.4b	6.4a
Grass Increasers[2]	19.0ab	14.0c	15.7bc	9.2d	19.7a
Perennial Grasses	87.8c	84.4d	91.1b	96.4a	88.7bc
Sedges *(Carex* spp.)	7.0b	10.3a	6.0bc	1.3d	4.2c
Perennial forbs	4.4a	4.3a	2.5b	2.1b	4.2a
Annual grasses	0.8	1.0	0.4	0.2	2.9

[1]Means for each species followed by the same letter are not significantly different at the .05 level.

[2]Small amounts of some other species also are included.

Table 3. Big bluestem[1] percentage of total plant population, Ordinary Upland range site in grazed pastures.

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

[1]Values within a year followed by the same letter are not significantly different at the .05 level.

The unburned pasture has consistently had a greater percentage of little bluestem than the burned pastures. This species was greatly reduced in the early burned pasture, and it appears that any burning may be detrimental to little bluestem.

The dominant increaser in the early burned pasture was sideoats grama, while the unburned pasture contained Kentucky bluegrass plus some Japanese brome (*Bromus japonicus* Thunb.) which reduced its range condition rating. Range condition was estimated on the basis of the percentage of original vegetation present as proposed by Dyksterhuis (1949). This estimate was based on the botanical composition as determined by the line transect data. Range condition of all pastures declined during the drought of the early 1950's (Table 4), but the mid- and late-spring burned pastures recovered rapidly after the drought while the one burned in early spring failed to do so.

Controlled burning was not destructive to vegetation of the True Prairie as evidenced by data from the ungrazed Aldous plots. An attempt was made to burn only when the soil surface was wet, thus minimizing damage to the living portion of the grass plants. There is ample evidence to show that accidental fires, which usually occur when the soil surface is dry, can be quite damaging to the vegetation (Hopkins et al., 1948; Launchbaugh, 1964). Fire may be a useful tool in range management to control the introduced weeds, Kentucky bluegrass and Japaanese brome. It may also be useful in livestock distribution, since animals prefer to graze previously burned areas of the range. However, the implications of reduced infiltration rates and probable reductions in forage yield must not be ignored. It appears that to prevent overutilization, a lower stocking rate may be necessary following burning. Fire apparently favored big bluestem and leadplant (*Amorpha canescens* Pursh), both valuable decreasers, but fire also favored smooth sumac (*Rhus glabra* L.), an undesirable shrub. Buckbrush (*Symphoricarpos orbiculatus* Moench) was controlled by late spring burning. There may be other undesirable species that would be favored by burning and become problems but which are not present in the experimental area.

Burning plus overgrazing probably reduces range condition faster than overgrazing without fire. Burning removes the protective mulch, and its removal increases water runoff and allows seedlings of invaders to become established more easily. An example was a large number of American elm (*Ulmus americana* L.) seedlings in the late burned pasture at the end of 1961. If adequate fuel is available the fire will remove them. Smooth sumac and the other weedy species undoubtedly benefit from the reduced competitive ability that results from overgrazing the desirable species.

Table 4. Range condition estimates[1] for Ordinary Upland range site in grazed pastures based on percentage of original vegetation present as determined by line transect data.

	Time of Spring Burning			
Year	Mar 20	Apr 10	May 1	Check
1950	74a	73a	76a	83a
1951	77a	76a	84a	80a
1952	68a	76a	84a	74a
1953	61a	71a	71a	71a
1954	54b	65ab	76a	71ab
1955	55b	76a	76a	70ab
1956	55b	72a	69ab	61ab
1957	54a	65a	61a	64a
1958	48c	66ab	77a	60bc
1959	60c	87ab	88a	70bc
1960	55b	83a	77a	71ab
1961	56b	83a	83a	70ab

[1]Values within a year followed by the same letter are not significantly different at the .05 level.

Summary

Late spring burning (May 1), which sometimes was just after growth commenced, was the least detrimental of the burnings tested. The problem could thus be narrowed to a comparison of late-spring burning and no burning.

The advantages of late-spring burning over not burning in the Flint Hills appeared to be: (1) an increase in big bluestem, (2) control of Kentucky bluegrass, Japanese brome, and buckbrush, and (3) more rapid beef gains. The disadvantages of late spring burning were: (1) reduced infiltration rate, (2) reduced soil moisture, (3) reduced forage yield, and (4) increases of smooth sumac and possibly other undesirable species that may be favored by fire. In some years there may be adequate precipitation in the Flint Hills to overcome the problem of soil moisture deficiencies caused by burning. Whenever burning is employed, great care must be exercised to insure proper stocking rate, and the operator should be alert to any increase of undesirable fire-favored species.

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