THE EFFECTS OF DATE OF BURNING ON NATIVE FLINT HILLS RANGE LAND

by

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TABLE OF CONTENTS

INTRODUCTION

Burning at one time or another during the year has been practiced in the Flint Hills range land since the 1880's. The primary reason for burning is to remove the unutilized herbaceous material of the previous year so that the new growth of vegetation may be grazed unhindered by old growth. Many of the landowners of the Flint Hills range lands lease their ranges to southwestern cattle producers who demand that these ranges be burned. This is desirable because of the more rapid growth of vegetation on burned ranges in spring, hence earlier fattening.

Although burning is not generally recommended for the Flint Hills, its widespread use as a tool in range management makes it necessary to study it further. This study is, therefore, designed to evaluate effect of date of burning. Earlier investigators have shown the fallacy of fall burning, so in these trials only early, medium, and late spring burnings are compared. Older work had evaluated the effects of burning in the absence of grazing, but these trials include moderate stocking.

It is the purpose of this experiment to compare data from bluestem pastures burned in early, medium, and late spring. This study was conducted on range land that is dominated by the climax true prairie species. The stocking rate is uniform over the experimental area so that any differences that arise may be considered due to the time of burning. These trials also include the classification of range lands according to site in order to allow comparisons of results under strictly comparable conditions and to serve as a basis in making future population trend studies.

REVIEW OF LITERATURE

The bluestem pastures of the Flint Hills occupy approximately four million acres in eastern Kansas and Oklahoma. The pastures usually are grazed from late April or early May until fall. On most of the pastures, the cattle are removed for market before the end of the growing season of the grasses. Since these pastures usually are not grazed in the winter, there often remains a large volume of ungrazed forage which may interfere with early grazing.

Since the terrain usually is too rugged to permit mechanical removal of the old growth, burning has been the accepted method of removal. Even before the white man settled this area, occasional fires raged over parts at irregular times, sometimes set by Indians and sometimes by natural causes such as lightning.

Burning and various aspects of burning have been controversial subjects for many years. Therefore, the Kansas Agricultural Experiment Station began trials at an early date to study the effects of burning. Hensel (1923) compared early March burned plots with some unburned plots for the period 1918-1921. There was considerably more growth of grasses on the burned plots than on the unburned plots during the early part of the growing season. Later in the season, however, the vegetation on the unburned plots tended to grow more rapidly than that on the burned plots. In fact, the average clipping yield at the end of the season was slightly higher on the unburned plots. Due to favorable moisture relations during the period studied, the total number of grass plants increased 21 percent on the unburned plots. Little bluestem

(Andropogon scoparius) increased with burning while big bluestem (A. furcatus) and Kentucky bluegrass (Poa pratensis) decreased. The number of weeds decreased on the burned plots, while showing an increase on the unburned plots.

Aldous (1934) studied four dates of burning, late fall, early, medium, and late spring. Forage yields on all burned plots were reduced as compared to the control. The yield was lowest on the plots burned in the late fall followed by plots burned in early spring, medium spring, and late spring in that order. Aldous showed, however, that the warming of the soil, exposed by removal of the old tops and surface mulch, stimulated early spring growth. Furthermore, grazing use following burning was more uniform because the portions grazed unevenly during the preceding season have been eliminated.

Penfound and Kelting (1950), studying the effects of an accidental fire on the little bluestem pasture, showed that growth started earlier in the spring on the burned areas. Where there were some unburned areas among the burned areas, the intensity of grazing was greater throughout the season on burned areas than on unburned ones.

Hopkins, et al (1948) studied an area in the mixed prairie accidentally burned twice within a year, once in the fall and once in the spring. The spring burning was more detrimental than the fall burning. Basal area was reduced 38 percent in the fall burned area and 20 percent on the area burned in the spring in comparison with an adjacent unburned area in the short grass habitat. In the little bluestem habitat, there was a considerable loss of the various species as a result of the fire, with little bluestem losing 35 percent of its previous basal area. The burned area produced 1609 pounds of air dry forage per acre compared to 3824 pounds produced on the unburned area.

According to Hanson (1939), fire has for thousands of years been one of the chief initial causes of secondary plant succession. Some species are more resistant to burning than others. In a severe forest or brush fire or in repeated burnings on the same area, resistance to fire may be of no avail, but in lighter burnings, and usually in grasslands, fires are highly selective in their effects. Hanson also cited evidence that in West Virginia burning the dry grass in the spring tends to kill the more desirable species and at the same time increases the early spring growth of broomsedge (Andropogon virginicus). In western North Dakota burning might improve the grazing value of areas of little bluestem and sandgrass (Calamovilfa gigantea) which ordinarily have very low palatability in that environment, but it is more desirable to retain such vegetation as reserves against drought.

Transeau (1935) expressed relations of fire to forest and grassland. Burning favors the persistence of prairie species. As an ecological factor, fire in a forest climate retards development and may result in scrub, but it will not result in prairie. In a prairie climate, burning helps to maintain, and perhaps rarely enlarges, the prairie.

Borchert (1950) has discounted the theory advanced by pioneer settlers and many early scholars that the prairies are a result of burning. Fire may have been an important element helping to advance the prairie eastward during the post-glacial dry period and to retard the invasion of the prairies by forests from the end of the dry period to the time of white settlement. The relatively rapid advance of the forest in the eastern portions of prairie since white settlement suggests this. However, fire would simply have been one part of the ecological complex of a region with the climate of the grassland. There is no reason to elevate it above other elements in the complex which were also influenced by the climate. Since dry and dead vegetation burns easily, the grassland climates favor fire, just as they favor grass whether there are fires or not. The climate of the forests generally does not favor burning.

Of 34 northern California ranches that were burned to control brush, Sampson (1944) found that, after two years, 29 of the ranches showed rapid reoccupation by the original brush. The two factors most favorable to burning were, (1) grazing animals could get over most of the area, whereas this was often not possible before burning, and (2) more palatable vegetation generally became available after burning.

Blaisdell (1953) showed that a planned burning to control sagebrush had deleterious effects on grasses and forbs. Ultimately, however, rhizomatous grasses and forbs were benefited somewhat. Some of the finer bunch grasses were severely damaged and did not recover in 15 years. The main benefits obtained from burning were increased availability of herbage and greater ease in handling livestock.

Aldous (1934) showed that burning had little effect in controlling weeds and brush unless it was done in the late spring. However, for weeds or shrubs such as sumac that reached the low point in the organic food reserves later than May, burning was not an effective means of eradication.

Weaver (1951) reported some increase in yield of grasses on burned areas in ponderosa pine forests. The higher yield was due to the removal of competing vegetation and pine-needle mats. In southern Mississippi, Wahlenberg (1937) showed that the two dominant native grasses were thinned out severely by the smothering effect of dead vegetation which accumulated under protection from fire. On the areas burned annually the original proportion and density of native grasses were more nearly maintained.

Greene (undated), also working in Mississippi, studied the effects of burning on virgin longleaf pine soils. After nine years of burning the forage yield of burned plots was about double that of unburned plots. This also was due to the reduction of competition. The organic matter content was 1.6 times higher on the burned-over soils. Chemical analysis of the soil showed that annual burning returned the non-volatile fertilizing elements to the soil immediately. The number of soil microorganisms increased in the burned soils. Finally, the soil moisture was as high on burned plots as on unburned plots.

In Georgia, Halls, et al (1952) have shown that without grazing the dominant grasses increased with burning. The total ground cover of herbaceous species increased considerably the first few years but later tended to remain quite stable. Grazing, following burning, resulted in marked decreases of the two dominant grasses. This permitted other herbaceous species more tolerant to grazing to increase.

Burning of grazing lands also has been practiced for many years in other countries. There, also, the improvement of grazing lands may not be the sole reason for burning. According to Rueda (1952), burning of pastures has been practiced for many years in Columbia, especially in the warmer regions. Soil sterility and conditions favorable for erosion are among the serious results of burning. Therefore, burning is recommended only to control weedy plants or pests such as leaf-cutting worms.

In South Africa, Phillips (1931) showed that the veld, if left alone for a number of years, became rank and coarse, depreciated in grazing value, and the dead grass culms did not readily turn into humus. The best grasses gradually died out and were replaced by coarser ones. Burning aided in keeping the better grasses in dominance. Fire may also be a factor in maintaining an open or savannah condition on vast areas.

According to Scott (1952), there are two purposes for burning in Rhodesia, (1) to control deciduous shrub and, (2) to obtain young, green grass for grazing as soon as much of the grass has become unpalatable. To control the deciduous brush effectively, it is necessary to produce a fire hot enough to damage the young trees and seedlings. Therefore, it is necessary to rest the veld for at least a part of the previous growing season so that a large amount of dry forage remains to be burned. The burned veld must then be rested for a part or perhaps all of the growing season following the fire to allow the grass to reestablish itself. Burning for control of shrub must be carried out about once in five years. Annual burning to obtain young, green grass should be carried out after the first spring rains of half an inch or more in 24 hours.

A problem encountered in burning Flint Hills ranges is the poor soil moisture relationship. Aldous (1934) showed that total forage yield was greatly reduced on early burned plots, especially in dry seasons. The reductions in yield were due chiefly to the loss of moisture from increased runoff and evaporation. The burned pastures remained bare and unprotected from the time of burning until topgrowth appeared in late April. Therefore, the early burned plots lay bare and were subject to severe runoff losses.

Duley and Kelley (1939) showed that soils protected by residues took up water at a much faster rate than unprotected soils. The infiltration rates also were higher and remained at relatively higher levels throughout long periods of application. Sod land with grass clipped close and surface debris removed gave infiltration rates only slightly higher than those of bare, cultivated soil. Soils that are well covered with mulch and dead material, on the other hand, may have little or no erosion on slopes of 15 to 20 percent or more.

Dyksterhuis and Schmutz (1947) demonstrated that, over wide differences in soil type, mulch had a greater influence on infiltration capacity than soil type, initial moisture, and rainfall intensity combined. They found that the major effect of mulch in erosion control was the elimination of raindrop impact rather than reduction of overland flow velocity. The complete prevention of erosion ordinarily is possible only under a cover sufficiently dense and close enough to the soil surface to prevent splashing of soil by raindrops. Without a layer of natural mulch, even in climax vegetation, retrogression to grassland communities with lower water requirements and loss of soil may be expected.

Anderson (1951) pointed out that the effect of burning on the carbohydrate relationship within the plant has not been studied. It is probable that reduced forage yields may be brought about by carbohydrate depletion of the grazed plants since burning makes close, early grazing possible. On unburned areas, a protective mat of previous years forage may offer enough protection from close, early grazing to prevent this early carbohydrate depletion.

It has been established that botanical composition is one of the best criteria by which to judge range condition. Sampson (1919) showed that the best way to detect overgrazing was to recognize the replacement of one type of plant cover by another. In grasslands, forage value and carrying capacity are highest where the cover is composed of climax vegetation and lowest where the cover is made up of vegetation most remote from the climax. Dyksterhuis (1949) used the technique of estimating range condition by the degree of deterioration from climax vegetation for a given site. The trend of range condition may be ascertained by comparing estimates of range condition for several years. Aldous (1934) studied the effects of burning on plant succession and density. Plots burned in fall had the greatest number of plants per unit area followed by early spring, medium spring, check and late spring burnings. As a whole, little bluestem showed an increase in percentage on the burned plots while big bluestem showed little gain and frequently a loss. This probably was due to the drouthier conditions induced by burning which favored the shallower rooted little bluestem over the deeper rooted big bluestem.

Thus burning is not always an improvement practice. But since many cattlemen demand that the old growth be removed to make early grazing possible, it is necessary to study the best time to burn compatible with maintaining range resources.

MATERIALS AND METHODS

This study is designed to evaluate effect of date of burning. In this experiment early, medium, and late spring burnings have been compared.

Experimental Area

The pastures used in this study are located five miles northwest of Manhattan, Kansas. These pastures are part of a larger tract of 1143 acres which was purchased by the Kansas Agricultural Experiment Station in 1946. This tract is typical of the Flint Hills pastures, soils and topography of which have been described by Fly (1946).

The vegetation has been described by Anderson (1951) as predominantly true prairie vegetation. Big bluestem, little bluestem, and indiangrass make up at least fifty percent of the total vegetation on the more favorable sites. Kentucky bluegrass had invaded the entire area.

In 1950, an area of 132 acres in the northwest corner of the 1143 acre tract was divided into three pastures of 44 acres each. They were divided so as to get as nearly the same amount of upland and lowland in each pasture as possible. The pastures have been grazed at an average rate of six acres per animal unit since 1947. Since 1950, the pastures have been burned annually in early, medium, and late spring (Table 1).

Table 1. Burning dates.

Pastures	Years			
	1950	1951	1952	1953
9 (early burned)	March 24	March 22	February 26	March 13
10 (medium burned)	April 13	April 13	April 7	April 9
11 (late burned)	May 2	April 26	April 28	April 30

Range Site Determination

The pastures have been mapped into site categories to associate the vegetation complex with its environment (the site) as basis for interpreting population changes and also to aid in segregating the effects of treatment from effects of site. It has been shown by Anderson and Fly (1954) that there was some homogeneity in vegetative cover among these soil groups. Therefore some of the soil groups were combined with others to form range sites. Plate I is a map of the experimental area showing the soil groupings which are listed in Table 2. Range Site 1, ordinary upland, has been described as, "Lands having sufficient depth of soil with medium or loamy texture and hence with suitable soil-plant moisture relations to support the type of vegetation

EXPLANATION OF PLATE I

Soils map of the experimental pastures showing the soil groupings according to physical characteristics.

PLATE I


2M1DEal 4-1
4F3DE 5-1
3F21DE 15-1
4v F4CL 5-1
3M1DEal 5-1
2M1DEal 4-1
3gF4CL 20-1
3gF4C 20-1
3M1DEal 3-1
3vF3CL 5-1
4vF4CL 35-1
3Fr4C 3-1
4vF4CL 5-1
2F3U 6-1
3Fr4C 3-1
2F3U 6-1
4vF4CL 45-1
4vF4CL 20-1
4vF4CL 45-1
4vF4CL 25-1
2F3U 6-1
4vF4CL 5-1
2F3U 6-1
2F3U 6-1
2F3U 6-1
2F3U 6-1
3M1DEal 4-1
4vF4CL 5-1
XUX 3-1
XUX 3-1
4vF4CL 25-1
2F3U 6-1
4vF4CL 25-1
4vF4CL 25-1
2F3U 6-1
2F3U 6-1
4vF4CL 25-1

Table 2. Descriptions of soil mapping units and their groupings into vegetative sites.

Range sites	Survey mapping symbols[(a)]	Description of soil mapping units
1	2F3U / 6-1	Deep, moderately heavy, gently sloping colluvial soils with slight erosion.
1	4vF4CL / 5-1	Shallow, very stony, moderately heavy, gently sloping cherty limestone soils with slight erosion.
1	4vF4CL / 20 or 25-1	Same as above but strongly sloping.
2	4vF4CL / 35 or 45-1	Same as above but steep or very steep.
1	3vF3CL / 5-1	Moderately deep, very stony, moderately heavy, gently sloping cherty limestone soils with slight erosion.
1	3Fr4C / 3-1	Moderately deep, moderately heavy, very gravelly, gently sloping cherty soils with slight erosion.
1	3gF4C / 20-1	Moderately deep, gravelly, moderately heavy, strongly sloping cherty soils with slight erosion.
1	3gF4CL / 20-1	Same as above except cherty limestone soils.
1	4F3DE / 5-1	Shallow, moderately heavy, gently sloping loess shale soils with slight erosion.
3	3F21DE / 15-1	Moderately deep, moderately heavy, tight, strongly sloping loess soils with slight erosion.
5	2M1DEal / 4-1	Deep, medium textured, gently sloping loess shale soils with thin surface soils, slight erosion.
5	3M1DEal / 3 to 5-1	Same as above except moderately deep soils.

(a) Symbols are taken from national standard symbols for coding soil properties, U. S. Dept. of Agric. Soil Conserv. Service. Guide for Soil Conservation Surveys. 1951.

that is climax on the zonal soils of the regional climate." Range Site 2, limestone breaks, is similar to ordinary upland except that it occurs on steeper slopes. Range Site 3, clay upland, has a less permeable soil than ordinary upland. Range Site 5, claypan, has a thin surface soil underneath which is a semipermeable, columnar-structured soil. Sites 3 and 5 have less moisture available for plants, thus supporting a preclimax type of vegetation. In this experiment Sites 1 and 2 were found to have sufficiently homogeneous vegetative populations to permit combining the data obtained from them. Sites 3 and 5 were found to occupy such small areas as to make comparisons impractical. Plate II shows these range sites with similar vegetative cover.

Sampling Methods

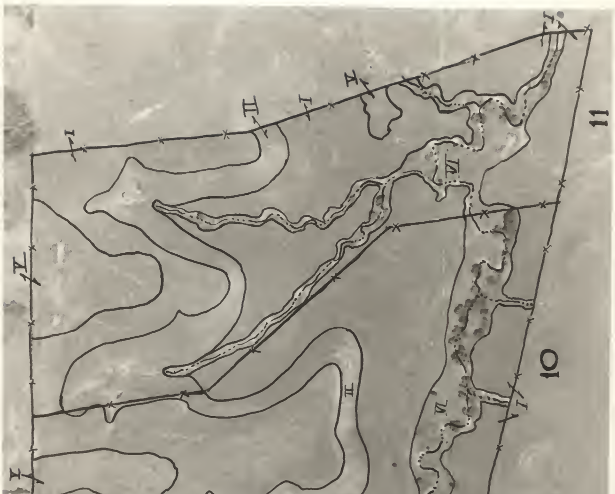
In this experiment, botanical composition has been studied by data obtained from randomized line-transect readings as described by Canfield (1941) and Parker and Savage (1944). The method was adapted by Anderson (1942) to the vegetation of the Flint Hills for both botanical composition and density estimates. Ten-meter lines were used for the sampling. It was assumed an area one centimeter wide was sampled giving each line an area of 1000 square centimeters. All live vegetation with its basal portion beneath the line and all upright culms touching the line were measured or counted.

The line transects were read at randomly selected places throughout the three pastures. A point was randomly selected near the southwest corner of each pasture. Lines were then read

EXPLANATION OF PLATE II

Groupings of range sites with similar vegetative cover.

PLATE II



at fifty-pace intervals in a northerly direction. Lines were read only if they fell in a vegetative site and not in disturbed areas such as stock trails or drainageways. Each group of lines read in a northerly direction made up a series. Several series of lines were read across each pasture. The location of each sampling site was marked on an aerial photograph of the pastures so that it could be placed in the proper range site as later determined by soil survey. The lines were read in June and July in 1947 and each year after burning started in 1950. The 1947 data were taken after a year of moderate stocking on all the pastures. To avoid differences in sampling due to stage of maturity of the vegetation, sampling was concluded in each pasture at about the same time. This was accomplished by reading a small portion of a pasture, then proceeding to the next pasture, and so on until sampling was completed.

To measure the top growth remaining at the close of the growing season, clipping samples were taken. The clippings were taken within a three-sided metal square, measuring 25.04 inches on each side, thus enclosing an area of 1/10,000 of an acre. Twenty-five clippings were randomly taken in each pasture. All the vegetation within the metal square was clipped at a height of one inch, oven dried for 48 hours, and weighed.

EXPERIMENTAL RESULTS

Line Transect Data

The density of the basal area of vegetative cover may be taken directly from the line transect data. Since each line samples an area of 1000 square centimeters, the total would give that part of 1000 occupied by vegetation, the remainder being bare ground or rocks.

An analysis of variance on the density of vegetation from Sites 1 and 2 for 1947 showed that the three pastures were statistically homogeneous. Table 3 shows a summation of the 1947 data. Analyses of variance were also calculated for the Site 1 and 2 data for 1951, 1952, and 1953, and are summarized in Tables 4, 5, and 6.

Table 3. Analysis of variance of total vegetation of Sites 1 and 2 in 1947.

Sources of variation	D/F	MS
Pastures	2	1634.9
Error	46	1122.1
Total	48	

The F value obtained in Table 3 is non-significant at the 5 percent level. Therefore, the hypothesis that a homogeneous population was sampled may be accepted. Thus, it is henceforth assumed that any differences detected in the plant population is due to the treatment, date of burning.

Table 4. Analysis of variance of total vegetation of Sites 1 and 2 in 1951.

Sources of variation	D/F	MS
Pastures	2	343.9
Error	93	516.6
Total	95	

The F value obtained in Table 4 is non-significant at the 5 percent level.

Table 5. Analysis of variance of total vegetation on Sites 1 and 2 in 1952.

Sources of variation	D/F	MS
Pastures	2	348.1
Error	73	498.7
Total	75	

The F value obtained in Table 5 is non significant at the 5 percent level.

Table 6. Analysis of variance of total vegetation of Sites 1 and 2 in 1953.

Sources of variation	D/F	MS
Pastures	2	5221.5**
Error	106	829.0
Total	108	

The F value obtained in Table 6 has a probability of occuring less than one percent when sampling a normal population. Therefore, the hypothesis is rejected that a homogeneous population has been sampled. Table 7 shows the means of the 1953 data and least significant differences at the 5 percent level (L. S. D.*).

Table 7. Means and L. S. D.'s* for total vegetation on Sites 1 and 2 in 1953. Means are based on unequal number of samples.

Pasture	Mean	L. S. D.* between pasture 9 and 10	L. S. D.* between pasture 10 and 11
9	119.3	13.7	12.6
10	131.1		
11	144.2		

Table 7 shows that pasture 11 has a significantly greater total plant population than pastures 9 and 10. The difference between pastures 9 and 10 could be considered significant only if one used the 10 percent level rather than the customary 5 percent level.

The pasture means shown in Table 7 may also be converted into percentages by dividing by 10 since a 1000 square centimeter area was the sampling unit. This would show an average basal area coverage of 11.9 percent, 13.1 percent, and 14.4 percent for pastures 9, 10, and 11, respectively.

Table 8 shows the species composition of Sites 1 and 2 as the percent of total plant population by pasture and for the years 1951 to 1953. Perennial grasses have averaged 82.4 percent of the total population. Three species, big bluestem, little bluestem, and indiangrass, were present in amounts averaging above 10 percent each. Sedges and rushes make up an average 9.8 percent of the population, annual grasses 0.3, perennial forbs 5.8, annual forbs 0.9, and shrubs 0.8 percent. Grasslike plants made up a total of 92.5 percent, and broadleaf plants only 7.5 percent, of the total plant population.

Weaver and Hanson (1941) have shown that certain native grass species decrease under pressure while others increase. Anderson (1951) has listed the following perennial grasses as decreasers for the Flint Hills: big bluestem, little bluestem, indiangrass, switchgrass (_Panicum virgatum_), prairie junegrass (_Koeleria cristata_), and prairie dropseed (_Sporobolus heterolepis_). The following are given as increasers: side-oats grama

Table 8. Species composition of sites 1 and 2 as percent of total plant population by pasture and year, 1951-1953.

Species	1951 Pasture 9	1951 Pasture 10	1951 Pasture 11	1952 Pasture 9	1952 Pasture 10	1952 Pasture 11	1953 Pasture 9	1953 Pasture 10	1953 Pasture 11
	%	%	%	%	%	%	%	%	%
Big bluestem	28.4	22.0	22.8	24.8	23.9	24.7	24.2	23.4	21.9
Little bluestem	18.2	20.3	28.4	19.7	19.7	23.3	19.1	19.9	25.1
Side-oats grama	8.4	3.6	4.5	7.8	4.2	5.2	9.4	5.1	4.5
Buffalograss	0.1	0.2	0.3	0.0	0.6	0.0	0.3	1.4	1.3
Kentucky bluegrass	4.1	8.4	5.3	7.3	7.7	6.5	6.9	8.9	14.8
Indiangrass	17.9	20.4	19.8	16.8	16.6	22.3	10.8	11.1	11.7
Blue grama	0.1	0.0	0.2	0.7	0.0	0.1	0.4	0.5	0.4
Hairy grama	0.2	0.1	0.1	0.7	0.0	0.1	1.7	0.1	0.1
Sand dropseed	0.0	0.1	0.0	0.0	0.0	0.2	0.3	0.3	0.0
Switchgrass	1.1	0.7	0.3	0.5	1.0	0.7	0.5	0.7	0.6
Purple lovegrass	0.9	0.9	0.8	0.0	0.0	0.0	0.5	1.3	0.3
Prairie junegrass	0.0	0.0	0.0	0.0	0.1	0.3	0.2	0.3	0.2
Scribner panic	0.7	1.6	1.3	0.5	1.4	1.2	0.2	0.8	0.7
Tall dropseed	3.7	2.0	2.1	2.1	3.1	2.6	1.5	2.7	1.8
Prairie dropseed	0.0	0.0	0.0	0.7	1.3	0.8	0.8	1.2	0.9
Other perennial grasses	0.1	0.5	0.3	0.7	0.4	0.1	0.4	0.5	0.2
Total perennial grasses	84.1	80.8	86.4	82.2	79.8	88.0	76.9	78.0	85.0
Sedges and rushes	9.3	10.9	7.8	11.3	13.7	7.6	9.1	11.5	7.3
Annual grasses	0.0	0.0	0.6	0.0	0.1	0.1	0.1	0.2	1.8
Perennial forbs	5.6	6.0	3.6	5.1	5.5	3.4	11.4	7.7	3.7
Annual forbs	0.5	1.5	1.0	0.2	0.2	0.3	1.7	1.1	1.6
Shrubs	0.5	0.9	0.6	1.2	0.8	0.7	0.9	1.6	0.5

(Bouteloua curtipendula), blue grama (B. gracilus), hairy grama (B. hirsuta), buffalograss (Buchloe dactyloides), Kentucky bluegrass, sand dropseed (Sporobolus cryptandrus), tall dropseed (S. Asper), scribner panic (Panicum scribnerianum), and purple lovegrass (Eragrostis spectabilis). These 15 species comprise more than 99 percent of the total perennial grasses.

Table 10 shows the means in percent of total vegetation of the three major decreasing species, big bluestem, little bluestem and indiangrass. The remaining three species, switchgrass, prairie junegrass, and prairie dropseed make up only a small percentage of the population and are combined under "others." Table 9 shows the appropriate analyses of variance making it possible to use the L. S. D. to detect the significant differences in the means shown in Table 10.

Table 9. Analyses of variance for Site 1 decreasers for 1951, 1952, and 1953, separately.

Sources of variation	D/F	MS
1951		
Pastures	2	44.9
Species	3	3058.0**
Pastures x Species	6	113.8**
Samples, same pasture and species	88	18.3
1952		
Pastures	2	66.9*
Species	3	2528.9**
Pastures x Species	6	25.2
Samples, same pasture and species	88	17.8
1953		
Pastures	2	23.2
Species	3	2726.3**
Pastures x Species	6	29.7
Samples, same pasture and species	96	27.1

* indicates significance at the 5 percent level.
** indicates significance at the 1 percent level.

Table 10. Site 1 and 2 decreasers as average percent of total vegetation, using the L. S. D.* to detect differences. Means are based on unequal number of samples.

	Years								
	1951			1952			1953		
	Pastures								
Species	9	10	11	9	10	11	9	10	11
	%	%	%	%	%	%	%	%	%
Big bluestem	28.4-*-22.0		22.8	24.8	23.9	24.7	24.2	23.4	21.9
	/=----*-------/								
Little bluestem	18.2	20.3-*-28.4		19.7	19.7-*-23.3		19.1	19.9-*-25.1	
	/-----*-------/						/-----*------/		
Indiangrass	17.9	20.4	19.8	16.8	16.6-*-22.3		10.8	11.1	11.7
				/-----*------/					
Others	1.1	0.7	0.4	1.2	2.3	1.8	1.5	2.1	1.7

* indicates differences which are significant at the 5 percent level. All other comparisons within a species and a year are non-significant. Values between which the asterisks appear differ significantly.

Table 10 shows a definite decrease of big bluestem in the early burned pasture and of indiangrass in all pastures in 1953.

Table 11 shows an analysis of variance for the total percent of decreasers in Sites 1 and 2 for each pasture for three years. Before calculating the analysis of variance, a test of homogeneity of variances showed that the variances were decidedly non-homogeneous. Therefore, results obtained from the analysis of variance should be interpreted conservatively. That is, only large differences should be considered significant.

Table 11. Analysis of variance for total percent of decreasers in Sites 1 and 2 for pastures and years.

Sources of variation	D/F	MS
Pastures	2	55.8*
Years	2	69.8**
Pastures x Years	4	2.1
Error	68	11.6

Table 12 shows the average total percent of decreasers and significant comparisons using the L. S. D. (5 percent level).

Table 12. Pasture-Year means for total percent of decreasers, using the L. S. D. * to detect differences. Means are based on unequal number of samples.

	Pasture			
Year	9	10		11
	%	%		%
1951	65.7	63.4	*	71.4
1952	62.4	62.4	*	72.2
	*	*		*
1953	55.6	56.5	*	60.4

* indicates differences which are significant at the 5 percent level, all other comparisons are nonsignificant. Values between which the asterisks appear differ significantly.

Table 14 shows the means in percent of total vegetation of the three major increasing species, side-oats grama, Kentucky bluegrass, and tall dropseed. The remaining six species, blue grama, hairy grama, buffalograss, sand dropseed, scribner panic, and purple lovegrass make up only a small percent of the population and are combined under "others." Table 13 shows the appropriate analyses of variance making it possible to use the L. S. D. to detect the significant differences in the means of Table 11.

Table 13. Analyses of variance for Site 1 and 2 increasers for 1951, 1952, and 1953, separately.

Sources of variation	D/F	MS
1951		
Pastures	2	12.5
Species	3	114.9
Pastures x Species	6	29.2**
Samples, same pasture and species	88	9.4
1952		
Pastures	2	7.0
Species	3	201.6**
Pastures x Species	6	6.8
Samples, same pasture and species	88	17.6
1953		
Pastures	2	5.7
Species	3	317.7**
Pastures x Species	6	43.0
Samples, same pasture and species	96	44.8

** indicated significance at the 1 percent level.

Table 14 shows only small differences within species for the three dates of burning over a period of three years.

Table 15 shows an analysis of variance for the total percent of increasers in Sites 1 and 2 for each pasture for three years. Before calculating the analysis of variance, a test of homogeneity of variance showed that the variances were decidedly non-homo-

Table 14. Site 1 and 2 increasers as average percent of total population using the L. S. D.* to detect differences. Means are based on unequal number of samples.

Species	1951			1952			1953		
	Pastures								
	9	10	11	9	10	11	9	10	11
	%	%	%	%	%	%	%	%	%
Side-oats grama	8.4-*-	3.6	4.5	7.8	4.2	5.2	9.4	5.1	4.5
	└-----*-----		-----┘						
Kentucky bluegrass	4.0-*-	8.4-*-	5.3	7.3	7.7	6.5	6.9	8.9	14.8
Tall dropseed	3.7	2.0	2.1	2.1	3.1	2.6	1.5	2.7	1.8
Others	2.1	2.9	2.7	2.0	2.1	1.6	3.2	4.3	2.8

* indicates differences which are significant at the 5 percent level, all other comparisons within a species and a year being non-significant. Values between which the asterisks appear differ significantly.

geneous. Therefore results obtained from the analysis of variance should be interpreted conservatively, that is, only large differences should be considered significant.

Table 15. Analysis of variance for total percent of decreasers in Sites 1 and 2 for pastures and years.

Sources of variation	D/F	MS
Pastures	2	4.9
Years	2	29.8*
Pastures x Years	4	3.9
Error	68	7.9

Table 16 shows the average total percent of increasers and significant comparisons using the L. S. D. (5 percent level).

Table 16. Pasture-Year means for total percent of increasers, using the L. S. D.* to detect differences. Means are based on unequal number of samples.

	Pasture		
Year	9	10	11
	%	%	%
1951	18.3	16.9	14.7
1952	19.1	17.0	15.8
		*	*
1953	21.0	21.0	24.0

* indicates differences which are significant at the 5 percent level, all other comparisons are non-significant. Values between which the asterisks appear differ significantly.

Clipping Data

As the 1953 growing season progressed, there appeared to be a difference in the amount of ungrazed top growth remaining on the three pastures. Visually, it appeared that the late burned pasture had a greater amount than the medium burned pasture and that the medium burned pasture had a greater amount of forage than the early burned pasture.

Table 17 is an analysis of variance of the clipping data. The non-significant F value suggests that a homogeneous population was sampled. If there was a true difference in the yields of top growth, the clipping data failed to show it. The average yield of top growth remaining at the close of the growing season was approximately one ton of dry matter per acre.

Table 17. Analysis of variance on clipping data on Site 1 and 2 in 1953.

Sources of variation	D/F	MS
Pastures	2	35.3
Error	72	1808.9
Total	74	

DISCUSSION AND CONCLUSIONS

It is the goal of those engaged in range research to obtain maximum livestock production consistent with the maintenance of the forage resource. This study is, therefore, concerned with the least harmful time to burn pastures, if burning is to be practiced, and with maintenance of high forage yield. The botanical composition and vegetative density are two of the most useful criteria by means of which to estimate range condition, and, over a period of years, to detect trend in range condition.

Before it is possible to make satisfactory comparisons of vegetative populations, it is necessary to establish vegetative sites based on soil survey. Such a survey is a satisfactory basis for comparison and makes it possible to place samples into groups that would reflect the responses to treatment. This permits more accurate interpretation of research data. Table 2 shows the soil groups that make up the various vegetative sites on the experimental area. Comparisons of vegetative composition are made only on Sites 1 and 2 because Site 3 does not occur in all pastures and Site 5 is present in such small areas that adequate sampling is impractical.

The vegetative density of the three experimental pastures was found by sampling to be homogeneous in 1947, before the burnings were started. Very small, non-significant F values were obtained for the 1951 and 1952 data (Tables 4 and 5), but the F value obtained for 1953 was highly significant (Table 6). Since 1950 and 1951 were abnormally wet years, it may be postulated that during those summers the vegetation on the early and medium burned pastures did not suffer from lack of soil moisture as they might have in normal or dry seasons. Extra summer rains compensated for losses of moisture from runoff and evaporation, and thus tended to offset the chief harmful effect of burning. However, the drouthy conditions of the summer of 1952 and the entire 1953 growing season reduced the vegetative density in the early and medium spring burned pastures. Table 7 shows that both the early and medium spring burned pastures had significantly less vegetative density than the late spring burned pasture. These results are contrary to the findings of Aldous (1934), who showed that, in ungrazed plots, vegetation became denser with early spring burning when compared to late spring burning. Therefore, it seems that the pressure of moderate grazing will tend to reduce the vegetative density less with late spring burning than with the two earlier burnings. Thus it may be concluded that late spring burning reduced vegetative density less than the other two burnings, and that leaving the ground bare for any period in the spring will tend to result in a drouthier condition than where cover has been maintained throughout the spring.

As to the botanical composition, studies have not been continued long enough to establish definite trends but certain changes can be noted. Table 8 shows the species composition of Sites 1 and 2 for the years 1951-1953. The decreasing species of grasses showed a significant decrease in all pastures in 1953. The percentage of decreasers in the late burned pasture remained higher than in the early and medium burned pastures (Table 12). Conversely, the increasing species showed a significant increase in the medium and late burned pastures in 1953 when compared to 1952 and 1951 (Table 16). Big bluestem showed a steady decrease in the early burned pasture while remaining fairly uniform in the other two pastures. Little bluestem showed a decline in the late burned pasture but still remained significantly higher than in the early or medium burned pastures. Big bluestem competes for moisture at a greater depth than little bluestem, emphasizing the hypothesis that the earlier burned pasture is drouthier than the late burned pasture. Indiangrass showed a large decrease in all pastures, but it may be noted that it did not decrease in the late burned pasture until the 1953 drouth. Kentucky bluegrass, which tends to disappear in drouthy areas, has shown a large increase in the late burned pasture.

The clipping data did not show a significant difference in forage top growth which visually appeared to be present. This suggests that the technique of taking clippings be thoroughly investigated, possibly deleting some of the heavier forbs which may tend to bias the weight of forage.

SUMMARY

An experimental area was set aside in 1950 to compare early, medium, and late spring burning. The area was divided into three pastures of equal size, with approximately the same amount of lowland, hillsides, and ridge-tops in each pasture. The pastures are moderately stocked, so that the observed responses may be assumed to be due to the effects of different dates of burning.

The pasture area was mapped, 12 different soils being grouped into three range sites. Each range site makes up a unit in which vegetation is homogeneous.

A study of the density of the vegetation showed that in drouthy years the difference between pastures is significant. The vegetation was significantly less dense on the early and medium burned pastures than on the late burned pasture.

An analysis of the total percent of decreasing species of grasses showed that there was a significantly larger amount of decreasers present in the late burned pasture than in the early and medium burned pastures. Also, there was a significantly smaller amount of decreasers present in all pastures in 1953 than in 1951 and 1952. These results emphasize the theory that burning places

pressure on the major climax species and causes a deterioration in range condition. If burning is to be practiced, however, the results indicated that late burning should be recommended.

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THE EFFECTS OF DATE OF BURNING ON
NATIVE FLINT HILLS RANGE LAND

by

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Burning has been practiced in the Flint Hills range land since the 1880's. Many of the southwestern cattle producers, who lease these ranges, demand that they be burned because burning permits earlier grazing.

This study is designed to evaluate effect of date of burning on native bluestem range lands under moderate grazing. Early, medium, and late spring burnings are compared on three 44-acre pastures. Burning started with the 1950 season. Since it is necessary to eliminate as much variation as possible between pastures to evaluate research data properly and to relate vegetation to its environment, the pastures have been mapped into site categories based on soil survey.

Four range sites were found on the experimental pastures, but only Sites 1 and 2, ordinary upland and limestone breaks sites, were present over a large enough area on the three pastures to make comparisons possible. Range Site 1, ordinary upland, is made up of soils having optimum characteristics to permit climax vegetation to grow. Range Site 2, limestone breaks, is similar to ordinary upland except that it occurs on steeper slopes. In this experiment, Range Sites 1 and 2 were found sufficiently homogeneous to enable combining the data obtained from these two sites. Both support vegetative populations of the regional climax.

In this experiment, botanical composition is studied by data obtained from randomized line-transect readings. Density and vegetative composition both may be studied from the data collected. The vegetative density was found to be homogeneous for the three pastures in 1947, the base year, and in 1951 and 1952. However, the vegetative density was found to be non-homogeneous on the three pastures in 1953. The average basal area coverage was found to be 11.9 percent, 13.1 percent, and 14.4 percent for the early, medium, and late burned pastures, respectively.

As to the vegetative composition, perennial grasses averaged 82.4 percent of the total population for the three years studied, 1951-1953. Three species, big bluestem, little bluestem, and indiangrass, were present in amounts averaging above 10 percent each. Sedges and rushes made up an average 9.8 percent of the population, annual grasses 0.3, perennial forbs 5.8, annual forbs 0.9, and shrubs 0.8 percent. Grasslike plants made up a total of 92.5 percent, and broadleaf plants, only 7.5 percent, of the total plant population.

The major decreasing species of grasses, big bluestem, little bluestem, and indiangrass, were analyzed individually for each year in an attempt to detect difference. Only minor variation, which may be attributed to sampling error, were detected. An analysis on the total percent of decreasing species of grasses showed that the late burned pasture had a significantly greater amount than the early and medium burned pastures. This analysis also showed a significantly smaller amount of decreasers in all pastures in 1953 than in 1951 and 1952. Conversely, there was an increase of the increasing grass species in 1953.

These results indicate that the drouth of mid 1952 which extended through 1953 placed undue pressure on the vegetation, resulting in a downward trend in range condition. Summer rains in 1950 and 1951 compensated for losses of moisture from runoff and evaporation, and thus tended to offset the chief harmful effect of burning. If burning is to be practiced, however, the results indicated that the late burning was not so detrimental as the early and medium spring burnings.