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DEFERRED GRAZING OF BLUESTEM PASTURES

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Proper grazing practices will make possible the maintenance of high-yielding bluestem pastures.

Deferred Grazing of Bluestem Pastures[1]

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INTRODUCTION

That part of Kansas known as the Flint Hills or bluestem pasture region occupies about five million acres. The original cover of native bluestem grasses still remains and is used for grazing on most of this area. A large portion of the land east of the Flint Hills is now cultivated, but there still remain in that section small acres that have never been cropped. Many of these areas are used as hay land and others are pastured.

In the Flint Hills most of the pastures are grazed by transient cattle from the ranges of the Southwest. These cattle are brought to pasture about May 1, or as soon as the bluestem grasses begin their spring growth, and are shipped out of the region as soon as they have made sufficient gains or have attained sufficient finish for marketing. Shipping begins as early as July and continues during the summer and early fall so that by September almost all of the transient cattle have been removed.

East of the Flint Hills most of the pastures are grazed by farm herds of dairy or beef cattle. These pastures usually are smaller, and are often more severely overgrazed than those in the Flint Hills. The bluestem grasses, the most desirable of the forage species, are grazed first and as a consequence are depleted almost to the point of complete elimination in some pastures. Brush, weeds, and weedy grasses have taken their place so that now these pastures are greatly reduced in productivity.

The bluestem pastures have steadily decreased in carrying capacity since they were first used extensively for grazing. Old grazing records show that prior to 1900 most of the bluestem pastures could be stocked at the rate of two acres for one mature cow or steer for a grazing season of six months beginning May 1. By 1933, or just before the recent years of drought, the best pastures could carry only one mature animal on four acres, while the average carrying capacity was five acres per animal. At the present time the average grazing capacity is about seven acres per animal.

Experiments were started about 25 years ago by the Kansas Agricultural Experiment Station in cooperation with Dan D. Casement, a cattleman at Manhattan, Kan., to obtain information on methods of grazing which would improve the productivity of native bluestem pastures. These experiments were planned and established in 1915 on typical bluestem pastures 10 miles north of Manhattan and detailed information was first recorded in 1916. Prior to 1913 these pastures had carried beef cattle at the rate of three acres per animal unit with no apparent damage to the grass. In 1914, four

1. Contribution No. 307, Department of Agronomy.

acres were allowed for each animal unit, but at the end of the grazing season the pasture seemed injured so that in 1915 five acres were allowed.

The early experiments were designed to study the effect of deferred and rotation grazing on the productivity and maintenance of stands of the bluestem grasses. Grazing was delayed until about September 1 each year on the deferred portion of the pasture. By that time the tall grasses had reached a fairly advanced state of maturity and had become greatly reduced both in palatability and in nutritive value. As a consequence it was not possible to obtain uniform or maximum utilization and about one-half of the vegetative cover remained at the end of the grazing season. In 1920, the date of deferred grazing was changed to June 15, allowing for some spring protection and also permitting the grass to be utilized while still leafy and palatable. By June 15, the grass usually had made sufficient growth to maintain its vigor under conditions of fairly close grazing.

TABLE 1.—*Effect of the deferred and rotation method of grazing on the carrying capacity of bluestem pastures. Acres per animal unit for 180 days.**

GRAZING PERIOD	1916	1917	1918	1919	1920	1921	1922	AV.
Season-long grazing	4.79	5.24	4.64	4.73	.....	.....	.....	4.85
Deferred until September 1	4.28	3.68	5.95	4.47	.....	.....	.....	4.62
Season-long grazing	.....	.....	.....	.....	3.67	4.10	4.55	4.11
Deferred until June 15	.....	.....	.....	.....	2.58	2.98	3.24	2.93

* Corrected for purposes of comparison to the equivalent of a six-month (180-day) grazing season.

During the four years when grazing was deferred until September 1, the carrying capacity[2] was about the same on the deferred pasture as on those grazed season-long (table 1). However, in the years 1920 to 1922, when grazing was deferred only until June 15, the deferred pasture had a decided advantage.

The grazing experiments on the Casement pastures were discontinued for a period after 1922 and resumed again in 1927 on a somewhat more elaborate plan. A deferred system of grazing was to be compared to season-long grazing by measuring gains of livestock and succession of vegetation in addition to the carrying capacity. Grazing on the pastures used season-long was started on the usual date, May 1. July 1 was selected as the date on which to begin grazing in the deferred pasture because root studies had shown that by this time, in a normal season, food storage in the roots of the native bluestem grasses had progressed to a point where the plant could maintain its vigor even though subjected to intensive grazing during the remainder of the season. The pastures had already been divided into four units, one large and three small, as follows: Pasture No. 1, 1,058 acres; pasture No. 2, 111 acres;

2. The term carrying capacity refers to the number of acres of pasture land required to graze a mature animal for the six-month grazing season (May-October).

pasture No. 3, 117 acres; and pasture No. 4, 125 acres. The original plan provided for grazing pasture No. 1 during the entire grazing season (May 1 through October), while the three smaller pastures were to be used in the deferred system, one to be protected until July 1 each year, after which it was to be grazed intensively in order to utilize the grass before it could become harsh and unpalatable. The others would then be deferred in turn in such a manner that each of the three smaller pastures would receive complete spring protection one year in each three. Failure of water supplies in pasture No. 4, however, made it necessary to abandon the original plan of rotating the deferred grazing. Instead, pasture No. 2 has been deferred, with a few exceptions, until July 1 each year. Occasionally a few head have been turned in before that date, and in three of the years, intensive grazing has actually been started before July 1. In 1929, grazing began on this pasture on April 24; in 1931, on May 28. In 1936, water shortgage in pasture No. 3 made it necessary to graze pastures Nos. 2 and 3 as a single unit, so grazing was started on May 6. Table 2 shows the dates on which the grazing was started each year in the various pastures. It will be noted that grazing was started on pasture No. 1 an average of 17 days earlier than on pasture No. 3. These are average figures, however, and are influenced by the fact that grazing on pasture No. 3 was deferred in 1929 and again in 1934. Furthermore, a few head of cattle were occasionally placed on pasture No. 1 in advance of the regular herd, and while this was recorded as the beginning of the grazing season, intensive use did not begin until the regular herd was turned into the pasture several days later. The difference between these two pastures in respect to the beginning of grazing is more apparent than real. More accurate measurements of the length of the grazing season may be seen in table 6, which shows the length of the grazing season per animal unit. Each animal unit remained on pasture No. 1 an average of 127.34 days per season and on pasture No. 3 an average of 130.46 days. Thus, the grazing season has been approximately the same on the two pastures. The grazing season was ended on all of the pastures at approximately the same date each season. This date was influenced somewhat by weather conditions, but usually occurred about the last of October, for by this time the bluestem grasses had become quite harsh, unpalatable, and depleted of much of their nutritive value. The dates on which the grazing season ended are also shown in table 2.

The pastures have been grazed by a breeding herd of purebred Hereford cows and May calves together with a few steers and heifers. There may be some criticism for not using steers of a definite age, as this would probably provide more accurate data, yet the conditions resulting from the use of a breeding herd more nearly approximate those of ranches producing beef cattle. Fairly large numbers of livestock have been used as indicated in table 3, a fact which greatly increases the reliability of the results. The total number of grazing animals in terms of animal units, four calves taken to equal one animal unit, are shown in table 3.

TABLE 2.—*Grazing seasons on Casement experimental pastures, 1927 to 1938, inclusive.*

PASTURE	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	Av.
No 1 On	4–1	4–19	4–23	4–15	4–17	4–22	4–25	4–20	5–1	4–25	4–19	4–25	4–20
Off	*10–30*	*11–30*	*11–9*	*11–1*	*11–4*	*11–12*	*11–17*	*10–30*	*10–1*	*11–20*	*11–15*	*11–9*	*11–7*
No. 2 On	7–1	7–1	4–24	6–24	5–28	6–28	6–27	6–25	7–1	5–6	6–18	7–25	6–16
Off	*10–31*	*11–22*	*11–10*	*11–1*	*11–5*	*10–29*	*11–14*	*10–25*	*10–20*	*11–4*	*10–29*	*11–1*	*11–3*
No. 3 On	4–20	5–7	5–20	4–24	5–1	4–21	5–5	6–22	5–14	5–6	4–28	5–5	5–7
Off	*10–31*	*11–29*	*11–10*	*11–1*	*11–5*	*10–29*	*10–28*	*10–27*	*8–5*	*11–4*	*11–13*	*11–1*	*10–29*

TABLE 3.—*Stocking record of Casement experimental pastures for deferred and season-long grazing. (1927-1938.)*

PASTURE AND AREA	Number of animals grazed by years.												Av.
	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	
No. 1 (1,058 A.)	352	327	322	368	416	388	335	407	344	254	351	349	351.0
No. 2 (111 A.)	132	82	92	122	207	.96	126	105	82	66	89	113	113.3
No. 3 (117 A.)	69	54	51	52	60	.92	63	51	30		63	107	63.1
	Number of animal units												
No. 1 (1,058 A.)	259.0	247.5	247.5	259.2	284.8	247.0	253.5	380.0	262.8	222.5	253.5	264.0	267.4
No. 2 (111 A.)	84.0	52.0	58.3	77.0	130.5	60.0	79.5	73.5	73.0	52.5	57.5	71.0	74.2
No. 3 (117 A.)	43.5	37.5	33.0	37.0	39.8	68.7	40.5	37.5	30.0		46.3	71.8	44.1

CLIMATIC CONDITIONS

The period during which this experiment was conducted includes one of the most severe droughts ever recorded in Kansas. Not only has rainfall been deficient, but summer temperatures have been unusually high, especially in 1934 and 1936. Table 4 contains a summary of the rainfall data measured during the growing season (March to November, inclusive) at the experimenal pastures. A rain gauge was located near the center of the area at the beginning of the experiment, and was visited after each shower. A summary of the temperatures for the months of May to September, inclusive, is contained in table 5.

From 1927 to 1931 rainfall had been fairly abundant and reasonably well distributed through the growing season (tables 4 and 5). Temperatures were favorable for growth of the prairie grasses. In 1932 and 1933, temperatures were about normal, but the rainfall was somewhat deficient although fairly well distributed. During the growing season of 1934, however, the rainfall was only about one-half of normal. June rains were deficient; July had no rain at all; while August had less than an inch which came in the form of light scattered showers, too small to be of any value in adding moisture to the soil.

This severe drought was accompanied by extremely high temperatures which added further to the damage resulting from the lack of moisture. During the summer of 1934, a total of 64 days had a maximum temperature of 100° or more. Maximum daily temperatures for the 46-day period, July 1 to August 15, averaged 107.7°F. During this period, only four days had maximum temperatures of less than 100° whereas the temperatures reached 110° or higher on 22 days, a maximum of 115° being recorded on July 14 and 15.

The summer of 1935 was less severe, although no rain fell in July and the temperatures were fairly high. In 1936, however, drought. and heat were almost as intense as in 1934. Rainfall was deficient in June, July, and August, totaling only 3.16 inches for the three months. May and June were warmer than in 1934, and the hot weather continued well into the fall. The 1937 grazing season was less severe than that of 1936. Summer rainfall was higher, and average temperatures somewhat lower, although the fall months were extremely dry. This, however, is less harmful to the bluestem grasses than summer drought. In 1938, summer rains were abundant until mid-August, after which no rains of any consequence fell until November. The summer temperatures were considerably more moderate than during the preceding five summers. This resulted in general improvement in the vegetative cover of bluestem pastures in the Flint Hills pasture region of Kansas. In both 1937 and 1938, large quantities of seed were produced by the native grasses. Another factor that influenced this general improvement in the bluestem pastures was the fact that the severe droughts of 1934 and 1936 had forced considerable reductions in stocking rates, and when the climatic conditions again approached normal the cattle population had not yet been increased. The result was light grazing, which virtually amounted to partial protection. This was undoubtedly of great benefit to the grass.

TABLE 4.—*Amounts of rain received during grazing season at Casement experimental pastures, 1927 to 1938, inclusive.*

	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
April	3.73	1.04	9.72	5.56	3.07	1.91	2.86	0.13	0.68	1.55	1.75	2.86
May	1.47	2.65	14.35	4.99	3.38	2.43	2.57	3.72	6.23	5.68	1.85	1.05
June	7.96	5.55	5.24	5.13	1.44	4.91	0.62	1.39	3.53	1.25	2.51	7.62
July	3.52	8.31	1.15	1.00	2.64	3.41	4.06	0.00	0.00	0.82	7.60	4.41
August	5.37	7.00	1.36	4.67	6.20	6.82	5.88	0.98	9.01	1.09	1.53	4.47
September	4.43	1.03	1.62	3.13	8.49	2.91	5.73	5.26	6.26	5.10	0.63	3.45
October	2.22	1.02	4.63	5.85	1.40	0.47	0.96	0.87	3.06	2.33	2.15	0.76
November	0.09	5.39	1.13	3.10	5.21	0.44	0.20	3.46	2.95	0.00	0.67	0.27
Totals	28.79	31.99	39.20	33.43	31.83	23.30	22.88	15.81	31.72	17.82	18.69	24.89

TABLE 5.—*Temperature data recorded at Manhattan during the summer months of 1927-1938, inclusive.*

YEAR	May			June			July			August			September		
	Mean max.	Mean min.	Mean av.	Mean max.	Mean min.	Mean av.	Mean max.	Mean min.	Mean av.	Mean max.	Mean min.	Mean av.	Mean max.	Mean min.	Mean av.
1927	75.5	53.2	64.4	81.3	61.5	71.4	88.2	64.7	76.4	81.5	60.5	71.0	80.8	59.3	70.0
1928	79.5	51.5	65.5	79.0	57.7	68.4	88.1	67.5	77.8	89.1	64.5	76.8	80.4	53.3	66.8
1929	70.7	51.7	61.2	84.1	61.9	73.0	90.1	68.9	79.5	90.5	66.8	78.6	80.5	56.1	68.3
1930	76.4	52.5	64.4	84.7	61.4	73.0	98.3	68.9	83.6	94.9	67.2	81.0	85.7	58.7	72.2
1931	74.4	49.1	62.7	91.5	67.1	79.3	97.5	68.6	88.0	87.5	62.8	75.1	90.7	66.1	73.4
1932	73.5	52.4	66.0	86.7	62.2	74.4	95.3	69.0	82.2	93.2	66.3	79.8	83.4	53.6	68.5
1933	78.0	52.9	65.4	100.0	67.1	83.6	95.6	68.3	82.0	91.2	65.6	78.4	87.6	62.2	74.9
1934	84.9	55.9	70.4	98.2	69.0	83.6	106.4	73.9	90.2	102.1	71.1	86.6	81.7	53.0	67.4
1935	69.2	51.2	60.2	82.0	59.9	71.0	100.5	72.8	86.6	95.0	67.7	81.4	82.3	58.4	70.4
1936	80.0	58.0	69.0	93.2	63.0	78.1	104.3	71.7	88.0	101.7	70.7	86.2	84.7	63.1	73.9
1937	79.8	54.5	67.2	88.3	63.7	76.0	97.2	68.6	82.9	98.4	70.7	84.6	86.5	58.6	72.6
1938	75.0	53.5	64.2	85.9	63.0	74.4	95.6	68.6	82.1	97.2	71.2	84.2	88.0	58.2	73.1

SOILS AND VEGETATIVE COVER

The area occupied by the experimental pastures is typical of the Flint Hills or Kansas bluestem pasture region. It is rolling to hilly and characterized by thin soils, limestone out-croppings and loose, cherty rock. The area had been used for grazing for a great many years prior to the beginning of this experiment; but since it had always been grazed in a conservative manner, the stands of vegetation were in good condition. The area has been described by Aldous[3] both as to soil characteristics and vegetative composition.

EFFECT OF DEFERRED GRAZING ON CARRYING CAPACITY

The carrying capacity of bluestem pastures varies considerably, depending largely on previous management. A great many pastures depleted by overgrazing and drought cannot support more than one animal unit on ten acres. On many of the better pastures, however, only six or seven acres per animal unit are required. On the pastures leased to southwestern cattlemen, it is a common practice to start shipping cattle to market as early as July, after which no more cattle are brought in. This lightens the grazing load during the growing season, and aids materially in maintaining stands of grass; and as a result these commercial pastures often have higher carrying capacities than comparable pastures grazed by local cattle.

East of the Flint Hills where the native pastures are smaller and often severely depleted as a result of overgrazing and early spring grazing, the carrying capacity is much lower than in the Flint Hills. As a result of this depletion, most of the pastures are extremely weedy and, since weed competition further retards the growth of grass already weakened by overgrazing, the carrying capacities of pastures in that section have been still further reduced.

That deferred grazing is beneficial to the short grasses of the Great Plains has been known for a long time, but its effect on the tall grasses or bluestems had not been determined experimentally except in the preliminary work discussed earlier in this bulletin. Sarvis[4] reported that on native pastures at Mandan, N. Dak., an increase in productivity of about 28 percent resulted from the use of a three-pasture system of deferred and rotation grazing. Sarvis found that five acres in the deferred and rotation system were able to produce as much feed as seven acres grazed season-long. At Ardmore, S. Dak., Cole and his associates[5] obtained similar results with a two-pasture deferred and rotation system and stated that a three-pasture system would have been more desirable. This

3. Aldous, A. E. The effect of burning on Kansas bluestem pastures. Kansas Tech. Bul. 38. 1934.

4. Sarvis, J. T. (1923). Effects of different systems and intensities of grazing upon the native vegetation at the Northern Great Plains Field Station. U. S. D. A. Dept. Bul. 1170.

5. Cole, J. S., Kilso, F. L., Russell, E. Z., Shepherd, J. B., Stuart, D., Graves, R. R. (1927). Work of the United States Dryland Field Station, Ardmore, S. Dak., 1912-1925, U. S. D. A. Techn. Bul. 17.

TABLE 6.—*Effect of deferred grazing in carrying capacity of bluestem pastures.*

	Pasture No.	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	Av.
Average length of grazing season. Days per animal unit.	(1)	136.8	167.6	131.1	118.7	101.0	124.1	129.1	104.1	126.4	124.2	146.9	127.8	127.34
	(2)	89.3	119.6	111.5	111.1	65.9	105.9	90.7	97.3	50.6	154.3*	66.8	48.7	84.86
	(3)	191.0	197.3	142.3	143.6	167.8	90.8	162.9	119.7	67.0		162.1	54.3	130.46
Carrying capacity (stocking rate, acres per animal unit).	(1)	4.08	3.85	4.27	4.08	3.72	4.28	4.17	2.78	4.03	4.76	4.17	4.01	3.96
	(2)	1.32	2.13	1.91	1.44	0.85	1.85	1.40	1.14	1.50	4.34*	1.93	1.56	1.50
	(3)	2.69	3.12	3.55	3.16	2.94	1.71	2.89	3.12	3.90		5.23	1.63	2.66
Acres per animal unit on basis of 6-months season.	(1)	5.38	4.13	5.86	6.19	6.63	6.21	5.81	4.81	5.74	6.90	5.11	5.65	5.61
	(2)	2.66	3.21	3.08	2.33	2.32	3.14	2.78	2.11	5.34	5.06*	5.20	5.77	3.18
	(3	2.54	2.84	4.49	3.96	3.15	3.39	3.19	4.69	10.48		5.81	5.40	3.67
Grazing days per acre.	(1)	33.5	43.5	30.7	29.1	27.2	29.0	30.9	37.4	31.4	26.1	35.2	31.9	32.2
	(2)	67.6	56.0	58.5	77.0	77.5	57.3	65.0	64.4	33.4	35.5*	34.6	31.1	54.8
	(3)	71.0	63.4	40.1	45.4	57.0	53.4	56.4	38.4	17.2		31.0	33.3	45.2

* Pastures Nos. 2 and 3 grazed as one unit because of failure of water supply in pasture No. 3.

experiment has shown that deferred grazing has equally beneficial effects on the carrying capacity, productivity, and maintenance of the tall grasses.

Pasture No. 2 has been grazed for a shorter time each year than pastures No. 1 and No. 3, an average of only 84.86 days per animal unit as compared to 127.34 and 130.46 days for pastures Nos. 1 and 3, respectively (table 6). The stocking rates have been much heavier on this pasture, however, as shown by the same table. It has been necessary to stock pasture No. 2 heavily after deferring so as to utilize the grass while it is still succulent and palatable. During the time the pastures were actually occupied they have been stocked at the following rates:

Pasture No. 1, 3.96 acres per animal unit.
Pasture No. 2, 1.50 acres per animal unit.
Pasture No. 3, 2.66 acres per animal unit.

This does not represent the true carrying capacity, however, because of the difference in length of time the pastures have been occupied; so in order to permit direct comparisons, the carrying capacities have been calculated on the basis of a six-months grazing season (180 days). They are as follows:

Pasture No. 1, 5.62 acres per animal unit.
Pasture No. 2, 3.18 acres per animal unit.
Pasture No. 3, 3.67 acres per animal unit.

By either method of figuring carrying capacity, the deferred pasture has had the advantage over those grazed season-long.

Expressed in terms of grazing days, each acre in pasture No. 2 furnished grazing for one animal unit for a period of 54.8 days per year, while pasture No. 8 yielded 45.2 days and pasture No. 1 only 32.2 days of grazing per acre (table 6).

GAINS OF LIVESTOCK

Since 1929, gains of livestock have also been used in measuring the effect of deferred grazing as compared to season-long grazing.

Pasture No. 2 has outyielded the other pastures both in terms of beef per acre and in terms of gains per animal unit per day (table 7). Seasonal gains per animal unit were somewhat smaller, but in this respect it must be remembered that the cattle grazed pasture No. 2 an average of only 85 days per animal unit per year, as compared to 127 and 130 days on pastures Nos. 1 and 3, respectively; and that while the pastures were occupied, pasture No. 2 was stocked at a much heavier rate.

On pasture No. 2, an average of 1.5 acres was required to produce a gain of 114.9 pounds per animal unit per season. This gain was achieved in 85 days. On the pastures grazed season-long, 3.96 acres and 2.66 acres were required to produce average seasonal gains of 153.6 pounds and 134.6 pounds, respectively, per animal unit. It required about twice the acreage of pasture under season-long grazing as under deferred grazing to produce one-third greater seasonal

TABLE 7.—*Effect of deferred grazing of bluestem pastures on gains of livestock.*

	Pasture No.	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	Av.
Gains of livestock, pounds per acre	(1)	28.4	51.6	44.2	38.2	41.0	10.6	48.6	33.5	39.1	39.1	37.4
	(2)	93.2	66.5	111.2	60.2	71.6	6.4	55.6	57.0*	81.3	48.3	65.1
	(3)	62.2	33.7	78.8	37.1	74.4	—17.3	45.6		22.4	31.3	42.5
Gains per animal unit (pounds)	(1)	121.5	210.5	164.3	163.8	171.0	29.6	195.6	159.1	163.2	156.6	153.5
	(2)	177.6	95.8	95.4	111.3	100.0	9.7	79.1	247.6*	156.9	75.6	114.9
	(3)	220.7	106.5	232.1	63.1	214.9	—85.1	178.0		117.4	51.0	134.6
Gains per animal unit per day (pounds)	(1)	0.93	1.05	1.63	1.32	1.32	0.28	1.55	1.28	1.11	1.23	1.17
	(2)	1.61	0.86	1.45	1.05	1.10	0.10	1.56	1.60*	2.35	1.55	1.32
	(3)	1.55	0.74	1.38	0.69	1.32	—0.71	2.65		0.72	0.94	1.09

* Pastures Nos. 2 and 3 grazed as one unit in 1936 due to failure of water supplies.

gains per animal unit. Furthermore, it took 40 to 50 days longer to produce the larger gains on the season-long pasture (Table 6). If gains made during these 40 or 50 days, while the cattle were pastured or fed elsewhere, could be added to the gains made on the deferred pasture, the total summer gains would doubtless be considerably greater than those on the pastures grazed season-long. In this experiment it has not been possible to obtain these data.

The advantage of deferred over season-long grazing is clearly shown when the ability of the land to produce is used as the basis of comparison. For the ten-year period (1929-1938) the deferred pasture has yielded an average of 65.1 pounds of beef per acre compared to 37.4 pounds and 42.5 pounds for the pastures grazed season-long (pastures Nos. 1 and 3, respectively). This difference is more clearly understood when the daily gains of livestock are considered. Cattle on pasture No. 2 have gained an average of 1.32 pounds per animal unit per day as compared to daily gains of 1.17 and 1.09 pounds per animal unit on pastures Nos. 1 and 3, respectively. The advantage is partially due to the increased vigor and stand of the grasses resulting from spring protection, but it is also due to the abundance of feed present at the beginning of the grazing season. The grass on the deferred pasture had been permitted to reach a height of about 10 inches before the cattle were turned in to graze. The cattle could then graze without wandering about, whereas this is not always the case during the early part of the grazing season in pastures grazed season-long.

EFFECT OF DEFERRED GRAZING ON VEGETATIVE COMPOSITION

To measure the effect of grazing treatment on stand and composition of vegetation, a series of permanent quadrats or plots one meter square was established in the experimental pastures in 1927; 25 in pasture No. 1; 17 in pasture No. 2; and 15 in pasture No. 3. Vegetative counts made at approximately two-year intervals are shown in tables 8, 9, and 10. Instead of listing each culm or stem, a modified list-chart system was used in which single stems were listed and grass clumps charted. The area occupied by the clumps (in square centimeters) was then added to the number of single specimens of each species. It is recognized that this figure does not represent the true number of culms nor the true area occupied, but time and funds have not permitted listing; and had charting alone been used, it would have been difficult, if not impossible, to assign proper values to single specimens. Since this system has been used consistently throughout the experiment, it furnishes means of making fair and accurate comparisons between species and between seasons.

By comparing the trends in vegetative composition in the three pastures, it can be seen that all grasses were somewhat depleted by the droughts of 1934 and 1936. Kentucky bluegrass *(Poa pratensis)*

TABLE 8.—*Vegetative composition of pasture No. 1 (grazed season-long) (average of 25 meter-square quadrats).*

Vegetation per quadrat.

Year	Grasses									Totals.		
	Big bluestem (*Andropogon furcatus*)	Little bluestem (*Andropogon scoparius*)	Indian grass (*Sorghastrum nutans*)	Side-oats grama (*Bouteloua curtipendula*)	Sand dropseed (*Sporobolus cryptandrus*)	Buffalo grass (*Buchloe dactyloides*)	Kentucky bluegrass (*Poa pratensis*)	Hairy grama (*Bouteloua hirsuta*)	Others	Grasses	Annual weedy grasses	Weeds
1938	61.5	16	1.5	286.5	130	51	.....	26.5	18	591	78	20
1936	76	13.5	.5	109.5	49	22	.....	14.5	12	297	22	84
1935	83.5	11	4.5	70	37	13	.....	10.5	15.5	245	50	100
1932	181.5	161.5	87	167.5	18.5	27.0	92	28	90	853	28	75
1930	159	88.5	84.5	115	7.5	3	113.5	10.5	65.5	646.5	2.5	70
1928	227.5	148	1.5	101.5	8.5	.....	242.5	17.5	82	829	2	171
1927	198.5	205.5	2.5	82.5	19.5	.....	181	39	117.5	846	12	98

TABLE 9.—*Vegetative composition of pasture No. 2 (deferred) (average of 17 meter-square quadrats).*

Year	Grasses									Totals.		
	Big bluestem (*Andropogon furcatus*)	Little bluestem (*Andropogon scoparius*)	Indian grass (*Sorghastrum nutans*)	Side-oats grama (*Bouteloua curtipendula*)	Sand dropseed (*Sporobolus cryptandrus*)	Buffalo grass (*Buchloe dactyloides*)	Kentucky bluegrass (*Poa pratensis*)	Hairy grama (*Bouteloua hirsuta*)	Others	Grasses	Annual weedy grasses	Weeds
1938	83.5	77	34	348.5	18.5	.....	.....	.....	31.5	592	107.5	19
1937	72	79.5	.....	443.5	24.5	.....	.....	.....	24	643.5	6	117
1936	72	70	1	120.5	2	7.5	.....	1	4	278	3.5	60
1935	111	73.5	5.5	94.5	.5	.5	.....	8	16	309.5	1	95
1932	208	183	62	183	6	17	162.5	4	97.5	923	2.5	65
1930	221	108	94	153.5	1.5	10	189.5	3.5	88.5	869.5	2.5	94
1929	204.5	135.5	91	140	8	25.5	259.5	.5	49	913.5	16	72
1928	247	194	6.5	126	.....	.....	293.5	5	59	931	1	86
1927	228.5	157.5	5	110.5	2	.....	395	6.5	24	929.5	4.5	97

TABLE 10.—*Vegetative composition of pasture No. 3 (grazed season-long) (average of 15 meter-square quadrats).*

Year	Grasses									Totals.		
	Big bluestem (*Andropogon furcatus*)	Little bluestem (*Andropogon scoparius*)	Indian grass (*Sorghastrum nutans*)	Side-oats grama (*Bouteloua curtipendula*)	Sand dropseed (*Sporobolus cryptandrus*)	Buffalo grass (*Buchloe dactyloides*)	Kentucky bluegrass (*Poa pratensis*)	Hairy grama (*Bouteloua hirsuta*)	Others	Grasses	Annual weedy grasses	Weeds
1938	96	26.5	3	230	111	65	.....	8	44	583.5	46	27
1936	126	29.5	4.5	155	42	2	.....	16	32.5	407.5	118	79
1935	97.5	28	6.5	85.5	21	7	2	20.5	20.5	288.5	72	146
1932	178	93	44.5	152	17	93.5	65	35.5	108.5	787	11	47
1930	223.5	56.5	44	130.5	7	19.5	119	4	119	723	2.5	143
1929	193.5	87	31	129.5	13	18.5	174	.....	80.5	727	39.5	104
1928	214	138.5	14	125	16	23	243	5.5	66.5	845.5	.....	103
1927	284	168	7	103.5	41.5	240	136	14	4	998	16.5	97

suffered the greatest damage, having been completely eliminated in all three pastures in 1934, which is in agreement with observations on other Flint Hill pastures. It has failed as yet to reappear, but its loss is probably not so serious as it might seem to be because bluegrass is not considered a particularly valuable addition to the vegetation of the tall-grass prairie. Its growing season does not coincide with that of the native prairie grasses, but, occurs earlier in the spring and later in the fall. Bluegrass is usually in a semi-dormant condition during the summer when the pastures are being grazed most intensively and hence does not furnish good grazing at the time when the native pastures are being used to best advantage. The loss of bluegrass is considered by many cattlemen to have benefited the native pastures.

In this study of the trends of vegetative composition, the severe droughts of 1934 and 1936 must be considered as well as the years 1932 and 1933, when moisture supplies had already begun to be deficient. There was a general decrease in total population of grasses beginning in 1934 followed by slight recovery in 1937 and 1938. It will be seen that this recovery was due largely to the increases of side-oats grama *(Bouteloua curtipendula)* and the short, grasses, hairy grama *(Bouteloua hirsuta),* buffalo grass *(Buchloe dactyloides),* and sand dropseed *(Sporobolus cryptandrus).*

All three pastures have followed the same general trends from year to year in respect to these changes in vegetative composition, but there are a few differences which should be noted. First, little bluestem *(Andropogon scoparius)* was not so severely depleted in pasture No. 2 as on the other two pastures. Throughout the bluestem region, little bluestem has been one of the most severely damaged species because of its relatively shallow root-system and because of the fact that it is found largely along ridge-tops and in other rather droughty locations.[6] More vigorous plants are known to be better able to withstand adverse conditions, and the protection afforded by deferred grazing has no doubt had some effect in helping maintain better stands of little bluestem on pasture No. 2 than on those grazed season-long.

Another important difference between these pastures is that while they have all shown a general increase in the number of shorter, more shallow-rooted and drought-hardy grasses, this increase in pasture No. 2 has been practically limited to side-oats grama. In pastures No. 1 and No. 3 side-oats grama has increased, but not to the extent that it has in pasture No. 2. On the other hand, sand dropseed and buffalo grass have increased on pastures No. 1 and No. 3 and not at all on No. 2. Sand dropseed is not a desirable pasture species and is not readily taken by livestock; so where it has invaded the pasture in the place of side-oats grama, the carrying capacity is lower. Buffalo grass, on the other hand, is both nutritious and palatable, but is a much smaller plant than the

6. Weaver, J. E., and Albertson, F. W. (1936). Effects of the great drought on the prairies of Iowa, Nebraska, and Kansas. Ecol. 17(4):567-639.

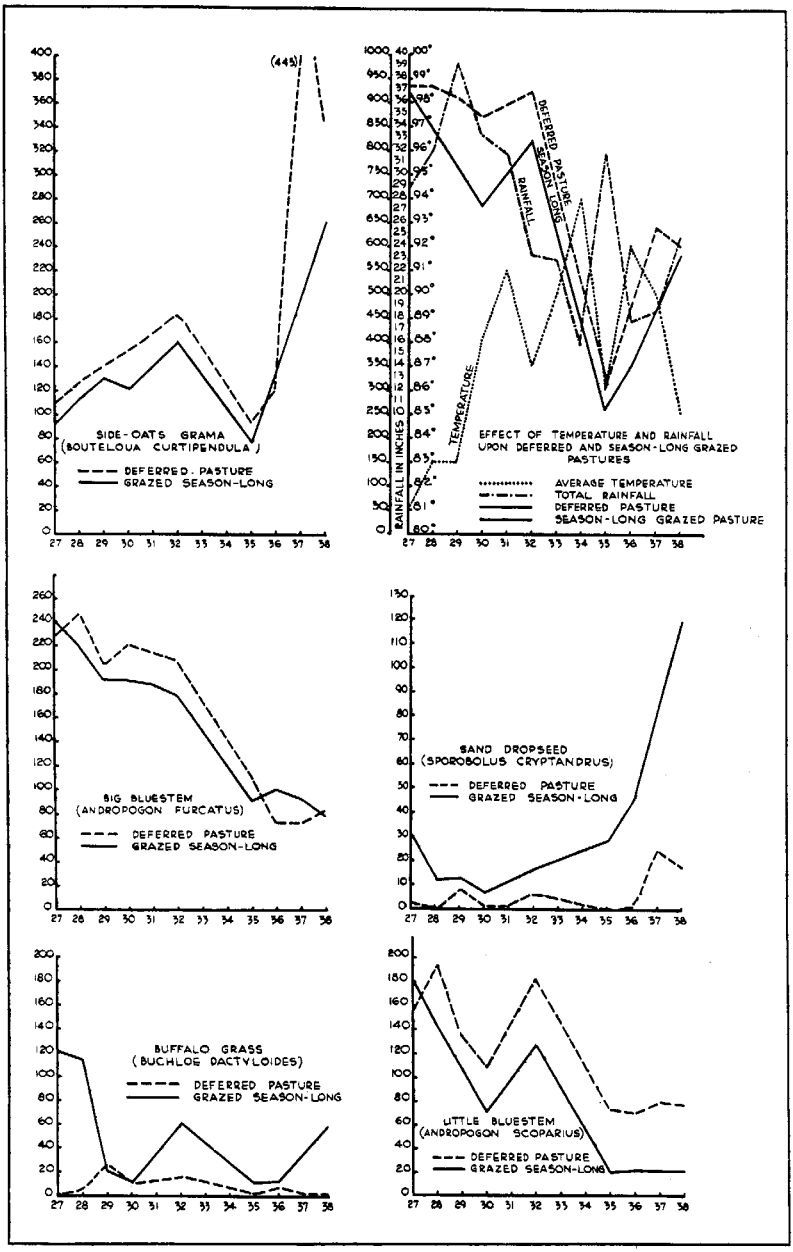


FIG. 1.—The effect of deferred grazing upon plant populations in bluestem pastures. (Taken from Tables 8, 9 and 10.)

bluestems and consequently has a lower carrying capacity. It is a much more desirable species than sand dropseed, however. These differences are clearly seen even by casual observation, the sand dropseed and buffalo grass being much in evidence on the pastures grazed season-long. The contrast between the pastures is clear along the fences that separate the pastures as seen in figure 2, which shows pasture No. 2 on the right and No. 3 on the left near the end of the grazing season. It is not probable that these differences in yield and carrying capacity can be attributed entirely to the changes in vegetation. While these changes undoubtedly play a part,, of more importance, perhaps, is the increased vigor of growth of the grasses resulting from spring protection in pasture No. 2. In addition, pasture No. 2 has always had a better protective cover at the end of the grazing season. This would tend to reduce water loss by runoff and the soil erosion that might result from such runoff. It would also tend to catch and hold snow. These factors make for increased amounts of available soil moisture and are reflected in increased yields of vegetation.

DISCUSSION

Grazing management is the most important factor in maintaining stands of grass and in maintaining the productivity of the land. Once a native pasture has been allowed to deteriorate, its restoration is a long and costly process, often involving years of protection from grazing and a great deal of tedious labor in weed control.

FIG. 2.—The deferred pasture on the right, over a ten-year period, has produced twenty-three pounds more beef per acre per year than the pasture on the left, grazed season-long.

An important part of any pasture-management program is the maintenance of the desirable vegetation. The grazing system must take into consideration the growth needs of the dominant species of pasture plants. This is especially true of grasses which, like the bluestems, cannot be plowed up and seeded down when stands become depleted.

Another factor which makes it imperative to maintain the bluestem pastures is that for the most part the land on which they are found is unsuited for any crop other than the native grasses.

Repeated experiments at the Kansas station and elsewhere have shown that perennial plants start their spring growth on reserve foods manufactured by the top growth of the previous season and stored in the roots. As spring growth becomes more rapid the drain on the food reserves becomes greater. Meanwhile, however, the new top growth begins to manufacture foods and when sufficient green growth has been produced, foods will be manufactured as rapidly as they are used up by the growth processes. As the plant becomes larger, more and more foods will be produced until there is an excess over the growth requirements. After this point is reached, storage in the roots is resumed and the root reserves are slowly built up for use in carrying the plant through the winter and for the initiation of new growth the following spring. It is important that the plant be allowed to attain considerable top growth in the spring before grazing is permitted. If the plant is clipped or grazed closely from the beginning of the growing season, it may never attain sufficient size to produce food as rapidly as the growth processes use it up.

When the top growth of a plant is removed at frequent intervals throughout the season, the plant is not permitted to store food in its roots but is forced, instead, to draw further upon reserve foods already present. The plant must then enter the winter dormant season in a starved and weakened condition, severely handicapped in its ability to make the proper growth the following spring. There will be not only a delay in the time of starting spring growth, but also a general reduction in yield and vigor. If excessive removal of top growth is continued year after year, the desirable pasture plants will be gradually eliminated by starvation and replaced by weeds or undesirable grasses.

Clipping experiments at Manhattan have demonstrated the effect of removing the vegetative growth before food storage had taken place. Yields of grass varied inversely with the frequency and closeness of clipping.[7] Stands of desirable vegetation on plots clipped each 2 weeks at a height of 1½ inches were almost completely eliminated by three seasons of such treatment. This is a considerably more drastic treatment than overgrazing, but it indicates what has caused the reductions of carrying capacity of the

7. Aldous, A. E. Effect of different clipping treatments on the yield and vigor of prairie grass vegetation. Ecol. 11(4):752-759. 1930.

bluestem ranges from two acres per animal unit to six or seven acres, the present, rating. The clipping experiment, accomplished in three seasons what has taken 40 years or more under season-long grazing.

A good system of grazing must permit maximum and uniform utilization of the forage, but it must also provide for the maintenance of a state of high productivity over a period of many years. Where the native pastures are concerned the productivity must be maintained indefinitely.

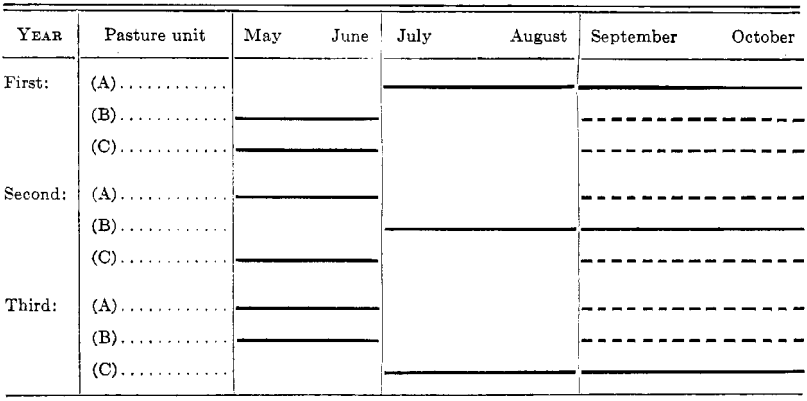
Deferred grazing provides such a system for the bluestem pastures of Kansas. On the short-grass pastures of the Great Plains, a system of deferred grazing can easily be established because the short grasses retain a great deal of their palatability and nutritive value after maturity so they can simply be reserved for fall or winter grazing. The bluestems present a somewhat different problem. They rapidly become harsh, unpalatable, and reduced in nutritive value as they mature and must, therefore, be pastured while in the growing condition if efficient utilization is to be had. Adous[8] has shown that the tall grasses made most of their growth during June, July, and early August. After this date they are low in protein and high in fiber. This need not prevent a pasture from being deferred, for the grasses are still growing rapidly when deferred grazing starts late in June. It is necessary, however, to complete the utilization of the forage at about the same time of year as under season-long grazing, so heavier stocking rates are possible. This heavy grazing permits rapid and efficient utilization of the forage.

There may be a tendency to permit extremely close grazing toward the end of the season on a pasture that has been deferred. This, however, should not be done, The same amount of vegetation should remain at the end of the season as in pastures grazed season-long, to serve as a protective cover during the winter and spring. In this experiment there has been a tendency to underutilize rather than overutilize, so a better than average protective cover has been left each fall.

A pasture may be deferred each year, if necessary, by providing other pasture until late in June; but fortunately, a pasture that is in fairly good condition does not have to be deferred each year. A plan has been developed whereby the pasture is divided into three units of approximately equal carrying capacity, each of which is deferred in turn so that at the end of three years each unit has been deferred. This plan is simply a modification of a deferred and rotation system, adapted to the tall-grass area. It allows spring protection, but permits utilization during the growing season as is seen in figure 3.

8. Aldous, A. E. Bluestem pastures. Kan. St. Board of Agric. Bienn. Rept. 33:184-191. 1931 and 1932.

FIGURE 3. *A plan for deferred system of grazing. The solid lines indicate the period when cattle are on the pasture, Dotted lines indicate the period when all three units can be grazed as one if necessary.*



Pasture unit A is deferred the first year, B the second, and C the third, according to this plan. While one unit is being deferred, the cattle are placed on the other two units. By July 1 the grass on the deferred unit will have made considerable top growth, and in order to utilize this efficiently it will have to be grazed rather quickly, so all of the cattle from the other two units are placed upon it. Later in the season, if the grass becomes closely grazed in the deferred pasture, the gates may be thrown open and all three units grazed as one. This period is indicated by the dotted lines in figure 3.

This system of grazing is especially applicable to pastures in private ownership and grazed by local cattle. Pastures grazed by transient cattle from the Southwest present a somewhat different problem. Leases usually demand that they remain on the same pasture throughout the grazing season, and until this can be changed, deferred grazing will have little place on the so-called commercial pastures.

SUMMARY

1. Experiments were started in 1916 to compare deferred and rotation grazing of the bluestem grasses with season-long grazing.

2. When grazing was deferred until September 1 the carrying capacity was not increased because it was not possible to obtain maximum or uniform utilization. However, when the beginning of the deferred grazing period was changed to June 15, there was a decided increase in carrying capacity.

3. The original set of experiments was discontinued in 1922, but since 1927 grazing deferred until July 1 has been compared to season-long grazing.

4. The deferred pasture has had a higher carrying capacity than those grazed season-long either in terms of time actually grazed or when converted to a six-months grazing season.

5. Gains of livestock have been greater on the deferred pasture than on the pastures grazed season-long. The deferred pasture has yielded an average of 65.1 pounds of beef per acre per grazing season compared to 37.4 pounds and 42.5 pounds for the two season-long pastures.

6. Gains per animal unit per grazing day have also been higher on the deferred pasture. Cattle on this pasture have gained an average of 1.32 pounds per animal unit per grazing day as compared to 1.17 pounds and 1.09 for the pastures grazed season-long.

7. Seasonal gains per animal unit have been somewhat smaller on the deferred pasture. However, it has required about twice the acreage on pastures grazed season-long to produce about one-third more gain per animal unit per grazing season. Furthermore, it has taken from 40 to 50 days longer each year to do this.

8. As a result of spring protection, stands of grass on the deferred pasture have been maintained in better condition in spite of the fact that it has been subjected to much harder use. At the end of each grazing season it has had a better cover of grass to afford protection against runoff and erosion during winter and spring.

9. Severe climatic conditions during the last several years of this experiment caused severe depletion of the grass population. Later when the depleted grasses were replaced, a great deal of sand dropseed and buffalo grass appeared on the pastures grazed season-long, whereas in the deferred pasture, side-oats grama was largely responsible for this replacement.

10. To permit deferred grazing, it is thought advisable to provide other forms of pasture during May and early June. For pastures where the stand and vigor of the vegetation are good, a plan of a deferred system of grazing is suggested in which supplemental pastures are not needed.