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Effect of Frequent Clipping on Plant Production in Prairie and Pasture*

J. E. Weaver and V. H. Hougen

The degeneration of native bluestem prairies of eastern Nebraska occurs slowly under moderate grazing or slight overgrazing but within two to five years where overgrazing is pronounced. Although the changes in the plant populations are continuous until the soil is finally almost bare, for convenience of study they have been grouped into several more or less distinct stages (Weaver and Harmon, 1935). An intermediate stage in deterioration is indicated by a great increase in the abundance of bluegrass (*Poa pratensis*), blue grama grass (*Bouteloua gracilis*), or buffalo grass (*Buchloe dactyloides*), the latter especially on low ground. Under long continued grazing and trampling, the native bluestems and most other prairie grasses disappear. This stage is characteristic of the bluegrass or short-grass pastures or a mixture of these. The purposes of this investigation were to ascertain the decrease in yield accompanying close grazing of virgin prairie, and to determine the relative yields of various types of prairie and of native pastures which replace them.

The clip quadrat method was employed, a total of 190 meter quadrats being used at six stations. Yield per unit area was determined at various intervals or at the end of the growing season. Height growth was used as a criterion of favorableness of environmental conditions, especially water content of soil and temperature, as well as an indicator of the effects of overgrazing. Dry weight of plants is one of the best quantitative characteristics of vegetation (Hanson, 1938), and increase in dry weight is the best measure of growth (West, Briggs, and Kidd, 1920). The clip quadrat has been widely used by numerous American investigators (Sarvis, 1923; Taylor and Loftfield, 1924; Aldous, 1930; Black, *et al.*, 1937) and has been found to be the most suitable form of the percentage production method on the grassveld in South Africa (West, 1936).

Although clipping studies serve as a valuable supplement to grazing experiments, they differ in several respects from actual grazing. The chief differences as observed by Culley, Campbell, and Canfield (1933) and others have been summarized by Weaver and Clements (1938) and the fact pointed out that clip quadrats are widely used.

In the early spring of 1933, typical experimental plots were selected in the several types of prairie and pasture at Lincoln, Nebraska. Exclosures were established and groups of meter quadrats laid out before the grasses resumed growth. The position in which the quadrats were placed was given careful consideration. The areas selected after years of acquaintance with the vegeta-

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tion were thoroughly representative of the conditions it was desired to study. The quadrats were located on typical sites to represent average conditions. The vegetation was clipped close to the ground with a pair of shears, care being taken not to injure the crowns. Although this treatment seemed severe, it was similar to grazing by cattle and horses confined to a portion of the same prairie which was fenced for pasturing in 1933. Similar close grazing was common nearly everywhere in the drought-stricken pastures and prairies of Nebraska and Kansas during 1934 to 1937.

LOCATION OF PLOTS

Little bluestem (*Andropogon scoparius*) consociation and the big bluestem (*A. furcatus*) consocieties were the two most extensive types of grassland occurring in true prairie. Because of their importance, three stations were selected in these types. One was in a nearly pure stand of little bluestem on a gentle north facing slope in the Belmont prairie just north of Lincoln. Small amounts of *Andropogon furcatus*, *Sorghastrum nutans*, *Poa pratensis*, and a few other grasses were present but forbs were not abundant. A second station was established on the lowland about a mile distant in an area of nearly pure *Andropogon furcatus* with small amounts of *Sorghastrum nutans*. A third occupied a west-facing slope in the Belmont prairie where the more mesic big-bluestem type at the foot of the hill first merged with and then gave way to the little bluestem and accompanying mid grasses on the upper slope. Three other stations were also selected: one in an adjoining upland pasture where *Bouteloua gracilis* and *Buchloe dactyloides* had replaced the bluestems, a second on the pastured lowland where these short grasses also occurred in nearly pure stands, and the third in a lowland pasture where the prairie grass had been replaced by bluegrass. All six stations were within an area of one square mile, hence aerial conditions were fairly similar. The upland soil is Lancaster loam, a mature soil of rolling topography derived from the Dakota sandstone formation. That of the lowlands is a colluvial phase of Wabash silt loam, immature, but deep and fertile. At the big-bluestem station it contained considerable sand.

WATER RELATIONS

Growth in the true prairie is so closely correlated with soil moisture, that a knowledge of the water relations is necessary to an interpretation of plant production. The year 1933 was preceded by one very favorable to growth, only one or two weekly periods during summer being without rainfall. With a single exception in the surface six inches, water was continuously available, at least in the amount of 3 to 5 per cent, at all depths to which the roots of grasses penetrate. Thus, the vegetation was in a vigorous condition when the experiment began.

Spring and early summer of 1933 were rather dry but there was much rain in July, drought during August, and an abundance of moisture late in August and in September. Available water content in the surface foot was nearly exhausted in June, but the deeper soil was continuously moist. Following an

abundance of moisture during midsummer, the surface soil became drier and dry soil extended deeper during the middle of August. This period was followed by abundant rainfall.

Water content of soil showed a deficiency during 1934. Following a dry winter, the rainfall in March was light. The heaviest rain in April or May did not exceed .24 inch. The entire summer was extremely dry, precipitation of only 2.47, .40, and 2.59 inches being recorded for June, July, and August, respectively. The abundant water supply in the first two feet of soil was greatly reduced during May and entirely depleted by midsummer. The moderate to small reserves of the deeper soil in spring were likewise greatly reduced in June and entirely depleted to a depth of 4 feet in August, the deeper soil to 6 feet retaining less than 2 per cent available moisture. Below 6 feet depth, moisture was constantly available throughout the drought, but only in small amounts. Drought continued during the winter and was not ameliorated until the following April.

The early spring of 1935 was dry, but rainfall of May, June, and July averaged about normal. Drought occurred during August. A fair to good water content of soil in spring and early summer promoted excellent growth. Soil moisture was depleted in August and the vegetation dried and practically ceased to grow.

STATION IN LITTLE BLUESTEM

A series of 20 quadrats was staked out in two groups of 10 each. The quadrats were spaced in such a manner that a distance of 12 inches intervened between the individuals in each row. They were in four parallel rows only a few feet distant. Five in each group were clipped, together with a marginal area 12 inches wide around each quadrat to insure lack of competition, and 5 only at the end of the growing season. This portion of the prairie had not been mowed the previous summer, but was burned early in the spring.

After each clipping, the plants renewed growth within a few days, the rate of growth varying chiefly with the water content of the soil. At the first cutting, on May 9, for example, the grasses were only 1.5 to 3 inches tall; at the second (May 27) about 5 inches, but on June 25 they averaged 7 inches in height. Even greater height (8 to 10 inches) was attained in July, but growth was progressively less thereafter. Growth of little bluestem in undisturbed, adjacent areas during the summer was determined at 7- to 15-day intervals by Flory (1936). Little bluestem increased from 1 inch in the single-leaf stage on April 26 to 11.5 inches on June 8. A height of 24 inches was attained by August, and about 40 inches when the flower stalks were fully developed in September.

Yields from the several quadrats were quite uniform, although not so high as during years of greater rainfall. The yield of the 10 control quadrats, cut on October 10 before the first killing frost, averaged 348 grams. This was 37 grams or 10 per cent less than the average yield from the quadrats clipped six

times. The increased yield from the clipped quadrats (Table 1) resulted in depletion of food reserves (Bukey and Weaver, 1938).

TABLE 1.—Yield in grams of air-dried material of clip quadrats of little bluestem during 1933.

No.	May 9	May 27	June 25	July 27	Aug. 27	Oct. 10	Total
1	20.4	61.0	111.0	118.8	75.7	22.0	408.9
2	21.4	54.5	91.8	115.0	71.2	24.8	378.7
3	17.0	66.0	89.8	112.1	78.0	27.4	390.3
4	12.8	59.0	76.2	100.6	69.7	24.2	342.5
5	20.0	76.5	114.0	118.2	76.8	22.4	427.9
6	19.6	77.5	109.8	115.7	73.7	21.1	417.4
7	21.0	73.0	99.2	120.9	79.4	23.1	416.6
8	18.2	67.7	88.5	108.8	62.0	22.2	367.4
9	17.0	66.2	70.0	109.1	60.9	19.1	342.3
10	19.5	61.7	78.8	114.0	66.4	20.3	360.7
Ave.	18.7	66.3	92.9	113.3	71.4	22.7	385.3
% yield 5		17	24	29	19	6	100

The late date of renewed activity of little bluestem is shown by its growth which was only 5 per cent of the season's yield on May 9, and 22 per cent by the end of May. The greatest growth occurred during June and July (53 per cent), it continued rather high during flower-stalk production in August, but was only 6 per cent thereafter. Flory (1936) has shown that the mean monthly production of dry matter (1931 to 1933 inclusive) of undisturbed prairie vegetation at this station was 2 per cent in April, 26 in May, 36 in June, 21 in July, 13 in August, but only 2 per cent in September.

During 1934, the clip quadrats of the preceding year were again clipped, but only 4 times, because of the extreme drought. The quadrats that were clipped but once, at the end of 1933, were also clipped 4 times, while a new lot of 10 adjacent quadrats was used as a control and cut only at the end of the season. The old growth of the previous year had been removed from them in early spring. Thus, in the fall total yields were had (a) from quadrats closely clipped for two seasons, (b) from those closely clipped one season, and (c) from unclipped controls.

Late in April, little bluestem in quadrats closely cut the preceding year was only one-half as tall as that in the controls, where it averaged 2.5 inches. Other plants gave similar differences. Moreover, the basal cover was sparser (Figs. 1 and 2). The low yields at the first clipping, on May 14, were the result of a poor early growth. Grass in the control quadrats was 5 to 8 inches tall, but that in the closely clipped ones only 2 to 5 inches. The clipped bunches were not filled with stems as were the controls, frequently they had living stems only around their borders.

Further study on June 2, after a single clipping, gave the following differences in height of grasses in the control, those clipped once in 1933, and those clipped closely in 1933 and 1934: little bluestem, 4 to 9, 2.5 to 5, and 2 to 4 inches, respectively, and big bluestem 8 to 11, 5 to 9, and 3 to 5 inches, in

the same sequence. With more frequent clipping, thinness of basal cover and an increasingly yellow-green color of the vegetation were clearly evident.

At the second clipping, on June 13, little bluestem was only 3 inches tall in quadrats clipped regularly the previous year, 5 to 8 inches in those clipped but once, but 6 to 10 inches in the new controls.

Grasses in the control quadrats were dried and had taken on their autumnal colors by July 22.* Those in quadrats clipped for the first year were 3 to 6 inches tall and, although somewhat wilted, they were fairly green. In quadrats cut closely the preceding year, plants were only 2 to 4 inches tall and the thin foliage was fresh and green. Clipping had reduced the water loss by transpiration and soil moisture was still available. Only 15 per cent of the total crop was produced after the third cutting on July 22.

The ten quadrats clipped only on October 20, gave an average yield of 135.5 grams. This was only 39 per cent as much forage as the ten control quadrats yielded the previous year. Except for a slight development following rains of September first, very little growth occurred after June 13, 1934. These new control quadrats yielded 20 per cent less than those clipped frequently for the first time in 1934, which produced an average of 170.2 grams. The grasses in the unclipped quadrats exhausted the available supply of water within reach of their roots earlier than did those whose demands for transpiration were frequently reduced by clipping. Hence, their growth continued slowly after the unclipped grasses had dried. Quadrats clipped frequently for a second year yielded only 68.7 grams or 51 per cent as much as the controls. Although these grasses also remained green, even after those clipped for the first year had finally dried, accumulated food was too greatly depleted to permit of much growth.

Cutting in 1935 was delayed until June 15. This was because of the severe drought of the previous summer which continued well into the spring of 1935. After two years of continuous close clipping, little grass remained alive. Clipping experiments on blocks of prairie sod (Biswell and Weaver, 1933) have clearly shown that few new roots are produced, while studies by Peralta (1935) on Sudan grass show that repeated clipping results in the death of the deeper root system somewhat in proportion to the number of cuttings. Little bluestem in the quadrats had nearly all died (Figs. 3 and 4). *Poa pratensis* showed an increase, big bluestem withstood the drought and close clipping quite well, and considerable side-oats grama (*Bouteloua curtipendula*) had appeared. The general grass level in the closely cut areas on June 15 was 4 to 8 inches. A thicker stand of grasses remained in quadrats cut closely but one year and the height was 7 to 10 inches. The stand was much denser in the control areas where the grass was 12 to 15 inches tall.

Abundant soil moisture resulted in good growth until terminated by drought about July 10. The quadrats were clipped six days later. The plants

* A complete description of the response of the prairie to the great drought of 1934 is given by Weaver, Stoddart, and Noll, 1935.



Fig. 1. Prairie at the little-bluestem station after mowing in the fall of 1933. Fig. 2. Similar area on Sept. 15, after one year of close clipping.

were so weakened and drought so severe that at the time of the last cutting, on September 10, the respective heights of foliage in areas cut two and one years and the controls were only 4.5, 5 to 7, and 16 to 20 inches. Flower stalks of little and big bluestem in the control quadrats were 30 and 40 inches tall, respectively. Yields are shown in Table 2.

TABLE 2.—Average yield in grams of air-dried material of quadrats of little bluestem during 1935.

Quadrats	June 15	July 16	Sept. 10	Total
Closely clipped 1933 and 1934	86.1	51.6	48.3	186.0
Closely clipped 1934	196.4	70.0	53.4	319.8
Controls .....	.....	.....	588.8	588.8

Examination of Table 2 shows not only the greatly decreased yield at each cutting of the quadrats most frequently clipped, but also the great decrease in total yield. Quadrats clipped during two preceding years produced only 58 per cent as much as those clipped during a single preceding growing season. Compared with the controls, the yield was only 32 per cent as great. Yield of plants clipped for two years was 54 per cent of that of the controls. Moreover, change in population was marked. Both bluestems practically disappeared and were replaced in part by side-oats grama. During 1936 this species formed a nearly pure, open stand, and indicated clearly its great increase which occurred over wide areas following the great drought.

Résumé

The year 1933 was only intermediately favorable to growth (yield of controls, 348 grams); 1934 was poorest (135.5 grams), and 1935 best (588.8 grams). The remarkable manner in which the grasses renewed growth after each of six cuttings the first year should be emphasized. Moreover, the yield of the several cuttings totaled 11 per cent greater than that of the controls. That this growth was made at the expense of reserve foods was clearly revealed by the reduced vigor and yield as well as by the high death rate the following season.

New controls the following year were again outyielded by new quadrats clipped four times. But yields from the grasses exhausted by frequent clipping during the preceding year were only 51 per cent as great as that of the controls, and 60 per cent less than quadrats clipped frequently for the first time. During the third year, quadrats clipped for a second year yielded only 54 per cent as much as the controls, and those clipped for a third year only 32 per cent as much. The effects of continuous close clipping are again shown by the fact that the quadrats clipped for a third year yielded only 58 per cent as much as those clipped two years. That two-thirds of the possible forage yield may be lost and the plants so greatly weakened by overgrazing for only three years is alarming. Yet the phenomenon, often intensified, has occurred in thousands of prairies and pastures throughout the west where drought left the ranges greatly overstocked.



Fig. 3. Little bluestem quadrat on Sept. 10, after two years of frequent clipping. Fig. 4. Similar quadrat after the vegetation had been clipped at frequent intervals for three seasons. Comparison with Fig. 1 reveals the almost complete destruction of the vegetation.

STATION IN BIG BLUESTEM

A group of 20 meter quadrats was selected for average cover on a plot of low, nearly level land on the flood plain of Salt Creek. The prairie had been mowed annually in September for a long period of years.

At the first cutting (May 9) the grass was only 1 to 4 inches high; at the second, on May 27, it was 4 to 7 inches tall, and at the third clipping, June 25, the foliage had again reached a height of 4 inches. In the control quadrats the grasses had attained a general level of 18 inches and a maximum height of 2 feet. This was about the normal height growth compared with that of previous years. At the fourth cutting (July 27) the average height was 6 inches, although a few flower stalks were 12 inches tall. On August 27, the grass had again reached a height of 7 inches; a few flower stalks were 18 inches tall and in the "boot" stage. *Euphorbia maculata* had become a bad weed forming 5 to 60 per cent of the basal cover. The general level of the controls was 32 inches but the flower stalks were about 5 feet tall.

The average yield from 10 control quadrats, cut on October 20, was 668.3 grams. This exceeded the average of the total partial yields (407.8 grams) by 64 per cent, differences being emphasized by the weight of the numerous flower stalks of the controls. Percentage distribution of yield was somewhat similar to that of little bluestem for the same season, being 9 per cent less during June and July and 5 per cent greater in August.

During 1934, three groups of 10 quadrats each were used. Those cut repeatedly in 1933 were clipped 4 times in 1934; the controls of 1933 were similarly clipped; and a new group of 10 quadrats was used as a control.

At the first cutting (May 15) the grasses in the control quadrats of the previous year were 6 to 10 inches high, those in the closely clipped ones only 3 to 5 inches. The latter were doing poorly and showed a greater invasion of bluegrass. By the first of June, the general level of big bluestem in the clip quadrats was 5 inches, that in the controls was 11. Although the drought was severe and growth retarded, the relatively shallowly rooted bluegrass was the only species that showed distress. At the time of the third clipping (July 22) the vegetation in the quadrats closely clipped in 1933 was very thin; the average height was about 5 inches. Lack of uniformity in growth was due in part to the drought since this was clearly apparent in the control quadrats as well, where the big bluestem was 8 inches tall and beginning to dry. In September, the grass in the control quadrats was only 10 to 12 inches tall. The areas closely clipped in 1933 had a new growth of 2 to 6 inches; but the grass in those cut frequently only during 1934 was 4 to 8 inches tall and the stand was much thicker.

The control quadrats on October 20 gave an average yield of 139.7 grams, which was only 21 per cent of the yield of the controls of the preceding year. Thus, the relative yield was reduced even more greatly than on the upland where the dry weight was 39 per cent as great as that of the 1933 controls (Table 3).

TABLE 3.—Yield in grams of air-dried material of clip quadrats of big bluestem during 1934.

Quadrats	May 15	June 13	July 22	Sept. 27	Total
Clipped 6 times, 1933	32.8	27.9	16.5	23.0	100.2
Per cent yield	33	28	16	23	100
Clipped once, 1933	56.4	42.1	32.0	27.6	158.1
Per cent yield	36	27	20	17	100
Controls .....	....	....	....	....	139.7

Quadrats clipped in 1934 yielded 158.1 grams, which was 13 per cent more than the controls. This was due to an expenditure of reserve foods in repeated renewal of growth, and to an increased soil-water reserve resulting from a decreased transpiring surface. Quadrats clipped for a second year gave an average yield of 100.2 grams which was only 72 per cent as great as the controls, and but 63 per cent as much as quadrats clipped closely only a single summer. Thus the destructive effects of continued clipping were clearly apparent. Owing to the burial of the area during the late summer of 1935 during artificial deepening of the creek bed, further data were not obtained.

Résumé

Behavior of big bluestem under frequent clipping resulted in continually renewed growth. Since the coarse, heavy flower stalks were not formed because of six clippings, these quadrats yielded only 61 per cent as much forage as the controls. But during the drought year (1934), when even the controls produced few flower stalks, the yield of four clippings from a new lot of quadrats exceeded that of the controls by 13 per cent. Thinning of the grass after a single year of clipping was marked and infestation of weeds pronounced. The yield during a second year of cutting was only 72 per cent of that of undisturbed quadrats. Quadrats clipped a second year yielded only 63 per cent as much as those similarly treated for a single year.

HILLSIDE STATION IN LITTLE AND BIG BLUESTEM

A portion of the Belmont prairie on rather hilly land had been fenced and used as pasture for cattle and horses. It was closely grazed for a single year (1932), after which a large enclosure was fenced against livestock. A similar, adjacent, ungrazed area in the prairie was also set aside for experimental purposes. These contiguous enclosures occupied a rather steep (10°) west-facing slope. Twenty representative meter quadrats were selected in the prairie and a similar number in the pasture. In both plots they extended from the top to the bottom of the slope. Alternate quadrats were clipped six times during 1933 and the remainder (controls) once, at the end of the season.

Renewal and rate of growth after clipping were similar to that at the preceding stations. Big bluestem grew about twice as rapidly as little bluestem which was also the first to degenerate and disappear. The quadrats, as

would be expected, gave an increase in yield from the top to the bottom of the slope. The average total yield of those cut six times was 332.9 grams. This was 2 per cent less than that of the controls (340 grams). In neither lot was the average yield as great as that from the quadrats on the gentle north hillside of the same prairie. The percentage seasonal yield was similar to that of the bluestems already recorded.

From observations in the pasture, it was evident by the middle of June that the bluestems had been handicapped by a single year of heavy grazing and trampling. Only remnants appeared above ground. Often the bunches and sods were merely outlined by living stems. Bluegrass, benefiting by the decreased competition of the native species, had increased rapidly. It partially filled the interspaces between the old prairie grasses, and, especially on the lower slopes, often formed a dense sod. By the end of the year it was in major possession of the entire lower slope. The dry season, however, was distinctly disadvantageous, the bluegrass appearing dead late in June.

The average total yield of the closely clipped pasture quadrats was 246.8 grams; yield of those clipped at the end of the season averaged 248.0 grams. This was a difference of less than 1 per cent from the yield of those clipped 6 times. Yields from these control pasture quadrats cut in October showed a decrease of 27 per cent over those similarly treated in the prairie. This decreased yield may be attributed directly to close pasturing in 1932. Percentage seasonal distribution of yield was similar in prairie and pasture.

Late in April of 1934, the prairie on the hillside was burned slowly against the wind. None of the cut quadrats in either prairie or pasture had enough materials to support a fire, but in this way a third lot of quadrats was cleared for use as a control in the prairie during 1934.

By May 13, one could easily select the clip quadrats of the preceding year in the prairie. Grasses and forbs were both greatly dwarfed. The stand was very open, and the grasses were only 2 to 5 inches tall as compared with 5 to 8 inches in quadrats cut only in the fall, where there was also a greater basal cover. In the clip quadrats *Poa pratensis* showed a marked increase on the lower slope and *Bouteloua gracilis* on the upper one. By midsummer all of the bluegrass and little bluestem had died on the mid and upper slope, but much of the more deeply rooted big bluestem survived.

The average yield of the ten new control quadrats, clipped on October 10, was 143.1 grams. This yield was only 42 per cent as great as from the ten control quadrats during the preceding year. Average yield from the previous controls, closely cut 4 times this season, was 139.5 grams, which was about 2 per cent less than the controls. The very low average yield (68.1 grams) from quadrats clipped two years was only 49 per cent of that from quadrats clipped during one year, and 48 per cent of the yield of the controls.

The pasture quadrats grazed or closely clipped for three consecutive years yielded only 39.5 grams. Those closely grazed one year, protected one year, and frequently clipped in 1934 yielded 97.5 grams or approximately 2.5 times

as much. The pasture yields, compared with those in prairie were, respectively, only 58 and 70 per cent as great.

The pasture had deteriorated so greatly that further studies were not made. In the prairie, data were secured during 1935 as shown in Table 4.

TABLE 4.—Yield in grams of air-dried material of clip quadrats from the bluestem hillside-prairie during 1935.

Quadrats	June 15	July 16	Sept. 11	Total
Clipped closely in 1933 and 1934	117.6	58.0	13.9	189.5
Clipped closely in 1934	150.1	68.5	25.9	244.5
Clipped once in 1934	---	---	---	426.6

Casual examination of Table 4 shows clearly the marked effects of continual clipping. Decreases from the control of quadrats closely clipped during two years were 43 per cent, and for three years (1933 to 1935 inclusive) they were 56 per cent.

Résumé

The yields from the mixed stand of little and big bluestem on the more xeric west slope were not greatly different from those afforded by little bluestem on the north hillside, except during the third year when they were about one-fourth less. During the first year, yields from both prairie and pasture were similar in that the dry-weight production from clipped and control mixed bluestem quadrats was only one or two per cent different. Yield from the year-old pasture, however, was approximately only 74 per cent as great. Here also invasion of bluegrass following the weakening of the bluestems was marked.

Yields of prairie quadrats clipped one and two years, respectively, were 98 and 48 per cent of the controls. Thus, a second year of clipping reduced the yields over those of one year by one-half. Quadrats in the pasture (protected one year after a single year of grazing) when frequently clipped yielded only 70 per cent as much as those in prairie. Quadrats grazed in 1932 and clipped in 1933 produced in 1934 only 58 per cent as much as prairie quadrats clipped two years. This illustrates the cumulative evil effects of too frequent utilization of the forage.

Quadrats in prairie clipped during two and three years, respectively, yielded in 1935, 57 and 44 per cent as much as the controls. Those clipped for three seasons produced only 77 per cent as much forage as those with two years of such treatment.

UPLAND STATION IN SHORT-GRASS PASTURE

A series of 40 quadrats was established in a pasture adjoining the Belmont prairie, which about 15 years earlier formed a portion of this unbroken tract. Because of the continued impact of grazing, considerable areas on the hill-sides had degenerated into an almost pure stand of short grasses, mostly *Bouteloua gracilis* but some *Buchloe dactyloides*. Two separate plots about

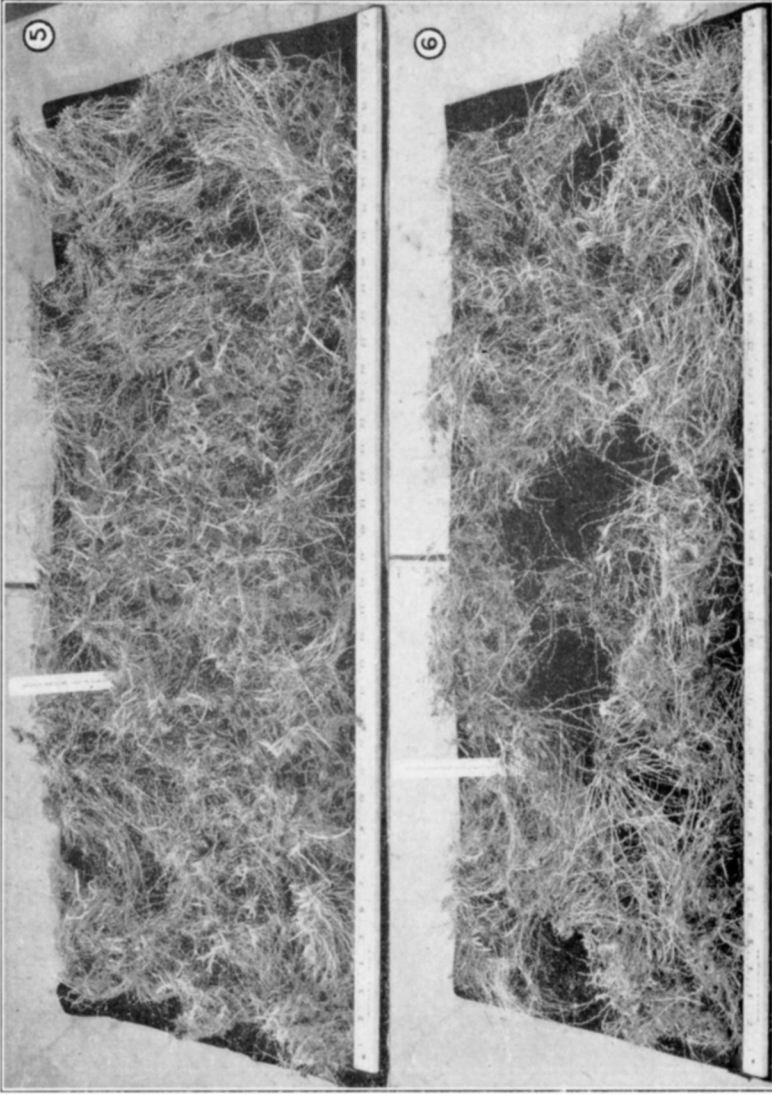


Fig. 5. Underground parts of big bluestem from one-half of a control quadrat on level lowland. Fig. 6. Materials from one-half of a quadrat closely clipped for two years.

one-fourth mile distant, each 0.5 acre in extent, were fenced and 20 representative quadrats were selected in each plot. Alternate quadrats were clipped five times during the growing season and the remainder once, in October.

The grasses were 2 inches tall at the initial cutting on May 10, 1933, and 2 to 4 inches on June 3. Late in June there was too little regeneration to warrant clipping, but the previously clipped grasses were green although those in the control quadrats were half dried. By July 15, a height of 1 to 1.5 inches had been attained, and, after clipping, the new growth was 2 inches tall late in August. Some flower stalks 4 to 12 inches tall had been developed by the blue grama grass. Only a little growth was made after the fourth cutting on August 27. Final harvest was on October 12.

The quadrats gave considerable differences in yield probably due to irregularities in previous grazing, local soil conditions, etc. The average yield from the one cutting of 20 quadrats was 181.7 grams; the average total of the partial yields from the 20 clip quadrats was 192.4 grams, or 6 per cent greater.

LOWLAND STATION IN SHORT-GRASS PASTURE

A portion of the pasture adjoining the prairie extended over level, rather low ground. It had formerly been occupied by *Andropogon furcatus*, *Sorghastrum nutans*, and smaller amounts of *Panicum virgatum*. A part of this pasture presented a disclimax of nearly pure stands of blue grama grass and buffalo grass. The accumulated debris on these areas was burned with a slow fire on a damp day. Twenty quadrats were then staked out in selected typical areas.

On May 10, the short grasses were only 1 to 2 inches tall. In general, height growth was greater than that on upland. At the October cutting, the height of foliage ranged from 2 to 3.5 inches, and flower stalks of blue grama were about 17 inches tall. Weeds were sparse or absent.

About the same proportion of grama grass and buffalo grass occurred in both clip quadrats and controls. The yields of both grasses varied widely, depending largely upon the basal cover, which ranged from 52 to 80 per cent. The quadrats cut five times gave an average total yield of 276.6 grams; those cut but once 212.2 grams. Thus, the yield of the former was 30 per cent greater.

LOWLAND STATION IN BLUEGRASS PASTURE

Other portions of the lowland area were clothed with a pure stand of bluegrass. It was lightly grazed in 1932, but fenced and burned in early spring of 1933. Ten quadrats were staked for close cutting and ten alternate ones to be cut only at the end of the growing season. Cuttings were made on May 1, June 4, July 14, August 27, and October 9; the partial percentages of the total yield at each cutting were 16, 16, 9, 46, and 13, respectively. The marked differences in yield of the several quadrats (203 to 393 grams) are characteristic of old bluegrass pastures. They often result from irregularities in grazing because of dung and the stimulating effect the latter has upon the yield.

The total average yield from the five cuttings was 274.8 grams or 5 per

cent more than that from the one cutting (263.0 grams) of the control quadrats.

Growth of bluegrass in early spring of 1934 was good but extremely dry weather ensued and the grass not only ceased growing but died.

Résumé

Dry weight production in both the upland and lowland short-grass areas as well as in the bluegrass pasture was greater (6, 30, and 5 per cent, respectively) from quadrats clipped five times than from the single seasonal cutting. Compared with production of the clip quadrats of the little bluestem during the same season, the respective yield in the upland pasture was only 50 per cent as great. Yields from the short-grass and bluegrass, lowland pasture were only 68 and 67 per cent as great, respectively, as were those from the big-bluestem lowland prairie similarly clipped. These data indicate great losses in forage when bluestem prairies are permitted through misuse to degenerate either into short-grass or bluegrass pasture.

EFFECTS OF FREQUENT CLIPPING UPON WEIGHT OF UNDERGROUND PLANT PARTS

Samples of sod, each one-half square meter in area and 10 centimeters deep, were secured from certain control quadrats and from others clipped during one or more years. The soil was carefully washed away and the stem bases, roots, and rhizomes entirely freed from adhering soil particles (cf. Weaver and Harmon, 1935). Control quadrats of little bluestem gave an average yield of 435 grams per sample of air dry underground plant parts. Decrease in dry weight of this plant material, based on the control, was 41 per cent after two seasons of close clipping and 59 per cent by July 25 of the third year. Moreover, much of this material was dead in 1935.

Similar samples of big bluestem are shown in Figs. 5 to 7. The sample from the control quadrat had a dry weight of 445 grams. Dry weight from the quadrat closely clipped two years was 33 per cent less and reduction in weight increased to 57 per cent by the middle of the following summer. Since the second sample and especially the third contained much dead material which was very light when dried, the losses in weight are even greater than indicated in the Figures.

DISCUSSION

Grazing, or clipping to simulate grazing, is a more or less destructive process since it removes much of the photosynthetic area from the plant. Preservation of pasture grasses depends upon manufacture and storage of foods by the plants in excess of those consumed in growth. Whenever grazing is so intensive that it permits complete and frequent removal of the green shoots it greatly reduces the manufacture of carbohydrates and prevents their storage in underground parts. Such abrupt decrease in photosynthetic activity causes a corresponding decrease in the growth of roots. Continued defoliation is extremely injurious and unless reasonable precautions are taken to

prevent it the effects are likely to become cumulative and cause serious deterioration of pasture or range. This may be followed by erosion, loss of nutrients, and general impoverishment of the soil.

Results from studies on the effects of the removal of the photosynthetic area are in agreement that the yield and vigor of the vegetation vary inversely with the frequency of clipping. Aldous (1930) applied clipping treatments at two-week intervals to prairie grasses (chiefly big and little bluestems) at Manhattan, Kansas. He found that the density of the vegetation decreased about 60 per cent in three seasons. Clipping at three-week intervals resulted in only 13 per cent reduction. Disappearance of valuable species was proportional to frequency of cutting. The higher nutritive value of the forage gained from frequent harvesting did not compensate the loss in yield.

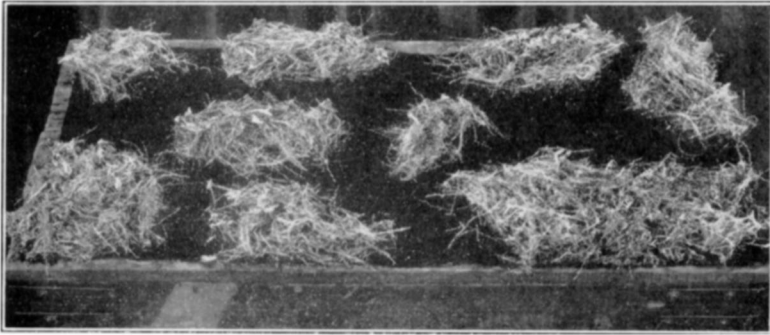


Fig 7. Roots and rhizomes from one-half square meter of big bluestem closely clipped for 2.5 years. The dry weight decreased from 445 grams (Fig. 5) to 296 grams (Fig. 6) and, finally, to 190 grams (Fig. 7).

Biswell and Weaver (1933) found not only that the total dry weight produced from sods frequently clipped after transplanting ranged from 13.1 to 47.5 per cent of that of the same species of prairie grass unclipped after transplanting but also that the clipped plants failed to produce new rhizomes and many of the old ones died. The length of the roots was greatly decreased, and the relative production of roots was more greatly reduced than that of tops. Plants weakened by repeated clipping renewed growth slowly if at all after the sods were frozen, although the controls made an excellent development. They give a comprehensive review of the literature.

McCarty (1938) has shown that the "Initial growth of herbage in spring is made at the expense of the carbohydrate accumulations stored in the basal organs during the preceding season. Concentration of carbohydrates in both herbage and basal organs of the plant is inversely related to the rate of herbage growth. This relationship is maintained throughout the entire annual cycle of growth. The accumulation of carbohydrate stores is delayed, therefore, until most of the annual herbage growth is produced." It is well known that all of the stored food is not ordinarily used in normal early growth of

perennial grasses. But if the new growth is removed by early grazing or clipping there results a diminution in the reserve food; a second close clipping may further deplete the supply. Thus, the progressive decrease in yield of the closely clipped quadrats and the final death of many plants may be readily understood.

SUMMARY

The yields from the several stations during the three years are shown in Table 5. From a survey of these data a number of conclusions may be drawn. The season of 1935 was the best for the growth of grasses, 1933 being intermediate, and 1934 distinctly the poorest.

TABLE 5.—Total production in grams of dry matter from the control and clip quadrats at the several stations, and percentage yield of clip quadrats in terms of yield of controls.

Species and criteria	Control '33	Clipped '33	Control '34	Clipped '34	Clipped '33+ '34	Control '35	Clipped '34+ '35	Clipped '33+ '34+ '35
Little bluestem	348.0	385.3	135.5	170.2	68.7 1	588.8	319.8	186.0 2
Percentage of control	....	111	....	126	51	....	54	32
Big bluestem	668.3	407.8	139.7	158.1	100.2 3	....	....	....
Percentage of control	....	61	....	113	72	....	....	....
Mixed bluestems	340	332.9	143.1	139.5	68.1 4	426.6	244.5	189.5 5
Percentage of control	....	98	....	98	48	....	57	44
Mixed bluestem pasture	248.0	246.8	....	97.5	39.5	....	....	....
Percentage of control	....	99	....	....	....	....	....	....
	Control on upland Short grasses	Clipped on upland Short grasses	Control on lowland Short grasses	Clipped on lowland Short grasses	Control on lowland Bluegrass	Clipped on lowland Bluegrass		
Yields in 1933	181.7	192.4	212.2	276.6	263.0	274.8		
Pct. of control	....	106	....	130	....	105		

1. Yield only 40 per cent as great as from quadrats clipped one year.
2. Yield only 58 per cent as great as from quadrats clipped two years.
3. Yield only 63 per cent as great as from quadrats clipped one year.
4. Yield only 49 per cent as great as from quadrats clipped one year.
5. Yield only 77 per cent as great as from quadrats clipped two years.

Total yields of the quadrats cut at frequent intervals for the first time exceeded those of the single yield from the controls at 4 of the 6 stations in 1933. With little bluestem the excess was 11 per cent; at the upland short-grass station, 6; at the lowland short-grass station the increase was 30 per cent; and at the bluegrass station, 5. On the hillside in prairie of little and big bluestem type, a slight decrease occurred. In the big bluestem, a decrease of 39 per cent was determined. This resulted undoubtedly from the heavy flower-stalk production of the controls. Similar results were obtained from the quad-

rats first clipped in 1934. Little bluestem yielded 26 per cent more than the control, except where it was intermixed with big bluestem where it yielded 2 per cent less. Big bluestem, failing during this drought year to produce flower stalks, yielded 13 per cent more from the several clippings than from the single harvest.

Quadrats closely clipped for two seasons always gave lower total yields than a single clipping of the controls. In little bluestem the yield averaged 49 and 46 per cent less, in big bluestem 28 per cent less, and in mixed little and big bluestem 52 and 43 per cent less than the controls.

Yields from quadrats frequently clipped during two years were likewise much lower than from those similarly clipped for only a single year. In little bluestem the former yielded 60 per cent less, in big bluestem 37, and in mixed bluestem 51 per cent less.

At two stations, clipping was continued in the same quadrats for a period of three years. Compared with the controls, yields were 68 and 56 per cent less, respectively, in little bluestem and mixed bluestem types. When the yields are compared with those from quadrats frequently clipped for two years they are found to be 42 and 23 per cent less, respectively. Thus there is a rapid decrease in yield following too close utilization of pasture. The plant parts underground also deteriorate. Decrease in dry weight varied from 33 to 41 per cent after two years of close clipping, and was 57 to 59 per cent in mid-summer of the third year.

Where upland, little-bluestem prairie degenerated into pasture of the short-grass type, the seasonal yield was reduced to 52 per cent when the vegetation was removed only in fall. Where it was removed by frequent clipping, as in close grazing, the yield was only 50 per cent as great.

A single year of close grazing reduced the next year's yield of mixed bluestem prairie to 74 per cent. When this was followed by a second year of clipping the yield decreased to only 29 per cent of that of virgin prairie similarly clipped.

Where big bluestem degenerated to short-grass pasture the forage yield measured once in fall was reduced to 32 per cent. Where clipping to simulate close grazing was practiced, the yield was decreased to 68 per cent. Similar comparisons of yield of big bluestem and bluegrass pastures on low ground gave a reduction to 39 and 67 per cent, respectively. Since the yields from short-grass and bluegrass are for a single year only, because of severe drought, they are merely indicative.

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