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The Effects of Clipping On Yield, Basal Cover, and Growth of Three Pasture Types in West-Central Kansas.

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THE EFFECTS OF CLIPPING ON YIELD, BASAL COVER, AND GROWTH OF THREE PASTURE TYPES IN WEST-CENTRAL KANSAS

being

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THE EFFECTS OF CLIPPING ON YIELD, BASAL COVER, AND GROWTH OF THREE PASTURE TYPES IN WEST-CENTRAL KANSAS

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A study was made to determine what effect various intensities of clipping had upon yield, basal cover, and growth of 3 pasture types near Hays, Kansas. The study was conducted for 2 growing seasons (1955 - 1956) on a bluestem dominated, a reseeded, and a shortgrass pasture. The pasture types were located on the lower slope of a large hill, with each type being similar in per cent slope, soil depth, and soil texture.

Grasses that were studied on the bluestem dominated pasture were big bluestem (Andropogon gerardi) and side-oats grama (Bouteloua curtipendula). The reseeded pasture was dominated by Elreno side-oats grama, with blue grama (Bouteloua gracilis) and buffalo grass (Buchloe dactyloides) forming an understory. This area was retired from cultivation in 1947 and planted to this mixture of Elreno side-oats grama, blue grama, and buffalo grass in the ratio of 5:1:1 respectively. Blue grama and buffalo grass were studied on the shortgrass pasture. Winter annuals, Japanese brome (Bromus japonicus) and little barley (Hordeum pusillum) were also included because of their tremendous abundance.

Twenty meter square quadrats were located in each pasture. These were pantographed at the beginning and at the end of the

study to determine the basal cover. The 20 quadrats were divided into 4 series of 5 quadrats, with each series being subjected to one of 4 clipping treatments.

Treatment 1 — Clipped every 2 weeks from June 1 to July 1.

Treatment 2 — Clipped every 2 weeks from June 1 until growth ceased

Treatment 3 — Clipped once a month from June 1 until growth ceased.

Treatment 4 — Clipped at the end of the growing season.

The mid-grasses were clipped at a height of 2 inches and the short-grasses at 1 inch. The clipped forage was air dried, weighed and computed to pounds per acre.

Height of growth was determined at each clipping period. Measurements were made of new growth prior to clipping of the quadrats and also of growth of unclipped quadrats.

Soil moisture was determined every week to a depth of 5 feet on each pasture type. Samples were taken in duplicate and an average per cent moisture for the 2 samples was recorded for each depth. Hygroscopic coefficient of similar soils was used to determine the approximate amount of soil moisture available for plant use.

Climate for the 2 growing seasons was characterized by low, uneven distribution of rainfall and deficiency of soil moisture accompanied by high temperatures and wind velocities. The rainfall for the 1955 growing season was about 2 inches above the 17 inch average, but over one-third of this was received in September. The rainfall during the 1956 growing season was the lowest on

record, with only a little over 7 inches being recorded. Production of the 3 pastures was usually greatest during the early spring or summer and then declined during the middle and latter part of the growing season. After the middle of July, except for sporadic greening, grasses were usually in a semi-dormant state with their leaves either rolled or folded.

The production of the perennial grasses during the first growing season was greatest under frequent and moderate clipping. However, the yield of these grasses was reduced to a greater extent the second growing season by frequent clipping than by moderate or non-clipping. The yield of the grasses varied only slightly from the first to the second growing season when they were not clipped.

All 3 pasture types had about the same perennial grass yield over the 2 growing seasons. However, because of the large yield of the annuals, the shortgrass pasture outproduced the bluestem and reseeded pastures. Prennial grass production varied from about 700 to 1,200 pounds per acre in 1955 and from about 400 to 600 pounds in 1956. The yield of the annual grasses increased under frequent and moderate clipping, but decreased under non-clipping. Their increase ranged from 200 to 1,000 pounds per acre. Yield of the forbs was not effected to any great extent, but generally increased under all clipping intensities.

Basal cover was reduced under all clipping treatments. Frequent clipping (treatment 2) was most injurious to the bluestem

and reseeded pastures, but the loss of basal cover on the short-grass pasture was greatest when it was unclipped. Loss of basal cover was generally less under moderate clipping.

Growth, like yield, was usually greatest under frequent or moderate clipping the first growing season, but growth the second growing season was the least under the most frequent clipping (treatment 1 and 2).

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INTRODUCTION

When the Great Plains Region was first settled by white man, a complete cover of grass existed and only a small portion of the range land was cultivated. Large herds of cattle were moved in and grazing became more intense as native prairie was broken for cultivation. With the range lands reduced in area, overgrazing increased and productivity of the grasses decreased. Desirable and high-producing grasses decreased in abundance and their place was taken by low-yielding, undesirable species more resistant to grazing than their counterparts. If grazing pressure became too intense, these resistant species also decreased and were replaced by useless weeds.

Because of the different degrees of utilization, areas too rough for cultivation and inaccessible for grazing were undisturbed, while some grazed areas were reduced to a mixture of mid and shortgrasses. Others were grazed so intensely that only shortgrass remained. Many cultivated areas were abandoned because of extreme climatic conditions and allowed to return to their original state by a process of secondary succession. After the drought of the "thirties", many submarginal areas were retired from cultivation and replanted to mixtures of introduced or native grasses. Many of these pasture types, each with a different degree of reduction are found throughout the Great Plains Region.

Obtaining adequate cover, forage, and seed from range and pasture lands has received considerable attention during the past three decades. Maintaining grazing lands in a high state of productivity is

based upon a knowledge of production of the vegetation. Many ranchers and farmers find difficulty in balancing the number of animals with the productivity of the pasture since they have little or no knowledge of the growth habits and production of range species.

The purpose of this study was to determine the effects of different intensities of clipping upon yield, cover, and growth of a big bluestem, reseeded, and short grass pasture. This study was conducted near Hays, Kansas, during the growing seasons of 1955 and 1956.

RELATED STUDIES

When it became apparent that overgrazing and reduction of ranges and the changes in the abundance of range species were related, many universities and experiment stations conducted studies which have resulted in a greater knowledge of grassland use. Crozier (1897) set up one of the earliest studies on herbage removal. Working with grasses of Michigan, he discovered that frequent mowing of various cultivated grasses reduced the yield to one-fourth of normal, and that yields were highest on the plots clipped least frequently.

The removal of foliage, whether it be by clipping or grazing, has a pronounced effect upon grasses and they record the history of past grazing use. Canfield (1948), working in Arizona, stated that grasses bear the brunt of grazing and, therefore, change more quickly than their less palatable associates. Using various pasture mixtures sown at Beltsville, Maryland, Hein and Henson (1942) compared the effects of clipping and grazing of sheep. They found that clipping was

more severe than grazing, as shown by the lower relative frequency of the grass mixture under clipping. They concluded that the added fertility from the droppings under grazing was undoubtedly partly responsible for this difference. On the other hand, Robinson et al. (1937) and Brown (1937) have reported little difference between yields of clipped versus grazed pastures.

The capacity of a plant to produce forage depends largely upon its ability to regenerate foliage tissue (Cook and Stoddart, 1953). Some investigators (Pool, 1948; Sampson, 1952; Stoddart and Smith, 1943) have suggested that grasses, as a group, withstand grazing better than other plants because their growing region is located near the base of the blade, and that growth is not arrested, even if the greater part of the leaf blade is removed. Branson (1953) pointed out that grasses with growing points high enough to be grazed decreased as intensity of utilization increased, while grasses with growing points at the ground level usually increased. All species with a high ratio of flower stalks to vegetative stems usually decreased in heavily grazed ranges.

Riegel (1947), in western Kansas, found the taller native grasses to be more susceptible to clipping than the shorter ones. In every case in which the grasses were clipped for several months, there was an increase in total height but a decrease in weight. Pasture types in relation to utilization were studied by Tomanek (1948) near Collyer, Kansas. The data indicated that both heavy and light utilization reduced the yield. Albertson et al. (1953) made a five-year

study of the effects of clipping on short grasses in west-central Kansas. They found that when approximately 50 per cent of the grass was left on an area, the amount removed from these locations over five years equalled total production on areas where all growth was harvest d.

Lacey (1942), in west-central Kansas, studied forage yield of shortgrass pastures under different intensities of grazing. The non-grazed pasture produced a yield of about 1,900 pounds per acre, but this was less than that of the lightly-grazed pasture. Forage yields and basal cover of short grass were greatest on lightly-grazed pastures. Moderate grazing maintained a constant yield. At Hays, Kansas, in 1953, Tomanek and Albertson found that basal cover increased with grazing but that there was a general decrease in tall grasses and an increase in shortgrasses. The non-grazed pasture produced twice as much forage as the heavily grazed.

Aldous (1930) applied clipping treatment at two-week intervals to prairie grasses at Manhattan, Kansas. He found the density of the vegetation decreased about 60 per cent in 3 seasons. Clipping at three-week intervals resulted in only 13 per cent reduction. Disappearance of valuable species was proportional to frequency of cutting.

Kelting (1954), working in the tall grass prairie in central Oklahoma, found that grazing increased the total plant production. Basal cover of a moderately grazed prairie was higher than that of a non-grazed prairie.

On a semidesert, black grama (Bouteloua eriopoda) range in Arizona, Canfield (1939) reported that persistent cropping of all herb-

age of this grass to a two-inch height or less eventually resulted in a destructive reduction of tuft area (basal cover). This occurred regardless of frequency of seasonal harvesting. Forage yield was reduced to zero and reproduction and even survival of the forage grass was prevented. Persistent cropping overshadowed all beneficial effects of above average rainfall.

Cassady (1953) discovered that clipping at 2 and 4 week intervals reduced grass production 41 per cent and 33 per cent, respectively. Clipping at 8- and 18-week intervals did not measurably reduce grass production.

Soon after the great drought of the thirties, Weaver and Albertson (1944) made a survey of the shortgrass pastures in western Kansas. In almost every instance, a decrease in production of blue grama and buffalo grass during periods of drought was found to be directly proportional to the intensity of grazing.

METHODS OF STUDY

Early in March, 1955, 3 areas were selected for study on the basis of the type of vegetation each supported. Consideration was given to the species, soil depth, soil texture, and slope. Grasses that dominated each area were studied during the 1955 and 1956 growing seasons as they grew and produced under different clipping intensities. Data were obtained on basal cover, monthly and seasonal yields, and increment. Environmental factors affecting growth were not measured, but were obtained from a weather station 1.5 miles east of the study area.

Twenty square-meter quadrats, each representative of the area in which it was located, were selected for study in each pasture. They were protected from grazing by portable exclosures from the spring of 1955 to the fall of 1956. The 20 quadrats of each pasture were divided into 4 series of 5 quadrats each, and a different clipping treatment applied to each series.

Treatment I -- Clipped every 2 weeks from June 1 to July 1.

Treatment II -- Clipped every 2 weeks from June 1 until growth ceased.

Treatment III -- Clipped once a month from June 1 until growth ceased.

Treatment IV -- Clipped at the end of the growing season.

Basal cover of each quadrat was determined with a pantograph and planimeter in the spring of 1955 after growth began and again in the fall of 1956. In determining the cover, the same person operated the pantograph arm throughout the study thus reducing to a minimum the chance of human error. Only places larger than approximately 0.75 inches in diameter were considered bare.

Buffalo and blue grama grass were charted together on the short grass disclimax pasture. This was done because of the intimate mixture in which the grasses occurred. For this reason also, they were not separated when clipped.

Measurements of growth, yield and cover under each treatment were recorded as averages of 5 quadrats. Because of extremely poor growing conditions during 1955 and 1956, not all quadrats could be clipped at the expected time. If growth was not sufficient to warrent clipping,

the series of quadrats would go unclipped until the next clipping date. Growth measurements in all quadrats were recorded at about 2-week intervals. Short grasses were clipped at 1 inch and midgrasses were clipped at 2 inches.

Monthly and seasonal yields of the vegetation were determined by weighing the clipped air-dried forage to the nearest 0.1 of a gram. This weight was then converted to pounds per acre.

The forbs in each pasture were rated numerically according to the following scale devised by Weaver and Fitzpatrick (1934):

1. - Very abundant
2. - Abundant
3. - Common
4. - Infrequent
5. - Rare

The numerical rating of the species was based upon abundance, size, duration, gregariousness, density, and basal cover.

The precipitation data cover the period from September, 1954, to September, 1956, and included deviation from normal for each month during the growing seasons and the total precipitation for each growing season. The mean temperature for each month was compared with the normal mean for that period.

In 1956, soil moisture determinations were made on each pasture at intervals of 1 week to a depth of 5 feet. The soil samples were taken with a geotome. Each soil sample was dried in an oven at 105° C. and weighed to find the percentage of moisture. The hygroscopic co-

efficients for similar soils at Hays, Kansas, were used for determining the available moisture at the depths of 0-6 inches, 6-12 inches, and for every foot thereafter. The soils were not exactly the same as those on the areas in which the study was made but were sufficiently similar for the purpose of this study. The soil moisture minus the hygroscopic coefficient of the soil was assumed to approximate the amount of soil moisture available for plant use.

DESCRIPTION OF STUDY AREAS

The study was conducted on 3 pasture types about 1.5 miles south and 1 mile west of Hays, Kansas. Two of the pasture types, one a reseeded and the other bluestem, are located along the west boundary of the college farm. The third, a shortgrass disclimax pasture, is privately owned and lies directly west and adjacent to the other pastures.

Topography of the area is dominated by a large hill with a long, gently sloping base upon which the 3 pastures lie. The area above the pastures was at one time a cultivated field which was abandoned about 1933. This area was vegetated by annual weeds with scattered remnants of mid and short grasses.

The reseeded and bluestem pastures lie on an east-facing slope of 6 to 8 per cent. These 2 pastures make up a 23-acre plot, of which 15 acres were once farm land. The native pasture constituted the 8 acres which was unfarmed. In 1949, the 15 acres of cultivated land were reseeded with a mixture of Elreno side-oats grama (Bouteloua curti-

pendula),[1] blue grama (Bouteloua gracilis), and buffalo grass (Buchloe dactyloides) in the ratio of 5:5:1 pounds per acre, respectively. This area was lightly grazed except for periods when it was ungrazed in order to harvest a seed crop of Elreno side-oats grama. The shortgrass pasture lies on a somewhat steeper slope (8 to 10 per cent) than the reseeded and bluestem pasture, and faces a northeasterly direction. This area contains 34 acres and has been heavily utilized for many years.

Investigations of the bluestem pasture were conducted only on big bluestem (Andropogon gerardi) and side-oats grama because they dominated the area (Fig. 1). Other grasses not included in the study, but present in small amounts were little bluestem (Andropogon scoparius), Canada wild rye (Elymus canadensis), blue grama, buffalo grass, purple three awn (Aristida purpurea), and western wheatgrass (Agropyron smithii). The winter annual, Japanese brome (Bromus japonicus), was present in limited amounts in 1955 but spread throughout the area in 1956. Texas crabgrass (Schedonnardus paniculatus) and squirrel tail (Sitanion hystrix) were also found in minute quantities. Wild alfalfa (Psoralea tenuiflora) and rayless thelesperma (Thelesperma gracile) dominated the forb population of this climax area. Sensitive briar (Morongia uncinata) was also prevalent, with stemless tetraneuris

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[1] Nomenclature of the grasses follows A. S. Hitchcock's "Manual of the Grasses of the U. S." (Revised by Agnes Chase, 1950), that of other species is according to "Flora of the Prairies and Plains of Central North America" by P. A. Rydberg, 1932.

Figure 1. Bluestem pasture with big bluestem and side-oats grama in the foreground and western wheargrass in the upper right hand corner. Other grasses present are Canadian wild rye and Japanese brome. Forbs are wild alfalfa and snake root.

(Tetraneuris stenophylla) and Missouri goldenrod (Solidago glaberrima) growing in societies throughout the area. Other forbs found in smaller quantities are listed in Table 1.

The reseeded area was dominated by the grasses to which it was planted in 1949 and had a cover of about 50 per cent. Elreno side-oats grama, although a sod forming grass, grew more like a bunch grass and gave the area a rough broken appearance (Fig. 2). This grass is of southern Kansas origin and was selected for its seed producing ability by the Soil Conservation Service at Manhattan, Kansas. The diameter of these bunch-like formations varied between 3 and 12 inches. Buffalo grass was more abundant than its original planting ratio. Islands of this stoloniferous grass were scattered throughout the area and often reached a diameter of 18 to 24 inches. Blue grama, the other dominant of this area, was found throughout in the form of small bunches 1 to 4 inches in diameter.

Forbs on the reseeded area were not as abundant in number or species as those of the native pastures (Table 1). Stiff leaved goldenrod (Solidago rigida) seemed to be the most abundant from first appearances, but many flowered aster (Aster multiflorus), being hidden by the grasses, was found to be as prevalent upon closer inspection. Sensitive briar was abundant in small local communities.

Buffalo grass and blue grama were the only perennial grasses present in the shortgrass area. These grasses formed a good cover (70 to 80 per cent) at the beginning of the study, but due to overgrazing, the areas between the clumps of grasses were free of mulch and congested with

Figure 2. View showing the rough, broken appearance of the reseeded pasture. Note the bunch-like characteristics of Elreno side-oats with blue grama and buffalo forming an understory.

Table I. Abundance of forbs on the native, reseeded, and shortgrass pastures. Numbers in each column represent the abundance; 1 - very abundant, 2 - abundant, 3 - common, 4 - infrequent, 5 - rare.

Forbs	Native	Reseeded	Shortgrass
Aster multiflorus	5	2	3
Aster oblongifolius	5		
Cheirinia aspera	4		
Cirsium undulatum	5	4	1
Echinacea angustifolia	4		
Gaura coccinea	4	5	5
Gutierrezia sarothrae			4
Kunhia glutinosa	5	4	5
Leucelene ericoides	4		
Lygodesmia juncea	3		
Malvastrum coccineum	4	5	3
Morongia uncinata	2	3	
Neomamillaria radiosa		5	5
Opuntia macrorrhiza			4
Oxalis stricta		5	
Polygala alba	5		
Psoralea tenuiflora	1	4	1
Ratibida columnifera		5	4
Scutellaria resinosa	4		
Senecio plattensis	5		

Table I. (continued)

Forbs	Native	Reseeded	Shortgrass
Sideranthus spinulosus	5		5
Solidago glaberrima	2		
Solidago mollis	4		
Solidago rigida	4	2	
Tetraneuris stenophylla	2		
Thelesperma gracile	1		
Townsendia exscapa	5		
Yucca glauca	5		

Weedy forbs*	Native	Reseeded	Shortgrass
Amaranthus retroflexus	x		
Ambrosia psilostachya	x	x	x
Chamaesyce spp.			x
Chenopodium album	x		x
Euphorbia marginata			x
Helianthus annuus	x		
Kochia scoparia		x	x
Lappula occidentalis	x	x	x
Leptilon canadensis		x	x
Melilotus alba		x	x
Melilotus officinalis		x	x

*The presence of weedy forbs in each pasture is indicated by an x.

Table I. (continued)

Weedy forbs*	Native	Reseeded	Shortgrass
Physalis lanceolata	x	x	
Plantago purshii			x
Salsola pestifer	x	x	
Sophia pinnata	x	x	x
Tithymalus arkansanus	x		

the winter annuals, Japanese brome and little barley (Hordeum pusillum). Many cow chips littered the pasture and the forbs were prominent only during the spring and early summer (Fig. 3). Wavy-leaved thistle (Cirsium undulatum) and wild alfalfa were the most common forbs. The late blooming many-flowered aster was also common, but only in scattered communities. Other forbs present are listed in Table I.

Many flowered aster was noted to be the most persistent forb in every pasture. This deep rooted plant was almost always the only forb to continue growth under all frequencies of clipping of this study. Occasionally, after periods of cool weather and light rains, western ragweed (Ambrosia psilostachya) would make some additional growth.

ENVIRONMENTAL CONDITIONS

The vegetation entered the 1955 growing season after being subjected to drought conditions which began in 1952 and continued through the growing season of 1956. Precipitation was low during the winter months before the 1955 growing season, but sufficient to produce good growth which was early (April 4) and rapid. As the season progressed temperatures rose above normal and precipitation decreased, causing a diminished growth rate of the vegetation and dormancy by the latter part of July. Precipitation for the 1955 growing season (April - September) was 19.42 inches; although this was 2.39 inches above the long time average, 7.63 inches came in September as hard dashing rains (Table II). Some growth was renewed in September from these rains, but it was not much more than a general "greening up".

Figure 3. View of the shortgrass area showing the fairly high cover of buffalo (light spots) and blue grama grass (dark spots). Forbs are wavy leafed thistle, many flowered aster, wild alfalfa and prairie cone flower.

Table II. Inches of precipitation with deviation from normal during the growing seasons of 1955 and 1956. Winter precipitation is also included.

	PRECIPITATION				
	Normal	1955	Deviation	1956	Deviation
Winter ppt.	5.02	3.30	-1.72	1.90	-3.12
April	2.21	3.01	+0.80	1.28	-0.93
May	3.51	3.51	-1.03	1.42	-2.09
June	4.09	3.70	-0.39	0.38	-3.71
July	2.87	2.09	-0.78	2.79	-0.08
Aug.	3.08	0.51	-2.57	1.07	-2.01
Sept.	2.27	7.63	+5.36	0.60	-1.67
Total	18.03	19.42	+1.39	7.54	-10.49

During the 1956 growing season conditions for growth were very poor. Although there was a fair supply of soil moisture in the spring of 1956 from the September storms of 1955, this was quickly depleted. The April - September total for 1956 season was 7.49 inches, approximately one-third less than during the same period in 1955 and 10.49 inches below the average. Precipitation during June was 0.38 inches; therefore, the vegetation depleted the soil moisture accumulated during the fall of 1955 and the grasses were reduced to a state of near dormancy.

Above-average temperatures occurred throughout the 1955 and 1956 growing seasons with the exception of June, 1955, and April and July of 1956 (Table III). With the temperature above normal and precipitation below normal conditions were not conducive for good vegetative growth.

Temperature during April of 1956 was 4.4 degrees below normal and the vegetation remained dormant until almost the last of the month. Precipitation in May was only one-third normal and therefore growth was hindered. Rainfall was only 0.38 inches in June, but when 2.79 inches were received in July the vegetation renewed its growth.

Soil moisture was greatest during April, when the reseeded area had available moisture to a depth of 5 feet, while the bluestem and shortgrass pasture had available moisture only to 3 feet (Table IV). Generally speaking, soil moisture decreased as the 1956 season progressed except during July. Here rainfall was almost normal (2.79 inches) and soil moisture was increased in the surface foot. During April, May and June, soil moisture decreased with depth, and in August

Table III. Mean temperature with deviation from normal during the growing seasons of 1955 and 1956.

	TEMPERATURE				
	Normal	1955	Deviation	1956	Deviation
April	53.0	57.2	+4.2	48.6	-4.4
May	62.4	65.1	+2.7	65.8	+3.4
June	72.4	69.9	-2.5	78.0	+5.6
July	78.7	83.2	+4.5	78.8	+0.1
Aug.	77.6	79.9	+2.3	80.0	+2.4
Sept.	69.0	70.6	+0.6	71.3	+2.3

Table IV. Approximate percentage of available soil moisture to a depth of 5 feet in the 3 pasture types during the 6 summer months of 1956.

Depth	Pasture	April	May	June	July	Aug.	Sept.
0-6	Bluestem	12.3	10.3	0.5	4.7	1.3	--
6-12		10.9	5.9	--	1.9	--	--
12-24		8.0	5.2	--	--	--	--
24-36		4.2	2.7	--	--	--	--
36-48		--	--	--	--	--	--
48-60		--	--	--	--	--	--
0-6	Reseeded	15.5	8.3	1.4	5.6	3.3	--
6-12		14.1	10.3	1.2	6.4	2.8	--
12-24		11.8	9.7	2.1	1.7	1.2	--
24-36		10.7	9.5	1.8	0.8	--	--
36-48		4.8	4.1	--	--	--	--
48-60		0.2	--	--	--	--	--
0-6	Shortgrass	11.3	--	1.7	--	--	--
6-12		9.3	1.6	--	0.5	--	--
12-24		7.8	1.3	--	--	--	--
24-36		2.2	0.3	--	--	--	--
36-48		--	--	--	--	--	--
48-60		--	--	--	--	--	--

and September there was very little, if any, available moisture at all depths.

Rainfall for both the 1955 and 1956 seasons was in the form of light scattered showers. Precipitation of this type did nothing to replenish the soil moisture supply and seldom did more than wet the surface of the soil. Occasional periods of showers and diminishing temperatures were sufficient to revive the vegetation for short periods after which it returned to near dormancy.

RESULTS

Since the years 1953 through 1956 were unfavorable for growth and reproduction of vegetation, the results of this study were somewhat different than might be expected. Precipitation was low and unevenly distributed; thus the effects of clipping were intensified.

Bluestem

Because big bluestem and side-oats grama are not particularly resistant to close utilization and extreme drought, the bluestem pasture suffered a heavy loss in yield when clipped frequently. Decrease of the cover and vigor of big bluestem and side-oats grama also allowed an invasion of Japanese brome and an increase of buffalo grass.

Treatment One (Clipped every 2 weeks from June 1 to July 1.)

The bluestem pasture produced 1,292 pounds of air dry forage per acre under this treatment in 1955; this was, however, reduced by about 50 per cent in 1956 (Table V). About two-thirds of the forage during both growing seasons was harvested in May, after which production fell off sharply. No growth was evident after June in 1955. However,

Table V. Monthly and seasonal yield of the bluestem pasture in pounds per acre under different clipping treatments for the 1955 and 1956 growing seasons. Age -- Andropogon gerardi, Bcu -- Bouteloua curtipendula, Bda -- Buchloe dactyloides, and Bja -- Bromus japonicus.

TREATMENT ONE

	1955						1956					
Grass	May	June	July	Aug.	Sept.	Total	May	June	July	Aug.	Sept.	Total
Age	474	316	--	--	--	790	176	72	--	--	68	316
Bcu	168	127	--	--	--	295	39	--	--	--	39	78
Bda	--	--	--	--	--	--	--	--	--	--	2	2
Bja	--	--	--	--	--	--	56	--	--	--	--	56
Forbs	179	28	--	--	--	207	183	23	--	--	--	206
Total	821	471	--	--	--	1292	454	95	--	--	109	658

TREATMENT TWO

	1955						1956					
Grass	May	June	July	Aug.	Sept.	Total	May	June	July	Aug.	Sept.	Total
Age	587	377	74	--	--	1038	207	78	162	--	--	447
Bcu	78	83	--	--	--	161	35	--	109	--	--	144
Bda	--	--	--	--	--	--	--	--	6	--	--	6
Bja	--	--	--	--	--	--	56	--	--	--	--	56
Forbs	18	2	--	--	--	20	57	7	5	--	--	69
Total	683	462	74	--	--	1219	355	85	282	--	--	722

Table V. continued

TREATMENT THREE

Grass	1955 May	June	July	Aug.	Sept.	Total	1956 May	June	July	Aug.	Sept.	Total
Age	569	372	--	--	--	941	249	--	189	--	--	438
Bcu	134	62	--	--	--	196	78	30	115	--	--	223
Bda	--	--	--	--	--	--	--	--	2	--	--	2
Forbs	151	36	--	--	--	187	205	11	3	--	--	219
Total	854	470	--	--	--	1324	532	41	310	--	--	882

TREATMENT FOUR

Grass	1955 May	June	July	Aug.	Sept.	Total	1956 May	June	July	Aug.	Sept.	Total
Age	--	--	--	--	572	572	--	--	--	--	750	750
Bcu	--	--	--	--	102	102	--	--	--	--	154	154
Bja	--	--	--	--	--	--	--	--	--	--	107	107
Forbs	--	--	--	--	6	6	--	--	--	--	35	35
Total	--	--	--	--	680	680	--	--	--	--	1046	1046

in 1956, because of near normal precipitation in July, 109 pounds of forage were harvested in September.

Big bluestem dominated the yield for both years by producing about two-thirds of the vegetation in 1955 and about one-half of that harvested in 1956. Side-oats grama, although having a somewhat larger basal cover than big bluestem, produced only 295 pounds of air-dry forage in 1955 and 78 pounds in 1956. Forb production was about 207 pounds for both years. Neither buffalo grass nor Japanese brome was found under this treatment in 1955. However, in 1956 Japanese brome contributed 56 pounds to the total forage production and buffalo grass 2 pounds.

The basal cover of big bluestem and side-oats grama was about 28 per cent at the beginning of the study but the frequent clipping and drought caused a reduction of over 40 per cent by the close of the second growing season (Table VI). This loss was equally divided between these 2 grasses, which had about the same cover at the start of the study. Buffalo grass established a cover of 0.2 per cent in 1956.

The combined growth of big bluestem and side-oats grama was 21.0 inches in 1955. This was reduced to less than 13 inches in 1956. Big bluestem attained a height of about 14 inches in 1955 and the height of side-oats grama was slightly more than 7 inches. The growth of both grasses was reduced about 4 inches in 1956.

Treatment Two (Clipped every 2 weeks from June 1 until growth ceased.)

Reduction of yield and basal cover of the bluestem pasture from 1955 to 1956 by this treatment was similar to that by treatment 1. The reduction of the amount of growth of big bluestem was almost twice as

much as in treatment 1 and the growth of side-oats grama was slightly less than that in treatment 1.

Total yield under this treatment was reduced from 1,219 pounds per acre of air dry forage in 1955 to 722 in 1956 (Table V). Approximately 50 per cent of the forage was harvested in May of both years, with the remainder being produced in June and July. There was no growth after July of either year.

Big bluestem, as in treatment 1, constituted the major portion of the yield during both growing seasons, although its production was reduced by over 50 per cent in 1956. Forage production of side-oats grama was reduced only slightly. In 1956 buffalo grass was able to establish itself somewhat better than it did under treatment 1, but still contributed very little toward the total yield. Japanese brome reacted as it did in treatment 1 and produced 56 pounds of air dry forage. Forb production was much less than under treatment 1, but increased from 20 pounds in 1955 to 69 pounds in 1956.

The reduction of basal cover from 1955 to 1956 by this frequent clipping was similar to that in treatment 1 (Table VI). However, big bluestem bore the brunt of the reduction (15.7 per cent to 6.4 per cent) while side-oats grama decreased only slightly (6.5 to 6.3). Buffalo grass had a cover similar to that in treatment 1.

In 1955, growth of big bluestem and side-oats grama under treatment 2 was somewhat more than under treatment 1 (Table VII). However, in 1956, growth was only about one-half of that under treatment 1, showing the effect of prolonged and close utilization. Big bluestem growth

Table VI. Per cent basal cover of the bluestem pasture under the different clipping treatments for the 1955 and 1956 growing seasons. Age--Andropogon gerardi, Bcu--Bouteloua curtipendula and Bda--Buchloe dactyloides.

Grass	Treatment One		Treatment Two		Treatment Three		Treatment Four	
	1955	1956	1955	1956	1955	1956	1955	1956
Age	13.5	8.1	15.7	6.4	12.4	7.9	17.5	10.0
Bcu	14.4	8.3	6.5	6.3	8.7	9.7	7.9	6.4
Bda	---	0.2	---	0.5	---	0.1	---	---
Total b. c.	27.9	16.6	22.2	13.2	21.1	17.7	25.4	16.4
Per cent loss of basal cover		40.4		40.4		16.7		33.9

Table VII. Growth in inches of the grass of the bluestem pasture for the 1955 and 1956 growing seasons under different clipping treatments. Age—Andropogon gerardi, Bcu—Bouteloua curtipendula, and Bda—Buchloe dactyloides.

Grass	Treatment One		Treatment Two		Treatment Three		Treatment Four	
	1955	1956	1955	1956	1955	1956	1955	1956
Age	13.8	10.0	15.2	3.5	13.0	13.0	8.2	10.0
Bcu	7.2	3.5	6.6	3.0	4.3	6.5	4.8	6.0
Bda	---	2.0	---	2.0	---	3.0	---	---
Total	21.0	15.5	21.8	8.5	17.3	22.5	13.0	16.0

decreased from 15.2 inches to 3.5 inches, while side-oats grama decreased from 6.6 to 3 inches. Buffalo grass attained a height of only 2 inches in 1956.

Treatment Three (Clipped once a month from June 1 until growth ceased.)

Moderate clipping of this treatment allowed the bluestem pasture to produce the greatest yield in 1955. Resulting loss of basal cover was the least from any treatment over the 2 growing seasons.

Total forage production in 1955 was 1,324 pounds per acre; in 1956, this was reduced by almost 500 pounds (Table V). As in treatments 1 and 2, most of the forage was produced in May, with the remainder being harvested in June and July. Because of drought conditions, there was no growth after June of 1955 and none after July of 1956.

Big bluestem, although its yield was decreased by over one-half from 1955 to 1956, made up almost 70 per cent of the yield in 1955 and 50 per cent of the yield in 1956. Side-oats grama increased its yield from 196 to 223 pounds of air-dry forage from 1955 to 1956. Buffalo grass was able to compete successfully with the dominants but yielded only 2 pounds of forage. Japanese brome did not appear in this treatment. Forb production was also greatest under this treatment. In 1955 there were 187 pounds of forbs harvested and this increased to 2.9 pounds in 1956.

Reduction of basal cover by this clipping frequency was not as great as in treatments 1 and 2 (Table VI). The basal cover of big bluestem was reduced by only one-third, while the cover of side-oats grama increased slightly. Buffalo grass had a basal cover of only 0.38 per

cent in 1956. Total growth in height was greater in 1956 than in 1955 (Table VII). Big bluestem produced the same amount of growth both years (13 inches), whereas side-oats grama increased its growth from 4.3 to 6.5 inches.

Treatment Four (Clipped at the end of the growing season.)

Total yield was increased from 680 to 1,046 pounds per acre from 1955 to 1956 under non-clipping (Table V). Big bluestem and side-oats grama increased by 178 and 52 pounds, respectively. Forbs increased their yield from 6 to 35 pounds, while Japanese brome, although not present in 1955, produced 107 pounds in 1956. Buffalo grass was not found in this treatment.

Reduction of basal cover under non-clipping over the 2 growing seasons was intermediate between close and moderate clipping (Table VI). Big bluestem suffered the greatest decrease (17.5 to 10.0 per cent) while the loss suffered by side-oats grama was small (7.9 to 6.4 per cent).

Growth of both big bluestem and side-oats grama was increased by more than 1 inch each (Table VII). This increased increment coupled with an invasion of winter annuals more than offset the loss in basal cover and resulted in a greater yield.

Reseeded

Treatment One (Clipped every 2 weeks from June 1 to July 1.)

Total yield in the reseeded pasture under this treatment was 1,226 pounds per acre in 1955, but this was reduced to 622 pounds in 1956 (Table VIII). During May and June of 1955, 964 pounds of air dry

Table VIII. Monthly and seasonal yield of the reseeded pasture in pounds per acre under different clipping treatments for the 1955 and 1956 growing seasons. Bcu--Bouteloua curtipendula, Bgr--Bouteloua gracilis, and Bda--Buchloe dactyloides.

TREATMENT ONE

	1955						1956					
Grass	May	June	July	Aug.	Sept.	Total	May	June	July	Aug.	Sept.	Total
Bcu	388	410	—	—	248	1046	310	36	—	—	166	503
Bgr	14	24	—	—	14	52	20	12	—	—	8	40
Bda	48	50	—	—	—	98	38	12	—	—	18	68
Forbs	27	3	—	—	—	30	11	—	—	—	—	11
Total	477	487	—	—	262	1226	370	60	—	—	192	622

TREATMENT TWO

	1955						1956					
Grass	May	June	July	Aug.	Sept.	Total	May	June	July	Aug.	Sept.	Total
Bcu	376	460	166	27	33	1062	196	144	216	—	—	556
Bgr	14	13	6	9	14	52	21	11	16	—	—	48
Bda	77	63	31	40	—	211	67	19	41	—	—	127
Forbs	17	21	—	—	—	38	15	—	6	—	—	21
Total	484	557	203	76	47	1367	299	174	279	—	—	752

Table VIII. (continued)

TREATMENT THREE

Grass	1955 May	June	July	Aug.	Sept.	Total	1956 May	June	July	Aug.	Sept.	Total
Bcu	616	337	109	--	54	1116	240	368	246	--	--	854
Bgr	74	13	--	--	7	94	29	17	21	--	--	67
Bda	85	26	--	--	--	111	52	17	37	--	--	106
Forbs	12	5	--	--	--	17	26	--	5	--	--	31
Total	787	381	109	--	61	1338	347	402	309	--	--	1058

TREATMENT FOUR

Grass	1955 May	June	July	Aug.	Sept.	Total	1956 May	June	July	Aug.	Sept.	Total
Bcu	--	--	--	--	903	903	--	--	--	--	865	865
Bgr	--	--	--	--	35	35	--	--	--	--	23	23
Bda	--	--	--	--	39	39	--	--	--	--	51	51
Forbs	--	--	--	--	77	77	--	--	--	--	45	45
Total	--	--	--	--	1054	1054	--	--	--	--	984	984

forage were harvested. This constituted over 80 per cent of the forage produced. In 1956, 70 per cent was harvested during these months.

Elreno side-oats grama dominated the production of forage for both years. It yielded 1,046 and 503 pounds for 1955 and 1956, respectively. The shortgrasses decreased in yield from 150 pounds in 1955 to 108 pounds in 1956. Forb production was decreased by two-thirds under this treatment.

Basal cover was reduced 50 per cent over the period of study (Table IX). Elreno side-oats suffered a loss of 23.1 per cent, while the cover of blue grama was reduced approximately one-half. Buffalo grass, on the other hand, was not decreased to any great extent. This stoloniferous grass had a cover of 5.7 per cent in 1955 and a cover of 5.6 per cent in 1956.

The grasses of this area had a total growth of 34.9 inches in 1955 but this was reduced to 26 inches during 1956 (Table X). Elreno side-oats attained a growth of 22.0 inches in 1955, and the growth of blue grama and buffalo grass was 8.4 and 4.5 inches, respectively. Reduction in growth of Elreno side-oats grama in 1956 was much less than for the shortgrasses.

Treatment Two (Clipped every 2 weeks from June 1 until growth ceased.)

The clipping intensity of treatment 2 stimulated the vegetation to a greater production that did treatment 1 (Table VIII). Forage production was maintained throughout the growing season of 1955 but only through July of 1956. Total amount of forage harvested in 1955 was

1,367 pounds per acre but was reduced by almost one-half during 1956. Elreno side-oats grama yielded over 80 per cent of the forage. As in treatment 1, blue grama and buffalo grass declined in yield from 1955 to 1956. Forb yield was also reduced.

Elreno side-oats and blue grama suffered heavily from 1955 to 1956 as indicated by the loss of basal cover (Table IX). Both grasses decreased by more than 50 per cent. Reduction of buffalo grass was not great, as it lost only 0.97 of 1 per cent of its basal cover.

Clipping stimulated the growth of the grasses in 1955, but reduced growth in 1956 (Table X). Total growth for 1955 was 39.3 inches and in 1956 it was only 15.5. Proportionally, Elreno side-oats grama had the greatest reduction (15 inches) followed by blue grama with 6 inches, and buffalo grass with a 2.5-inch reduction.

Treatment Three (Clipped once a month from June 1 until growth ceased.)

Under monthly clipping the vegetation produced a good yield for both the 1955 and 1956 growing seasons (Table VIII). In 1955 1,338 pounds per acre of air dry forage were produced, and this was reduced by only 280 pounds in 1956. Forage was produced from May through September of 1955, with the exception of August when climatic conditions were not conducive to growth. During 1956, however, vegetation could be harvested only in May, June and July. Most of the forage in 1956 was produced in May; June was the largest producing month in 1955.

The amount of forage produced by Elreno side-oats was over 1,100 pounds in 1955 but this was decreased by almost 300 pounds in 1956. Buffalo grass yield for 1956 (106 pounds) was about equal to that of

Table IX. Per cent basal cover of the reseeded pasture under the different clipping treatments for the 1955 and 1956 growing seasons. Bcu--Bouteloua curtipendula, Bgr--Bouteloua gracilis, and Bda--Buchloe dactyloides.

Grass	Treatment One		Treatment Two		Treatment Three		Treatment Four	
	1955	1956	1955	1956	1955	1956	1955	1956
Bcu	41.4	18.3	38.3	16.1	31.9	16.0	36.3	25.1
Bgr	4.4	2.0	5.1	1.7	6.5	2.1	5.0	1.3
Bda	5.7	5.6	7.0	6.0	6.7	6.0	4.7	3.2
Total b. c.	51.5	25.9	50.4	23.8	45.1	24.1	46.0	29.6
Per cent loss of Basal cover		49.7		52.7		46.5		35.6

Table X. Growth in inches of the grasses of the reseeded pasture for the 1955 and 1956 growing seasons under different clipping treatments. Bcu--Bouteloua curtipendula, Bgr--Bouteloua gracilis, and Bda--Buchloe dactyloides.

Grass	Treatment One		Treatment Two		Treatment Three		Treatment Four	
	1955	1956	1955	1956	1955	1956	1955	1956
Bcu	22.0	15.5	25.3	10.4	20.8	10.0	10.2	7.0
Bgr	8.4	6.5	9.5	3.0	8.3	5.3	3.5	4.0
Bda	4.5	4.0	4.5	2.1	5.8	4.8	2.5	3.0
Total	34.9	26.0	39.3	15.5	34.9	20.1	16.2	14.0

1955, but the yield of blue grama was reduced from 100 to 70 pounds during 1956. The pounds of forage produced by forbs during 1956 was increased 15 pounds over the 17 pounds produced in 1955.

The basal cover under this treatment was reduced about as much as it was in treatment 1, with Elreno side-oats and blue grama bearing the brunt of the loss. The basal cover of buffalo grass, however, was affected only slightly by this clipping treatment (Table IX).

The grasses grew a total of 34.9 inches in 1955 but there was about a 43 per cent reduction in growth during 1956. Elreno side-oats growth was reduced by almost 11 inches and growth of blue grama and buffalo grass were reduced 3 and 1 inches, respectively (Table X).

Treatment Four (Clipped at the end of growing season.)

Clipping the vegetation at the end of the growing season appeared to have very little effect upon the yield for the next growing season (Table VIII). A reduction of less than 75 pounds was noted from 1955 to 1956. Forage produced by Elreno side-oats was reduced only from 903 to 865 pounds per acre and forage produced by blue grama was reduced by 12 pounds. Buffalo grass and forbs, however, increased in yields.

Reduction of basal cover was also least under this treatment (Table IX). This reduction was from 46.0 per cent in 1955 to 29.6 per cent in 1956. Elreno side-oats grama was reduced from 36.3 to 25.1 per cent, and blue grama and buffalo grass suffered over a one-third reduction.

Growth, like yield, changed very little over the 2 growing seasons on unclipped quadrats (Table X). Total growth was reduced some-

what (16.2 inches to 14 inches). The short grasses increased in height, while the growth of the Elreno side-oats grama decreased over 3 inches.

Shortgrass

Treatment One (Clipped every 2 weeks from June 1 to July 1.)

A yield of 1,474 pounds per acre of air-dry forage was produced in 1955 and 1,359 pounds in 1956 (Table XI). All of the forage was harvested during May and June of 1955 but only during May and September of 1956. Buffalo and blue grama grass produced over two-thirds of the forage the first season but only one-third the second season, when there was a tremendous increase in the winter annual population. Forb production increased from 18 to 34 pounds.

Basal cover was high (80.3 per cent) at the start of the 1955 growing season but was reduced by almost one-third by the end of 1956 (Table XII). Total growth was not great (11.1 inches) for the 1955 season with blue grama attaining a height of about 6.5 inches and buffalo grass about 5 inches (Table XIII). Growth was 3 inches less in 1956, with blue grama being reduced 1.4 inches, and buffalo 1.7 inches.

Treatment Two (Clipped every 2 weeks from June 1 until growth ceased.)

This treatment produced the highest total yield for both 1955 and 1956 (Table XI). The amount of forage produced was 1,904 and 2,141 pounds per acre for the 1955 and 1956 growing seasons, respectively. The production of buffalo and blue grama grass was reduced from 1,248 pounds in 1955 to 483 pounds in 1956 but the winter annuals increased their production of forage over 1,000 pounds. The largest amount of

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Table XI. Monthly and seasonal yield of the shortgrass pasture in pounds per acre under different clipping treatments for the 1955 and 1956 growing seasons. Symbols of the grasses are derived from the first letter of the generic name and the first two letters of the species name: Bgr--Bouteloua gracilis, Bda--Buchloe dactyloides, and Bja--Bromus japanicus, and Hpu--Hordeum pusillum.

TREATMENT ONE

	1955						1956					
Grass	May	June	July	Aug.	Sept.	Total	May	June	July	Aug..	Sept.	Total
Bgr-Bda	725	379	--	--	--	1104	247	--	--	--	134	381
Bja-Hpu	352	--	--	--	--	352	944	--	--	--	--	944
Forbs	18	--	--	--	--	18	34	--	--	--	--	34
Total	1095	379	--	--	--	1474	1225	--	--	--	--	1359

TREATMENT TWO

	1955						1956					
Grass	May	June	July	Aug.	Sept.	Total	May	June	July	Aug.	Sept.	Total
Bgr-Bda	837	395	16	--	--	1248	267	--	216	--	--	438
Bja-Hpu	608	--	--	--	--	608	1617	--	--	--	--	1617
Forbs	46	3	--	--	--	49	25	--	16	--	--	41
Total	1491	398	16	--	--	1095	1905	--	232	--	--	2141

Table XI. (continued)

TREATMENT THREE

Grass	1955 May	June	July	Aug.	Sept.	Total	1956 May	June	July	Aug.	Sept.	Total
Bgr-Bda	780	148	—	—	—	928	244	—	309	—	—	553
Bja-Hpu	523	—	—	—	—	523	1178	—	—	—	—	1178
Forbs	81	35	—	—	—	116	56	—	15	—	—	71
Total	1384	183	—	—	—	1567	1478	—	324	—	—	1802

TREATMENT FOUR

Grass	1955 May	June	July	Aug.	Sept.	Total	1956 May	June	July	Aug.	Sept.	Total
Bgr-Bda	—	—	—	—	740	740	—	—	—	—	671	671
Bja-Hpu	—	—	—	—	413	413	—	—	—	—	203	203
Forbs	—	—	—	—	—	—	—	—	—	—	138	138
Total	—	—	—	—	1153	1153	—	—	—	—	1012	1012

Table XII. Per cent basal cover of the shortgrass pasture under different clipping treatments for the 1955 and 1956 growing seasons. Bgr--*Bouteloua gracilis*, and Bda--*Buchloe dactyloides*.

Grass	Treatment One		Treatment Two		Treatment Three		Treatment Four	
	1955	1956	1955	1956	1955	1956	1955	1956
Bgr-Bda	80.3	57.5	72.1	46.6	71.2	51.4	73.7	32.6
Per cent loss of Basal cover		28.4		35.4		27.8		55.8

Table XIII. Growth in inches of the grass in the shortgrass pasture for the 1955 and 1956 growing seasons under different clipping treatments. Bgr--*Bouteloua gracilis* and Bda--*Buchloe dactyloides*.

Grass	Treatment One		Treatment Two		Treatment Three		Treatment Four	
	1955	1956	1955	1956	1955	1956	1955	1956
Bgr	6.4	5.0	8.5	4.0	5.5	4.2	3.8	5.0
Bda	4.7	3.0	4.3	2.5	3.5	2.8	2.4	3.0
Total	11.1	8.0	12.8	6.5	9.0	7.0	6.2	8.0

forage was produced in May of both years. Forage was composed of both grasses and forbs in June of 1955 but only of grasses in July. In 1956, however, no forage was produced in June but, with rains in July, grasses and forbs almost equaled their production during May.

Basal cover was reduced somewhat more for this treatment than for treatment 1 (Table XII). Cover decreased from over 70 per cent in 1955 to less than 50 per cent in 1956.

Total growth was greatest under this clipping intensity (Table XIII). The total growth for both grasses was 12.8 inches in 1955 but was reduced to almost one-half that amount during 1956. A reduction of 4.5 inches was noted for blue grama and buffalo grass was reduced by 2.5 inches.

Treatment Three (Clipped once a month from June 1 until growth ceased.)

Under this treatment the yield was similar to that under clipping treatment 2 (Table XI). In 1955, 1,567 pounds per acre of forage were produced and over 1,800 pounds in 1956. May was the largest producing month. Grass production decreased by almost one-half from 1955 to 1956 but the total yield was kept high by heavy production of annuals in 1956. Forbs produced somewhat more than they did under either treatment 1 or 2 but had a general reduction in 1956.

Basal cover was reduced least under this treatment (Table XII). A loss of 27.8 per cent occurred from 1955 to 1956.

Growth was not stimulated much by this clipping treatment (Table XIII). The grasses grew a total of only 9 inches in 1955 and this was reduced by 2 inches in 1956. Blue grama had slightly more than a 1

inch reduction (5.5 to 3.8) and buffalo grass had slightly less (3.5 to 2.8).

Treatment Four (Clipped at the end of the growing season.)

The yield was considerably less under this treatment than under the more frequent clipping intensities (Table XI). The 740 pounds of forage received from perennial grass was reduced by about 70 pounds from 1955 to 1956 and the decrease in forage of the winter annuals was about one-half (413 to 203 pounds). By the end of the 1955 season there were no forbs available for clipping because of drought conditions. Although 1956 was a much drier year, the hard rains of July provided sufficient moisture for the production of 138 pounds of forbs.

The reduction of basal cover under this treatment was much greater than expected (Table XII). The loss was 55 per cent or one-half to two times greater than more severe clipping treatments.

Although there was a reduction in basal cover, total growth increased over the 1955 growing season (Tables XIII and XI), with the growth of blue grama increasing about 1 inch and buffalo grass increasing about 0.5 inches.

DISCUSSION

Climatic conditions for the two growing seasons were adverse. The first season, 1955, had above average precipitation but more than 40 per cent of this was received in September and was of little value to the vegetation in 1955. During 1956, precipitation was less than one-half of the amount received during 1955. Growth in the spring of 1956 was late because of very cool weather in April. In June only 0.38

inches of precipitation were received and a severe reduction in growth occurred. Frequent high winds and above normal temperatures also prevailed during the summer months of both seasons, making conditions very unfavorable for growth. However, there were periods of sporadic rainfall followed by cool temperatures (July, 1956) which revived the vegetation to some degree. Available soil moisture was present during the spring of 1956 but declined through the summer and was generally absent after July.

Clipping, whether monthly or every 2 weeks, increased production over non-clipping in 1955. However, during 1956, when drought conditions were more severe, yields were decreased to a greater extent under frequent clipping than under moderate or non-clipping on the bluestem and reseeded pastures. However, because of the tremendous increase of annuals in 1956, production of the shortgrass pasture exceeded that of 1955, even though the amount of forage produced by perennial grasses was less.

The shortgrass pasture produced more than the mid-grass dominated bluestem and reseeded pastures under every clipping treatment during the 2 growing seasons, which is not generally the case under normal rainfall. Riegel (1947) and Franks (1953) found the opposite to be true when they investigated yields of native grass species of western Kansas under more favorable moisture conditions. Their study included only perennial grasses and not drought-escaping annual grasses which eventually thrive under heavy utilization. These grasses usually attained their maturity early in the summer with their seed being produced by the first of June,

and therefore did not suffer from drought and clipping. When heavy rains were received in September, 1955, they provided a generous supply of soil moisture the next spring for the annuals and allowed them to increase their production from two to three times that of the preceding year. However, when the shortgrass went unclipped the amount of forage produced by the annuals decreased, undoubtedly the result of the stems drying up and loss of seeds.

Production was greatest during the spring and early summer when soil moisture was available and hot desiccating winds were infrequent. However, when soil moisture was near the critical point, yield fluctuated with the rainfall. For example, production of forage was fair during May of 1956 but, when only 0.38 inches of precipitation was received during June, yield was reduced greatly under treatments 2 and 3. In July, when over 2.50 inches of rain fell, the grasses increased their yield to about as much or even more than that produced during May.

The greatest reduction in yield between 1955 and 1956 occurred when the vegetation was clipped from June 1 to July 1 (Treatment 1). This was undoubtedly caused by deficient rainfall during June of 1956. However, some forage was harvested in September as a result of the rains received in July. No forage was produced after July in 1955 under treatment 1 except on the reseeded area.

The close clipping of treatment 2 (Clipped every 2 weeks from June 1 until growth ceased) reduced yield of the bluestem and reseeded areas from 1955 to 1956 to a greater extent than did the moderate clipping of treatment 3. Yield of the shortgrass pasture was increased by

frequent and moderate clipping because of the tremendous amount of forage produced by annual grasses. This increased production by annuals more than offset that decrease suffered by buffalo and blue grama under treatments 2 and 3.

Yield under non-clipping was not nearly as great as yield from frequent clipping, but yield from non-clipping the second growing season was not reduced as much as frequent clipping. In fact, on the bluestem pasture yield of all vegetation was increased by non-clipping. This increase was probably the result of the heavy rains received in September of 1955, coupled with an invasion of annual grasses and vigorous plant growth.

Increment of top growth, like yield, was usually greatest during the first growing season (1955). Frequent clipping stimulated growth in 1955, but this excessive growth evidently decreased the vigor of the grasses because in 1956 growth was reduced the greatest amount where clipping was the most intense. Moderate clipping (Treatment 3) reduced increment less than frequent clipping (Treatments 1 and 2) over the two growing seasons. Increment increased where the native bluestem and shortgrass areas were not clipped; however, the growth of the reseeded pasture decreased slightly by non-clipping.

Albertson et al. (1953) studied the effects of various intensities of clipping on shortgrass during periods of abundant rainfall. They discovered that during the first year of clipping growth was greatest on closely clipped areas and least on non-clipped. However, after the second year of the study, growth was least where clipping was most intense.

Under frequent clipping, blades of the grasses became lighter in color, shorter, fewer and more slender. This was true for both growing seasons but more so during the second growing season. However, under frequent clipping the grasses usually remained green longer than did those subjected to moderate or non-clipping. It was also noted that when clipped frequently the grasses responded more quickly to sporadic showers and cool temperatures.

Drought conditions that prevailed during both years of the study restricted the production of flower stalks on the 3 pastures. This was more common of the mid-grasses, especially big bluestem and side-oats grama of the bluestem pasture. Flower stalks were short and most of the heads remained in the boot when the grasses went into dormancy. However, during periods of available moisture (July, 1956) some seed heads did appear from the boot, although they were small.

Because of the larger percentage of basal leaf surface of buffalo grass, the growth of this species was reduced less over the 2 growing seasons than other species under similar treatments. However, stolons of buffalo grass were much shorter under frequent clipping than when they were not clipped.

Basal cover of all grasses except buffalo grass was greatly reduced over the 2 growing seasons by all treatments. Crowns of grasses which had a bunchy growth habit began to deteriorate near the center during the latter part of the first growing season. Tillering became less and less and had practically ceased by the summer of 1956, and only scattered remnants of original crowns remained. The sod-forming grasses

which were made up of many small "tufts" were decreased in basal cover by the killing of these tufts due to clipping or drought or a combination of these two factors.

Clipping treatments which caused the greatest reduction in basal cover over the two growing seasons varied with the pasture type. Frequent clipping for the entire season (Treatment 2) was most injurious to the bluestem and reseeded pasture, while reduction of the shortgrass area was greatest under non-clipping.

Schultz et al. (1955) found that when plots containing brush seedlings and grass are unclipped soil moisture is depleted at a faster rate and to a greater extent than when clipped. Perhaps this is the reason for the tremendous loss of basal cover the short grass suffered under non-clipping.

The least amount of loss occurred in treatment 3 on the bluestem and shortgrass pastures, but the loss in the reseeded pasture was smallest under non-clipping. Buffalo grass had the vigor to establish itself in quadrats of the bluestem pasture that were clipped, but non-clipping prevented this, probably because of the competition resulting from the more vigorous big bluestem and side-oats grama.

It was interesting to note that when side-oats grama was associated with big bluestem in the ratio of approximately 0.4 or 0.8 to 1, clipping reduced its cover very little. In fact, this grass increased its basal cover under treatment 3 when found in the above ratio. However, when the two grasses had about the same basal cover both were reduced about 50 per cent over the two growing seasons by frequent clip-

ping. Big bluestem was reduced the most by treatment 2 and the least by treatment 3, whereas side-oats grama's greatest reduction occurred under treatment 1.

Elreno side-oats and blue grama bore the brunt of the loss of basal cover on the reseeded pasture. Buffalo grass of the reseeded area was reduced very little by any treatment but its greatest loss occurred when non-clipped. The vigor of the dominant, side-oats grama, undoubtedly was too great when non clipped to allow buffalo to spread. Clipping the shortgrass pasture every 2 weeks from June 1 to July 1 resulted in a reduction of basal cover similar to that when the area was clipped monthly for the entire season.

Evidently, because of moisture conditions, the yields of pasture types do not differ greatly during periods of drought. Pastures dominated by higher producing, more mesic midgrasses do not seem to be able to cope with drought conditions like pastures made up primarily of shortgrasses. The weedy annuals which are found so frequently with overgrazing probably are, under proper management, a source of forage if grazed when palatable.

As during periods of normal precipitation, clipping frequently during periods of drought is more injurious (decrease in yield and basal cover) to pastures than moderate clipping. However, loss suffered from non-clipping of shortgrass and midgrass areas during periods of drought appears to be as great or greater than those suffered from frequent clipping.

SUMMARY

A study was made to determine the effects of various intensities of clipping yield, basal cover, and growth of 3 pasture types. The study was conducted for 2 growing seasons (1955-1956) on a bluestem, reseeded, and shortgrass pasture. They were located on the lower slope of a large hill, with each area having appriximately the same degree of slope and same soil depth.

Each pasture type was subjected to 4 intensities of clipping:

I — Clipped every 2 weeks from June 1 to July 1.

II -- Clipped every 2 weeks from June 1 until growth ceased.

III -- Clipped once a month from June 1 until growth ceased.

IV — Clipped at the end of the growing season.

Twenty quadrats, 4 series of 5 quadrats each, were located in each pasture. The quadrats were clipped at the time prescribed by each clipping treatment and the clipped forage was air dried, weighed, and computed to pounds per acre.

The basal cover of each quadrat was determined in the spring of 1955 and again in the fall of 1956 by the use of a pantograph. The basal cover was an average of the 5 quadrats in each clipping series.

Growth was measured at approximately 2-week intervals. Measurements were made of new growth prior to clipping and also of growth on the unclipped quadrats.

Grasses which were studied on the bluestem pasture were big bluestem (Andropogon gerardi) and side-oats grama (Bouteloua curtipendula).

On the reseeded pasture, investigations were made on Elreno side-oats grama, blue grama (Bouteloua gracilis), and buffalo grass (Buchloe dactyloides). The third area studied was the shortgrass pasture which was dominated by blue grama and buffalo grass with the winter annuals, Japanese brome (Bromus japonicus) and little barley (Hordeum pusillum), congesting the open spaces between clumps of perennial grasses.

Soil moisture was determined with a geotome every week during 1956 to a depth of 5 feet on each pasture type. Samples were taken in duplicate and the approximate amount of available moisture for the 2 samples was recorded for each depth.

Climatic conditions for the 2 growing seasons were adverse. Rainfall was low or obnormally distributed, with deficient soil moisture being accompanied by high temperatures and wind velocity. The 1955 growing season received over 19 inches of rainfall, while the rainfall for 1956 was only slightly more than 7 inches.

Production of the 3 pasture types was usually greatest during the months of May and June, and then declined sharply with little or no forage being produced after July. However, the production of forage fluctuated with the rainfall when soil moisture became available in the presence of cool temperatures. After the middle of July, most of the grasses were in a semidormant stage with their leaves either rolled or folded. Growth was continuous for the 1955 growing season on the reseeded pasture only under frequent clipping (Treatment 2).

The amount of perennial grass forage produced by each pasture usually decreased from 1955 to 1956 under each treatment. Reduction

varied from about 65 per cent under frequent clipping to less than 10 per cent under non-clipping. The exception was the bluestem pasture which increased its forage production by over 360 pounds per acre, when it was clipped at the end of the growing season (Treatment 4).

The results of this study indicate that during periods of drought, the yield of perennial grasses vary only slightly. It was found that rarely more than 300 pounds separated the yield of the pasture types under any one treatment. However, a shortgrass pasture that is highly infested with winter annuals will produce more forage than a midgrass pasture and a pasture that is composed of mid and shortgrasses.

Frequent clipping during periods of drought, as during normal precipitation is more injurious to the yield and basal cover of perennial grasses than moderate clipping. However, when the vegetation was clipped at the end of the growing season, the loss of basal cover was just as much or greater than that suffered under frequent clipping. Yield varied only slightly during the 2 growing seasons under non-clipping.

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