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Cows, Calves and Grass: Effects of Grazing Intensities on Beef Cow and Calf Production and on Mixed Prairie Vegetation on Western South Dakota Ranges

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AGRICULTURAL EXPERIMENT STATION
SOUTH DAKOTA STATE COLLEGE Brookings
IN COOPERATION WITH
SOIL CONSERVATION SERVICE, U. S. D. A.

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Cows, Calves and Grass

A DIGEST

Cattlemen on South Dakota's ranges are concerned primarily with getting maximum beef production—not just for today or tomorrow, but for the next quarter of a century or more that lies ahead. One of the key factors in beef production is the most favorable stocking rate for summer grazing.

Summer grazing trials have been conducted under typical range conditions at the Cottonwood Range Field Station for nine years, 1942 through 1950, in an attempt to answer some of the problems.

Hereford cows and calves were grazed for a 7-month grazing period from about May 1 to November 30 each year at heavy, moderate and light rates of grazing. The heavy rate of stocking provided about 9 acres per cow per season, or an average of 1.4 acres per cow per month for the 9-year period. For moderate stocking, about 15 acres per cow per season were allowed, or an average of 2.2 acres per cow per month. The light rate of stocking provided about 21 acres per cow for the season, or 2.9 acres per cow per month.

Percent Calf Crop Not Affected By Grazing Rates

Grazing intensities during the experiment had little, if any, effect upon the percent calf crop weaned or the ability of cows to settle early in the breeding season. During the second period of the trial, the percent calf crop weaned from the heavily grazed pastures actually exceeded that from the lightly grazed by 10 percent. In 1950, the calf crop weaned from the heavily grazed pastures dropped to 55 percent, but this is only one year's result and the yearly variation in percent calf crop weaned was extremely high throughout the experiment.

Fall Weight and Condition of Cows Reduced by Heavy Grazing

The greatest single effect of heavy grazing on cow and calf production was in body weight of cows, with the cows on the heavily grazed pastures remaining consistently lighter than those with more grass. Five months of similar winter feeding failed to compensate for heavy grazing during the summer. In 1950, the last year reported, the cows from the heavily grazed pastures were 123 pounds lighter than those from the moderately grazed, and those from the lightly grazed pastures were 64 pounds heavier than those from the moderately grazed.

All cows gained in weight until about August 1, held their weight or lost slightly during August and September, and lost sharply during October and November. This seasonal trend, irrespective of treatment, was probably due to loss in nutritive value of the forage, which normally declines in value as it matures.

Calf Weights Reduced By Heavy Grazing

The weaning weights of the calves were definitely reduced by heavy

stocking during both periods of the 9-year study. During the last period, the light rate of grazing produced calves which were fatter as well as heavier than the calves under heavy grazing.

Calf weights were influenced by rate of grazing to a lesser degree than cow weights. The average weaning weights of calves, corrected to a standard 190-day age, were 355, 363, and 386 pounds for the 9-year period on heavy, moderate, and light rates of grazing, respectively. This indicates an 8-pound and 31-pound advantage for moderate and light grazing compared with heavy grazing.

There were no apparent differences in calf weights under light, moderate, or heavy grazing until about August 1, but following that date, the calves nursed by cows on pastures with more grass available made the greatest daily gains. The time at which differences in weight gains of the calves began to be apparent coincided closely with the cessation of weight gains in the cows.

Gains Per Acre Decline With Continued Heavy Grazing

Cow and calf gains per acre were in favor of the heavy rate of grazing throughout the first eight years of the 9-year period. The advantage for heavy grazing steadily declined however because of the deterioration of the range. Cow and calf gains per acre are a valuable measure of the productivity of a pasture; nevertheless, this measure may be very misleading unless it is considered along with individual cow and calf gains, condition of the cow and calf, and condition of the range.

Heavily Grazed Pasture Fails to Carry Cattle for Full Season

In 1949 the cattle had to be removed from one heavily grazed pasture 65 days before the close of the grazing season, and on the second heavily grazed unit, 45 days before the end of the season. One pasture set up as a moderately grazed pasture also ran out of grass a month before the grazing season was over. In this case, cow and calf gains per acre do not tell the full story, for if the cattle had remained on experimental pastures for the full season, they would have suffered severe losses.

Grazing Rates Change Amount And Kinds of Grasses

The rate of grazing has influenced the character of the vegetation and changed the range condition. The original vegetation on Northern Great Plains ranges was mixed grasses, with those of short and medium height present in nearly equal proportions. The shallow-rooted, low-growing, short grasses, such as blue grama and buffalograss, produced less than half the total foliage grown in an average year. The medium height grasses, called mid-grasses, such as western-wheatgrass, green needlegrass, and sideoats grama, produced the bulk of the foliage.

The cows and calves on the heavily, moderately, and lightly stocked ranges grazed an average of 63, 46, and 37 percent of the total foliage produced annually during the nine years. The heavy rate of grazing practically killed out the mid-grasses, leaving a continuous sod of short grasses. The moderate rate of grazing maintained the mid-grasses throughout the ex-

periment, and the light rate showed an increase in the percentage of mid-grasses.

Range Condition Lowered By Heavy Grazing

This experiment indicates that the 63 percent average annual removal of foliage on the heavily grazed pastures caused the range to deteriorate. Range condition dropped from 70 percent in 1942 to 51 percent in 1950, barely remaining in the "good" range condition class. The average annual removal of foliage of 46 percent on the moderately grazed pastures maintained the range condition above 70 percent. An average annual removal of foliage of 37 percent on the lightly grazed pastures resulted in an increase in range conditions from 73 percent in 1942 to 81 percent in 1950, which is in the "excellent" range condition class.

Heavily Grazed Pastures Produce Less Grass

Although there were strong year-to-year fluctuations, total foliage production declined sharply under heavy use, held its own under moderate use, and increased under light use. Foliage yield was measured by clipping in which the plots were clipped to crown level.

The yield of foliage under heavy grazing was reduced from 1569 pounds per acre in 1942 to an average of 1262 pounds during the 9-year period. A large part of this difference in yield was due to a change in the forage species on the range. High yielding mid-grasses, such as western wheatgrass, needleandthread, and green needlegrass decreased under heavy grazing, while the lower yielding short grasses, such as blue grama and buffalograss, increased under heavy grazing.

This is the sign that greets passers-by on Highway 16, two miles east of Cottonwood

Another large portion of this difference in yield was likely due to reduced vigor of the grasses on the heavily grazed pastures. Whenever the amount of plant food manufactured is reduced by repeated removal of green leaves under heavy grazing, root development is restricted, and forage production is decreased.

It was very evident that hail, insects, and rodents were users of the grass as well as the cattle, and that they also affected future production of the ranges.

Recommended Stocking Rate

On the basis of beef production and the reaction of the vegetation to the different intensities of grazing, it appears that a stocking rate of about 2¼ acres per cow per month, or 0.45 cow month per acre, would be an optimum stocking rate for the Cottonwood area during years of average rainfall. This would necessitate from 15 to 16 acres for a cow and calf for a 7-month grazing period. The live-

stock should consume an average of not more than 40 to 55 percent of the total foliage produced in an average year (weight, not height, of grasses being the measurement used).

A good rule of thumb to follow is: **"Graze half and leave half, and the half grazed becomes larger and larger."** This experiment bears this out in foliage yields.

A guide to degree of use that has recently been introduced to ranchers in South Dakota is shown in the Appendix of this bulletin. Nine degrees of use are shown by number, degree, and description, with degree No. 5—full use—the heaviest that can be made consistent with the growth requirements of range plants to maintain range condition and foliage production. Full use corresponds to the 40 to 55 percent found in this experiment to be the amount of use that will maintain conditions and productivity of native grasslands.

Other Factors Important

Cows made their highest gains during the period when the grasses were highest in protein, which averaged more than 7.0 percent early in the season. When the grasses contained only 5.5 to 6.0 percent protein, usually in August, the cows just maintained their weight, or experienced small losses. As the protein content of the grasses consumed dropped to 4.0 to 4.5 percent, cows on all rates of grazing lost weight, even though ample forage may have been available.

These investigations have also emphasized the importance of rainfall in range beef production. No method of grazing management can prevent drought, but conservative grazing can lessen the shock by providing some carry-over of forage, as well as maintaining higher grass production during dry years.

Cows, Calves and Grass

Effects of Grazing Intensities on Beef Cow and Calf Production and on Mixed Prairie Vegetation on Western South Dakota Ranges

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The range area of South Dakota includes approximately 30 million acres and constitutes nearly one-fourth of the land commonly designated as the Northern Great Plains in the two Dakotas, Nebraska, Montana, and Wyoming (Fig. 1). About 75 percent of the South Dakota range area is being grazed. In recent years this land has provided summer grazing for about 500,000 beef breeding cows and calves, plus a large number of steers, heifers, sheep, and horses. The amount and continuity of returns from this grazing enterprise depend to a great extent upon the management of livestock and range during the summer grazing season.

One of the foremost problems in balanced use of the range of western South Dakota is the fluctuating annual production of native forage. The amount of forage produced in any year is dependent mainly on the precipitation during the growing season, condition of the range, moisture reserves in the soil, and seasonal temperatures. Any one year or period of years may have below average rainfall and higher than average temperatures with consequent low forage production. Other years or period of years may have above average rainfall and lower than average temperatures with high forage production. Other combinations of weather may affect forage production so that stocking the ranges for maximum production and sustained yields of forage becomes a difficult problem. (Albee, *et al.* 1948.)

This bulletin reports the results of a 9-year summer grazing experiment on native ranges in western South Dakota. The experiment was designed to determine the effects of climate and different intensities of grazing on (1) beef production, (2) maintenance of range condition, and (3) foliage yields. Hereford cows and calves were used in the experiment. The work was conducted at the Cottonwood Range Field Station which is located slightly south of the center of western South Dakota and midway between the Missouri River and the Black Hills (Fig. 1). It is in the upper watershed of the Bad River.

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Acknowledgment is made to Dr. Charles Hobbs, former Head of the Animal Husbandry Department, to I. B. Johnson, Director of the Agricultural Experiment Station, and to the former superintendents of the Cottonwood Range Field Station: Robert Smith, George Dobesh, and Carl B. Larsen, for their contributions to this work.

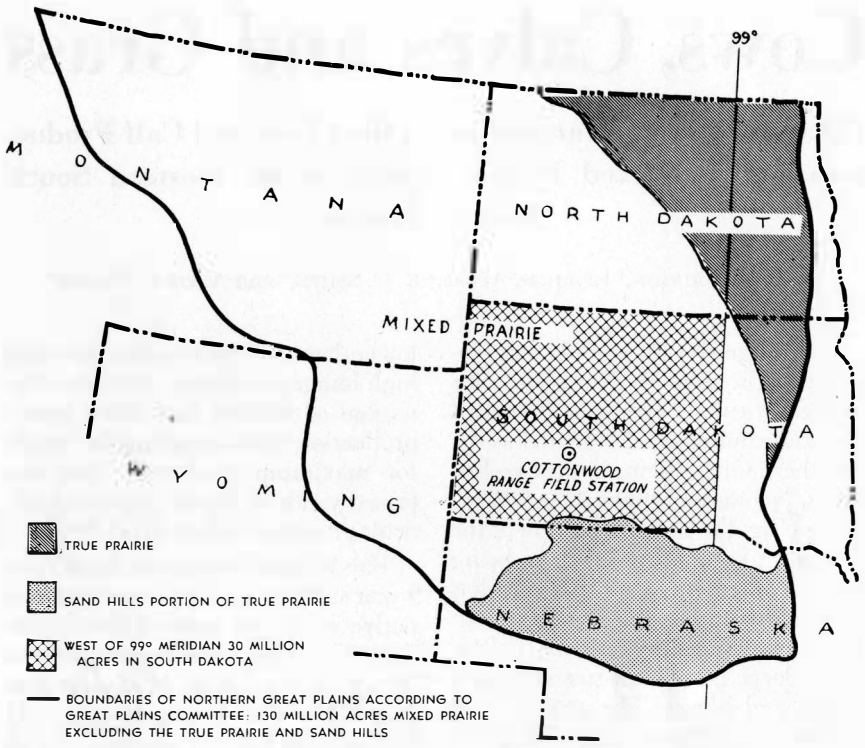


Fig. 1. Boundaries of the Northern Great Plains, according to the Great Plains Committee

Review of Related Investigations

Because of the need for a proper understanding of good range management, cattle grazing experiments have been carried out at several stations in the Northern Great Plains during the past 35 years. All range producers will be interested in the results obtained from these related experiments as a background to understanding the findings of the Cottonwood experiment, and consequently, a brief review is presented at this point.

Cow and Calf Experiments

At the United States Range Livestock Experiment Station, Miles City, Montana, Woolfolk and Knapp (1949) compared the effects of heavy, moderate, and light rates of grazing on weights and gains of range calves. The tests were made with cows and calves, and eight calf crops gave average weaning weights of 395, 428, and 423 pounds respectively for the three rates of grazing. The calves at birth were similar in weight regardless of rates of grazing. The lower weights at weaning, resulting from heavy stocking, still persisted at 18 months of age.

Hurtt and Woolfolk (1940) reported a 6-year study with beef cows and

calves at Miles City, Montana, in which heavy, normal, and light grazing intensities were compared. The calf weights weaned per cow from the above three treatments averaged 225, 282, and 274 pounds respectively.

S. E. Clarke, *et al.* (1943) at the Dominion Range Experiment Station, Manyberries, Alberta, Canada, compared 20 acres, 30 acres, and 40 acres per cow for a 7-month, summer grazing period. The average gains per cow for the heavy, moderate, and light rates of grazing were 158, 200, and 242 pounds respectively. Weaning weights of calves for the three rates of grazing were 353, 395, and 404 pounds respectively.

Steer Experiments

Sarvis (1941) studied effects of rates of stocking with steers at the Northern Great Plains Field Station, Mandan, North Dakota. He found that 2-year-old steers made maximum daily gains on native mixed prairie range over a 20-year period when 7 or 10 acres were allowed per steer for a 5-month grazing season. Daily and seasonal gains were very unsatisfactory when either 3 or 5 acres were allotted per steer. The highest gain per acre was obtained from the 3-acre-per-steer pasture, but the average length of the grazing period had to be reduced to approximately 3½ months. A 5-year study at Mandan, with yearling steers at different rates of grazing, gave results in gains per steer and per acre similar to those for 2-year-old steers. However, gain per acre is a poor measure of the merit of a pasture or a system of grazing unless it is considered along with other measures such as gain per head, condition of the cattle, length of grazing season, and the condition of the range.

Black, *et al.* (1937) at the Ardmore Field Station, Ardmore, South Dakota, compared heavy and moderate rates of grazing native ranges with 2-year-old steers for a period of 12 years. They found the steers on heavily grazed pastures gained 161 pounds per season and those on moderately grazed areas gained 220 pounds each. The pounds of beef yield per acre under heavy and moderate intensities of grazing were 21.8 pounds and 15.8 pounds per acre respectively. However, the heavily grazed pastures failed to carry the cattle throughout the entire grazing season during 5 of the last 6 years of the experiment, giving an average period of 114 days compared to 136 days for the moderately grazed pastures.

Effects on Native Vegetation

At Mandan, Sarvis (1941) reported that under the two lighter rates of stocking there was little or no injury to the vegetation traceable to the effects of grazing. Under the two heavier grazing rates, needleandthread and prairie junegrass were driven out of the pastures by heavy grazing and the most prevalent forb,[5] fringed sagewort, increased early in the experiment, then decreased. Blue grama was able to withstand the close grazing.

In Sarvis' study, square meter plots were clipped at Mandan at 20-day, 30-day, and 40-day intervals as well as once each year and once every two years. The total production of air-dry plant material of all species in the plots clipped at these intervals was 45,

[5]Forb is a non-grasslike herbaceous plant (a weed in the range stockman's language).

55, and 64 percent of that from plots cut once a year. Weaver (1939) showed that frequent clipping of plots in Nebraska resulted in a marked reduction in total foliage as compared with clipping once per year.

Similar clipping experiments were carried out at Ardmore by Black *et al.* (1937) to represent various intensities of grazing. Blue grama and buffalograss yields were only slightly affected by frequent clipping, while western wheatgrass production was reduced severely, and the plains bluegrass yield was reduced to a less extent. Western wheatgrass produced the most forage when clipped only at the end of the growing season. Black, *et al.* (1937) concluded that vegetation was not injured by close grazing as long as steers had enough grass to make satisfactory gains.

At Manyberries, Canada, Clark *et al.* (1943) considered that soil moisture was the principal limiting factor to plant growth. There was a close relationship between the seasonal precipitation-evaporation ratio and annual foliage yields. Grazing intensities of 20, 30, and 40 acres per head for a 7-month grazing season showed the true grazing capacity to be slightly more than 30 acres per head. At the rate of 20 acres per head, the cattle did not make normal gains and the plant cover showed definite signs of deterioration. The mid-grass species, such as needleandthread, suffered more from heavy grazing than did blue grama and other short grasses. The effects of overgrazing at Manyberries were found to consist chiefly of a progressive decrease in the abundance, vigor, and yield of the more palatable species, associated with a corresponding increase in unpalatable forbs.

Clipping experiments by Lang and Barnes (1942) at the Archer Field Station in southeastern Wyoming showed that the short grasses (blue grama and buffalograss) yielded more when harvested frequently at the ground level than they did when protected during the growing season and harvested after growth ceased. Conversely, mid-grasses were found to yield significantly higher under protection and harvesting at the end of the growing season than under frequent clipping. Annual forbs made the same response as mid-grasses, while perennial forbs reacted like the short grasses.

Physical Factors of the Experimental Ranges

Soils and Topography

The soils at the Cottonwood Range Field Station are dense, slowly permeable clays derived from the Pierre formation typical of a large portion of western South Dakota. The surface soil becomes relatively thin on the steeper slopes, with shale rock scattered on top of some ridges and knolls. The Pierre clay is a heavy soil ranging in texture from a silty clay loam to a heavy clay. Usually it is dark brown in color.

The elevation at the Cottonwood Range Field Station is 2414 feet above sea level, as recorded by the U. S. Weather Bureau. The topography is gently rolling to rolling, with slopes

varying from 3 to 10 percent. Within the pastures, there is seldom a slope steep enough to break the continuous grass cover.

Climatic Factors

Precipitation and temperature are important climatic factors influencing plant growth on western South Dakota ranges. Evaporation is also a factor but has not been recorded at the Cottonwood Station.

Precipitation: The average annual precipitation at the Cottonwood Station during the 41-year period, 1910–1950, was 14.7 inches (See Appendix Fig. 1). An average of 11.7 inches, or 79.6 percent of the total, fell in the 6-month growing season, April 1 to October 1. During the period of this experiment, 1942–50, the average annual precipitation was 14.3 inches, with 11.4 inches, or 79.7 percent, falling in the growing season. Thus the precipitation during the time of this experiment was very similar to that of the 41-year period.

As shown in Fig. 2, May and June, with 3.05 and 3.26 inches of rainfall respectively, had the highest average rainfall in the years 1942–50. This, coupled with the April rainfall of 1.60 inches, was very important in influencing foliage growth for the season. Because averages can be misleading, Fig. 3 shows the spring and summer precipitation by years in relation to the average or normal long-time precipitation. In 1942, '43, '46, and '48 spring rainfall was above average and only in 1949 and 1950 was it seriously below average. Anything less than 75 percent of average has been considered as drought. Summer precipitation was deficient in all except one year, 1946, and in six of the years it was below the 75 percent drought line. Spring and summer precipitation in 1949 and summer precipitation in 1950 were all below the drought line. These conditions had a decided influence on growth of foliage during these years. Hurtt (1951) shows the

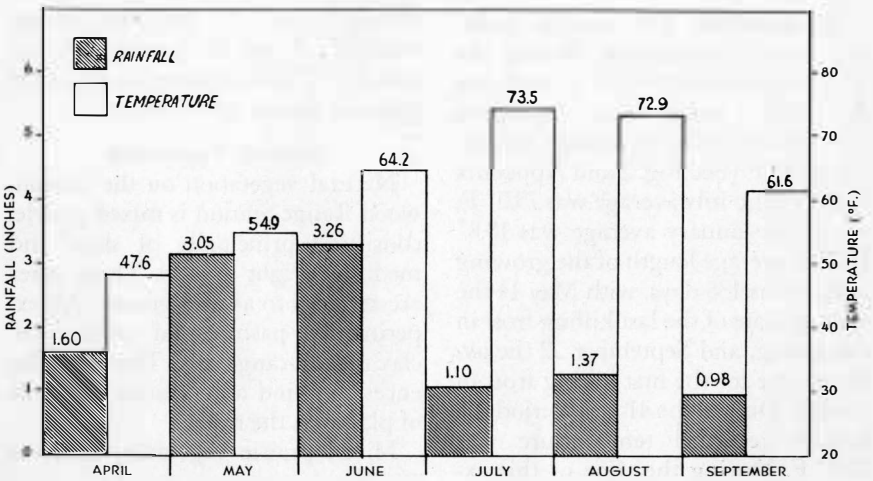


Fig. 2. Average monthly rainfall and temperature for the 1942–50 period

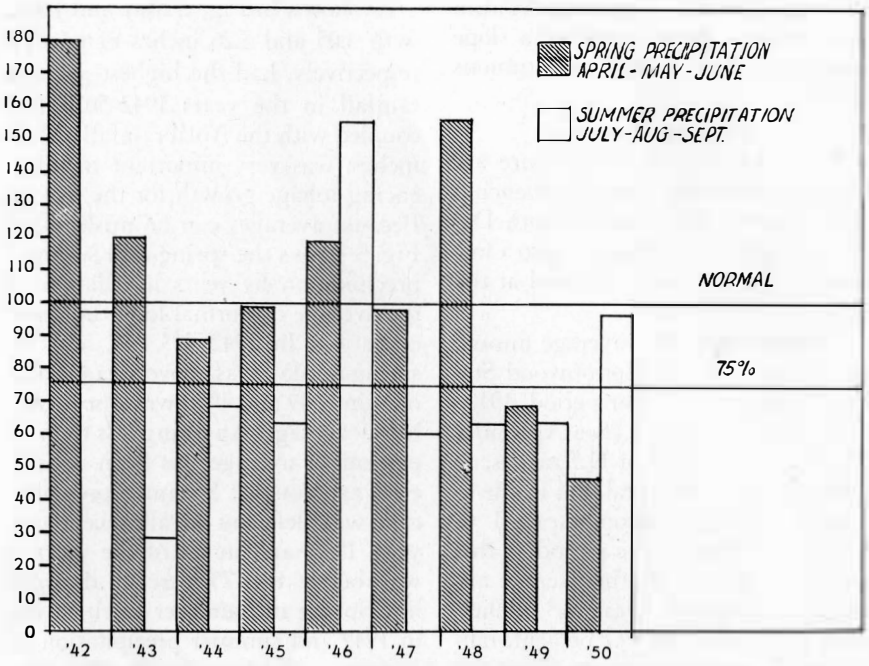


Fig. 3. Spring and summer rainfall as percent of normal for the years, 1942–50

seriousness of extreme drought on range vegetation at Miles City, Montana.

Temperature: The average growing season temperature during the 1910–50 period was 63.3° F. with the April-June temperature averaging 56.8° F, and July-September averaging 69.9° F (See Fig. 2 and Appendix Fig. 1). The July average was 75.0° F, while the January average was 18.8° F. The average length of the growing season was 136 days, with May 14 the average date of the last killing frost in the spring, and September 27 the average date for the first killing frost in the fall. During the 41-year period the highest recorded temperature was 116° F. During the time of this experiment (1942-50) the average growing season temperature was 62.4° F., with the April-June temperature averaging 55.6° F., and July-September averaging 69.3° F. The July average was 73.5° F. and the January average was 18.4° F. The average length of the growing season was 134 days.

Natural Vegetation

Natural vegetation on the Cottonwood Range Station is mixed prairie, consisting principally of short and medium height grasses. These latter are referred to as mid-grasses. All experimental pastures fall within the clay upland range site.[6] The site influences the kind and relative amounts of plants on the range.

Mixed prairie vegetation forms a

[6]A range site is the combination of climate, soil and other conditions of an area.

continuous grass cover over the experimental range area. While more than 85 species of plants have been observed on these ranges since the experiment began, less than a dozen have furnished more than 90 percent of the total foliage growth. The dominant short grasses and grasslike plants are blue grama, buffalograss, threadleaf sedge, needleleaf sedge, and sandberg bluegrass.

Among the dominant mid-grasses are western wheatgrass, green needlegrass, needleandthread, sideoats grama, and little bluestem.

The list of plants in the Appendix, page 38 includes most of those found on the Cottonwood Station during the period of experiment.

Each plant species found has been classified according to its response to heavy grazing, as given by Dyksterhuis (1949). Native range plants that decreased under heavy grazing were termed "decreasers." Western wheatgrass was the most common decreaser. Native plants that increased continually, or for a time and then decreased under heavy grazing, were called "increasers." Buffalograss increased under heavy grazing through the experiment, while blue grama increased for seven years, then decreased. Both the decreaser and increaser plants were part of the original or climax vegetation of the area.

The term "invaders" was applied to those plants that were not originally present in the native vegetation, but which invaded following range deterioration. All annual and some biennial and perennial plants fall within this group.

Each range plant belongs in one of the three groups of plants—decreaser, increaser, or invader. On each of the pastures, the sum of the relative coverage estimates of decreasers, increasers, and invaders always adds up to 100 percent.

The Experiment

The cattle used in the experiment were high-grade Hereford cows and registered Hereford bulls during the first 5-year period. During later years the grades were gradually replaced with purebreds so that both grades and purebreds were used. Once a cow was assigned to an experimental lot she remained in the lot as long as she was in the herd. This was done in order to get the cumulative effect of the treatment on the cows.

Three different rates of stocking the pastures were studied. These rates were designated as heavy, moderate, and light and provided 1.4, 2.3, and 3.1 acres per animal unit per month during the first 5-year period. For the next period the *planned* stocking rate was increased 25 percent thus allowing 1.1, 1.8, and 2.5 acres per animal unit per month. These stocking rates resulted in eight cows per lot, with duplicate lots for each stocking rate, during the first period and ten cows per lot in the later period.

Two pastures for each of the three treatments were laid out on the basis of a range survey in 1939 and checked in 1941. The division into pastures was made in such a manner as to have as nearly as possible equal forage pro-

ducing capacity per acre in all pastures. Each series of three was laid out around a hub with a well and water tank at the hub (See Fig. 4). Because an equal number of cows was used in each lot, the pastures varied in size and this meant that the cattle in the lightly grazed pastures had to travel slightly farther to water when they were grazing the ends of the pastures farthest removed from the water. In no case was the distance greater than one mile.

The cattle were kept on the pastures for seven months, May 1 to November 30 inclusive, except as explained under results reported later in this bulletin. The bulls were turned with the cows about June 20 and removed around September 20 each year. Two bulls were used each year with each bull being rotated daily among the three pastures in each series. This meant that each of the bulls spent about one month on each pasture in his series. The calves were weaned about November 1 each year.

It was necessary to have some positive measure of productive capacity of the range in terms of foliage yield and this was obtained by means of clipping. Three exclosures (small fenced areas from which the cattle were excluded) were placed in each pasture but moved to new locations each year so that they would be on areas grazed the previous year. Within each exclosure 6 one-yard-square plots were staked.

The plan was to clip three of these at crown level three times each year. The first clipping was made about June 15 and in years when regrowth occurred, additional clippings were made about August 15 and after the end of the grazing season. In only one year, however, was there sufficient regrowth to provide foliage for clipping at the end of the season. Air dry weights of the clippings were used as a measure of the foliage harvested at each location, and from these the yield per acre in each pasture was calculated. Following the spring drought of 1949 no foliage was available for the August 15 clipping as no regrowth occurred after June 15. The other three plots within each exclosure were clipped once at the end of the grazing season. The data from these clippings made on these plots are given in the Appendix. The difference between the yields from three clippings and one clipping can be considered a measure of the loss of foliage from weathering and removal by insects, rodents, hail, and other similar factors.

At the close of each grazing season, plots were clipped outside the exclosures. The differences between the yield of the protected 3-clip plots and grazed plots were used to calculate foliage utilization percentage. The clipped material was analyzed each year to obtain the protein content under varying conditions.

Visual estimates of foliage utilization were made at the close of each grazing season for each pasture as a whole. This method considers the entire area of each pasture instead of representative small plots and has some advantage for this reason.

The relative coverage of each range plant species was also taken each fall, estimating the percentage which each species produced of the total foliage

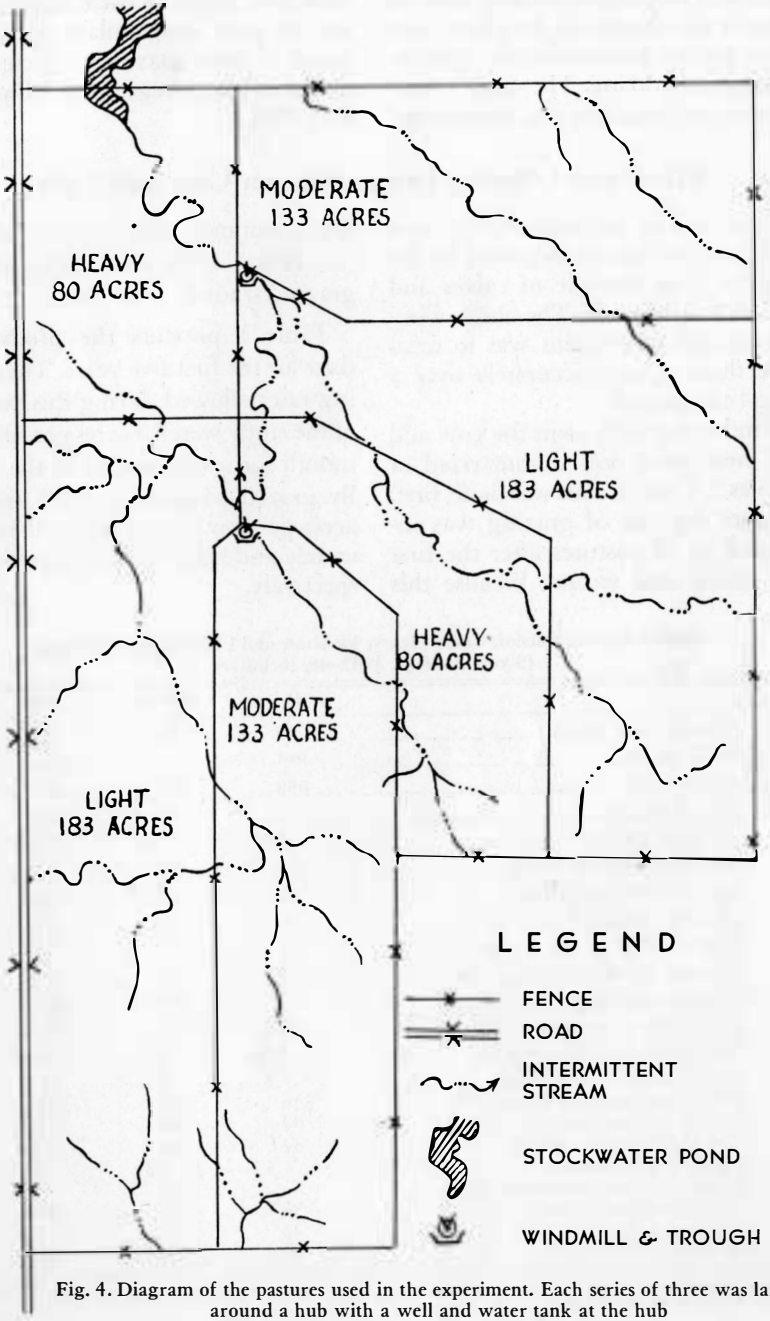


Fig. 4. Diagram of the pastures used in the experiment. Each series of three was laid out around a hub with a well and water tank at the hub

growth. These estimates were made to observe the changes in the plant cover from year to year under the three intensities of grazing. The range condition of each pasture was determined each year, based on the relative coverage of each range plant species in terms of their maximum occurrence in the original vegetation. (Dyksterhuis 1949.)

Effects of Grazing Intensities on Cow and Calf

The yield of the range for the cow and calf producer is measured by the returns from the sale of calves and culled female stock. The chief objective of this experiment was to measure these returns accurately over a long-time period.

Production data from the cow and calf herd have been summarized in Tables 1, 2, and 3. This was done, first, because the rate of grazing was increased in all pastures after the first five years, and second, because this brings out more clearly the accumulative effects of the three intensities of grazing studied.

Table 1 presents the production data for the first five years. The grazing rates allowed during this portion of the study were 1.4 acres per cow per month for seven months in the heavily grazed pastures, and 2.3 and 3.1 acres per cow per month in the moderately and lightly grazed pastures respectively.

Table 1. Beef Production Under Heavy, Moderate and Light Rates of Grazing (5-year Average, 1942–46, Inclusive)

	Heavy	Moderate	Light
Number cows (total)	80	80	80
Initial wt., lbs.	883	893	914
Final wt., lbs.	950	939	997
Gain or loss, lbs.	67	46	83
Condition (Fall)*	6.4	6.4	6.9
No. calves dropped (total)	71	75	74
No. calves weaned (total)	69	69	68
Calf crop weaned, %	86	86	85
Birth wt., lbs.	71	71	73
Weaning wt., lbs.	367	373	384
Weaning age, days	197	187	186
Weaning wt., corrected to 190 days, lbs.	361	375	387
Daily gain calves on pasture, lbs.	1.49	1.59	1.67
Condition calves at weaning	7.7	8.1	7.8
Calf wt. weaned/cow in herd, lbs.	316	321	326
Calf wt. weaned/acre, lbs.	32	19	14
Cow and calf gains/acre, lbs.	32	18	15
Acres per cow/month	1.4	2.3	3.1
Foliage utilization measured by:			
Weights from clipped plots, %	54	34	29
Visual estimates, %	42	23	15
Salt per cow and calf, lbs.	20.6	20.2	18.4

*The cows and calves were rated in condition from 0 to 14 with 14 being the fattest group. A rating of 7 indicates average condition on good range.

When the cows were placed in the experiment they were similar in age, size, condition, and weight in all three groups. Once a cow was assigned to a group she remained in that group throughout her useful life. This provided data on the cumulative effect of the grazing intensities rather than the effect of only one year. Some replacements were made each season in order to keep the age of the herd constant and similar to that usually maintained by ranchers.

The three grazing intensities differentiated the cows in weight as the experiment progressed, regardless of the fact that all were handled alike during the winter months. The cows on the lightly grazed range made the largest summer gains and maintained a good proportion of this gain throughout the winter months. The difference became larger as the experiment progressed until at the end of the fifth year the cows from the heavily, moderately and lightly grazed areas weighed 990, 1026, 1062 pounds respectively. These fifth-year figures are probably more important in evaluating the rates of grazing than the 5-year average figure as it was not until the third year that any real differences began to appear. Apparently the pastures had enough reserve to stand over-utilization for a few years without causing much, if any, damage to the cows.

The cows in all lots did a good job of producing calves. Intensity of grazing during the five years studied did not differentiate the groups in birth weights of calves, or percent calf crop weaned. However, the pastures with more grass did produce faster-gaining calves. The weaning weights were 367, 373, and 384 pounds respectively from the heavy, moderate, and light rates of grazing. Adjusting the weaning weights to a standard age of 190 days gives weights of 361, 375, and 387 pounds for the three groups. The calf weight weaned per cow was in favor of the light rate of grazing.

During the first five years, the cow and calf gains per acre were definitely in favor of the heavy rate of grazing—32 pounds for heavy rate of grazing as compared to 15 pounds for the light rate. It must be remembered that the treatments were just beginning to affect the ranges. Gains per acre alone do not take into account the condition of the calves and cows, comparative cost of wintering thin and well-fleshed animals, and sustained range production.

With the heavy grazing rate during this period, the cattle were only grazing approximately one-half of the grass that was on the range. Due to the relatively large amount of grass left on all the ranges each fall, the grazing rate was increased 25 percent in all pastures for the second period of the experiment. Table 2 gives the production data of cows and calves under the increased grazing rates. The *actual* grazing rates were 1.2, 1.9, and 2.5 acres per cow per month for a 7-month grazing period for the heavy, moderate, and light grazing rates respectively.

The spring weights of the cows in all lots remained similar in this period. This is due chiefly to the fact that many new cows were added to the herd each spring which prevented long-time effects from being established. The procedure of keeping a

Table 2. Beef Production Under Heavy, Moderate, and Light Rates of Grazing (3-year Average Under Increased Grazing Rate, 1947-49, Inclusive)

	Heavy	Moderate	Light
Number cows (total)	59	59	60
Initial wt., lbs.	938	936	938
Final wt., lbs.	845*	902†	976
Gain or loss, lbs.	–93	–34	38
Condition (Fall)	4.9	5.8	7.2
No. calves dropped (total)	55	52	56
No. calves weaned (total)	53	48	48
Calf crop weaned, %	92	81	80
Birth wt., lbs.	72	73	71
Weaning wt., lbs.	340	356	370
Weaning age, days	178	192	183
Weaning wt. corrected to 190 days, lbs.	349	354	375
Daily gain calves on pasture, lbs.	1.45	1.47	1.59
Condition calves at weaning	6.9	6.5	7.6
Calf wt. weaned/cow, lbs.	306	290	296
Calf wt. weaned/acre, lbs.	38	22	16
Cow and calf gains/acre, lbs.	18	15	15
Acres per cow month	1.2	1.9	2.5
Foliage utilization measured by:			
Weight from clipped plots, %	75	59	48
Visual estimates, %	73	55	33
Salt per cow and calf, lbs.	19.5	19.0	16.5

*In 1949 cows were removed from one heavily grazed pasture on September 26, and from the other heavily grazed pasture on October 15 because of shortage of grass.

†In 1949 cows were removed from one of the moderately grazed pastures because of shortage of grass.

cow on one grazing rate once she was assigned to it was followed on the few cows that continued in the herd throughout the period. In spite of the rapid turnover of cows, the average fall weights were distinctly different. There was a spread of 57 pounds between cows from heavily grazed and moderately grazed pastures and 131 pounds between heavily grazed and lightly grazed pastures.

In 1949, the last year of the trials reported in Table 2, the cows from both of the heavily grazed pastures and one of the moderately grazed pastures had to be removed before the end of the summer grazing period to prevent severe cow and calf losses. It will also be noted that the cows from the heavily and moderately grazed pastures in the second period were lighter in the fall than in the spring. This is an exceedingly expensive management system in a range country as it necessitates winter gains which are always more costly than summer gains.

Again the calf crop was good in the heavily grazed group. During the 3-year period the percent calf crop weaned excelled the moderately and lightly grazed groups by 11 and 10 percent, respectively. The number of calves dropped was similar in all groups and it seems doubtful if the difference in percent calf crop raised was other than random variation. The weaning weights of the calves again favored those on the lighter grazing rates. In these trials the calves in the heavily grazed pastures were slightly

younger than the others but the number of cattle involved was too small to be certain that it was due to treatment. Correcting weaning weights to a standard 190-day-age weight gives weights of 349 pounds, 354 pounds and 375 pounds respectively for the heavy, moderate, and light rates of grazing.

The cow and calf gains per acre again favored heavy grazing, but the differences were becoming less, 18, 15, and 15 pounds for heavy, moderate, and light rates of grazing, respectively. The high percent of calf crop weaned contributed a large portion of the excess weight in the heavily grazed pastures and it is questionable if this was the result of heavy grazing.

In the spring of 1950 the grass on the two heavily grazed and one moderately grazed pastures was so poor that grazing was deferred for one month. The cows and calves were placed on the two lightly grazed and one moderately grazed pastures on the sixth of May. The 1950 growing season was relatively dry, so it was necessary once again to remove cattle from the heavily grazed pastures before the close of the grazing season. All the cattle were removed on September 16, although there was sufficient grass to have carried the cattle longer in the other pastures. The data for 1950 are shown in Table 3.

Table 3. Beef Production Under Heavy, Moderate, and Light Rates of Grazing in the Ninth Year of the Trials, 1950*

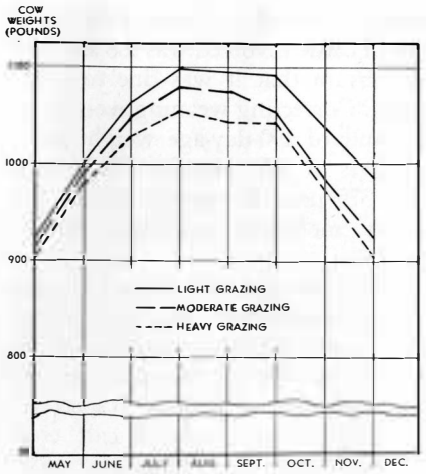
	Heavy	Moderate	Light
Number cows	20	20	20
Initial weight, lbs.†	963	948	952
Final weight, lbs.	936	1049	1118
Gain or loss	–37	101	166
Condition (Fall)	5.0	7.2	8.0
No. calves dropped	14	16	19
No. calves weaned	11	12	17
Calf crop weaned, %	55	60	85
Birth weight, lbs.	66	62	71
Weight of calves (Sept. 16), lbs.	270	278	306
Weaning weight, lbs.	338	337	380
Weaning age, days	188	200	193
Weaning wt., corrected to 190 days, lbs.	339	330	378
Daily gain calves on pasture, lbs.	1.43	1.49	1.76
Condition calves at weaning	5.2	3.8	5.9
Calf weight (Sept. 16)/cow, lbs.	148	167	254
Calf weight weaned per cow, lbs.	186	202	323
Calf weight weaned per acre, lbs.	18	13	14
Cow and calf gain/acre (Sept. 16), lbs.	9	17	20
Acres per cow/month	2.1	3.2	4.0
Foliage utilization measured by:			
Weight from clipped plots, %	70	60	48
Visual estimates, %	62	45	28
Salt per cow and calf, lbs.	15.5	14.7	10.0

*Shortage of grass in the spring of 1950 made it necessary to defer grazing on the two heavily grazed and one moderately grazed pastures until May 31. The other moderately grazed pasture and both lightly grazed pastures were stocked May 6. The dry season made it necessary to remove cattle from the heavily grazed pastures September 16, and at the same time they were removed from all other pastures, though there was sufficient grass on them to have carried the cattle longer.

†Weights taken on May 6.

Although the data in Table 3 are based on only one year's work, the accumulative effect of continuous heavy grazing is evident. By September 16, the time the cattle were removed, there was a difference of 192 pounds in the weight of cows on the heavily grazed and lightly grazed ranges. The differences in calf weight weaned per cow also were large with the cows on the lightly grazed ranges producing 137 pounds more calf per cow than those on the heavily grazed ranges. The cow and calf gains per acre were greatest for the first time on the lightly grazed pastures. The size of difference probably needs to be discounted some as it was closely associated with the high percent of calf crop weaned in the lightly grazed pastures. Percent calf crop has been one of the most variable characteristics in the experiment, depending apparently on several factors other than available grass.

Calf weight weaned per acre is one of the important factors in determining profits from the cow-calf enterprise. These weights for the period studied are given in Tables 1, 2, and 3. Few comments have been made in this publication regarding these values because this experiment was not sufficiently extensive to determine the maximum calf weight weaned per acre which could be obtained over a long period. Maximum sustained beef production requires sustained high forage production. Therefore, it appears best at this time to recommend stocking rates that will maintain good to excellent range condition. Additional research may show some alteration of these rates to be more profitable.



Months	Grazing Rates		
	Heavy	Medium	Light
May	906	911	924
June	983	992	1002
July	1029	1046	1066
August	1054	1077	1098
September	1048	1075	1098
October	1037	1055	1091
November	976	988	1037
December	905	924	988

Fig. 5. Monthly weights of cows on heavy, moderate, and light rates of grazing for the period, 1942–49, inclusive

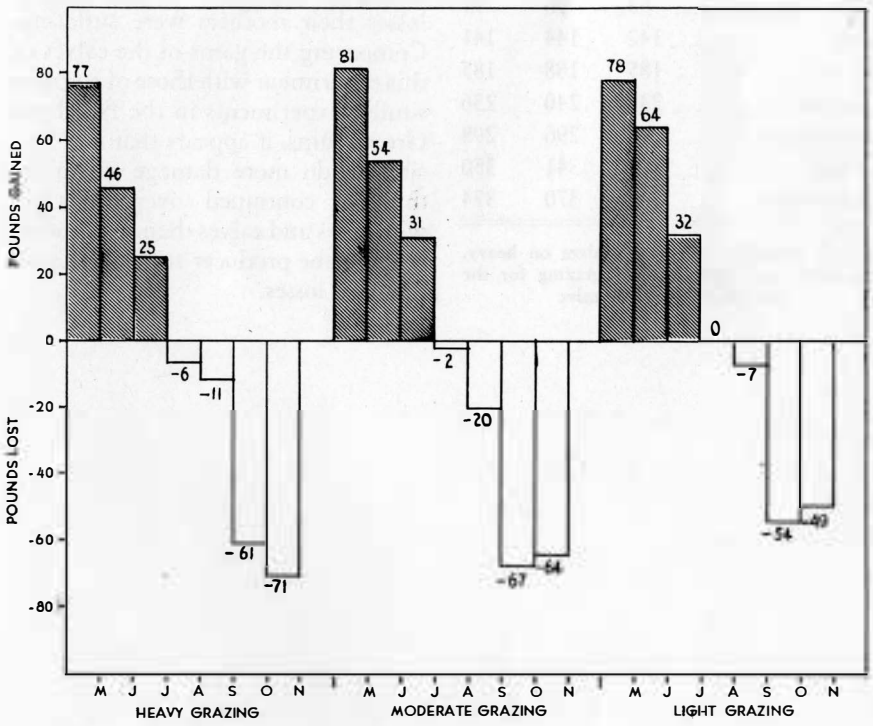
Figure 5 shows the average weights per cow taken on the first of each month during the grazing season for the cows on the three different intensities of grazing, for the years 1942–49, inclusive. The weight curves of the cows on the three intensities of grazing never overlapped. The cows with the most grass were always the heaviest. All groups gained rapidly from May 1 until August 1. The cows on lightly grazed pastures with plenty of grass, maintained their weight until

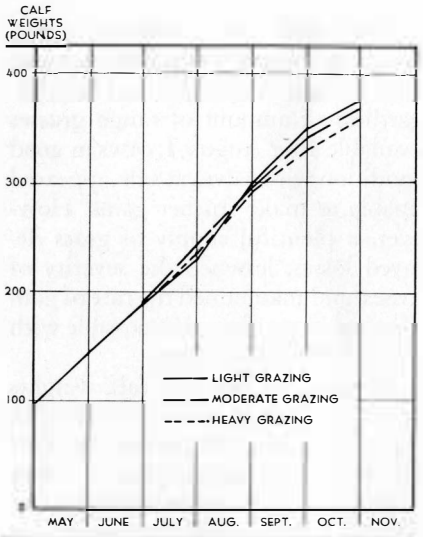
about October 1. The other two groups started to lose weight somewhat earlier. All groups lost heavily between October 1 and December 1. This appeared to be due as much to lack of sufficient protein in the grasses as to shortage of grass. The cows with the least grass lost weight the most rapidly. By December 1 there was 83 pounds difference between those on heavily grazed pastures and those on lightly grazed pastures.

The monthly gains and losses per cow are shown in Figure 6 for the cows on the three rates of grazing. These are the same data as in Figure 5, but portrayed on the basis of losses and gains, rather than body weight. It is very clear that cows on native ranges in western South Dakota make their gains in May, June, and July. Regardless of amount of range grasses available after August 1, cows in good condition with calves at side, appeared unable to make further gains. However, a plentiful supply of grass delayed losses, lessened the severity of losses, and maintained the rate of gain of calves better than that possible with a limited supply of grass.

Figure 7 shows the calf weights taken on the first of each month. The amount of grass in this study had little effect upon the growth rate of calves as long as all cows were gaining. After August 1 the groups of calves began

Fig. 6. Monthly gains and losses of cows on heavy, moderate, and light rates of grazing for the period 1942–49, inclusive





Months	Grazing Rates		
	Heavy	Medium	Light
May	93	96	91
June	142	144	141
July	185	188	185
August	238	240	236
September	290	296	298
October	331	341	350
November	360	370	374

Fig. 7. Monthly weights of calves on heavy, moderate, and light rates of grazing for the period, 1942–49, inclusive

to pull apart. The mothers that were maintaining higher weights kept their calves gaining more, though by November 1 the total weights of the calves were not greatly different. The calves in all lots continued to gain until November 1. This was not true with any of the groups of cows.

Figure 8 shows the average monthly gains of the calves raised on the three intensities of grazing. These are the same data shown in Figure 7 but shown as calf gains per month rather than total body weight. It will be noted that the calf gains were maintained at almost one pound per day during the last month before weaning, regardless of the weight losses their mothers were suffering. Comparing the gains of the calves in this experiment with those of steers in similar experiments in the Northern Great Plains, it appears that it is possible to do more damage to ranges through continued over-utilization with cows and calves than with steers, without the producer suffering heavy financial losses.

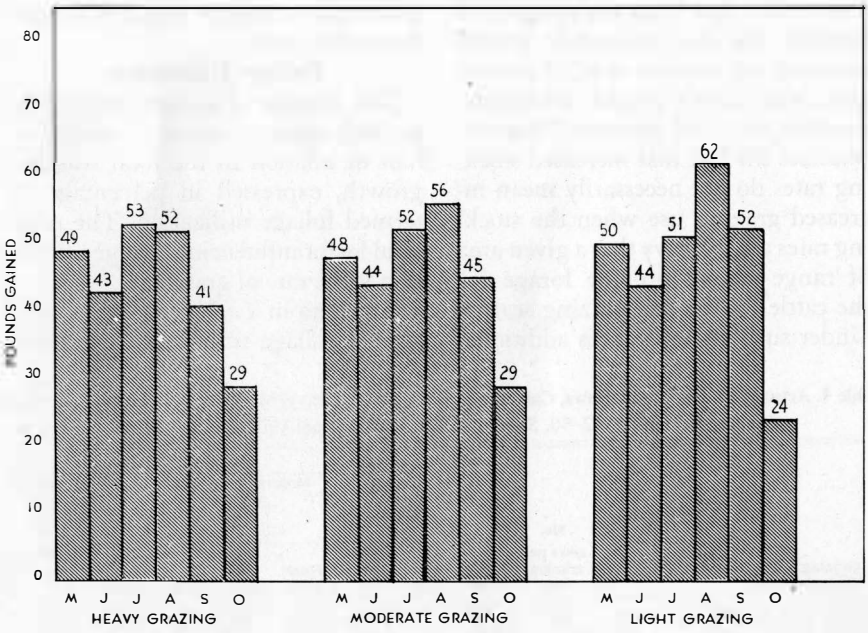


Fig. 8. Monthly gains of calves on heavy, moderate, and light rates of grazing

Effects of Grazing Intensities on Mixed Prairie Vegetation

Continuous high production of livestock on western ranges can be maintained only by keeping the range forage production at a high level. Therefore, it is necessary to know something about the factors, including intensity of grazing, that influence foliage production.

The degree to which foliage was removed from the pastures influenced the relative coverage of decreaser, increaser, and invader plants on the experimental ranges. Changes that occurred in relative coverage affected range condition and foliage production. These interactions are discussed in the sections to follow.

Actual Grazing Use

In the previous section the grazing rates have been stated in general terms of acres per cow per month. The actual amount of grazing that the pastures received under each of the three intensities during the experiment is shown in Table 4 in terms of animal unit months (AUM). As mentioned previously, the stocking rates were increased 25 percent after the first five years to utilize a greater proportion of the foliage produced each year.

Because of the necessity of removing cattle from some of the pastures in 1949 and 1950, the average grazing use during the last four years on the heavily grazed pastures was increased only

2 percent rather than the planned 25 percent. For the moderately grazed pastures, the increase was 9.7 percent and for the lightly grazed pastures the increase was 13.7 percent. This emphasizes the fact that increased stocking rates do not necessarily mean increased grazing use when the stocking rates are so heavy that a given area of range cannot provide forage for the cattle for the full grazing season. Under such circumstances additional grazing area must be found or the cattle must be sold.

Foliage Utilization

The amount of foliage removed by grazing animals, rodents, insects, or hail in relation to the total seasonal growth, expressed in percentage, is termed foliage utilization. The principal factor influencing foliage utilization is the rate of grazing.

The data in Table 5 show the total annual foliage utilization, expressed

Table 4. Actual Grazing Use by Cows, Calves, and Bulls Under Heavy, Moderate, and Light Grazing, by Grazing Seasons, 1942-50. Shown in Terms of Animal Unit Months (AUM)

Grazing Season (Inclusive date)	No. of days	No. cows per grazing rate	Actual Stocking* (Animal Unit Months) Heavily stocked pastures 1 & 4 160 acres Total† AUM	AUM per acre	Acres per AUM	Moderately stocked pastures 2 & 5 266 acres Total† AUM	AUM per acre	Acres per AUM	Lightly stocked pastures 3 & 6 366 acres Total† AUM	AUM per acre	Acres per AUM
1942 May 12—Dec. 4	207	16	112.4	.70	1.43	112.4	.42	2.38	112.4	.31	3.23
1943 May 1—Dec. 1	215	16	116.7	.73	1.37	116.7	.44	2.27	116.7	.32	3.12
1944 May 3—Nov. 30	212	16	115.1	.72	1.39	115.1	.43	2.33	115.1	.31	3.23
1945 May 2—Dec. 3	216	16	117.2	.73	1.37	117.2	.44	2.27	117.2	.32	3.12
1946 May 2—Dec. 5	218	16	118.3	.74	1.35	118.3	.44	2.27	118.3	.32	3.12
5-Year Average	213.6	16	115.9†	.72	1.39	115.9†	.44	2.27	115.9†	.32	3.12
1947 May 2—Dec. 3	216	20	146.0	.91	1.10	146.0	.55	1.82	146.0	.40	2.50
1948 April 30—Nov. 30	215	20	145.3	.91	1.10	145.3	.55	1.82	145.3	.40	2.50
1949‡ May 2—Dec. 1	214	20	—	—	—	—	—	—	144.7	.40	2.50
May 2—Dec. 1	214	10	—	—	—	73.3	.51	1.96	—	—	—
May 2—Nov. 1	184	10	—	—	—	61.3	—	—	—	—	—
May 2—Sept. 26	148	10	51.3	.67	1.49	—	—	—	—	—	—
May 2—Oct. 15	167	10	55.7	—	—	—	—	—	—	—	—
1950‡ May 6—Sept. 16	134	20	—	—	—	—	—	—	91.3	.25	4.00
May 6—Sept. 16	134	10	—	—	—	46.7	.31	3.23	—	—	—
May 31—Sept. 16	109	10	—	—	—	36.3	—	—	—	—	—
May 31—Sept. 16	109	20	74.7	.47	2.13	—	—	—	—	—	—
4-Year average:											
Light	194.8	20	—	—	—	—	—	—	131.8†	.36	2.78
Moderate	187.9	20	—	—	—	127.2†	.48	2.08	—	—	—
Heavy	174.4	20	118.2†	.74	1.35	—	—	—	—	—	—
9-Year average:											
Light	205.2	17.8	—	—	—	—	—	—	123.0†	.34	2.94
Moderate	202.2	17.8	—	—	—	121.0†	.45	2.22	—	—	—
Heavy	196.2	17.8	117.0†	.73	1.37	—	—	—	—	—	—

*One cow, with or without calf, and one bull are each considered as one animal unit.
†Two bull-months grazing use, anually per grazing rate, are included in these averages.
‡Because of shortage of grass in both of the heavily grazed and one moderately grazed pastures the cows and calves were removed before the end of the 1949 grazing season to prevent cow losses. For the same reason grazing on these three pastures was deferred during May 1950. When the shortage of grasses occurred in these three pastures in September 1950 the cattle were removed from all experimental pastures.

Table 5. Total Annual Foliage Utilization Under Heavy, Moderate, and Light Intensities of Grazing, as Determined by Clipped Plots and Visual Estimates, Expressed in Percentage

Year	Determined from Clipped Plots			Determined by Visual Estimates		
	Heavy	Moderate	Light	Heavy	Moderate	Light
1942	45	23	3	23	14	9
1943	34	25	13	42	25	17
1944	63	32	38	40	21	12
1945	64	37	37	50	28	16
1946	64	55	52	55	26	19
5- year Av.	54	34	29	42	23	15
1947	78	70	55	67	48	29
1948	70	44	27	75	58	32
1949	76	64	62	78	58	38
1950	70	60	48	62	45	28
4-Year Av.	74	60	48	70	52	32
9-Year Av.	63	46	37	55	36	22

in percentage, on the pastures in the experiment. These estimates of utilization were determined by two methods (1) from clipped plots inside and outside exclosures, and (2) by visual estimates made entirely independently by a trained range specialist on the basis of observations of the entire grazed areas and the exclosures. These visual estimates are shown only for comparison and to show the relationship with the data from clipped plots which are used in the following discussion.

It will be noted that on the heavily grazed ranges, the average utilization in the first five years was 54 percent and increased to 74 percent in the last four years when the stocking rate was increased 25 percent. The 9-year average utilization was 63 percent. When this utilization is related to the foliage harvested, as shown in Tables 5 and 8, it becomes evident that the utilization was too great to permit the heavily grazed pastures to maintain their productivity. In contrast, the foliage harvested from the other two rates of grazing indicated that they were able to maintain or increase their productivity as the experiment progressed.

The moderately grazed pastures maintained their 1942 productivity when the utilization was 34 percent during the first five years and actually showed a slight increase in productivity during the last four years at 60 percent utilization. The 9-year average was 46 percent.

Foliage utilization in the lightly grazed pastures averaged 29 percent for the first five years of the experiment and increased to an average of 48 percent in the last four years. This gave a 9-year average utilization of 37 percent. Foliage harvested from the lightly grazed pastures increased markedly in the first five years, and made a moderate increase during the last four years. Foliage production suffered in all pastures from the severe spring drought of 1950 following the growing-season drought of 1949.

One of the main factors limiting foliage yield has been a change in the

proportion of various species of plants in the pastures. The first noticeable change was a reduction in the proportion of the taller growing, heavier yielding grasses and an increase in short grasses. This change was especially noticeable in the heavily grazed pasture.

A portion of the reduced yield may have been due to the fact that the midgrasses remaining were weakened so that their productivity was reduced. It must be kept in mind that foliage production is an essential function of the living plant. The leaf manufactures food, part of which is returned to the roots to keep them healthy and strong. If too much of the leaf surface is removed during the growing season the plant is weakened and eventually destroyed. This is the reason that only a part of the foliage on the ranges should be used each year and the degree of use becomes an important factor in range management. Until recent years it was thought that as much as 75 percent of the foliage could be utilized annually without damage to the plants but more recent evidence indicates that that degree of utilization is too high.

From the results obtained during this experiment at Cottonwood, it is indicated that range production can be maintained or increased under 40 to 55 percent utilization, depending on seasonal variations in rainfall, frequency of hail storms, presence or absence of large numbers of rodents and insects, and season of use.

Lightly grazed pasture shows full utilization at the end of the dry season of 1949. Range condition is excellent on this clay upland range site with rolling topography

Effects on Relative Coverage of Decreaser, Increaser, and Invader Plants

As was previously mentioned, grazing intensities have an effect on the proportion of the various types of range plants that are found in the pastures, and an explanation has been given of the terms, "decreasers," "increasers," and "invaders."

The data in Table 6 show the changes in relative coverage of these three groups of plants under heavy, moderate, and light rates of grazing. The decreaser species are generally the mid-grasses, such as western wheatgrass, green needlegrass, needleandthread, and little bluestem, which produce much more foliage volume growth per acre than the short grasses, such as blue grama, and buffalograss, which are the principal increaser species.

The relative coverage of the invader species did not appear to be materially affected by rate of grazing in the nine years of the experiment.

At the end of the experiment grazing had just begun to break down the continuous cover of the short grasses (increasers) in the heavily grazed pastures to allow some invaders to come in. The invaders that did come in were readily grazed early in the spring so they did not show up by midsummer or late in the grazing season. The invaders were generally more conspicuous under the light and moderate rates of grazing, because the cattle were not forced to eat them early in the season. After maturity in late spring, most of the invaders were relatively unpalatable to cattle.

Based upon the relative foliage productive capacity of the decreasers compared with the increasers, it is evident that the heavily grazed pastures have deteriorated during the time of the experiment. The decreasers have been drastically reduced. Little change has occurred in the relative coverage of the decreasers and increasers in the moderately grazed pastures, whereas the relative coverage showed a definite improvement in the lightly grazed pastures.

Table 6. Changes in Relative Coverage Percentages of Decreaser, Increaser, and Invader Species Under Heavy, Moderate, and Light Rates of Grazing

Year	Heavy Percentage			Moderate Percentage			Light Percentage		
	Decr.	Incr.	Inv.	Decr.	Incr.	Inv.	Decr.	Incr.	Inv.
1942	32	60	8	35	56	9	35	56	9
1943	23	71	6	30	61	9	30	60	10
1944	22	73	5	35	61	4	36	58	6
1945	26	69	5	36	61	3	36	62	2
1946	26	72	2	35	65	0	39	61	0
5-Year Average	26	69	5	34	61	5	35	60	5
1947	18	79	3	35	63	2	40	58	2
1948	16	79	5	42	56	2	50	46	4
1949	10	86	4	34	63	3	44	53	3
1950	8	84	8	31	64	5	40	56	4
4-Year Average	13	82	5	36	61	3	43	54	3
9-Year Average	20	75	5	35	61	4	39	57	4

Effects on Range Condition

Range condition, as used here, simply means the percentage of the present vegetation that is original (or climax) vegetation for the site. On these pastures, the sum of the percentages of all the decreasers and increasers that normally were present in the original vegetation is the range condition, expressed as a percentage. In wholly original vegetation the range condition would be 100 percent. As range deteriorates from the original vegetation under grazing pressure the condition percentage departs from 100 percent. A 40 percent loss of original vegetation would result in a 60 percent range condition. (Dyksterhuis 1949.)

These pastures had not fully recovered from the drought damage of the 1930's when this experiment started, as is shown in Table 7. The range condition averaged 72 percent with little variation at the beginning. Small differences showed up in the first 5-year averages.

In this period the condition of the moderately and lightly grazed pastures was maintained while the condition of the heavily grazed pastures was reduced by 7 percent.

During the last four years, while the moderately grazed pastures improved slightly in condition, the heavily grazed pastures lost an additional 10 percent condition, and the lightly grazed pastures gained 10 percent.

By the end of the ninth year of the study, these changes brought the heavily grazed pastures to 51 percent condition and the lightly grazed to 81 percent, compared with 73 percent for the moderately grazed pastures.

Table 7. Range Condition, Expressed as Percentages, As Affected by Heavy, Moderate, and Light Rates of Stocking

Year	Range Condition Percentages		
	Heavy	Moderate	Light
1942	70	72	73
1943	61	68	68
1944	60	74	75
1945	63	71	74
1946	61	70	75
5-Year Av.	63	71	73
1947	56	71	78
1948	54	82	90
1949	50	74	82
1950	51	73	81
4-Year Av.	53	75	83
9-Year Av.	58	73	77

Effects on Foliage Production

Foliage production on native ranges is influenced by the amount and effectiveness of the precipitation, intensity of grazing, range vegetation present, and range condition. Annual and seasonal rainfall and carryover soil moisture have caused fluctuations in foliage production throughout this experiment. The influence of the moisture supply has generally affected all pastures to a similar extent.

Grazing intensities have also had a great influence on the foliage production of the pastures. The method of determining yields was by clipping the foliage from protected plots within each of the pastures, air drying and weighing the plant material obtained, and calculating the yields per acre.

Table 8 and Figure 9 show the calculated pounds per acre of foliage harvested on the heavily, moderately, and lightly grazed pastures. The table also gives the relative yields from the heavy rate and light rate of grazing, calculated as a percent of the moder-

ately grazed pasture yields for comparison. The similarity of the clipped weights from all pastures in 1942 and 1943 indicates the uniformity of their productive capacity when the experiment started.

The yield during the first year of the experiment was 5 percent higher for the heavy rate of grazing, and 8 percent lower for the light rate, compared with the moderate rate of grazing. The 1943 yields were even closer together than in 1942. In 1944 and on through the experiment, the heavily grazed pastures yielded from 7 to 43 percent less, and the lightly grazed pastures yielded 21 to 68 percent more than the moderately grazed pastures. The greatest variations occurred in 1949.

The 9-year average yield for the moderately grazed pastures was 20 percent higher than the yield for the heavily grazed pastures and 30 percent lower than the yield from the lightly grazed pastures. Foliage harvested from the moderately grazed pastures showed a slight decline in the first three years, but recovered so that the average of the first five years closely approximated the yield during the first two years of the experiment. Reference to Table 8 shows that during three of the last four years, the yields were higher than the average of the first five years, indicating that the 9-year actual stocking rate of 2.2 acres per cow per month on the moderately grazed pastures was nearly correct for the period 1942–1950 under the conditions of this experiment.

Effects on Protein Content of Clipping Grasses at Different Times

The rate of gain of cattle on range grasses is usually closely related to the protein content of the forage. Table 9 shows the protein content of the grasses as clipped at the different seasons in the pastures grazed at different intensities.

Table 8. Foliage Harvested, In Pounds Air Dry Per Acre, as Measured by Three Clippings Each Year on Heavily, Moderately and Lightly Grazed Pastures*

	Heavy		Moderate		Light	
Year	Pounds	Percent of moderate	Pounds	Percent	Pounds	Percent of moderate
1942	1569	105	1488	100	1371	92
1943	1451	99	1470	100	1512	103
1944	1178	93	1269	100	2025	160
1945	1400	87	1601	100	1943	121
1946	1212	69	1758	100	2371	135
5-Year Av.	1362	90	1517	100	1844	122
1947	1625	74	2185	100	2725	125
1948	1234	66	1883	100	2398	127
1949	908	57	1589	100	2673	168
1950	781	88	892	100	1400	157
4-Year Av.	1137	69	1637	100	2299	140
9-Year Av.	1262	80	1571	100	2046	130

*Clippings were made about June 15, August 15, and at end of grazing season. Three clippings were obtained in 1942 only.

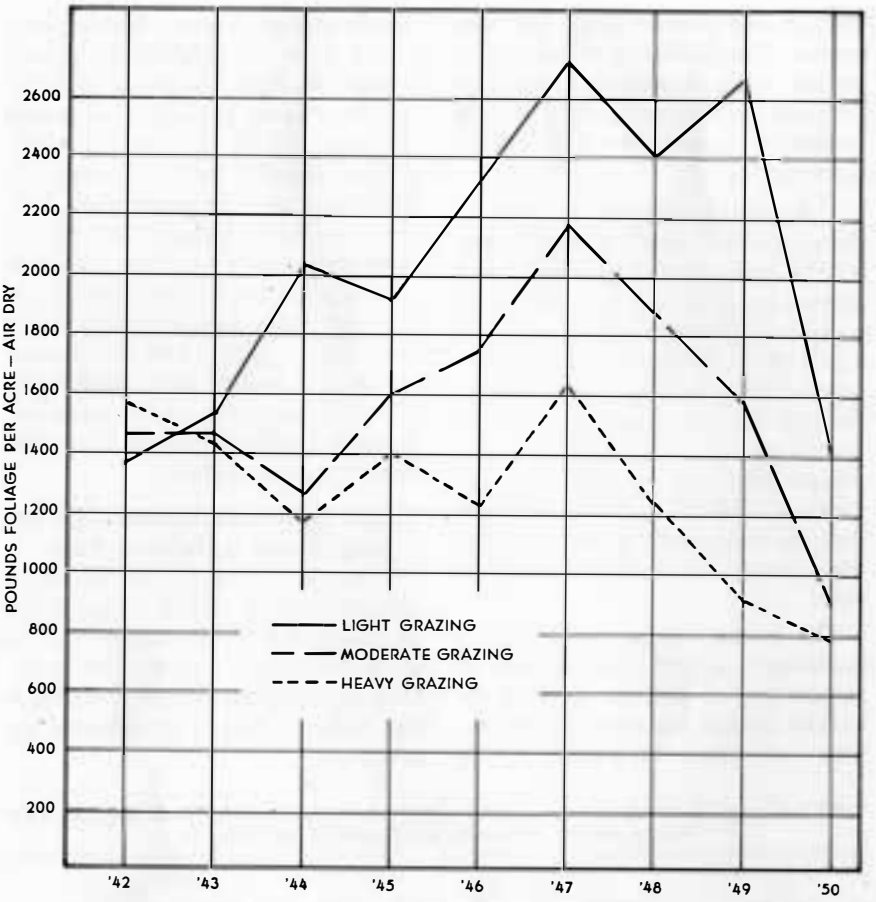


Fig. 9. Pounds of foliage harvested per acre (air dry) under heavy, moderate and light rates of grazing. See Table 8. The spring and summer droughts of 1949 and severe spring drought of 1950 reduced foliage production in all pastures materially

The protein contents of the June 15 samples for most years are somewhat lower than would be expected in new growth of native grasses at that time of year. This was undoubtedly due to the dead grass from previous year's growth that was in the clippings. In general, the protein values of the grass from the heavily used pastures were higher than those of the lightly grazed ones. This was especially true in June, again demonstrating a larger amount of old grass in the samples from the two lighter rates of grazing. The poor moisture conditions of 1949 are reflected in the low protein content of the early clippings. The December samples had a higher protein content for that year of any of the previous years in which the study was made.

No clippings were made in August

1949 because of the poor growth which the grasses had made during the summer. However, late fall rains did support some fall growth which was clipped in December. This fall clip was high in protein as compared with the previous years because there was very little coarse material from normal early summer growth.

The 1950 samples were all higher in protein than samples from the other years, but these consisted of very short grass (new growth) with little residue left over from previous years.

The December clip in 1950, like that of 1949, is abnormally high in protein and represents late fall growth after fall rains. The yields of the clip-

Table 9. Protein Content of Grasses from Different Pastures Clipped at Different Times of the Year

	3 Clippings—Approximate Dates			1 Clipping—Approximate Dates	
				Inside exclosure	Outside exclosure
	June 15	Aug. 15	Dec. 1	Dec. 1	Dec. 1
1942					
H*	9.50	10.20	4.40	3.60	—
M	9.00	7.90	4.25	3.90	—
L	10.10	7.70	4.30	3.90	—
1943					
H	8.35	5.49	No	3.23	3.51
M	8.71	5.64	Clip	3.57	4.0
L	7.51	5.51		3.60	3.92
1944					
H	7.40	6.00	No	3.70	—
M	6.50	6.20	Clip	4.40	—
L	6.90	5.90		3.80	—
1945					
H	7.20	5.86	No	3.05	3.17
M	6.31	5.95	Clip	3.06	2.75
L	6.71	6.72		3.13	2.71
1946					
H	8.15	6.21	No	4.01	4.03
M	7.03	5.89	Clip	3.64	3.53
L	6.59	6.31		4.09	3.87
1947					
H	7.51	6.17	No	4.50	4.17
M	6.57	6.42	Clip	4.07	3.87
L	6.29	6.60		4.25	4.04
1948					
H	7.04	5.93	No	3.78	4.21
M	7.10	6.67	Clip	3.73	3.91
L	6.33	6.67		4.43	4.13
1949					
H	5.83	No	No	4.92	5.22
M	5.54	Clip	Clip	4.56	4.92
L	5.86			4.62	5.20
1950					
H	9.24	7.72	No	6.70	7.33
M	7.96	7.04	Clip	6.64	6.72
L	8.43	8.11		6.50	7.12
Av. (All years)					
H	7.80	6.70	4.40	4.17	4.52
M	7.19	6.46	4.25	4.13	4.24
L	7.19	6.69	4.30	4.26	4.43

*H = Heavily grazed pastures; M = Moderately grazed pastures; L = Lightly grazed pastures.

pings were especially low in 1950 because of drought conditions as indicated in Table 8.

It should be noted that the cows were making their high gains during the period when the grasses were highest in protein. During the time the grasses contained only 5.5 to 6.0 percent protein, the cows just maintained their weight, or experienced small losses. When the cows ate the grass with 4.0 to 4.5 percent protein, all lots lost weight regardless of the amount of forage available.

Discussion

Through the process of evolution, the mixed-prairie vegetation of the Northern Great Plains developed with a definite plant succession in balance with soil development and the climate. Influencing this balance were natural hazards, such as drought, grasshopper infestations, prairie fires, as well as wildlife represented by large animals and rodents. The natural or climax vegetation was composed of mid-grasses and short grasses on nearly equal terms. The proportions of the two types changed from time to time under the influence of the factors mentioned above but returned to equal proportions under favorable conditions. (Weaver and Clements, 1929.)

In this natural environment the range condition was maximum, or 100 percent. The relative coverage of range plants, i.e. grasses, sedges, forbs, and shrubs, was optimum for each range site variation existing under these climax conditions.

Civilized man entered the scene with his domestic livestock but without an understanding or appreciation of the limitations on the use of the native vegetation. The resulting increased load of grazing animals upset the natural balance and caused a change in the relative coverage of range plants and a lowering of range condition, in many cases to the point of range destruction. The greatest error in using the range has been the failure to realize that part of the foliage of the growing plants must be left on the plant to permit it to grow and develop food reserves in the roots for further growth.

This has been demonstrated clearly in the study reported in this bulletin, which shows the serious effect that continued over-utilization has on subsequent foliage production and consequently on livestock production. It was shown that continued heavy grazing reduced range condition from 70 percent in 1942 to 50 percent in 1949 and 51 percent in 1950. Under moderate grazing, range condition remained about the same, whereas under light grazing an improvement took place with an increase in range condition from 73 percent in 1942 to 82 percent in 1949 and 81 percent in 1950.

What happened was that decreaser plants, primarily the mid-grasses, were reduced in relative coverage under heavy grazing, and some were destroyed. This was because too much of the foliage was removed each year and the plants did not have an opportunity to put food reserves back into the roots. The short grasses became

dominant, because by their habit of growth they were able to escape defoliation to the same extent and consequently were not damaged severely. The moderate and light rates of grazing left enough of the foliage to permit the taller growing plants to remain in healthy, vigorous condition and thus maintain or increase foliage production. The present study showed a 50 percent reduction in foliage yield under the heavy rate of grazing compared with the light rate during the last four years of the experiment. This was because the short grasses do not have the high yielding capacity of the taller growing midgrasses.

The experiment at Cottonwood showed that, with the conditions normal to that area, utilization of 40 to 55 percent of the grass each year was about right if production was to be maintained or increased. This compares favorably with grazing studies with yearling heifers, reported by Costello (1944) in Colorado, which showed that utilizing 37 percent of the foliage was about right for maintaining bunchgrass ranges in good condition. On the other hand, Woolfolk (1949), reporting on work near Miles City, Montana, recommended utilizing not more than 29 percent of blue grama, 20 percent of western wheatgrass, and 19 percent of threadleaf sedge (by sheep) in order to maintain the range in good condition.

This indicates that a higher rate of utilization may be safe in most South Dakota areas than in drier areas in some of our neighboring states. Out of these results has grown the rule of thumb: "Graze half and leave half, and the half grazed becomes larger and larger." Under the moderate and light rates of stocking, the foliage production in 1942 was 1488 and 1371 pounds per acre respectively. The average for these stocking rates of 1517 and 1844 pounds per acre for the first five years was increased to 1637 and 2299 pounds per acre, respectively, for the last four years. Under the heavy rate of stocking, the foliage production was 1569 pounds per acre in 1942, but this was reduced to an average of 1362 pounds for the first five years and further reduced to an average of 1137 pounds for the last four years.

Possibly this whole matter can be presented more clearly by the data in Table 10, showing the relation between foliage production, degree of utilization, and the calculated amount of foliage removed by the grazing cattle, grasshoppers, rodents, etc.

It can be seen that under heavy grazing, foliage production decreased, and only by utilizing a higher percentage was it possible to maintain the amount consumed by the animals.

Table 10. Data Showing the Relationship Between Average Foliage Production, Degree of Utilization, and Foliage Removed by Grazing Animals, Insects, and Rodents (Acre Basis)

	Heavy Stocking			Moderate Stocking			Light Stocking		
	Av. foliage production	Utilization	Foliage removed	Av. foliage production	Utilization	Foliage removed	Av. foliage production	Utilization	Foliage removed
	lbs.	%	lbs.	lbs.	%	lbs.	lbs.	%	lbs.
5-year av. (1942-46)	1362	54	735	1517	34	516	1844	29	535
4-year av. (1947-50)	1137	74	841	1637	60	982	2299	48	1104

Under moderate and light grazing, foliage production increased and at the same time the amount of foliage removed was increased; in fact, it was more than doubled under the light rate of grazing. This emphasizes the fact that yields under heavy grazing become smaller and smaller, whereas under moderate and light grazing more and more becomes available until full production is obtained.

Another important fact brought out by this study is that weights and gains of cows and calves are not good indicators of range condition or deterioration of ranges until after severe damage has been done. Cow weights were greater on the lightly grazed pastures than on those heavily grazed, and calf gains likewise were greater, but the differences were not great until the final years of the experiment. This points up the fact that the main difficulty in recognizing the danger of overgrazing is that the effects do not show up drastically in one year if the ranges are in good condition when overgrazing starts. In the present study, it was not until the eighth and ninth years that the cumulative effects became really evident and by that time the range was severely damaged.

Heavy grazing actually gave the best results on cow and calf gains per acre for the first eight years. But grazing at such intensities that cattle must be fed heavily during late summer and winter is an extremely costly practice.

All of the factors that have been discussed point up the fact that range livestock producers must continually study their stocking rates in order to maintain proper balance between available feed and number of livestock. It is evident that from an economic standpoint a producer cannot afford to let grass be wasted, but from what has been written above it should be equally evident that grass left ungrazed is not wasted.

Summary

1. For nine years, 1942–1950 inclusive, the South Dakota Agricultural Experiment Station, in cooperation with the Soil Conservation Service, conducted a summer grazing experiment to measure the effects of heavy, moderate, and light rates of grazing on beef cow and calf production and on mixed prairie vegetation at the Range Field Station near Cottonwood, South Dakota.

2. The cows on the lightly grazed pastures made the greatest summer gains each year and were in the best condition for going into the winter. The cows on the heavily grazed pastures made the least gains and in some years actually lost weight and were in poor condition for wintering. Average fall weights were 950, 939, and 997 pounds for cows on heavy, moderate, and light rates of grazing during the first five years of the experiment. For the next three years, the average weights were 845, 902, and 976 pounds and in the final year 926, 1049, and 1118 pounds for the three grazing rates. The final year weights were taken earlier than in previous years and do not show the effects of late season losses, but they do show the actual differences between the three lots

of cattle. The weights were similar for the three groups each spring.

3. Average weaning weights, corrected to a standard 190-day age, were 361, 375, and 387 pounds for heavy, moderate, and light grazing rates for the first five years. For the next three years, the average weights were 349, 354, and 375 pounds, and in the final year they were 339, 330, and 378 pounds.

4. During the first five years, the pastures were stocked at the rates of 1.4, 2.3, and 3.1 acres per cow month for the heavy, moderate, and light grazing rates, respectively. For the last four years, the stocking rates were increased 25 percent, allowing 1.1, 1.8 and 2.5 acres per cow per month. Because of shortage of grass in the heavily grazed pastures and one moderately grazed pasture in 1949 and 1950, the planned rates were not maintained. The average stocking rate for the last four years actually worked out to 1.4, 2.1, and 2.8 acres per cow month.

5. These stocking rates resulted in 54, 34, and 29 percent average utilization of foliage during the first five years and 74, 60, and 48 percent for the last four years on the heavy, moderate, and light grazing rates, respectively. The 9-year average utilization was 63, 46, and 37 percent.

6. Under the conditions of this experiment, an annual removal of 40 to 55 percent of the available foliage was the maximum utilization rate under which the range vegetation could be maintained. This degree of utilization was obtained at approximately .45 animal unit month per acre, or 2.25 acres per animal unit per month. These and related experiments have resulted in a rule of thumb: "Graze half and leave half, and the half grazed will get larger and larger."

7. Relative coverage of decreaser plants was reduced markedly under heavy grazing, maintained at the original under moderate grazing, and increased under light grazing. Starting with about 32 percent decreasers in 1942, heavy grazing reduced decreasers to 8 percent; moderate grazing showed a slight reduction; and light grazing gave an increase to 40 percent by 1950.

8. Range condition percentage was markedly reduced under heavy, maintained under moderate, and increased under light rates of grazing.

9. When compared with yields from moderately grazed pastures, the production in pounds of foliage per acre from heavily grazed pastures averaged 10 percent less during the first five years and 31 percent less during the last four years. On the other hand, the lightly grazed pastures produced 22 percent more than the moderately grazed pastures under the first five years and 40 percent more during the last four years.

10. Protein content of the grasses was determined on clippings taken in June, August and December. Cattle made their best gains when the protein content of the grass was about 5.5 to 6 percent.

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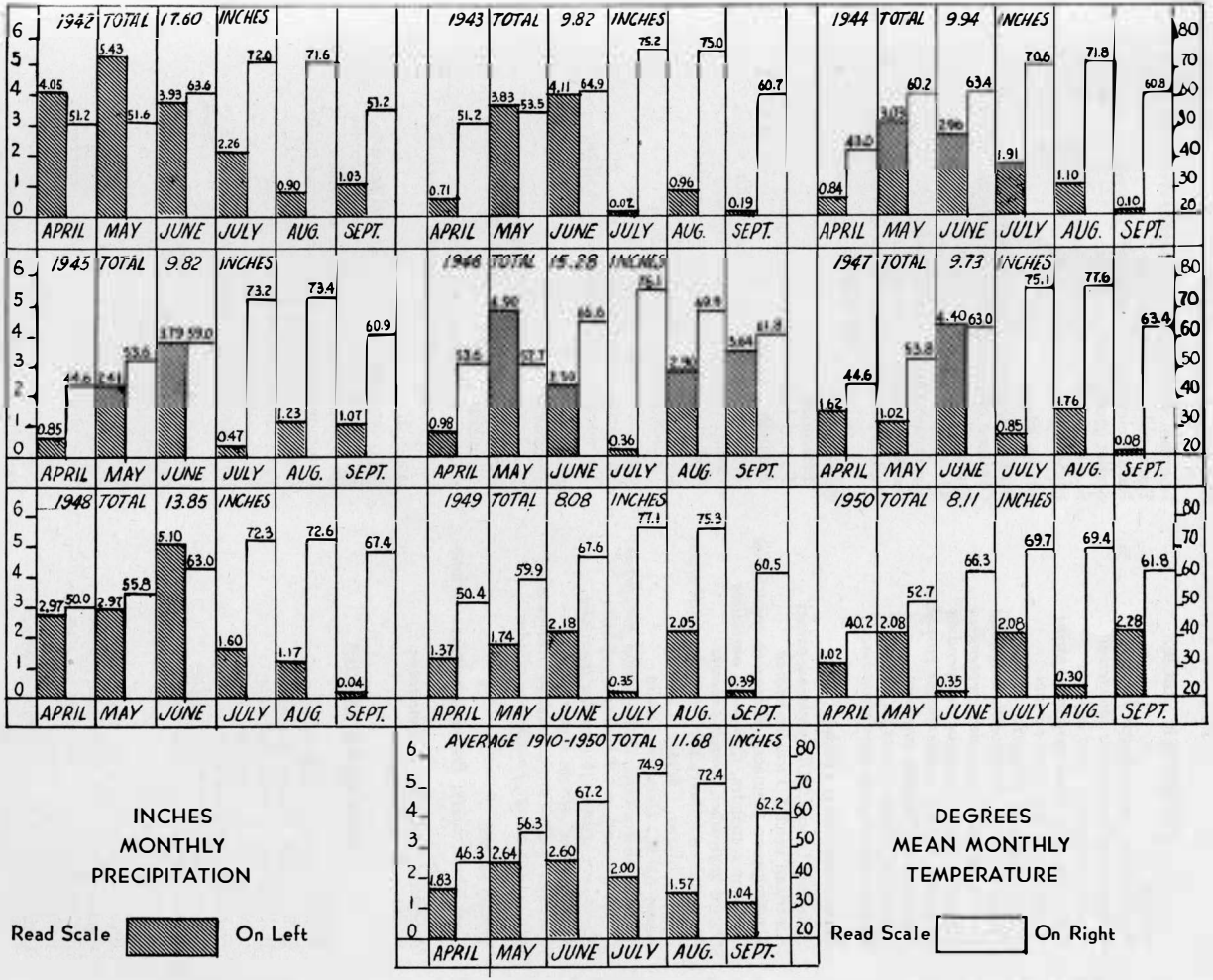
Appendix

Appendix Table 1. Foliage Harvested, in Pounds Air Dry Per Acre, as Measured by One Clipping at the End of Each Grazing Season on Heavily, Moderately, and Lightly Grazed Pastures*

Year	Heavy Pounds per acre	Moderate Pounds per acre	Light Pounds per acre
1942	1529	1515	1485
1943	1393	1269	1470
1944	670	1014	1409
1945	910	1127	1401
1946	998	1292	1825
5-year av.	1100	1243	1518
1947	705	970	1810
1948	863	1480	2025
1949	390	843	1092
1950	459	540	800
4-year av.	603	958	1432
9-year av.	880	1117	1480

*Compare with Table 8, page 29.



Appendix Fig. 1. Seasonal precipitation in inches and mean temperatures in degrees Fahrenheit at Cottonwood Station

Common and Botanical Names* of Range Plants Found in the Experimental Pastures at Cottonwood on Clay Upland Range Site

DECREASER SPECIES

Grasses

Big bluestem, *Andropogon furcatus*
Canada wildrye, *Elymus canadensis*
Green needlegrass, *Stipa viridula*
Little bluestem, *Andropogon scoparius*
Needleandthread, *Stipa comata*
Prairie junegrass, *Koeleria cristata*
Prairie sandreed, *Calamovilfa longifolia*
Sand dropseed, *Sporobolus cryptandrus*
Sideoats grama, *Bouteloua curtipendula*
Stonyhills muhly, *Muhlenbergia cuspidata*
Switchgrass, *Panicum virgatum*
Threadleaf sedge,† *Carex filifolia*
Western wheatgrass, *Agropyron smithi*

Herbaceous Plants (Forbs)

American licorice,‡ *Glycyrrhiza lepidota*
American vetch,‡ *Vicia americana*
Blacksampson echinacea, *Echinacea angustifolia*
Common comandra, *Comandra umbellata*
Dotted gayfeather, *Liatris punctata*
Groundplum milkvetch,‡ *Astragalus crassicarpus*
Hairy goldaster, *Chrysopsis villosa*
Bigtop dalea,‡ *Dalea enneandra*
Purple prairieclover,‡ *Petalostemon purpureus*
Silverleaf scurfpea,‡ *Psoralea argophylla*
Slimflower scurfpea,‡ *Psoralea tenuifolia*
Textile onion, *Allium textile*
Threenerve goldenrod, *Solidago trinervata*
White pentstemon, *Pentstemon albidus*

Woody Plants

Black chokecherry, *Prunus virginiana melanocarpa*
American plum, *Prunus americana*
Woods rose, *Rosa woodsi*

INCREASER SPECIES

Grasses

Blue grama, *Bouteloua gracilis*
Buffalograss, *Buchloe dactyloides*
Hairy grama, *Bouteloua hirsuta*
Inland saltgrass, *Distichlis stricta*
Needleleaf sedge,† *Carex eleocharis*
Red threeawn, *Aristida longiseta*
Sandberg bluegrass, *Poa secunda*

Herbaceous Plants

Broom snakeweed, *Gutierrezia sarothrae*
Common yarrow, *Achillea millefolium*
Cudweed sagewort, *Artemisia gnaphalodes*
Fringed sagewort, *Artemisia frigida*
Grassy deathcamas, *Zigadenus gramineus*
Heath aster, *Aster ericoides*
Ironplant goldenweed, *Aplopappus spinulosus*
Plains phlox, *Phlox andicola*
Rush skeletonplant, *Lygodesmia juncea*
Scarlet gaura, *Gaura coccinea*
Scarlet globemallow, *Sphaeralcea coccinea*
Upright prairieconeflower, *Ratibida columnaris*

Woody Plants

Brittle pricklypear, *Opuntia fragilis*
Common pricklypear, *Opuntia vulgaris*
Plains pricklypear, *Opuntia polyacantha*
Silver sagebrush, *Artemisia cana*
Skunkbush sumac, *Rhus trilobata*
Small soapweed, *Yucca glauca*
Western snowberry, *Symphoricarpos occidentalis*

INVADERS

Grasses

Perennials

Foxtail barley, *Hordeum jubatum*

Annuals

Barnyardgrass, *Echinochloa crusgalli*
Cheatgrass brome, *Bromus tectorum*
Common witchgrass, *Panicum capillare*
Japanese brome, *Bromus japonicus*
Little barley, *Hordeum pusillum*
Sixweeks fescue, *Festuca octoflora*
Stinkgrass, *Eragrostis cilianensis*
Tumblegrass, *Schedonnardus paniculatus*

Herbaceous Plants

Perennials

Bigbract verbena, *Verbena bracteata*
Mexican dock, *Rumex mexicanus*

Biennials

Bull thistle, *Cirsium lanceolatum*
Curlycup gumweed, *Grindelia squarrosa*

Annuals

Belvedere summercypress, *Kochia scoparia*
Buffalobur nightshade, *Solanum rostratum*
Common purslane, *Portulaca oeleracea*
Common ragweed, *Ambrosia artemisiafolia*
Common sunflower, *Helianthus annuus*
Erect knotweed, *Polygonum erectum*
Horseweed fleabane, *Erigeron canadensis*
Lambsquarters goosefoot, *Chenopodium album*
Oriental cocklebur, *Xanthium orientale*
Prairie pepperweed, *Lepidium densiflorum*
Prickly lettuce, *Lactuca serriola*
Redroot amaranth, *Amaranthus retroflexus*
Rough falsepennyroyal, *Hedeoma hispida*
Snow-on-the-mountain euphorbia, *Euphorbia marginata*
Stickseed, *Lappula redowski*
Tumbling russianthistle, *Salsola kali tenuiflora*
Vegetable-oyster salsify, *Tragopogon porrifolius*
Woolly indianwheat, *Plantago purshi*

*Reference. "Standardized Plant Names," 2nd Ed. Kelsey, Harlan P. and William A. Dayton.
†Grasslike plant.
‡Native legumes.

U.S.D.A., SOIL CONSERVATION SERVICE

Northern Great Plains Region

A. E. McClymonds, Regional Conservator

June 1949—E.J.D.

GUIDE TO DEGREE OF USE (Utilization Check)

No.	Degree	Qualitative Description	End-of-season adjustments that may be considered (Spaces to be filled locally)
1	Unused	No livestock use	
2	Slight	Practically undisturbed	
3	Light	Only best plants grazed	
4	Moderate	Most of the range being grazed. Little or no use of poor plants	
5	Full	All of the range being grazed. The primary forage species are properly utilized	
6	Close	All of the range plainly shows use and major sections are closely cropped. Some use of low-value plants	
7	Severe	Hedged appearance of shrubs and trampling damage. Primary forage plants almost completely used. Low-value plants carrying grazing load	
8	Extreme	Range appears stripped of vegetation. Primary forage plants weak from repeated cropping. Low value plants closely grazed	
9	Destructive	Much death loss of primary species. Only remnants of good plants survive. Appearance approaches that of a corral	

Adapted from "A field method of judging range utilization" by M. H. Deming, Mimeo., U.S.D.I., Div. of Grazing, 1939.—E. J. Dyksterhuis, 1944.