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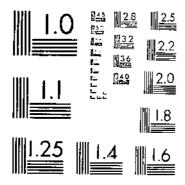
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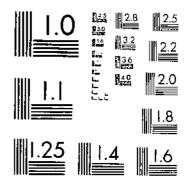
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TB-538 (1937) USDA TECHNICAL BULLETINS UPDATA LEFFECT OF METHOD AND RATE OF GRAZING ON BEEF PRODUCTION AND PLANT

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UNITED STATES DEPARTMENT OF AGRICULTURE WASHINGTON, D. C.

EFFECT OF METHOD AND RATE OF GRAZING ON BEEF PRODUCTION AND PLANT POPULATION OF PASTURES AT BELTSVILLE, MD.

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INTRODUCTION

About half of all the livestock feed in the United States is furnished by the grazing lands, the care and development of which received but minor consideration until recent economic changes in the status Tof agriculture brought about a keener appreciation of pastures and a demand for more authentic information of their possibilities. is difficult to compare the returns from permanent pastures with those from cropped land because pasture returns must be interpreted in terms of animal products, the prices of which fluctuate rapidly and widely, and also because many pastures are located on untillable land, usually the most unproductive part of the farm.

The experiment herein described was planned in order to obtain more exact information as to the returns that may be expected from a permanent pasture on soil comparable in productivity with that used for cultivated crops when such a pasture is grazed by beef cattle that are not given any supplemental feed. The results are cattle that are not given any supplemental feed. considered applicable to soils of moderate fertility in the Middle

Atlantic States and in the eastern part of the Corn Belt.

The plan of the experiment herein reported was prepared by H. N. Vinall, senior agronomist, Division of Forage Crops and Diseases, Bureau of Plant Industry, and W. H. Black, senior animal husbandman, Animal Husbandry Division, Bureau of Animal Industry, in the summer of 1928. The chemical determinations in the herbage studies were made by H. L. Wilkins, assistant chemist, Division of Forage Crops and Diseases, and R. E. Davis, assistant blochemist, Animal Husbandry Division. Acknowledgment is made to E. W. McComas, animal husbandman, and A. T. Semple, formerly associate animal husbandman, Animal Husbandry Division, for assistance in the grazing studies during the first 2 years.

Exact data in regard to the production of pastures under different systems of grazing with beef cattle are lacking. Numerous articles and some experimental results comparing rotation grazing and continuous grazing of fertilized pastures by dairy cattle have been published. Rotation grazing with the application of fertilizers to pastures is an intensive method of management adapted to high-producing dairy cows, but it is not likely to prove profitable in general livestock production. The only publication noted that specifically reports a comparison between continuous and alternate and between heavy and light grazing with beef cattle is Bulletin 204 of the Virginia Agricultural Experiment Station.² This bulletin showed as an average for 3 years an annual gain of 198 pounds per acre for heavy grazing as compared with 111.7 pounds per acre for the light. The bulletin also showed:

The heavily grazed field had a more even turf and was much freer from weeds than the lightly grazed field at the close of the five years' experiment. * * * * The practice of alternate grazing is of doubtfut value.

The results at the Virginia station were obtained on a limestone soil and on an old established bluegrass-redtop turf which had not been plowed for 12 years. It is interesting to compare the results obtained in Virginia with those (described herein) on the pasture at Beltsville, Md., newly seeded with a rather complex mixture on a typical Coastal Plain soil.

LOCATION OF EXPERIMENT AND SOIL TYPES

The Division of Forage Crops and Diseases of the Bureau of Plant Industry, in cooperation with the Animal Husbandry Division of the Bureau of Animal Industry, began in 1928 at Beltsville, Md., an experiment to compare continuous light grazing with continuous heavy grazing, and continuous heavy with alternate heavy grazing. The results were measured in pounds of beef produced and in the effect of the various methods of grazing on the composition and permanence of the pasture flora.

The 18 acres of land used for the experiment is on the animal husbandry farm of the National Agricultural Research Center at Beltsville, approximately 15 miles northeast of Washington, D. C. It is gently rolling and for the most part slopes to the east. There is no tile drainage, but an open ditch along the east side of the field provides both surface and subsurface drainage. The soil is predominantly Sassafras silt loam except near the ditch, where it is Ochlochnee silt loam.

PREVIOUS TREATMENT OF LAND

The area had been in pasture for a number of years previous to 1926, and there is no record of any fertilizer having been applied prior to that date other than some barnyard manure. In 1926 the land was fall-plowed and 1 ton of ground limestone per acre was applied. In the spring of 1927, 5 tons of manure, 175 pounds of 16-percent superphosphate, and 80 pounds of muriate of potash per acre were added. Biennial sweetclover was then seeded at the rate of 15 pounds per acre. The stand was poor, but it was grazed some

^{*} CARRIER, L., and Oakley, R. A. The management of blue-grass pastures. Va. Agr. Exp. Sta. Bull. 204, 18 pp., ilius. 1914.

during the season, and in the fall the land was again plowed in preparation for another spring seeding of sweetclover. Limestone was again applied at the rate of 1 ton per acre, along with 4 tons of manure per acre. In the spring of 1928 sweetclover was seeded at the rate of 15 pounds per acre; a good stand resulted and furnished good pasture until the last of July, when the land was prepared for seeding the experimental pasture.

CLIMATIC CONDITIONS

In this region of the United States the quantity and distribution of rainfall are the climatic factors having most effect on crop yields,

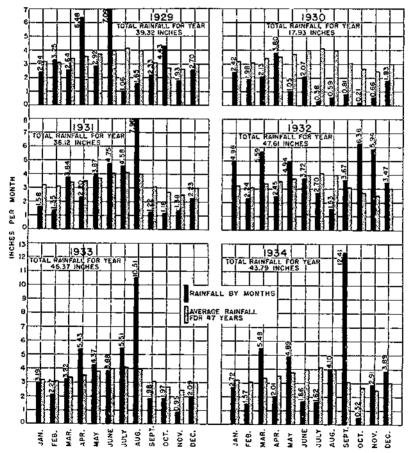


FIGURE 1.—Rainfall at Beltsville, Md., by months, for each year, 1929-34.

and this is especially true of pastures. The rainfall during the period of the experiment varied from the most severe drought in history to a season which was almost ideal for herbage production.

Figure 1 shows the monthly precipitation for the period 1929 to 1934, inclusive, in comparison with the normal or average over a 47-year period ended with 1934. These data alone, however, do not present a true picture. For example, in 1932, the total rainfall was

above normal, but much of it fell in hard, beating rains which adversely affected the mechanical condition of the soil, and in addition much of it was lost in run-off. The average rainfall data were obtained from College Park, Md, since the records were not started at Beltsville, Md., until 1929. However, the average is applicable to Beltsville, as the two places are only 5 miles apart.

While the 1928 data are not included, it may be stated that the rainfall was heavy in August and September but below normal the remainder of the year. In 1929 the April and June rainfall was over 3 inches above the average for each month, but much of this fell in short periods, causing considerable loss of moisture. During the last 6 months of the year the total was 9.37 inches below the average.

In 1930 this region suffered from the most severe drought on record, accompanied by excessively high temperatures which tended to accentuate the conditions. The deficiency in rainfall for that year was 23.33 inches, the total precipitation being only 17.93 inches, or about 43 percent of the normal. This drought really extended from July 1929 through February 1931. In this period of 20 months there were only 2 months (October 1929 and April 1930) when the rainfall equaled or exceeded the normal, and the actual deficiency was 36.1 inches, or 50.8 percent of the normal.

During 1931, although the annual rainfall was somewhat below normal, it was adequate during the growth season, March to August inclusive, and this assured a good pasture season. The rainfall in August was excessive but not sufficient to build up the reserve of soil moisture which had been so depleted by the 20 months of drought. From September to December the rainfall was again below normal.

The season of 1932 was peculiar in that the total rainfall during the year was 6.90 inches above normal, but during July, August, and part of September the crops and pastures suffered from lack of moisture almost as much as in 1930. During this year most of the rains were very heavy, and their effectiveness was decreased by run-off.

In 1933 the total for the season was 4.66 inches above normal, but this excess can all be credited to one rain, on August 24, of 7.31 inches in a 24-hour period. In general, however, the moisture was well distributed, especially during the growing season, and this, in addition to below-normal temperatures, resulted in an excellent season for pastures.

The season of 1934 was similar to that of 1932 except that the distribution of rainfall was even more erratic, varying from 2.52 inches below normal in July to 9.24 inches above in September. The deficiency of 4.82 inches during June and July had a depressing effect on pasture production.

PLAN OF THE EXPERIMENT

The 18-acre field was divided into an 8-acre, a 5-acre, and two 2-acre pastures, with a lane connecting each pasture with the weighing yard, as indicated in figure 2. The 8-acre pasture (A-1) was intended to be grazed continuously at the rate of one animal unit to 2 acres, the 5-acre pasture (A-2) continuously at the rate of one animal unit per acre, and the two 2-acre pastures (A-3N and A-3S) alternately at the same rate as A-2 (one animal unit per acre).

Grazing at the rate of one animal unit to 2 acres was considered light grazing and at the rate of one animal unit per acre was considered heavy grazing. The data obtained and observations made indicate that these terms describe with fair accuracy the actual rates of grazing. The animals used, however, were not mature, and the actual rate was somewhat lower than intended. Considering both the age and the average weight of the animals for the 6-year period, the actual rates of grazing, calculated according to the standard proposed by Vinall and Semple, were equivalent to 2% acres per animal unit for the light grazing and 1% acres per animal unit for the heavy grazing.

In alternate grazing it was originally planned to change the animals from one pasture to the other every 2 weeks, but after the second year the grazing period was increased to 3 weeks, which method was

continued through 1932.Neither of these intervals of alternate grazing appeared superior to continuous grazing as indicated in the pounds of gain per acre, and it was decided in the spring of 1933 to govern the period of grazing according to the growth stage of grasses and legumes. In 1933 and 1934 the periods of grazing were approximately as follows: (1) 4 weeks on A-3N; (2) 6 to 8 weeks on A-3S; (3) 6 to 8 weeks on A-3N; (4) 4 weeks on A-3S; (5) 2 to 4 weeks This methon A-3N. od of alternating the cattle on the two pastures was designed to effect the consumption

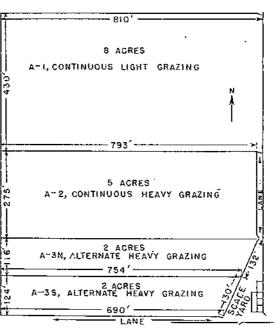


FIGURE 2.—Plan of the pasture-management experiment, animal husbandry farm, National Agricultural Research Center, Beltsville, Md.

of all the herbage on a given pasture before the animals were moved. The 6 to 8 weeks on pasture A-3S during the early part of the season resulted in the accumulation of a heavy growth of rather mature herbage on A-3N, which, however, was consumed rather completely by the animals in the 6 to 8 weeks following. A-3N was grazed first in 1933 and A-3S in 1934.

SEEDBED PREPARATION AND SEEDING

The land was plowed in August 1928, and about the middle of September it was double-disked twice. After the limestone was applied the ground was harrowed with a spring-tooth harrow, and

³ Vinall, H. N., and Semple, A. T. Unit days of grazing. (Notes.) Jour. Amer. Soc. Agron. 24: 836-837, 1932.

immediately after the fertilizer application it was cultivated with a spike harrow. The seedbed was in excellent tilth at the time of

seeding, September 27.

In order to insure uniform treatment of all the pastures, the 18 acres were seeded as one field and divided later into experimental plots or pastures. A heavy seeding of a complex mixture was used even though such expensive seedings are not recommended in practice. For experimental reasons it was considered best to include seeds of all pasture plants adapted to this region in order to observe the contribution made by each under regulated grazing.

The following mixture was sown broadcast at the rates indicated:

Sam Santanhar 1000	Pounds
Sown September 1928:	per acre
Kentucky bluegrass (Poa pratensis)	12
Region (Agrosis alba)	3
Timothy (Phicum praiense)	4
Orunard grass (Dactutis atomerata)	4
Micadow lesque (Festuca etation)	4
itanan ryegrass (Lohum multiflorum)	Ŕ
referritat ryegrass (L. perenne)	4
Red clover (Trifolium nralense)	3
MISIKE CLOVER (T. hubridum)	9
White Dutch clover (T. repens)	5
Sown March 1929:	
Korean lespedeza (Lespedeza stipulacea)	4
Common lespedeza (L. striata)	10
	10

One-half of the mixture (exclusive of the lespedezas) was seeded lengthwise of the field and harrowed lightly, after which the remainder was seeded crosswise and covered with a cultipacker. Previous to seeding, samples were taken, and a germination and purity test of each lot of seed was made. The lespedezas were seeded broadcast on the surface early in March 1929.

LIME AND FERTILIZERS USED

A detailed acidity test of the surface soil was made every 100 feet to a depth of 4 inches over the entire field, and limestone was applied to those areas requiring it, as indicated by the test. One and even two tons per acre were needed on certain areas of the field, the greater amounts being required on the higher portions. A total of 10 tons was applied on the 18 acres.

On September 26, 1928, the field received an application of 400 pounds per acre of 16-percent superphosphate and 100 pounds per acre of sulphate of potash (50 percent K₂O). No nitrogen fertilizer was used, as it was felt that the growth of sweetclover plowed under previous to seeding would supply sufficient available nitrates, and this assumption was verified in the rapid and luxuriant fall growth of the seeding.

No other applications of limestone or fertilizers were made except in the spring of 1931, when 100 pounds per acre of nitrate of soda, 400 pounds per acre of 16-percent superphosphate, and 100 pounds per acre of muriate of potash (50 percent K_2O) were applied to all pastures. This was done to aid the pastures in recovering from the severe drought of 1930.

RESULTING STANDS AND TREATMENTS PREVIOUS TO GRAZING

An excellent stand of the mixture resulted from the seeding because fall weather conditions were almost ideal. Italian ryegrass made an especially rapid growth, as did orchard grass and timothy. The clovers germinated well, but did not make much fall growth because of

the competition from the luxuriant grass growth. This dense growth, however, protected the clovers during the winter and early spring, when young clover seedlings without such protection tended to heave out.

The growth in the spring of 1929 was very rapid, and the stand was uninjured by the winter. The lower portion of the field, however, contained considerable wintercress (Campe barbarea) and field peppergrass (Lepidium campestre). Early in May, when these weeds were in full bloom, this area of the field was clipped and the growth removed; this practically destroyed all of these weeds before the seed matured. The grass on the clipped area recovered so rapidly that in 3 weeks' time it was impossible to observe any difference between the clipped and unclipped areas.

Early in April the field was surveyed, and the division and lane fences were erected. Permanently marked quadrats for plant-popu-

lation studies were located in each pasture.

GROWTH CONDITIONS

The pastures made very rapid growth in the spring of 1929, as indicated by the condition of the herbage at the beginning of the grazing season (fig. 3). It was decided to clip the excess growth on



Figure 3.—Type and condition of steers and growth of grass at beginning of grazing season, May 1, 1929, 7 months after the grass was seeded.

June 14, and 940 pounds per acre of field-cured hay of good quality was taken from the lightly grazed pasture, but the growth mowed on the other pastures was allowed to remain in the swath, to be eaten by the grazing animals. The greatest percentage of the herbage harvested as hay was Italian ryegrass, because of its rapid growth, and it continued to be the predominating grass until midsummer. It is evident from the plant-population records that an excellent stand was obtained of all the species in the seed mixture, and in this respect the quadrats are quite representative of the pastures.

Two possible explanations are offered for the presence of Canada bluegrass in the pasture herbage although it was not included in the seed mixture. (1) A few plants were observed in the field previous to preparing the seedbed; and (2) the purity tests of seeds showed a small amount of Canada bluegrass seed in the redtop and orchard grass seed, but in such small quantities as to pass the purity specifications. Mention is made of the presence of Canada bluegrass at this time because of the prominence it assumed in the pasture flora as the experiment progressed.

The most significant fact in the 1929 data was the uniformity of the number of plants of each species seeded and the maintenance of this uniformity in the various quadrats. These results indicate that sufficient seed of each species was sown for an initial stand and that the presence or absence of any species in the following years has depended on its longevity and its ability to withstand the competition of other

species under grazing conditions.

Plant growth was slow after midsummer because of the lack of rainfall, and by the end of the grazing season all pastures were grazed quite close. In the late fall the pastures were harrowed with a spiketooth harrow and Scotch chain harrow to scatter the droppings.

Because of the lack of moisture during the preceding fall and in the spring of 1930 the growth was rather slow. Early in March of 1930 the pastures were packed with a roller weighted with 600 pounds, to set the young plants that had been heaved during the winter. On May 10 the Kentucky bluegrass, orchard grass, and the ryegrasses began to form seed heads, and by that time the first effects of the drought were apparent. The mature grass was moved and removed as field-cured hay in the following quantities per acre on June 20: From A-1, 1,710 pounds; from A-2, 390 pounds; and from A-3N and A-3S, 320 pounds. Regardless of the deficient moisture, the grasses showed many small green shoots after the mowing, but failed to make any considerable growth because of the drought and the continued grazing. The pastures were practically devoid of herbage at the end of the season, and for this reason no readings of the plant populations in the quadrats were made in the fall.

In the spring from 25 to 31 percent of the ground was bare, as a result of the drought in the fall of 1929. The Italian ryegrass had practically disappeared, but perennial ryegrass was present on all the plots. Kentucky and Canada bluegrass, timothy, orchard grass, and redtop furnished almost 60 percent of the total possible cover of

70 to 75 percent.

The pastures made slow growth in the spring of 1931, even though they had received an application of complete fertilizer. The continuously and lightly grazed pasture was in the best condition on May 1, when grazing was started, having an average growth of approximately 6 inches. The continuously and heavily grazed pasture was in very poor condition on this date, but the adequate rainfall in May increased the growth, and by the last of that month there was an abundance of herbage. On A-3S, one of the alternately grazed pastures, there was a 12-inch growth and a heavy stand of grass on May 15, when the animals were moved to it after pasturing for 2 weeks on A-3N.

All the pastures continued to make excellent growth the remainder of the season, furnishing an excess of herbage. In August the excess growth on the continuously and lightly grazed pasture (A-1) became so heavy that it was decided to clip the growth to a height of 4 inches, and 760 pounds per acre of field-cured hay was obtained from this pasture. The other pastures were clipped, but the excess growth was

allowed to remain on the pasture.

The plant-population data from the quadrats show a decrease in Kentucky bluegrass from 14 percent in the spring of 1930 to less than 2 percent in the spring of 1931 under continuous light grazing, while the Canada bluegrass during the same period increased from 22 percent to 38 percent. Perennial ryegrass and meadow fescue had practically disappeared in all the quadrats. The white Dutch clover increased under continuous heavy grazing, making up almost 7 percent of the ground cover. Weeds were more numerous under heavy

grazing than under light grazing.

All the pastures were grazed quite closely late in the fall of 1931, because it appeared at that time that the pastures would not be available for further experimental work. Because of this close grazing, the pastures made slow growth in the spring of 1932. At the time grazing was started, on May 4, however, the grass was 4 to 6 inches The continuously and lightly grazed and the alternately and heavily grazed pastures were similar in plant population, as they had a mixture of all grasses, while the continuously and heavily grazed pasture was composed predominantly of Kentucky and Canada bluegrass and white clover. Weeds were more prevalent in the pastures during this year than at any time in the course of the experi-White clover attained its maximum density during the spring on the continuously and heavily grazed pasture, making up over 38 percent of the total ground cover. During this same season the annual lespedezas began to assume prominence in the continuously and lightly grazed pasture. It was estimated that they made up at least 25 percent of the forage during July, August, and part of September. They came up to a good stand in the heavily grazed pasture but were suppressed by close grazing at the beginning of their growth period. The plant population as described above for the pasture in general corresponded very closely to that found in the permanent quadrats.

In 1933 grazing was not started until May 10, at which time the pastures had made very luxuriant growth. The orchard grass and timothy were 10 to 12 inches high in pasture A-1 and 6 to 8 inches high in A-2 and A-3 on this date. White clover made up almost 25 percent of the stand on the heavily grazed pastures and continued to be prominent until midsummer. On the lightly grazed pasture, in the carly part of the season, there was at least a 10-percent stand of a legume, black medic (Medicago lupulina). Its origin is hard to explain, unless the seed had been in the soil for a number of years and the climatic conditions at this time became ideal for its growth. After the black medic had matured a heavy seed crop in mid-July, the lespedeza began a rapid growth, which, it was estimated, furnished at

least 50 percent of the forage from July 15 until October 15.

The percentage of bare ground decreased in all the quadrats during the season, especially in that in the lightly grazed pasture. In this pasture Canada bluegrass, timothy, and orchard grass made up over 70 percent of the cover. In the quadrats located on the heavily

grazed pasture Kentucky bluegrass and white clover continued to be

quite prominent.

The herbage in the pastures was about 4 inches tall when grazing began on May 2, 1934, and growth continued satisfactorily until about July 1, when it was seriously retarded by lack of moisture, especially on the heavily grazed pastures. The lightly grazed pasture had sufficient excess growth if the annual lespedezas are taken into consideration. They supplied approximately 50 percent of the forage, making it sufficient to furnish ample feed for the cattle until the rams late in August caused a renewed growth. This was the first season that Korean lespedeza contributed much to the grazing; however, the common lespedeza still predominated over the Korean in these pastures.

The plant-population estimates on the permanent quadrats in 1934 showed that Canada bluegrass was becoming more abundant in the heavily grazed pasture, although it was not yet as prominent there as in the lightly grazed pasture, where it constituted almost 50 percent of the soil cover. The white Dutch clover decreased over 10 percent on the heavily grazed quadrat, probably because of the competition from buckborn, which appeared in great abundance during the dry weather in June and July. The quadrats located on the alternately grazed pastures maintained about the same stands of Kentucky

bluegrass as they did in 1932 and 1933.

PLANT-POPULATION STUDIES

METHODS

One quadrat 3 by 3 feet was located on a representative area in each pasture, and readings were made on each square foot in the spring, at the beginning of the grazing season, and again in the fall when grazing was discontinued. The results reported are averages of the spring and fall readings on the nine square-foot areas in each quadrat and are believed to represent the seasonal plant population. In 1929 counts were made of individual plants of each species except the clovers, which were entered as a group. No attempt was made to distinguish the three species of clover that had been seeded, and after

1929 white Dutch was the only clover present in the quadrats.

Beginning in 1930 it was impossible to determine the individual plants of the turf-forming species, and from that time on the plant-cover determinations were made by estimating the percentage of the areas covered by each species. In addition the percentage of the area that was bare ground was included. Since there was an almost 100-percent stand in the spring of 1929, bare ground was supposed to represent a loss of stand caused by winter-killing, drought injury, or the natural disappearance of annuals and biennials. If a dropping happened to fall within any quadrat and was not removed before the plants were smothered, such an area was omitted in calculating the percentage of ground cover.

The most difficult problem in estimating the ground cover of various pasture plants was to determine what credit should be given to the annual lespedezas. At the time of making the spring estimates the lespedezas were in the seedling stage, and when the fall count was made they were grazed off or mature and the ground they actually covered was a very small percentage of the ground they covered in

the summer during their maximum growth. Notes were taken, however, during this period of optimum growth, and the lespedezas were credited with their contribution to the pasture sward in the

general notes for the season.

In estimating the percentage of weeds no attempt was made to separate them into their various species. The vegetation classified as weeds was made up of all the species that would be considered harmful to a permanent pasture even though they were grazed by the animals at certain stages of growth. The most prevalent species were crabgrass (Digitaria sanguinalis), buckhorn (Plantago lanceolata,) field paspalum (Paspalum lacce), and dandelion (Taraxacum officinale).

CHANGES DUE TO GRAZING SYSTEMS

In considering the changes in plant population as affected by the different systems of grazing, probably the most significant was the final prominence of Canada bluegrass, timothy, and orchard grass and the disappearance of Kentucky bluegrass and white Dutch

clover under light grazing (table 1).

At the close of the experiment there was some indication that timothy was gradually decreasing and orchard grass increasing in Weeds were never a serious factor under light grazing; importance. for although the records of 1932 and 1933 show 10 and 6.8 percent, respectively, of weeds, this was due largely to the presence of crabgrass encouraged by the heavy rainfall during the late summer. Crabgrass, however, was never sufficiently abundant in any of the pastures to suppress the perennial grasses. It is unfortunate that the method used in determining the plant population does not give to the annual lespedezas proper credit for their contribution to the

pasturage.

Changes in the plant population of the quadrat in the continuously heavily grazed pasture tended in general toward a turf of bluegrass and white clover. In the fall of 1933 Kentucky bluegrass constituted almost 50 percent of the plant population. In 1934 the proportion of Kentucky bluegrass decreased coincidently with an increase in the Canada bluegrass, which had shown a uniform decline from 22.9 percent in 1931 to 11.2 percent in 1933. The increased percentage of Canada bluegrass in 1934 may be due in part to the June and July drought, which killed some of the Kentucky bluegrass. Timothy and orchard grass made up less than 10 percent of the plant cover after 6 years of heavy grazing. White Dutch clover reached a maximum of 26 percent in 1932 but gradually declined to 7 percent in 1934. The abundance of white clover is known to vary widely from year to Weeds did not seriously compete with pasture plants under heavy grazing.

Heavy alternate grazing had a more pronounced effect on the plant population than either of the other methods of grazing used. Under this method redtop was much more abundant than under continuous light or continuous heavy grazing, and timothy was as abundant as under light grazing. Orchard grass, which made up 15 percent of the stand at the end of the experiment under light grazing, had almost disappeared from the alternately grazed pastures. The proportion of plant cover represented by clover was about 10 percent during the last 2 years. Weeds were more abundant and more species were

present with alternate than with continuous grazing.

Table 1.—Initial stands and percentages of bare ground and of ground cover supplied by different grasses and legumes for a period of 6 years under different methods of grazing

	P	isture A	l−1, cor	ıg	Pa	sture A	-2, con	tinuou	s heav	y grazi	ng	Pastures A-3N and A-3S, alternate heavy grazing												
Item	Plants per square foot in initial stand, 1929				Bare ground or plant cover					ground or plant cover Plants per square foot in initial stand, 1929 Bare ground or plant						lant co	Plants per square foot in initial stand, 1929			Bare ground or plant cover				
	Spring	Fall	1930 1	1931	1932	1933	1934	Spring	Fall	1930 1	1931	1932	1933	1934	Spring	Fall	1930 t	1931	1932	1933	193			
Bara ground Kentucky bluegrass Canada bluegrass Timothy Orchard grass Redtop Italian ryegrass Pereunial ryegrass Meadow fescue Clovers 3 Lespedeza Woeds	Number 3 1 5 3 4 4 4 3 5 8 2	Number 5 2 6 4 3 1 6 6 2 4 3 1 1	Per- cent 31.1 14.2 22.2 14.4 9.4 4.4 .0 4.0 4.0 42.0 42.0	Per- cent 21.6 1.2 38.1 32.1 4.8 .0 1.8 .0 .0 .1	Per- cent 17.5 5.3 35.0 17.7 11.5 2.8 .1 .0 .0 .1 44.0 10.0	Per- cent 12. 6 5. 9 46. 4 11. 6 13. 2 2. 5 0 9 0 1 1 42. 0 6. 8	I' r-cent 10. 2 8. 6 50. 1 15. 3 15. 0 .0 .0 .0 .T 41.0	Num- ber 4 2 T 6 2 2 3 4 3 7 7 2	Number 3 2 8 2 6 T 4 1 4 1	Per- cent 25. 6 23. 3 16. 7 2. 3 7. 7 1. 1 8. 9 3. 3 . 4	Per- cent 27. 0 22. 4 22. 9 11. 0 .0 .0 .0 6. 7 .3 7. 2	Per- cent 17.5 24.7 16.2 2.6 3.6 .3 .1 1.0 26.2 .1 7.7	Per- cent 14, 2 46, 6 11, 2 5, 2 1, 5 2, 0 2, 0 47, 0 3, 8	Per- cent 10.3 40.2 28.1 5.0 3.9 2.2 0 7.0 T 2.6	Num- ber 6 T 5 2 3 6 3 7 18 6	Number 4 T 7 3 5 T 5 2 4 2 T	Per- cent 25.6 18.5 0 19.2 3.9 14.1 .6 7.3 5.3 3.4 424.0 2.1	Per- cent 37.3 19.0 2.2 29.0 1.2 3.5 0 .1 1.0 1.2 .4 6.1	Per- cent 20.0 35.0 3.9 16.6 2.0 6.5 .0 .7 .0 5.3 .1 9.9	Per- cent 19.8 36.4 .7 13.9 .4 .7.3 .0 .4 .0 .9.2 44.0 11.9	Per cent 12. 39. 1. 16. 8			

Spring count only.
 T=trace.
 Clovers include red, alsike, and white Dutch in 1929, after which only white Dutch remained.
 Number of plants per square foot.

Among the problems encountered in obtaining plant-population data was the difficulty, already discussed, of obtaining an accurate measure of the annual lespedezas. It was difficult also to estimate accurately the percentage of ground cover for turf-forming grasses and legumes, such as Kentucky bluegrass and white clover, where they were growing in close association. The bunch grasses, as timothy and orchard grass, do not present such a problem in themselves, but during this experiment it was not unusual to find Kentucky bluegrass present in the bunches or clumps of timothy or orchard grass, and in effect the two species were apparently occupying the same ground area.

In order to make comparable the data for different years, the readings were made as nearly as possible on the same date each year. It is realized that plant-population estimates obtained from a large number of small areas distributed at random over the pastures would

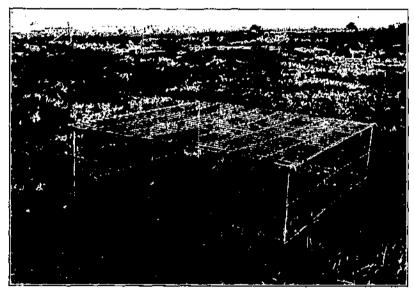


FIGURE 4.-Wire cage (4 by 4 feet) used to keep the herbage from being grazed,

have been more representative of the sward than the single large fixed quadrats. The fixed quadrat was used for the purpose of measuring the permanence of the various species included in the seed mixture.

HERBAGE STUDIES

METHODS

Yields of grass in the various pastures were determined during the seasons of 1933 and 1934 by placing two woven-wire cages in each pasture to prevent the animals from grazing on those particular areas (fig. 4). These cages, 4 by 4 feet and 18 inches high, were constructed of no. 9 galvanized wire soldered together at the joints. The size of the mesh was 2 by 6 inches, which was small enough to prevent animals from reaching through but sufficiently open to prevent any shading effect. Metal stakes five-sixteenths of an inch in diameter

and 24 inches long were driven into the ground in each corner to hold

the cages in place.

The herbage was harvested by hand plucking every 14 days during the flush growth and every 28 days later in the season. These pluckings were made at 28-day intervals, on the date on which the grazing animals were weighed. When pluckings were made at 14-day intervals they were taken in the middle of the weighing period. attempt was made to pluck the grass as close as the animals would graze under normal conditions. Each time the grass was harvested the cages were moved to a new area as nearly representative of the grazed area as possible. When the cages were moved to a new location the excess growth remaining on the new area was removed; hence the yields for the ensuing period represented only new growth. In 1933 the excess growth or herbage not consumed was discarded, but in 1934 this material was saved for determination of the yields and chemical composition.

Yields were calculated in pounds per acre, both as green and as dry matter, the dry matter or water-free weight being obtained by drying the herbage from each plucking in an electric oven at a temperature of 98° C. until it reached a constant weight. The herbage from the two cages was combined and a composite sample taken for chemical

analysis, the yield being calculated from the totals.

The herbage samples for chemical analysis were first dried at a temperature of approximately 50° C. immediately after being harvested, in order to prevent spoilage. When in an air-dried condition they were stored at ordinary room temperatures until analyzed.

YIELDS OF HERBAGE

In the last 2 years of the experiment (1933 and 1934) an attempt was made to measure by agronomic methods the yields of herbage in the various pastures. Any effects of the various grazing systems on the productiveness of the pastures should be apparent in these last years. The yields obtained from pluckings, as described under experimental procedure, are given in table 2.

Considering only the totals, it appears that in 1933 the continuously lightly grazed pasture produced 1,120 pounds more dry matter per acre than the continuously heavily grazed pasture, and 687 pounds more than the alternately heavily grazed pasture. A large part of this difference in favor of lightly grazed pasture must be credited to the unusually high production in August and September, when the annual lespedezas were making their maximum growth. In all the pasture, over 50 percent of the total yield was obtained by July 6. The production per day during June was nearly three times that of July and about twice as great as in August and September.

In 1934 the yields of dry matter for all three pastures were practically

equal and averaged about 40 percent lower than in 1933.

The yields for the 2 years were similar, however, in that over 50 percent of the total was produced before July 6. In both years, therefore, over one-half the total herbage was produced during the first one-third of the regular grazing season. This emphasizes the importance of supplemental pasture or feed during midsummer whenever the permanent pastures are grazed to capacity during the flush growth of spring and early summer; otherwise the rate of grazing must be regulated in May and June so that some of the excess growth will be available in midsummer. It will be noted that during August and September 1934 the herbage yields from the heavily grazed pastures were slightly higher than those from the lightly grazed pasture; this was due to the heavy growth of crabgrass and buckhorn. These weeds were abundant because the pastures had been closely grazed prior to the heavy rains, and the abundance of moisture combined with the freedom from shading provided ideal conditions for their development.

Table 2.—Yield per acre and moisture content of grass pluckings taken at 14- or 28-day intervals during the seasons of 1933 and 1934

High percentage of buckhorn.
 High percentage of crabgrass.

Each year, except those marked by drought, considerable unconsumed herbage remained in the pastures after the flush growth period. The amount was greatest, of course, in the lightly grazed pasture, and under this rate of grazing much of the excess herbage produced in the spring remained untouched until the end of the season (fig. 5). Under the heavier grazing rates the excess herbage was reduced gradually throughout the season, and little or none remained uneaten when the cattle were removed in the fall (fig. 6).

In order to measure as nearly as possible the contribution made by this excess growth to the feed obtained by the animals under the three grazing systems, pluckings of the unconsumed herbage were made every 28 days beginning May 31, 1934. These estimates are given, in pounds of green and water-free herbage per acre, in table 3, which also indicates the moisture percentage for each plucking. A new area was plucked each time, so that records for each succeeding date continue to include unconsumed herbage which had been produced in May and June.

The data in table 3 help to complete the picture of what happens under light and heavy grazing when the pasture is not clipped at any time. The dry matter of unconsumed herbage in the heavily grazed pastures was greatest June 27, and from that date the quantity decreased until none was left in the continuously heavy-grazed pasture



FIGURE 5.—Growth of grass and legumes at the end of the regular grazing season, Oct. 20, 1933, after 5 years of continuous light grazing.



FIGURE 6.—Growth of grass and legumes at the end of the regular grazing season, Oct. 20, 1933, after 5 years of heavy grazing.

by September 19. Under alternate grazing, by October 17, when the season ended, all herbage had been consumed, which indicates that at this rate of grazing the current growth of herbage was insufficient to

satisfy the animals and they supplemented this new growth with additions from the more mature herbage remaining from the spring growth. By the last of July the spring growth was quite mature and dry, as indicated by the low percentage of moisture. The increasing percentage of moisture in the later (Aug. 22 and Sept. 19) pluckings from the alternately grazed pasture was due very largely to the presence of crabgrass. The encroachment of crabgrass was apparently due to the system of grazing and the abundance of rainfall in August. Chemical analyses of this excess growth (table 4) indicate that the cattle were getting, as one would expect, feed rather low in protein and high in carbohydrates.

Table 3.—Estimated quantity per acre and moisture content of unconsumed herbuge remaining on the various pastures at different dates during the grazing season of 1984

Date of harvest	undê		on Inu-	unde	e and n r beavy o razing (/	ontinu-	Herbage and mosture under heavy alternate grazing (A-3N and A- 3S)					
	Green weight	Dry matter	Mois- ture	Green weight	Dry matter		Green weight	Dry matter	Mois- ture			
May 31. June 27. July 26 Aug. 22 Sept. 19 Oct. 17	Pounds 1, 252 1, 552 1, 443 1, 225 1, 307 1, 552	Pounds 807 807 719 686 503 670	70, 7 60, 9 50, 2 44, 0 61, 5	1, 688 1, 280 517	Pounds 425 526 280 251 0	Percent 74. 8 58. 0 45. 8 54. 0	Pounds 1, 198 1, 116 613 790 518	321 386 312	Percent 73, 2 05, 4 49, 1 58, 0 72, 6			
Total	8,331	3, 552		4,030	1,482		4, 235	1, 493				

Under light grazing (A-1) is found a situation entirely different from that under heavy grazing (table 3). In A-1 the dry matter of unconsumed herbage increased until July 26 and a gradual decrease followed until September 19, from which date there was an appreciable increase again until the middle of October. The high moisture percentage found in the unconsumed herbage in September and October indicates that the grass was then growing more rapidly than the animals consumed it. The quantities of unconsumed herbage shown for the lightly grazed pasture at different times throughout the season indicate that the animals utilized some of this in August and the early part of September. There remained, however, slightly more of this excess growth at the end of the season (Oct. 18) than there had been at the end of June.

From a practical standpoint this reserve of pasturage at the end of the regular grazing season is by no means a total loss. Such surplus may be used as a late-fall or winter pasture for thin stock cattle which would otherwise require larger quantities of expensive harvest feed to keep them in good condition.

CHEMICAL COMPOSITION OF HERBAGE

Table 5 gives the chemical composition of the herbage in the three pastures as obtained by analyses of the pluckings made at intervals during the grazing seasons of 1933 and 1934. These pluckings were intended to represent the herbage being eaten by the animals. This material probably approximates in composition the feed consumed at different times of the year as compared with the unconsumed herbage represented in table 4.

Table 4.—Chemical composition of the unconsumed herbage obtained by pluckings made at 28-day intervals during the grazing season of 1934

Method of grazing and date of	Ash Ether extract			Crude fiber		Crude protein		oro pro	ue" tein	Nonprotein nitrogen		Nitrogen-free extract		Calcium		Phosphorus		Mois-	
harvest	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	ture
Continuous light grazing May 31 June 27 July 26 Aug. 22 Sept. 19 Oct. 17	Per- cent 2.02 2.26 2.62 3.06 2.56 2.50	Per- cent 6.91 5.78 5.27 5.46 6.66 6.48	Per- cent 0.89 1.36 1.54 1.51 1.30	Per- cent 3. 05 3. 49 3. 10 2. 69 3. 06 3. 01	Per- cent 9, 71 12, 66 15, 75 17, 57 11, 83 11, 78	Per- cent 33, 15 32, 37 31, 62 31, 38 30, 73 27, 26	Per- cent 3, 03 3, 30 3, 18 3, 90 3, 69 5, 03	Per- cent 10, 35 8, 44 6, 39 6, 96 9, 59 11, 64	Per- cent 2,50 2,87 2,78 3,46 3,26 4,45	Per- cent 8, 85 7, 34 5, 58 6, 17 8, 48 10, 20	Per- cent 0.33 .32 .30 .34 .32 .44	Per- cent 1, 13 .83 .51 .60 .83 1, 01	Per- cent 13, 75 19, 62 26, 81 30, 08 19, 34 22, 44	Per- cent 46, 92 50, 19 53, 83 53, 71 50, 24 51, 95	Per- cent 0.08 .11 .13 .16 .20 .32	Per- cent 0, 28 .28 .27 .29 .53 .73	Per- cent 0.03 .09 .08 .10 .08 .09	Per- cent 0.30 .24 .16 .18 .22 .21	Per- cent 70, 70 60, 90 50, 20 44, 00 61, 50 56, 80
Average Continuous heavy grazing: May 31. June 27 July 26 Aug. 22	1, 79 2, 51 2, 72 2, 29 2, 33	7. 10 6. 10 5. 01 4. 97	.83 1.39 1.37 1.37	3. 28 3. 37 2, 52 2, 97 3. 04	7. 65 12. 60 18. 41 14. 77	30. 35 30. 66 33. 97 32. 11	3. 07 3. 72 3. 19 3. 75	12, 20 9, 05 5, 89 8, 16	2, 40 3, 28 2, 83 3, 38 2, 97	9. 51 7. 97 5. 22 7. 35	.51 .33 .28 .28	2. 03 . 81 . 51 . 61	12, 03 21, 00 28, 60 23, 92 21, 39	47. 73 51. 09 52. 77 51. 99	. 15 . 14 . 24 . 20	.58 .35 .44 .43	. 08 . 10 . 10 . 09	. 33 . 25 . 18 . 19	74. 80 58. 90 45. 80 54. 00
Average Alternate heavy grazing: Alay 31 June 27 July 26 Aug. 22 Sopt. 19	1, 86 2, 32 2, 76 2, 56 1, 91	6, 95 6, 72 5, 40 6, 19 6, 98	.84 1.27 1.57 1.36 .98	3. 12 3. 67 3. 07 3. 29 3. 58	8, 63 10, 38 17, 17 12, 73 8, 16	32, 21 30, 08 33, 60 30, 74 20, 78	3. 10 3. 89 3. 38 4. 76 3. 87	11. 57 11. 27 6. 62 11. 50 14, 12	2, 62 3, 38 3, 04 4, 27 3, 27	9. 78 9. 80 5. 95 10. 31 11. 93	.36 .38 .26 .37 .45	1. 34 1. 10 . 50 . 89 1. 65	12. 49 16. 78 26. 31 20. 11 12. 63	46. 50 48. 63 51. 48 48. 58 46. 08	.10 .17 .14 .15 .12	.39 .49 .28 .37 .43	.09 .10 .11 .10	.33 .28 .21 .23 .29	73. 20 65. 50 48. 90 58. 60 72. 60
Average	2, 28	6, 45	1. 20	3, 35	11.41	31. 28	3, S0	11.02	3. 32	9. 55	. 36	1. 10	17, 66	48. 27	. 14	. 39	. 10	. 27	63. 76

Table 5.—Chemical composition of herbage pluckings made at stated intervals during the grazing seasons of 1933 and 1934
SEASON OF 1933

Nethod of analysis and data of	Ash of grazing and date of		Ether extract		Crude	Crude fiber		protein		ue'' tein	Nonprotein nitrogen		Nitrogen-free extract		Calcium		Phosphorus		Mois-
harvest	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	
Continuous light grazing: May 25 June 7 July 6 Aug. 2 Aug. 30 Sept. 28 Oct. 26	Pcl. 1. 97 2. 01 2. 38 2. 42 2. 01 2. 24 3. 22	Pet. 7, 42 7, 21 6, 71 7, 28 6, 49 6, 46 7, 01	Pct. 0, 82 .83 1, 17 1, 45 .79 1, 58 1, 57	Pct. 3. 10 2. 99 3. 32 4. 35 2. 57 4. 54 3. 41	Pct. 8. 24 8. 96 10. 23 9. 06 7. 78 8. 04 12. 95	Pet. 30, 97 32, 13 29, 14 27, 22 25, 17 23, 17 28, 16	Pct. 2.77 2.88 3.85 4.57 5.35 5.83 4.92	Pct. 10. 40 10. 33 10. 97 13. 71 17. 32 16. 80 10. 70	Pct, 2, 42 2, 21 3, 21 4, 10 4, 88 5, 05 4, 51	Pct, 9, 10 7, 93 9, 15 12, 30 15, 79 14, 54 9, 80	Pcl. 0. 26 . 50 . 48 . 35 . 36 . 59 . 31	Pcl. 0. 98 1. 80 1. 37 1. 06 1. 15 1. 70 . 68	Pct. 12, 88 13, 38 17, 67 15, 92 15, 09 17, 21 23, 44	Pct. 48. 43 47. 94 50. 33 47. 80 48. 82 49. 60 50. 95	Pct. 0. 09 .11 .24 .26 .36 .36 .22	Pct, 0, 35 , 38 , 69 , 77 1, 16 1, 03 , 48	Pct. 0.09 .09 .09 .15 .09 .12 .13	Pct. 0. 33 . 34 . 27 . 44 . 30 . 34 . 29	Pct, 73, 41, 72, 11 64, 86 66, 70 69, 09 65, 29 54, 00
A verage	2, 32	6. 94	1.17	3, 47	0, 32	27, 99	4, 31	12.89	3, 77	11, 23	. 41	1, 25	16, 51	49, 12	. 23	. 69	. 11	. 33	66. 49
Continuous heavy grazing: May 25 June 7 July 6 Aug. 2 Aug. 30 Sept. 28 Oct. 26	1. 97 2. 06 2. 53 2. 07 2. 12 2. 37 3. 57	7. 48 7. 46 7. 45 7. 67 7. 61 7. 54 7. 81	.86 .88 1,22 1,19 .69 1,60 1,63	3, 28 3, 19 3, 59 4, 40 2, 48 5, 10 3, 56	8, 14 8, 59 9, 92 6, 53 6, 11 6, 73 11, 32	30 05 31, 13 29, 25 24, 18 21, 98 21, 44 24, 76	2. 87 3, 09 3. 70 3. 50 4. 91 5. 88 7. 43	10. 90 11. 20 10. 91 12. 97 17. 66 18. 74 16. 25	2, 37 2, 45 3, 01 2, 93 4, 57 5, 00 6, 70	9, 03 8, 86 8, 87 10, 87 16, 43 15, 93 14, 67	.37 .49 .52 .43 .26 .67	1.41 1,76 1.53 1.58 ,93 2,12 1.19	12. 58 13. 14 16. 71 13. 85 14. 06 15. 03 21, 05	47, 85 47, 60 49, 30 51, 31 50, 57 47, 87 48, 02	.14 .16 .27 .22 .30 .30	. 52 . 58 . 81 . 81 1. 07 . 97 1. 05	.09 .09 .10 .11 .11 .12 .15	.36 .33 .29 .39 .38 .38	73, 71 72, 39 66, 09 73, 00 72, 19 68, 60 54, 29
Average	2.38	7. 57	1. 15	3. 66	8. 10	26. 24	4. 48	14, 09	3. 86	12.09	. 47	1.50	15, 33	48. 93	. 27	. 83	. 11	. 35	68. 61
Alternate heavy grazing: May 25. June 7. July 6. Aug. 2. Aug. 30. Sept. 28. Oct. 26.	1. 74 1. 95 2. 39 1. 95 1. 88 2. 21 3. 74	6. 66 7. 50 6. 81 7. 61 7. 30 7. 18 9. 11	.78 .86 1.22 1.08 .93 1.54 1.67	2, 99 3, 31 3, 47 4, 20 3, 61 5, 01 4, 06	8. 88 7. 96 10. 47 6. 19 6. 08 7. 11 8. 42	33. 90 30. 63 29. 82 24. 17 23. 64 23. 09 20. 49	2, 56 3, 21 3, 46 3, 65 3, 26 4, 80 6, 15	9, 76 12, 35 9, 86 14, 27 12, 68 15, 58 14, 96	2, 12 2, 43 2, 96 3, 02 2, 89 4, 24 5, 60	8. 11 9. 36 8. 42 11. 79 11. 26 13. 76 13. 62	. 32 . 50 . 38 . 45 . 26 . 42 . 41	1, 24 2, 26 1, 08 1, 86 1, 03 1, 37 1, 00	12. 34 12. 20 17. 69 12. 90 13. 66 15. 28 21. 26	47, 11 46, 93 50, 40 50, 39 53, 16 49, 60 51, 72	.09 .15 .21 .18 .15 .22 .35	.34 .58 .60 .72 .60 .72 .86	.09 .09 .11 .10 .10 .12 .16	.35 .33 .30 .40 .39 .38 .39	73, 82 74, 01 64, 89 74, 38 74, 30 69, 20 58, 90
Average	2, 27	7.45	1.15	3, 81	7, 87	20. 53	3. S7	12.78	3, 32	10.90	.41	1.41	15.05	49. 90	. 19	. 63	.11	. 36	69, 93

Table 5.—Chemical composition of herbage pluckings made at stated intervals during the grazing seasons of 1933 and 1934—Continued SEASON OF 1934

Method of grazing and date of	A.	sh	Ether	extract	Crude	fiber	Crude	protein	"Tr pro		Nonp nitro		Nitrog exti		Calc	dum	Phost	ohorus	Mois-
harvest	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water- free	Green	Water free	ture
Continuous light grazing: May 18 May 31 June 27. July 26 Aug. 22 Sept. 19 Oct. 17	Pcl., 2,00 2,27 2,57 2,43 2,20 2,51 2,44	Pct. 7.51 9.02 6.58 5.11 6.97 9.71 8.67	Pct. 0, 86 , 80 1, 20 1, 43 1, 15 1, 01 1, 18	Pcl. 3, 25 3, 18 3, 06 3, 02 3, 63 3, 91 4, 21	Pct. 8, 14 6, 62 12, 65 14, 12 8, 14 6, 29 6, 42	Pcl. 30-62 26.26 32.35 29.73 25.76 24.28 22.81	Pct. 3.02 3.68 3.01 3.93 5.17 4.35 4.87	Pct., 11,37 14,50 7,70 8,28 16,36 16,79 17,32	Pct. 2,31 2,99 2,65 3,42 4,65 3,77 4,11	Pct. 8.70 11.87 6.77 7.19 14.71 14.56 14.61	Pct. 0.53 .52 .27 .39 .40 .44	Pet. 2.01 2.05 .70 .83 1.25 1.68 2.04	Pct. 12,74 12,00 10,76 25,71 15,07 11,88 13,38	Pct. 47, 91 47, 62 50, 54 54, 13 47, 69 45, 86 47, 63	Pct. 0. 12 . 17 . 11 . 16 . 21 . 13 . 13	Pct. 0.44 .66 .29 .34 .55 .48	Pct. 0. 08 . 08 . 12 . 03 . 00 . 07 . 07	Pct. 0.30 .32 .30 .17 .29 .26 .26	Pct. 73, 40 74, 80 60, 90 52, 50 68, 40 74, 10 71, 90
Average.	2.35	7.65	1, 09	3.47	8, 91	27, 41	4.00	13, 20	3,41	11.20	.45	1.51	15.79	48, 77	. 15	. 48	.08	. 27	68.00
Continuous heavy grazing: May 18. May 31. June 27. July 26. Aug. 22. Sept. 19. Oct. 17.	1.78 2.18 2.43 2.52 2.07 1.91 2.00	7, 69 9, 95 6, 08 5, 73 8, 21 8, 64 9, 43	.76 .67 1.28 1.36 1.03 .88 .95	3. 31 3. 06 3. 22 3. 10 4. 07 3. 91 4. 30	6, 20 5, 36 12, 71 13, 18 6, 03 5, 06 4, 33	26, \$2 24, 48 31, \$5 20, 96 23, 94 22, 61 19, 50	3. 80 3. 46 3. 77 3. 72 4. 85 3. 64 4. 35	16. 43 15. 79 9. 44 8. 45 19. 24 16. 27 19. 50	2. 68 2. 63 3. 30 3. 33 4. 39 3. 13 3. 76	11, 50 12, 03 8, 26 7, 57 17, 42 13, 08 16, 95	. \$4 . 62 . 36 . 29 . 35 . 30 . 44	3. 64 2. 83 . 89 . 66 1. 37 1. 72 1. 98	10. \$5 10. 44 19. \$3 23. 31 11. 34 11. 01 10. 62	46. 95 47. 65 49. 69 52. 98 44. 99 49. 13 47. 84	. 13 . 21 . 22 . 18 . 21 . 15	. 58 . 94 . 56 . 40 . 85 . 60 . 69	.08 .07 .11 .09 .08 .06	.35 .34 .28 .20 .32 .29 .29	76. 90 78. 10 60. 10 56. 00 74. 80 77. 60 77. 80
Average	2. 14	7.00	. 99	3. 57	7, 55	25, 59	3.94	15, 03	3.32	12.54	. 47	1.87	13, 91	48, 46	. 18	. 67	.08	. 30	71, 61
Alternate heavy grazing: May 18. May 31. June 27. July 26. Aug. 22. Sept. 19. Oct. 17.	1.80 2.05 2.42 2.31 2.02 1.75 2.02	7, 90 8, 87 6, 71 5, 66 8, 01 7, 71 8, 06	.76 .71 1,27 1,41 1,07 .82 .87	3, 32 3, 09 3, 52 3, 44 4, 25 3, 62 5, 49	6 45 6, 42 11, 31 12, 04 6, 33 5, 48 5, 86	28, 30 27, 81 31, 33 29, 43 25, 10 24, 14 23, 44	3, 40 3, 44 3, 68 3, 69 4, 81 3, 31 3, 84	14, 90 14, 90 10, 20 9, 03 19, 10 14, 58 15, 37	2, 43 2, 70 3, 27 3, 22 4, 28 2, 83 3, 35	10, 64 11, 69 9, 06 7, 87 17, 00 12, 45 13, 38	. 73 . 56 . 31 . 36 . 40 . 36 . 38	3. 20 2. 42 . 86 . 87 1. 58 1. 60 1. 50	10, 63 10, 66 17, 52 21, 56 11, 11 11, 46 12, 54	46, 63 46, 13 48, 52 52, 72 44, 07 50, 48 50, 14	. 17 . 17 . 18 . 20 . 13 . 11	. 73 . 72 . 49 . 50 . 51 . 49 . 57	.08 .08 .11 .09 .10 .07	.36 .30 .22 .38 .29 .30	77, 20 76, 90 63, 90 59, 10 74, 80 77, 30 75, 00
A verage	2, 05	7.50	.99	3, 53	7. 70	27.08	3. 74	14,01	3. 15	11.73	. 44	1, 72	13. 64	48, 39	. 16	. 57	. 09	.31	72, 03

The composition of the dry matter as shown in table 5 indicates that in 1933 the crude protein was lowest in the May pluckings and gradually increased until late August and September. The seasonal relation of the protein content (table 5) is not as nearly in accord with the results obtained in clipping plots as are the data for 1934, which show a period of high protein values in early spring, followed by a low in late June and July, and a second period of high values in late August and September, when lespedeza was abundant. Calcium followed much the same trend as protein throughout the season, but the phosphorus content remained fairly uniform except for a consistent decline in July of both years. On an average, the ratio of calcium to phosphorus was approximately 2:1, which is a desirable one according to nutrition studies of these elements. The amount of each element was also adequate throughout, except possibly in the lightly grazed pasture in 1934, where the seasonal average for calcium was 0.48 percent and that for phosphorus 0.27 percent.

The crude fiber in the herbage of the various pastures was comparatively low, and, as might be expected, the average percentage was highest in the lightly grazed, lowest in continuously and heavily grazed, and about intermediate in the alternately and heavily grazed pasture. Naturally, conditions were reversed in respect to the crude protein content of the herbage, the average for the 2 years being 13.05 percent for the lightly grazed, 14.56 percent for the continuously and heavily grazed, and 13.4 percent for the alternately and heavily grazed pastures. The results indicate a ration sufficiently rich in

protein for the needs of beef animals.

GRAZING STUDIES

CATTLE USED

Yearling steers of Aberdeen Angus, Hereford, and Shorthorn breeding were used during the course of the experiment. They ranged in grade from Low Medium to Choice as feeders at the beginning of the experiment. The lower grades of cattle were used in 1929, 1931, and 1933, and the higher grades in 1930, 1932, and 1934.

METHOD OF HANDLING STEERS

The steers were divided into three groups, each consisting of steers representative in regard to average grade and weight. The groups were handled as follows:

Group 1.—4 steers, grazed continuously on 8 acres (pasture A-1).

Group 2.—5 steers, grazed continuously on 5 acres (pasture A-2).
Group 3.—4 steers, grazed alternately on two 2-acre pastures (A-3N and A-3S).

The steers were weighed on 3 successive days at the beginning of each year's work. The average of these three weights was used as the initial weight, and the date of the third weighing was taken as the initial day of the experiment. Throughout the grazing season the cattle were weighed at intervals of 28 days with the exception of the first year, weights being taken at about the same hour each weigh day. The steers were weighed on 3 successive days at the close of the experiment, the average of these weights being used as the final weight, the last weight being taken on the day the experiment closed.

No supplemental feed was used while the animals were on pasture. Water was available in all paddocks at all times. Salt was weighed

into each lot and was accessible to all animals throughout the grazing season (table 6).

Table 6.—Salt provided per steer on pasture

Group no.	Quanti prov	ty of salt ided—
· .	Per day	Per senson
1 2 3	Ounces 1, 9 1, 8 1, 9	Pounds 18.6 17.4 18.4

COMPARATIVE GAINS UNDER DIFFERENT SYSTEMS OF GRAZING

The average weights and gains of the steers for the different grazing seasons and for the whole period of the experiment, from 1929 to 1934, inclusive, are shown in table 7.

Table 7.—Average weights and gains of steers during the various grazing seasons and for the period 1929-34

	Average	weight	Average gain				
Grazing period and group no.!	Initial	Fingi	Per steer	Daily per steer	Per acre		
First season, May 1 to Oct. 16, 1020 (168 days);	Pounds	Pounds	Pounds	Pounds	Pounds		
Group I	585	940	355	2.11	177.5		
Group 2	583	681	98	. 58	98.0		
Growp 2	574	721	147	.88	147.3		
Group 3. Second season, May 1 to Aug. 21, 1930 (112 days):	21.4	741	147	.03	141,1		
Second season, May 1 to Aug. 21, 1939 (112 cmys):		Hea	4.00	!	70.3		
Group J.	594	752	158	1.41			
Group 2	593	688	95	. 848	94.8		
(Froity 3.	610	700	90	. 80	89. 3		
Phird season, May 1 to Oct. 16, 1931 (168 days):							
Group L	539	873	334	1.08	166.1		
Group 2	520	863	343	2.04	342.6		
Orong 3	520	81G	296	1.76	205.		
Fourth senson, May 4 to Sept. 21, 1932 (140 days):					1		
Group 1	624	938	314	2.24	156.1		
Group 2	542	760	218	1.56	218.		
		828	213	1.52	212.		
Group 3. Fifth season, May 10 to Oct. 25, 1933 (108 days):	1/10	020	1				
Carres 7	492	811	310	1.90	159.		
Group 1	459	701	232	1.38	232.		
Group Z.	459 469	701	232	1.38	231.		
Group 3	400	401	2532	1.35	231.		
Sixth season, May 2 to Oct. 17, 1934 (168 days);			I				
Group I	456	717	261	1. 55	130.		
Group 2.	456	647	191	1.34	190.		
Grown 3	460	650	190	1.13	189.		
Period of experiment (1920-34):			!	ļ.	ı		
Group 1	548	835	287	1.87	145.		
Group 2	527	723	196	1, 26	196.		
Group 3	541	730	195	1. 25	194.		

¹ Group 1, 4 steers; group 2, 5 steers; group 3, 4 steers.

RESULTS IN 1929

In 1929 the pasture had a very thick stand of grasses and legumes, with a growth that averaged over 10 inches in height at the time grazing was started, May 1. In an attempt to utilize this heavy growth, the rates of grazing were doubled for the first 28 days, with 1 steer per acre on pasture A-1 and 2 steers per acre on each A-2 and A-3 pasture.

During this period these extra steers on the pasture produced an additional 75.1 pounds of gain per acre in pasture A-1, 111.2 pounds in A-2, and 108.2 pounds in A-3. When these gains are added to the seasonal gain per acre the following production should be credited to each pasture: A-1, 252.6 pounds; A-2, 209.8 pounds; and A-3, 255.5 pounds. For the remainder of the season the various pastures were grazed at the rates indicated in the plan of the experiment.

The steers on all pastures continued to make gains of over 1 pound per head per day until the last of August, when the lack of moisture severely reduced the production of herbage. The average gains of

the steers in the various groups are shown in table 7.

The excess growth that accumulated during the early summer on the lightly grazed pasture (A-1) was sufficient to provide feed for the remainder of the season, so that the steers on this pasture continued to gain until October 16 (fig. 7). On the heavily grazed pastures (A-2



Figure 7.—Steers and pasture at the end of the first grazing season under continuous light grazing, October 16, 1929.

and A-3) the surplus growth had been consumed by August 21, and the steers on the one continuously grazed (A-2) lost weight at the rate of 2.46 pounds per head per day during September and October, while those on the alternately grazed pasture (A-3) lost 1.92 pounds per head per day in September and 1.0 pound per head per day in October. In the last 2 months the steers on A-2 lost 58.5 percent and those on A-3 lost 35.7 percent of the gains made prior to August 21 (figs. 8 and 9). Under good farm practice the steers would have been removed from the pastures about September 1, or given supplementary feed sufficient to maintain their weight. The results are of value, however, in indicating the importance of supplementary or temporary pastures on which to carry livestock during the drought periods of late summer, when heavy grazing is practiced. Gains during the 1929 season are shown graphically in figure 10.



FIGURE 8.—Steers and posture at the end of the first grazing season under continuous heavy grazing, October 18, 1929.



FIGURE 9.—Steers and pusture at the end of the first grazing season under afternate heavy grazing.

October 16, 1929.

RESULTS IN 1930

The grazing season in 1930 was reduced to 112 days because of the severe drought. All of the steers made good gains during May and June, and group 1 continued to make substantial gains in July. Pastures A-2 and A-3, however, began to show the effect of heavy grazing about the first of July, and group 2 made only slight gains and group 3 showed a slight loss during this month. The average gains of the steers in the various groups are shown in table 7.

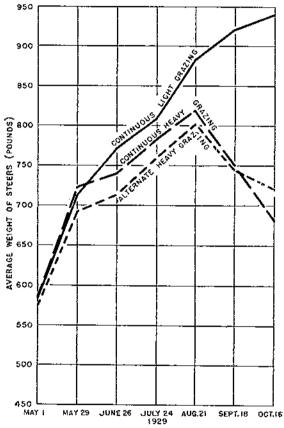


FIGURE 10.—Average weights of steers by 28-day periods during the grazing season of 1920.

Grazing was continued until August 21, when all groups were losing weight rapidly. In addition to the drought, two factors contributed to the reduction of herbage available for grazing. On June 20 (before the beginning of the drought) the excess growth was removed from all pastures by clipping with a field mower. If this surplus herbage had been allowed to remain it probably would have furnished sufficient pasturage to extend the gains over a longer period. A fire that burned over a portion of pasture A-1 during the first week in August materially reduced the amount of herbage available in

that pasture. Gains during the 1930 season are shown graphically in figure 11.

RESULTS IN 1931

In 1931 each group made good gains during May and June, but during July the steers on both the heavily grazed pastures made practically no gain, while the steers on pasture A-1 made an average daily gain of 1 pound per head. The steers on the heavily grazed pastures began to gain in August and continued to make good gains

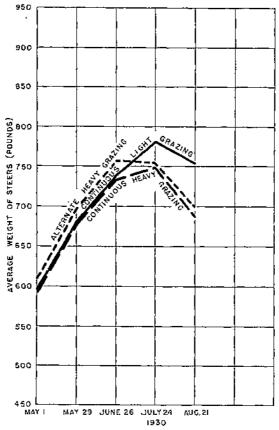


FIGURE 11.—Average weights of steers by 28-day periods during the grazing season of 1000.

the rest of the season (fig. 12). The average gains of the steers in the various groups are shown in table 7.

After the experiment was closed, pasture A-1 still contained an abundance of herbage, although 760 pounds of air-dry hay per acre had been removed during the first week in August. In an effort to utilize this excess growth 40 steers were turned on this pasture, and it furnished them excellent grazing for over 3 weeks. Records were not taken of gains in weight.

RESULTS IN 1932

In 1932 all groups made satisfactory gains during the 140-day grazing period except the one on the heavily grazed pasture (A-2), which lost an average of 0.54 pound per head per day during the last 28-day period. This loss was due to lack of herbage caused by the midsummer drought and the heavy grazing which removed the

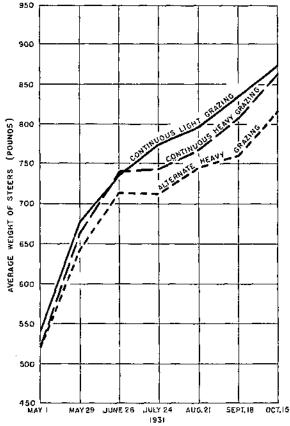


FIGURE 12.-Average weights of steers by 28-day periods during the grazing season of 1931.

excess spring growth early in the summer. During this same 28-day period group 1 made an average daily gain of 1.43 pounds and there appeared to be enough pasturage remaining to have carried the steers with satisfactory gains until the end of the grazing season late in October. The average gains of the steers in the various groups are shown in table 7 and in figure 13.

RESULTS IN 1933

The grazing season in 1933 extended over the normal period, and each group made satisfactory gains every month except during July, when group 1 showed a daily loss of 0.16 pound and groups 2 and 3 heavier losses of 0.46 and 0.91 pound per head per day, respectively.

The above-normal rainfall after July improved the pastures to such an extent that all groups made satisfactory gains the remainder of the season. The average gains of the steers in the various groups are shown in table 7.

The change in the intervals of grazing on the alternately grazed pastures, as explained on page 5, was started during this season. While the new method appeared to have some advantage over the old method, it did not give any increase in beef production over continuous grazing at the same rate.

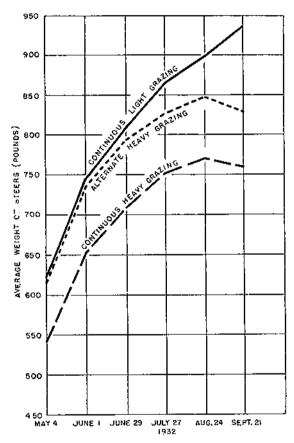


Figure 13.-Average weights of steers by 28-day periods during the grazing season of 1932.

At the end of the regular grazing season pasture A-1 had a heavy growth of grass and annual lespedeza remaining, and to utilize this excess growth 20 yearling Hereford steers were turned in for a 28-day period. These steers averaged 369.2 pounds in weight at the beginning of the period and 393.9 pounds at the end, which made an additional 61.7 pounds of beef per acre to be credited to pasture A-1, or a total of 221.1 pounds per acre for the season. The results indicate the possibilities of following a system of light grazing with beef animals during the regular grazing season and utilizing the surplus growth for carrying thin feeder cattle during the late fall. This

method of grazing would produce beef animals with a high finish, and the gains per acre would probably be nearly equal to those obtained from heavy grazing. Gains during the 1933 season are shown graphically in figure 14.

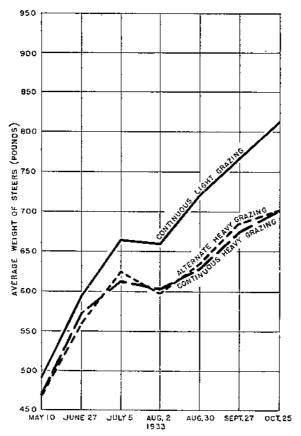


FIGURE 14.—Average weights of steers by 28-day periods during the grazing season of 1933.

RESULTS IN 1934

In 1934, good gains were made until the last of July, when the early summer rainfall deficiency so reduced the pasture growth on the heavily grazed pastures that the steers lost over a pound per head per day during August. During this same period the steers on the lightly grazed pasture gained 0.7 pound per head per day. Groups 2 and 3 continued to show slight losses until the middle of September. The group on the alternately grazed pastures failed to make any greater gains than the group on the continuously grazed pasture of the same size as the two alternately grazed pastures. The average gains of the steers in the various groups are shown in table 7. The gains are shown graphically in figure 15.

Pasture A-1 again had surplus growth remaining at the end of the regular grazing season, and the 13 steers that had been used in the experiment were all placed in this pasture for a period of 28 days. During this time there was a total gain of 182 pounds, or slightly over 25 pounds per acre.

AVERAGE GAINS FOR PERIOD 1929-34

The average gain per steer for the 6 years was greatest for those on the pasture lightly grazed. There is no significant difference in the average gains from the two heavily grazed pastures, one continuously and the other alternately grazed at the same rate per acre.

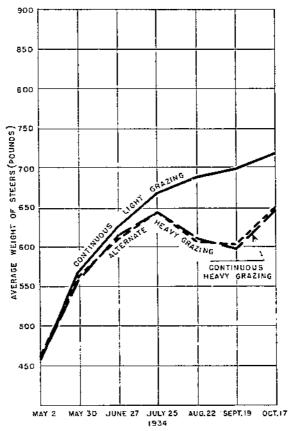


FIGURE 15.-- Average weights of steers by 28-day periods during the grazing season of 1034,

The gain per acre was greatest for the cattle on the heavily grazed pastures, being almost identical for the cattle on the two pastures, while for those on the lightly grazed pastures it was much less.

The average gains for the various groups of steers over the 6 years

are shown in table 7.

During the first 56 days all three groups of cattle made satisfactory gains. From that period on to the close of the grazing season the steers on the alternately and heavily grazed pasture and on the con-

tinuously and heavily grazed pasture made very small gains and finished the season at practically that same weight level. On the lightly grazed pasture the steers continued to gain until the last 28-day period, when their weight remained stationary. The average gains during each 28-day period are shown graphically in figure 16 for the 6 years of the experiment.

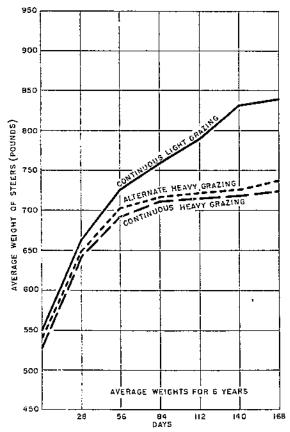


FIGURE 16.+ A verage weights of steers at 28-day intervals during the period of the experiment of 1929-34.

ESTIMATED QUANTITY OF DRY MATTER CONSUMED BY THE STEERS

In calculating the quantities of dry matter consumed by the steers grazed according to the different systems of grazing included in this experiment, certain assumptions are necessary. On the assumption that similar rates of gain are associated with similar rates of intake, use was made of the data on dry matter consumed by the various groups of steers in a Missouri feeding experiment.⁴

Estimates of the quantity of grass eaten were made on the basis of the 6-year averages of the weights taken at 28-day intervals as compared with similar rates of growth of the Missouri cattle. With the

^{*} Moulton, C. R., Trowbridge, P. F., and Haigh, L. D. Studies in animal nutrition. 1. Changes in form and weight on different planes of nutrition. Mo. Agr. Expl. Sig. Research Bull. 43, 111 pp., illus. 1921.

exception of the latter part of the first 56 days of this experiment, approximately similar rates of growth were shown in the Missouri data. During this period the pasture-fed steers grew somewhat faster than the full-fed Missouri steers.

The weight curves of all groups during the first 56 days were practically the same. During the succeeding 112 days (the fifty-seventh to the one hundred and sixty-eighth day), the animals of groups 2 and 3 made small gains, whereas those of group I continued to grow

at a satisfactory rate except during the last 28-day period.

The feed consumption of each group during the first 56 days was computed from the feed consumed by group 1 of the Missouri cattle. Since this was a period of increasing feed consumption, averages of 10-day periods were taken. The lower limit of weight in each case was the average weight of the steers when they were turned on the

pasture paddocks.

For the remaining 112 days the quantity of grass consumed by group 1 was arbitrarily assumed to represent the same feed value as the dry matter consumed by the half-fed cattle of group 2 of the Missouri experiment, since both these groups made approximately the same rate of growth. Since the dry-matter consumption in the Missouri experiment was practically constant during this period, the average feed consumed (10.56 pounds of dry matter per animal per day) was used instead of the dry matter consumed in the 10-day averages, on which was based the feed consumption during the first 56 days.

For groups 2 and 3 the average dry matter (7.76 pounds of dry matter per animal per day) consumed by group 3 of the Missouri

experiment (maintenance) was used.

The consumption of dry matter in round numbers was accordingly calculated as given in table 8.

Table 8.—Calculated consumption of dry matter by steers in Beltsville experiments

]	Dry 1	untter cons	umed		
Group no.	Animals	Area in paddoek	First fifty-six days	Fifty- seventh to one hundred and sixty- eighth day	Total	Dry matter con- sumed per acre	Dry metter con- sumed per animal
1 3	Number 4 5 4	Acres 8 5 4	Pounds 3, 000 3, 900 3, 000	Pounds 4, 700 4, 300 3, 500	Pounds 7, 700 8, 200 6, 500	Pounds 962 1, 640 1, 625	Pounds 1, 925 1, 640 1, 625

Results during the first 56 days are low, probably for two reasons:
(1) The rate of gain in the latter part of the grazing period was slightly higher than that of the Missouri cattle, and (2) the Missouri cattle received dry feed. The hay probably had a greater crude-fiber content than the grass. The results of the estimates indicate that the animals in groups 2 and 3 ate essentially the same amounts of grass and that they consumed all the feed available.

The animals in group 1, on the other hand, with a larger area per animal in which to graze, consumed more grass and did not graze the

pasture to the maximum extent.

Comparison of the dry matter consumed per acre would indicate that about 40 percent of the grass produced remained in pasture A-1. This statement is subject to modification in that as the grass became scarce in the summer the animals grazed the pasture more closely than they did earlier in the year and undoubtedly used the reserve that had accumulated.

As the Missouri steers (high-grade Herefords) were similar in breeding and weight and made about the same gains as those used in this experiment, it may be assumed that practically the same quantities of dry matter were consumed. While there may be a difference in the quality of the dry matter in the grass used by the Beltsville steers and that of the grain mixture and alfalia hay used by the Missouri cattle, the gains produced by a given quantity of dry matter from each source would probably show but little variation.

SUMMARY AND CONCLUSIONS

Different rates and methods of grazing have a pronounced effect on the plant population. Canada bluegrass, timothy, orchard grass, and lespedeza predominate under light continuous grazing; Kentucky bluegrass and white Dutch clover predominate under heavy continuous grazing.

Over one-half the total herbage was produced during the first onethird of the regular grazing season, as determined by harvesting the

growth from protected areas.

In a test of different rates of grazing, the grass in the lightly grazed pasture will not be entirely consumed by the animals. Under such conditions the gains made by the animals are not likely to be correlated with the yields obtained by mowing or plucking the grass.

The average ratio of calcium to phosphorus in the harvested herbage was approximately 2:1, which is recognized as a satisfactory

ratio.

The protein content of the herbage averaged 13.67 percent for 2 years for all pastures, indicating a ration sufficiently rich in protein

for beef animals.

Under conditions of the experiment, no significant differences were observed in the gains made by steers on pastures grazed heavily and alternately, and on pastures grazed heavily and continuously, at the rate of one head per acre over the 6-year period. The 6-year average gain per steer on the continuously and heavily grazed pastures at the rate of one steer per acre was 196 pounds, as compared with 194 pounds for those on pastures alternately and heavily grazed. Steers on the continuously and lightly grazed pasture, stocked at the rate of one animal to 2 acres, made an average gain of 287 pounds per steer, as compared with an average of 195 pounds for the steers on the pastures heavily grazed. The steers that gained the additional 92 pounds each were considerably better finished; they had grazed at the rate of 2 acres per head.

Average gain per acre for the 6-year period was 145 pounds for the lightly grazed pasture, 196 pounds for the continuous heavy grazing,

and 194 pounds for the alternate heavy grazing.

Surplus forage, which remains at the end of the regular grazing period when pastures are not closely grazed, can be used advantageously by thin feeder cattle in the late fall and early winter.

If the animals are to make satisfactory gains when heavy grazing is practiced, some provision must be made for supplemental feed or pasture during late summer when plant growth is retarded by hot,

dry weather.

During 1933 and 1934, when the lightly grazed pasture was grazed after the close of the regular season, an additional average gain of 43 pounds per acre was obtained. This, added to the gains per acre obtained during the regular grazing season, made an average total gain per acre of 188 pounds, as compared with 211 pounds, the average for the heavily grazed pastures during the same years.

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