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GRAZING INVESTIGATIONS ON THE NORTHERN GREAT PLAINS

AGRICULTURAL EXPERIMENT STATION
NORTH DAKOTA AGRICULTURAL COLLEGE
FARGO, NORTH DAKOTA

IN COOPERATION WITH THE

UNITED STATES DEPARTMENT OF AGRICULTURE
NORTHERN GREAT PLAINS FIELD STATION
MANDAN, NORTH DAKOTA

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FOREWORD

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Chilcott's faith in the Northern Plains is well summed up in a portion of a sentence from his U. S. Misc. Circ. No. 81, Supplement 1, in which he wrote: **"There is no region of comparable size in the 17 Western States that is as well suited to the production of as good quality of grass-fed beef as is found in Western North Dakota and South Dakota and Eastern Montana and Wyoming."**

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To Johnson Thatcher Sarvis, Associate Agronomist, Division of Dry Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture, author of this bulletin and a modest son of the Plains himself, now retired after nearly 30 years of faithful service, goes the gratitude of his co-workers, past and present, for bringing to fruition this 25-year study on the value and use of grass by beef cattle.

H. L. WALSTER, Director
North Dakota Agricultural Experiment Station

GRAZING INVESTIGATIONS ON THE NORTHERN GREAT PLAINS

By J. T. SARVIS, Associate Agronomist, Division of Dry Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture, in cooperation with the Department of Animal Husbandry, North Dakota Agricultural Experiment Station.[1]

Value and Use of Grass

THE rapid settlement of western North Dakota took place shortly after 1900. Livestock grazing over its prairies was an old industry before these "boom days", as cattle raising is one of the oldest industries of the white man. The legend of the "Great American Desert" persisted for many years before it was recognized as a natural cattle country. This realization developed through the fact that vast herds of buffaloes roamed at will across what was later designated as the "Great Plains". They drifted to the northern Plains for their summer range and grew fat on the "buffalo grass" not yet desecrated by the plow. With the ultimate slaughter of the buffaloes, Longhorns were eventually trailed from the southwest to the grass covered northern Plains. The normal lifetime of a man has elapsed since the Longhorns, that have been replaced by the uniform herds of the present day, first set hoof in this part of the Plains.

With the advent of the settlers, many thousands of acres of native sod were broken up and turned into cultivated land for the production of flax and wheat. It would eventually have been vastly better for the country and range livestock production, if much of the plowed land had remained in its primitive state. The native range provided excellent feed for grazing animals, but much of it was unfit for "dryland farming" because of its location, physical composition, or topography. The native grasses with their tenacious roots held the soil firmly against the active elements of wind and rain. With the loss of this anchorage, whole areas have locally become a desolate waste, and much of the damage has taken place within the past 10 years. A great deal of effort has been exerted to bring some of this cultivated and "waste land" back to grass. It is a long and slow process, and in the end it will be only an imitation of the old range.

The "back to grass" movement brings up the fear that too much grass will be produced. More grass can be used without an undue increase in the number of livestock. If given the opportunity, the present number of livestock would consume with benefit vastly more grass as pasture and hay. In many areas where winter grazing is practiced because of unavailable forage, many would turn to winter feeding if forage became abundant and readily attainable. It was pointed out a number of years

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ago that "hay is of greater relative importance to cattle production than grain, since sufficient roughage is essential for best results in wintering cattle" (*40*)[2]. Grass is one crop that can be readily stored in stacks and kept in good condition for many years, and used when most needed. What would a carry-over of hay have meant to farmers and ranchers in the northern Plains during 1933, 1934, and 1936? The intrinsic value of grass is greatly underestimated. Vastly more has been lost by not producing and preserving sufficient grass than by producing too much. It is not unusual to see an article in some newspaper, to the effect that the early fall snowfall covered much of the grass and grazing ground and that the demand for feed has increased so that the price of hay is now three to four times what it was in the fall. The production of more feed and better feeding would insure a more uniform number of livestock over a series of years, by reducing the losses and urgent disposal of stock because of feed shortage.

Native ranges were given little attention or consideration during the days of the cattle kingdom. Promiscuous grazing was the universal practice. The introduction of barbed wire into the Great Plains shortly after its invention about 1875, doomed the open range, and gradually the raising and pasturing of cattle was modified. The Great Plains has been termed the "pasture region" (*17*) because so much of the grazing land is under fence. It was not until some time after 1900 that range management investigations were given thoughtful and serious consideration as a part of the agriculture of the Great Plains. In the 1940 Yearbook of Agriculture (5) this statement appears:

> "The growing of livestock on the range, their production on fenced pastures, and crop production are merely different phases of agriculture. Croplands now produce 35 percent of the feed for livestock in the range territory; the balance still comes from range land. On much of the range, livestock production would be very difficult and precarious if crops did not furnish the feed needed to carry the livestock through the winter. Range and ranch are now inseparable. Western agriculture, a 13-billion-dollar enterprise, is in large part a complex of interdependent crop farming and grazing of range land."

The last five years have seen more attention directed to the improvement and care of pastures or ranges than during the previous history of the range. The production and care of grass has become a major factor in dryland agriculture, and more sincere interest is now taken in its development, culture, and use than previous to the desolating droughts accompanied by the inevitable dust storms. As a consequence, the desire and demand for information relating to grasses, pastures, and grazing problems have increased many fold during the last 5 to 10 years. Extensive grass investigations were well under way shortly before and after 1900. These investigations were not the first in this country for as early as 1869 the United States Department of Agri-

[2] Italic numbers in parenthesis refer to Literature Cited, p. 107.

culture reported upon grass trials that had been conducted on its grounds. When the slogan "rain follows the plow" became prevalent soon thereafter, practically all the grass work was dropped, particularly that with native species. If these investigations had continued, many of the recent urgent problems might have been avoided or more readily solved. More extensive and universal grass investigations have again been inaugurated, starting 5 or 6 years ago in the northern Plains. The demand in the "boom days" was to break up the prairie sod and put it into flax and wheat. The recent demand was just as urgent to develop methods to put the same land back to grass, to control and prevent water and wind erosion. A grassland agriculture especially adapted to the Great Plains may eventually develop.

In 1913, the United States Department of Agriculture, Bureau of Plant Industry, Division of Dry Land Agriculture, established the Northern Great Plains Field Station at Mandan, North Dakota. Members of the staff of the North Dakota Agricultural Experiment Station, Prof. J. H. Shepperd, in particular, had long been interested in the production of beef cattle on the ranges of western North Dakota. With the establishment of the field station at Mandan, arrangements were made between the United States Department of Agriculture and the North Dakota Agricultural Experiment Station, mainly through the efforts of Prof. Shepperd, to conduct a grazing experiment on native range at the Mandan station. The experiment was started with preliminary work in 1915 and is known as "The Cooperative Grazing Experiment".

In an article published in 1919 (26), Prof. J. H. Shepperd, then Vice Director of the State Experiment Station, stated:

> "For many years the writer has believed that a large area of land in the western half of North Dakota should be kept in native prairie sod for pasturing livestock and has held that it will produce vastly more return in that way than can be obtained from the same land if plowed and cropped.
>
> "The 1908 report of the field operations of the Bureau of Soils of the United States Department of Agriculture, covering a survey of the portion of North Dakota lying west of the hundredth meridian, confirms this view and in its statement lists 6,645 square miles of land which I interpret from their description is adapted only for grazing. The land west of the hundredth meridian in North Dakota constitutes about three-fifths of the area of the State. The rough or grazing land constitutes about 17 percent of the area, and is equivalent to 184 townships of land.
>
> "In 1913 an active campaign on the part of the writer resulted in an arrangement for a trial to determine the carrying capacity of a native range pasture of wild grasses to be conducted cooperatively by the North Dakota Agricultural Experiment Station and the United States Department of Agriculture on the Northern Great Plains Field Station at Mandan, N. Dak."

The present publication presents the results of 25 years of these grazing investigations, covering the period from 1916 to 1940, inclusive. It shows the effects of different intensities and

methods of grazing upon the native vegetation, and their influence upon the gains and condition of the cattle used as the unit of measure. The use and value of pastures utilizing adapted domesticated grasses and legumes were not neglected and are included. Since livestock are dependent upon vegetation as their source of feed while grazing, it is essential that a sufficient quantity of forage be provided for that purpose. This is true not only for one season but must cover a period of years, if the range livestock industry is to thrive and continue. How well range or pasture meets these requirements is best determined by the livestock themselves. They furnish the best and most reliable measure by which a range, pasture, or system of grazing must finally qualify in order to be permanently adopted. Unless a range continues to provide sufficient forage, it does not meet the requirements of good range management, the necessities of the livestock, and the needs of the rancher.

Soil and Topography of the Pastures

The land where the pastures are located is about 3.5 miles south of Mandan along State Highway No. 6. It is part of the area locally known as the Custer Flats. The altitude is approximately 200 feet higher than the field station, or nearly 1,950 feet above sea level. Originally it was a school section, and for a number of years previous to 1915 it had been used for the production of native hay. It was in excellent condition for grazing when acquired in trade for other Government land by the United States Department of Agriculture. The density of the vegetation was high. The experiment was therefore started on a range in a high state of production. The problem was to determine the best method of utilizing a good stand of forage. In order to study the effects of overgrazing it was necessary first to reduce or deplete the existing vegetation.

The soil in the section used for the various pastures does not differ greatly from land throughout the region. Compared to some localities the soil is lighter in texture while with others it is heavier. The soil is a medium heavy, silty clay loam. It contains nearly 20 percent of clay in the surface foot and over 50 percent of silt. It is underlaid in most cases by a clay subsoil. The pasture soil has been more fully described in other publications (*9*, *24*, *31*, *33*). The soil is well adapted for the production of vegetation, which does not differ greatly in kind over a large part of this region of the northern Plains. Moisture can readily penetrate into the soil and is well retained for the use of growing vegetation.

The 640-acre section is mostly level prairie with the exception of approximately 100 acres in the northwest corner which is rolling and cut by ravines. The nature of a large part of the country is rolling to sharply rolling. The aerial view, Figure 1, shows the contour of the land, and the drainage through the northwest

part of the section. One of the dams shown in Figure 1 was constructed in the fall of 1923 to conserve water and furnish a supply for the reserve steers. Since that time three more dams have been constructed along the same coulee. One of them is shown near the north fence line in Figure 1. The sharply rolling to rough and hilly land shown in this part of the section is considered more desirable for grazing than is the more level to gently rolling land in the rest of the section, most of which would be well-adapted for the production of cultivated crops. The location of the main pastures are considered excellent for a grazing ex-

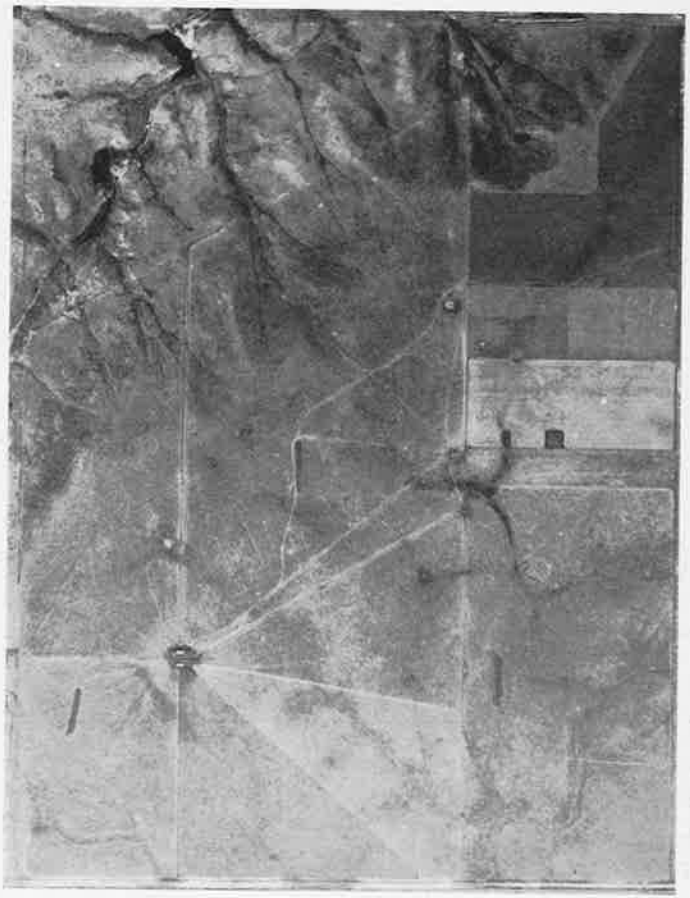

Figure 1.—Aerial view of the pastures of "The Cooperative Grazing Experiment".

The fence lines, contour of the land, drainage along the coulee (two dams show along it) to the north, isolation transects, pastures centering at corrals, cultivated pastures, mowing experiment, and small reserve pasture are all shown, (see figure 2). Division A of the rotation pasture was grazed in the spring, B in the summer, and C in the fall. The light colored field in the cultivated pastures, was fallowed. The two small dark areas within it, were small grass nurseries. Photographed August 16, 1938. (Film for reproduction furnished by the Agricultural Adjustment Administration, Western Division Laboratory, Salt Lake City, Utah.)

periment of the nature of the one under discussion. The vegetation and its density were so uniform that any differences obtained as a result of grazing would be attributed to the effects of pasturing and not to differences in the kind and density of the forage. The amount of land required for grazing varies in different parts of the northern Plains region. In some parts the density of the vegetation normally differs, and in others the intensity of grazing, especially during recent years, has reduced the amount of forage available for grazing. It is believed the results recorded in this publication, will apply with modifications, to most of western North Dakota, across into South Dakota, and to adjoining parts of Wyoming and Montana. The effects of grazing upon vegetation will apply to a much wider region.

Major changes or depletion of the vegetation take place slowly in this portion of the region. In some other parts of it, pronounced reduction may occur within 1 or 2 years of severe overgrazing or major droughts such as those that obtained in 1934 and 1936. The nature of the soil in some localities is such that severe disturbing factors influence the production of vegetation suddenly and sharply. This is true in areas of the so-called "hard or tight" soils. Recovery under favorable conditions is also usually rapid, but takes place at a lesser acceleration.

Climatic Factors Affecting Range and Livestock

Climatic conditions prevailing in this section are typical of the northern Great Plains. They are intimately associated with vegetative production and the livestock that are dependent upon it. Temperatures, especially those of winter, exert an influence on the livestock. Good range, either seasonal or yearlong, is the result of the various climatic factors and the kind of vegetation developed through their influence. Because of the peculiar climatic conditions of the northern Great Plains Region, native grasses "cure on the stem", and are not killed by frost, as are those under higher moisture conditions. They therefore do not readily lose their nutritive elements, but continue in excellent condition for grazing into late fall or throughout the winter. Stockmen generally do not like to see falls that are favorable to continued growth of grass, so that it does not cure properly before winter. Its nutritive value under such conditions is considered inferior to that normally cured. Blue grama and buffalo grass usually cure at about their normal time regardless of conditions favorable for continued growth.

Climatic data for this vicinity are available covering a period of 66 years. The United States Weather Bureau of the Department of Commerce has a station located at Bismarck, North Dakota, on the east side of the Missouri River, about 5 miles from Mandan. The records date back to 1875. Meteorological observations were begun at the Mandan field station in August 1913 and have been continuous since that time. The data discussed

here cover the 25 years 1916-40, except such as are incidental to a clearer understanding of the production of forage during the years before the grazing experiment began.

Temperatures, especially extremes of heat and cold, exert a pronounced influence upon the production of forage and the comfort of livestock. The highest temperature recorded during the 25 years under consideration was 115° F. in July 1936, and the lowest was -46° in February 1936. These were also the extremes of record for this locality. The lowest monthly mean temperature, 8°, normally occurs in January, and the highest, 72°, in July. The average annual mean was 41°. The longest cold spell during the 25 years was in January and February 1936.

The frost-free period at the field station averages 138 days, extending from May 10 to September 25. The range has been from 165 days in 1922 to 119 days in 1940.

The wind movement, especially that close to the surface of the ground, is another important factor bearing upon forage production. Hot winds in summer may burn the vegetation in a short time so that only parched feed is left for grazing. High, cold winds in fall may keep stock from grazing normally. The average wind velocity, as measured by an anemometer 2 feet above the ground, for the 25 years 1916-40 was 6.1 miles per hour. April and May are the months of highest wind velocity and July and August the lowest. The highest velocity attained for any 24-hour period during the 25 years was 27.9 miles per hour from the northwest in June 1937. Soil blowing has taken place to a serious extent in some cultivated fields, but none in the pastures of the grazing experiment where the soil was protected by native vegetation.

The evaporation from a free water surface during the warm season from April to September ranged from over 29 inches in 1927 to over 40 inches in 1936, with an average of approximately 35 inches. The highest monthly average occurs in July and the lowest in April. A season of high rainfall generally is associated with one of low evaporation.

Forage production for a given season may be governed by one or many climatic factors. Some winters may be long and cold, with the prairies covered by a mantle of snow to a depth of several feet. Other winters may be mild throughout, with the prairies remaining practically free from snow, so that livestock can graze without difficulty, such as that of 1940-41. Some summers, such as 1936, may be hot and dry, with moisture so scant that all vegetation is stunted throughout the growing season. Some years the rainfall is so abundant that the native vegetation grows luxuriantly from early spring throughout the season.

While all climatic factors are important to the production of livestock, precipitation is most essential. Livestock can be pro-

tected against the cold of winter and the heat of summer, but if rainfall fails, the fact is soon apparent in a shortage of feed and water, and disaster follows. This fact was evidenced by the droughts of 1934 and 1936.

Of all the climatic factors that affect the production of forage for grazing livestock, rainfall exerts the most pronounced influence, in the northern Plains. The relation of precipitation to the production of native forage is not entirely the same as it is for the production of the common farm crops. In a detailed study of the moisture determinations made on sod at the pastures, Cole and Mathews (*9*) stated:

> "On the other hand, the longer growing season of the sod plants and the deeper rooting systems of some of the plants present in sod contribute to a more complete exhaustion of water on sod than on cropped land."

The native vegetation exhausts the soil moisture more completely than wheat, because the many kinds of plants have different root systems, forming different layers below the ground. Some grasses, such as blue grama, have an extensive root system near the surface of the soil. Other grasses and plants have roots extending from 2 to 6 feet into the soil, and roots of some plants commonly penetrate 8 to 10 feet, while others may go much deeper. The layering below ground of roots of prairie vegetation has been studied particularly in Nebraska, and discussed in a special publication (*29*). Early season precipitation April, May, and June (especially the first half) exerts a greater influence on the production of native grasses than it does on such crops as wheat. Spring wheat for example, is sown at a definite period and harvested when mature. The growing period is shorter than for native vegetation, and when harvested its use of moisture is ended for the season. A gain in soil moisture under these conditions usually takes place before the next spring. Grain stubble holds snow, and corn ground usually stops some snow besides carrying some reserve moisture. The native vegetation starts its growth in early spring, usually before wheat is seeded. Some species of native plants are mature by the time the growth of wheat is nicely started. Native vegetation generally covers a longer growing period than does wheat. Its drain on soil moisture therefore is more extensive. The need of early spring moisture is more urgent and necessary for native vegetation than it is for spring wheat, because of its early seasonal growth. It is natural that abnormal seasonal conditions should occasion marked exceptions to this general guide. Yields of native hay in a mowing experiment are available for the period from 1921 to 1933 along with yields of spring wheat for the same years. The coorelation between April-June precipitation and the annual production of native forage for the 13 years is significant. In 1924 low precipitation in April and May was followed by a heavy June rainfall, and the yield of native forage was the highest for the years considered. Native vegetation started its growth later than usual in

the spring, and the growing season was rather cool. In 1925 the April-May precipitation was practically the same as in 1924, but the yield of native forage was much below normal, even though the following June rainfall was higher than in 1924. The spring growth of native vegetation in 1925 started very early. The rainfall in April and May may mean a good crop of native forage, but unless later rains come, small grains may be a failure. A light production of native forage may accompany a good crop of small grain. A normal rainfall during April and May practically insures a good growth of the native grasses, whereas a heavy rainfall will usually result in abundant production. This has been well illustrated during a number of years, but especially so in 1935, when precipitation for April and May was one of the highest of record over much of the northern Plains. The influence of early precipitation will carry through the season, even though the following months are below normal in amount. If the precipitation is low during the early season, the production of forage will generally be greatly reduced or a near failure, even though rainfall later in the season is above normal. Under the same conditions the production of wheat may be normal or above. In 1921 with a high rainfall for April and May, the production of native hay was practically normal, while the wheat crop was one of the lowest of record, because of a light June rainfall. In 1927 with the highest rainfall of record for April and May and good rainfall following, both hay and wheat were much above normal in yield. The following year the April-May precipitation was one of the lowest of record, but the June rainfall was high. The yield of hay was below normal and that of wheat much above average. The correlation between precipitation and yields of spring wheat have been discussed in a recent publication (*8*) by the Division of Dry Land Agriculture. It is possible to know with a marked degree of assurance sometime in advance if range stock can be carried the full season, or if they will need to go to market before the normal time.

The precipitation for the 25 years the grazing experiment has been in operation is shown in Table 1. The amounts for the years 1914 and 1915 are also shown but are not included in any averages. The high precipitation for those years is presented in order to show the very favorable conditions that existed immediately preceding the start of the grazing experiment. A more detailed account of precipitation in relation to crop production was given in recent bulletins of the Division of Dry Land Agriculture (*24, 33*). While a large percentage of the rains fall in quantities of less than half an inch during a 24-hour period and may be of minor benefit to crops, such amounts may be of benefit to some of the grasses, such as blue grama.

The long-time average of precipitation for this vicinity has been 16.40 inches for the 66 years of record. The average when the station started was 17.41 inches. Since the grazing experiment started in 1916, the average for the 25 years has been 14.47 inches.

Table 1.—Monthly, seasonal, and annual precipitation at the Northern Great Plains Field Station for the period 1914-40

(Data in inches. T=Trace)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonal Apr.-Sept.	Annual
1914	0.07	0.05	1.89	1.55	3.57	10.68	1.35	1.89	1.24	0.90	0.31	0.37	20.28	23.87
1915	.07	T	.30	1.11	4.98	6.32	6.48	.63	1.84	1.85	.34	.14	21.36	24.06
1916	.28	.09	1.88	.93	1.69	2.25	3.55	2.04	.92	.27	.07	1.10	11.38	15.07
1917	.28	.19	.35	1.87	.35	2.56	1.58	.89	1.97	.05	.03	.19	9.22	10.31
1918	.20	.11	.45	2.61	2.45	.68	2.47	2.03	.63	.27	.45	1.02	10.87	13.37
1919	.08	.80	.83	1.72	3.95	1.12	.85	1.22	.49	.98	1.19	.25	9.35	13.48
1920	.52	.20	1.21	.58	1.72	1.85	2.68	1.81	1.29	.25	.37	.21	9.93	12.69
1921	.18	.09	.79	2.59	3.05	.82	3.38	.25	1.58	1.39	.87	.24	11.67	15.23
1922	.28	1.55	.52	.66	2.05	3.43	3.17	.32	2.31	.64	1.60	.82	11.94	17.35
1923	.36	.38	.16	1.85	1.18	1.94	4.12	1.15	2.31	.54	.28	.14	12.55	14.41
1924	.03	.25	.28	1.68	.41	5.56	2.07	2.35	1.34	1.94	.06	.28	13.41	16.25
1925	.28	.03	.44	.94	1.18	7.34	.33	1.31	.99	.69	.15	.38	12.09	14.06
1926	.71	.22	.04	.13	2.41	1.20	2.19	1.31	2.38	.18	.30	.44	9.62	11.51
1927	.18	.14	1.17	1.37	6.65	2.00	2.37	3.16	.49	.44	1.56	.77	16.04	20.30
1928	.20	.07	.23	.99	.55	6.32	4.94	2.24	.89	.19	.06	.17	15.93	16.85
1929	.80	.31	1.47	1.75	2.68	.99	1.20	.81	1.56	1.81	.14	.70	8.99	14.22
1930	.19	1.68	T	1.71	2.23	1.50	2.40	2.00	2.56	1.85	1.13	.13	12.40	17.38
1931	.05	.44	1.62	.43	2.14	1.65	4.32	1.01	3.11	1.46	.47	.74	12.66	17.44
1932	.44	.19	1.00	1.99	3.48	3.33	1.90	.70	.24	2.12	.19	.18	11.64	15.76
1933	1.23	.34	1.02	.86	1.83	2.18	1.80	.41	.27	.55	.90	.52	7.35	11.91
1934	.06	.05	.58	.63	.17	3.78	1.10	.25	.47	.73	.17	.14	6.40	8.13
1935	.13	.36	1.13	3.09	2.63	2.85	4.71	1.34	.22	T	.96	.88	14.84	18.30
1936	.61	.72	1.12	.48	.04	.43	0	.55	1.46	.17	.61	.24	2.96	6.43
1937	.86	.49	.48	1.38	1.29	5.65	1.83	1.34	1.37	.43	.34	.63	12.86	16.09
1938	.54	1.06	.64	.97	2.42	3.11	2.90	.72	1.25	.21	1.04	.18	11.37	15.04
1939	.67	.62	.44	.74	1.93	4.65	1.69	2.19	.17	.54	T	.31	11.37	13.95
1940	.45	.03	.93	4.24	1.20	1.95	2.73	.25	1.28	1.69	.98	.41	11.65	16.14
Average:														
1916-35	.32	.37	.76	1.42	2.14	2.67	2.56	1.33	1.30	.82	.55	.47	11.41	14.70
1916-40	.38	.42	.75	1.45	1.99	2.77	2.41	1.27	1.26	.78	.56	.44	11.14	14.47
1936-40	.63	.58	.72	1.56	1.38	3.16	1.83	1.01	1.11	.61	.59	.35	10.04	13.53

The 5-year period, 1916-20, was one of the lowest of record with an average of 12.98 inches. This was only 0.54 inch above the average of the 5 driest years that can be selected during the previous long-time record. The 5 years 1936-40 averaged only slightly above those of 1916-20 or 13.53 inches. The 5 driest years during the 25-year period 1916-40 averaged only 9.66 inches, and 4 of the driest years of record occurred during this period. The severe drought frequently mentioned in this publication refers in particular to the years of 1934 and 1936, when the precipitation was the lowest during the 66 years of record available for this district. The very small amount of rainfall during the season of 1936, shows clearly why practically no vegetative growth took place.

The quantity of precipitation during the winter months is normally so small that it is of minor importance. The winter precipitation averages less than 10 percent of the annual total. The snowfall for the year averages approximately 30 inches, and during years of favorable amounts, it exerts a marked influence on the production of forage for the following season. This is especially true in affording moisture for starting the grasses in the spring. A pasture that is grazed near the normal amount for the season is benefitted by the annual snowfall. The vegetation remaining standing will catch and hold snow. A pasture that is closely grazed usually remains bare during the winter, as there is nothing to hinder the snow from blowing away.

Rainfall records were recorded at the pasture for the months of May to September, starting in 1921. Some seasons there were marked differences between the monthly and seasonal amounts at the pasture and the field station. In 1939 for example, the precipitation was 13.00 inches at the pasture and 10.63 inches at the field station. The averages for the 21 years were 9.92 inches for the 5 months at the pasture and 9.93 inches at the field station.

In 1931 wind velocity records were started at the pasture. The averages for the 10 years were 6.7 miles per hour at the pasture for the 5 months, and 5.7 miles per hour at the field station. The extreme average difference between months was 1.3 miles per hour for May. The pasture is approximately 200 feet higher than the station, and the anemometer is located on the open prairie.

The precipitation during the year is sometimes so deficient or the individual quantities are so small, that no system or rate of grazing can surmount the resulting drought, so as to avoid a shortage of forage for grazing. During other years, the proper rate of grazing may carry the stock through the season without serious loss in weight. A season of heavy rainfall will usually produce a heavy crop of forage and will afford a carryover for future use.

Density and Composition of the Native Vegetation

When the experiment was started a number of different methods were employed in a study of the composition and density of the native vegetation. Liberal use was made of square meter list quadrats. These were staked so they could be used as permanent recording stations over a series of years. The same ones are still in use. Temporary list quadrats were also employed. These were simply listings of different species of the vegetation within the meter frame that was dropped at random as the operator walked across the pastures. Counts, measurements, and estimates were all made by use of the meter quadrat. The temporary ones were found to be of most value as a means of making a quick determination of vegetative conditions. They were employed occasionally as means of a check in connection with the permanently located quadrats, and to increase the number of estimates. Duplicate determinations were made at the site of each quadrat. Originally there were 40 permanent quadrats located in each pasture. These radiated from a square base of 16 quadrats, one of which was charted, and where photographs were annually taken. Maps of certain quadrats were made during the early days of the experiment. The conclusion was, however, soon reached that they were of minor value, except as an original record, unless a number of them could be made in each pasture. The density of the vegetation was such that the time required precluded the undertaking. It was thought that a large number of less refined determinations were more desirable than a few of questionable value.

Extensive use was made of clipped quadrats as a means of determining composition in connection with production and elimination of species. It should be remembered that when this experiment started, few of the methods taken for granted today were in use. A crude form of pantograph was used here as early as 1917 or 1918, but it was not entirely successful. It is recognized that the later use of the chartographs now available would have been highly desirable, especially if the number of mapped quadrats could have been large enough to be of most value. Equipment and assistance, however, were not available to do the work. Use has not yet been made of the modified line-transect method of determination, except in a limited way. This method should be highly desirable under the conditions that obtain here. The use of this method would likely show a somewhat lesser density than the determinations that have been made. It would then be necessary to reduce the forage acre requirement, but the grazing capacity would remain unchanged. It is recognized that a large number of determinations is also important with the employment of this method. The methods used were those that could be carried on over a wide area in a short time with a minimum of assistance.

The density of the vegetation when the experiment started, as reported in earlier publications (*22*, *23*), was approximately 60

Figure 2.—View of native vegetation before grazing started, in what later became the 30-acre pasture.

The white plants are *Psoralea argophylla*. Those with dark centers are *Echinacea angustifolia*. *Artemisia frigida* is nearly obscured by grass, but appears in the left foreground. The tall grass is *Stipa comata*. July 28, 1915.

percent. The section of land had not been severely grazed for a number of years before this time, but was used for the production of prairie hay. This density may seem high, but it should be recalled that both 1914 and 1915 were years of high rainfall as shown in Table 1. All vegetation had made an abnormal growth and development, so the density was greater at that time than it was a few years later and to date, and likely had been for some time in the past. The heavy growth produced in 1915 is shown in Figure 2. In the beginning of the experiment, the vegetation was highly uniform over the pastures, with the exception of minor variations due to soil and exposure. This fact was highly desirable and important in starting an experiment of this nature.

The density or "basal cover" of the native vegetation in the pastures at the present time ranges from approximately 40 to 50 percent. The term basal cover as here used, means the extent of ground surface actually covered by plants after the foliage has been removed by grazing or clipping (figure 3). Foliage cover is the vegetation above the ground, and is well illustrated in Figure 4. These points were discussed in an early publication in connection with this experiment (*22*). The low point in density for all

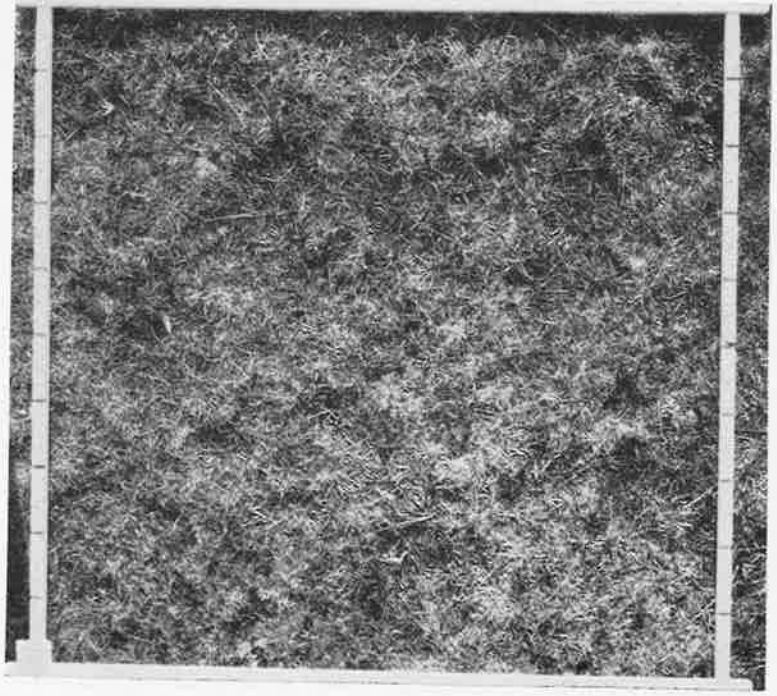

Figure 3.—Closely grazed quadrat in the 30-acre pasture.

View from above to show basal cover and density, which was estimated at approximately 60 percent. *Bouteloua gracilis* makes up much of the cover, but many other species occur. Compare with Figures 2 and 4. October 10, 1916.

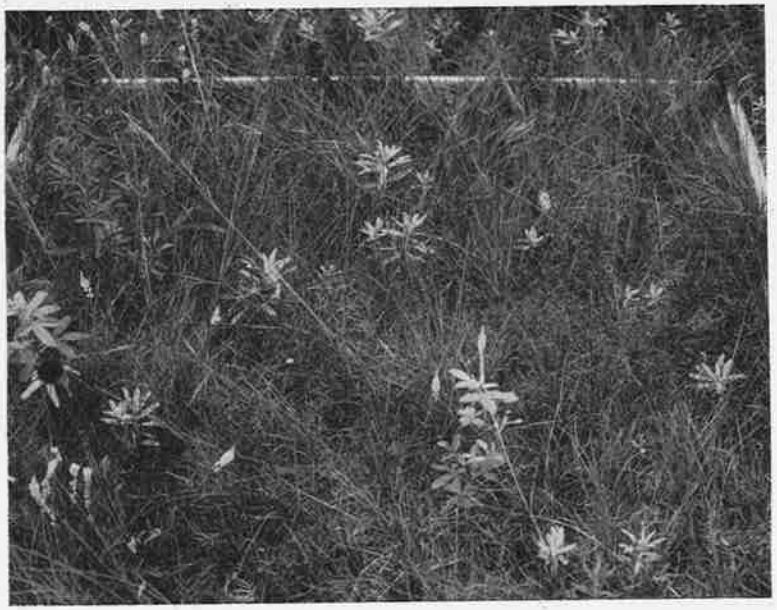

Figure 4.—Close view of native vegetation (foliage cover) before grazing started, in what later became the 100-acre pasture.

Part of the white plants are *Psoralea argophylla* and part *Artemisia gnaphalodes*. The one with the dark center is *Echinacea angustifolia*. The tall grass is *Stipa comata*. The short curly grass is *Bouteloua gracilis*. July 28, 1915.

Figure 5.—Close view of quadrat in the 30-acre pasture.

Practically no growth had started here by this time. *Bouteloua gracilis* had been weakened by the drought. The vegetation reached its lowest density in 1935, during the 25 years of record. May 17, 1935.

pastures was reached in the spring of 1935, following the severe drought of 1934. The condition at that time is well illustrated in Figure 5. At that time estimates made by various range examiners in connection with the range program, placed the density at from approximately 30 to 45 percent. The lowest density was found in the heavily grazed pastures. Further determinations during that year showed that blue grama reached its lowest point in density. The smallest pasture is, however, better now than some of the larger ones, due mainly to the recovery and increase of blue grama and western wheatgrass. At the present time the total density for the different pastures would rank approximately as follows: 100-acre, 48 percent; 70-acre, 41 percent; 50-acre, 35 to 40 percent; 30-acre, 47 percent; and rotation, 45 percent. The lower density in the 70-acre has not been caused by overgrazing, but is rather the result of a few poor exposures and soil. The lowest in the 50-acre pasture is partly because of an area of poor exposure, and partly because it has suffered more from overgrazing, because of a longer seasonal grazing period than in the 30-acre tract. The density of blue grama is approximately 40 percent in the 100-acre pasture and 45 in the 30-acre pasture.

The composition and density of the native vegetation are intimately associated with the livestock industry in the northern Great Plains. The effects of grazing on the grasses, and proper range management to conserve and perpetuate the valuable species are vital to the industry. The kinds of grasses and other plants growing in an area are highly important in relation to the value of the range for grazing purposes. The kind and quality of the vegetation, mainly the grasses, are not only highly significant in relation to the immediate needs of grazing, but also in relation to systems and intensities of grazing.

The area selected for the grazing experiment was one of a highly developed vegetative type, such as commonly found in this region of the Plains. Unmanaged and indiscriminate use of the range is a destructive process, but properly controlled grazing may be beneficial to the vegetation. Grazing the kind of vegetation in this area should be so adjusted that its composition and density can be maintained in a normal state, as nearly as is consistent with the best utilization of the forage and the requirements of the livestock. Unless reasonable precautions are practiced, the effects of grazing on a given area are likely to become cumulative and result in serious deterioration of the native range or the farm pasture.

The composition of the native vegetation growing in the pastures of the Cooperative Grazing Experiment does not differ greatly from that found over much of western North Dakota and adjacent portions of Montana, Wyoming, and South Dakota. The density of the vegetation in the vicinity is somewhat higher than in some other parts of the region. A large number of species of plants are found growing on the range in this area, but the ones

most important as forage for grazing animals number only about 25 to 30. Of this number, four species produce a large percentage of the forage. Some species are highly important because of their abundance and grazing value. Other species of little grazing value may be important because cattle do not like them, and they are able to flourish and become competitors of the more desirable forage. Such species may be able to command advantage of overgrazed pastures or ranges and increase to such an extent that the grazing capacity is greatly reduced. This is brought about by the crowding and weakening of the valuable species, and a reduction in the quality of the forage.

The following species of plants occur over the section of land where the grazing experiment is located. Some are of minor importance, while others are of major value. The species are listed in their approximate abundance as they grow on the range.

Dominant Species

Blue grama (*Bouteloua gracilis* (H.B.K.) Lag.) is the most valuable grass in the pastures and throughout the region. It forms small mats or "patches", usually a few but sometimes several inches across, and is seldom found forming a closed sod over an extensive area. It is a perennial from fibrous roots that form a mass in the first 14 to 20 inches of soil. It stands at the head of the list because of its abundance, value for grazing, palatability, drought resistance, and ability following a dry period to make a rapid recovery with a rainfall that exerts little influence on many of the deeper rooted species. In abundance, it has a greater basal cover at the present time than all other species combined. It has increased in basal cover since the experiment started in 1916. This has been because of the heavy growth of other species during the favorable years of 1914 and 1915, and their consequent thinning out since that time, especially after 1930 and particularly during the drought years of 1934 and 1936. In the various pastures blue grama has a basal cover of from between 35 and 40 to 45 percent, depending on the intensity of grazing, and the degree that other species have been thinned out. In the heavily grazed pastures it makes up nearly all the cover. Many of the other species had been reduced in amount because of overgrazing sometime before the drought years. Blue grama was able to take the brunt of the grazing and make an increase in stand.

This increase has been brought about, not by reseeding of the grass but by its ability to increase the size of its mats by tillering (*11*). It is not a regular and consistent seed producer. It is only during favorable seasons that a plentiful crop of viable seed is produced. Under exceptional conditions such as obtained in this area in 1938 and in 1939 through central South Dakota a "bumper" seed crop is produced. The best crops of seed previous to these years were in 1927 and 1928. In 1938 it was not uncommon to find seed stalks 2 feet or more in height (figure 6). This unusual condition conveyed the impression that the range had entirely "come back". One of the reasons why it produced such a good seed crop was because the mats were not so dense as normally, and the distribution of rainfall was adequate to keep it growing through seed maturity.

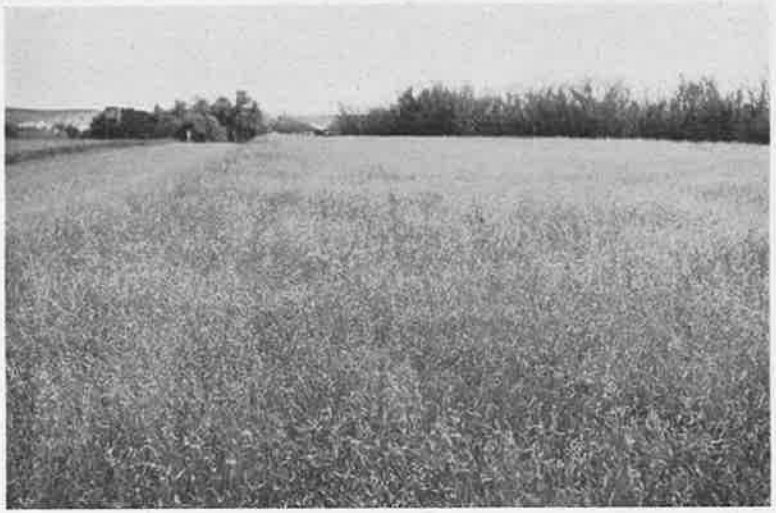

Figure 6.—Blue grama showing the heavy growth and seed crop. The seed stalks average 18 to 20 inches in height. August 24, 1938.

In palatability blue grama ranks at the top along with a number of other species. For cattle it is rated as 80 percent palatable.[3] This figure is based on the degree it is relished by cattle and its proper range use. So far as the degree cattle relish it is concerned, it would rank 100 percent. Its beef producing ability is very high. In 1927 and 1928 the steers in the 50-acre pasture had little else to eat but blue grama during July and August and made higher gains than those in any of the other pastures. It is greatly relished during all periods of the season, from as soon as it is large enough to graze up to the time it is mature and cured for winter dormancy. After other species are mature, cattle will hunt out blue grama in preference to anything else and will readily graze it throughout the winter if it is within their reach. When an abundance of seed stalks are produced, as in 1938, they are not particularly liked. Chemical analysis made of mature stalks that year showed them to be very low in protein content, as later shown in table form.

[3] The palatability ratings as used in this publication are based on a list prepared at this station in 1935 for use in the range program in this area. They are based mainly upon the use made by the cattle of the different species in the pastures of the grazing experiment. Ratings may differ in other areas, not because some are wrongly rated, but because of different soil and growing conditions that may change their use by cattle.

In the pastures and over much of this area, blue grama stood up better under the droughts of 1934 and 1936 than practically all other grasses. From reports (*16*) in other sections of the northern Plains, it did not fare so well as it did here. Soil conditions sometimes exert a marked influence on the ability of plants to survive under drought. The soil in this area is not a "hard soil", but is one readily penetrated by rain. Light rains that will have little influence on other grasses will start a new growth of blue grama. The ability to make a quick recovery following a dry period is one of the most remarkable and valuable characteristics of blue grama.

It has been stated that the weakness of blue grama is the fact that it does not furnish early spring grazing. A single grass cannot be expected to carry all the points desirable for grazing throughout the entire season. The fact that it does not start growth early in the spring is probably largely responsible for its ability to withstand adverse conditions and heavy grazing. It produces excellent grazing after many other species have passed their best stage of palatability. Since blue grama does not usually start its spring growth here before early May, it avoids much of the period of most severe grazing. While other species have started growth by this time, they are grazed in their most tender stage. Another point claimed as a weakness of blue grama is that it does not produce a large volume of growth. This is true when based on mature plants. But its volume of production is often greatly underestimated. Its ability to make a rapid recovery after it is grazed or following a dry spell allows it to produce several crops for grazing during the season. This fact is well illustrated by its production as later discussed under clipped quadrats. The percentage of blue grama produced in the frequently clipped quadrats is higher than in those cut less frequently or only once a year.

Blue grama is also accused of increasing under heavy or overgrazing. It is fortunate that it has the ability to stand up under heavy use and produce feed for grazing. The fault lies in the fact that overgrazing has been allowed to take place. It may also be that the weakness lies in some of the other species that cannot stand up so well under heavy grazing.

Blue grama usually starts its spring growth early in May and matures its seed crop late in July or early August. Some years it produces very few flower stalks. This is not always because it has not made a good vegetative growth, but because moisture conditions were not right to keep it growing at the proper period for seed stalks to develop. If it is grazed early in the season and allowed to rest later, it very often does produce flower stalks and some seed. Such a condition frequently occurs in the spring-grazed division of the rotation pasture. It did not produce a good seed crop from 1916 to 1922.

The nature and habits of blue grama fit it very well for grazing in combination with a cultivated pasture, especially one composed of grasses that make their best growth early in the spring and are ready for grazing two to three weeks before native range. Blue grama is rated highly in this area for grazing at most seasons of the year.

Western wheatgrass (*Agropyron smithii* Rydb.) which is very common over much of the northern Plains, is now rated as second in importance in the pastures. In 1916, when the grazing experiment was started, it was rated among the primary species. This was not because it was abundant over the prairie, but because it occurred rather extensively on lower ground and was scattered over the prairie. If sod were broken in 1916 and allowed to "go back", it would readily produce a pure stand of western wheatgrass. This showed that the grass was fairly well distributed in the sod. It is a perennial with strong and vigorous creeping rootstocks, which enable it to spread readily. It is usually the first grass to come back into abandoned cultivated fields, the rapidity of recovery depending upon the length of time the land was under cultivation.

While western wheatgrass is rated as second in importance, its density is not high. In few places over the pastures does it have a 10 percent basal cover. It makes up about 5 to 8 percent of all species at the present time. It seldom forms pure stands over a large acreage in this area, as it does in western South Dakota. It has more than doubled in amount during the past 10 years. This increase first came into prominence after the droughts of 1934 and 1936. Attention has been called to increases in the prairie region since the drought where it almost entirely replaced former grasses (*29*, *37*), and showed an increase of from 1 to 5 percent in southeastern Montana (*16*).

It is rated at 80 percent in palatability for cattle. In reality it is not relished by them to the same degree as blue grama and some other species. Some seasons it seems to be eaten better than others. This is likely because of the influence of moisture conditions on the nature of growth. When the grass is young it is readily grazed, but if too closely cropped at that time it is likely not to make much growth during the rest of the season. In the frequently clipped quadrats, it made very little growth after one to three cuttings and was much below blue grama in production under those conditions. While it furnishes good pasture in the spring and summer, it is better adapted for winter grazing because of the nature of its growth. It has been pointed out (*3*) for an area where it is much more abundant than here, that it is a better hay grass than a pasture grass. This does not mean that it is not valuable for grazing, but that it is more valuable for forage in the form of hay. It is the famous "wheatgrass hay" of the northern and central Plains. Good wheatgrass hay at one time commanded a premium on the market. It is sought

after as baled hay for stockyard feeding and especially for race horses. If the grass is not cut early enough, the hay may contain a serious amount of ergot. When ergot is abundant during certain seasons, it may seriously affect cattle.

Western wheatgrass has stood up here under heavy grazing better than all other grasses, except blue grama. It has persisted in a shallow draw in the 30-acre pasture during the years it has been heavily grazed and has become more prominent over the rest of the pasture within recent years.

Western wheatgrass starts growth early in the spring, usually early in April, but its growth is slow compared to that of some other grasses. When conditions are favorable it produces a good crop and matures usually in August. It does not regularly produce a heavy seed crop in this area. Some years very few heads develop. It is more susceptible to the influence of early moisture than many other grasses. If production records were available, it is likely it would show a higher correlation with precipitation for April or April and May than for other periods. Heavy rains in early spring practically insure a good crop of hay from it. In 1935 when heavy precipitation occurred over much of South Dakota in March and April a "bumper" crop of it was produced. Later rains are required to mature a good seed crop. Much of the seed was "burned up" before it filled in 1935 over parts of South Dakota. During that year, the grass grew tall and headed out, and areas were observed where it was over 3 feet in height. In some places it was not recognized because of its rank growth following several years of drought. It also responds readily to flood irrigation, and under such conditions heavy crops of hay are produced. Advantage is taken of this fact in many areas where water spreading is possible.

Western wheatgrass seed, most of it harvested from natural stands, has come onto the commercial market since the drought of 1934. It is being sown on fields alone and in mixture with other grasses. It is likely that it may prove disappointing in many places, as it spreads so rapidly under cultivation that it soon becomes sod bound and its production is then greatly reduced. This can be overcome by mechanical means to some extent. The germination of the seed is also very slow, and sometimes stands are not readily established. Its best use is likely to be found in mixture with other grasses, especially bunch grasses, for both hay and pasture. It has a ready use for seeding on ditch banks and along the newer highways, where a strong binding grass is highly desirable. It is not hard to kill under cultivation. Usually one good plowing will completely subdue it. It is able to grow under alkaline conditions, and can endure more alkali than most other species.

Thread-leaf sedge (*Carex filifolia* Nutt.), more commonly known as "niggerwool", is a grasslike plant belonging to the sedge family, which is closely related to the grasses. It is a perennial

growing in dense bunches over the prairie. It forms a dense and tough sod that binds and holds the soil against wind and water erosion. It has a mass of black fibrous curly roots that form the "bumps" in prairie roads and wear out slowly, still holding the soil after the tops are dead. It is the earliest forage plant to start growth in the spring in this area. Some green growth can generally be found on it in late March. It comes into flower early, and the seed is mature ordinarily by May 20. It seldom produces a good seed crop, as the flowers are often caught by frost. The most recent crops of value were in 1935 and 1937. It is ranked as third in dominance because of its abundance. Its greatest value is for grazing extremely early in the spring. In palatability, it is rated as 70 percent for cattle. While it is young, cattle eat it readily. It soon becomes tough and dries up and is then more or less avoided. It has a cover of 3 to 5 percent. It does not produce much secondary growth after it is once grazed down. Its primary value lies in its earliness, and the fact that it can grow and thrive on poor locations and exposures where not much else can survive.

Needle-and-thread (*Stipa comata* Trin. and Rupr.) is the "needlegrass" or "speargrass" of the northern Plains. It is a perennial bunch grass from fibrous roots. It starts growth early in the spring, sometimes in late March but more often in early April, and reaches maturity during July. The sharp needles drop a short time later. This grass was originally considered as second in dominance and importance. It was credited with a basal cover of approximately 10 percent. It was severely damaged by the drought of 1934 and again in 1936 in the pastures where it still remained. This injury was more or less general throughout this area, but in parts of central South Dakota little damage to it could be observed. In 1937 needle-and-thread could not have been ranked as a dominant species in the pastures. It has made a remarkable recovery since that time, and by 1940 it was well on its way back to normal.

Needle-and-thread furnishes good grazing early in the season before the needles form, and after the needles have dropped it again furnishes some feed. While the needles are on the plants it is avoided to some extent by cattle. A needlegrass range is dangerous to use for sheep, as the needles collect in the wool and work into the skin. It does not rank as high in palatability as many of the other grasses. It is rated at 60 percent for cattle.

This grass is extremely sensitive to grazing and will go out under heavy use. It had practically disappeared under heavy grazing in the 30-acre pasture before 1925. It was one of the first plants to be eliminated in the frequently clipped quadrats, and it was reduced in many of the others. In 1937 very few plants could be found in the pastures. In 80 quadrats that were listed in 1940, an average of 1.1 plants per quadrat was found in the 30-acre pasture. At the same time, an average of four well-de-

veloped plants per square meter were listed in the 100-acre pasture and a lesser number in other pastures.

When needle-and-thread was at the height of growth in the pastures, and in full head, the impression was gained that very little else was growing over the area. It made up over 50 percent of the native hay.

Other Grasses

A number of grasses, in addition to the dominant species that have been considered, occur over the pastures. They are more localized on certain soil types, along ravines, or in other spots suitable to their development. Some of them furnish valuable forage, but others are of little or no value. Their total production is small. The grasses discussed below are listed in their approximate order of abundance as they appear in some part of the grazing section. A few other species of lesser importance are not listed.

Green needlegrass[1] or feather bunchgrass (*Stipa viridula* Trin.) grows on some of the better soil areas. It is a perennial bunchgrass and furnishes excellent forage early in the season. It does not carry sharp pointed needles as does needle-and-thread. The grass can be grazed at anytime without injury to stock. Needlegrass is an unsatisfactory name for it, because it carries the stigma of the more common and easily recognized needle-and-thread. Farmers are prejudiced against it before they will give it a trial under cultivation. It is rated as 70 percent palatable. The seed is highly viable, and the grass is readily established under cultivation. It is now being used extensively in Soil Conservation Service projects in North Dakota. The seed carries short awns and hairs on the seed and needs to be processed before it will seed from a grain drill.

Side-oats grama (*Bouteloua curtipendula* (Michx.) Torr.) is scattered over dry hillsides. It furnishes good feed, but is not abundant enough to be an important factor in forage production. It rates 80 percent in palatability.

Prairie sandgrass (*Calamovilfa longifolia* (Hook.) Scribn.) is a tall coarse grass with strongly spreading rootstocks. It is a good indicator of a sandy soil. It occurs on some of the poorer ridges in some of the pastures. It is low in palatability and is rated at only 20 percent. In other areas under different conditions it is rated higher, but here it is avoided by cattle even under close grazing. In other parts of the area under drought conditions on the open range, it was observed that everything but this was taken.

Six-weeks fescue (*Festuca octoflora* Walt.) is an annual grass from very shallow and poor roots. It is really a weed of seasonal appearance where it occurs in the pastures. Some years very little may appear, but at other times much more of it is present. One year in particular it came on in abundance over several spots

[1] Green needlegrass is widely used for this plant but is misleading because the grains are not sharp.—O. A. Stevens.

in the pastures. It was reported from many places in the area, and some feared that it was taking over their pastures. It matures early and turns brown, when it can be seen at some distance. It grows very thick and practically covers the ground. It is of no value for grazing by cattle. The roots are so shallow and weak that it is readily pulled up and usually discarded. Its only value is as a protection to the soil, as it will grow in poor and exposed situations.

Saltgrass or alkaligrass (*Distichlis stricta* (Torr.) Rydb.) grows in strongly alkaline soil from strong creeping rootstocks. It is low growing and forms a dense sod. It occurs along the coulee below the dam shown in Figure 1. It is of little value for grazing. When grazed it breaks off below the soil and is often "spit out" by cattle. It is a good soil binder and prevents erosion by heavy rains.

Canby bluegrass (*Poa canbyi* (Scribn.) Piper) occurs in a few spots in the reserve pasture. It is an early bunchgrass and furnishes good grazing while young. It is dependent on early rainfall for its best production. It sometimes occurs along with the following, but it usually prefers better soil.

Sandberg or western bluegrass (*Poa secunda* Presl.) occurs in a few places in the reserve pasture. It is a bunchgrass normally lower growing than *P. canbyi*. It is very early, and in areas where it is abundant it is the first grass to "green up". It is dependent on early rainfall and produces good grazing when it makes sufficient growth. It matures early and soon dries up. It is an important and valuable grass throughout its range and is more abundant west of here. Its increase since the drought has been reported in Montana (*16*).

Plains bluegrass (*Poa arida* Vasey) grows in strongly alkaline spots, and usually occurs in such areas along coulees. It grows from a creeping rootstock.

Big bluestem (*Andropogon furcatus* Muhl.) occurs along some of the coulees in the pastures. It is a perennial, slowly spreading by rootstocks. Normally it does not start its spring growth until near the middle of May. It is very tender and juicy in its young stage and is greatly relished by cattle. They will graze it in preference to anything else early in the season. It rates at the top in palatability at that time. Wherever it occurs in the continuously grazed pastures it is always closely grazed and kept so during the season. In the fall-grazed division of the rotation pasture, after it is mature it is more or less avoided by cattle, until they become short of other feed. If not closely grazed, it becomes coarse and stemmy and loses its palatability as it approaches maturity. This fact has been shown in Kansas (*2*). Its chemical composition shows a low protein content even in the flowering stage.

Little bluestem (*Andropogon scoparius* Michx.) is a bunchgrass, growing on exposed hillsides over the prairie. Before the drought it was much more common than big bluestem. It was formerly seen in the fall on hillsides, where it was conspicuous because of its red colored stems. The drought of 1934 weakened it, and that of 1936 killed many of the plants and weakened the others to such an extent that it was practically eliminated in many spots where it grew in the pastures. It is slowly coming back. In areas where little bluestem covered 50 to 70 percent of the ground, it was entirely eliminated by the drought, as determined by special studies (*34*). Big bluestem seemed to withstand the drought here better than did little bluestem, even on areas equally exposed. It is rated low in palatability in this section, or at 30 percent. In other sections where it is more abundant, it is considered a valuable grass for grazing. The cattle here seem to avoid it. This may sometimes be because of the old stems that are stiff and protect the young growth in the spring. Where it occurred in the closely grazed pastures and was once eaten off, it seemed to be taken rather readily. Under cultivation, young growth was grazed with apparent relish. One year out of twenty (1935) it was cleaned up during September in the large pasture, where a large patch of it occurred. It was thought this might have been because the steers came from the Kansas City market and were used to eating this grass, but the same condition was observed in adjoining pastures grazed by native cattle. There was not a shortage of feed in the pasture.

Slender wheatgrass (*Agropyron trachycaulum* (Link) Malte) and bearded wheatgrass (*A. subsecundum* (Link.) Hitchc.) are bunchgrasses that occur to a very limited extent in the pastures. They both furnish a small amount of good grazing.

Porcupine grass (*Stipa spartea* Trin.) is the large needlegrass. It occurs in a very few spots on the better soil types in the pastures. It is low in palatability. The needles are larger and sharper than those of needle-and-thread.

Plains muhly (*Muhlenbergia cuspidata* (Torr.) Rydb.), commonly called "wiregrass", is scattered over the pastures in small patches. It is tough and wiry. It is low in grazing value and usually avoided by cattle. The grass is a yellowish green color. It is the one that causes the "chug" when a patch is hit with the mowing machine, and it helps to dull the sickles.

Prairie Junegrass (*Koeleria cristata* (L.) Pers.) was originally very common over all the pastures. It is a perennial bunchgrass from fibrous roots. The plants usually occur singly instead of being crowded together. It is one of the earliest grasses to start growth in the spring and is one of the first to mature. It furnishes luxuriant green feed early in the season and is readily eaten by cattle, its palatability being rated at 80 percent. It soon dries up and the foliage is almost entirely lost to cattle in areas that are deferred for fall grazing.

During some of the earlier years, when Junegrass was in head and flower, it had the appearance of being very abundant over all the pastures. The drought of 1934 combined with that of 1936 practically eliminated this grass where it was growing under the most favorable conditions. A careful examination of the vegetation in the lightly grazed large pasture revealed only a very few plants in 1937. In 1938 a few more were noted, and in 1940 nearly two plants per square meter were found. It is evident that it will soon be back to normal in this pasture. It went out under heavy grazing in the 30-acre pasture by 1925, and none appeared in 1940 in the quadrats in that area, although some plants were found in favored spots in other parts of the pasture.

Buffalo grass (*Buchloe dactyloides* (Nutt.) Engelm.) is a mat forming grass that spreads rapidly by means of runners on the surface of the ground. Blue grama and niggerwool are often confused with it. It occurs in only two or three spots in the pastures, and to a very limited extent in this area. It is scattered in more or less favored spots, such as ravines, farther west in the State. In western South Dakota it is the dominant grass. Buffalo grass has a better reputation for grazing and is more widely known by a popular name than any other single grass in the Great Plains.

Other Plants

Grasses make up the bulk of the vegetation in this part of the Plains. A number of other plants, however, make up a considerable portion of the vegetative cover. Some of the plants may furnish desirable forage for grazing, but others may be classed as weeds.

A few sedges or grasslike plants grow along the coulees or on the higher prairie. Some of these are valuable for grazing when they are in prime condition for use.

Carex heliophila Mack., leaves are soft and of a yellowish color. The name "yellow sedge" has been applied to it in connection with this experiment. It was formerly considered one of the dominant species along with *C. filifolia*. It was nearly eliminated by the drought of 1934 followed by that of 1936. It is now found in only a few low spots and along some of the ravines. It was early and produced excellent feed. It was rated at 80 percent in palatability. It is a perennial with slowly spreading rootstocks. The plants often appeared singly, with flat yellowish leaves. Its grazing period extended over a longer part of the season than that of niggerwool, and it was not particularly avoided by the end of the grazing season. This little sedge stood up well under grazing or frequent clipping, but failed to survive the drought. So far it has not recovered to a marked extent.

C. Eleocharis Bailey, is a little wiry sedge that grows mixed with the other vegetation throughout the pastures. It furnishes a small amount of feed, as it is normally short and usually grows

as single plants. It is also rather tough, even in its young stage of growth. While it is common on the higher ground, it also grows along the coulees, where it attains a larger size. *C. scoparia* Schkuhr. (pointed broom sedge) is a larger sedge that grows only along coulees or depressions where water normally stands in the spring. It is apparently relished by cattle, as it is often found to be closely cropped. *C. praegracilis* W. Boott (clustered field sedge) has rootstocks that are strong and tough and are excellent soil binders. It requires a fairly wet soil, or one that is well soaked up in the spring. The plant is not eaten to the extent of the preceding species.

The following plants are classed as weeds, but some of them are eaten by cattle at various times with apparent relish. They make up less than 10 percent of the total vegetation at the present time. Formerly they produced a greater amount, but many of them were thinned out by the drought. The three species commonly called "sages" are the dominant ones of the weeds. They were not injured to a great extent by the drought.

Fringed sagebrush, silver sage, or pasture sagebrush [1] (*Artemisia frigida* Willd.) is a sort of small shrub, perennial from a woody base. It produces few to many stems. In some areas it is considered of grazing value for cattle. In the grazing experiment, it is considered low in grazing value for cattle and the most undesirable species in the pastures. It is bitter, and cattle do not like it and will not eat it until forced to do so because of the lack of other feed. Sheep are reported to eat the plant much better than cattle. Cattle do not seem to hesitate in eating it in the form of hay. It is an indicator of overgrazing as it will come into pastures that are heavily grazed. It is normally present in the vegetation of this region. It is rated at 10 percent in palatability for cattle.

Cudweed sagewort (*Artemisia gnaphalodes* Nutt.) is a perennial from spreading rootstocks. It is more commonly known here as white sage. The plants usually appear as single stems. It is not so bitter as *A. frigida* and is more readily eaten by cattle, and is rated at 30 percent palatability. It has persisted in all pastures but was weakened in the heavily grazed ones.

Green sagebrush (*Artemisia dracunculoides* Pursh.) is a perennial from a woody base. It is green in color and taller growing than the preceding sages. It rates 30 percent in palatability for cattle. Cattle do not hesitate to eat it during the season. It is not bitter, but more aromatic. As a seasonal indicator of plant vigor, it is fairly reliable. It does not stand up under heavy grazing as well as the other species of Artemisia. In 1935 it produced a heavy growth (figure 7). In the 30-acre pasture it went out under the heavy grazing before the period of drought, and at the present time it does not appear in this pasture, in any of the established list quadrats.

[1] I have used "Little Sage" and "White Sage" respectively for this and the next species. They are not shrubby.—O. A. Stevens.

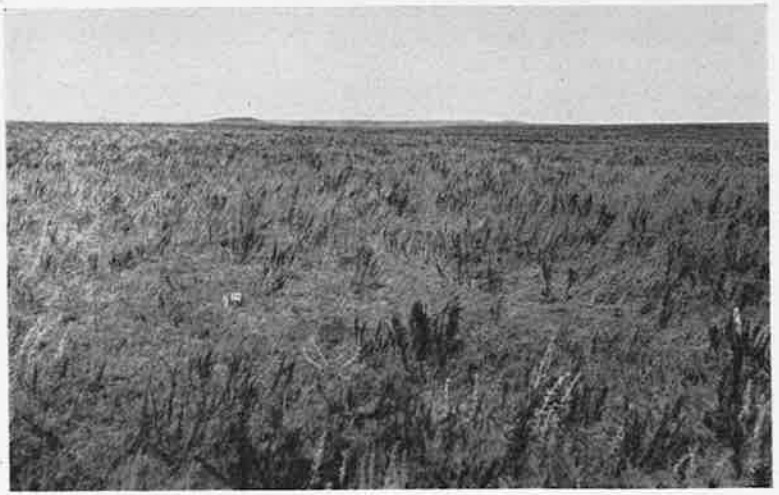

Figure 7.—Vegetation in the 100-acre pasture showing the heavy growth of weeds, especially *Artemisia dracunculoides* (dark plants), following a drought year. These were the rankest in growth during the 25 years. October 17, 1935.

Wreath aster [1] (*Aster multiflorus* Ait.) is a dense-flowered fine-leaved white aster that is rather common over the pastures. It is a perennial with rootstocks and is eaten by cattle at times with apparent relish. It was injured little by the drought.

Rough pennyroyal (*Hedeoma hispida* Pursh.) is a small annual plant that is abundant during some seasons over all pastures. In 1935 it was most abundant, and it produced over 400 plants per square meter as an extreme number. It is a mint and of no value for grazing.

Woolly Indianwheat [2] (*Plantago Purshii* R. & S.) is another shallow-rooted annual that is very common on some of the poorer areas during seasons favorable for its growth. It is a small white weed with round heads and produces abundant seed. These apparently are able to remain in the soil for sometime and grow when conditions are favorable. It is of no grazing value for cattle. It is often called rattail plantain.

Dwarf goldenrod [3] (*Solidago pulcherrima* A. Nels.) is a perennial from slowly spreading rootstocks. It is liked by cattle during part of the season. It does not become harsh as do many other plants.

Purple coneflower (*Echinacea angustifolia* DC.) A perennial from a woody base, purple coneflower has hairy leaves, and pinkish flowers around a spiny center. This species was formerly one of the most common and conspicuous of the weeds. It was practically eliminated by the drought but is slowly coming back. When the plant matures, it is avoided by cattle.

[1] I have used "White Prairie Aster" for this.
[2] I have used "Prairie Plantain".
[3] "Early goldenrod" is appropriate here.—O. A. Stevens.

Prairie coneflower (*Ratibida columnaris* (Sims) D. Don.) is not a bad weed, but it is not nearly as abundant as before the drought. It is eaten to some extent by cattle.

Silverleaf scurfpea[1] (*Psoralea argophylla* Pursh.) belongs to the legume family, along with sweetclover. It is a small-stemmed perennial. When the experiment was started it was one of the most common plants in the pastures. When it was at the height of its development along in July, it was most conspicuous and obscured many of the other species. The white plants shown in Figure 2 are this plant. It had the appearance of being more abundant than counts revealed. It was badly injured by the drought, and many plants were killed. It is now found only along coulees or in low places.

Stiffleaf vetch (*Vicia sparsifolia* Nutt.) is a perennial native legume. It is abundant during favorable seasons. It is valuable for grazing, and cattle eat it readily.

There are no poisonous plants occurring in the pastures in enough abundance to cause serious damage to grazing cattle. Loco weed or crazyweed (*Oxytropis Lambertii* Pursh.) occurs in small areas in some of the pastures. There have not been any cases of poisoning caused by it.

Many other plants appear scattered over the pastures, as there are a total of 250 to 300 species recorded. They are mostly of minor value, except as they help to form a cover to protect the soil against water and wind erosion. It is an unusual season when some one species does not appear more conspicuous than the others or is outstanding. In 1915 the silver-leaved legume was abundant and very conspicuous with its silver leaves (figure 2). During some other years needle-and-thread appeared to obscure everything else. In 1919 white sage gave some of the pastures a white cover. From 1920 to 1925 silver sage practically covered the heavily grazed pastures. Following the drought of 1934 many mustards appeared over the prairie. The most noticeable of these was peppergrass (*Lepidium densiflorum* Schrad.). This was reported to have caused a great deal of trouble by tainting milk. It was abundant clear across the northern Plains. In some areas it was so thick that little else grew, and it was thought a new weed had made its appearance. Green sage appeared later in the season and was conspicuous because of its unusual height, the tallest of record (figure 7). Early in 1937, wild onions (*Allium* spp.) were the thickest of years early in the season. In the fall Russian thistles (*Salsola pestifer* A. Nels.) appeared in bunches over the prairie and entirely covered the ground over extensive areas. Such a condition was never known before according to available information. Then in 1938 the great growth of blue grama grass obscured practically everything else. Rainfall was just right for it, so that its growth was not retarded at any time during the season. It matured the heaviest seed crop known so far as records are available.

[1] This is still in need of a good common name. It bears no peas and is not scurfy.—O. A. Stevens.

The composition of the native vegetation, made up as it is of numerous grasses and other plants, furnishes a variety of feed for grazing livestock throughout the season. The palatability of the total vegetation for cattle is high. The average for the important grasses and grasslike plants (sedges) is not far from 75 percent. This means the area is well adapted for cattle grazing. This fact is highly significant in the management of the range and systems of grazing to maintain its high productivity and value.

Effects of the Drought upon the Vegetation

A great deal has been reported and written concerning the severe drought of 1934 followed by a worse one in 1936, over much of the northern Plains. In reality it was not the immediate results of the drought of those years that caused the damage to the vegetation. It was rather the culmination of a series of lesser droughts starting in 1929 that caused the final damage. There was only one good year (1932) during the period between 1929 and 1934. This was followed by a favorable year in 1935, and then by the cold, heat, and drought of 1936. The high winds did their worst damage in 1933 and continued through 1934. Grasshoppers also added their toll to the damage and in many areas, their consumption of the vegetation exerted a greater influence upon its destruction than did the drought.

While there was much damage to, and killing of the vegetation in many parts of the region, there was not the severe killing of the vegetation in this vicinity as in areas south and west of here. Damage was severe in the southern Plains as reported in a special study of the area following the drought (*25*). Damage caused by the drought has been studied in Nebraska and publications are available concerning it. It was stated (*36*): "when the great drought came, it alone rarely or never killed all the vegetation. The effect was that of thinning the stand."

The outstanding effects of the drought in the pastures of the grazing experiment were the weakening and killing of much of the needle-and-thread, Junegrass, little bluestem, yellow sedge, and many of the plants commonly classed as weeds. In some of the pastures the total quantity of the vegetation was reduced nearly half. Areas not far from here were observed where less than 5 percent of cover remained. This condition was caused by both drought and grasshoppers. The latter were not a factor in the pastures of the grazing experiment during any of the years. Further mention of the effects of the drought will be found under the discussion of the individual species.

The start of growth of the vegetation in the spring of 1935 was extremely slow and late, although moisture was excellent. It is only problematical as to what might have resulted if the April rainfall had not been much above normal. Grasses that normally should have shown a good growth early in May did not appear until early June. Practically the only green vegetation for grazing

during the latter half of May was niggerwool, and its production was light. Blue grama was so slow in making a start that it was feared it was all dead. The first growth of it showed only a few green leaves on what appeared to be dead mats. However, a larger percentage of these later "greened up". Some of the mats were dead, especially in areas that had been overgrazed or badly exposed, but the survival was high. Under normal conditions a small percentage of them gradually die out especially in their center. Another unusual condition in 1935 was the enormous quantity of weeds especially the mustards appearing over the prairie, that are normally limited in amount. They were favored by the lateness of the start of other vegetation and its reduction in stand. The seed of many of these plants remains in the soil for many years. In some areas it is likely that small seeds like those of peppergrass were carried in by the high winds, just preceding 1935. While the prairie in some areas looked green, in reality there was little feed fit for grazing. In some of the worse affected places such conditions still persisted in the spring of 1940. The effects of a drought or overgrazing on native vegetation extend over a period of years. It is likely the scars of the drought of 1934 and 1936 will persist in certain areas for some years to come.

In 1938 general reports to the effect that the grass had entirely "come back" were commonly circulated. This observation was brought about by the abnormal growth and heading out of blue grama. When this grass was in head and ripened it could be seen for long distances on either side of the highways. Figure 6 affords an idea of the growth of blue grama at that time. An examination of the grass showed that the mats were thin, and its growth tall but not dense. This condition as well as the very favorable and well distributed rainfall favored the production of a heavy seed crop. The immense seed crop produced that year as shown in Figure 8 was scattered on the ground and later some new plants became established.

Under normal conditions marked changes in the vegetation take place slowly in this area. It is true that under heavy grazing, changes do take place, but not to the same extent as in some other places. Reports and observations in some other states show that a marked reduction in the stand of the vegetation can be brought about by one or two years of overgrazing, clipping, or severe drought. Results of investigations in the Custer National Forest in Montana (*16*) show that a reduction in density from over 30 percent to less than 10 percent took place between 1930 and 1936.

The results of 20 years of heavy grazing in the pastures of this experiment show that cattle have not been able to kill the vegetation. It is not unlikely that it would have been thinned out considerably more, if early and premature grazing had been practiced.

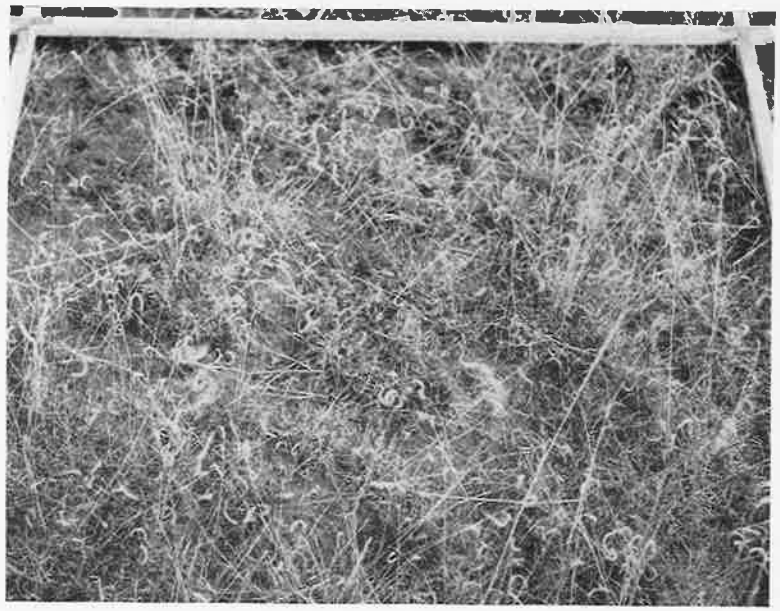

Figure 8.—Close view of quadrat in 100-acre pasture showing numerous seed heads of blue grama. Similar heavy seeding took place in all native pastures. September 9, 1938.

Effects of Grazing upon the Vegetation

There is somewhat of a parallel between the effects of grazing and that of drought upon the native vegetation. A number of the same species of plants that were adversely affected by the drought were also injured by heavy or over-grazing. For example, both needle-and-thread and Junegrass were injured by the drought and by heavy grazing previous to that time. This held true for several of the weedy plants.

In the small pasture, needle-and-thread and Junegrass were practically driven out of the vegetation by heavy grazing previous to 1925. The average number of plants per square meter in 1940 was 1.1 plants of needle-and-thread and none of Junegrass in the quadrats of the 30-acre pasture, although some plants were found in favored spots. At the same time an average of 3.9 plants of needle-and-thread per square meter were found in the 100-acre pasture, and 1.8 of Junegrass. This shows both these grasses are markedly influenced by the intensity of grazing. The same general condition prevailed for red three-awn (*Aristida longiseta* Stend.) bunches which appeared in all pastures at the beginning of the experiment. At the present time it is difficult to locate any in the 30-acre pasture, but some are found in the large pasture. This species was greatly reduced by the drought, and its elimination is desirable, as it is of little grazing value.

The weedy plants that are sensitive to grazing are green sage, white sage, purple cone flower, and the silver-leaved legume. They were driven out by heavy grazing. In 1940 no plants of the green sage were found in the quadrats of the small pasture. The white sage persists for a much longer period, but it has been thinned out under heavy grazing.

One of the sages that has been most affected by grazing is the silver sage (*Artemisia frigida*). It is of particular importance in the vegetation, because it serves as an indicator of overgrazing. This was especially true during the earlier years of the experiment. In the heavily grazed 30-acre pasture, silver sage increased rapidly up to 1925. For a time it remained somewhat stationary. After 1925 it started on a decline in size of plants, and after 1928 decreased in number of plants in the quadrats. Table 2 shows the number of plants of silver sage in the quadrats in both the larger and smaller pastures during different years. Comparisons are made between these pastures because they represent the extremes between intensities of grazing. The number is shown for only a few of the 25 years, but the trend is clear. Moisture conditions were most likely largely responsible for the reduction in number of plants, rather than the heavy grazing. The moisture reduction gradually increased along with the number of plants, until the plants began to compete with each other for the moisture. The first pronounced indication of the decline in the growth of the plants was in 1925, and by 1927 it was definite as illustrated in Figure 9.

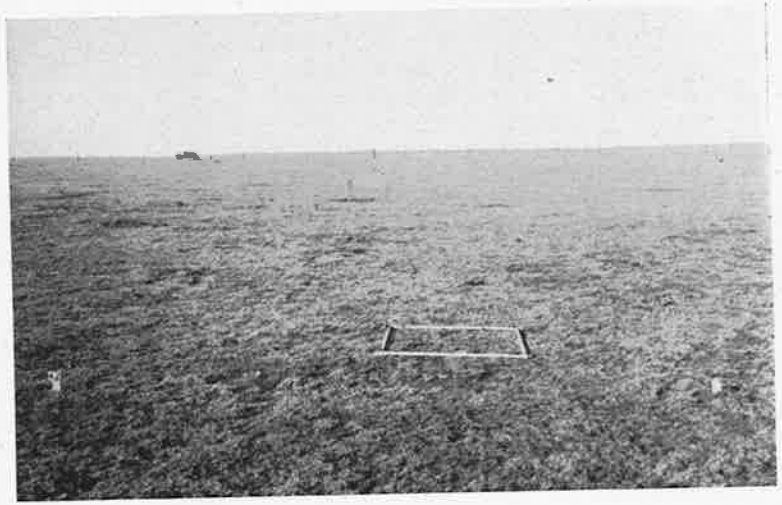

Figure 9.—View of 30-acre pasture at close of a favorable season.

No plants of *Artemisia frigida* show at this time. The plants have become smaller and not so coarse. Compare with Figure 12. October 19, 1927.

The heavy precipitation in both 1914 and 1915 filled the prairie sod with water to its field carrying capacity to the depth (6 feet) that soil samples were taken. The heavy grazing in the 30-acre pasture and the consequent removal of the taller growing, deeper rooted grasses prevented rapid use of the subsoil moisture. The silver sage was therefore able to obtain abundant moisture from the subsoil, and as a result it made a heavy growth and increased because of the reduced competition from other plants. The heavier growth of grass in the 100-acre pasture had exhausted the available moisture in the subsoil, and there was no increase of silver sage in it. After the subsoil moisture was exhausted by the heavy growth and increase of silver sage, it ceased to flourish in the 30-acre pasture. The importance of the role of soil moisture must therefore be considered as a part of the proper management of grazing land.

Table 2.—Number of plants of *Artemisia frigida* per square meter in the 100-acre and the 30-acre pastures, for different years, during 1915-40.

Pastures (acres)	Number of quadrats	Year listed							
		1915	1922	1924	1928	1932	1935	1938	1940
100	80[1]	5.0	7.5	8.3	8.2	4.0	8.8	3.8	2.6
30	80[1]	4.7	24.9	28.1	22.8	9.0	6.1	5.0	2.9
100	16[2]	51	60	66	85	44	77	4	3
30	16[2]	17	184	304	592	176	89	11	6

[1] Average number of plants.
[2] Total number of plants.

During the rapid development of silver sage the total number of plants in the heavily grazed area not only showed a heavy increase in number, but the individual plants increased in size over those in the lightly grazed pasture. The plants were taller, greater in diameter and produced more stems per plant. Figure 10 illustrates the size an individual plant attained. Measurements made in 1922, when the plants were near their peak of development, showed an average height of 220.8 millimeters, a diameter of 18.4 millimeters, and 11.8 stalks per plant in the 100-acre pasture, and a height of 272.8, diameter of 22.7, and 18.4 stalks per plant in the 30-acre pasture. It is clear that a heavy increase took place in the 30-acre pasture, compared to what may be considered a more or less normal condition in the 100-acre pasture. Even under normal conditions the numbers will fluctuate from year to year in the same area. Whenever some disturbing factor enters, such as intense continuous grazing in the 30-acre pasture, silver sage is ready to take advantage of the weakened condition of other species. This sage is bitter and cattle do not like it, refusing to eat it until forced to do so, because of the lack of all other feed. However, when the sage was at the height of its production in the early twenties, the cattle lost weight with an abundance of it available for feed. The abundance of this plant is shown in Figure 11, com-

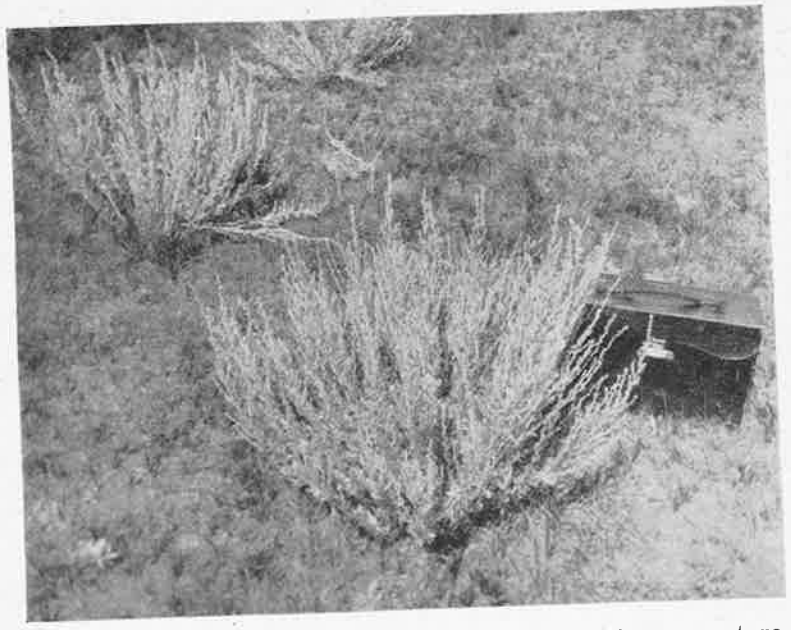

Figure 10.—Single plant of *Artemisia frigida* in the 30-acre pasture.

This plant was 18 inches tall, 4 inches in diameter, and produced 58 flower stalks. July 14, 1922.

pared to normal vegetation. It was not unusual to see stalks of this plant, that the cattle had pulled off and spit out, scattered over the pasture. They eat the young growth in the spring when it is mixed with new grass better than at other times. During the early phase of the experiment it was thought that the individual plants were long lived. A number of normal plants were staked in the fall of 1928. At the end of 6 years they were all dead. The population of this plant apparently changes rapidly, with changing conditions.

In order to emphasize the effects of overgrazing in relation to silver sage, the photographs in Figures 2 and 12 are presented for comparison. Figure 2 shows the vegetation in the 30-acre pastures before grazing in 1915, and Figure 12 shows the same area in 1923. The same area is again shown in Figure 13, following a favorable season, and Figure 14 shows it again following a year of severe drought. These clearly show the increase and decline of silver sage. The growth after a season of rest is shown in Figure 15. The plants attained a good size but the number was greatly reduced below what it was in 1923. A view of the same area is shown in Figure 16. No plants of *A. frigida* can be seen at this time. Shortly after 1920, plans were discussed for changing the system or rate of grazing in the 30-acre pasture. It was felt that the answer to the question of overgrazing had been established.

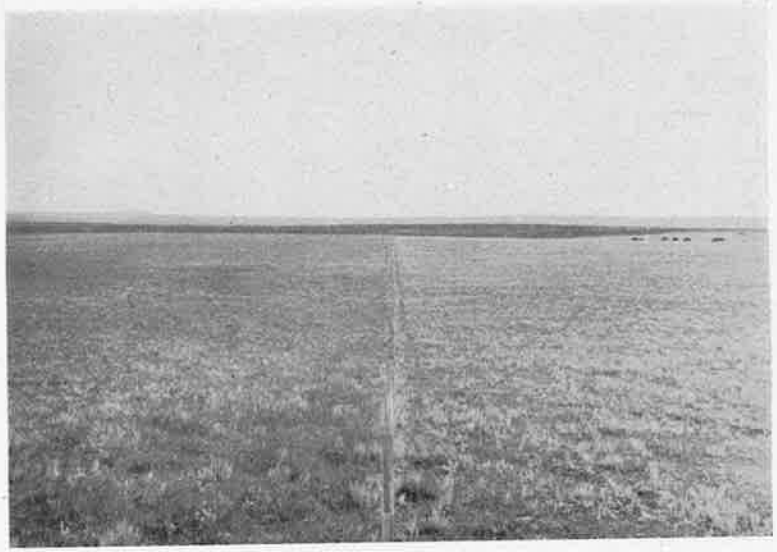

Figure 11.—View along fence line between 70-acre pasture (left) and 30-acre pasture (right).

Note the abundance of *Artemisia frigida* on right. The first indication of the weakening of the plants was noted during this season. July 22, 1924.

Figure 12.—*Artemisia frigida* in the 30-acre pasture.

Note the abundance and coarseness of the plants. There was an average of 25 plants per square meter recorded here during this season. July 17, 1923.

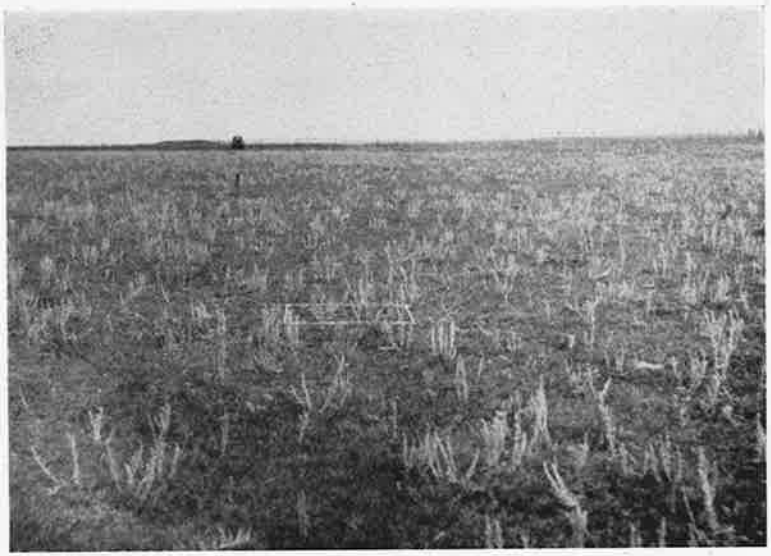

Figure 13.—*Artemisia frigida* in the 30-acre pasture during a favorable season.

This was the most growth made by it during the last 5 years. The number of plants were still twice as many per square meter as in any of the other pastures. July 15, 1932.

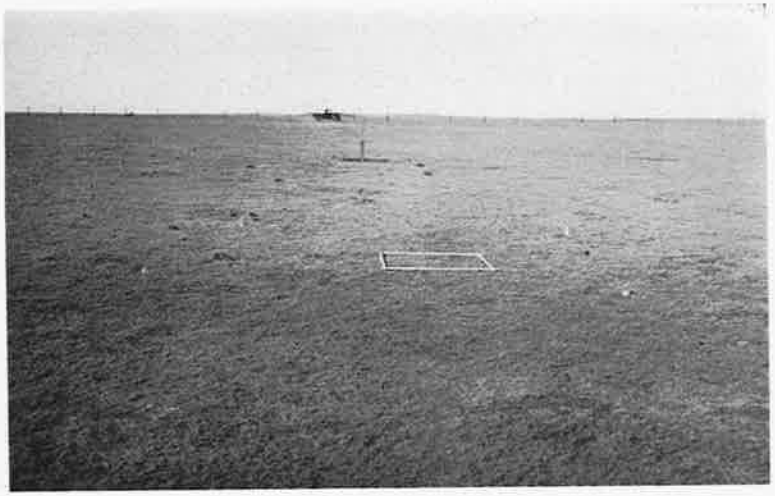

Figure 14.—Close grazing in the 30-acre pasture at the end of a drought year.

The steers were on this pasture only 55 days during the season. October 11, 1934.

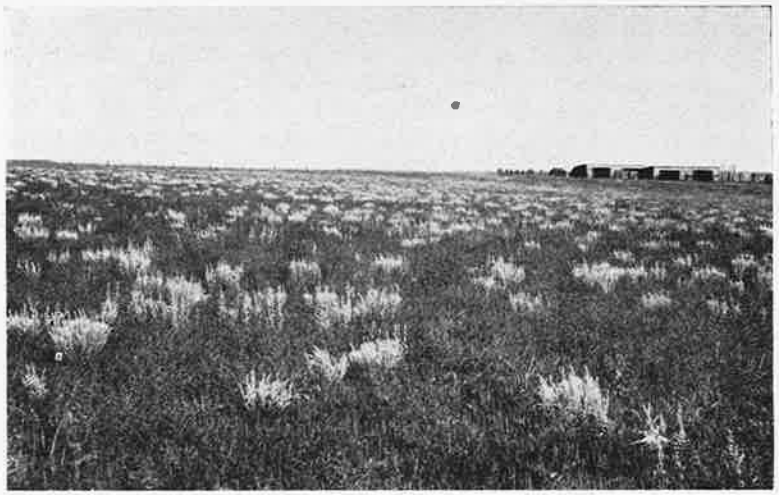

Figure 15.—*Artemisia frigida* and Russian thistles in the 30-acre pasture.

The thistles blew across this area and new plants were able to take advantage of the weakened condition of the other vegetation. The pasture was not grazed during the season. July 16, 1935.

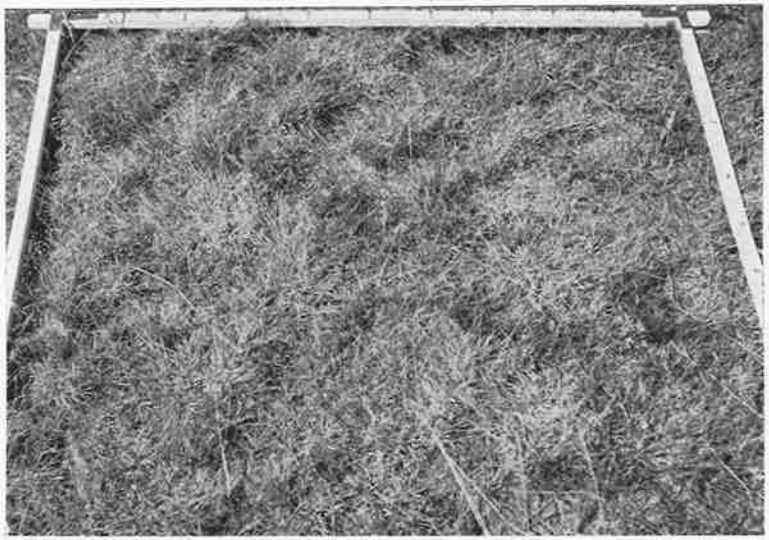

Figure 16.—Close view of quadrat in the 30-acre pasture.

Compare this with Figure 5 when the vegetation appeared to be nearly all dead. The cover is mostly blue grama. No plants of *Artemisia frigida* appear here. July 17, 1940.

The decline in the size of the plants became evident by 1925. It was pointed out that a change would be undesirable until it was clearly established what would take place under a continuance of the same rate of grazing. This illustrates the necessity and desirability of continuing a field of investigation of this nature over a long series of years. Had a change been made after 1925, a wrong conclusion would have been drawn from the results of 10 years of severe grazing in this particular pasture. Other factors such as drought and rest periods were introduced since that time, so that a complete answer is obscure at the end of 25 years.

In discussing degrees or intensities of grazing in this publication, it should be clearly understood that they are comparative between pastures. Severe or overgrazed pastures often mentioned here, would be considered excellent range as compared with some other areas in other parts of the region. Lightly grazed pastures are those wherein the vegetation has remained in more or less of a normal condition throughout the course of the experiment. Normally grazed areas are those that have furnished plenty of feed to allow the cattle to put on maximum gains, under normal conditions, without injury to the vegetation. Severely grazed pastures are those that are grazed so heavily that they cannot provide enough feed for the cattle to make normal gains, yet the vegetation is able to return to near a normal condition with rest periods. By overgrazing is meant that areas have been grazed with too many cattle on too few acres, so that some of the desirable species have been driven out. The time required to restore such an area to a normal grazing condition, would be longer than for pastures severely grazed.

The amount of native vegetation annually removed by grazing animals is highly important. The quantity of foliage cover on a pasture at the close of the season indirectly determines its grazing capacity under a system of continuous grazing. Table 3 shows the estimated percentage of foliage cover removed by grazing. The percentage cannot be shown for all years, but enough is shown to afford an idea of the intensity of grazing. The quantity removed is estimated, because any such method as mowing would disturb the condition of the pasture more than the annual

Table 3.—Estimated percentage of the foliage cover removed by grazing in the various pastures

Pasture (acres)	Cover removed by grazing (percent)					
	Two-year-old steers			Yearling steers		
	High	Low	Average	High	Low	Average
100	85	30	58	80	35	50
70	100	50	77	100	40	64
50	100	70	97	95	60	71
30	100	95	99	100	75	86
70 (Rot.)[1]	100	53	89	93	57	72
35 (Bromegrass)	100	85	94	100	50	74
7 (Crested wheatgrass)	100	60	87	95	40	65
12.5 (Crested wheatgrass)	—	—	—	95	40	65

[1] Including 1918 and 1919.

grazing. Clipping certain areas would afford an indication of the amount of forage remaining, provided enough such measurements could be made. Estimates have been made since the start of the experiment. If all vegetation were removed it was considered as 100 percent grazed. Other estimates were based on variations of this condition. Since it is not possible to show the estimates for all years in Table 3, the highest amount is shown for each pasture, along with the lowest, and the average, for both 2-year-old and yearling steers. In the 100-acre pasture the highest consumption, 85 percent, occurred in 1936, while the 70-acre was grazed 100 percent in 1934. The smaller pastures were often 100 percent grazed. In the rotation pasture an average of 89 percent of the vegetation was removed. This amount shows the higher utilization of the vegetation in this pasture. For the larger pastures the highest amount used usually occurred during July and August, while in the 50-acre pasture the highest was for June, July, and August. But in the 30-acre unit the highest was during May to July. The 70-acre pasture shows an average removal of cover of 77 percent, and the pasture normally carried the cattle with practically maximum gains. This fact shows that normally 20 to 25 percent of the vegetation should remain standing after the close of the grazing season, in order to avoid overgrazing under a system of continuous grazing. When the quantity of foliage cover removed approaches 90 to 95 percent, close grazing becomes necessary. Under such conditions, cattle cannot put on a maximum gain.

The accumulation of old growth sometimes creates an undesirable condition on ranges. A year or two of heavy growth may lead to uneven grazing and to a fire hazard. In some parts of the region this has occurred with favorable seasons. No trials have been conducted on burning of the old growth in connection with the grazing experiment. In some parts of the Plains this has been a general practice under conditions of an excess carryover of old vegetation. Trials on burning bluestem pastures in Kansas (*1*) have demonstrated that following years of heavy production, areas will not be grazed properly. From these trials it was suggested, if burning was to be undertaken that it should follow years of a heavy carryover of dead grass and be done only in the spring. Too much old grass in the native vegetation sometimes leads to reduced gains of cattle as they do not consume as much of it as they do of new grass which is more nutritious (*6*). This is also later shown by the chemical composition of samples of weathered grass. There was, however, no indication of lowered gains in the large pasture of this experiment, with 2-year-old steers at least.

There were few factors other than the grazing by cattle to influence the effects of grazing upon the vegetation. There were no rodents to consume enough vegetation to become an influencing factor. Damage to the vegetation by insects was slight throughout the course of the experiment.

Additional Investigations Relating to the Grazing Experiment

An experiment of the nature of the one under consideration involves numerous studies that have a direct connection with the grazing problems. A number of different studies were carried on during the course of the investigations. It is not possible to discuss each of these in completeness in the present publication. Some of them would afford material for a special discussion. Mention of them is made here as they are related to the investigations already discussed.

Soil Moisture determinations were made in the open pasture of the 100-acre and the 30-acre units. In addition determinations were made in the isolation transect of the 30-acre pasture. The soil samples were taken to a depth of 6 feet, in 1-foot sections. The soil was filled with moisture to the full depth of sampling at the beginning of the experiment. This was gradually depleted and the soil has not been filled since. There was less moisture in the 30-acre pasture after it became closely grazed than in any of the other locations. A higher moisture content was usually found in the protected area than in the others. The lighter-grazed 100-acre pasture normally carried more moisture in the spring than did the heavily grazed one.

Seeding trials on native sod were made by seeding different grasses directly into the native sod. In some cases the sod was first disked and seeding was done with a grain drill. In others, only the drill was used. Other trials were made by simply scattering the seed upon the sod. None of the trials were ever highly successful. In vegetation with a density of that in the pastures, such attempts are generally failures. Some success was attained by scattering seed and screenings of crested wheatgrass over the native sod in the fall. A few spots proved successful. When the native sod has been thinned out or depleted by overgrazing, a better practice is to regulate the rate of grazing so that the vegetation can recover by natural reseeding and normal growth. It is perhaps fortunate that such grasses as crested wheatgrass cannot be readily established in native sod. If they could be, the balance between them and native vegetation might be so upset that an abundance of feed would occur in the early season, without proper forage for grazing later in the season. Some places that were badly thinned out by the drought might be aided by artificial seeding. In such cases it would be better to use such native grasses as blue grama, western wheatgrass, or other species that normally are found on the range under consideration.

Mowing experiment: The mowing experiment phase of the studies was started for two reasons (1) to determine the quantity of hay annually produced, and (2) to determine the effects of annual and biennial mowing upon total production. The mowing experiment was started in 1919, but regular annual and biennial cuttings were not effective until 1921. It was suspended in 1934, when it was necessary to use the area for pasture, but has been reestablished since that time. The area consisted of 9 acres. One series of 3 acres was cut annually, each acre being weighed separately. On each side of the annual units were the ones cut once in two years. One series was mowed in even years (1940) and one in odd years (1939). The yield of hay in the annual units has averaged 310 pounds per acre. The range was from 29 pounds in 1926 to 652 pounds in 1924. In the biennial units the average for 13 years has been 736 pounds per acre. The range was from 348 pounds in 1931 to 1,385 pounds per acre in 1924. The yield averaged 2.37 times as much in the two-year units as it did in those mowed annually. This confirms the general view of farmers that they usually get more hay from areas cut only once in two years. The increase was not all accounted for by the growth of the previous year. The plants were larger and more robust in the biennial units, as shown by measurements over a series of years. From determinations made for similar clipped quadrats, the average percentage of old growth recovered was 39. The lowest percentage (8.9) of old growth was in 1935 following the drought of 1934, and the highest (91 percent) was in the drought year of 1936 following the heavy growth of 1935.

The annual yield of forage afforded a good idea of the amount of vegetation produced for grazing during a given season. The rest period afforded the biennial units, indicated the reason why the deferred and rotation system of grazing provided more feed for grazing, as it was apparent the same condition prevailed in each case. Hay from this experiment was used in a digestion trial at the North Dakota Agricultural Experiment Station (*6*). The results of this trial showed marked differences in palatability of hays cut at different periods. Hay cut in July was the most palatable, the October cutting next, and the April cutting the least palatable. The April cutting consisted entirely of vegetation produced the previous year.

Clipped quadrats: A series of "clipped quadrats" were established in 1917. The vegetation was cut, or clipped, close to the ground with a pair of roaching shears. It was clipped closer than it is possible for cattle to graze, but would simulate close grazing by sheep; care, however, was taken not to destroy the plant crown. This method of quantitative determination was adopted to obtain data on the period of most active growth of the different species and to determine the effect on subsequent growth of the frequency of removal of vegetation. The main object was to determine what species would be first to disappear under frequent clipping, and what ones would continue longest under severe abuse. It was thought the quadrats cut frequently would represent in some degree the heavily grazed pastures, while those cut less often would approach the lighter grazed pastures.

May 1 was fixed as the date from which the period for all clippings started. Clippings were made at 10, 20, 30, and 40-day intervals, and at the end of the season (annual). The end of the season was considered as near September 1, as very little growth normally takes place after that time. In 1921 a set of quadrats was included for biennial removal of the vegetation. In these the total amount of the old growth (that of the previous season) was recovered separately from that of the current year. The quadrats were 1 square meter in size and were cut in duplicate. It is recognized that no two square meters of native vegetation are exactly alike. However, the quadrats were located as uniformly as possible. The differences in amount of vegetation were not great enough to overcome the effects of different intensities or frequencies of clipping or to obviate the value of this method of analysis. All clippings were weighed in grams both green and after becoming air dry. It was not always possible to make clippings at the regular fixed intervals. During periods of drought or years of drought, there was frequently not enough new growth to clip. Sometimes only blue grama furnished enough growth for cutting. In 1936 there was not enough growth to cut on any of the quadrats, except those cut annually and biennially, and the amount on these was the smallest of record.

The average weights in grams and the percentages of the different species or groups are shown in Table 4. Only the quantity cut from the biennial quadrats is included for 1936, and over 90 percent of the total was the growth of 1935. No other methods of clipping were undertaken, as the density of the vegetation made the mechanics of the operations too great, with available facilities.

The quadrats clipped at 10-day intervals were discontinued at the end of 1921. This was largely because the results up to that time had been very similar to those in the 20-day quadrats.

A great deal of data was collected during the course of the clippings on the various quadrats. Only the averages can be shown in Table 4. The frequently clipped quadrats show a higher percentage of blue grama than do those cut only once a year. This fact shows why blue grama is so valuable for grazing in this area, as it makes frequent recovery after it is grazed. The production of it in the annual quadrats shows only its growth for the season. Height measurements were made at each clipping, and the total height growth for the season was more in the quadrats frequently clipped than in those cut only once a year. In some cases it was nearly twice as great. The total production of all species in the frequently clipped quadrats, however, was less than half that in those cut only once a year. Frequently clipped quadrats, in the prairie region of Nebraska showed a marked reduction in total forage as compared with one cutting (*35*). The percentages in the biennial quadrats are based on the total of all species including the growth of the previous season. The percentages are therefore less than those of the annual quadrats. Based only on new

Table 4.—Average annual quantity of vegetation produced by different species and groups of plants on quadrats clipped at different intervals, during the years, 1917-35

Species or Group	Weight and percentage designation	Quantity of vegetation per square-meter quadrat clipped at stated intervals									
		20 days[1]		30 days[1]		40 days[1]		Annual[2]		Biennial[3]	
		Green	Dry	Green	Dry	Green	Dry	Green	Dry	Green	Dry
Bouteloua gracilis	Grams[4]	39.91	22.81	50.99	**28.36**	40.84	23.51	25.47	19.38	28.83	21.93
	Percent	40.44	**49.26**	43.10	**49.96**	29.31	35.55	16.16	18.74	9.65	10.05
Stipa omata	Grams	2.51	1.51	4.19	2.46	4.89	2.96	17.12	13.38	23.99	17.40
	Percent	2.54	3.26	3.54	4.34	3.51	4.47	10.86	12.93	8.02	7.98
Other grasses	Grams	3.28	1.76	5.22	2.71	11.67	5.79	10.04	7.83	15.33	11.43
	Percent	3.32	3.80	4.41	4.77	8.37	8.75	6.37	7.57	5.13	5.24
Carex filifolia	Grams	9.83	5.10	9.29	4.87	16.56	8.76	21.26	**16.68**	17.59	13.83
	Percent	9.94	11.01	7.86	8.57	11.88	**13.24**	13.49	16.13	5.88	6.34
Carex heliophila	Grams	11.03	5.51	15.10	7.76	14.58	7.74	10.33	**8.08**	13.95	10.68
	Percent	11.17	11.91	12.77	13.67	10.47	11.71	6.55	7.81	4.67	4.90
Other plants	Grams	32.22	9.61	33.52	10.61	50.81	17.38	73.41	38.09	120.67	64.29
	Percent	32.59	20.76	28.32	18.69	36.46	26.27	46.57	36.83	40.38	29.49
Total all species	Grams	**98.84**	46.28	118.31	56.78	139.35	66.13	157.63	103.44	298.87	218.04
	Percent	100	100	100	100	100	100	100	100	100	100

[1]Covers the period 1917 to 1934 (18 years).
[2]Covers the period 1917 to 1935 (19 years).
[3]Covers the period 1921 to 1935 (15 years).
[4]Grams per quadrat can be converted to pounds per acre by multiplying by the factor 8.922.

growth they are very similar. The old growth recovered, based on the years of record, amounted to 39 percent.

The group of "other grasses" in Table 4 was made up of *Koeleria cristata*, *Agropyron smithii*, and *Muhlenbergia cuspidata*. In the earlier periods *Aristida longiseta* appeared in some of the quadrats. After 1931 there were practically no plants of the Carex species left in the 20- or 30-day quadrats. The "other plants" were made up mainly of *Artemisia gnaphalodes*, *A. dracunculoides*, and *A. frigida*. *Solidago pulcherrima* and *Psoralea argophylla* also appeared frequently along with other species that made up small amounts.

The effects of erosion were clearly apparent in the frequently clipped quadrats. Those cut annually and biennially did not show any erosion.

The clipped quadrats have clearly shown that blue grama stood up under frequent cutting better than any other species. The period of most active growth came during June and July, at the same time the cattle usually put on their highest gains. The nutritive content of the grasses was also highest during the same period.

A set of quadrats was established and first cut in 1920, in relation to the rotation pasture. One set was clipped when the cattle were turned into a given division and when they were taken out of it. Another set was cut only when the cattle were taken out of a division. The results showed that nearly 50 percent of the growth was made while the cattle were on the spring division.

With two exceptions, no growth was available for cutting when the cattle were taken off the fall division. The total average amount (dry weight) produced was very similar for the spring, summer, and fall divisions, or 33, 35, and 32 percent, respectively.

Isolation Transects: Areas that became known as "isolation transects" were set aside in the 100-acre and the 30-acre pastures and in one division of the rotation pasture. The transect was 300 feet long; one series of units (each 20 feet square) were opened to grazing each year, while another set on the opposite side was closed to grazing at the same time. The series through the center remained under complete protection. The transect in the 30-acre pasture is shown in Figure 17. The lower-growing plants such

Figure 17.—View across isolation transect in the 30-acre pasture showing the removal of foliage cover on either side, during the first season of grazing.

The bunches of grass in the background are *Aristida longiseta* that the cattle refused to eat. October 10, 1916.

as blue grama and niggerwool were eventually nearly eliminated by the taller growing species. This was brought about by the accumulation of old vegetation and shading by the taller species. This fact shows the danger of using areas that have long been under protection as an index of the former condition of the vegetation. This fact has recently been discussed for other areas (*10*). The effect of extra moisture is also a factor that may have a marked influence upon the subsequent growth and nature of the vegetation under such conditions. In the closely grazed pasture, the steers would reach through the fence for the vegetation. In

1923 woven wire was placed around the lower part of the fence (figure 18). Approximately 10 years later it was noted that a marked change was taking place in the nature and growth of the vegetation in the transect. Western wheatgrass began to increase in density and amount of growth as shown in Figure 19. In 1940

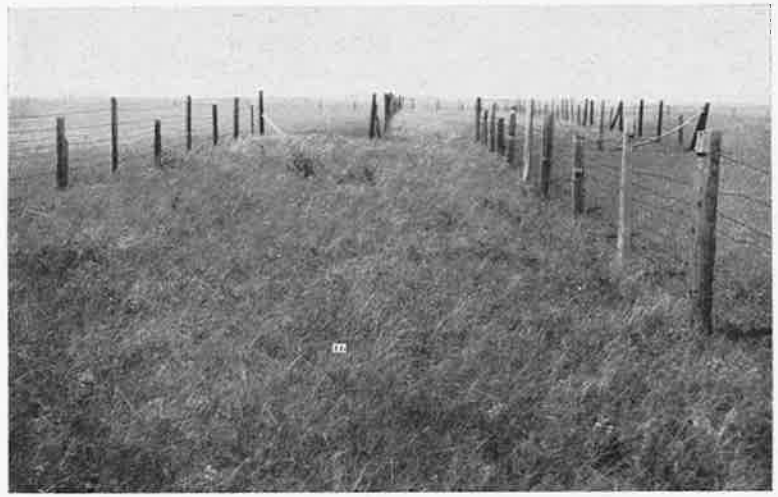

Figure 18.—Isolation transect in the 30-acre pasture.

Western wheatgrass had not increased noticeably by this time. Vegetation in foreground had been under protection since 1915. July 20, 1927.

Figure 19.—Western wheatgrass in isolation transect of 30-acre pasture.

This grass has increased rapidly here since 1934 because of extra moisture from snow trapped by the woven wire fence and the protected vegetation. October 8, 1937.

there was more western wheatgrass growing in the area than any other species. The increase and invasion of western wheatgrass has been reported in other areas (*29*, *37*). It is a fact often observed that western wheatgrass will increase rapidly wherever it receives an extra supply of water, such as by means of spillways under highways, or by water spreading systems. The woven wire fence and the protected vegetation acted as a snow-trap and accumulated extra moisture that benefitted the grass. Since the pasture was usually bare, the transect was the only obstruction encountered by the snow. The same condition did not hold true for the transect in the 100-acre pasture. The vegetation left standing in the lightly-grazed pasture acted as a barrier to the snow so that the transect did not collect so much of it, and there was no abnormal increase in the amount of western wheatgrass.

During the years before the effects of the western wheatgrass became pronounced, the 30-acre transect revealed a number of facts. *Artemisia frigida* remained practically normal in the central units that were never grazed. In the units that were opened to grazing annually *A. frigida* was normal when the units were opened but increased in size and number as grazing progressed. In those closed yearly to grazing, *A. frigida* decreased in size and number of plants as the units progressed under protection. The time required for the vegetation to reach a more or less normal condition was approximately 7 years in the units that were overgrazed and then placed under complete protection. This was true of other species besides *A. frigida*, such as blue grama, and niggerwool. The period required would be longer under more severe abuse from overgrazing.

Quantity of water consumed by steers: A number of determinations were made during the period from 1923 to 1927 on the amount of water used by the steers. Measurements were made of the daily amount consumed in two of the pastures during different periods. The results showed that during the heat of the season, July and August, the 2-year-old steers consumed 10 to 12 gallons of water per head daily. This indicates the need of an ample water supply at all times.

Chemical composition of the vegetation: Samples of native grasses, cultivated grasses, and other native plants were collected during the course of the experiment for the determination of their chemical properties. The samples were collected during different years and at various periods during the season. A previous publication (*12*) showed the composition of a number of native grasses and other plants, collected in the pastures of the grazing experiment, previous to 1930. In Table 5 is presented the analyses of a number of samples collected since the publication appeared. Determinations were made on a number of samples that do not appear in the table. Usually only early and late season samples are included, but intermediate determinations were made. The number shown is half of those collected. The table shows the

TABLE 5 . – Chemical composition of different grasses from the pastures of the Cooperative Grazing Experiment and field plots, Northern Great Plains Field Station, collected during the years 1930 to 1938 1/

(All samples calculated to 15 percent moisture content)

Species	Year of growth	Date sampled	Stage of growth	Ash	Crude protein (Nx6.25)	Ether extract	Crude fiber	Nitrogen free extract	Nitrogen	Phosphorus	Calcium	Magnesium
Agropyron cristatum	1930	–	Early fall	9.61	24.58	2.92	17.94	29.95	---	---	---	---
(Crested wheatgrass)	1931	–	Early fall	11.24	23.32	4.02	20.42	26.00	---	---	---	---
Do.	1931	4-7-32	Weathered	13.04	13.51	2.32	26.61	22.50	---	---	---	---
Do.	1931	7-17-32	Weathered	34.54	6.79	1.53	20.01	22.13	---	---	---	---
Do.	1932 2/	6-8	Full head	14.06	21.78	3.84	21.27	24.04	---	---	---	---
Do.	1932	4-19-33	Weathered	11.86	13.84	2.02	24.26	33.22	---	.112	---	---
Do.	1932	7-19-33	Weathered	33.83	6.94	1.50	20.78	21.95	---	.095	---	---
Do.	1933 2/	4-20	5 in. high	9.31	35.39	3.02	12.73	24.55	---	.436	---	---
Do.	1933	7-19	Mature	5.64	7.14	2.27	25.84	44.11	---	.111	---	---
Do.	1934	7-6	Growth 6-6 to 7-6	10.40	18.33	2.67	20.20	33.40	2.931	.204	.474	.178
Do.	1936	9-20	Growth 9-5 to 20	10.18	29.69	3.96	15.17	26.00	4.751	.353	.178	.297
Agropyron smithii	1932	4-20-33	Weathered	7.79	5.13	3.09	29.02	39.97	---	.111	---	---
(Western wheatgrass)	1932	7-19-33	Weathered	12.54	6.20	1.13	27.40	37.73	---	.105	---	---
Do.	1933	6-6	Early	7.16	19.66	3.36	20.98	33.84	---	.274	---	---
Do.	1933	7-19	–	6.60	13.26	4.13	23.66	37.33	---	.150	---	---
Do.	1934	7-7	Few heads	9.74	12.99	2.46	23.48	36.33	2.079	.179	.404	.131
Do.	1937	9-20-36	Weathered	10.31	3.77	.82	31.51	38.59	.603	.518	.076	.051
Andropogon furcatus	1932	4-20-33	Weathered	7.32	2.10	1.71	31.69	42.16	---	.101	---	---
(Big bluestem)	1932	7-19-33	Weathered	12.69	3.68	1.40	27.64	39.32	---	.069	---	---
Do.	1933	6-6	Very young	7.29	12.59	2.03	19.46	43.63	---	.270	---	---
Do.	1933	7-19	Heading	7.06	8.51	2.13	24.84	42.46	---	.178	---	---
Do.	1933	8-17	Late bloom	7.26	3.65	2.09	29.07	42.91	---	.142	---	---
Boutelous gracilis	1931	2-26-32	Weathered	12.16	5.10	1.65	24.98	41.11	---	---	---	---
(Blue grama)	1931	10-6-32	Weathered	10.10	5.46	1.16	28.38	38.90	---	---	---	---
Do.	1932	6-1	Very early	6.78	11.02	1.57	24.49	41.16	---	---	---	---
Do.	1932	9-10	Mature	9.35	5.41	2.08	25.38	42.78	---	---	---	---
Do.	1932	4-19-33	Weathered.	11.53	4.17	1.22	25.66	42.42	---	.060	---	---
Do.	1932	6-14-33	Weathered	13.41	5.31	1.57	24.15	40.57	---	.075	---	---
Do.	1933	5-25	Very early	9.13	11.67	1.04	23.95	39.21	---	.185	---	---
Do.	1933	6-14	Near maximum	7.11	11.67	1.60	22.79	41.83	---	.221	---	---
Do.	1935	8-27	Drying up	8.42	6.87	1.39	25.84	42.48	1.100	.097	.346	.110
Do.	1938	9-1	Mature stems	7.17	4.81	2.08	29.63	41.31	.769	.355	.100	.156
Do.	1938	9-1	Mature leaves	10.95	4.73	1.76	26.33	41.23	.757	.595	.133	.141
Do.	1938	11-11	Mature stems	5.65	2.65	1.22	33.51	41.97	.423	.317	.055	.058
Do.	1938	11-11	Mature leaves	10.41	3.66	1.57	28.29	41.07	.586	.481	.094	.083
Bromus inermis	1930	–	Early fall	9.49	24.50	3.90	15.75	31.36	---	---	---	---
(Smooth bromegrass)	1931	–	Early fall	11.49	22.14	3.88	19.10	28.39	---	---	---	---
Do.	1931	4-7-32	Weathered	11.16	10.86	1.56	25.20	36.22	---	---	---	---
Do.	1931 2/	7-17-32	Weathered	16.50	3.71	1.17	28.25	35.37	---	---	---	---
Do.	1932 2/	6-8	Full head	11.55	17.53	2.99	22.53	30.40	---	---	---	---
Do.	1932	4-19-33	Weathered	7.74	10.52	2.01	24.46	40.27	---	.099	---	---
Do.	1932	7-19-33	Weathered	9.49	2.84	1.30	31.12	40.25	---	.028	---	---
Do.	1933 2/	4-20	3 in. high	10.26	33.58	3.45	13.51	24.18	---	.594	---	---
Do.	1933	7-19	Mature	6.26	9.28	2.72	26.52	40.22	---	.134	---	---
Do.	1934	7-6	Growth 6-6 to 7-6	10.13	21.01	3.84	19.22	30.80	3.362	.240	.518	.262

1/ Data furnished through the cooperation of T. H. Hopper, Agricultural Chemist, N. Dak. Agricultural Experiment Station.

2/ Samples from field station plots.

high protein content of crested wheatgrass in its early stage of growth in both spring and fall. The protein content is nearly as high as in some concentrated feeds. The protein declines rapidly as the grass approaches maturity. When fully mature its composition does not differ greatly from the straw of some of the grain crops. It appears to deteriorate more rapidly from weathering than many of the native grasses. During an open winter such as that of 1940-41, it furnishes a lot of good feed. The fall of 1940, in many places, was favorable for starting new growth, and much of this remained in good condition for winter use. The samples of blue grama show a high protein content when the grass is in prime condition for grazing during the earlier part of the season. In 1938 when it produced a heavy growth and seed crop, samples of both mature leaves and stems were collected. It will be noted that the protein content of the stems was low, and somewhat below that of the leaves. Similar samples were collected later and the following spring before new growth started. These determinations, however, are not available for inclusion in the table.

A series of samples of crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) and Russian wild-rye (*Elymus junceus* Fisch.) grown in 42-inch rows were collected for chemical analyses during the season of 1939. Samples were collected from May 8, when new growth was approximately 7 inches high, until October 12, when growth was approximately 7 inches high, until October 12, when all the plants had been mature for nearly 3 months. A total number of seven progressive samples were collected for each species, at intervals of about 2 weeks until July 19. After this date only the October samples were obtained. Samples were also collected of new growth made after the original and following samplings. In some cases as many as seven samples were collected from the same area. The different cuttings showed clearly that Russian wild-rye made more recovery and new growth during mid-season than did crested wheatgrass. This is one reason why grazing trials are being started with Russian wild-rye, in comparison with crested wheatgrass, and the reason it has been included in a pasture mixture.

Complete chemical determinations on the samples are not available for inclusion in Table 5. Protein determinations have been completed for study.[4] These determinations indicated that crested wheatgrass carried more protein than did Russian wild-rye from May 8 until just before flowering on June 7, approximately equal on June 21, and less on July 5 and 19, while Russian wild-rye dropped nearly 1 percent at the late sampling. The range in protein content for crested wheatgrass was 25.19 percent on May 8 to 9.25 percent on October 12. The Russian wild-rye samples ranged from 23.34 percent on May 8 to 8.38 percent on October 12. The results would likely differ with samples from solid plantings for pasture.

The composition of the various species show they are highly nutritious for grazing animals during most of the season. Practically all species decrease in nutritive value as they approach maturity. Big bluestem appears to decline more rapidly than other native species. The cultivated grasses decrease more rapidly in nutritive value than most native ones. This is the main reason why cultivated grasses are more valuable for early season grazing than at other periods of the year. The cattle put on their highest gains during the time the grasses contain their highest nutritive content, as shown in the various tables of steer gains.

Plan of the Grazing Experiment

The basic plan of the grazing experiment as outlined in 1915 has been continued during the 25 years with some additions and modifications. The arrangement of the pastures as they were during 1940 is shown in Figure 20. Four of the native pastures follow the system of continuous grazing. The cattle have access to the same area during the whole season. These pastures are 100, 70, 50, and 30 acres in size and were grazed at the rate of 10

[4] Data furnished through the cooperation of E. P. Painter, Agricultural Chemist, North Dakota Agricultural Experiment Station.

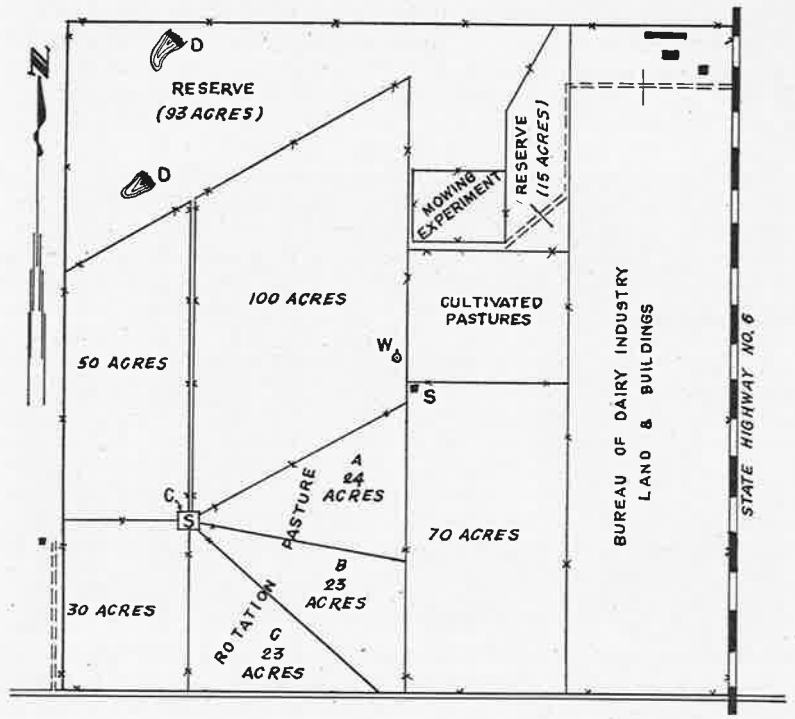

Figure 20.—Field plan of The Cooperative Grazing Experiment pastures, as they appeared in 1940; C, corrals; D, dams; S, sheds; and W, deep well.

(Drawing furnished through the cooperation of the Soil Conservation Service, Area Office, Mandan, North Dakota. J. L. Schlanser, area draftsman.)

steers to each pasture or one steer to 10, 7, 5, and 3 acres, respectively. Different intensities of grazing were obtained by a variation in the size of the pastures rather than in the number of cattle grazed per pasture. It was planned to have one pasture large enough so that it would normally be undergrazed, and one small enough so it would be overgrazed. The 250 acres comprising the four pastures were fenced in 1915, and grazed for approximately 115 days with fifty-three 2-year-old steers. The cross fences between the various pastures were constructed during the fall of 1915, and grazing of the pastures started in the spring of 1916. The four pastures have, therefore, been grazed under the continuous system for 25 seasons, from 1916 to 1940, inclusive, except as later described.

Continuous grazing of the native vegetation does not allow it any protection from the stock during any part of the growing season. When the cattle are turned into a pasture in the spring

they are able to pick out the choice grasses each year at about the same period of growth. By doing this they eventually kill out some or all of them. A continuous system of grazing does not allow for the best requirements of plant growth, nor does it afford the most efficient utilization of the vegetation during the grazing season.

In order to overcome to a marked extent the disadvantages of continuous grazing, a "deferred and rotation" system of grazing was added. This system of grazing was put into effect by the addition of a 70-acre "rotation pasture" in 1918. Rotation grazing was not new when this experiment started, as it was discussed at least as early as 1895 (*30*), and later in further detail (*14, 19*).

It was desired to compare the grazing value of some cultivated pasture plants with native vegetation. In 1921 a field of bromegrass was established adjoining the pastures. A 10-acre tract of the bromegrass was broken in the fall of 1924 and seeded to sweetclover in the spring of 1925. Crested wheatgrass came into prominence as a grass well adapted to the northern Plains, and 7 acres of bromegrass were broken in the fall of 1931 and seeded to crested wheatgrass in the spring of 1932. Other cultivated pastures have been added since that time and are described later.

The pasture designated as the "reserve" is used to carry the cattle before the experiment opens in the spring and after it closes in the fall. It is also used to carry extra steers during the grazing season. These are held in reserve for use in case of accident to any of those in the regular pastures.

The value of this precaution has been demonstrated during several different years. Whenever a steer was injured or became sick, it was possible to replace him with a normal animal and complete the season on a given pasture with the regular number of cattle. During two seasons cattle were struck by lightning. The reserve pasture was also used to carry the cattle from any of the pastures that became so short of feed that the stock had to be moved before the end of the grazing season. A smaller reserve pasture was used in connection with the cultivated pastures. The steers in the large reserve pasture are supplied with water from a dam shown in Figure 21, and another one constructed later (figure 22). The rolling nature of this part of the grazing section is well illustrated in these figures.

Sheds and corrals were constructed at the intersection of the four continuously grazed pastures in the fall of 1915. The wagon scales for weighing the cattle were set alongside one of the sheds. A deep well was drilled at the center of the section. A supply tank was provided, and water was piped to a trough at the intersection of the four corrals. Pipe lines were extended to other pastures as they were established. The sheds were for the use of the cattle as they desired. Sometimes they are used extensively,

depending upon various factors. They are desirable but not essential. Brush and trees are available for shade in the reserve pasture.

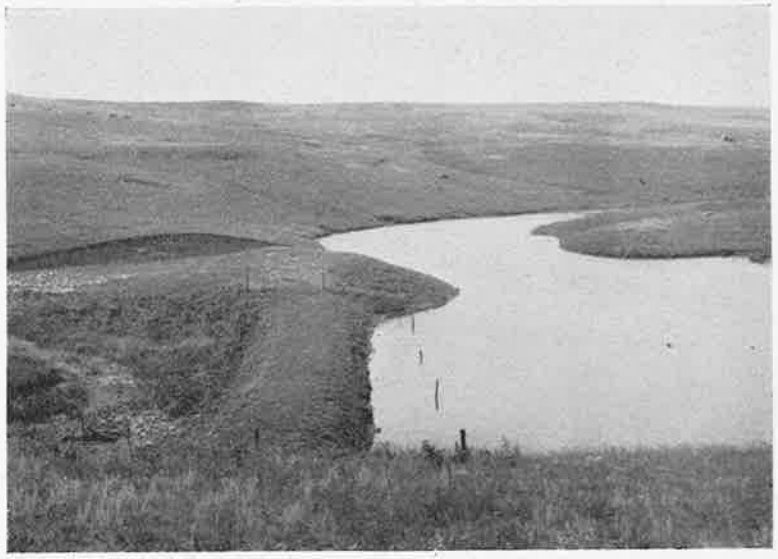

Figure 21.—Dam constructed in the fall of 1923 in the reserve pasture.

The nature of the rolling country is clearly seen here. The dam furnishes water for the reserve steers. August 12, 1924.

Figure 22.—New dam in reserve pasture constructed in 1933.

This was the first dam built in this vicinity under the direction of the CCC. Note the rolling nature of the land. October 9, 1933.

The period of grazing was set for 5 months during the season from the middle of May to the middle of October. The grazing season opened May 11 in 1939; May 21 in 1921, 1922, 1930, and 1938; May 26 in 1917, 1923, 1924, 1936, and 1937; at the beginning of June in 1916, 1919, 1920, and 1935; all other years the opening date was May 16. The opening date was set near the middle of May in order to avoid so far as possible the damage caused by early spring grazing. The average date of opening has been May 20 and the closing date approximately October 18. During this period the native vegetation makes its active growth and the livestock make their greatest increase in weight. Winter grazing is not taken into consideration in this experiment. With the production of more feed on land that was broken up for wheat production, there is little need to depend on winter grazing, which is often hazardous in this section of the Plains because little natural protection is afforded. Under special conditions winter grazing is successfully practiced in certain districts, especially where older steers are run.

Cattle Used in the Experiment

In an early publication (*26*) dealing with the grazing experiment, Prof. Shepperd stated: "One of the first factors to be determined in this trial seemed to be that of the unit of measure in pasturing with cattle. The 2-year-old beef steer was decided upon as the unit, as (a) he seemed to be the unit most used by ranchmen figuring on this question; (b) he has about the average capacity for consumption between yearlings, cows, and large steers; and (c) he is not disturbed like the heifer by periods of oestrum or by calving during the trial."

The cattle were furnished by the North Dakota Agricultural Experiment Station. They were purchased each year by the State Station and shipped to the Sunny stockyards just west of Mandan, or trailed to the pasture when distance permitted, and during recent years they have been delivered at the pasture by truck. Sometimes the cattle were bought on the St. Paul, Minnesota, market, and once in 1935 following the severe drought of 1934, on the Kansas City market. More often they were purchased from ranchers or farmers in this vicinity or a little farther west in the State. The kind of 2-year-old steers used were mixed lots of the standard beef breeds for the 15 years 1916 to 1930, as shown in Figure 23. The predominating breeds most usually represented were grade Angus, Herefords, and Shorthorns, as such lots were ordinarily more readily obtainable. It sometimes happened that one or two were purebreds. For the 5 years beginning with 1931 and including 1935, the entire lot for each year was high grade Hereford steers. One year (1933) about half of the lot were purebreds. The type of steers used during this period are shown on the front cover which pictures the steers on the 100-acre pasture in 1931. Usually the steers were from herds where a purebred bull was used on grade cows. They were shipped after the close

Figure 23.—Type of 2-year-old steers used during 1916-30.

These were on the 70-acre pasture. Grade Angus, Herefords, and Shorthorns were in the lot. October 16, 1923. (The type of 2-year-old Herefords used from 1931-35 appears on the front cover. These were on the 100-acre pasture in 1931.)

of each grazing season, sometimes direct to market in Chicago, St. Paul, or West Fargo, but more often to the Agricultural College where they were carried on feeding experiments for varying periods.

Dr. Trowbridge, Director of the North Dakota Agricultural Experiment Station from 1918 to 1934, had been desirous for some time to carry on slaughter trials in connection with steers used in the grazing experiment. It was not possible to do this until 1933, when the first slaughter trials were made. These were continued in 1934 and 1935, and with yearling steers in 1936. At each weighing period, two steers were trucked to Fargo, where the slaughtering and other determinations were conducted. The results of these investigations are in readiness for publication.

The average spring weight of a 2-year-old steer was considered at approximately 750 pounds. The average weight of the steers actually started on the 100-acre pasture for the 20 years was 748 pounds. The weight for the other pastures was approximately the same, as all lots each year were divided as uniformly as possible according to weight for each pasture.

The average weights ranged from 678 pounds in 1922 (following a severe winter) to 834 pounds in 1935. The average weight per head was 765 pounds the first 5 years (1916-20), 723 pounds the second 5 years (1921-25), 734 pounds the third 5 years (1926-30), and 771 pounds the fourth 5 years (1931-35), when all Herefords were used. One year (1922) the average was below 700

pounds, 10 years it was between 700 and 750 pounds, 7 years between 750 and 800 pounds, and 2 years (1919 and 1935) over 800 pounds.

Difficulty was occasionally experienced in obtaining the class of cattle desired for the experiment, as they were ordinarily purchased in the spring of the year, when ranchers were reluctant to dispose of them. In 1916 it was necessary to purchase part yearlings and part 2-year-olds. Records were kept of the weights and gains of each class. The gains appearing in the tables for that year are based on the 2-year-olds as they were distributed throughout the different pastures. A similar experience occurred in 1918, when it was again necessary to purchase part yearlings and part 2-year-olds. A further complication occurred in 1918 by the fact that it was necessary to include about half heifers in the lot. The gains for 1918 were computed to a 2-year-old basis by using the gain per head obtained. During the 2 years that part yearlings and part 2-year-olds were used in the experiment, the number of cattle per pasture was increased in order to bring the total initial weight up to approximately 7,500 pounds.

A modification was made in the grazing experiment starting in 1936 and continuing through 1940. High grade yearling Hereford steers were substituted for the 2-year-olds previously used. This change was made because for some time more yearlings than 2-year-olds had been selling on the market as feeders. The type of yearlings used during this period is shown in Figure 24. The steers were purchased in the spring of 1936-37 by the State Experiment Station. Because of a shortage of funds, it has not been

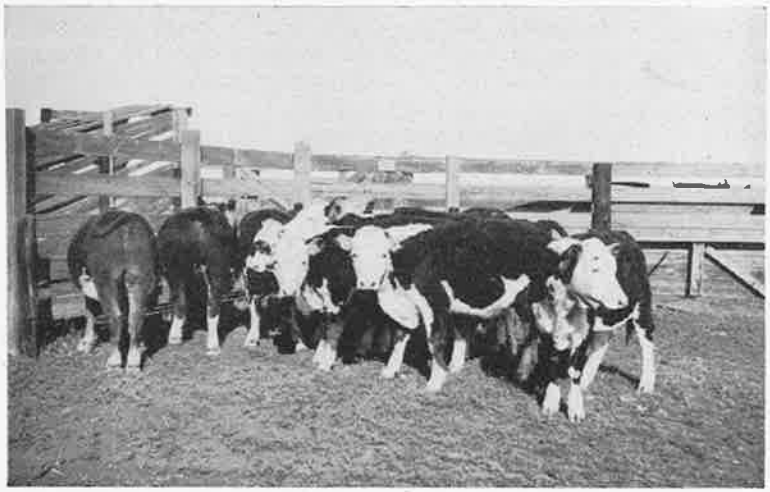

Figure 24.—Yearling steers showing the type used since the change was made to younger stock.

This lot grazed the 50-acre pasture during the season. September 13, 1940.

possible for the State to purchase the cattle since that time. The steers have been borrowed from a large ranch just north of Mandan. The same number of yearlings were grazed in each pasture as were 2-year-olds previous to 1936. This was done in order to determine, in-so-far as possible, the relation between the consumption of grass of the two ages and sizes.

The results of the 5 years 1936-40 clearly indicate that the yearlings do not have as great a capacity for the consumption of grass as do 2-year-olds. From the amount of feed left in the pastures each season, it is apparent that the number of yearlings should be increased by 30 to 40 percent in order to approximate the 2-year-old consumption of forage. Even with this number the starting weight per pasture would average much less than for 2-year-olds. Since 1936 was the driest year of record, very little new growth appeared in the pastures that year. From data obtained in the clipped quadrats, over 90 percent of the native vegetation available for grazing was that of 1935. During 1936 practically all the vegetation was removed by the cattle from the larger pastures. Therefore, in 1937 these pastures started out on an even basis so far as the amount of forage remaining in them was concerned. Since 1936 more vegetation has been left in these pastures by the yearlings than was normally left by 2-year-olds, in spite of the fact of a thinning out of the vegetation by drought. Figures 25 and 26 show the vegetation left by yearlings at the close of the season in 1939 in the large and the small pastures. The small pasture was normally grazed for the season. Further

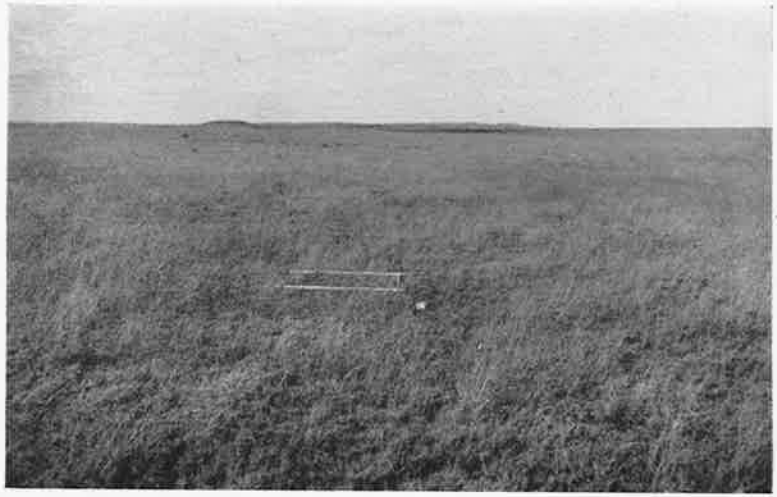

Figure 25.—Amount of foliage cover remaining at end of season in the 100-acre pasture after 155 days of grazing by yearling steers.

It was estimated that 35 percent of the vegetation was removed in this pasture by grazing. Practically no weeds appear here this year. Compare with Figure 7. October 9, 1939.

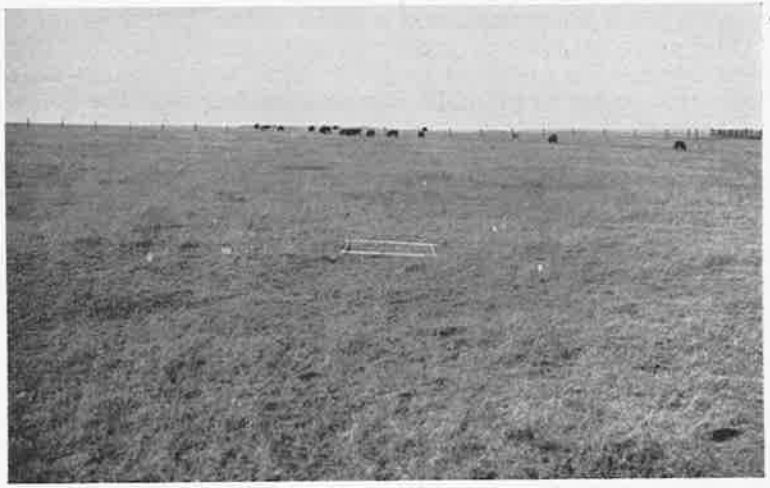

Figure 26.—Amount of foliage cover remaining at end of season in the 30-acre pasture, after 155 days of grazing by yearling steers.

It was estimated that 75 percent of the vegetation was removed in this pasture by grazing. Practically no weeds appear here as in the 100-acre unit. October 9, 1939.

mention of the amount of foliage cover consumed will be found under the discussion of each pasture.

The average initial weight of the yearling steers when started on pasture was 474 pounds per head. This was about 63 percent of the average weight of the 2-year-olds. This percentage was not far from the relationship in the consumption of forage. The range in average initial weights of the yearling steers was from 439 pounds in 1940 to 514 pounds in 1938.

The cattle were wintered as a rule under ordinary farm conditions. They therefore did not enter the grazing season under conditions that would be either to their advantage or disadvantage. They were in normal and thrifty condition when the grazing season opened. An effort was always made to obtain as uniform a drove of steers as possible. Over the period of years, the cattle averaged near to those that are found on many farms and ranches.

The cattle were provided with salt in all pastures throughout the season. In the larger pastures, the salt box was placed at the far side of the pasture. The importance of the location of salt on the range has been discussed in a special publication (*4*). During recent years the cattle have been supplied with bone meal. They have made free use of it during all seasons it has been available.

Weighing the Cattle

The cattle were weighed at regular intervals throughout the grazing season. This is a highly important feature in an experiment of this nature. Since the main source of information in the experiment is through the cattle, their response to the different intensities of grazing is of the highest importance. Their weights and gains were determined in a similar manner to those in experimental feed lots.

The cattle were weighed on three consecutive days at the beginning and close of the grazing season, or at the termination of grazing on a given pasture. Should a storm or some other factor intervene, the weights of 2 days were used, or another weighing made, if possible. During the 25 years of the experiment, few such instances occurred.

Whenever the initial and final weighings were made, a member of the Animal Husbandry Department from the State Experiment Station was usually present and graded the steers on the basis of feeders. The grading of the steers was first undertaken in the spring of 1923. Prof. J. H. Shepperd, Chairman of the Department, usually did the grading during the earlier years, and was succeeded by Prof. E. J. Thompson during the later ones.

The average of the three weighings was determined for the initial and final weights. The other weighings throughout the season were made on one day. If the weights at the end of any period appeared abnormal in any respect they were checked the following day. It sometimes happened that a given lot refused to drink, or became too thirsty and then overfilled before weighing. Since the steers were quite regular in their grazing, resting, and watering habits, all weighings were made in the afternoon at each period, so that the cattle were usually well filled. The steers had free access to water at all times and were not weighed unless it was certain they had been given an opportunity to drink.

After the average initial weights were obtained, the steers were separated into groups for the various pastures. The total weights for the different lots were made as nearly equal as possible for those pastures grazed with the same number of steers. A proportionate weight was selected for other pastures where the number differed. Other factors were also taken into consideration in dividing the cattle. The aim was to obtain as nearly comparable groups for each pasture as possible, based on weight, breed, and grade.

Whenever the grazing season opened in May, the next weighing was made on May 31. The following weighings were made at the end of regular 30-day intervals. The final weighings were made so that the last period completed 150 days, unless the length of season was modified because of feed shortage or other reason. Weighings were made at the stated periods so that the gains or losses would correspond to the months, upon which practically

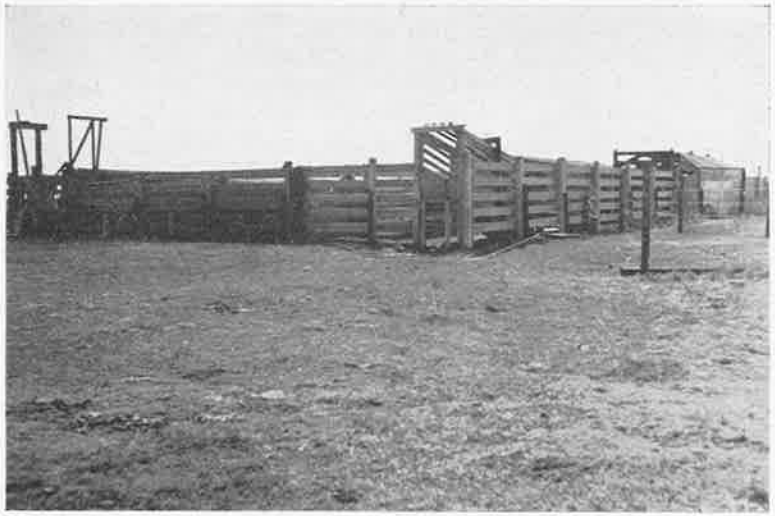

Figure 27.—Corral, branding chute, loading chute, and scales.
The scales are protected from wind on all sides. April 11, 1941.

Figure 28.—Scales with rack for weighing steers.

The gates are operated from the outside by means of the ropes and pulleys. The gate automatically locks by means of a spring catch. May 28, 1941.

all seasonal records are based. The 28-day period commonly used in feed-lot experiments was not adopted, because it was desired to keep the records on a monthly basis. In an experiment of this nature the gains for "June" or any other month carry much more weight and significance than the gains for the "second or third periods".

Figure 27 shows the main corral used for cutting out the cattle that make up the various lots, and through which all steers pass to a smaller corral leading onto the scales. The scales and the rack upon them are shown in Figure 28. The gates to this rack are operated from the side of the rack near the scale box by means of ropes and pulleys. These gates not only add to the convenience in weighing the steers, but the cattle are less disturbed during the process of weighing, as no one appears before them to open and close the gates. The scales are protected on all sides from the wind.

Gains of the Cattle[5]

When this experiment was started it was not definitely known how much gain per steer the native forage of this locality was capable of producing, under normal grazing conditions. From the 20 years' grazing record with 2-year-old steers, it has been definitely established that a maximum gain of over 300 pounds per head can be normally expected. This gain is based upon those obtained in the larger pastures where plenty of forage was normally available during the summer grazing period of five months. A grazing experiment has been conducted in Canada (*32*) for a number of years. The gains of 2-year-old steers at that point averaged nearly 50 pounds per head higher than those in the 100-acre pasture in this experiment. The period of grazing in Canada extended from April 1 to November 15. Two-year-old steers gained over 50 pounds per head less than those in the 100-acre pasture in a grazing experiment conducted in southwestern South Dakota (*3*), with about a 10-day shorter grazing season.

The relation between the quantity of native forage available for grazing and its influence upon their seasonal gains has been clearly shown by the cattle. They are a reliable indicator of the condition of a pasture or range. If the cattle put on reasonable or near normal gains, it was evident that the range was not overgrazed. But if the gains were low, it was just as clear that the cattle were short of feed and had to graze a short range. Such a practice, if continued too long, can lead only to overgrazing and deterioration of the range.

It is recognized that the cattle take on a "fill" early in the season that appears as gains. It is further recognized that with the approach of cold weather in the fall they "shrink". If there be

[5] The discussion of gains is based mainly upon those of 2-year-old steers. Yearling steers have not been run long enough to establish the normal gain that may be expected. For purposes of discussion and comparison, a gain or loss of 20 to 25 pounds per head is considered significant.

objection to recording the fill as a gain, the same objection should hold in registering the shrink as a loss. Since it is not within the power of the experimenter to entirely control either, they must stand as recorded. However, as previously mentioned, the steers are usually held on reserve grass several days before they are started on the various pastures. The response of the cattle to different intensities and systems of grazing and the vegetation prevailing in a locality is best expressed by means of their pounds of gain. The changes in weight of the cattle throughout the season, and their gains during different periods of the season were recorded regularly throughout the 25 years of this experiment. The steers in the 100- and 70-acre pastures in particular, show higher gains during the early part of the season. The gains decrease as the season advances, and in October they are very light or even show a loss. The low gains during this time do not mean that seasonal grazing should be discontinued at the end of September. The fall period is the time of transition or adjustment of cattle between summer and winter. It is the time when the cattle put on the "finish" so often referred to by stockmen, which is apparently a hardening process brought about through a reduction in the quantity of water that they drink, the dry feed they eat, and a change in the condition of the flesh. If cattle are without food or water for 24 hours in the fall they will "shrink" less than they would during the same length of time earlier in the season when their body contains more water than it does in the fall.

Tables are presented to show the gains of the steers for each pasture in this experiment for each year it was in operation. Other publications (*23*, *26*, *28*, *31*) have shown the nature of the experiment and the average gains of the steers, but gains for individual years were not included. The tables in this bulletin contain a vast amount of information that can be presented most effectively only in tabular form. Each year is a story in itself of vegetation, steers, climatic conditions such as rainfall, heat, and drought, and insects affecting both animals and plants. The story of seasonal climatic influences is found under a special section, but that of the steers appears in the tables. The tables show only gains or losses of the steers and are not complicated by the inclusion of initial or final weights. These are only incidental in the present study but are given consideration elsewhere. The tables are presented in such a manner that any one can use them for special studies to cover different periods, series of years, or combination of years. The tables furnish all the essential information necessary to show clearly the influence of different intensities of grazing, kinds of vegetation, and systems of grazing on the gains of the steers. The different seasonal conditions also appear as factors affecting the production of beef under range conditions. The averages for different months of the season are included, along with the total gains for the season, the average gain per head, daily gain per head, gain per acre (total or average), and the total days grazed per season. The average gain per 100 pounds liveweight is not included in the tables, but the averages are shown in a separate table.

All the gain factors (monthly, seasonal, total, per head, daily, and per acre) shown are significant, but some of them are more valuable than others as the best measure of a pasture or system of grazing. If too much emphasis or dependability is placed on the wrong factor of gain, erroneous conclusions are likely to be drawn from the figures appearing in the tables. For example, the gain per acre is the factor most often emphasized in a discussion of pasturing results. Sometimes it is the only factor taken into consideration to show the value of a pasture or system of grazing. The gain per acre (either per head, total per pasture, or total per acre), however, has little or no value in itself. Gain per acre is correlated with the size of the pasture, or the number of acres grazed, and not the gains of the cattle. This point was discussed in an earlier (1923) bulletin, (*23*), dealing with this experiment. The data accumulated since that time only confirm and intensify the facts then presented. Of the four pastures continuously grazed with 2-year-olds, the highest gain per acre on native vegetation was made by the steers in the 30-acre pasture, as shown in the tables of gains. Yet it does not follow that this is the best pasture or that the most desirable or dependable system of grazing was practiced in its management. The 30-acre pasture was low in all other gain factors and in the average days grazed. The gains in the rotation pasture were equal in per acre gain, and significantly higher in all other gain factors and in average days grazed. The fact is clear that the high gain per acre in the 30-acre pasture was not the result of the cattle doing exceptionally well, but because they made all of their seasonal gain before the end of July, or in less than 70 days, on a smaller acreage than contained in any of the other native pastures.

If the gain per acre is to be accepted as the sole measure of the efficiency of a grazing system or for the production of beef, then a low gain per head must be accepted, and the stock must be disposed of by midseason. A system of grazing that requires the disposal of cattle at this time cannot be commended. The cattle are not ready or in the best condition for market, nor is it desirable to start them in the feed lot so early in the season. If they are moved to another pasture, it would be much the same as putting them on a larger acreage in the beginning. The steers grazing the 30-acres were removed from their pasture as soon as they showed a decided or significant loss in weight. This fact contributed to their high gain per acre. It is obvious that had they been forced to remain on their pasture long enough, the result could have equalled no gain, or even a loss if they survived.

When a loss in weight occurred during the season, it was seldom recovered by the close of the grazing period. A loss caused by some minor injury, usually was later recovered, provided

plenty of feed was available for grazing. In cases wherein it was necessary for the steers to graze a pasture closely, their final gains were permanently reduced. This fact is well illustrated by the performance of the steers in the 30-acre pasture. During practically all the years, it was necessary to remove them to the reserve pasture before the close of the grazing period. From 1917 to 1933 (1934 is excluded because of the very unfavorable season) the average length of the grazing season was 149 days in the 100-acre pasture. The 30-acre steers grazed their pasture for an average period of 110 days, during the 17 years. During this time their average gains were 161 pounds per head on their pasture, and an additional 75 pounds for 39 days on the reserve pasture. For the same periods, the steers in the 100-acre pasture gained averages of 275 pounds and 34 pounds. The steers from the 30-acre pasture gained well on the reserve pasture, but they could not recover the 114 pounds lost while grazing a short range during the earlier part of the season. The steers from the 30-acre pasture did not fail to gain on the reserve pasture during any of the years they completed the season on it. Their gains on it ranged from 11 pounds per head in 1924 (10 days) to 154 pounds in 1926 (90 days). That year they lacked 74 pounds per head of equaling the gains in the larger pasture. For the same periods the gains of the steers in the 100-acre unit ranged from -9 (there were four cases when they showed a loss) in 1932 to 125 pounds per head in 1926.

In order that the cattle may produce the maximum gain per head, the acreage must be large enough so they will have an abundance of feed before them throughout the season. A high gain per head is an essential necessary to meet the growth requirements of younger cattle, or to produce grass-fat beef for market.

The gain factors just discussed do not take into consideration another result of grazing that is of paramount importance. The effect of grazing upon the vegetation was not given an equivalent place in the discussion. Grass is the raw material upon which a rancher is dependent for his welfare, and the stock for their maintenance and gains. Should the grass fail for a single season, as it did in 1934, disaster follows. In arriving at the determination of the proper grazing capacity of a pasture, range, or system of grazing, the vegetation must be given relative consideration. In a previous publication (*23*) dealing with this grazing experiment this statement appeared: "therefore, the most efficient system of grazing is one that will insure sufficient forage during the entire season to produce the greatest total gain, with the least number of cattle on the minimum unit of land, without permanent injury to the native vegetation." In order to determine such a combination of factors, actual results must be obtained under controlled grazing. The results of 25 years of such determinations are discussed under the individual pastures.

Grazing Capacity of the various Native Pastures

The investigations in connection with this experiment are not completed, even though they have been in operation for 25 years. Some modifications have been made, and more are likely to be made in the future. But it is likely the basic plan will be continued. The results of the next 25 years may be of more value and significance than those of the past 25 years. The results to the present time are of much value as a guide to the effects of different systems and intensities of grazing upon the vegetation and the cattle utilizing it. Grazing cattle on the native grasses has been in progress in some part of what is now North Dakota since it was settled by the white man. Therefore, the past 25 years and the next 25 are in reality a comparatively short period. It is doubtful that the intensive grazing, if continued in the smaller pastures, will allow the vegetation to recuperate enough to permit 2-year-old steers to make maximum gains even under a series of most favorable years, if grazed at the same rate as practiced during the past 25 years.

It may sometimes appear that the grazing capacity of the vegetation, as measured by the effects of different intensities of grazing, is antagonistic to the most economical gains of the cattle and to efficient range management. However true this might appear, the two must eventually go together. The cattle are entirely dependent upon the native vegetation for their food supply while grazing. Any system or intensity of grazing that will allow the range plants to continue their maximum seasonal production will be reflected in the gains of the cattle. The greatest immediate profit may not be realized by the most efficient system of grazing. Grass can be heavily pastured for a few seasons, with apparent profit. But the cumulative effect of such a practice may so reduce any following benefits, that the apparent profits will more than be absorbed. The influence of overgrazing may be reflected not only in the immediate gains of the cattle, but cows under such conditions may drop fewer calves, the following season. Results in Montana (*13*) show that as an average for 5 years a 73 percent calf crop resulted on overgrazed range, 84 percent on that moderately grazed, and 80 percent on a lightly grazed range. The weaning weight of the calves averaged 197, 257, and 248 pounds, respectively, when pro-rated to all the cows in each lot. It takes more time for a range to be brought back to normal grazing capacity than it does to destroy the vegetative cover. This would be especially true, should a few dry years combine with overgrazing. The income to a rancher can be spread over a long series of years, provided attention is paid to the proper grazing of the range or pasture.

A guide to the proper use of the native range is found in the results of grazing presented in a discussion of the individual pastures.

The 100-acre Pasture

The 100-acre pasture was grazed at the rate of one 2-year-old steer to 10 acres for the 20 years 1916-35. It has been undergrazed on the average. This was shown by the high gains of the steers, the condition of the vegetation, and the amount of it annually removed by grazing. There has not been a marked change in the nature of the vegetation from its composition in 1915, except that brought about through factors other than grazing. Fluctuations in volume of production took place from year to year depending upon climatic conditions, mainly precipitation. This pasture was in practically as good condition for grazing at the end of 1935 or 1940 as it was when the experiment started. The severe droughts of 1934 and 1936 caused a serious decrease in the amount of needle-and-thread and Junegrass. This, however, was not because of grazing, as the same grasses suffered as badly under complete protection. It is clear that this rate of grazing for a period of 5 months has not injured the vegetation. Neither has the vegetation benefited by the light grazing. If anything it may have deteriorated slightly because of under grazing, but not in the same manner as other pastures have suffered by overgrazing. This deterioration is shown by the increased coarseness of the "weeds" during favorable seasons, and the accumulation of old vegetation, which the cattle avoid whenever possible. It was pointed out in a previous publication (*6*) dealing with this experiment, that steers on digestion trials would not eat as much hay with old growth in it, as they did hay cut from new growth. At no time during the 20 years was it necessary to move the cattle from this pasture because of feed shortage. The cattle were moved before the close of the grazing season in 1933 and 1934, but this was because all other pastures were exhausted and all cattle were shipped. The pasture would have carried the steers another 15 days in each of these years.

The gains of the steers in this pasture are presented in Table 6. These require little discussion, except to point out some things the table cannot show. The low gain in 1917 was due mainly to cold weather that occurred in October. This was true of the gains in all pastures. The only loss in September during the 20 years occurred in 1921. This was caused by a rain and cool weather that extended over several days before the middle of the month. The field note book for that time showed the cattle were weighed after the storm, and lost heavily during the first 15 days of the month, and they did not recover from it as well as did those in some of the other pastures. The low gain in July 1923 was caused by the worst infestation of flies during the 20 years. This condition was true on ranches in this area, and less cattle than normal were shipped from them. These steers did not regain the loss during the rest of the season. The season of 1926 was the worst drought experienced up to that time, so far as the production of forage was concerned. The steers, however, put on a near-normal

Table 6.—Monthly and seasonal gains of ten 2-year-old steers on native range at the Northern Great Plains Field Station for the 20 years 1916-35, and of 10 yearling steers for the 5 years 1936-40

100-ACRE PASTURE[1]

Year	Total gains or losses (—) in pounds										Total days grazed
	Monthly						Seasonal				
	May	June	July	Aug.	Sept.	Oct.	per pasture	per head	per head daily	per acre	
1916	...[2]	925	775	500	640	60	2,900	290.0	1.93	29.0	150
1917	120	1,195	580	370	520	—370	2,415	241.5	1.56	24.2	155
1918	395	670	745	620	545	95	3,070	307.0	1.98	30.7	155
1919	...	1,330	500	470	440	120	2,860	286.0	2.04	28.6	140
1920	...	1,370	630	500	465	20	2,985	298.5	1.99	29.9	150
1921	525	1,015	540	780	—190	355	3,025	302.5	2.02	30.3	150
1922	560	1,100	840	355	500	35	3,390	339.0	2.26	33.9	150
1923	310	1,085	440	690	260	25	2,810	281.0	1.87	28.1	150
1924	145	1,145	1,055	665	340	— 30	3,320	332.0	2.21	33.2	150
1925	250	950	910	455	220	175	2,960	296.0	1.97	29.6	150
1926	555	840	750	255	545	85	3,030	303.0	2.02	30.3	150
1927	535	980	790	590	600	30	3,525	352.5	2.35	35.3	150
1928	590	645	585	750	400	— 60	2,910	291.0	1.94	29.1	150
1929	625	1,035	845	420	235	—130	3,030	303.0	2.02	30.3	150
1930	420	1,100	685	170	475	155	3,005	300.5	2.00	30.1	150
1931	1,055	925	835	600	485	—150	3,750	375.0	2.50	37.5	150
1932	770	940	660	480	500	— 95	3,255	325.5	2.17	32.6	150
1933	690	945	810	510	205	...	3,160	316.0	2.34	31.6	135
1934	590	1,020	720	710	85	...	3,125	312.5	2.31	31.3	135
1935	...	2,005	380	855	555	—135	3,660	366.0	2.52	36.6	145
Average[3]	508	1,061	704	537	391	10	3,109[4]	310.9	2.10	31.1	148
1936	340	595	490	— 45	...	...	1,380	138.0	1.45	13.8	95
1937	375	755	690	660	330	250	3,060	306.0	2.19	30.6	140
1938	500	495	425	660	230	250	2,560	256.0	1.77	25.6	145
1939	515	660	575	500	300	100	2,650	265.0	1.71	26.5	155
1940	650	900	420	605	330	— 20	2,885	288.5	1.92	28.9	150
Average	476	681	520	476	298	145	2,507[4]	250.7	1.83	25.1	137

[1]This pasture was continuously grazed for the periods indicated at the rate of 1 steer to 10 acres.
[2]A blank space indicates the pasture was not grazed during that period and is not included in computing averages.
[3]Average for days grazed during monthly periods; May (12), June (30), July (30), August (30), September (30), and October (21).
[4]These averages do not equal the sum of the monthly averages, because the grazing periods were not uniform.

gain. The favorable season of 1925 afforded a carryover of feed. The driest year of the 20 was 1934, yet in both 1926 and 1934 the gains of the steers in this pasture were practically normal. The drought had little effect on the gains so long as the steers had plenty of grass, even a carryover of old grass. The pasture, however, was grazed closer in 1934 than at any time previous. The highest gain during the 20 years was in 1931 and can be accounted for by a good bunch of steers, the high gain in May, and above average gains for three of the other months. While the production of forage was not so good as in many other years, the season was favorable, there were few flies, and it was not extremely hot. The loss in October was caused by a cold spell during the final weighing period. The average gain per head in the 100-acre pasture was the highest obtained, but it was only slightly above that of the steers in the 70-acre pasture. The size of the pasture forced it to return the lowest gain per acre.

The results of 20 years of grazing 2-year-old steers at the rate of 1 steer to 10 acres for five months show the acreage was too high for this period. The pasture was normally undergrazed, as determined by the amount of vegetation left in the pasture at the close of a normal grazing season. The average amount of foliage cover removed for the 20 years was 58 percent. The range in quantity was from 30 percent in 1916 to 85 percent in 1934. Two acres per month furnished more feed than necessary to allow the steers to produce their maximum gain per head. However, it would not be quite enough for a 12-month grazing period, because the pasture was grazed during the time the vegetation made its maximum growth. It would require about 2.2 to 2.4 acres or slightly over per month for year-long grazing under this system and rate of use.

The gains of yearling steers are also shown in Table 6. The period of 5 years is too short a time to establish definitely the maximum gain per head that may normally be expected from a yearling steer. The pasture was grazed with the same number of yearlings as 2-year-olds previous to 1936. The season of 1936 was the hottest and driest year of record in this vicinity and over most of the northern Plains. It was the only year the pasture failed to carry the steers for the full grazing period. The loss of weight in August showed the pasture was closely grazed. Very little new growth of vegetation was produced in 1936, and the steers were practically dependent on the carry-over from the favorable production in 1935. Disregarding 1936, the average gain per head was practically the same as that of 2-year-olds for the lowest 4 years that may be selected out of the 20. The only year the yearlings came near to equaling the average gain per head of 2-year-olds was in 1937. This followed the heavy grazing in 1936 when practically all the old vegetation was removed from the pasture. The favorable season of 1937 for the production of new forage likely provided the steers with feed that they relished, and the fact that October was exceptionally favorable so that no loss was recorded allowed the steers to put on this high gain. From the 5 years of grazing by yearlings it is clear that they do not consume as much forage as do 2-year-olds. The average amount of foliage cover removed by the yearlings during the 4 years 1937-40 was estimated at 43 percent, compared with an average of 58 percent by 2-year-old steers during the 20 years.

The 70-acre Pasture

The 70-acre pasture was grazed at the rate of one 2-year-old steer to 7 acres, during 20 years from 1916 to 1935. The amount of forage produced was ample to allow the steers to put on near the maximum gain per head. For all practical purposes this pasture is a duplicate of the 100-acre one. The results relating to vegetation and cattle have paralleled each other during most of the years.

The native vegetation has not been injured by prolonged heavy grazing. This fact is shown by the condition of it throughout the years and its high survival following the severe drought. As

was true in the larger pasture, needle-and-thread and Junegrass were weakened and thinned out by the drought. But this was not due to overgrazing previous to that time. Other plants such as white and green sage were not driven out by this rate of grazing, and silver sage did not make an abnormal increase or growth at any time.

From 1916 to 1929 or 14 years this pasture occupied the 70 acres where the rotation pasture is now located. The substitution was made in the spring of 1930. The determining factor that prompted this change was to afford better watering facilities for the steers in the rotation pasture. The change did not materially affect the gains of the steers, so that no break is shown in Table 7. As was true with the larger acreage, the cattle have averaged somewhat greater gains since all high grade Herefords were used, starting in 1931. This pasture has not been overgrazed, nor has it shown the same effect of undergrazing that is somewhat apparent in the larger pasture. Under this rate of pasturing, an excess of forage was provided during favorable seasons, and, in the poorer years, the amount of feed produced was sufficient to carry the usual number of steers without overgrazing or undue loss in gain. When extremely dry years occur, such as those experienced in 1934 and 1936, the herd must be reduced by early disposal or removal to a source of feed supply. It is possible to determine early in the season if a normal supply of grass is likely to be produced. The amount of early precipitation is a fairly accurate indicator of the possibilities of seasonal feed supply.

In order to protect a pasture from vegetative injury under a system of continuous grazing, it is necessary that normally 20 to 25 percent of the vegetation remain standing at the close of the season. In areas that contain higher percentages of unpalatable vegetation, this amount would need to be based upon the more valuable forage species.

The gains of 2-year-old steers are shown in Table 7 for the 20 years. These generally followed closely those in the 100-acre pasture. Forage was sufficient to carry the cattle the full season during all years, except for the severe drought of 1934 when it failed at the end of 120 days. Compared with the gains of steers in the 100-acre pasture there was the same low gain in 1917 and only a light gain in September 1921 while the 100-acre steers registered a loss. The total difference for the season was not particularly significant. A low July gain was shown by both in 1923. In 1926 the gain in the 70-acre pasture was significantly lower than that in the 100-acre pasture. The 70-acre pasture was closely grazed that year, and the cattle showed as much loss in October as there was gain for those in the larger pasture. While this pasture was closely grazed in 1933, it probably would have carried the animals another 15 days without undue loss in weight. The flies and mosquitoes were extremely severe during July 1935 and the gains for that month were only about half of normal.

Table 7.—Monthly and seasonal gains of ten 2-year-old steers on native range at the Northern Great Plains Field Station for the 20 years 1916-35, and of 10 yearling steers for the 5 years 1936-40

70-ACRE PASTURE[1]

Year	Total gains or losses (—) in pounds										Total days grazed
	Monthly						Seasonal				
	May	June	July	Aug.	Sept.	Oct.	per pasture	per head	per head daily	per acre	
1916	...[2]	1,035	885	610	635	— 50	3,115	311.5	2.08	44.5	150
1917	140	1,010	445	555	370	—390	2,130	213.0	1.37	30.4	155
1918	595	1,055	575	330	495	130	3,180	318.0	2.05	45.4	155
1919	...	1,510	420	700	310	50	2,990	299.0	2.14	42.7	140
1920	...	1,350	690	495	595	— 70	3,060	306.0	2.04	43.7	150
1921	560	990	590	750	100	185	3,175	317.5	2.12	45.4	150
1922	580	1,110	920	400	380	25	3,415	341.5	2.28	48.8	150
1923	395	1,105	440	645	330	0	2,915	291.5	1.94	41.6	150
1924	265	1,125	860	580	510	—130	3,210	321.0	2.14	45.9	150
1925	490	655	720	460	230	135	2,690	269.0	1.79	38.4	150
1926	320	1,085	630	295	510	— 80	2,760	276.0	1.84	39.4	150
1927	630	1,010	765	540	560	150	3,655	365.5	2.44	52.2	150
1928	440	740	670	780	450	—100	2,980	298.0	1.99	42.6	150
1929	610	1,060	845	560	165	—155	3,085	308.5	2.06	44.1	150
1930	370	1,025	710	330	450	145	3,030	303.0	2.02	43.3	150
1931	965	1,050	830	630	385	—150	3,710	371.0	2.47	53.0	150
1932	700	960	700	540	420	—165	3,155	315.5	2.10	45.1	150
1933	695	875	730	625	145	...	3,070	307.0	2.27	43.9	135
1934	650	815	970	320	— 15	...	2,740	274.0	2.28	39.1	120
1935	...	1,860	340	945	520	— 80	3,585	358.5	2.47	51.2	145
Average[3]	525	1,071	687	555	377	— 31	3,083[4]	308.3	2.08	44.0	148
1936	305	615	440	— 15	...	...	1,345	134.5	1.42	19.2	95
1937	320	850	525	1,000	240	95	3,030	303.0	2.16	43.3	140
1938	505	465	370	780	230	160	2,510	251.0	1.73	35.9	145
1939	445	730	635	480	350	60	2,700	270.0	1.74	38.6	155
1940	625	870	420	605	260	0	2,780	278.0	1.85	39.7	150
Average	440	706	478	570	270	79	2,473[4]	247.3	1.81	35.3	137

[1]This pasture was continuously grazed for the periods indicated at the rate of 1 steer to 7 acres.

[2]A blank space indicates the pasture was not grazed during that period and is not included in computing averages.

[3]Average for days grazed during monthly periods; May (12), June (30), July (30), August (30), September (29), and October (21).

[4]These averages do not equal the sum of the monthly averages, because the grazing periods were not uniform.

This was also true in the larger pasture. The total gain for the year was high, largely because of the good gain in June. The cattle in 1935 had very little feed available in the reserve pasture in early spring. They failed to gain during the time they were on the reserve area, and gained rapidly as the grass improved early in June.

The results of grazing this pasture show that an area of 7 acres per head grazed during the season of maximum vegetative production has provided approximately the required forage to graze a 2-year-old steer continuously for 5 months. But it does not follow that a monthly rate of 1.4 acres per head would be sufficient to carry an animal for a period of 12 months. The progressive increase of forage removed increases after the cessation of its normal growth. The requirement would be over 1.5 times this amount. The rate of grazing practiced in this pasture permitted the steers to gain near the maximum number of pounds as measured by the average return in the 100-acre pasture. The

average amount of foliage cover removed by grazing was 77 percent, ranging from 50 percent in 1916 to 100 percent in 1934.

The gains of yearling steers as presented in Table 7 were very close to those in the 100-acre pasture during each year. There was not a significant difference during any year nor in the average. As was true in the larger pasture the younger steers did not average as high gains or consume as much forage as did 2-year-olds.

Since 1936 was the poorest year of record, the gains for that year are of minor value. In 1937 the smaller pastures were not grazed. Therefore, the comparison for the 3 years 1938-40 are most significant. The average gains in the smaller pastures for the 3 years were not greatly different than those for the 70- or 100-acre pastures.

The 5 years 1936-40 average amount of foliage cover removed by grazing was 64 percent. The range in amount was from 100 percent in 1936 to 40 percent in 1939. For the 3 years 1938-40 it averaged 47 percent.

Close grazing of the 70-acre pasture in the dry year of 1936 is shown in Figure 29. The same general close grazing took place in all pastures during that year.

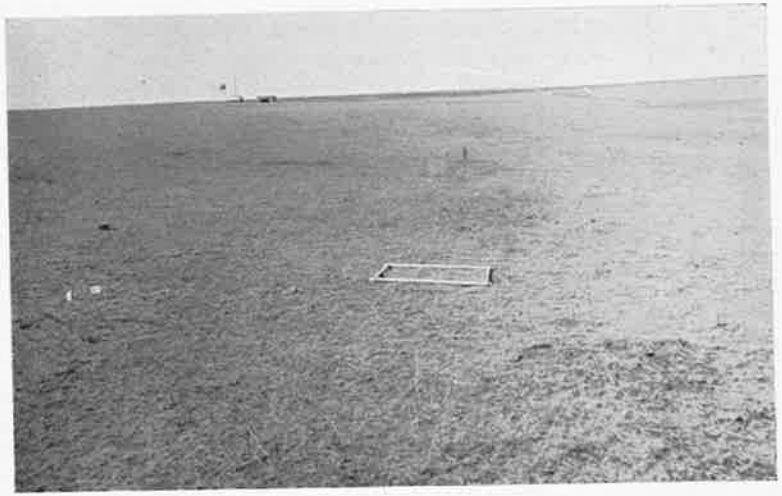

Figure 29.—Close grazing in the 70-acre pasture at the end of the season of the most severe drought of record.

This pasture was the most severely grazed during its 25 years. September 9, 1936.

The 50-acre Pasture

The grazing rate in the 50-acre pasture was one 2-year-old steer to 5 acres, during the 19 years from 1916 to 1934. It was not grazed in 1935. This was not a planned part of the experiment but was brought about by a shortage of funds to purchase the full requirement of steers for the season. It was felt that the smaller pastures could rest for a season without greatly interfering with the experimental results. It now appears that this rest was an unfortunate interruption of the progress of the experiment. The conditions that followed and the change to another class of steers provided a combination that cannot be measured in terms of vegetative use or recuperation.

A modification was made in the use of this pasture during the 3 years 1932-34. It was desired to determine what effect supplemental feeding of cottonseed cake would have on the gains of the steers. They consumed 1.7 pounds of cake per head daily in 1932, 1.3 pounds in 1933, and 2.2 pounds during 75 days in 1934. They were started off each year with a small amount, that was increased as they became accustomed to eating it. The only year that the cake seemed to be effective was during the favorable season of 1932. The gains of these steers that year were practically equal to those in the larger pastures. The use of cake was discontinued, as it did not appear that it could make up for a shortage of forage, and its expense did not justify its continuance. Also, when grazing was resumed in this pasture in 1936, a change was made in the class of steers used. It was thought that in 1932 the probable increased gain due to the use of cake just about paid for the amount consumed. It is recognized that the gains for the 3 years are included in the averages of the 19 years. The average gains as they stand are significantly higher than those of the smaller pasture. They are lower than the gains of the rotation pasture grazed at the same rate as this unit. The exclusion of the years when cake was fed would not change the relative position of the gains of the steers.

In 1934 the cattle were not started on the 50-acre pasture until July 1. There was practically no feed available at the opening of the season. It is likely it would have been necessary to remove them in a short time had they been started in this pasture. One good rain occurred in June, and some growth started, which was practically all used by the steers before the end of July.

Overgrazing adversely affected the vegetation in the 50-acre pasture during practically the full 19 years of its use. This condition was indicated by the increase in the number of plants of silver sage, the reduction and near elimination of needle-and-thread, Junegrass, white sage, green sage, and other plants. Blue grama was thinned out and weakened more than it was in any of the other native pastures. This condition was most apparent in the spring of 1935.

The gains of 2-year-old steers in the 50-acre pasture are given in Table 8. Too heavy grazing in this pasture resulted in average gains lower than those made in the larger pastures. During the first 2 years, the supply of feed was ample, but after that a shortage of forage made it necessary to remove the steers from the pasture before the end of the grazing season six times. The necessary close grazing tended to obscure the effects of seasonal influences on the gains of the steers.

The comparative gains of most interest and value are with those of the rotation pasture, where the same average rate of grazing was practiced. The average gain per head was significantly lower for the 50-acre pasture. In Table 8 will be found average gain factors for three different periods. These are for purposes of direct comparison with a similar table for the rotation pasture. It is of value to note that all gain factors are less for the steers in the continuously grazed pasture. Further comparisons will be found under the discussion of the rotation pasture.

Table 8.—Monthly and seasonal gains of ten 2-year-old steers on native range at the Northern Great Plains Field Station for the 19 years 1916-34, and of 10 yearling steers for the 4 years 1936 and 1938-40

50-ACRE PASTURE[1]

Year	Total gains or losses (—) in pounds										Total days grazed
	Monthly						Seasonal				
	May	June	July	Aug.	Sept.	Oct.	per pasture	per head	per head daily	per acre	
1916	...[2]	1,290	1,010	485	490	—210	3,065	306.5	2.04	61.3	150
1917	165	1,180	520	695	— 80	—320	2,160	216.0	1.39	43.2	155
1918	550	930	530	370	495	—180	2,695	269.5	1.74	53.9	155
1919	...	1,150	430	850	30	—230	2,230	223.0	1.59	44.6	140
1920	...	1,290	440	435	115	— 60	2,220	222.0	1.64	44.4	135
1921	450	1,150	630	570	—220	—305	2,275	227.5	1.52	45.5	150
1922	600	1,135	840	445	205	—125	3,100	310.0	2.07	62.0	150
1923	320	965	225	820	195	—400	2,125	212.5	1.42	42.5	150
1924	155	1,155	930	655	410	—400	2,905	290.5	1.94	58.1	150
1925	285	730	830	365	170	85	2,465	246.5	1.64	49.3	150
1926	365	715	220	—220	...	...	1,080	108.0	1.03	21.6	105
1927	585	925	955	640	290	—210	3,185	318.5	2.12	63.7	150
1928	400	535	640	890	305	—280	2,490	249.0	1.66	49.8	150
1929	390	1,170	850	285	—145	—265	2,285	228.5	1.52	45.7	150
1930	280	1,075	600	— 55	—420	...	1,480	148.0	1.14	29.6	130
1931	950	1,105	570	405	—420	...	2,610	261.0	1.93	52.2	135
1932	725	985	720	430	490	— 75	3,275	327.5	2.18	65.5	150
1933	700	770	925	120	—260	...	2,255	225.5	1.80	45.1	125
1934	...	...	875	5	—240	...	640	64.0	0.85	12.8	75
1935	...	...	...	...	...	...	.....	.....	....	....	...
Average[3] ...											
1916-34	461	1,014	671	431	78	—213	2,344[4]	234.4	1.67	46.9	140
1918-34	483	987	659	412	63	—204	2,313[4]	231.3	1.68	46.3	138
1927-34	576	938	767	340	— 50	—208	2,278[4]	227.8	1.71	45.6	133
1936	400	630	335	120	...	...	1,485	148.5	1.56	29.7	95
1937	...	...	...	...	...	...	.....	.....	....	....	...
1938	425	515	470	565	185	— 90	2,070	207.0	1.43	41.4	145
1939	560	675	565	400	170	45	2,415	241.5	1.56	48.3	155
1940	635	1,000	385	615	320	40	2,995	299.5	2.00	59.9	150
Average	505	705	439	425	225	— 3	2,241[4]	224.1	1.65	44.8	136

[1]This pasture was continuously grazed for the periods indicated at the rate of 1 steer to 5 acres.
[2]A blank space indicates the pasture was not grazed during that period and is not included in computing averages.
[3]Average for days grazed during monthly periods (1916-34); May (12), June (30), July (30), August (30), September (29), and October (20). Period 1918-34; averages for same years the rotation pasture was grazed, and 1927-34 years that rotation pasture was grazed with an even 14 steers.
[4]These averages do not equal the sum of the monthly averages, because the grazing periods were not uniform.

It was evident that the 50-acre pasture deteriorated from the 19 years of heavy grazing. The vegetation has not been ruined, but its productivity has been lowered to such an extent that several years of judicious management would be required to restore it to normal grazing capacity. The low gains of the steers also reflect the heavy grazing rate.

From all information available it appears that the present density of the vegetation is lower in this pasture than in the 30-acre one. This fact is not necessarily in conflict with the size of the two pastures. The 50-acre pasture was grazed for a longer period on the average, the cattle put in more time traveling over it, and they grazed a short range for a longer time. The vegetation, therefore, received more abuse than that in the smaller pasture. The foliage cover removed by grazing averaged 97 percent. The range in percent was from 70 in 1916 to practically 100 for all other years.

The rate of 1 acre per head monthly was not enough to allow a steer to put on a maximum gain during a period of 5 months. There was never any carryover of feed after the first 2 years. This rate of grazing did not carry the cattle the full season of 5 months during all the years. The pasture is far from ruined by overgrazing. The main contributing factor to this was the fact that grazing did not start on it until after May 15. Severe early grazing was therefore avoided. It could be brought back to normal production under the proper system and rate of grazing.

The gains of the yearling steers in the 50-acre pasture will be found in Table 8. The pasture was not grazed in 1937 for the same reason as in 1935. The 1935 ungrazed growth of vegetation was available for forage in 1936. This fact allowed these steers to put on gains slightly above those in the larger pastures and significantly higher than those in the rotation pasture. The steers in this pasture in reality had more feed available for grazing in 1936 than did those in any other native pasture. There was little or no new growth, and the larger pastures and the rotation pasture were practically clean at the end of 1936. Since 1936 was the driest year of record, and this area was not grazed in 1937, the years most comparable are 1938-40. The average for these three years is not significantly lower than the averages for the larger pastures. This further confirms the lower grass consumption of yearlings. There has been a definite yearly tendency toward higher gains than those made in the rotation pasture. This point will be further discussed in connection with the gains of yearlings in the rotation pasture. The amount of foliage cover removed by the yearling steers averaged 71 percent, and ranged from 60 percent in 1939 to 95 percent in 1936. The average for the 3 years 1938-40 was 63 percent.

The 30-acre Pasture

The heaviest rate of grazing was practiced in the 30-acre pasture. It was overgrazed throughout the 19 years 1916-34. Three acres allowance for a 2-year-old steer was not enough to support him for a full season. This area is considered severely overgrazed in comparison with other pastures in this experiment; but if compared with some areas not far distant, the 30-acre pasture would be considered in excellent condition. The reason its condition was not worse was because extremely early grazing was not practiced in it during any of the 19 years. It also had a year of rest following the severe drought of 1934, as did the 50-acre unit.

This pasture was overgrazed as measured by the gains of the steers and by the condition of the native vegetation. Blue grama was able to withstand the heavy grazing and increase its density. This was the only reason why it was possible to continue grazing. If no blue grama had existed in it at the beginning, grazing would have been out of the question by the end of 1925. The pasture would have been practically denuded of vegetation, and erosion by wind would have been possible.

Silver sage increased rapidly during the early years of the experiment. From 1920 to about 1925 there appeared to be little other vegetation in the pasture (figure 12). This increase in the number and size of plants was directly traceable to the heavy rate of grazing. Both green sage and white sage were greatly weakened, and few plants of the former can be found in this pasture at the present time. Needle-and-thread and Junegrass were practically eliminated by 1925.

The gains of 2-year-old steers in the 30-acre pasture are shown in Table 9. The steers did not make normal gains during any of the 19 years, as is well illustrated by the monthly and seasonal gains shown in the table. The tract was unable to produce enough forage to support the cattle for a full grazing period, except in 1916, and then they lost heavily during October. They grazed the area in October only one other year of the 19-year period. The steers were on the pasture in September during 11 years, and made a gain in that month only in 1916. They were on the pasture 17 years in August, and lost weight during 6 of them. In comparison with the gains of the steers in the larger pastures, the gains averaged below normal for each month of the season. During the earlier years of the experiment, and in later years when vegetative production was markedly above normal, the gains in June were near normal. The seasonal gain factors were previously discussed. The gain per head was the lowest of any of the native pastures. The gain per acre, however, was higher than for any of the other continuously grazed pastures, and equal to that of the rotation divisions. The high gain per acre was directly traceable to the size of the unit grazed rather than to favorable gains of the steers.

Table 9.—Monthly and seasonal gains of ten 2-year-old steers on native range at the Northern Great Plains Field Station for the 19 years 1916-34, and of 10 yearling steers for the 4 years 1936 and 1938-40

30-ACRE PASTURE[1]

Year	Total gains or losses (—) in pounds										Total days grazed
	Monthly						Seasonal				
	May	June	July	Aug.	Sept.	Oct.	per pasture	per head	per head daily	per acre	
1916	...[2]	1,160	935	535	440	—285	2,785	278.5	1.86	92.8	150
1917	150	920	525	— 55	—300	...	1,240	124.0	1.08	41.3	115
1918	300	1,045	140	70	...	...	1,555	155.5	1.48	51.8	105
1919	...	1,265	115	410	...	...	1,790	179.0	1.99	59.7	90
1920	...	1,175	675	— 90	...	...	1,760	176.0	1.96	58.7	90
1921	635	965	240	390	—540	...	1,690	169.0	1.47	56.3	115
1922	490	960	730	185	—470	...	1,895	189.5	1.58	63.2	120
1923	415	925	40	345	—220	...	1,505	150.5	1.31	50.2	115
1924	160	1,195	755	560	— 45	—180	2,445	244.5	1.75	81.5	140
1925	185	565	895	80	—145	...	1,580	158.0	1.37	52.7	115
1926	230	410	105	...	...	...	745	74.5	1.24	24.8	60
1927	675	785	730	295	— 65	...	2,420	242.0	1.79	80.7	135
1928	0	400	885	740	—325	...	1,700	170.0	1.26	56.7	135
1929	130	935	385	— 10	—260	...	1,180	118.0	0.98	39.3	120
1930	310	725	120	—300	...	...	855	85.5	0.86	28.5	100
1931	975	725	335	—250	...	...	1,785	178.5	1.70	59.5	105
1932	740	870	680	40	—265	...	2,065	206.5	1.53	68.8	135
1933	405	470	185	...	...	...	1,060	106.0	1.41	35.3	75
1934	...	...	750	—385	...	...	365	36.5	0.66	12.2	55
1935	...	...	...	...	...	...	.....	.....	....	....	...
Average[3]	387	861	486	151	—200	—233	1,601[4]	160.1	1.47	53.4	109
1936	420	695	340	115	...	...	1,570	157.0	1.65	52.3	95
1937	...	...	...	...	...	...	.....	.....	.....	.....	...
1938	385	620	445	490	170	95	2,205	220.5	1.52	73.5	145
1939	565	635	565	440	190	45	2,410	241.0	1.55	80.3	155
1940	610	985	355	775	210	— 5	2,930	293.0	1.95	97.7	150
Average	495	734	426	455	190	35	2,279[4]	227.9	1.68	76.0	136

[1]This pasture was continuously grazed for the periods indicated at the rate of 1 steer to 3 acres.

[2]A blank space indicates the pasture was not grazed during that period and is not included in computing averages.

[3]Average for days grazed during monthly periods; May (12), June (30), July (29), August (30), September (23), and October (23).

[4]These averages do not equal the sum of the monthly averages, because the grazing periods were not uniform.

Severe overgrazing occurred during the 19 years. This rate of grazing has no application for the production of beef, the normal growth of stock, or for the protection of the vegetation. The amount of foliage cover that was annually removed averaged practically 100 percent. This means the pasture was closely cropped each year, so that practically no available feed remained. The practice was to keep the steers on the pasture until they showed a decided loss in weight. A loss of 25 or more pounds per head was considered significant. Sometimes the steers would remain on their pasture for a period of 30 days or more without a visible supply of forage, and without gain or loss. When this condition of the pasture approached, the cattle were weighed frequently in order to register their loss when it occurred. Usually the loss came suddenly. When it was pronounced and established, the steers were moved to the reserve pasture. This brings out the value of a set of scales. When cattle are forced to graze a short range they cannot put on normal gains or growth. They

may, however, appear to be doing well, when a record of weights would show they were not gaining or even were losing.

The 30-acre pasture rested during 1937 following the severe drought of 1936. A full quota of cattle were not available for all pastures, as was true in 1935. The gains of the yearling steers appear in Table 9. Since 1936 was the driest year of record, the gains for that year were low. They were, however, slightly higher than those of the steers in the 50-acre unit and significantly higher than those in the larger pastures. This unit was closely grazed in 1934, but was not grazed in the favorable season of 1935, and the growth of that year was carried over for use in 1936. Since there was little new feed produced in 1936, these steers had more feed available than those of the larger pastures. The gains for the 3 years 1938-40 are directly comparable with those for the same years in the other pastures. The average gain per head for the 3 years was 251.5 pounds. This was practically the same as for the steers in the 50-acre pasture and less than 20 pounds per head below those for the larger pastures. The fact that the gains were not lower shows the pasture was but little overgrazed during that time. It is clear that the yearlings did not consume as much forage as did the 2-year-olds. The quantity of foliage cover removed by the yearlings during the 4 years averaged 86 percent. For the 3 years 1938-40 the average was 82 percent, not far from the requirements necessary to avoid overgrazing.

The 70-acre Deferred and Rotation Pasture

The 70-acre deferred and rotation pasture was established in 1917 and first grazed in 1918. It is locally referred to as the rotation pasture. It has been grazed for 18 years, with 2-year-old steers. After the four continuously grazed pastures were in operation, it became evident that the experiment would not be complete, without the addition of another system of grazing, as a matter of comparison. For the 12 years from 1918 to 1929 this pasture occupied the area where the 70-acre pasture is now located. The change in location was made in order to afford better watering facilities for the steers in the rotation pasture throughout the season. The present arrangement, as shown in Figure 20, allows the steers to water at the central corral. The previous arrangement of the divisions made it necessary for the steers to travel through a lane to the water trough. The cattle often spent an undue amount of time around the water, before they returned to grazing. They sometimes remained in the pasture until unduly thirsty before a trip was made to water. It was also thought desirable to determine if a change in location of the two pastures would have any effect upon the gains of the steers. The results obtained since the change was made show little or no difference in the gains. The gains in this pasture, the 100-acre pasture, and the 70-acre unit have averaged somewhat higher since grade Herefords have been used starting in 1931. Grazing exerted little influence on the vegetation, as there was not any marked change

or injury in either location. So far as the gains of the steers are concerned, the change in location did not make enough difference to necessitate a break in the years of record for either pasture.

The system of deferred and rotation grazing was developed by the Forest Service of the United States Department of Agriculture (*14*, *19*). It was first applied in the management and control of grazing in the National Forests. The system is so designed that a pasture or range is divided into three or more approximately equal parts. Each division is grazed during different periods of a season. The grasses in one division are allowed to come to maturity for 2 successive years before they are utilized by the stock in the fall of each year. The mature seeds of the grasses or other forage plants are scattered on the ground and aided in their planting by trampling of the livestock. While this manner of reseeding is highly important in some sections (*20*), it is not an important factor in this area. The density of the vegetation was already high, so that it was difficult for new seedlings to become established. The heavy crop of seed of blue grama in 1938 was scattered on the ground (figure 8) and a number of seedlings started growth in 1939. A small percentage finally was established. From determinations made in the fall of 1939, it was evident that more seedlings started growth in the rotation pasture than in any of those continuously grazed.

So far as it has been possible to determine, there has been no significant benefit from reseeding of the grasses under this system of grazing in this experiment. It is likely that more reseeding would have resulted if the area had been overgrazed in the beginning. The important and valuable benefit from this manner of grazing has been through the physiological effect upon the individual plants, rather than by their reseeding and the establishment of new plants. They have benefitted by the rest periods, and the fact they were periodically allowed to develop a normal growth and mature before they were grazed. Continuous close grazing weakens the plants by decreasing their food supply and the consequent storage of reserve food material in their roots. Under continuous close grazing the quantity of root materials in the surface soil decreases and eventually the fibers binding the soil are destroyed, so that wind and water erosion may become a serious factor and the effectiveness of normal rainfall be greatly reduced.

Deferred and rotation grazing differs from resting a pasture or deferring grazing on it for a short period. The latter provides for one part of an area to rest for a period of the season so that the grasses in particular may mature a seed crop before the area is grazed. The whole area may be grazed up to late spring, instead of resting all season until fall. In deferred and rotation grazing an area usually is divided into three or more parts. The different divisions are systematically grazed in rotation and each unit is deferred two successive times until fall before it is grazed.

The plan may extend over a period of years or as long as the range is in use. A diagram illustrating this system of grazing is shown in figure 30. This plan is for a pasture divided into three equal parts such as was used in this grazing experiment. It takes 6 years for a complete cycle. This is because one unit is deferred until fall for 2 years in succession before it is used. This deferring rotates from one division to another, but all units are grazed at some time each year.

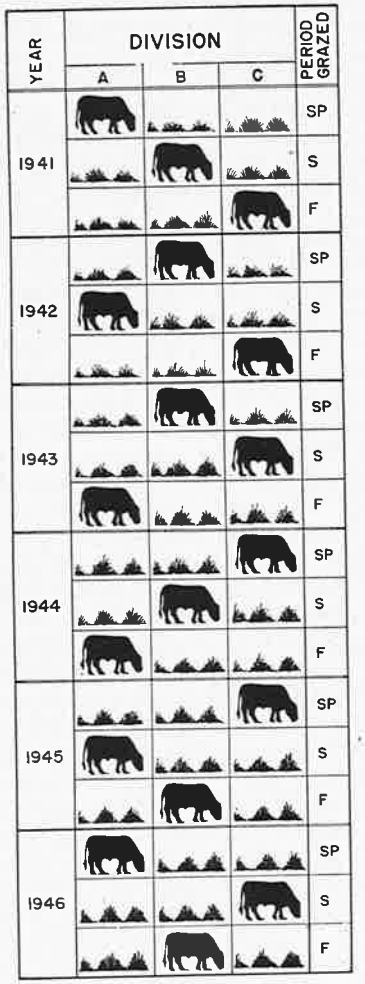

Figure 30.—Diagram showing the order of grazing the deferred and rotation pasture for a complete cycle. Columns A, B, and C represent the three divisions of the pasture. Each year is separated into three grazing periods indicative of spring (Sp), summer (S), and fall (F). The steer represents the grazing periods and the grass the rest periods.

Drawing furnished through the cooperation of the Soil Conservation Service, Area Office, Mandan, North Dakota. J. L. Schlanser, area draftsman.

The plan in Figure 30 illustrates the application and management of deferred and rotation grazing. When an area is laid out and grazing started, division A is grazed in the spring, B in the summer, and C in the fall. The second season B is grazed in the spring, A in the summer, and grazing on C is again deferred until fall, so the grasses reach maturity for the second year. Divisions A and B are treated in the same manner during the following years. From the plan it will be noted that following two successive years of fall grazing on C, it is next grazed in the summer. This is done so that any seedings that may have started growth will have a better opportunity to become established before they are grazed or trampled. The plan as originally outlined called for a reduction in the number of stock following each year of rest on a given division. This part of the plan has not been followed in this experiment, because of the density of the vegetation and the small amount of reseeding.

The periods of grazing the rotation pasture have usually been from May 15 to June 30 for the spring period; July 1 to August 15 or the end of August for the summer period; and the remainder of the season for the fall period. When grazing started later than May 15, the changes were made at a correspondingly later period. It was usually planned to graze each division approximately one-third of the season. A fixed date was not set for changing the steers from one division to another. The feed requirements of the cattle were considered as of paramount importance. Seasonal conditions also exerted an influence upon the time of change. For example, in 1935 following the drought of 1934, and the late start of vegetation, the spring division carried the steers only 20 days before they were out of feed. It was necessary to make the change at once. The three divisions of the pasture, however, carried the cattle for the full season. Later use has also been made of vegetative growth that came into the spring-grazed unit after the steers were moved to the summer division. Whenever conditions were such that the fall-grazed division became too short, no hesitancy was made in using new growth that might occur in another division. The plan has been to make the best utilization of the grass, during the varying seasons without attempting to follow fixed dates for changing from one division to the next. Usually conditions were such that the change from one division to another followed an approximate date. Over one-third of the grazing season remained after the valuable forage species were normally mature. Grazing therefore, did not take place in the fall divisions until such species had made their normal seasonal growth.

The advantages of deferred and rotation grazing in this particular area are to be found in the beneficial effects upon the vegetation. This is brought about through the rest periods afforded the vegetation, because the same areas are not grazed at the same time each season. Choice species most relished by the stock are not closely grazed each year early in the season. Under

continuous grazing, such grasses as big bluestem are always closely grazed first in the spring as growth begins, and the plants become so weakened they make very little growth or eventually disappear. This has happened to a small area in the 100-acre pasture where big bluestem was originally dominant. A higher utilization of the vegetation can be obtained under deferred and rotation grazing than under the same rate of continuous grazing. The utilization of the vegetation has been higher in the rotation pasture for the gains of the steers than for those in any of the other native pastures. The high utilization was not followed by the consequent serious injury to valuable forage attendant upon continuous close grazing. It is evident that the production of forage has been higher under this system of grazing than under the same rate of continuous grazing. This was because the vegetation was periodically given a chance to make a normal growth before it was grazed. The higher production was confirmed by the yield of forage in units mowed once in two years. These produced over twice as much hay as those mowed each year.

The disadvantages of deferred and rotation grazing are to be found in the extra fencing required to put the system into operation. The cost of fencing is an important item, but not to the same extent as previous to the introduction of the electric fence. Another item of utmost importance is the location and quantity of water. In order to be of most value, each division of a rotation pasture should contain watering facilities. If such an arrangement is not available, the divisions should be so arranged that a central watering point can be utilized. The stock should not be required to travel too far for water, especially through a narrow lane. If a lane leads to the water supply, the stock may spend too much time around the trough. Also the stock may stay away from water longer than if it were readily available. Such an arrangement is most likely to result in reduced gains. The most ideal conditions for the location of the divisions for a system of deferred and rotation grazing would be an area with a live creek running through it. Rough and broken areas afford a good location for divisions of a rotation pasture, which could be arranged to provide better use of the vegetation along the coulees and on the slopes. Overgrazing of the more choice vegetation could be avoided and better use be made of the grasses on the higher ridges.

It sometimes happens that a ranch or farm may be so divided by roads and section lines that the range could readily be grazed according to a plan of deferred and rotation grazing. If such a condition exists it would be advantageous to apply the plan, even though the number of stock carried were not increased.

If plenty of range is available, little benefit can be expected by following a system of deferred and rotation grazing. The real value of the system is as a means of improving a range already overgrazed and bringing it back to a higher state of production. If it is necessary to practice close grazing, the deferred and rota-

tion system should be applied in order to avoid as far as possible serious injury to the vegetation. As pointed out by Sampson and Malmsten (*21*), "cropping a pasture each year to the maximum of its forage production is sure sooner or later, to cause a sharp decline in its grazing capacity." If enough range is available for continuous grazing at the proper rate, so that normally approximately 25 percent of the better vegetation remains at the close of the season, there would be no object or advantage in changing to rotation grazing. Under such conditions cattle would put on their maximum gains, as they have in the 100- and the 70-acre pastures. If the cattle have enough native forage available to put on the maximum gains it will produce, no other method or system of grazing can be expected to increase them. With a pasture divided into three parts, it is obvious that it will be necessary to graze each unit closely before a change is made to the next one. When cattle are required to graze a short range they cannot put on maximum gains. Therefore, they will usually complete a period with gains below those of cattle that have had plenty of feed before them for the same time. When gains are lost by cattle during a part of the season, they very seldom regain them during the rest of the grazing period.

The above discussion shows that the results from a system of deferred and rotation grazing cannot well compare with continuous grazing practiced at the proper range use for the area. In order for deferred and rotation grazing to appear to advantage, it must be compared with close or overgrazing. This fact is well illustrated by a study of the results obtained in the 70-acre rotation pasture, and the 50-acre continuously grazed area. The rate of grazing was approximately the same in each pasture. When the rotation pasture was established, it was not known what rate of grazing would be most applicable to it. After a few years it became evident that a direct comparison with the rate in the 50-acre pasture would be highly significant.

The vegetation in the rotation pasture has not been injured to any serious extent by grazing, in contrast to the same rate of grazing in the 50-acre continuously grazed pasture. This fact is indicated by the gains of the cattle and the condition of the various grasses.

The gains of 2-year-old steers grazed in the rotation pasture are highly important. This is because they were made under a system of grazing different from that ordinarily found in general use on ranches. Table 10 shows the gains of the steers made during the 18 years from 1918 to 1935. Three sets of averages are presented for ready reference and comparison with similar sets in Table 8, showing the gains of the steers in the 50-acre pasture.

The number of steers in the rotation pasture varied during the first half of the period, but the average was 14, or 1 steer to 5 acres. In 1920 the season was started with 14 head, but 2 more were added during July. The average number for the season

was 15 (to the nearest whole number). The year of 1926 was one of drought. The pasture was started with 16 steers, but it soon became evident that it could not support that number more than part of the season. Early in July, nine were moved to the reserve pasture. The remaining seven head completed the season on the pasture. The average number grazed for the 150 days was 10. In 1935, because of the lateness of the start of the grasses, the number of steers was reduced to 12. The average number carried for the 18 years was approximately 14, or one steer to slightly over 5 acres.

Table 10.—Monthly and seasonal gains of 2-year-old steers on native range at the Northern Great Plains Field Station for the 18 years 1918-35, and of yearling steers for the 5 years 1936-40

70-ACRE ROTATION PASTURE[1]

Year	Total gains or losses (—) in pounds										No. of steers	Acres per head	Total days grazed
	Monthly						Seasonal						
	May	June	July	Aug.	Sept.	Oct.	per pasture	per head	per head daily	per acre			
1918	555	775	350	530	405	15	2,630	263.0	1.70	37.6	10	7.00	155
1919	...[2]	1,340	490	830	70	—160	2,570	257.0	1.84	36.7	10	7.00	140
1920	...	1,780	1,055	625	760	0	4,220	281.3	1.88	60.3	15	4.67	150
1921	1,130	1,440	960	910	80	— 20	4,500	264.7	1.76	64.3	17	4.12	150
1922	910	1,440	1,440	460	585	135	4,970	310.6	2.07	71.0	16	4.38	150
1923	540	1,630	265	1,275	230	70	4,010	250.6	1.67	57.3	16	4.38	150
1924	370	1,550	1,300	875	900	—260	4,735	295.9	1.97	67.6	16	4.38	150
1925	300	1,135	1,215	755	150	270	3,825	239.1	1.59	54.6	16	4.38	150
1926	625	1,030	465	195	150	100	2,565	256.5	1.71	36.6	10	7.00	150
1927	755	1,210	1,005	855	555	160	4,540	324.3	2.16	64.9	14	5.00	150
1928	725	555	835	775	965	—230	3,625	258.9	1.73	51.8	14	5.00	150
1929	630	1,355	830	695	245	—145	3,610	257.9	1.72	51.6	14	5.00	150
1930	345	1,525	680	550	—210	95	2,985	213.2	1.42	42.6	14	5.00	150
1931	1,435	1,095	870	1,010	90	0	4,500	321.4	2.14	64.3	14	5.00	150
1932	930	1,240	1,140	390	300	— 85	3,915	279.6	1.86	55.9	14	5.00	150
1933	820	870	1,070	760	— 90	...	3,430	245.0	2.13	49.0	14	5.00	115
1934	725	850	555	1,000	—420	...	2,710	193.6	1.61	38.7	14	5.00	120
1935	...	1,755	725	905	600	— 95	3,890	324.2	2.24	55.6	12	5.83	145
Average[3]													
1918-35	720	1,254	847	744	298	— 9	3,735[4]	268.9	1.84	53.4	13.9	5.04	146
1918-34	720	1,225	854	735	281	— 4	3,726[4]	266.1	1.82	53.2	14	5.00	146
1927-34	796	1,088	873	754	179	— 34	3,664[4]	261.7	1.84	52.4	14	5.00	142
1936	530	810	420	—125	...	...	1,635	116.8	1.23	23.4	14	5.00	95
1937	475	1,075	740	915	310	55	3,570	255.0	1.82	51.0	14	5.00	140
1938	695	625	600	890	280	70	3,160	225.7	1.56	45.1	14	5.00	145
1939	565	1,105	570	470	160	325	3,195	228.2	1.47	45.6	14	5.00	155
1940	775	1,300	435	595	370	—185	3,290	235.0	1.57	47.0	14	5.00	150
Average	608	983	553	549	280	66	2,970[4]	212.1	1.55	42.4	14	5.00	137

[1]This pasture was grazed according to a system of "deferred and rotation grazing" at the rate per head shown in the table.

[2]A blank space indicates the pasture was not grazed during that period and is not included in computing averages.

[3]Average for days grazed during monthly periods; May (13), June (30), July (30), August (30), September (28), and October (17). Averages 1918-34, for comparison with same years for the 50-acre pasture, and 1927-34 years this pasture was grazed with an even 14 steers.

[4]These averages do not equal the sum of the monthly averages, because the grazing periods were not uniform.

The average gains of the steers for the 18 years was 268.9 pounds per head, or 47 pounds less than the gains of the steers in the 100-acre pasture for the same period. The gain was 37.6 pounds higher than the gains in the 50-acre pasture. In 1918 and 1919 this pasture was grazed with 10 steers, the same as the other

ones. The gain per head, however, was lower than in the 100- or the 70-acre pastures. This was because the cattle had to graze a short pasture toward the end of each grazing period on a given division. Since they were short of feed part of the time they could not put on maximum gains. In comparison with the gains produced in the 50-acre pasture, they were practically equal in 1918, higher in 1919, and significantly higher in 9 of the other 15 years. The gains of the steers in the 50-acre pasture were never significantly higher with the same rate of grazing than those of the rotation pasture, except in 1932, which was a favorable season and when the steers in the 50-acre pasture received 1.7 pounds per head of cottonseed cake daily. The gain per acre averaged higher for the 18 years in the rotation pasture than in the 50-acre area. This is an example where a comparison of gains per acre is of value, because the rate of grazing was the same. In the 30-acre pasture the gain per acre was practically equal to that in the rotation pasture, but the gain per head was more than 100 pounds lower.

It is of interest to note that the gains in October were somewhat better in the rotation pasture than in the 70-acre pasture. There was, however, a loss three times in September compared to one minor loss for the 70-acre pasture.

The fact that the rotation pasture was started 2 years later than the others did not allow it to average quite so long a grazing season. The small difference is of minor importance over the series of years.

Another comparison of significance is between the combined total gains of the 50- and the 30-acre pastures, and those of the rotation pasture. There was 30 percent less cattle in the rotation pasture; but their total gain was less than 4 percent below the total for the two smaller pastures. The gain per head was approximately 73 pounds more in the rotation pasture, on 87.5 percent as much land as the 80 acres of the two smaller pastures.

The foliage cover removed by grazing with 2-year-old steers after the number was increased, averaged 92 percent. The range was from 87 percent in 1924, 1927, 1931, and 1935 to 100 percent in 1934. The averages for each division was 92 percent in A and B, and 93 percent in C. In 1934 each division was grazed 100 percent.

The lower part of Table 10 shows the gains of yearling steers for the past 5 years. This period is too short to establish average gains that might be normally expected. The gains in this pasture are highly significant, because they are less in 3 of the 4 years of comparison than those of the smaller pastures. The fact that the smaller pastures were not grazed in 1935, provided them with a greater supply of forage in 1936, when little new feed was produced. Plenty of feed remained in the divisions of the rotation pasture at the close of the seasons of 1938, 1939, and 1940. The

steers had plenty of feed before them at all times, but they failed to put on gains equal to those in the other native pastures. The only explanation so far as it was possible to observe or determine was that yearling steers are more reluctant to travel than are 2-year-olds. It was clearly discernible that grazing was heavier nearer the watering trough. The yearlings seemed to prefer to graze a short pasture rather than to travel to the far side of it. Salt was placed at the far side of the divisions, but this did not alter the results. In the case of 2-year-olds the divisions were always grazed uniformly.

The foliage cover removed by grazing with yearling steers averaged 72 percent. The range was from 57 percent in 1939 to 93 percent in 1936. For the 3 years 1938-40 the average was 62 percent.

Cultivated Pastures

The use of cultivated or domesticated grasses for pasture in the northern Plains has been steadily increasing within recent years. The greatest increase has taken place within the past 10 years, due mainly to the need of more pasture and the seeding of abandoned farmland. The value of cultivated pastures is now more fully realized than previous to the drought. The possibilities in the use of cultivated pastures in combination with native range is yet to be fully conceived. Experimentation in the proper use of cultivated pastures has barely been touched upon in the northern Plains.

The possibilities of the value and use of cultivated grasses were early recognized in connection with the cooperative grazing experiment. The first cultivated pasture was established in 1921 adjacent to the native pastures. Others have been established since that time, and more will be used as new and improved varieties come into existence in the progress of grass investigations.

Cultivated pastures are of most value for spring use, before the native ones are ready or fit for grazing. The grasses now in general use start their growth early in the spring and are usually ready for pasturing by the time the native prairie is getting nicely started. Cultivated grasses are in prime condition for early grazing. Because of this fact they are of exceptional value for lambing and calving. The new grass improves the condition of the stock, stimulates the milk flow, and the pasture can be located on limited areas near the ranch or farm buildings so the stock can be kept under close observation and readily cared for as needed. In contrast to native pastures, cultivated ones can readily be restored if the stands are weakened or destroyed, by overgrazing or other causes. Cultivated pastures can be utilized to a higher degree than native ones without the same danger of overgrazing. It was pointed out in 1930 (*15*) that: "The ideal pasture arrangement would be a relatively small crested wheatgrass pasture for early

spring and early summer grazing while the native range makes its most rapid growth." The real value of cultivated pastures lies in the fact that they can be used at a time when most damage is likely to occur to native range because of too early and close grazing. It was pointed out a number of years ago (*20*) that: "Removal of the herbage year after year during the early part of the growing season weakens the plants, delays the resumption of growth, advances the time of maturity, and decreases the seed production and fertility of the seed." The use of cultivated grasses will take the grazing load off the native ones early in the season. Stock can be transferred to native range in early summer, while they are still gaining in weight. The use of a combination of cultivated and native pastures would be of value in helping to solve the grazing problem in the northern Plains.

While cultivated pastures are likely to find their greatest use in early spring, they are useful to a lesser extent during other periods of the season. Some of the grasses make a good fall growth when moisture conditions are favorable. Good rains during August or early September will stimulate a new growth that is readily grazed by livestock.

Several grasses are available for use in planting for cultivated pastures. Some of these can be sown alone or in mixture with other grasses and sweetclover. The best cultivated pasture for general use is likely a mixture of several grasses. Such a combination will afford a better and longer period of grazing and furnish a variety of feed. Cattle become tired of one grass, no matter how palatable it is, and reach through the fence for weeds or any other kind of vegetation.

Further trials with different grasses and mixtures may show that drilling the different species in strips may in some cases be more desirable than mixing them together on the same area. The stock then would have a chance to graze certain ones while they were in prime condition for grazing without trampling down some of the others. Strips of different grasses would be most useful for smaller pastures.

The grazing rate of cultivated pastures varies greatly from year to year, as rainfall exerts a greater influence on them than is usual with native ones. The grasses and legumes that have been used in pasture trials at the Mandan Field Station are discussed under their respective pastures.

The Bromegrass Pasture

The first cultivated pasture established was one of smooth bromegrass (*Bromus inermis* Leyss.) in the spring of 1921.. Thirty-five acres of prairie sod were broken that spring, and bromegrass was sown on the well-disked sod. The seeding rate was 10 pounds per acre. It was cut for hay in 1922 and yielded 1 ton per acre. It was first grazed in the spring of 1923. Figure 31 shows the

condition of the bromegrass after the first season of grazing. The bromegrass was practically all dead in the spring of 1935, following the heavy grazing and severe drought of 1934. The size of the pasture and the number of cattle were changed from time to time, but it was grazed for 12 years 1923-34 at an average rate of one 2-year-old steer to approximately 3 acres, for an average seasonal period of 111 days.

Bromegrass is highly relished by cattle, its palatability being rated at 80 percent. It furnishes excellent pasture and the cattle do well on it. It furnishes the best pasture early in the season. As the grass nears maturity and becomes harsh and woody, it is not so readily eaten. The gains of the steers are shown in Table 11. They made high gains early in the season while the grass was in prime condition for grazing. As the season advanced, the gains decreased with the maturity of the grass. In 1927, 1928, 1930, 1932, and 1933, it was grazed between 85 and 90 percent. The other years it was over 90 percent grazed, and the amount of foliage removed on the average amounted to 97 percent. Had the steers been removed from the pasture before they lost weight the average gain per head would have been higher. The grazing rate was high, and the gain per acre was high.

The gains of the steers in this pasture and on reserve well illustrate the value of a cultivated pasture in combination with native range. When the steers finished grazing the bromegrass pasture they were transferred to a reserve unit. A special 15-

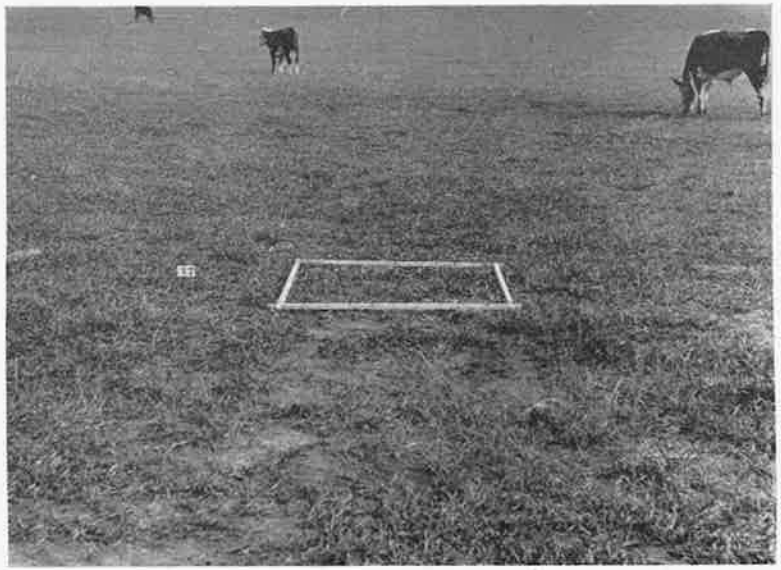

Figure 31.—Bromegrass pasture during its first season of grazing. Note the good cover. October 16, 1923.

Table 11.—Monthly and seasonal gains of 2-year-old steers on a cultivated pasture at the Northern Great Plains Field Station for the 12 years 1923-34

BROMEGRASS PASTURE[1]

Year	Total gains or losses (—) in pounds										No. of steers	Acres per head	Total days grazed
	Monthly						Seasonal						
	May	June	July	Aug.	Sept.	Oct.	per pasture	per head	per head daily	per acre			
1923	565	2,000	180	780	—150	—700	2,675	167.2	1.19	76.4	16	2.19	140
1924	275	1,825	1,065	390	315	—310	3,560	254.3	1.82	101.7	14	2.50	140
1925	200	730	870	140	—245	...[2]	1,695	169.5	1.47	67.8	10	2.50	115
1926	225	650	95	275	235	—345	1,135	189.2	1.58	45.4	6	4.17	120
1927	465	665	495	385	245	...	2,255	375.8	2.78	90.2	6	4.17	135
1928	340	345	700	705	100	...	2,190	273.8	2.28	87.6	8	3.13	120
1929	515	800	...	390	...	...	1,705	213.1	2.84	68.2	8	3.13	75
1930	330	915	500	— 60	...	...	1,685	210.6	2.11	67.4	8	3.13	100
1931	870	680	570	— 25	...	...	2,095	261.9	2.49	83.8	8	3.13	105
1932	770	1,030	470	295	...	...	2,565	256.5	2.44	91.6	10	2.80	105
1933	620	1,000	610	...	...	...	2,230	223.0	2.97	79.6	10	2.80	75
1934	160	320	475	— 75	...	...	880	176.0	1.76	31.4	5	5.60	100
Average[3]	445	913	548	291	83	—452	2,056[4]	226.3	2.04	75.0	9.1	3.02	111

[1]This pasture was continuously grazed for the periods and rates shown in the table. The pasture contained 35 acres in 1923-24; 25 acres 1925-31; and 28 acres 1932-34.

[2]A blank space indicates the pasture was not grazed during that period and is not included in computing averages.

[3]Average for days grazed during monthly periods; May (13), June (30), July (29), August (28), September (23), and October (18).

[4]This average does not equal the sum of the monthly averages, because the grazing periods were not uniform.

acre native reserve pasture was made available for the use of these steers after they were removed from the bromegrass pasture. During the seven years 1927-33 they averaged 102 days on bromegrass and gained 259 pounds per head. They were on the reserve pasture for an average period of 41 days and gained another 55 pounds per head, or a total of 314 pounds per head in 143 days. For the same periods the 100-acre steers gained 277 pounds per head in 102 days, 36 pounds in 41 days, and a total of 313 pounds per head in 143 days. The total average acres required per head for the 143 days was 4.93 for the steers on bromegrass and native reserve, and 10 for the steers in the 100-acre native pasture. If the comparison were made with the 70-acre pasture, the acreage for the combination would be approximately 2 acres per head lower than for the native pasture.

The high gains of the steers on bromegrass and supplementary native pasture during the 7 years may seem to contradict the previous statement that steers cannot recover lost gains later in the season. During the seven years, however, the steers remained on the bromegrass pasture only twice in September and made small gains each time. They showed only slight losses three times in August. Therefore, they had not been forced to graze a short pasture for a period long enough to reduce greatly their normal gains. These facts confirm the statement that cattle should be moved from a cultivated pasture while they are still gaining. Such a combination of pastures would be most valuable on a farm unit where native range is limited and intensive grazing is necessary.

The 10-acre Sweetclover Pasture

Sweetclover has been used as a cultivated pasture for a number of years throughout North Dakota. A bulletin of the North Dakota Agricultural Experiment Station (27) showed its use and value in the Red River Valley. It was tried in connection with the grazing experiment here in 1926 and 1928. It furnished good pasture when a crop was available, but it was discontinued because of the difficulty in maintaining a pasture. It did not readily reseed under the dry conditions. In order to keep a pasture available here, it would need to be in a crop rotation so that it could be seeded each year. Land and facilities were not available at the grazing section to do this, but on plots in a crop rotation at the station there were few years when a stand of sweetclover was not established.

Figure 32.—Heavy growth of sweet clover during a favorable season. July 26, 1928.

In the fall of 1924, 10 acres were broken out of the 35-acre bromegrass pasture. The sod was worked down in the spring of 1925 and seeded to sweetclover May 1 at the rate of 10 pounds per acre without a nurse crop. Both the yellow and the white blossom varieties were used, by seeding half the area to each kind. A rather thin stand resulted. The 10 acres were seeded again that fall in an effort to start seedlings for the following year. It was ready for pasture by May 15 and was grazed in 1926. The gains of the steers are shown in Table 12. The steers did not particularly like the sweetclover, but they ate it and gained well early in the season. The season was dry, and it was grazed down by July 15. The area was reseeded in the spring of 1927 by drilling the same varieties into the stubble, and an excellent crop resulted for use in 1928. The heavy growth of 1928 is shown in Figure 32. The plants grew well and furnished

an abundance of feed for that year. Six extra steers were turned in with the others in midsummer and remained for 30 days, but they did not do well on it. The ones that had been eating it from the beginning of the season continued to eat it well. The ones that were not used to it gained only 42 pounds per head while the others gained 76 pounds per head. The gains shown in Table 12 are for the steers on the pasture for the full season. One of the steers kept bloating on it during part of the season but seemed to suffer no ill effects. His seasonal gain was a little above the average of the lot.

Table 12.—Monthly and seasonal gains of 2-year-old steers on different cultivated pastures at the Northern Great Plains Field Station during the 9 years 1926-35, and of yearling steers for 5 the years 1936-40

Year	Total gains or losses (—) in pounds										No. of steers	Acres per head	Total days grazed
	Monthly						Seasonal						
	May	June	July	Aug.	Sept.	Oct.	per pasture	per head	per head daily	per acre			
10-ACRE SWEET CLOVER PASTURE[1]													
1926	140	345	310	..[2]	...	...	795	159.0	2.65	79.5	5	2.00	60
1927	...	...	...	...	...	...	...	...	...	...	...	...	...
1928	245	385	420	435	— 55	...	1,430	286.0	2.38	143.0	5	2.00	120
Average[3]	193	365	365	435	— 55	...	1,113[4]	222.5	2.47	111.3	5	2.00	90
10-ACRE BROMEGRASS PASTURE													
1929	290	400	660	— 10	...	...	1,340	212.7	2.02	134.0	6.3	1.59	105
1930	55	820	675	...	— 90	...	1,460	202.8	2.03	146.0	7.2	1.39	100
1931	890	545	155	...	...	...	1,590	227.1	3.03	159.0	7.0	1.43	75
Average[5]	412	588	497	— 10	— 90	...	1,463[4]	214.3	2.30	146.3	6.8	1.46	93
7-ACRE CRESTED WHEATGRASS PASTURE													
1933	210	400	350	...	...	...	960	240.0	3.20	137.1	4	1.75	75
1934	75	295	310	...	...	...	680	170.0	2.62	97.1	4	1.75	65
1935	...	910	125	—205	...	...	830	166.0	1.84	118.6	5	1.40	90
Average[6]	143	535	262	—205	...	...	823[4]	190.0	2.47	117.6	4.3	1.62	77
1936	130	35	...	...	...	...	165	41.3	1.65	23.6	4	1.75	25
1937	170	290	280	140	75	— 65	890	222.5	1.60	127.1	4	1.75	140
1938	210	190	125	...	...	...	525	131.3	1.88	75.0	4	1.75	70
1939	185	375	155	...	...	...	715	178.8	2.23	102.1	4	1.75	80
1940	285	395	110	100	— 25	— 45	820	205.0	1.37	117.1	4	1.75	150
Average[7]	196	257	168	120	25	— 55	623[4]	155.8	1.68	89.0	4	1.75	93
12.5-ACRE CRESTED WHEATGRASS PASTURE													
1936	125	365	545	20	...	...	1,055	175.8	2.34	84.4	6	2.1	75
1937	275	355	380	350	40	—150	1,250	208.3	1.49	100.0	6	2.1	140
1938	325	365	130	50	195	...	1,065	177.5	1.54	85.2	6	2.1	115
1939	310	530	205	...	—120	...	925	154.2	1.62	74.0	6	2.1	95
1940	775	930	400	...	...	...	2,105	175.4	2.92	168.4	12	1.0	60
Average[8]	362	509	332	140	38	—150	1,280[4]	177.8	1.83	102.4	7.2	1.74	97

[1]Each pasture was continuously grazed for the periods and rates per head shown in the table.

[2]A blank space indicates the pasture was not grazed during that period and is not included in computing averages.

[3]Average for days grazed during monthly periods; May (15), June (30), July (30), August (30), and September (15).

[4]These averages do not equal the sum of the monthly averages, because the grazing periods were not uniform.

[5]Average for days grazed during monthly periods; May (13), June (30), July (30), August (30), and September (30).

[6]Average for days grazed during monthly periods; May (15), June (30), July (27), and August (30).

[7]Average for days grazed during monthly periods; May (11), June (28), July (30), August (30), September (30), and October (15).

[8]Average for days grazed during monthly periods; May (11), June (30), July (27), August (18), September (30), and October (15).

Sweetclover is recommended as a part of all grass mixtures for either hay or pasture. There are two reasons for this: (1) The second season after seeding it will produce a crop that will add to the value of the grass because of its high protein content; and (2) it helps the physical condition of the soil and is beneficial to the grass for 2 or 3 years because of an increased nitrogen supply. The amount of sweetclover in the mixture should not exceed 1 to 1.5 pounds per acre. If the quantity is too heavy, it will smother out the grasses, unless moisture conditions are exceptionally favorable. The yellow blossom variety is considered more satisfactory than the white blossom for dryland pastures, because it is finer stemmed and more hardy.

The 10-acre Bromegrass Pasture

In 1928 it was apparent that bromegrass was coming back into the sweetclover field. The growth was so good in the spring of 1929 that it was grazed as a 10-acre bromegrass pasture. The growth of the grass was greatly stimulated by the effects of the sweetclover and was superior to that in the other bromegrass pasture. The effect was less in 1930 and only slightly apparent in 1931.

The gains of the steers for the 3 years 1929-31 are shown in Table 12. The gains were good, both the grazing rate and the gain per acre being high. The gain per head was markedly higher than that of the steers in the 30-acre pasture for the same years.

Crested Wheatgrass[6]

Crested wheatgrass was first introduced into this country in 1898 (*38*). So far as known seed from this introduction was not increased. Another introduction was made in 1906 under several Plant Introduction numbers. Much of the present day seed traces back to these numbers. A number of other introductions have been made since that time. The grass was grown at a number of Experiment Stations in the northern Plains, but it did not attract especial attention until it was planted at the Mandan Field Station in the spring of 1915. Its vigorous growth, good production, and apparent desirable characters soon marked it as a grass worthy of continued trial and increase. The original planting is still in production at this station and produced its 25th continuous hay crop in 1940. So far as known it is the oldest planting in the country still in continuous production. Nursery plantings were made at the Belle Fourche, South Dakota Experiment Farm in 1908, and at Dickinson, North Dakota Substation in 1909. But these plantings were not continued. The Belle Fourche plantings were continued for several years, and all the Mandan Field Station seed traces back to these plantings and selections of them. In 1917 a small quantity of seed was produced in the Mandan plot. A small amount was sent to M. L. Wilson, then County Agent Leader in Montana, in the spring of 1918. This was dis-

[6]Unless otherwise specified the Standard variety is understood.

tributed to 15 county agents in the State. In the spring of 1921 a larger amount was sent to the Extension Agronomist in Montana for distribution to farmers. Shortly after this, a farmer in Montana offered the first seed for sale in the country so far as known, but he found no one wanted it. He gave some seed to his neighbors and by 1928 was able to sell some to a North Dakota seed firm. The first large field of it was planted in rows for seed production in the spring of 1921 near Dickinson, North Dakota. This field has been in continuous seed production since that time. In 1929 a North Dakota seed company listed the seed in their catalog at $28.00 per 100 pounds. This was the first commercial seed offered for sale so far as known. It was described as "The most important grass introduction that we have for the general plains conditions. Absolutely cold hardy." Many small lots of seed were distributed to farmers in this region from the Mandan Station since seed production was increased in 1920. Small lots have been sent into many other States and Canada for trial.

Crested wheatgrass has progressed from a promising grass in 1917 at the Mandan Station to the leading and outstanding grass for use as hay and pasture in the northern Great Plains. More seed of it is now produced in the northern Plains than of all other grasses of a similar nature. It was the grass available and proved by trial as well adapted for planting on abandoned land and eroded fields, following the severe drought, as protection against wind and water erosion. Many hundreds of acres of it have been planted in western North Dakota, and in one district in Montana over 200,000 acres of it has been planted on abandoned farmland. Its use for pasture dates back to 1923 when a small pasture was grazed with dairy cows at the Ardmore (South Dakota) Field Station (7). The first planting for pasture in connection with the cooperative grazing experiment was made in the spring of 1932, but a small field of it had been used as pasture for a few cows at the station as early as 1920. When the bromegrass pasture was planted in 1921, not enough seed of crested wheatgrass was available in the country to plant the 35 acres.

Crested wheatgrass has proved itself to be of exceptional value for all classes of livestock in the northern Plains. Its palatability rating for cattle is 80 percent, the same as for bromegrass. But like practically all other grasses it becomes tough and woody as it nears maturity. Its greatest place and value for pasture is for early spring use. A recent Montana publication (*39*) calls attention to this fact. It is the earliest grass of those now in use to start spring growth. At this station it sometimes starts its spring growth during March, normally early in April, and so far never later than May 1. It is normally ready for grazing by April 10 to 25, about the time the native prairie is starting to "green up". It is usually ready for grazing about 3 or 4 weeks before native range is ready for use or should be used. Because of its early and rapid spring growth, crested wheatgrass is of

exceptional value for use as a lambing or calving pasture. It furnishes its best grazing during May and June, but the period may sometimes extend into early July.

When the best pasture period is over, the cattle should be transferred to native range, before they start losing weight because of close grazing or heading of the grass. The leaves of crested wheatgrass have the unusual ability of remaining green throughout the winter. Many of these continue to grow after the beginning of new spring growth. The grass may be seeded for pasture in early spring, early fall, or late fall. The rate of seeding should be 8 to 12 pounds of good seed per acre for pasture, but lesser amounts will usually be sufficient for hay or as protection against wind or water erosion. There should be no confusion between seeding for pasture and for the best seed production. The heavier rate is more desirable for pasture, because the growth will not become stemmy so soon and the larger number of leaves produced will be most palatable for stock. Horses will even avoid the coarser growth for thicker and more tender growth. When moisture conditions are favorable in August or early September, a good fall growth that is greatly relished by stock will be produced. The protein content of new growth in both spring and fall is high, sometimes running over 30 percent as shown in Table 5. Crested wheatgrass does not cure so well on the stem as many of the native grasses. This is shown by its chemical composition in Table 5 and in Montana bulletin 388 (*39*). It is, therefore, not particularly well adapted for winter grazing. It has been grazed throughout the season here, and winter grazing has been under trial at the Judith Basin Branch Station, Moccasin, Montana and to a limited extent by ranchers in other parts of the region.

The 7-acre Crested Wheatgrass Pasture

The gains of the steers on the 7-acre crested wheatgrass pasture are shown in Table 12. The pasture was broken out of the bromegrass field in the fall of 1931. The sod was worked down and seeded to crested wheatgrass on May 11, 1932, at the rate of 11 pounds per acre, without a nurse crop. A good stand resulted, and it was pastured for the first time in 1933. Two-year-old steers were grazed for the 3 years 1933-35. The steers gained well in 1933 while they were on the pasture. In 1934 the grass made practically no growth in early spring because of the drought. The steers were nearly out of feed early in June, but a good rain on the 6th soon brought the grass back. Another good rain on the 16th produced enough grass so it carried them for the rest of the month and most of July. Figure 33 shows the close grazing of the pasture and its condition in the fall of 1934, when it had the appearance of being dead. In 1935 the steers were increased by one, when the early spring growth of native grass was below normal. The growth of crested wheatgrass was heavy, and the steers could not keep it down even though two more were added.

Figure 33.—Crested wheatgrass (7-acre) pasture that was established in 1932 and first grazed in 1933.

Note the good stand. No growth took place here after the steers were removed on July 20. It went into the winter in this condition. October 11, 1934.

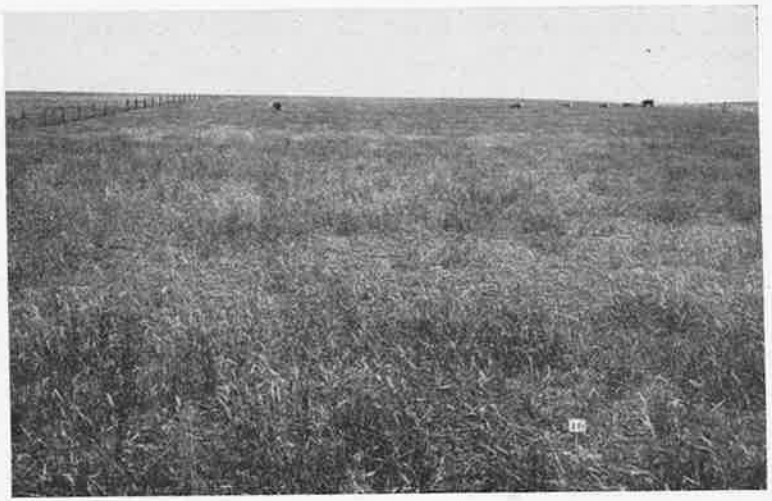

Figure 34.—Crested wheatgrass pasture showing recovery and growth following the severe drought of 1934.

Two extra steers were added July 1 to help keep down the growth. There was no fall growth. July 16, 1935.

The steers were carried through August, which was a mistake so far as gains were concerned, as the grass had matured and they lost weight on it. Figure 34 shows the heavy growth of crested wheatgrass in this pasture in July 1935, following the severe drought of 1934. The average gain factors for the 3 years were not high, except for the month of June. The acres per head were low, and the gain per acre was high. The cattle were carried on the pasture too long to allow them to put on the best gain. They should normally be moved at the end of June or in early July.

Gains of the yearling steers for 1936-40 are shown in Table 12. In 1936, the driest year of record, the grass made very little spring growth and the steers were without feed in 25 days. The pasture did not recover during the rest of the season. There was no drought injury apparent the following spring, in contrast to bromegrass pasture in 1935. The production of forage was good in 1937, and the steers remained on the pasture for the full season, but their gain was below that of steers in the larger native pastures, as the gains dropped off rapidly after July. They were again carried on the pasture for the full season in 1940. Their gain dropped off rapidly after July, and the total for the season was much lower than the gains of steers in the four native pastures. The four steers gained 197.5 pounds per head during the first half of the season and only 7.5 pounds for the last half. In the four continuously grazed native pastures, the steers gained over 90 pounds per head during the last half of the season. There was an abundance of crested wheatgrass available for grazing in 1940, and the pasture was only half grazed. These results confirm the previous statement that crested wheatgrass is best adapted for early season grazing. Enough of the grass will carry the cattle through the season, but gains and growth will likely be reduced.

The 12.5-acre Crested Wheatgrass Pasture

The field now known as the 12.5-acre crested wheatgrass pasture was established in 1935. In the spring of 1935, after it was definitely decided that the bromegrass in that pasture was dead, 12.5 acres of it were broken up late in May. The field was worked down into a good seedbed and was seeded to a grass mixture the first week in June, as moisture was ample from recent rains and the seedbed was excellent. The mixture consisted of 4 pounds Standard crested wheatgrass, 1 pound Fairway crested wheatgrass, 5 pounds bromegrass, 1 pound western wheatgrass, and 2 pounds yellow blossom sweetclover. The seed was all mixed together and planted with a single-disk grain drill, with an agitator in the drill box. The seed was uniformly spread over the field at the rate of 13 pounds per acre. The depth of seeding was about half an inch. Good rains continued and the season was reasonably cool. A good stand resulted, with a heavy growth about 3 feet tall of grass and a heavy growth of weeds. The field was not disturbed during the season. A heavy snowfall during the

winter filled it with snow. As early as possible in the spring of 1936 the old growth was mowed, raked, and hauled from the field. The grass and sweetclover soon started an excellent and rapid growth. The illustration (figure 35) shows the field in July after it had been grazed with 6 steers for 15 days. The growth was so heavy that approximately one third of the field was cut for hay and yielded over a ton per acre. The stand of sweetclover was thicker than desirable. The season of 1936 was the driest of record. The pasture, however, was the best one available for grazing that year, as there was little new growth of native forage. The steers were moved at the end of 75 days, only a short time before all pastures failed. In 1937 it was evident that the only grass that finally became established was the varieties of crested wheatgrass. The proportion of the two appeared about the same in the field as the seeding rate. The season of 1937 was favorable for the growth of grass after early spring, and the gains of the steers, as shown in Table 12, were the highest during the 5 years the pasture was grazed. The season of 1938 was also favorable for the production of the grass. The steers gained well early in the season, but the July and August gains were light, and they were removed from the pasture. Good rains came early in September, the grass made a rapid recovery, and the steers were returned to the pasture and gained well on the new growth. The protein content of the grass at that time was high, as shown in Table 5. During 1939 the pasture provided good grazing early

Figure 35.—Field seeded in 1935 to a mixture of grasses and 2 pounds per acre of yellow sweetclover.

The sweet clover and some grasses were over 2 feet tall in many places at this time. This was the best pasture available for grazing in 1936. The 12.5 acres were grazed for 75 days with 6 yearling steers. About one third of the heaviest part was cut for hay shortly before this time. Photo by W. C. Palmer, N. Dak. Agr. Exp. Sta. June 26, 1936.

in the season, but it was burned by heat by the end of July. The steers were on the small native reserve pasture during August and early September. A good rain came early in September, and when new growth started, the steers were returned to the crested wheatgrass pasture. The rain had come so hard that it did not soak into the soil and the grass soon failed. The steers lost weight, because there was not enough feed available to support them. In the spring of 1940 early rains gave the grass a good start and there was a heavy growth. The cattle gained well during the time they were on the pasture. One half of the field was cut for hay early in June and yielded at the rate of 1,188 pounds per acre. The other half soon became tough, and the steers were removed. The number of steers were doubled in 1940 in an attempt to graze the grass down before it became too stemmy, but it had too much of a start before they were turned into it on May 16. The gains of the steers in this crested wheatgrass pasture averaged somewhat better than those in the smaller one. This was mainly because the pasture was grazed somewhat lighter during 4 of the 5 years.

The stand of the crested wheatgrass in the 12.5-acre field was not uniform nor heavy enough, except in parts of it. The pasture was heavily grazed in 1936. In 1937 it was about 75 percent grazed, and some reseeding took place. In 1938 it produced a heavy seed crop before it was mowed the last week in August. The yield was 624 pounds per acre. The scattered seed started an early fall growth, and many of the thin areas were filled in. But as so often happens in this sort of seeding, the stand came on too thick in many spots. If such spots become established, they are always the first ones to dry up under drought. In 1939 the pasture was lightly grazed, and much of the fall seeding became established. A hot, dry spell occurred toward the end of July. The grass burned up before it had a chance to dry up. It made poor feed for the steers, and they were removed. The burned growth was later mowed and removed from the field, yielding 844 pounds per acre. This was done to allow new growth a better chance if favorable rains came in the fall. In 1940 the pasture was only half grazed, even though the number of steers were doubled. Reseeding again took place on the uncut area.

Crested wheatgrass should be grazed heavily enough early in the season so that few seed stalks will develop. Whenever numerous stalks develop and reach maturity, they should be clipped off before grazing starts in the spring. If they are not removed grazing will not be uniform, as the cattle will avoid the old growth and graze the same areas as the year before. This would more aptly apply to the smaller farm pastures, but the fact is the same in the larger ones. A good practice to follow in handling crested wheatgrass pasture on a farm, would be to graze it early in the season, until about June 15 or early July. Then move the cattle to native pasture and mow any remaining crested wheatgrass and put it up for hay. In this way the most efficient

use could be made of the pasture and the grass. Under such a plan the pasture would be in prime condition for fall grazing, whenever rains were sufficient to produce fall growth.

It is recognized that grazing has not been started early enough on the crested wheatgrass pastures to keep down the formation of seed stems. This was largely because watering facilities were not satisfactory for early use. Very often the cattle did not arrive soon enough at the pasture for earlier grazing. A better utilization can be made of crested wheatgrass by earlier use. The steers grazed on crested wheatgrass in the Montana experiment (*39*) gained more per head than those in this experiment, with an earlier opening of the grazing season. Plans are under way to start grazing on crested wheatgrass when it is considered ready for use in the spring. It should not be grazed until it is 3 to 4 inches high and better about 5 to 6 inches. A safe practice to follow is never to start grazing it before it is large enough for the stock to obtain a meal without walking over the pasture more than necessary. If too much tramping takes place in early spring when the ground is likely to be soft, the grass will soon be tramped so badly it is apt to be thinned out severely. Crested wheatgrass fits in with the use of native grasses in the northern Plains in an ideal manner. It will provide early new feed and carry the stock until native grasses are ready for grazing. The native range is thereby relieved of the heavy load of spring grazing when it is in the greatest danger of injury by premature overgrazing.

From results in the use of crested wheatgrass as pasture as part of the cooperative grazing experiment, rather definite conclusions can be drawn regarding its grazing capacity. The grazing rate has been high and the grazing period longer than necessary for early season use. But from these facts it appears evident that 1.5 to 2 acres will graze a steer from the time the grass is ready until the middle of June or early July under normal spring and rainfall conditions. It is recognized that its use in connection with native range can be best applied on farms or ranches with small herds. The restoration of much of the cultivated land in the ranch areas to grass, which has been mainly crested wheatgrass, will afford conditions for its use with many of the larger herds. If the entire herd cannot be carried on crested wheatgrass, it would be possible to carry the young stock on it that would benefit most, and thus materially reduce the native range load during the early part of the season.

It has often been stated that the weakness of crested wheatgrass was that it would not provide pasture during mid-summer when most needed. The weakness of blue grama has been pointed out that it would not furnish early pasture. No one grass can be expected to fulfill all the needs for year-round use. The fact that these grasses grow at the times they do should be applied in their use. The results of this experiment point to the fact that these grasses are the most valuable ones available for pasture and range because they do possess these characteristic growth habits.

The 10-acre Mixed Pasture

The remainder of the old bromegrass pasture was not broken in 1935 but was left to determine further if the grass might not come back. The field, however, grew up to weeds, mainly pepper grass, one of the mustards, which was prevalent over the region that year. In the spring of 1936 the weeds were burned in place. The field was prepared for seeding by May 7, but drought continued, and the field was not seeded or cultivated during the remainder of the season.

The early spring of 1937 was dry, and a seedbed was not prepared until June 15. Moisture conditions became favorable, and a grass mixture was seeded on June 21. This date was normally too late, but the grass came up well. However, cutworms took most of it and young grasshoppers the rest. In the spring of 1938 conditions were unfavorable and no attempt was made to seed the field. It was kept in clean fallow, and a good seedbed was prepared for early fall seeding, providing a good rain came at the proper time. Good rain began on September 5 and extended over several days, so seeding was not possible until September 12. The seedbed was in ideal condition for planting. It was well packed by rain and was cloddy enough to hinder ordinary wind erosion. Seeding was done with a single-disk grain drill. Figure 36 shows the field just after it was seeded. A grass mixture was planted

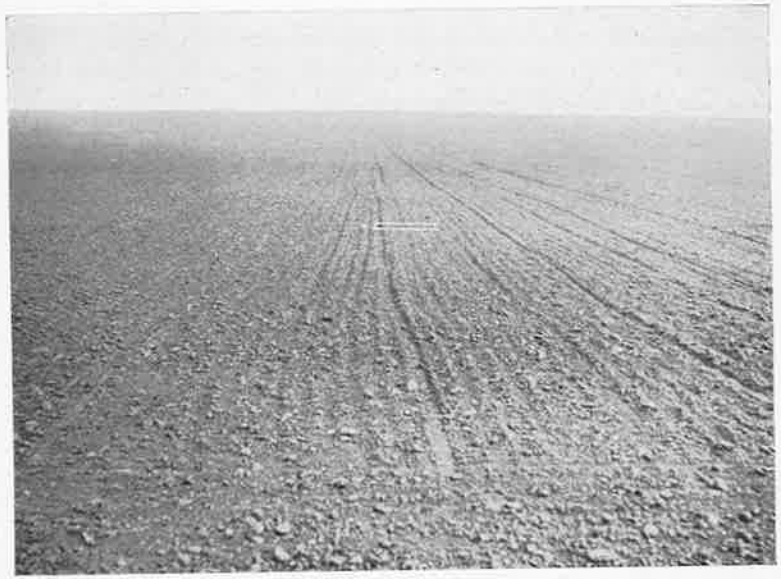

Figure 36.—Field seeded to a mixture of grasses on September 12, showing ideal condition of seedbed, cloddy and ridged by single disk drill. September 29, 1938.

on 10 acres of the field, consisting of 4 pounds crested wheatgrass,[7] 1.5 pound bromegrass, 1 pound western wheatgrass, 1 pound slender wheatgrass, and 0.5 pound Russian wild-rye.[8] This grass was recently further described (*18*). The seeding rate was 7.5 pounds per acre. In addition to the grass mixture, yellow blossom sweetclover was planted from the alfalfa or grass seeder attachment on the drill. The grass started growth within a week and was 3 to 4 inches tall when it went into the winter. Very little of the sweetclover germinated in the fall.

The grass started growth early in the spring of 1939, and later rains helped to establish a most satisfactory stand. It was fully 3 feet tall before it was a year old, as shown in Figure 37. The field was not disturbed in 1939. The old growth was mowed early the following spring and hauled from the field. The pasture was grazed in 1940 with 10 steers, or at the rate of one steer per acre. The early growth was so heavy they could not graze it down. One half of the field was fenced off on May 25 and cut for hay on June 7 when crested wheatgrass was just coming into head, and yielded 1,793 pounds per acre. New growth of all species developed rapidly after the early cutting was removed. The field was ready for grazing by early July, with new and palatable forage. Under favorable conditions, this practice would extend the grazing season on cultivated pastures in this area. The other half carried the steers for 75 days with an average gain of 179.0 pounds per head. In 1940 besides a good stand of crested wheatgrass, there were found per square meter over 3 plants of bromegrass, over 2 of western wheatgrass, over 1 of slender wheatgrass, 1 of Russian wild-rye, and over 5 of sweetclover. The 5 acres of pasture furnished an abundance of feed and was only 60 percent grazed when the steers were removed to the reserve pasture. Many of the plants had become harsh and woody. The established stand was not thick enough to afford the best pasture in 1940 as the plants became coarse too soon.

[7] The crested wheatgrass used in the mixture came from a selection made in the crested wheatgrass nursery in 1926. The seed was planted and from the lot one outstanding plant appeared. It was divided into over 50 small cuttings and started in the greenhouse, in the spring of 1933. The plants were later set in the field. Seed from these plants was planted in an isolated plot. The seed in the mixture came from this plot. The selection is known as M19 and is noted for its leafiness carried up well on the stem, and its strong seedling vigor.

[8] This grass (*Elymus junceus*) was first introduced into this country in 1927. A small amount of this introduction was planted in the grass nursery at the Mandan Field Station in the spring of 1928 and again in 1929. The seed used in the mixture originated from the 1929 nursery row. Seed of this grass is not now (1941) available on the market. It is a promising bunchgrass for use as pasture. It is now in the same position as was crested wheatgrass shortly after 1920. It may become a valuable pasture grass. Bulletin 300 by the North Dakota Agricultural Experiment Station gives further details concerning the grass.

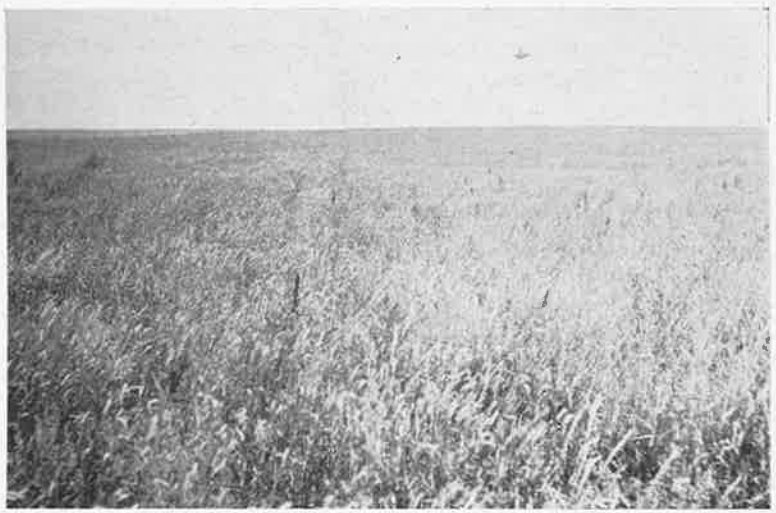

Figure 37.—View showing growth of grass mixture seeded September 12, 1938.
The crested wheatgrass averaged well over 30 inches in height. Spring planting of grasses with more weeds in upper right. August 2, 1939.

The 6-acre Palatability Pasture

About a third of the remaining 6 acres of the old bromegrass pasture was planted on September 14, 1938, to a number of different grass species in separate plots, and is known as the palatability pasture. The remainder was planted the following spring to other grass species. The grasses consisted of bromegrass, a number of selections of crested wheatgrass, Russian wild-rye, Fairway crested wheatgrass, and a number of native species. These plots were planted for palatability grazing trials.[9] The plots were first grazed in the spring of 1940. While the trial was for only one season, the steers showed a definite preference for certain grasses. The steers showed their preference for bromegrass, as was expected. Next in order was Standard crested wheatgrass, especially the selection M19 which was closely grazed adjacent to the Fairway variety. It is recognized that one trial means very little, but it was clear that the steers avoided Russian wild-rye early in the season as they did Fairway crested wheatgrass.[10] Both the grasses would likely be readily eaten if the steers did not have a choice but were confined to an area with only one species available for grazing. Most of the native species such as western wheatgrass, Canada wild-rye (*Elymus canadensis* L.), switchgrass (*Panicum virgatum* L.), and big bluestem were readily eaten. The trials are to be continued, and as time progresses more definite information will be available regarding the preference of cattle for many other grasses.

[9] This phase of the experiment was conducted in cooperation with the Division of Forage Crops and Diseases, Bureau of Plant Industry, and the Division of Nurseries, Soil Conservation Service.

[10] The same preferences held true in 1941.

Gains in All Pastures

Table 13 presents the average gains per head of the steers for the years the grazing experiment has been conducted. This table is included to provide a summary of the gains of the steers of all pastures for ready reference. It includes the average gain per 100 pounds live weight which is not shown in the tables for the individual pastures.

Table 13.—Average monthly and seasonal gains of 2-year-old steers on pasture at the Northern Great Plains Field Station during the years 1916-35, and of yearling steers during the 5 years 1936-40

Kind of pasture	Average acres grazed	Average gain or loss (—) per head (pounds)								Pounds	
		May	June	July	Aug.	Sept.	Oct.	Season	Daily	Gain per acre	Gain per 100 lbs. live wgt.
Two-year-old steers											
Native	10	51	106	70	54	39	1	311	2.10	31	41.7
Do.	7	53	107	69	56	38	— 3	308	2.08	44	41.4
Do.	5	46	101	67	43	8	—21	234	1.67	47	31.7
Do.	3	39	86	49	15	—20	—23	160	1.47	53	21.5
Do. (Rotation)	5	50	90	61	54	22	— 1	269	1.84	53	36.1
Bromegrass	3	52	96	63	31	13	—41	226	2.04	75	31.1
Crested wheatgrass	1.6	36	119	63	—41	..	..	190	2.47	118	25.4
Sweetclover	2.0	39	73	73	87	—11	..	223	2.47	111	29.7
Bromegrass	1.5	70	105	46	— 2	—18	..	214	2.30	146	29.6
Yearling steers											
Native	10	48	68	52	48	30	15	251	1.83	25	53.3
Do.	7	44	71	48	57	27	8	247	1.81	35	52.6
Do.	5	51	71	44	43	23	0	224	1.65	45	47.2
Do.	3	50	73	43	46	19	4	228	1.68	76	47.8
Do. (Rotation)	5	43	70	40	39	20	5	212	1.55	42	45.1
Crested wheatgrass	1.75	49	64	42	30	7	—14	156	1.68	89	33.3
Crested wheatgrass	1.74	48	69	48	23	7	—25	178	1.83	103	39.4

Summary

The cooperative grazing experiment reported upon in this bulletin was established by the United States Department of Agriculture in cooperation with the North Dakota Agricultural Experiment Station, at the Northern Great Plains Field Station, near Mandan, North Dakota in 1915. Its objects were to determine the grazing capacity of the native range and the effects of different systems and intensities of grazing upon the native vegetation.

The land used for the experiment is not materially different than other vast areas in western North Dakota and adjacent territory. It is not so rough or rolling as that ordinarily used for grazing, but it was well adapted for experimental purposes because of the uniformity of soil, contour, and vegetation.

The climatic conditions under which the experiment was conducted are typical of the northern Great Plains. Extremes of heat, cold, and drought occurred during the course of the experiment, and new records for all of them were set during the 25 years. Precipitation for the 25 years from 1916 to 1940 averaged 14.47 inches, whereas the long-time average for the vicinity is 16.40 inches. Early seasonal precipitation exerts a greater influence upon the production of native forage than upon other crops.

The native vegetation where the grazing experiment was conducted does not differ greatly in kind from that over a large section of this part of the northern Plains. Its density, however, is higher than in many other parts of the region. The native vegetation is made up of a great many species of plants, but approximately 90 percent of the forage for grazing animals is produced by only a few. The dominant species are blue grama, western wheatgrass, niggerwool sedge (a grasslike plant), and needle-and-thread. The droughts of 1934 and 1936 thinned out and killed a number of species, especially needle-and-thread, Junegrass, little bluestem, one of the sedges, and a number of other plants commonly referred to as weeds in the composition of the vegetation.

The original plan of the grazing experiment called for four continuously grazed pastures, that were grazed at the rate of one 2-year-old steer to 10, 7, 5, and 3 acres, respectively. In 1918 a pasture for a system of deferred and rotation grazing was added for comparison with those under a system of continuous grazing. Cultivated pastures were added later and became a part of the grazing experiment. The period of grazing during each season covered a period of five months, from near the middle of May to near the middle of October.

Two-year-old steers were used as the unit of measure in the pastures for the period from 1916 to 1935. In 1936, yearling steers were substituted for 2-year-olds. The same number of yearlings per pasture were used from 1936 to 1940, as were 2-year-olds previously. The yearling steers did not consume as much forage as did the older ones.

The gains of both 2-year-old and yearling steers are shown in a series of tables that show the gains for each month of the season for each year the experiment was conducted. The maximum gain of 310 pounds per head was produced in the pasture grazed at the rate of one steer to 10 acres. The lowest gain per head was in the small pasture, but it produced the highest gain per acre, which item taken by itself is of little significance in evaluating a pasture or system of grazing.

The grazing capacity of the native vegetation of the area included in this experiment is best shown by the gains of the cattle and the condition of the vegetation in the various pastures. In order for a native pasture to produce normal gains under a system of continuous grazing, approximately 25 percent of the vegetation should remain standing at the close of the grazing season.

The 100-acre pasture, grazed at the rate of one 2-year-old steer to 10 acres, was larger than necessary to produce the maximum gain per head during a period of 5 months. The pasture was normally undergrazed. There was little or no injury to the vegetation traceable to the effects of grazing.

The 70-acre pasture grazed at the rate of one 2-year-old steer to 7 acres, was practically a duplicate of the 100-acre pasture so far as gains of the steers was concerned. It provided approximately the necessary amount of forage required to produce the maximum gain per head for a period of 5 months, under a system of continuous grazing. The vegetation was not seriously affected by grazing over the period of years. The quantity of vegetation annually removed by grazing was approximately the correct amount for the system of grazing practiced in its use.

The 50-acre pasture, grazed at the rate of one 2-year-old steer to 5 acres did not produce enough forage to allow the animal to put on the maximum gain per head, nor to graze him for the full season. The pasture was over-grazed as evidenced by the gains of the cattle and the condition of the vegetation. Some of the plants were driven out of the pasture by heavy grazing before the advent of the droughts of 1934 and 1936. The pasture is not ruined and could be restored to a normal grazing capacity under proper care and management.

The 30-acre pasture was grazed at the rate of one 2-year-old steer to 3 acres. It was overgrazed throughout its period of grazing with 2-year-old steers. The pasture provided only enough forage to carry the steers for an average seasonal period of 109 days. The gain of the steers was reduced to 160 pounds per head. The pasture was severely overgrazed as shown by the greatly reduced gains of the steers, and the fact that a number of plants disappeared under heavy use before the influence of the droughts of 1934 and 1936. Silver sage increased in number and size of plants up until about 1925. This change was directly brought about by the influence of heavy grazing. Blue grama was able to withstand the heavy grazing and increase somewhat in density during the course of the experiment. This pasture would require several years of the proper rate and system of grazing to bring it back to a normal grazing capacity. The fact that the 50- and 30-acre pastures were not more seriously affected by overgrazing was because grazing in them did not start until after the middle of May so that most of the important plant species were not heavily grazed at the most critical period of their growth.

The 70-acre deferred and rotation pasture was grazed at an average rate of one 2-year-old steer to approximately 5 acres. The gain per head of the steers was intermediate between those in the 50-acre pasture and those in the 100- and the 70-acre pastures. This system of grazing allowed the maximum utilization of the vegetation without serious injury to it, such as accompanies overgrazing. So far as gains of the steers are concerned, this system of grazing does not compare favorably with continuous grazing at the proper rate, such as that followed in the 70-acre pasture. Since the utilization of the vegetation was higher under the system of deferred and rotation grazing, it was necessary for the cattle to graze closely a division of the pasture before they were

transferred to another one. Whenever close grazing becomes necessary cattle cannot put on maximum gains. Compared to the same rate of continuous grazing, the gains of the cattle were significantly higher under the system of deferred and rotation grazing. The real value of a system of deferred and rotation grazing is to aid in restoring an overgrazed area to a normal grazing capacity, or for use when close grazing must be practiced.

A number of cultivated pastures, starting with bromegrass in 1921, have been in use during the course of the grazing experiment. Crested wheatgrass came into prominence for use as hay and pasture after 1920. It is now recognized as the best grass for early spring pasture in the northern Great Plains. All the cultivated plants used as pasture in this experiment produced an abundance of feed for use during the early part of the season, and the cattle gained well on all of them during the early season. As the season advanced and the plants approached maturity, the gains of the cattle dropped rapidly. Cultivated pastures are of most value for grazing during the early part of the season, up until the end of June or early July. The stock should then be moved to native range. In case of a favorable season and heavy production of the cultivated grasses, they can be cut for hay after the stock are moved. There is no advantage in trying to carry the cattle all season on crested wheatgrass, even when an abundance of mature forage is available for grazing. The results of this experiment show that the cattle will put on good gains on crested wheatgrass early in the season, but very low gains after it is mature. If the cattle are transferred to the native range before they start losing weight, they will usually finish the season with normal maximum gains per head.

Yearling steers were grazed in the various pastures from 1936 to 1940. This period was too short to establish definitely the average gain per head that might be expected from this class of stock. It was clearly established that yearlings consumed less forage than did 2-year-olds. The amount consumed was approximately 60 to 65 percent of that of 2-year-olds.

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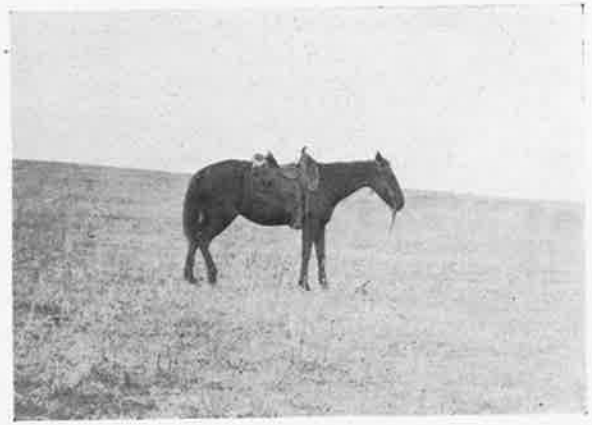

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