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Stocking Northern Great Plains Sheep Range for Sustained High Production

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INTRODUCTION

The northern Great Plains, which includes approximately the western half of North and South Dakota, the northeast quarter of Wyoming, and the eastern two-thirds of Montana, constitutes one of the largest and most important range-livestock areas in the United States. The major part produces nutritious native forage, the utilization of which determines the economic and social pattern of the region. Only a relatively small proportion is cultivated.

[1] In cooperation with the U. S. Bureau of Animal Industry and the Montana Agricultural Experiment Station. The author acknowledges the assistance and cooperation of several members of these agencies and of numerous employees of the Forest Service who assisted in conducting this experiment. Special acknowledgment is made to Martin J. Doyle, B. A. I. shepherd, who served faithfully and well throughout the experiment.

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Much of this range is grazed by cattle and horses, but sheep also use a considerable part of it. Although wool and feeder lambs are the chief market products of the local sheep industry, the development of ewe lambs and yearling ewes into breeding animals by grazing them for several months to a year on the range is becoming an increasingly important type of range sheep husbandry in the northern Great Plains.

In this area the low production of supplemental hay and the high cost of imported feeds, plus generally open winters and the relatively good forage value of cured range herbage, encourage range grazing for long periods annually. It is a common practice to graze sheep on the range continuously for 9 to 11 months and even year long when forage is available and weather is not too severe. One of the major problems which northern Great Plains sheepmen face is how to stock their ranges to get the greatest possible production year after year without deterioration of the forage and soil upon which their continued and successful operation depends. The effect of past grazing use and the frequent occurrence of severe drought contribute to the wide variations in stocking which occur in the region.

It has been most difficult to determine the acreage of range per sheep per month; i. e., the rate of stocking that will give best results over a long period. A common but questionable practice has been to stock heavily during favorable years and then attempt to adjust downward when unfavorable weather and forage conditions occur. This has led many operators into financial ruin because, unfortunately, a crisis may develop more rapidly than adjustments can be made during unfavorable seasons. Furthermore, the range deteriorates severely under heavy stocking. On the other hand, stocking so light as to entirely avoid heavy sales of livestock during drought years is not practical because heavy carrying charges and other expenses make such a practice unprofitable. The urgent need for information on how to stock northern Great Plains sheep range for sustained production led to the study here reported.

HOW THE PROBLEM WAS STUDIED

The Northern Rocky Mountain Forest and Range Experiment Station in cooperation with the Bureau of Animal Industry and the Montana Agricultural Experiment Station conducted a study of sheep grazing from 1936 through 1941 to determine and develop guides to proper stocking of northern Great Plains range for sustained sheep production without deterioration of the forage and soil resource. The study centered on lands of the United States Range Livestock Experiment Station, about 10 miles southwest of Miles City, Mont. This location is typical of northern Great Plains range. Three experimental pastures (fig. 1) of 332, 476, and 847 acres were established and stocked with yearling ewes to provide 9.5, 13.6, and 24.2 acres of range per head in 1936, the first grazing season. During that first season, 1936, the range pastures received 0.48, 0.34, and 0.19 sheep-months of grazing use per acre, respectively. The smallest pasture was stocked heavily, the next larger one conservatively, and the largest pasture lightly throughout the entire test.

Because of favorable weather after late 1937 and substantial recovery of the range from the severe droughts of 1934 and 1936, it was necessary to increase the number of sheep in each pasture to maintain

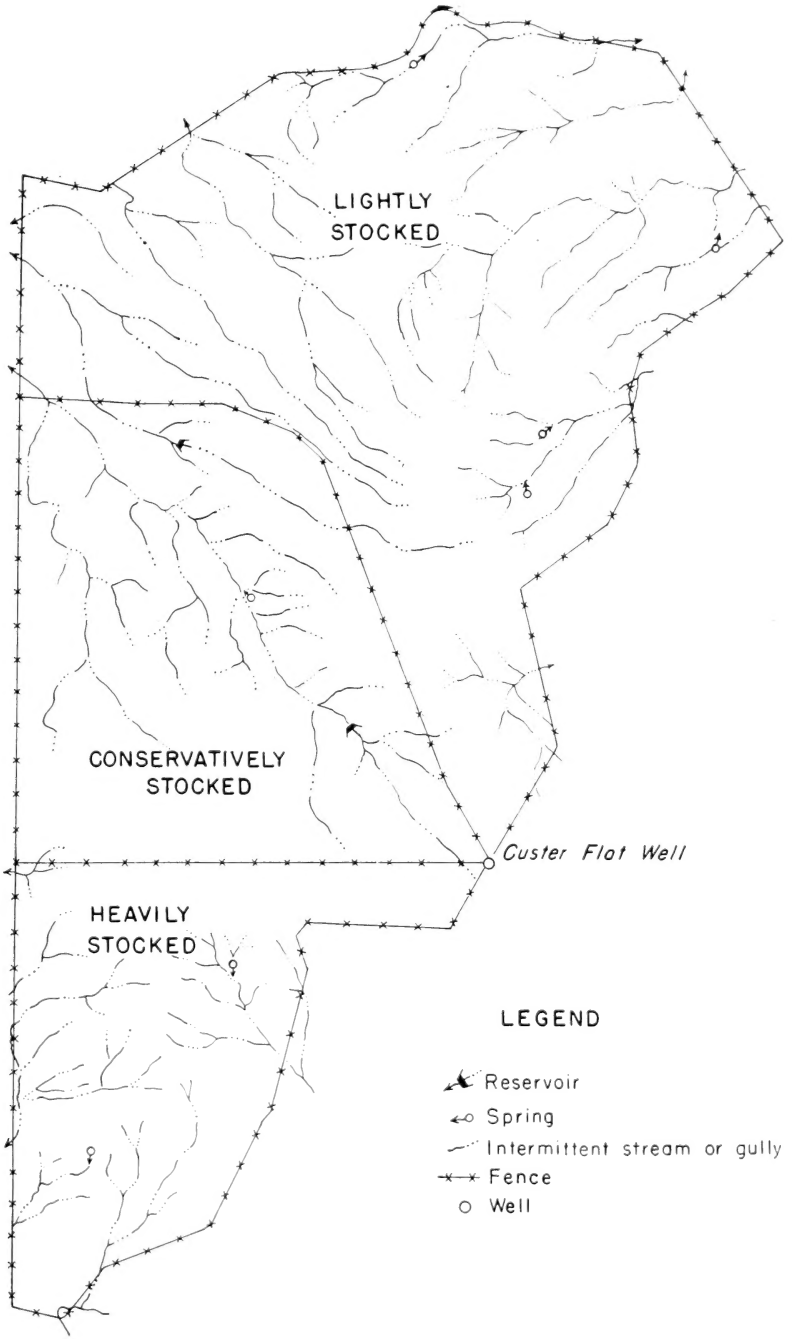

FIGURE 1.—The experimental pastures.

these three relative rates of stocking. During the last year, 1941, the pastures received 2.55, 1.78, and 1.00 sheep-months of grazing use per acre, respectively, and for the 6-year period stocking averaged 1.35, 0.94, and 0.53 sheep-months per acre under heavy, conservative, and light stocking. Table 1 shows the grazing season for each year, the number of yearling ewes that were grazed, and the actual grazing use for each pasture each year throughout the study.

TABLE 1.—*Actual grazing use by yearling Rambouillet ewes in three experimental pastures, by grazing season, 1936–41*

Grazing season, inclusive dates	Number of yearling ewes per pasture	Stocking (sheep-months)					
		Small pasture (332 acres)		Middle-sized pasture (476 acres)		Large pasture (847 acres)	
		Total	Per acre	Total	Per acre	Total	Per acre
June 16–Oct. 30, 1936	35	159. 8	0. 48	159. 8	0. 34	159. 8	0. 19
Apr. 28–Nov. 24, 1937	35	250. 7	. 76	250. 3	. 53	250. 2	. 30
Mar. 16–Nov. 23, 1938	42	352. 1	1. 06	350. 7	. 74	352. 0	. 42
Mar. 22–Nov. 20, 1939	55	444. 6	1. 34	444. 6	. 93	444. 6	. 52
Mar. 22–Nov. 16, 1940	80	631. 6	1. 90	635. 8	1 34	632. 6	. 75
Mar. 18–Nov. 17, 1941	104	845. 6	2. 55	845. 7	1. 78	845. 9	1. 00
Total	351	2, 684. 4	8. 09	2, 686. 9	5. 64	2, 685. 1	3. 17
Average	58. 5	447. 4	1. 35	447. 8	. 94	447. 5	. 53

The sheep were quite uniform, well-bred, dry yearling Rambouillet ewes from the flocks of the United States Sheep Experiment Station at Dubois, Idaho. A new group was obtained each spring, grazed in the pastures, then returned to Dubois at the close of the grazing season. Except in 1936, when severe drought occurred, and in 1937, the grazing season extended from about mid-March to late November. Weights of the individual sheep on each pasture were recorded at the start, at 28-day intervals throughout, and at the end of each grazing season.

A forage inventory provided the original appraisal of the range vegetation and the basis for stocking the experimental pastures. Permanent meter-square chart quadrats were used to study changes in the range vegetation due to grazing and weather. Herbage production as affected by degree of stocking was further studied by harvesting the herbage from small plots that were ungrazed in 1942. Other characters of the range, such as number of plants per unit area, size of plants, and percentage of plants producing seedstalks, were studied by various sampling techniques and the data compared for the differently stocked pastures and ungrazed areas. At the end of each grazing season a survey of utilization was conducted in each pasture.

During the first 3 years of the experiment the surveys consisted of reconnaissance-type estimates of utilization, but after 1938 the stubble-height method (*3*) [2] and approved sampling techniques were employed.

[2] Italic figures in parentheses refer to Literature Cited, p. 39.

The data from these vegetative studies and the weights of the sheep, plus records of actual grazing use and numerous observations and informal records of plant palatabilities and the grazing habits of yearling ewes, formed a basis for evaluating the various degrees or intensities of stocking.

CHARACTER OF NORTHERN GREAT PLAINS RANGE

Northern Great Plains range, sometimes called mixed prairie (*1*) and short-grass (*9, pp. 460–462*) range, supports a cover of native vegetation in which the short grasses are generally dominant. The variable soils and topography combine in many ways and each situation is characterized by certain range plant species or groups of

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FIGURE 2.—Blue grama and bluestem wheatgrass and rolling topography characterize a large part of the northern Great Plains range.

species. As might be expected, not all of these situations were represented on the experimental range. Fortunately, however, four major situations which are representative of a large part of the northern Great Plains range composed practically all of the experimental area.

Well-drained soils and rolling topography (fig. 2) characterize vast areas in the northern Great Plains. These sandy clay loams have a high water-absorbing capacity and normally remain moderately moist well into the growing season if conservatively managed. The vegetation, which on the average covers 25 to 35 percent of the ground surface, is composed largely of grasses and grasslike plants, but numerous weeds or forbs as well as some cactus, sagebrush, and other shrubs are also present. The principal species are blue grama, bluestem wheat-

grass, threadleaf sedge, and needle-and-thread. Several less important grasses are also present. Forbs, such as scarlet globemallow, prairieclover, biscuitroot, several species of Indianwheat, and other low-value annuals provide some forage during their growing season. Big sagebrush is rather common, and fringed or pasture sagebrush is frequently present. Because they produce a great amount and variety of forage, these rolling grassy areas have the highest grazing value. They are best adapted to summer and fall grazing owing to the abundance of late-starting blue grama and the variety of herbaceous plants which are green and succulent in summer.

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FIGURE 3.—The hilly areas, where coarse grasses are abundant, are most valuable for early spring or winter grazing.

The high proportion of perennial grasses which cure well on the ground make these areas suitable also for late fall and winter grazing. However, little protection from storms is provided by the gently rolling topography, and the low-growing blue grama and threadleaf sedge are likely to be unavailable because of snow.

Sandy to gravelly loam soils and moderately steep topography combine to characterize other parts of the northern Great Plains range (fig. 3). These soils have a high water-absorbing capacity with consequent low runoff but dry out rather rapidly. The vegetation normally covers about a fifth to a quarter of the soil surface and consists principally of coarse perennial grasses and grasslike plants. Forbs are not conspicuous but one or more browse species may be rather abundant. Some of the most abundant grasses are bearded bluebunch wheatgrass, side-oats grama, needle-and-thread, bluestem wheatgrass, stonyhills muhly, and blue grama. Scarlet globemallow, lupine, and licorice, as well as skunkbush sumac and small soapweed,

are characteristic. These hilly grass areas are most valuable either as early spring or winter range, when old forage from the previous year's crop is acceptable to sheep. Some protection from the weather is afforded livestock by the hills during early spring storms and the forage is seldom made unavailable by snow. The first green forage in the spring appears in these hilly areas.

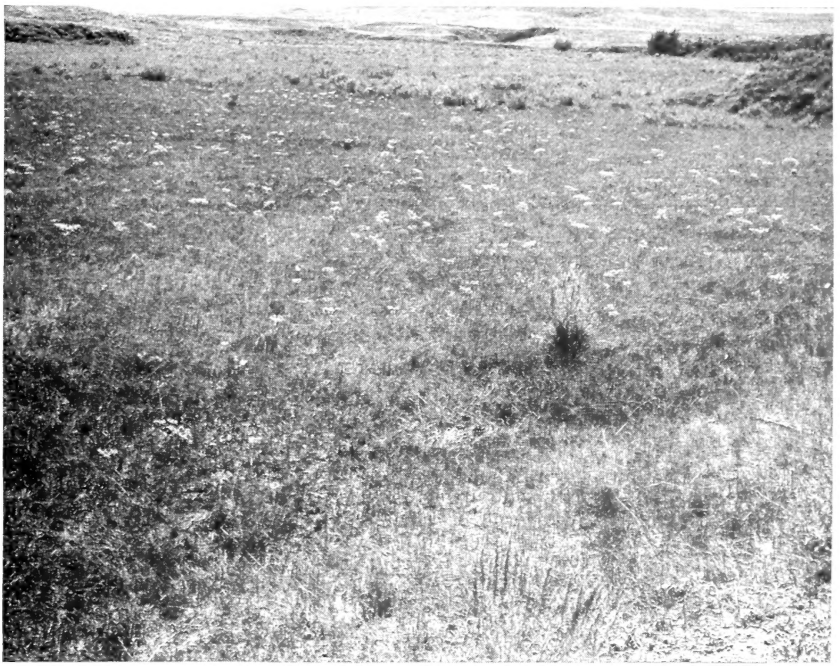

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FIGURE 4.—The level or very gently sloping bottom lands are most productive and constitute an important part of the northern Great Plains range.

The flood plains of the major streams constitute another important variation of the northern Great Plains range (fig. 4). These areas are characterized by generally heavy, frequently alkaline, clay soils, and level or very gently sloping topography. The heavy soils absorb water very slowly but remain moist longer than lighter soils. Puddling of the surface layer caused by trampling of the wet soil or by intense rainfall may retard water absorption and make runoff excessive. About a third to a half of the soil surface is normally covered with vegetation, largely perennial grasses, the most important of which is bluestem wheatgrass. Nearly pure stands of bluestem are common on these bottom areas, especially on those portions which are sometimes flooded by runoff from adjacent slopes following heavy rains. Buffalograss, green needlegrass, and Sandberg bluegrass are also important on these bottom lands, and some blue grama may be found on the drier edges. Herbaceous forbs compose a very small and unimportant part of the vegetation. Silver sagebrush is frequently present on these heavy soils. Forage production per unit area is higher on these flood plains than on any other part of the northern Great Plains range. This is undoubtedly due to the deep soils and the greater amount of flood water received.

Because stock water is often available and the vegetation remains green longer than on other areas, these bottoms are best suited to summer grazing. Early spring use, particularly when the soil is wet, may cause damage through trampling.

The rough parts of the northern Great Plains, sometimes called badlands, comprise another important part of the range (fig. 5). The

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FIGURE 5.—The rough parts of the northern Great Plains are sparsely vegetated and are chiefly valuable as winter range.

topography is rough and broken with precipitous slopes and sharply cut canyons. The soil is heavy, often alkaline, and locally may be rather rocky. It is often referred to as "gumbo" and extensive areas may be called gumbo ranges. Because of the tightness of the soils and the steepness of slopes, water absorption is slow and runoff is very rapid. On some sites, moisture seldom penetrates deeper than a few inches. The very sparse vegetation consists chiefly of perennial grasses, but browse is often sufficiently abundant to convey the aspect of a browse range. Bluestem and bearded bluebunch wheatgrass, along with blue grama and alkali sacaton, are the most important grasses on these rough areas. Forbs such as scarlet globemallow, dwarf phlox, and evening-primrose make up a small percentage of the vegetation. The remainder is composed of big sagebrush, black greasewood, greenplume rabbitbrush, common winterfat, and shadscale saltbush.

These browse species, particularly winterfat and saltbush, have an unusually high protein content (*2*) during the winter, when many grasses and other species are low in protein and generally high in lignin content. Because of this and the protection that the hills provide against storms, such areas have a particular value for late fall or winter grazing. Scarcity of stock water usually prevents extensive use of these rough portions of the range in summer, and steep topography, plus the sticky gumbo soil, makes them generally unsuitable for extensive early spring use.

THE FORAGE AND ITS UTILIZATION

Of the many plant species which compose the northern Great Plains range, nearly all provide forage for sheep at some time during the year. Their forage values are unequal and palatability varies with many factors. The bulk of the forage is provided by about 25 species. Still a smaller number, mostly perennial grasses, normally provide forage yearlong. These, blue grama, bluestem wheatgrass, needle-and-thread, and threadleaf sedge, are considered key species. Good range management aims to maintain and improve the density and vigor of key species on the range. Certain weed and browse species are also of high importance, particularly for the variety they furnish, but these will ordinarily not be grazed too heavily when stocking is conservative and is regulated by the estimated allowable use of the important key grasses or grasslike plants.

Growth and Development of the Forage

Spring growth of the range forage begins generally in late March or early April and ends during late July or occasionally early August. Some additional growth may occur following fall rains in August or early September. Either inadequate soil moisture or too low temperature may limit growth at the start of the season but of the two factors, lack of soil moisture is perhaps the more influential. It is not uncommon to find green forage present as soon as the snow melts, provided the snow has melted slowly and the soil has absorbed some moisture. If snow removal is rapid and runoff excessive, soil moisture is likely to be low and the start of growth somewhat retarded unless spring rains follow soon after. Forage growth is closely correlated with April to September precipitation, which is about 70 percent of the 13.06-inch annual long-time average for Miles City (fig. 6). Most of the forage is produced during May and June, which are normally the 2 months of greatest rainfall.

Sandberg bluegrass and threadleaf sedge start growth earliest in spring (table 2). The production of forage by these early starting species is extremely important because it materially lengthens the grazing season. These species complete their growth cycles early in the season and frequently produce fair amounts of forage in years

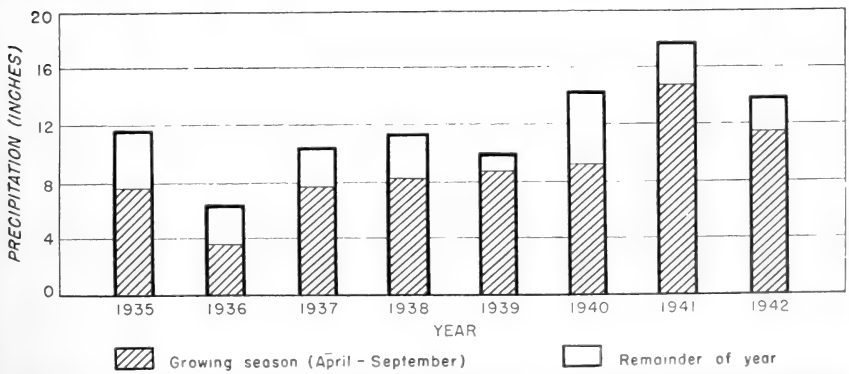

Figure 6.—Annual and growing-season precipitation, Miles City, Mont., 1935–42.

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when summer drought greatly reduces the production of late-growing forage plants. Because herbage growth is normally slow in early spring, the experimental ewes were forced to subsist largely on the previous season's growth for the first few days of the grazing season. They were observed to search for cured herbage but after the new growth of Sandberg bluegrass and threadleaf sedge reached sufficient height to be available, the old growth was seldom grazed.

TABLE 2.—*Stages of development of five important forage species on northern Great Plains range* [1]

Species	Spring growth starts—	In boot [2]	Spring growth completed
Sandberg bluegrass	Middle of March	Late April	Mid-May to late June.[3]
Threadleaf sedge	Middle to late March.	Early to mid-April.	Late May.
Bluestem wheatgrass	Late March to early April.	Early June	Late July.
Blue grama	Middle to late April	Middle to late June.	Do.
Buffalograss	Late April	June	Do.

[1] Dates given are average.
[2] Early stage of seed-head production.
[3] Varies widely, depending on spring rainfall.

Bluestem wheatgrass, needle-and-thread, and certain other grasses start growth soon after Sandberg bluegrass and threadleaf sedge.

As the days lengthen and become warmer, blue grama, buffalograss, and the summer forbs such as scarlet globemallow and prairie-clover begin growth. The length of the growing period of these forbs and the variety of such species which appear are closely related to the amount and distribution of rainfall received. Blue grama and buffalograss, like most of the perennial grass species, flower and complete their growth by midsummer. Seed ripens and is disseminated during late summer and early fall.

The late summer and early fall periods are characterized by the flowering of composite forbs such as hairy goldaster and prairie sunflower and most of the browse species. These plants produce seed before the first frost but dispersal frequently occurs during the following winter.

Relative Grazing Values

Preferences of the sheep for the many forage species varied with weather, condition and abundance of forage, and many other factors. In general, practically every species that occurred in the pastures was utilized to some extent at some time during the grazing season. Even pricklypear was grazed to a limited extent in early summer before the spines on the new joints became rigid. Observations of grazing on the species which provide the bulk of the forage are summarized in table 3. The principal grasses and grasslike plants are very palatable and provide forage from early spring until late fall. These species also provide winter grazing unless unavailable because of snow. A few other less abundant grasses supply some additional forage. The forbs,

TABLE 3.—*Use by sheep and relative abundance of important forage plants on experimental pastures, northern Great Plains range, by species*

Species	Part of plant grazed most	Season of greatest use	Relative abundance	Relative palatability [1]
PRINCIPAL SPECIES				
Grasses and grasslike plants:				
Bluegrass, Sandberg	Leaves	Spring, early summer, and fall.	Common	VG
Buffalograss	do	Summer	do	VG
Dropseed, sand	do	do	do	G
Grama, blue	do	Summer and fall	Abundant	VG
Needle-and-thread	do	Early summer and fall.	do	G
Sedge, threadleaf	do	Spring, early summer, and fall.	do	VG
Wheatgrass, bluestem	Leaves and seed heads.	Summer and fall	do	G
SECONDARY SPECIES				
Grasses:				
Grama, side-oats	Leaves	Early summer	Occasional	G
Muhly, stonyhills	do	Summer and fall	do	F
Wheatgrass, bearded bluebunch.	Leaves and old growth.	Spring	do	G
Forbs:				
Agoseris, pale	Flowers and leaves.	Summer	Common	VG
Biscuitroot [2]	Flowers, leaves, and fruit.	Early summer	do	VG
Gaura, scarlet	Flowers and leaves.	Summer	do	VG
Globemallow, scarlet.	do	do	do	G
Goldaster, hairy	do	Late summer	do	G
Indian wheat, woolly	Leaves and seed	do	do	G
Onion, textile	Flowers and leaves.	Early summer	do	VG
Prairieclover, purple.	do	Summer	do	G
Prairieclover, slender white.	do	do	do	G
Segolily	Flowers	Spring and early summer.	do	G
Sunflower, prairie	Flowers and leaves.	Late summer	do	G
Browse:				
Rose, Fendler	do	Summer	Common	F
Sagebrush, big	Leaves	Fall	Abundant	F
Sagebrush, fringed	do	do	Common	F
Sagebrush, silver	Leaves and twigs	Summer and fall	do	G
Saltbush, Gardner	Leaves	do	Occasional	G
Saltbush, shadscale.	Leaves and seed	do	do	G
Sumac, skunkbush	Fruit	Summer	Common	F
Winterfat, common	Leaves and twigs.	Summer and fall	do	G

[1] During season of greatest use: VG—Very good; G—Good; F—Fair.

[2] Includes several species in three genera, *Cogswellia*, *Musineon*, and *Cymopterous*.

although very palatable, were available largely in summer and therefore supplied forage only temporarily. The most important browse species furnished only a small amount of forage in summer and fall. These species are of greater importance for winter grazing.

The very palatable Sandberg bluegrass and threadleaf sedge were readily eaten by the sheep in spring and early summer and again in the fall when new growth appeared. At these seasons but particularly in early spring, these two species supply a high percentage of the forage for sheep. Bluestem was relished when it was fresh and green in early summer and again in the fall, when rain or snow softened the cured leaves. The ripe seed heads were particularly well liked at that time. The new growth of needle-and-thread was well liked, but the sheep did not graze this species after the plants produced heads unless new fall growth was produced following August or September rains. Blue grama and buffalograss were grazed throughout the summer and to some extent in the fall, depending upon weather and snow conditions. A greater variety of succulent vegetation was available in early summer than at any other season. The flowers of weeds were particularly attractive to the sheep.

Besides the grasses and forbs, several browse species regularly made up a substantial part of the forage. The various species of sagebrush and saltbush were frequently browsed, and winterfat and rose were also readily taken. The sheep also ate the fruit of skunkbush sumac and black chokecherry. Many of the late-blooming forbs were palatable to the sheep, and their appetites for these species and the various browse plants increased as the grasses cured with the advancing season.

How the Forage Was Utilized

Obtaining a reliable appraisal of grazing use on a range involves observations of large numbers of individual plants of the most important forage species. The measurement of grazed stubbles and a tally of numbers of key plants grazed along transects drawn as chords of concentric circles around the central well provided a basis for appraising herbage utilization on the experimental sheep ranges. Previously recorded ungrazed plant heights and height-weight tables for each species made possible the conversion of stubble heights and percentages of total numbers of plants grazed to percentage of herbage, figured to ground level, removed by grazing.

The important forage plants were grazed to a low stubble height (table 4) in all pastures even though more range acreage and forage were available for each sheep under conservative and light stocking than under heavy stocking. Variations in utilization between pastures stocked at different intensities resulted more often from differences in the percentage of the total number of plants that were grazed. This percentage varied with degree of stocking, height growth of the individual plants, succulence of the herbage, weather, and other factors. Height growth was an important factor affecting utilization from year to year even though grazed stubbles and percentage of the number of plants taken remained fairly constant. Regrowth after early fall rains complicated appraisal of utilization, particularly in threadleaf sedge. In this species it could not be distinguished from spring growth and its occurrence lengthened grazed stubble height and reduced percentage utilization.

TABLE 4.—*Utilization of important forage species under various rates of stocking, by species and season, 1939–41*

Species and grazing season	Heavily stocked			Conservatively stocked			Lightly stocked		
	Average stubble	Plants grazed	Utilization	Average stubble	Plants grazed	Utilization	Average stubble	Plants grazed	Utilization
	Cm.	*Percent*	*Percent*	*Cm.*	*Percent*	*Percent*	*Cm.*	*Percent*	*Percent*
Blue grama:									
1939	1.6	56	39	1.6	51	29	1.6	27	16
1940	1.1	59	47	1.8	42	29	1.5	42	31
1941	1.1	60	46	1.4	41	29	1.5	23	15
Average	1.3	58	44	1.6	45	29	1.5	31	21
Bluestem wheatgrass:[1]									
1940	5.5	60	41	6.1	29	18	5.1	37	26
1941	4.8	65	48	6.9	41	22	7.1	28	17
Average	5.2	63	45	6.5	35	20	6.1	33	22
Threadleaf sedge:									
1939	2.2	56	28	2.3	46	17	2.7	34	12
1940	1.9	58	43	2.4	36	25	2.7	23	15
1941	2.2	49	35	1.9	18	14	2.3	11	8
Average	2.1	54	35	2.2	33	19	2.6	23	12

[1] Grazing use in 1939 too light to be estimated.

Blue grama received greater use every year in the heavily stocked pastures than in the others. Stubbles varied only slightly but a higher percentage of plant numbers were grazed under heavy stocking.

Grazing use of bluestem in all situations was so light in 1939 that it could not be precisely estimated by available techniques. During the last 2 years of grazing, the comparative use as between pastures followed about the same trend described for blue grama. Without exception, however, bluestem grazing was most prevalent in the fall and if the season had extended beyond November, heavier use of this species would undoubtedly have resulted in all pastures. Stubbles on grazed plants showed more height variation than did those of blue grama, but this was greatly overshadowed by the wider spread in percentage of plant numbers grazed.

Threadleaf sedge, like other species, was grazed most in the heavily stocked pasture. Stubbles were low in all pastures but over 50 percent more individual plants were grazed on the heavily stocked pasture than in the conservatively stocked pasture.

In general, all species were most relished by the yearling ewes when the plants were young, green, and tender. Green forage was grazed when available, regardless of the amount and kind of cured forage present. In spring the sheep traveled excessively in search of the first green plants although a large amount of cured forage was available. A few species, mostly perennial grasses that started growth in

early spring and greened up again in the fall, were grazed considerably both spring and fall but largely disregarded during the remainder of the grazing season.

The sheep seldom grazed one species to the exclusion of others but usually mixed the species sufficiently to provide a wide variety. They grazed the pastures irregularly and often returned to closely grazed areas for any new growth that might have appeared since the last visit.

HABITS OF THE YEARLING EWES

Knowledge of the natural habits of range sheep is important both in the management of the range and in the proper handling of the animals themselves. Study and observation of the yearling ewes, their responses to weather conditions and topographic features, and their preferences for different forage species through the season provided some knowledge of their habits.

In this experiment the sheep were not herded but were free to move and graze as they wished. However, each group was located and counted twice daily and periodically was driven to the corral for weighing by the attendant, who spent full time looking after them. No effort was made to direct their movements over the range. Under these conditions all the vagaries of sheep nature were allowed full freedom except as restricted by weather, available water and forage, and the pasture fences. Some concentration and unnecessary trampling occurred under this system of handling, and distribution of grazing was uneven and irregular. The Rambouillet yearlings were gregarious for the most part, but occasionally a group would divide into two or more small bunches following a predator attack or other disturbance.

Principal Activities

GRAZING

The yearling ewes grazed largely during the daylight hours, particularly in the spring, early summer, and fall, when days were not too hot. In midsummer, however, when insects were bothersome and the days long and hot, they frequently grazed at night.

Various grazing formations were observed, depending upon the forage, the weather, and other factors. A wide arc formation, three or four sheep deep, was frequently observed on rolling blue grama areas when the sheep were very hungry in early morning or following confinement in the corral at weighing time. In this formation they were well spread out and moved very slowly, obtaining the maximum amount of forage for the time involved and area covered. At other times the ewes moved rapidly in a close, compact formation, grazing only the most desirable or easily accessible plants. This habit was frequently observed in late evening immediately before bedding, when hunger was not very evident. Apparently only choice forage was sought during this period. An unusual formation was often seen around skunkbush sumac or chokecherry thickets when the ewes would crowd in closely and browse until nearly every ripe fruit within reach was taken (fig. 3, p. 6). Sometimes they reached the higher ones by standing with front feet in a bush or on another sheep.

There was a tendency toward spotty, irregular grazing in all the pastures. The ewes would return repeatedly to closely grazed areas

for any small bit of new forage and would leave adjacent spots with apparently choice but older and more mature forage almost entirely ungrazed. Except in early spring, they seemed reluctant to graze areas which supported old forage from a previous crop even though large quantities of green forage were intermixed. In the fall the sheep were less active and consequently the area covered in a day was much less than in a day of summer grazing. Range sheep naturally graze very irregularly and are likely to damage the range locally by heavy grazing and trampling unless their movements are controlled by fencing or good herding.

BEDDING

The ewes usually bedded down at night, particularly during the cool seasons and when predators were not active. In late evening an hour or more after sunset they would lie down in a compact group where a fence or other obstruction provided some real or fancied protection from enemies, and would be up grazing again at the first hint of dawn. There was no indication of a desire to return each night to an established bed ground. Instead, the sheep bedded near a fence or any other obstruction which happened to be close at hand whenever night overtook them. Jardine observed this tendency in his early studies of pastural sheep grazing (7). Evidently therefore, the one-night bedding-out system encouraged on national-forest ranges fits a natural habit of range sheep and is adapted for more widespread use on northern Great Plains range. It is advantageous to the sheep as well as to the welfare of the range. The advantages of the one-night versus the multiple-night bedding system in maintaining the range, increasing lamb and wool production, and reducing losses from poisonous plants on mountain summer ranges have been well emphasized by Doran and Cassady (*5*).

In summer, when insects were most active, short bedding periods were alternated with intervals of grazing at night. These night activities were determined by actual observations and by retracing the courses traveled during the night. In the fall, particularly after snow came, the yearling ewes remained longer on the bed ground, frequently until midforenoon, and were more inclined to seek a sheltered spot for bedding than during the milder seasons.

RESTING

The daylight hours at any season in the northern Great Plains provide ample time for sheep to eat their fill of range forage, provided it is abundant and the animals are unmolested. In the experimental pastures, particularly the conservatively and lightly stocked ones, the yearling ewes frequently alternated between grazing and resting during the day. To rest they would stand or lie singly or in small groups and chew their cuds. The rest periods were usually of short duration but were frequently repeated during a day. In summer, except during the periods of greatest insect activity, the sheep commonly left the bed ground at dawn, grazed for an hour or two, then rested perhaps as long as an hour. Afterwards grazing was resumed and frequently continued well into the forenoon. These rest periods were distinctly different both in nature and purpose from those periods spent bedded down at night or "shaded up" for protection

from insects during the day. When the sheep rested they apparently felt well-fed and content to remain quiet and ruminate. This was conducive to better weight gains and improved welfare, and was considered as indicative of satisfactory management.

FIGHTING INSECTS

Range sheep that are herded have the well-known habit of congregating on summer days, frequently near watering places. This practice is commonly known as shading up. It is usually attributed to hot weather and has become so entrenched in the daily routine that herders sometimes appear to encourage the practice by keeping their sheep congregated, often near water, for a considerable part of the day even though natural conditions may not prompt the sheep to congregate. Such concentration from midmorning until late afternoon causes damage to the range.

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FIGURE 7.—Sheep congregated, or shaded up, under a high bank near a developed spring.

In the experimental pastures the yearling ewes frequently congregated during the day, but observations indicated that it was primarily for protection from insects. They frequently grazed for short periods during the hottest part of the day if insects were inactive, then congregated at other times when temperatures were lower but insects obviously more troublesome. Barren, dusty places or steep, browse-covered slopes sometimes near water (fig. 7) were very often selected, but actual shade was not a requirement. Little, if any, rest was gained when the ewes congregated under these conditions because a substantial part of a group was constantly in motion as individuals lay down, got up, kicked, or moved about to dislodge annoying insects.

Unnecessary congregating should not be encouraged by poor herding or other questionable practices. There can be little doubt

that excessive trampling is one of the major causes of damage on sheep range. Countless steps by the narrow, sharp hoofs of the sheep cut the crowns of forage plants and loosen the soil around them. The loose soil is then moved by wind, and the shallow roots become exposed, dry out, and frequently die.

WATERING AND SALTING

The experimental yearling ewes did not water regularly even though watering places were plentiful and well distributed. It was not unusual for a group to drink three or four times in a single day but at other times and for no apparent reason the same group would go to water only every other day. Even in the hottest part of summer, the sheep would occasionally go 2 days without a drink. Puddles formed by melting snow in early spring, and small ponds formed during showers in summer, served temporarily as watering places. In the

F-415234

FIGURE 8.—A small spring which was developed and the water piped into troughs to improve distribution in the pastures.

fall, water was taken less frequently than in summer. When snow covered the range, water was seldom taken.

A number of small springs and seeps were developed in the pastures to provide additional watering places. This resulted in noteworthy improvement in distribution as compared to watering at one central location. Such weak springs (fig. 8) are quite common on many dry ranges where shale formations outcrop. These developments demonstrated that small springs have a definite value in a range sheep

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operation when the cost is moderate and storage troughs are provided to collect the slight flow. A spring which yields only one-fourth to one-half gallon per minute will water a band of 700 to 1,200 ewes every other day on the average if adequate storage facilities are supplied.

Salting away from water in an attempt to improve distribution and lighten the use near the watering places was unsuccessful. The yearling ewes did not graze the pastures uniformly and, therefore, seldom returned to the salt again, even though driven to it once, when it was placed a great distance from water. This indicates that the established practice on the national forests (*7*) of salting range sheep at night on the bed ground is preferable to salting away from water and that little use can be made of salt as an aid to distribution of sheep on these ranges.

Influence of Natural Factors

WIND

Of all the climatic factors which affected the movement of the ewes, wind was the most influential. Between April 1 and November 13, 1941, the manner in which 3 groups grazed with respect to wind direction was observed and recorded 522 times. Based on these observations, the sheep grazed into the wind 44 percent of the time, with the wind 30 percent, and sidewise to the wind 26 percent of the time. Even before this record was made, the tendency for sheep to graze into the wind was noticed and used to advantage in locating the various groups. A gentle to moderate wind from any direction would frequently attract the sheep to the corresponding corner of the pasture, and knowledge of this fact often saved time and miles of travel in inspecting the flocks in the various pastures. This knowledge of the reaction of range sheep to wind is useful in formulating handling systems. Under the 1-night bedding system, alternate routes of travel can be planned ahead to take advantage of anticipated wind movement.

TEMPERATURE

High summer temperatures frequently restrict the movements and grazing habits of range sheep. In the experiment, the effects of hot weather were apparently complicated by insect activity. The groups of yearling ewes were frequently observed grazing at midday under a scorching sun and at other times when insects were particularly troublesome they would shade up throughout most of the daylight hours even though it was not particularly hot. Only at night was much grazing done under such conditions. In the absence of insects, however, the sheep pursued their normal activities with little regard for temperature even on the hottest days. In their early studies of sheep grazing Jardine and Anderson (*8*) recognized this tendency and recommended that range sheep should not be restricted by close herding if both the sheep and the range were to be maintained in the best possible condition.

Low temperatures restricted the movements of the sheep. A group would frequently remain for 2 or 3 days during a cold period in a small rough drainage where forage and some protection from the

weather were available. This habit was evident particularly if there was snow on the ground. A combination of low temperature and high wind sometimes caused the sheep to drift down wind. These observations suggest that rough ranges which provide protection from storms and cold winds should be reserved for winter grazing.

Influence of Fences

The fences obstructed to some extent the natural movements of the sheep and served as barriers along which grazing use was frequently so concentrated as to do considerable damage to the range (fig. 9). As a result, the pattern of grazing use in each pasture resembled a series of irregular concentric bands ranging from very heavy along the boundary fences to somewhat lighter in the interior of the pastures. The Rambouillet sheep instinctively sought the shelter of some sort of barrier for shading up or resting and the fences were selected most frequently. Some of the effects of these instinctive habits on both the ewes and the range could undoubtedly have been avoided if greater care had been used in locating the pasture fences. These experiences indicate that fences complicate the natural movement of sheep over the range. Unnecessary or poorly located fences are an obstacle in the proper use and management of typical northern Great Plains range.

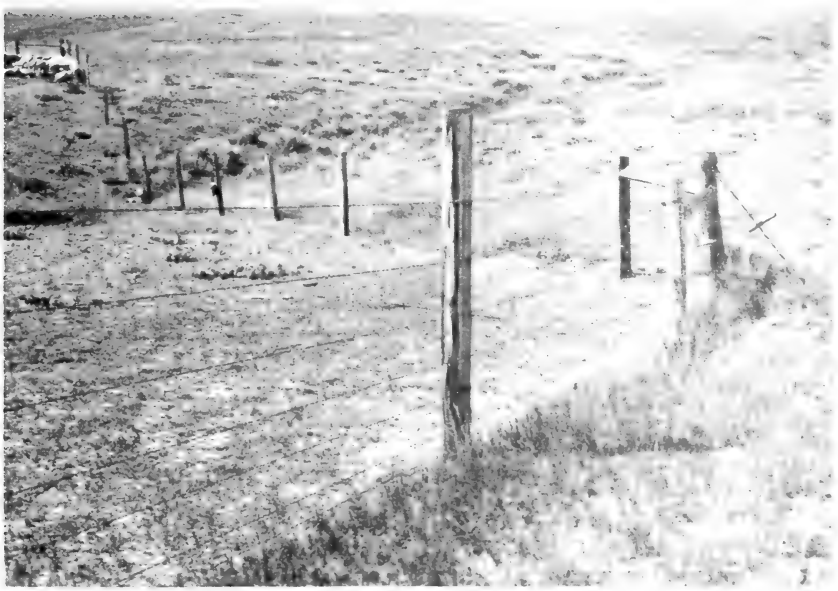

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Figure 9.—The sheep repeatedly rested or shaded up along pasture fences, often causing severe damage to the range vegetation.

Influence of Predators

The experimental ewes were frequently attacked by coyotes, bobcats, and renegade dogs. Death losses due to these predators were high each year and additional unmeasured losses also undoubtedly occurred in the form of reduced weight gains due to disrupted activities. The combined efforts of a Government hunter and the shepherd, who tended the sheep and who had considerable experience and skill in trapping, failed to control the predators or prevent heavy losses. Prior to the start of the experiment, losses were light on this same area when the sheep were herded. Predator attacks increased the nervousness of the sheep and made them more easily disturbed.

Several motives for attack by the predators were apparent. Some, probably the renegade dogs and immature coyotes, killed for fun and caused the heaviest losses. Their attacks were infrequent but sometimes involved the groups in every pasture with the loss of a dozen or more sheep in one night. Transient coyotes occasionally killed to satisfy hunger and a female coyote or bobcat with young sometimes killed one sheep each night until the den and the young were located and destroyed. These females with young caused heavy losses and their attacks were most frequent through late June and July when the young were being taught to provide for themselves. Many of the ewes lost as a result of predator attacks died from injuries received while fleeing at night in rough, broken country. Attacks were most numerous at night but were also recorded in daylight hours. Direct observations of daylight attacks indicated that the coyotes first frightened the sheep, and then killed the individuals that left the group. A frightened, running sheep was at their mercy.

An electrically charged wire spaced 6 inches from the ground and the same distance below the next higher wire of the boundary fence served temporarily to reduce the number of predators that entered the pastures. Coyotes soon became "educated," however, and were observed searching for depressions under the fence through which they could crawl without contacting the charged wire. Maintenance of a charged wire so close to the ground was expensive and would probably not be practical on a ranch. These experiences indicate that predator losses are likely to be too high in the northern Great Plains to justify large-scale, free pasture grazing by Rambouillet sheep. However, in northwestern South Dakota, where predators are few and are closely controlled during lambing, when sheep are constantly observed and extra care is provided, pasture grazing has been practiced successfully. The practice may have advantages elsewhere in the northern Great Plains.

Habits Indicate Desirable Management Systems

Because range sheep tend to return repeatedly to favored grazing areas until heavy use and range damage occur, and because predators are usually numerous and not closely controlled in the northern Great Plains, it is inadvisable to turn sheep loose to freely graze large fenced areas of range. The foregoing observations and experiences indicate how knowledge of the natural habits of range sheep may be used in devising handling systems that will aid in obtaining good range and livestock management on northern Great Plains range. Slow, quiet handling with some latitude for choosing the direction of movement

with reference to the wind and freedom to graze and rest alternately for short periods is beneficial to the sheep and the range. Frequent changes of bed grounds and overnight camps make for better distribution over the range and uniform use of the forage. Many well-distributed water developments will also aid in more uniform grazing use. Predator losses can be decreased through the presence of a vigilant herder. All of these factors, coupled with conservative stocking, help to improve the welfare of range sheep and safeguard the range.

EFFECTS OF HEAVY, CONSERVATIVE, AND LIGHT STOCKING

For several years prior to 1936, the first year of the sheep-grazing experiment, the experimental range was grazed conservatively each summer by a band of herded sheep and a few horses. This conservative use preceding the experiment permitted the range to maintain high vigor and productivity until severe drought struck in 1934. Nearly normal rainfall occurred in 1935, but the range failed to recover from the effects of the previous drought year. Severe drought occurred again in 1936, accompanied by grasshopper infestations, and vegetation density and herbage production were reduced even below the low levels reached in 1934. On adjacent similar ranges grazed conservatively by cattle, total vegetative density was reduced by these two drought years to 9 percent of its 1933 level (*6*).

Recovery of short-grass range from the effects of severe drought was slower on the pasture heavily stocked for 6 years than on the pastures conservatively and lightly stocked. This was manifest in the thinner vegetative cover, smaller sized plants, shorter plant heights, and reduced herbage production per unit area on the heavily stocked pasture. Low-value annual species were more abundant at the end of the grazing experiment on the heavily stocked pasture than on the others and in 1942 their herbage made up a high proportion of the weight of the vegetation harvested from a series of plots. To the stockman these effects of heavy stocking mean less forage, a shorter grazing season, greater drought and winter risks, and higher production costs.

Effects on Density of the Vegetation

In 1938, the third season of grazing, when effects of the 1934 and 1936 droughts were still evident, meter-square chart quadrats, hereafter referred to as plots, in all stocking intensities and in areas fenced that year had rather low total densities; 765 square centimeters on the heavy, about the same on the light, and 809 and 850, respectively, on the conservatively grazed and on plots recently fenced (table 5).

Practically no recovery from this low level was shown in 1939. The decline in little bluegrass just about offset the increase in blue grama and other dependable perennial grasses on the lightly stocked and ungrazed plots. Under heavy and conservative stocking, an actual decline in total density occurred.

After 1939 the total density improved on all plots regardless of grazing use. By 1941 total density of perennial species under heavy stocking had increased 326 square centimeters per plot, while the

conservative, light, and ungrazed plots increased 297, 370, and 508 square centimeters, respectively, on the average.

Without any grazing in 1942 and following the favorable rainfall of 1941, the perennial vegetation made remarkable recovery in density on all plots. For the 5 years 1938–42, total perennial vegetative density increased 749, 849, 1,143, and 1,172 square centimeters, respectively, on the heavily, conservatively, and lightly grazed and ungrazed plots.

TABLE 5.—*Average density of important range vegetation on meter-square experimental plots, by stocking rate and year, 1938–42*

Stocking rate and year	Blue grama	Bluestem wheatgrass	Little bluegrass	Other perennial grass and grasslike plants	Perennial forbs	Browse	Total, all perennial species
Heavy:	*Cm.*[2]	*Cm.*[2]	*Cm.*[2]	*Cm.*[2]	*Cm.*[2]	*Cm.*[2]	*Cm.*[2]
1938	158	7	588	12	0	0	765
1939	300	14	290	27	3	1	635
1940	545	26	158	60	5	4	798
1941	765	30	55	90	6	15	961
1942	1, 267	38	36	139	4	30	1, 514
Conservative:							
1938	96	18	683	12	0	0	809
1939	217	23	418	18	2	(1)	678
1940	357	32	247	40	3	4	683
1941	737	55	99	51	5	28	975
1942	1, 427	50	35	104	4	38	1, 658
Light:							
1938	100	29	630	17	0	0	776
1939	221	48	484	28	5	0	785
1940	441	51	382	43	25	9	951
1941	856	81	133	46	23	17	1, 156
1942	1, 612	73	107	93	22	12	1, 919
Ungrazed:[2]							
1938	135	17	667	31	0	(1)	850
1939	273	31	495	58	2	(1)	859
1940	570	38	295	101	4	(1)	1, 008
1941	949	77	140	178	5	18	1, 367
1942	1, 512	73	62	345	4	26	2, 022

[1] Less than 1 Cm.[2]

[2] These areas were fenced in 1938 and thereafter entirely protected from sheep grazing.

BLUE GRAMA

In 1938, blue grama covered 1 to 2 percent of the ground surface on the average and composed 12 to 20 percent of the total perennial vegetative cover. There was a greater density of blue grama on plots in the heavily stocked pasture at that time than in any of the other pastures or the ungrazed areas. During the 4 years of grazing, 1938–41, blue grama density increased through the establishment of new plants and the enlargement of old ones by 814, 756, and 641 square centimeters per plot on the ungrazed, lightly, and conservatively stocked pastures, respectively, but under heavy stocking the increase was only 607 square centimeters per plot. In the relatively good rainfall year of 1942, when none of the pastures was grazed, blue grama made striking density increases on all plots; 502, 690, 756, and 563

square centimeters on the average on the heavily, conservatively, and lightly grazed, and ungrazed plots, respectively.

For the 5 years 1938–42, the greatest increase, 1,512 square centimeters, occurred on the plots under light stocking. These plots also had the highest final grama density. The total increase under conservative stocking was slightly smaller as was final density. On the protected plots, blue grama density increased 1,377 square centimeters per plot and the 1942 density was intermediate between the lightly and conservatively stocked levels for that year. Under heavy stocking the increase in blue grama density between 1938 and 1942 was only 1,109 square centimeters per plot. In 1942, when none of the pastures was grazed, plots on range that had previously been heavily stocked had the lowest density of all situations.

BLUESTEM WHEATGRASS

The density of bluestem increased each year from 1938 through 1941 under all intensities of stocking and under protection. The greatest increase over the 4 years, 60 square centimeters per plot, occurred on the ungrazed areas. Under heavy stocking, the increase was 23 square centimeters compared with 37 and 52 per plot under conservative and light stocking. Thus, recovery of this valuable forage species was directly related to the rate of stocking; least where grazing use was heaviest, and progressively more through conservative and light grazing to protection.

In 1942, when rainfall was relatively good, bluestem density actually decreased on the plots that were conservatively and lightly stocked even though grazing was not permitted that year. At the same time, it continued to recover from past grazing use and drought on the plots that were heavily grazed.

For the 5 years 1938–42, the greatest total increase in bluestem density occurred on the plots protected from sheep grazing since 1938. The fact that bluestem density continued to increase on the heavily grazed plots after grazing ceased but actually declined on areas previously grazed lighter and protected, illustrates how much heavy grazing delayed the natural tendency of this range to reach a balance following a major drought disturbance.

By 1942 the lightly grazed and ungrazed plots had equal densities of bluestem. Plots on the conservatively grazed area had only two-thirds as much bluestem density and the heavily grazed plots only about half as much as those protected and lightly grazed.

LITTLE BLUEGRASS

Largely because of its ability to grow early in spring when moisture is available and then lie dormant during the dry summer, little bluegrass increased during and immediately after the drought when later starting species were losing density. By 1938 it composed 75 to 85 percent of the vegetative cover exclusive of cactus and browse on plots in the sheep pastures. From 1938 through 1942 it declined steadily under all three intensities of grazing and even with protection from sheep grazing. This steady decline just about offset the increase in density of other perennial species in 1939 under light grazing and protection and caused a decline in total density under conservative and heavy stocking. Under heavy stocking the loss in little bluegrass density in the 4 years 1938–41 was 91 percent as compared with 86

percent on the conservatively grazed pasture, and only 79 percent with light stocking and protection. By 1942 little bluegrass made up only 2 to 6 percent of the vegetative cover on the plots.

OTHER PERENNIAL GRASSES AND GRASSLIKE PLANTS

The group of other perennial grasses and grasslike plants, composed of species such as sand dropseed, needle-and-thread, and threadleaf sedge, recovered very slowly under all degrees of stocking. Greater competition from the principal perennial species which were recovering rapidly under conservative and light stocking retarded recovery of this group more than did heavy grazing and somewhat less competition in the small pasture.

By late 1942, the density of this group had just about doubled as compared with the 1941 level on plots in the areas previously stocked conservatively and lightly. On the heavily grazed plots the increase after grazing was slightly more than 50 percent above the 1941 level. The trend under protection was comparable with that on the conservatively and lightly stocked plots.

PERENNIAL FORBS AND BROWSE

Browse species and perennial forbs, although common on the experimental range, were very sparse or entirely absent from all plots in 1938. They increased slowly under all situations throughout the study but none became important constituents of the plots.

Effects on Number and Size of Plants

Under average weather and with good grazing management, the principal clump-forming forage species in the northern Great Plains are vigorous and well-spaced, but they seldom form a complete cover. Severe drought in 1934 and 1936 greatly reduced the stand of perennial forage plants in the northern Great Plains (*6*) and it is evident from

TABLE 6.—*Average number of plants, by species, on 2 by 5 decimeter plots randomly located in 1942, after 6 years of sheep grazing at various stocking rates*

Species	Heavily stocked	Conservatively stocked	Lightly stocked	Ungrazed
Clump-forming:	*Number*	*Number*	*Number*	*Number*
Blue grama	1. 18	0. 75	0. 81	0. 47
Threadleaf sedge	2. 66	7. 73	5. 20	1. 02
Little bluegrass	. 71	. 43	. 37	1. 19
Needle-and-thread	. 16	. 68	. 41	. 12
Total	4. 71	9. 59	6. 79	2. 80
Single stem:				
Bluestem wheatgrass	8. 73	8. 19	13. 82	21. 36
Threadleaf sedge	. 87	. 40	. 24	2. 93
Total	9. 60	8. 59	14. 06	24. 29
All annual species	64. 74	13. 65	34. 17	67. 53

the vegetative-density record in table 5 that the stand was still at a low level in 1938.

In 1942, the first season after grazing was terminated in the pastures, and following the good growing season of 1941, there were fewer plants of the 4 major clump-forming species per unit of area on the heavily stocked range than on the other grazed areas (table 6). Collectively, blue grama, threadleaf sedge, little bluegrass, and needle-and-thread averaged about 10 and 7 plants per plot on the conservatively and lightly stocked pastures but only about 5 plants on the area heavily stocked. Also, the average size of plants of these 4 clump-forming species was less per plot under heavy stocking than under conservative or light (table 7). On plots ungrazed after early 1938, the plants of these 4 species combined were the fewest in number and the smallest in size of those in all situations.

TABLE 7.—*Average area of plants, by species, on 2 by 5 decimeter plots randomly located in 1942, after 6 years of sheep grazing at various stocking rates*

Species	Heavily stocked	Conservatively stocked	Lightly stocked	Ungrazed
	*Cm.*²	*Cm.*²	*Cm.*²	*Cm.*²
Blue grama	11. 97	12. 30	12. 47	7. 51
Threadleaf sedge	2. 21	1. 62	1. 71	2. 13
Little bluegrass	1. 53	1. 33	1. 66	1. 89
Needle-and-thread	3. 11	5. 16	7. 30	6. 56
Total	18. 82	20. 41	23. 14	18. 09

BLUE GRAMA

Individual plants of blue grama were more numerous in 1942 on heavily stocked range than on conservatively and lightly stocked range by 57 and 46 percent, respectively (table 6). The areas protected from sheep grazing from 1938 to the end of the experiment had fewer blue grama plants than any of the grazed pastures. Although most numerous on plots heavily grazed, the plants were slightly smaller than those on lighter grazed plots (table 7). The closer grazing and more severe trampling associated with heavy stocking prevented small blue grama mats from merging into compact clumps. Heavy stocking also apparently retarded the enlargement of individual established clumps of blue grama. On protected areas both numbers and size of blue grama plants were restricted by competition with other species for soil moisture and nutrients.

THREADLEAF SEDGE

In 1942 the pasture heavily stocked previously had less than three plants or clumps of threadleaf sedge per plot in comparison with nearly eight for the conservatively stocked and five for the lightly stocked (table 6). Even though the plants were slightly larger on the area heavily stocked than elsewhere (table 7), this difference was sufficient to account in part for the 1942 plot densities summarized in table 5. Since threadleaf sedge plants were less numerous but slightly

larger on the heavily stocked pasture than elsewhere in 1942, after 6 years of sheep grazing, heavy stocking evidently had such effects as killing the small plants that survived the drought or preventing the establishment of new plants following the drought. The important point is that threadleaf sedge was only about half as abundant on the small pasture after 6 years of heavy stocking as on other pastures stocked more lightly. On the area protected after early 1938, the plants were intermediate in size between those on heavily and conservatively stocked range but were very sparse.

NEEDLE-AND-THREAD

Needle-and-thread grass, another important clump-forming species and one of the most sensitive to grazing, was by 1942 very sparse in the heavily stocked pasture. Plants on the sample plots averaged only about one-fourth and one-half as numerous, respectively, as on the conservatively and lightly stocked pastures (table 6). Besides being much less numerous, needle-and-thread clumps were less than half as large on the heavily stocked pasture as in the lightly stocked and unstocked areas (table 7). The plants were somewhat smaller on the conservatively stocked than on the protected and lightly grazed areas but still considerably larger than under heavy stocking. Heavy grazing and trampling retarded the recovery from drought of surviving needle-and-thread plants and limited the establishment of new plants from seed. These findings strengthen the plot-density data and help explain the sparser stand of vegetation on the heavily stocked pasture.

BLUESTEM WHEATGRASS

In 1942 there was nearly twice as many stems of bluestem per plot on the lightly stocked range and more than twice as many on areas protected since 1938 as on the heavily stocked. There was little difference in the stand of bluestem on conservatively and heavily stocked areas. Because of its single-stemmed growth habit, bluestem does not form a sod but by means of underground rootstocks increases rapidly in the stand when relieved from grazing. The large number of stems per plot on the lightly stocked and protected areas undoubtedly helps to account for the greater total density on these areas in 1942.

ALL ANNUAL SPECIES

Low-value annual species such as woolly Indianwheat and sixweeks fescue were five and two times more abundant in the heavily stocked pasture by 1942 than in the other two grazed pastures, respectively (table 6). By retarding the recovery of palatable perennial species, heavy stocking permitted an increase in annual species (fig. 10) which at best are only temporary and provide a limited amount of forage.

Effects on Height Growth of Blue Grama and Bluestem Wheatgrass

Height growth of blue grama leaves and seedstalks was greater in 1942 on the conservatively stocked pasture by 22 and 3 percent, respectively, than on the heavily stocked pasture (table 8). On the protected areas the leaves and seedstalks were 55 and 10 percent taller than on areas stocked heavily during 6 previous years. The propor-

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FIGURE 10.—Six years of heavy sheep grazing and trampling changed the vegetative composition of typical northern Great Plains range to a dense stand of low-value annual plants mostly woolly Indianwheat except in the protection of pricklypear clumps.

tion of plants producing seedstalks was very similar in the ungrazed areas and the conservatively stocked pasture. In the heavily stocked pasture, however, about 10 percent more of the plants produced seed stalks than in the conservatively stocked pasture and 5 percent more than in the ungrazed areas. Although heavy stocking retarded height growth, it stimulated the production of seedstalks in blue

TABLE 8.—*Average maximum length of leaves and height of seedstalks, and proportion of plants that produced seedstalks, by rate of stocking and species, 1942*

Stocking rate and species	Length of leaves	Height of seedstalks	Plants with seedstalks
	Cm.	*Cm.*	*Percent*
Heavy:			
Blue grama	9	30	91
Bluestem wheatgrass	28	56	17
Conservative:			
Blue grama	11	31	83
Bluestem wheatgrass	30	60	13
Ungrazed:			
Blue grama	14	33	87
Bluestem wheatgrass	35	61	15

grama. It is not inferred that greater seedstalk production as a result of heavy stocking means greater production of viable seed. Although data are not available, heavy grazing may have actually reduced the quantity of good seed produced even though more seedstalks appeared on the heavily than on lighter stocked areas.

Leaves of bluestem grew taller on the conservatively stocked pasture and the ungrazed areas in 1942 by 7 and 25 percent, respectively, than on the heavily stocked pasture, and seedstalks were 7 and 9 percent taller (table 8). However, the plants on the heavily stocked pasture produced more seedstalks that year by 31 and 13 percent than plants on the conservatively stocked and ungrazed areas. Thus, as with blue grama, heavy stocking retarded the height growth but stimulated seedstalk production. Again, however, the effect on production of viable seed is not known, but heavy stocking may well have caused the production to decline.

Effects on Herbage Production

Where intensive use of range vegetation retards its recovery from drought, the result is less herbage production, less usable forage, and lower grazing capacity.

Table 9.—*Production of air-dry herbage per acre and estimated usable forage per acre* [1] *under various stocking rates, by species, 1942*

Species	Heavily stocked		Conservatively stocked		Lightly stocked		Ungrazed	
	Herbage	Estimated forage	Herbage	Estimated forage	Herbage	Estimated forage	Herbage	Estimated forage
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Perennial grasses:								
Blue grama	149	66	250	73	279	59	515	149
Bluestem wheatgrass	110	50	245	49	445	98	653	131
Threadleaf sedge	124	43	365	69	204	24	39	7
Other perennial grasses	87	52	198	119	109	65	108	65
Total	470	211	1, 058	310	1, 037	246	1, 315	352
Perennial forbs	143	29	94	19	93	19	40	8
Browse	(2)		1	(2)	45	2	33	2
Total	613	240	1, 153	329	1, 175	267	1, 388	362
Annuals	815	163	79	16	306	61	437	87
Total, all species	1, 428	403	1, 232	345	1, 481	328	1, 825	449

[1] Estimates of usable forage for blue grama, bluestem, and threadleaf sedge derived by applying utilization figures in table 4 to pounds of air-dry herbage per acre. For other species the following factors were used for all stocking intensities: other perennial grasses, 60 percent; perennial forbs, 20 percent; browse, 5 percent; annuals, 20 percent.

[2] Less than 1 pound.

Not all herbage, even of the most palatable species, can be considered as usable forage. Of the many factors involved, the necessity of leaving considerable herbage to protect the soil and insure regrowth of the range vegetation is most important. Since grazing capacity is based only on herbage that should properly be used instead of total herbage produced, a conversion is necessary. To make this conversion, total pounds of air-dry herbage for each key species were weighted by the average percentage grazing use obtained during 3 years (table 4, p. 13) in the sheep pastures under each intensity of stocking. For other species or groups of species for which average use percentages were not available, weighting was done by applying estimated factors for all areas regardless of degree of stocking. These data (table 9) indicate the proportionate part of total herbage that was considered to be usable forage on the differently stocked areas.

In 1942, when the pastures were not grazed, the pasture that had been heavily stocked for 6 years produced less perennial-type herbage per acre, based on samples hand-clipped to a 1-centimeter stubble, than either of the other pastures (table 9). Even when the yields of blue grama, bluestem, and threadleaf sedge were mathematically converted into usable forage, the advantage was still with the conservative and light stocking rates. With the addition of annual-type herbage, however, the area that was heavily stocked showed greater production in total herbage than the conservative and in usable forage than all but the ungrazed area. The fact that the annual type forage is nutritious only when lush and green and that it dries and weathers away quickly, offsets any advantage the greater quantity might appear to have. Year-long sheep operations in the northern Great

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FIGURE 11.—Six years of conservative sheep grazing did not materially change this typical northern Great Plains range. Palatable perennial grasses are abundant but low-value annuals very inconspicuous.

Plains are dependent upon adequate range forage at all seasons. The perennial species, which in 1942 produced more herbage and more usable forage on areas that had been conservatively and lightly stocked than on the heavier stocked pasture, are the only ones that can be depended upon to provide forage at all seasons of the year (fig. 11).

Individual perennial species show in general the same comparisons as the entire group of perennial plants. The lower production both of herbage and usable forage for all perennial species on the heavily stocked area confirms the lower density, smaller size, and shorter height growth of plants already mentioned as evidence that heavy stocking retarded recovery.

Effects on the Soil

Heavy stocking removed too much herbage from the range and reduced the accumulation of litter on the soil surface, thereby exposing the soil surface to washing and blowing. Trampling on these barren, unlittered surfaces lossened the topsoil for easy removal by the wind and exposed the roots of the plants. On flat or level sites, some of the most persistent plants survived on pedestals a few inches higher than the surrounding surfaces.

On slopes in the sandy loam soil type, heavy grazing and trampling loosened the soil and coarser subsoil materials which were moved down the slopes by gravity (fig. 12, *A*). Under conservative and light stocking there was little evidence of accelerated erosion or soil movement due to grazing even on the steepest slopes (fig. 12, *B*).

Effects on the Sheep

Heavy stocking affected the grazing habits of yearling ewes by forcing them to return to areas already too heavily grazed more often than they naturally would have done. This caused extremely heavy use on certain areas because there were fewer favored places to return to in the smaller pasture. Also, with less forage in the heavily stocked area, the yearling ewes necessarily spent considerably more time searching for forage than those on conservatively and lightly stocked range. Seasonal gains in weight averaged 32 and 33 pounds per head on the conservatively and lightly stocked ranges, and 31 pounds on the heavily stocked range. These differences were statistically significant when corrected for age and initial weight of the ewes.

At the start of the grazing season the yearling ewes weighed from 70 to 77 pounds. Carry-over forage, together with a little green growth, was sufficient in all pastures to permit some gain during the first few weeks of each season, beginning in late March. This carry-over was confined to limited areas on the heavily stocked pasture but was available over most of the conservatively and lightly stocked pastures. An apparent loss of weight occurred at shearing time, usually during the third 28-day period, but this was followed by another period of rapid gain (table 10). By midsummer the choice forage was usually gone from the heavily stocked range and the yearling ewes gained less rapidly than earlier. The weight trends for the sheep grazed at the heavy intensity were similar to the trends for the others, but the tendency to lag at a somewhat lighter weight after midseason was noticeable. Weight gains usually continued with

FIGURE 12.—*A*, This bank and talus deposit in the head of a small drainage in the sandy loam soil type resulted from too heavy grazing and trampling. *B*, Natural erosion, though evident on this steep heavy clay soil, was not noticeably accelerated by grazing and trampling under conservative stocking.

some variations until late August or early September. After this date, a period of leveling off or even of slight decline in weight extended largely throughout September, but when there was ample green fall growth after late September or October rains, a noticeable gain occurred in all lots through late October or early November. Average final weights ranged from 101 to 109 pounds during the 5 years.

TABLE 10.—*Average weights on approximately comparable dates, and seasonal gain of yearling Rambouillet ewes, by rate of stocking and year, 1937–41* [1]

Stocking rate and year	Average weight by 28-day periods										Average seasonal gain [2]
	Start	1	2	3	4	5	6	7	8	Final	
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Heavy:											
1937	74. 5	85. 2	86. 1	89. 7	99. 0	97. 6	94. 9	99. 8	-------	105. 3	30. 8
1938	71. 9	80. 8	93. 6	100. 9	97. 9	101. 6	107. 4	105. 5	101. 7	103. 9	32. 0
1939	74. 7	74. 6	98. 5	102. 6	94. 5	99. 0	105. 2	103. 6	103. 9	107. 9	33. 2
1940	76. 8	77. 7	85. 4	86. 1	94. 0	95. 8	99. 7	99. 5	96. 3	100. 6	23. 8
1941	71. 5	78. 1	88. 1	96. 8	92. 8	92. 3	98. 5	96. 2	99. 5	106. 1	34. 6
5-year average	-------	-------	-------	-------	-------	-------	-------	-------	-------	104. 70	30. 77
Conservative:											
1937	74. 0	85. 3	82. 9	91. 9	98. 8	101. 3	98. 2	102. 6	-------	103. 6	29. 6
1938	71. 7	80. 2	97. 8	101. 6	99. 9	102. 3	103. 0	102. 6	106. 2	107. 2	35. 5
1939	73. 0	81. 1	91. 6	97. 5	90. 3	97. 8	103. 1	103. 4	109. 3	107. 7	34. 7
1940	75. 4	73. 4	88. 2	87. 6	93. 2	95. 8	99. 8	98. 6	99. 2	101. 5	26. 1
1941	72. 6	77. 7	87. 9	99. 7	92. 4	96. 5	99. 1	98. 5	102. 4	107. 2	34. 6
5-year average	-------	-------	-------	-------	-------	-------	-------	-------	-------	105. 55	32. 03
Light:											
1937	72. 1	82. 2	81. 4	87. 2	94. 5	96. 3	98. 4	100. 4	-------	105. 3	33. 2
1938	70. 0	78. 6	91. 6	95. 6	97. 4	102. 3	102. 1	103. 3	103. 3	106. 9	36. 9
1939	70. 7	75. 7	91. 7	98. 3	91. 1	92. 9	99. 7	99. 9	104. 9	105. 3	34. 6
1940	76. 7	80. 2	89. 8	88. 7	94. 8	98. 6	100. 8	100. 5	102. 1	103. 3	26. 6
1941	73. 5	79. 1	89. 4	100. 5	96. 7	94. 8	100. 1	99. 5	104. 0	108. 8	35. 3
5-year average	-------	-------	-------	-------	-------	-------	-------	-------	-------	106. 24	32. 98

[1] 1936 was a drought year and the grazing season extended only from June 13 to Oct. 30; the sheep weights for 1936 are not tabulated.

[2] Average seasonal gain is exclusive of shorn-fleece weight, which averaged approximately 11 pounds in all lots throughout the study. Shearing was usually done during the third or fourth 28-day period.

DEGREE OF FORAGE USE RECOMMENDED FOR NORTHERN GREAT PLAINS SHEEP RANGE

The degree of forage use obtained on a range during a given grazing period is directly affected by the rate of stocking. However, forage use may also be influenced by such factors as weather and poor distribution of livestock. Estimates of degree of use are valuable as checks on the rate of stocking and provide a basis for adjusting it along with other management practices.

The conservatively stocked pasture showed the best balance between forage utilization and sheep weights. The estimates obtained therefrom for bluestem wheatgrass, blue grama, and threadleaf sedge (table 4, p. 13) are considered a reliable basis for recommended rates of forage use.

Because of its fine texture and generally high palatability, blue grama was grazed to lower stubbles than any other species. A larger percentage of the herbage of this species was removed under conservative stocking than of either bluestem or threadleaf sedge. Not more than 29 percent of the herbage of blue grama should be removed by grazing on a properly stocked sheep range comparable to the experimental range. Such use results from grazing 45 percent of the total number of individual plants to an average stubble of 0.6 inch (1.6 centimeters). Costello (*4*) recommends a 1½-inch stubble for blue grama on properly grazed cattle ranges in Colorado, where this species grows taller, is more abundant, and composes a greater percentage of the vegetative composition than in the northern Great Plains.

In accordance with the utilization obtained under conservative stocking (table 4), bluestem should not be grazed to an average stubble shorter than 2½ inches, and not more than 35 percent of the plants should be grazed for proper use on northern Great Plains sheep range. Such use removes about 20 percent of the herbage produced.

For threadleaf sedge, grazed stubbles should average about 0.8 inch. The percentage of individual plants grazed should not exceed 33 to 35 percent. This degree of grazing removes 19 to 20 percent of the herbage.

To insure that all parts of a range similar to the experimental area are conservatively grazed in accordance with these recommended guides, a definite seasonal plan of use should be followed. Growth, development, and seasonal palatability of range forage, and the grazing habits of sheep indicate that each portion of the range, according to topography, soil, and composition of the vegetation, can be grazed to the best advantage at a certain season of the year. The first grazing in March or sometimes earlier should be confined to the areas having moderately steep topography and sandy or gravelly loam soils where bluebunch wheatgrass and other coarse species provide ample old forage from the previous year's crop. Seldom is the carry-over herbage entirely unavailable because of snow.

With the coming of new growth there is a natural movement of the sheep to the rolling areas having sandy clay loam soils where a variety of perennial grasses predominate. Less important species contribute a great deal to the summer forage and plans should provide for utilizing them to the best possible advantage. Flood plains or bottom areas along the main drainages are also most useful during summer. Their heavy soils are only slightly disturbed by trampling during the dry summer and the bluestem and buffalograss are then green and

more palatable than they are later. These species, plus the blue grama and the many forbs of the rolling areas, should carry the burden of grazing until late fall, when storms encourage movement to the rough hills for browse and coarse grass forage as well as the protection such areas afford. Range areas especially adapted to grazing during critical winter or early spring periods should be reserved throughout the summer and early fall in order to have them in good condition when urgently needed. Some variation from this plan of seasonal use may be necessary to obtain the use of all areas to the best advantage on individual ranges.

Conservative stocking, frequent utilization checks, and regulated seasonal grazing will not insure phenomenal success in range sheep production or wholly eliminate the risks incident to a drought, but they will stabilize operations over a long period of time and help to perpetuate the range resources.

RECOMMENDED STOCKING RATE FOR NORTHERN GREAT PLAINS SHEEP RANGE DURING AVERAGE 8- to 9-MONTH SEASON

Rate of stocking, the relative intensity of animals on a range, is usually expressed as the number of acres of range allowed for each animal for a specific period. It may also be expressed in numbers of livestock per section (640 acres) of range for the period. Range managers find such numerical expressions useful, but recognize that at best they are only guides to grazing capacity on comparable ranges. Such a guide must be checked against results of stocking on a given range and changes made as required to avoid stocking too heavily for safety or too lightly for best results in the long run.

During the 6 years of the grazing experiment, 1936–41, the stocking was increased each year after 1936 (table 1, p. 4, and fig. 13) in all pastures as the range recovered from drought. This was accomplished in 1937 by lengthening the grazing season and in 1938 to 1941 by annual increases in the number of sheep grazed, which brought corresponding reductions in acreage per head. Precipitation increased materially each year, except 1939, during the period (fig. 13). With the favorable weather forage production increased also, as judged by the amount of unused forage left on the ground at the end of each grazing season.

In 1941, the last year of the test, when the range had recovered somewhat from drought and weather was quite favorable for growth, the middle-sized pasture was stocked at the rate of 0.56 surface acre per month per yearling ewe.

A margin of safety in allotting range forage is essential because dry or drought years of low forage production often occur. If there is no such margin or reserve of forage, abnormal expense for supplemental feed or heavy liquidation may be necessary in order to avoid disastrous sheep losses. Although no supplemental feeding was done in the experiment, it would have been required in the heavily grazed pasture had the sheep been left on the range any longer each season. The quantity, cost, and availability of supplemental feed reserves to meet such emergencies on a ranch should be considered in determining the additional range area needed to assure stability and safety for the range operator. Twenty percent of additional range is the recom-

mended minimum that should be allowed to meet the ever present risk of unfavorable weather.

On this basis, 0.56 surface acre per yearling ewe per month, the average allowance under conservative stocking during 1941, plus the 20 percent margin, amounts to 0.67 acre per yearling ewe month. Thus about 5.4 acres is considered the minimum acreage for a dry yearling ewe on good northern plains range similar to the experimental range during a relatively favorable season of 8 months beginning in March.

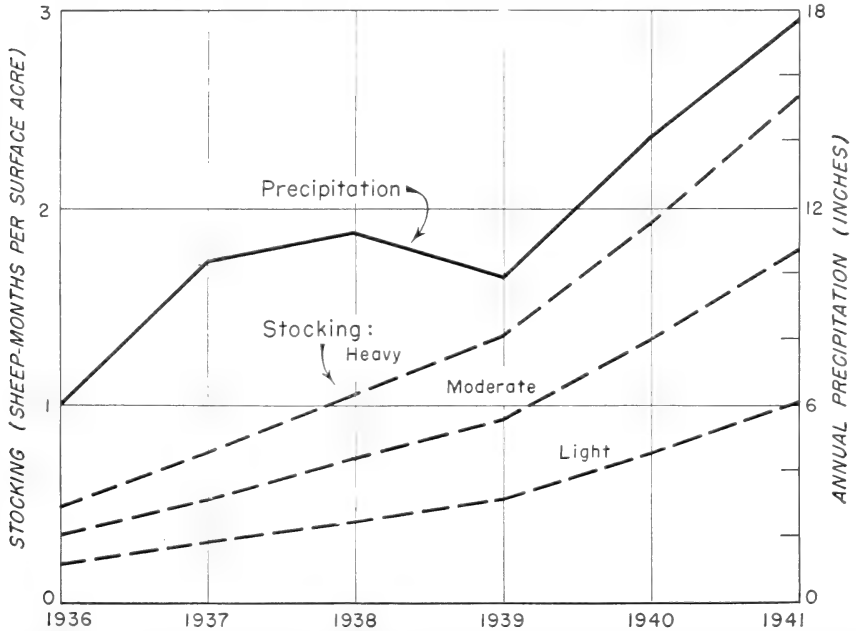

FIGURE 13.—Total annual precipitation was increasingly favorable each year after 1936, except in 1939, and stocking was increased accordingly in all pastures.

SUMMARY

The northern Great Plains constitute one of the most important range areas in the United States for the production of wool, feeder lambs, and replacement breeding ewes. In this region, the major range problem confronting sheep ranchers is how to stock their range (1) to get the greatest possible production year after year without deteriorating the forage and soil and (2) to permit recovery from drought within a reasonable time.

To obtain guides to proper stocking of northern Great Plains range, the Northern Rocky Mountain Forest and Range Experiment Station, in cooperation with the Bureau of Animal Industry and the Montana State Agricultural Experiment Station conducted a study of sheep grazing near Miles City, Mont., from 1936 to 1941. Three range pastures, having areas of 332, 476, and 847 acres, were established and stocked each year with equal numbers of yearling Rambouillet ewes to maintain three relative intensities of grazing. Studies of density, composition, and herbage production of the vegetation, plus surveys

of utilization, periodic weights of the sheep, and observations of their grazing habits formed a basis for evaluating the three rates of stocking.

Many combinations of soil and topography, each characterized by certain range plant species, are found in the northern Great Plains. Only four of the major situations were well represented on the experimental range. The rolling areas of sandy clay loam soils are generally occupied by blue grama, bluestem wheatgrass, other less important grasses, a few herbs, and some big sagebrush. Rougher areas having sandy to gravelly loam soils and characterized largely by bunch-forming grasses make up a considerable part of the range. Bottom areas are usually level or gently sloping, have heavy clay soils, and are largely given to bluestem, buffalograss, and silver sagebrush. The roughest portions are sometimes called badlands. The soil is heavy and alkaline and the topography rough and broken. A variety of browse species and a few hardy grasses and forbs compose a scanty cover on these areas.

Herbage production occurs largely during the main growing season, April through September, coincident with about 70 percent of the average annual rainfall. Spring growth begins generally in late March or early April and is completed on the average by late July or early August. During favorable years some additional herbage may be produced in early fall by a few species that resume growth following August or early September rains.

Although the northern Great Plains range supports a wide variety of native plants, most of the forage is provided by about 25 of the most palatable species. The palatability and forage value of these as well as other species varies with season of the year, stage of development, and composition in the stand. On the experimental range all species were most palatable when the plants were fresh and succulent early in the growing season. Changes in forage value and palatability during the grazing season affected its utilization by the sheep. Greater utilization of the key species, blue grama, bluestem, and threadleaf sedge, which resulted under heavy stocking as compared to conservative and light stocking, was due to a higher percentage of the total number of individual plants grazed rather than to lower grazed stubble heights.

The principal activities of the yearling ewes were grazing, bedding, resting, and fighting insects. Grazing was accomplished largely during daylight hours except in midsummer when insects and high temperatures induced shading up. Under these conditions the yearling ewes frequently fed at night, alternating short periods of grazing with frequent brief rest periods. During cool seasons and when insects were not prevalent, the yearling ewes bedded throughout the night, usually near a fence or other obstruction. Watering habits were very irregular and salt was regularly used only when placed near a watering place. When salt was placed away from water in an attempt to aid distribution, the unherded sheep seldom found it.

Natural factors such as wind and temperature affected the yearling ewes. Their movements showed a strong relation to wind direction. Both extremely high and low temperatures tended to restrict their movements. The pasture fences affected the movements of yearling ewes. This resulted in heavy grazing use near the fences and progressively lighter use at increasing distances from them. Predators disrupted their activities and caused many actual losses in addition to unmeasured losses in weight gain and general welfare.

Important range plants and the vegetation as a whole were considerably affected by heavy stocking with sheep for 6 years, as compared with conservative and light stocking. Recovery of vegetation from drought levels was retarded, and there was much less increase in total vegetation density. Although blue grama plants were more numerous, they were smaller in size at the close of the experiment. Both the number and size of needle-and-thread plants were decreased. Bluestem wheatgrass also became less abundant, and showed reduced height growth. Low-value annuals, on the other hand, increased manyfold.

Because of the high proportion of annuals growing in the heavily stocked pasture in 1942, the total production per acre of range herbage, clipped to a centimeter stubble, was actually larger than in other pastures. This was not a real advantage, however, since at best annual plants are low in palatability and cannot be depended upon to provide forage for several months each year. The dependable perennial species, mostly grasses, produced considerably more herbage on the conservatively and lightly stocked range. Converted to usable forage by applying the percentage of utilization resulting from conservative stocking, production still favored conservative over heavy stocking. The comparative weights of annual- and perennial-type herbage plus the greater number of annual plants present at the close of the experiment indicate that 6 years of heavy stocking with sheep caused the composition of the range vegetation to shift from a predominance of perennials to a predominance of low-value annual species. Some movement of topsoil, particularly on the slopes, occurred under heavy stocking.

On heavily stocked range, the yearling ewes gained significantly less weight during the average grazing season than those on conservatively and lightly stocked range. Average seasonal gains over a 5-year period were 31, 32, and 33 pounds, respectively. Up to midsummer, the difference in gain between lots on differently stocked range was hardly noticeable, but throughout late summer and fall the ewes on heavily stocked range lagged badly in weight gains. Starting weights ranged from 70 to 77 pounds and final weights from 101 to 109 pounds on the average.

A minimum of 0.67 surface acre of range, similar to the experimental range, per month or 5.4 acres for an 8-month season beginning in March is recommended for normal development and maintenance of a dry yearling ewe. This rate of stocking will also allow some improvement in the range vegetation and provide for a desirable carry-over of unused forage at the end of each grazing season. Utilization of the range should be gaged by the percentage of plants grazed and average stubble heights to which certain key species are taken by sheep. Sheep range similar to that studied should be considered properly used when the three key species, blue grama, bluestem, and threadleaf sedge, are grazed rather uniformly over the range in accordance with the utilization guides given in this publication. The guides include a measure of safety against a low forage crop during drought and do not take into account possible regrowth of herbage after grazing.

In addition to conservative stocking and uniform, proper utilization of key forage species, use of the range in accordance with a seasonal plan lends stability to range-livestock operations and aids in minimizing the risks due to drought.

COMMON AND BOTANICAL NAMES OF SPECIES MENTIONED

GRASSES AND GRASSLIKE PLANTS

Bluegrass, Sandberg (syn. little bluegrass)	*Poa secunda*
Buffalograss	*Buchloe dactyloides*
Dropseed, sand	*Sporobolus cryptandrus*
Fescue, sixweeks	*Festuca octoflora*
Grama, blue	*Bouteloua gracilis*
Grama, side-oats	*B. curtipendula*
Muhly, stonyhills	*Muhlenbergia cuspidata*
Needle-and-thread	*Stipa comata*
Needlegrass, green	*S. viridula*
Sacaton, alkali	*Sporobolus airoides*
Sedge, threadleaf	*Carex filifolia*
Wheatgrass, bluestem	*Agropyron smithii*
Wheatgrass, bearded bluebunch	*A. spicatum*

HERBACEOUS PLANTS

Agoseris, pale	*Agoseris glauca*
Biscuitroot	*Cogswellia* sp.
Cymopterus	*Cymopterus* sp.
Gaura, scarlet	*Gaura coccinea*
Globemallow, scarlet	*Sphaeralcea coccinea*
Goldaster, hairy	*Chrysopsis villosa*
Indianwheat, woolly	*Plantago purshii*
Licorice	*Glycyrrhiza* sp.
Lupine	*Lupinus* sp.
Mariposa	*Calochortus* sp.
Musineon	*Musineon* sp.
Onion, textile	*Allium textile*
Phlox, dwarf	*Phlox* sp.
Prairieclover, purple	*Petalostemum purpureum*
Prairieclover, slender white	*P. oligophyllum*
Primrose, evening	*Oenothera* sp.
Sunflower, prairie	*Helianthus petiolaris*

BROWSE PLANTS

Chokecherry, black	*Prunus virginiana melanocarpa*
Greasewood, black	*Sarcobatus vermiculatus*
Pricklypear, plains	*Opuntia polyacantha*
Rabbitbrush, greenplume	*Chrysothamnus graveolens*
Rose, Fendler	*Rosa woodsi fendleri* (syn. *R. fendleri*)
Sagebrush, big	*Artemisia tridentata*
Sagebrush, fringed	*A. frigida*
Sagebrush, silver	*A. cana*
Saltbush, Gardner	*Atriplex gardneri*
Saltbush, shadscale	*A. confertifolia*
Soapweed, small	*Yucca glauca*
Sumac, skunkbush	*Rhus trilobata*
Winterfat, common	*Eurotia lanata*

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