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YIELDS AND CONSUMPTION OF FORAGE IN THREE PASTURE-TYPES: AN ECOLOGICAL ANALYSIS

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J. E. WEAVER**

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**UNIVERSITY OF NEBRASKA
CONSERVATION AND SURVEY DIVISION**

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**Yields and Consumption of Forage in Three
Pasture-Types: An Ecological Analysis**

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Contents

	Page
Introduction	1
Location, topography, and soil.....	2
Vegetation	2
Western wheat grass type.....	3
Bluegrass type	6
Relict prairie type.....	8
Methods of study.....	12
Grazing and yields in 1943.....	13
Monthly consumption of forage.....	14
Height of grazing.....	19
Total yields	21
Relation between consumption and yield.....	22
Climatic factors, consumption and yield.....	24
Grazing and yields in 1944.....	24
Spring grazing	26
Monthly consumption of forage.....	27
Total yields	32
Relation between consumption and yield.....	33
Comparisons with 1943.....	35
Height of grazing and behavior of chief forage species.....	36
Kentucky bluegrass	39
Western wheat grass.....	42
Prairie grasses and forbs.....	45
Chief native grasses.....	45
Other native grasses.....	52
Introduced weedy grasses.....	53
Native forbs	53
Introduced weedy forbs.....	55
Roughs	57
Disappearance of roughs.....	58
Formation of new roughs.....	60
Fate of marked bunches.....	61
Seasonal residues and grazing trends in the several types	62
Residues in other pastures.....	63
Grazing trends	66
Discussion	67
Summary	71
Literature cited	75

Yields and Consumption of Forage in Three Pasture-Types: An Ecological Analysis

INTRODUCTION

NATIVE pastures in eastern Nebraska and adjacent states have undergone profound changes as a result of drought. Bluestems (*Andropogon*) and associated grasses have been thinned and weakened, although recovery has been marked since 1941. In many pastures they were replaced by western wheat grass (*Agropyron smithii*) or other invading species. In nearly all, wheat grass now occurs in considerable abundance. Kentucky bluegrass (*Poa pratensis*), into which many overgrazed native pastures had degenerated, was almost completely killed by the drought, or greatly damaged as in western Iowa.¹ Despite these widespread changes, few studies have been made on the relative yields, preferences of stock, and consumption of forage in these several grazing types, and none where all three occurred in the same range or pasture. Consequently, in the fall of 1942, when a native bluestem pasture was found with a part of it degenerated into a good bluegrass sod and other portions covered with wheat grass, the present study was planned.

Practical information on pastures, pasture grasses, and utilization of forage is much in demand. As pointed out by Allred (1941), the importance of livestock production at present assumes the deepest significance of historic time. A large part of livestock products must come from operators of native grasslands. The task of maintaining these grazing lands in a high state of productivity is fundamentally based upon a knowledge of the vegetation; in fact, a knowledge of native plants and forage conditions is vital to the successful management of pasture or range. Conservation of range land can be accomplished only by attention to correct grazing. Native prairie has been the home of grazing animals for untold centuries. Prairie plants are eminently adapted to grazing, and conservative grazing is little or no more harmful to native pastures than is total protection. But to main-

¹ A comprehensive study of pasture types of the Midwest and of changes in them due to drought has been reported in Nebraska Conservation Bulletin No. 22.

tain production, moderate grazing must be practiced. Forage production from a pasture in good condition may be several times as great as from one in an advanced degree of degeneration. Poor pastures, like poor crops, are expensive.

LOCATION, TOPOGRAPHY, AND SOIL

The pasture occupies a level tract of approximately 50 acres about three miles northeast of Havelock, a suburb of Lincoln, Nebraska. It lies just east of the junction of Stevens Creek, which bounds it on the south and west, and Salt Creek. The land is nearly level but has no saline depressions such as are commonly found on the flood plain of Salt Creek. It is well drained, and only a few widely scattered low spots are indicated by the presence of slough grass (*Spartina pectinata*). A shallow ravine with rounded sides extends entirely across it but this was covered mostly with bluegrass sod. This would have extended throughout except that the water from the well which was located near the southern end was pumped continuously when the wind blew, and the excess water accumulated in this low ground. The soil is Wabash silt loam, very dark in color, porous, and highly productive.

VEGETATION

The original vegetation was bluestem prairie with relict patches of slough grass and tall panic grass (*Panicum virgatum*). Patches of buckbrush (*Symphoricarpos*) also occurred and a few small green ash (*Fraxinus pennsylvanica lanceolata*) grew near the streams. For many years the prairie was mowed for hay. But during the great drought, which began in 1934, the grasses were considerably damaged by desiccation and by burial under deposits of wind-blown dust from surrounding cultivated fields. The deepening of the channel of Salt Creek previous to the drought had lowered the water table and this, coupled with drought, resulted in changes in the composition of the vegetation. Perhaps partly as a result of the disturbances following 1934, this meadow, which formerly had been mowed each fall for its large yield of excellent hay, was grazed regularly after 1939. When the present study began, in the fall of 1942, the pasture was composed of three rather distinct types or communities of plants—western wheat grass, relict prairie grasses, and bluegrass—aside from weeds on the creek banks, Figs. 1 and 2.



Fig. 1.—View in the pasture looking southwest. The tall, light-colored grass on this side of the cattle is western wheat grass (*Agropyron smithii*) with a patch of buckbrush (*Symphoricarpos*). The cattle are grazing in the relict prairie type. Photo September 1, 1944.

Western Wheat Grass Type

Invasion and increase of western wheat grass¹ was a direct result of the dry soil and high winds. Large amounts of wind-borne dust were deposited in this prairie. In places, especially along the northern border, it was piled in great drifts sometimes two feet in depth. In other places it formed more or less circular mounds 12 to 18 inches high and a rod or less in width, but elsewhere it was deposited in layers of varying thickness, sometimes several inches in depth. Under the deeper deposits all vegetation was destroyed and wheat grass promptly covered these drifts and mounds or thick dust layers wherever they occurred. Sometimes the cover of dust resulted in incomplete destruction of the pre-drought vegetation and some survived or at least recovered after several years of dormancy. Thus, the wheat grass type was usually pure, but it sometimes included as much as 15 per cent

¹ Hereafter, for brevity, this species will be designated as wheat grass.



Fig. 2.—View in the pasture looking southeast across an area of western wheat grass (dark) into the bluegrass type (light). A cage-like enclosure with basal area of 29 square feet is shown in the foreground and two others in the distance. Sacks of grass from the first harvest, May 29, 1944, were placed on enclosures while clippings were being made elsewhere.

of the native vegetation which had not died or had recovered where covering by dust was less severe. These patches of vegetation appeared in summer as irregularly shaped islands in the sea of wheat grass.

Areas of wheat grass, while largest on the south, east, and north sides of the pasture, were scattered throughout. Many of the more or less isolated and often roughly circular patches were 3 to 5 rods wide, others were smaller, and the main areas were continuous over many square rods. But all were characterized by very definite and easily discernible boundaries. Early in the great drought wheat grass frequently occupied areas in the prairies of eastern Nebraska where desiccation had destroyed most or all of the native vegetation and where no noticeable dust deposits occurred. A few such places may have originated in this manner even on this lowland. The irregular deposition of dust in some places and not in others often resulted from differ-



Fig.3.—Typical stand of wheat grass as it appeared late in June. Note the coarse stems, lack of foliage near the soil, and absence of other species. These plants have not produced flower stalks. Much of this pasture type was scarcely grazed in 1944.

ences in wind direction, height and density of vegetation as a factor in slowing wind movement and causing deposit, but various other factors were also involved.

The wheat grass type is typically a one-species stand and always the one species is dominant. It is a coarse grass with numerous, rigid, vertical stems and abundant rhizomes, Fig. 3. The seed may germinate under favorable conditions even if buried two inches deep in the wind-blown soil. Once firmly established, the plants, if they have been buried, may grow vertically upward through 12 or more inches of soil and produce seed the same year (Mueller 1941). Spreading by rhizomes is rapid and often several feet per year. Thus, this species is remarkably well adapted to grow in dust-covered or drought-depleted places and to rapidly increase the extent of the territory originally invaded.

Growth begins very early in spring and several weeks before the bluestems and most other prairie grasses renew their activities. Many of the drought years were characterized by moist springs and dry summers, conditions very favorable for the

growth and spread of wheat grass, which forms flower stalks and spikes in June.

Bluegrass Type

The bluegrass type is a community where somewhat more than half and often nearly all of the vegetation is composed of Kentucky bluegrass. Since bluegrass is rarely found intermingling with wheat grass, except sometimes in ravines, origin of the type has resulted from bluegrass more or less completely replacing the native prairie grasses. Over about five acres in the fork of the creeks, on soil that had once been plowed but then abandoned, this type also occurred. Horseweed (*Leptilon canadense*), Kochia or summer cypress (*Kochia scoparia*), hemp (*Cannabis sativa*), and other weeds which had formerly occupied the area thus bared began to give way to bluegrass in 1943 and this grass took almost complete possession the next year.

Kentucky bluegrass was introduced from Europe. It has spread widely since the coming of the white settlers and is now found practically everywhere in the true prairie. In a large measure, its success as an invader under mowing or grazing was due to its vigorous early growth. It is the first grass to appear in spring. By the middle of April, when the bluestems begin to renew activity, it is well developed. Early in May the flower stalks begin to develop. Blossoming occurs, seeds are formed, and much food is manufactured and stored in roots, rhizomes, and crowns before the new growth of native grasses seriously competes with the invader for light, water, and nutrients. During the hotter part of the summer, this grass of northern origin is less vigorous. It often becomes semidormant until early in September when it is revived by the cooler weather and autumnal rains. It then continues growth well into winter. For example, during 1943 bluegrass dried and lost most of its green color in August but early in September it became green and produced good forage until November. During the moist, relatively cool summer of 1944 it remained green at all times.

It should be pointed out that this was one of the few bluegrass pastures left in eastern Nebraska, but bluegrass came back in a remarkable manner in 1943 and 1944. Except where furnished with water from a high water table or with runoff water from uplands, bluegrass pastures had been destroyed by the severe



Fig. 4.—View of the bluegrass type where native prairie species have been entirely replaced by Kentucky bluegrass (*Poa pratensis*). This illustrates the usual close, uniform grazing of this grass except about dung. October 6, 1944.

drought not only in Nebraska but parts of western Iowa as well (Weaver and Hansen 1941).

The area of the entire pasture covered by bluegrass in 1942–43 was difficult to determine. The southern portion, perhaps two-fifths of the entire pasture, still had considerable soil covered with tall weeds, as horseweed and lamb's quarters (*Chenopodium album*), and with ungrazed stands of wheat grass. A careful estimate assigned two-fifths of the land to wheat grass and weeds, two-fifths to native prairie, and the remaining fifth to bluegrass. But by 1943 the weeds were of little significance. The patches and larger areas of wheat grass were much more clearly defined. Much of the former weedy land had been claimed by bluegrass, which had also greatly extended its territory elsewhere as intensive grazing for several years had reduced much of the prairie grass to or near the point of extinction. Heavy grazing except

of wheat grass kept much of the bluegrass (and prairie relicts occurring in it) in the condition of a lawn, Fig. 4. A basal cover of 75 to 84 per cent was found 0.5 inch above the soil in well established stands. In 1943, after dividing the whole pasture into long narrow strips, it was estimated that wheat grass occupied one-third, relict prairie somewhat less than one-third, and bluegrass and weedy areas the remainder.

Relict Prairie Type

Drought and several years of grazing had considerably modified this lowland prairie from its probable original condition. Slough grass occurred in a portion of the ravine but this area was shared by an equal mixture of tall panic grass. A few small, isolated patches of pure slough grass did occur elsewhere in slight depressions, but like the former often possessed a dense undergrowth of bluegrass. None of the patches of tall grasses were grazed below 10 to 15 inches; they stood out prominently since they were surrounded by shorter vegetation.

The chief species was big bluestem (*Andropogon furcatus*). It was still abundant. Relict stems distributed more or less over the entire area revealed its former wide distribution. Little bluestem (*A. scoparius*) had also been widely scattered and could be found as bunches in various stages of degeneration even where bluegrass had formed a dense sod, Figs. 5 and 6. Tall dropseed (*Sporobolus asper*), a coarse bunch grass of low preference for grazing, had probably increased (as elsewhere) during the years of drought. It sometimes occurred in small open patches but more usually as large isolated bunches. Since the bunches were usually grazed only 8 to 10 inches high even in late fall when forage was scarce, they furnished a measure of protection to the more palatable grasses—bluestems, needle grass (*Stipa spartea*), and others. Needle grass was widely scattered throughout the relict prairie type and isolated bunches or clumps remained for a long time in bluegrass sod. This drought-enduring species had benefited by the open cover. Considerable seed was produced each year and seedlings were abundant where the ground was more or less bare locally.

Scribner's panic grass (*Panicum scribnerianum*) is a normal constituent of the understory of prairie. It increased greatly here as elsewhere as a result of the open ground resulting from



Fig. 5.—Relict prairie of big bluestem (*Andropogon furcatus*), little bluestem (*A. scoparius*), and penn sedge (*Carex pennsylvanica*) that has been grazed high since there was considerable last year's debris intermixed with the new growth. Photo July 29, 1943, before the extensive close grazing of fall had begun.

drought and deposit of dust. It occurred very abundantly in the relict prairie type but also in stands of bluegrass that were still open. In many drought-bared places it formed half of the foliage cover and in some places as much as 80 per cent. Ungrazed mature plants attained a height of 8 inches, but the closely grazed ones were only 0.5 to 1 inch tall. Penn sedge (*Carex pennsylvanica*), a low-growing plant of grass-like appearance, increased following the drought and was so abundant that it furnished considerable forage.

Although short grasses form a common stage in degenerated native pastures in the Salt Creek valley, only two small mats of buffalo grass (*Buchloe dactyloides*) were found. But blue grama (*Bouteloua gracilis*) was represented locally by several small patches; the largest covered only a few square rods. In one place

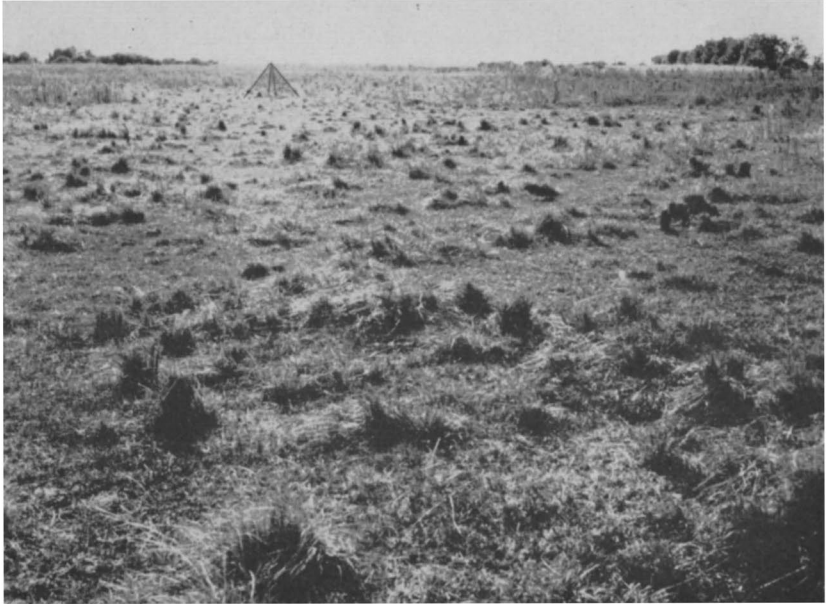


Fig. 6.—An early stage in the reduction of native prairie to bluegrass. It illustrates close, fall grazing of the bluestems, needle grass and others, and of the invading bluegrass in 1943. The half-grazed bunches are mostly tall dropseed and little bluestem, but various other bunch grasses also occur. Photo September 19.

it formed an understory to wheat grass. Side-oats grama (*Bouteloua curtipendula*) was common locally but too small in total amount to furnish much forage. Sand dropseed (*Sporobolus cryptandrus*), an invader from the mixed prairie westward, is well adapted to grow in dust-covered or loose, warm soil. It occurred in small patches in many places, sometimes being the only perennial grass. Prairie dropseed (*Sporobolus heterolepis*), also a bunch grass, was a common constituent of the prairie vegetation but one of only moderate abundance. Thus, the relict prairie type was composed of a relatively large number of both mid and tall grasses and a few short grasses. Wheat grass was not a component. Bluegrass formed an understory almost throughout with a 1 to 5 per cent stand which often increased to 10 to 30 per cent. The transition to the bluegrass type resulted from repeated close grazing retarding the growth of the bunch grasses and big bluestem as well as the aggressive habit of blue-

grass in forming a dense continuous sod. In midsummer 1943, the chief grasses (aside from invading bluegrass) were listed as follows in order of their abundance: big bluestem, needle grass, tall dropseed, Scribner's panic grass, penn sedge, little bluestem, and prairie dropseed.

No native forbs are especial components of bluegrass and wheat grass pastures. These grasses are both invaders and severe competitors of other species. The better they are developed the purer the stand. But this is not true of native prairie. It possesses a very large number of legumes, composites, and other non-grasslike herbs, mostly of high forage value. In fact, they are regular components of grasslands. Many decrease under grazing—those for which the stock have the greater preference; others, mostly uneaten by range animals, increase. Thus, the condition of any native pasture may be determined by examining (1) the prairie grasses that *decrease* under grazing (practically all of those mentioned in this type), (2) the forbs that *decrease* under grazing, (3) the grasses that *increase* under grazing (bluegrass, side-oats grama, etc.), and (4) the forbs that *increase* under grazing; that is, they become native weeds. If the pasture is badly overgrazed a group of invading species enters as (5) introduced weedy grasses and weedy forbs. These groups of species are listed and their habits described elsewhere (Weaver and Hansen 1941).

The abundance of good native grasses and a large variety of highly palatable native forbs showed at once that this was still a high-grade pasture. Entrance of wheat grass, as in ungrazed prairies, was clearly the effect of drought and dust. But the presence of the large proportion of bluegrass (normally only 1 to 5 per cent in prairie) which spread rapidly both years, largely at the expense of the native species, indicated, as will be shown, too heavy stocking.

Native forbs had been greatly reduced everywhere throughout Nebraska prairies by drought. Because of decrease due to drought and grazing none occurred here in such abundance as to furnish much forage or, with one exception, to constitute an important weed. Forbs will be considered later.

METHODS OF STUDY

Careful examination of conditions in the entire pasture was made each month from April to October, inclusive. The findings, as well as notes on observations made at almost weekly intervals, were recorded for study. Emphasis was placed on the development of the individual species in relation to dry and moist periods and especially to the degree to which they were grazed and their response to grazing. Strong portable exclosures, each 29 square feet in area, were used. Each consisted of a frame of four steel fence posts 7 feet in length bolted together at the top but spread at the base where they were bolted to wooden strips 4 x 4 inches in width and 5 or 6 feet long. The ends of the posts extended beyond the strips about 2 inches. The frame was covered with a heavy grade of woven fencing wire from the bottom to a height of 6 feet. Ten such exclosures were used for determining monthly yields the first year, but 15 the second. The purpose of the exclosures, which were moved to a new location each month, was to determine, by clipping, the total monthly yield. By subtracting from this yield the weight of vegetation from a similar but grazed area, the amount of forage consumed was obtained. At the present time, according to Fuelleman and Burlison (1939), "there apparently is no better method [than that of clipping to simulate grazing] except the measurement of pastures by the use of grazing animals or combinations of clipping and grazing." The latter method, of course, was not feasible where the several pasture types were all available for grazing by the same herd of cattle.

In addition to the relation between consumption and yield, a study was also made of the nature of "roughs" or ungrazed patches of a few square feet or square yards where, because of accumulated debris, presence of less palatable grasses, weeds, or dung, the new growth was left undisturbed. Ten such areas were staked but left open to grazing and examined twice each summer. Conversely, ten similar areas, one only a few feet from each of the preceding widely scattered roughs, where close grazing had occurred were staked and examined regularly to ascertain if new roughs developed in them. Finally, ten widely scattered areas were selected where bunches of the most important prairie species both grazed and ungrazed occurred. A permanent stake was centrally placed and a nail, with a number stamped

in its head, was driven into the center of its top. A number 10 iron nail was placed in the soil in the center of each of the bunches whose fate was to be studied. The direction and distance of each bunch from the central stake was plotted on a chart and the bunch re-examined once or twice each growing season. This furnished a definite record of the behavior of the bunches of each species thus charted.

Exclosures were placed in the pasture on April 28, 6 days after grazing began. They were scattered widely in the northern half of the pasture. Two were placed in wheat grass that had been grazed the previous year and one in ungrazed wheat grass. Two more were set up where bluegrass had been grazed previously and one in a rough of bluegrass with slough grass and tall panic grass. The four remaining ones were placed in grazed relict prairie.

The method of selecting the place for the exclosure was as follows. Two areas in which the vegetation was as nearly the same as could be found and within about 10 feet of each other were chosen, one for clipping after a month and the second, also to be clipped at the same time, as a control. A coin was then tossed to determine which of the two areas should be exclosed. The exclosure was then placed over it and stakes were driven into the soil in each of two corners to keep it from being pushed aside. Since the sides of the exclosure sloped inward from the base it was not disturbed by the stock. The control area was also clearly marked. At the time of clipping, new places for the exclosure and control were selected in the same general area, since both of the former plots were clipped by hand close to the ground, closer than the cattle could graze. By subtracting the dry weight of vegetation of the control from that clipped in the exclosure, the monthly yield from the 29-square-foot area was obtained. Clipping was uniform at all times, since one or the other of the writers was in direct charge of it each month (Klingman, Miles, and Mott 1943).

GRAZING AND YIELDS IN 1943

The prairie had been grazed by 38 yearling steers in 1942. In 1943, the fourth grazing season for this grassland, 45 head of yearling steers, born the previous April or very early May, and one mature cow, were driven to the pasture, where they remained from April 22 to October 30. Mr. Michael Moran, the

owner, who weighed the steers in spring and fall, informed the writers that the weight in April varied between 400 and 450 pounds per animal, and that in October between 650 and 700 pounds.

Spring in 1943 was very cool and about two weeks later than normal. Soil was moist in early spring and later wet by heavy rains to a depth of several feet.

Monthly Consumption of Forage

Air-dry weight in grams of forage obtained at each of the 5 clippings under the exclosures in 1943 and on similar adjacent areas of the same size, and the amount of forage consumed in each unit area, are shown in Table 1.

Table 1.—Air-dry weight in grams of forage from the exclosures and controls, and the amounts consumed each month by the stock in 1943. Figures in parentheses are average heights of grazing in inches.

	BLUEGRASS 1		BLUEGRASS 2		BLUEGRASS 3		
	May 25						
Exclosure	242	(2.5 8*)	341	(2.5 8*)	472	(6 15*)	
Control	22	(1.5)	189	(1.5)	367	(6)	
Consumed	220		152		105		
	June 25						
Exclosure	475	(4 9*)	383	(4 10*)	1,636	(19 28*)	
Control	261	(1.5-4)	236	(2.5-3)	1,040	(10)	
Consumed	214		147		596		
	July 25						
Exclosure	617	(3.5)	679	(4)	1,253	(19 28*)	
Control	226	(1.5)	365	(2)	986	(7)	
Consumed	391		314		267		
	August 25						
Exclosure	285	(2.5)	381	(2.5)	1,334	(8)	
Control	100	(.5-1)	123	(.5-1.5)	922	(5)	
Consumed	185		258		412		
	October 2						
Exclosure	116	(2)	159	(2.5)	1,069	(8)	
Control	50	(.5)	75	(.5)	700	(3)	
Consumed	66		84		369		
	PRAIRIE 4		PRAIRIE 5		PRAIRIE 6		PRAIRIE 7
	May 25						
Exclosure	662		550		517	455	
Control	406		284		380	289	
Consumed	256		266		137	166	
	June 25						
Exclosure	1,265		1,472		1,221	1,242	
Control	749		881		823	933	
Consumed	516		591		398	309	

Table 1.—Continued.

		WHEAT GRASS 8		WHEAT GRASS 9		WHEAT GRASS 10	
July 25							
Exclosure Control	1,199		1,147		1,422		1,336
	820		739		919		909
Consumed	379		408		503		427
August 25							
Exclosure Control	1,065		892		967		1,007
	802		704		720		694
Consumed	263		188		247		313
October 2							
Exclosure Control	831		873		772		724
	409		480		345		415
Consumed	422		393		427		309
May 25							
Exclosure Control	463	(9)	301	(6)	846	(13)	
	352	(4-8)	178	(3)	673	(4-10)	
Consumed	111		123		173		
June 25							
Exclosure Control	1,011	(13 22*)	1,012	(14 22*)	1,570	(17 25*)	
	661	(10)	665	(12)	1,079	(15)	
Consumed	350		347		491		
July 25							
Exclosure Control	812	(17 25*)	721	(13 21*)	1,607	(20)	
	754	(10)	686	(10-12)	1,363	(13)	
Consumed	58		35		244		
August 25							
Exclosure Control	792	(14)	803	(14)	1,388	(14)	
	751	(10)	711	(12)	1,243	(12-13)	
Consumed	41		92		145		
October 2							
Exclosure Control	823	(15-18)	795	(15-18)	1,278	(6‡)	
	558	(12)	612	(12)	1,239	(4)	
Consumed	265		183		39		

* Height of flower stalks.

‡ Lodged.

At the first clipping (May 25) the amount of bluegrass consumed was small, only 152 to 220 grams from clean areas previously very closely grazed. The higher figures for clippings and the lower ones for forage consumed in Exclosure No. 2 are due to the fact that bluegrass here was more vigorous, since it had in previous years suffered less intense grazing. A still higher yield but a third less consumption of forage was recorded from No. 3, a rough which was lightly grazed.

The most important grasses in the relict prairie exclosures were, in order of abundance of foliage, needle grass, big bluestem, blue-

grass, penn sedge, and little bluestem. Total yield from the enclosures varied from 455 to 662 grams. The ungrazed forage also was large in amount, 284 to 406 grams. The amount consumed under the irregular grazing also varied considerably, from 137 to 266 grams.

Variation in density of stand of western wheat grass is shown in Enclosures 8 and 9, and in their immediate vicinity. The forage consumed was only 111 and 123 grams, respectively. The heavy yields both under and near Enclosure 10 show that grazing here was comparatively light considering the amount of forage available. This was largely due to the old standing debris.

During this first period (April 22 to May 25) grazing was well distributed over the entire pasture. The parts that were weedy (except areas of *Kochia* which were grazed later) furnished considerable amounts of little barley (*Hordeum pusillum*) and small quantities of downy brome (*Bromus tectorum*). Patches of bluegrass in the dense stands of horseweed were also grazed. Moreover, penn sedge, which at this time furnished much forage, occurred in dense patches in otherwise almost bare areas, or it was intermixed with invading bluegrass.

At the second clipping, June 25, the amount of the bluegrass consumed was nearly twice as great as in May, but the grass was growing rapidly and was not grazed so closely. In June, species of relict prairie furnished more attractive grazing since the new growth obscured more completely the dried, ungrazed foliage of the preceding year. The amount of prairie grasses consumed was more than twice that eaten in May, Fig. 7. Wheat grass, although grazed at a height of 10 to 12 inches, supplied three times as much forage to the growing stock as during May. Considerable wheat grass was removed since the new growth occurred well above the old debris and because it was still relatively tender. However, grazing was high, 10 to 12 inches.

Bluegrass made a better growth in July than previously, owing to the warmer but moist weather. It was also grazed more closely than in June. The amount consumed had doubled. Less forage had been taken from the rough area, however, during this period compared with the preceding one. High consumption of prairie grasses was maintained in all four areas during July since good rains wet the soil. The total amount was almost the same as in June. Wheat grass, which had previously nearly completed its

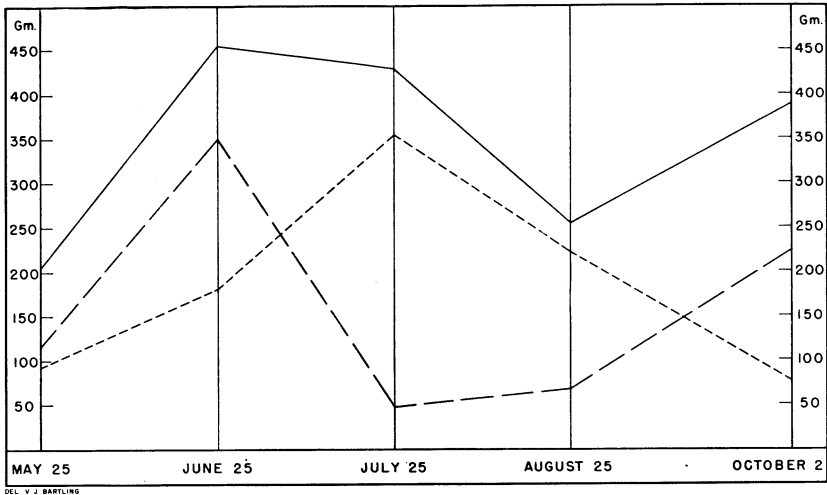


Fig. 7.—Average amount of forage in grams consumed per unit area (29 square feet) in the bluegrass type (short broken lines), prairie type (continuous line), and wheat grass type (long broken lines), each month as indicated in 1943. Consumption from roughs is not included.

foliage growth, was grazed only above 10 to 12 inches, and consumption was very low, only about one-seventh that in June. Also only half as much wheat grass had been removed from the rough.

Drought in August decreased the growth of all grasses. The amount of bluegrass consumed, in spite of closer grazing (.5 to 1.5 inches), decreased more than one-third. Almost twice as much forage was removed from the rough, however, as from both enclosures of formerly closely grazed bluegrass. Consumption of relict prairie grasses near the four enclosures decreased more than one-third of the previous amount. Quantity of forage removed from the previously slightly grazed wheat grass was very small. When bluegrass grew but slowly and partly lost its green color during the drought and heat of August, the cattle grazed a great deal in the relict prairie roughs. They also consumed considerable amounts of Kochia, reducing the plants to a height of 4 to 6 inches over an area of about 5 acres near the creek. But in September Kochia and other edible weeds dried.

Rains in late August and early September, together with cooler autumnal weather, resulted in the renewal of growth. But green

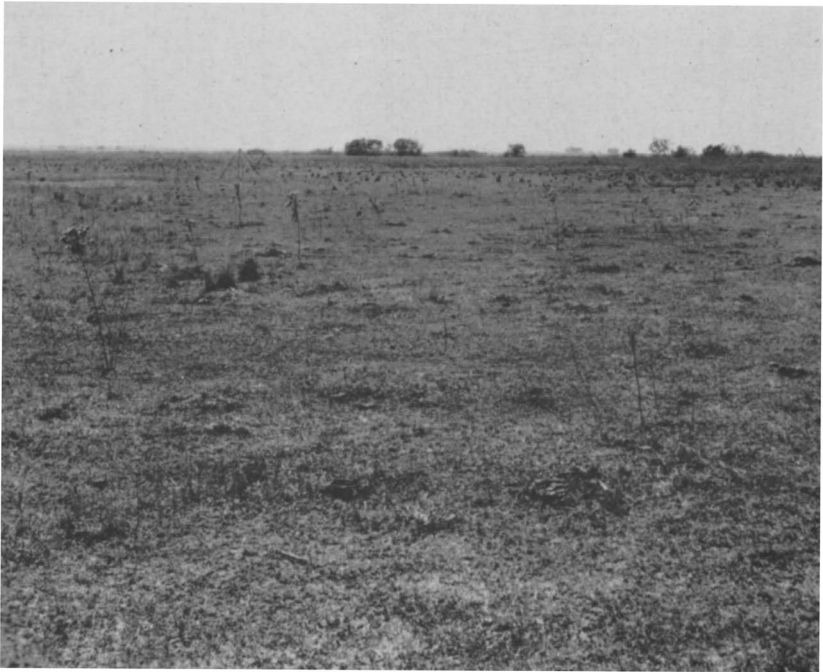


Fig. 8.—Closely grazed bluegrass and remaining prairie grass on October 16, 1943, when other green forage had become far less abundant than formerly. Isolated bunches of prairie grasses, except in background, and bluegrass roughs had practically disappeared.

forage was not abundant. Bluegrass was grazed very closely (0.5 inch) and more uniformly than before, and even to 3 inches in the roughs. The yields in all enclosures, however, were very much less than in August. The relict prairie was grazed more closely than at the previous clippings. So much of the half-dry prairie grass was consumed by the cattle that the prairie roughs in the bluegrass type all but disappeared, Figs. 8 and 9. The new growth of wheat grass and the general shortage of foliage resulted in the consumption of a large amount of wheat grass, but less (39 grams) was removed from the rough than at any previous clipping, since here the plants had lodged. About two-thirds dry forage was removed in obtaining the one-third that was green. In many places wheat grass was reduced to a height of 10 inches, Fig. 10.



Fig. 9.—Bluegrass rough on October 16, 1943. Bluegrass had been protected by the coarse stems of slough grass and tall panic grass which were now reduced to a height of 11 to 14 inches. Although lodged and containing much dried foliage, bluegrass was now grazed to a height of 2 inches.

Height of Grazing

An examination of Table 1 shows that previously grazed bluegrass was almost consistently grazed to a height of 1.5 to 3 inches, except after midsummer, when it was grazed as closely as 0.5

Table 2.—Height in inches of the most abundant grasses in the plots of relict prairie at each clipping in 1943. Heights in the control (grazed) plots are in parentheses.

TIME	PLACE	BIG BLUESTEM	NEEDLE GRASS	PENN SEDE	BLUE- GRASS	LITTLE BLUESTEM	TALL DROPSSEED
May 25	Exclosure	5-15	13-15	6-7	4-6	4-7	
	Control	(3-4)	(3-14)	(4-7)	(.5-4)	(4-6)	
June 25	Exclosure	8-16	18-36	7-8	4-10	6-14	
	Control	(3-10)	(16-18)	(4-6)	(.5-4)	(4-6)	
July 25	Exclosure	15-20	16-19	7-11	8-10	11-15	12-16
	Control	(4-9)	(13-15)	(4-10)	(.5-4)	(4-9)	(8-10)
August 25	Exclosure	8-26	10-14	6-10	4-5	7-11	11-14
	Control	(3-4)	(3-14)	(2-4)	(.5-4)	(2-4)	(4-10)
October 2	Exclosure	5-6	10-12	3-6	2-4	5-6	10-14
	Control	(2-3)	(3-5)	(2-3)	(.5-4)	(2-3)	(4-7)



Fig. 10.—Condition of wheat grass near Enclosure 10 on October 16, 1943. Fall grazing has reduced it to a general height of 11 inches, but it had been irregular and in places flower stalks over 2 feet tall remained.

inch. Grazing in the rough varied from a height of 6 to 10 inches during spring and summer, but it was less (3 to 5 inches) in fall. Conversely, wheat grass was grazed high (4 to 10 inches) even in spring and not below a general level of 10 to 12 inches during the rest of the season. Conditions in the rough were the same, except that this particular control plot was grazed to 4 inches late in fall.

Kinds of grasses were so numerous and heights of grazing of the several species in prairie so variable that an average grazing height would have had little meaning. In Table 2 the height of the more abundant grasses at the several clippings is given.

Examination of the grazing heights of big bluestem in the control shows that they were low in May, June, and July, even when growth was rapid, but decreased consistently after July. The closest grazing occurred in fall. The same general trend is shown by height of plants in the enclosures. Needle grass followed very similar trends. Penn sedge was grazed moderately to closely all

season, and was shortest in the October controls. Much bluegrass was grazed closely throughout the season, and its height also decreased markedly in the exclosures after July. Like all of the preceding, closest grazing of little bluestem occurred in late summer and fall. In the exclosures it reached its greatest height in July. Even tall dropseed showed a gradual decrease in height after midsummer.

Total Yields

It may be assumed that the average amount of growth or yield in any type during the first month was represented by the air-dry forage under that exclosure, since all debris from the previous year was carefully separated from the new growth and discarded. During the second month total yield was the amount that grew under the new exclosure less the amount (portion of new growth remaining ungrazed) in the control for the preceding month. For example, the yield of bluegrass (May 25 to June 25) in Exclosure 1 Table 1, was 475 minus 22 or 453 grams. These data have been calculated from the two monthly exclosures in the closely grazed bluegrass type, the four in relict prairie, and the two in previously grazed wheat grass,¹ Fig. 11.

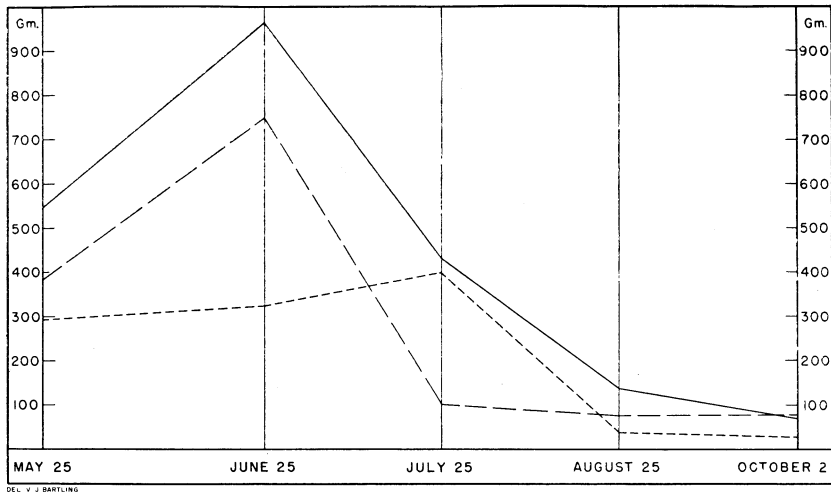


Fig. 11.—Average yield in grams per unit area (29 square feet) in the bluegrass type (short broken lines), prairie type (continuous line), and wheat grass type (long broken lines) each month as indicated in 1943.

¹ In a few instances where the residue of wheat grass of the preceding month was greater than the ungrazed vegetation in the exclosure, it was considered that no growth had occurred.

An examination of Figure 11 shows that bluegrass, owing to cool weather and well distributed showers, continued growth during June and July. Wheat grass reached its maximum development in June, and made very little growth if any thereafter. If undisturbed, needle grass and June grass normally reach their maximum development late in June but big bluestem, little bluestem, and tall dropseed about a month later. Under grazing, however, the average maximum yield of prairie grasses was attained in June, a fair amount of forage was produced in July, but very little during the relatively dry August and September. This resulted largely from the continued grazing outside the enclosures. Closely clipped plants of the same species in an ungrazed prairie made a rapid recovery when clipped late in July (Weaver and Albertson 1944).

Relation Between Consumption and Yield

The relation between yield of forage and the amount consumed in the bluegrass type is shown in Figure 12-A. In the closely grazed bluegrass type yield in May and June and even in the moist, relatively cool month of July, considerably exceeded consumption of this grass. But thereafter grazing was so close that all available forage was removed. In the bluegrass rough (Enclosure 3), however, there was considerable litter remaining. Bluegrass yielded a total of 1.78 tons per acre; nearly all of which (1.68 tons) was consumed.

In the relict prairie type the yield of forage was exceeded by the amount consumed after July, Fig. 12-B. By comparing this graph with the preceding it may be seen that both the amount of forage produced and the amount consumed were much greater than that of bluegrass. Likewise there was more forage left unconsumed. Total yield in prairie was 3.54 tons per acre of which 2.86 tons were eaten.

In wheat grass, Fig. 12-C, yield far exceeded consumption in the early portion of the year, but after August, consumption was largely that of forage already produced. Total yield was 2.30 tons per acre of which only 1.33 tons were consumed. Since much of the year's production remained uneaten, it hindered grazing the next year. This phenomenon was even more pronounced in the wheat grass rough.

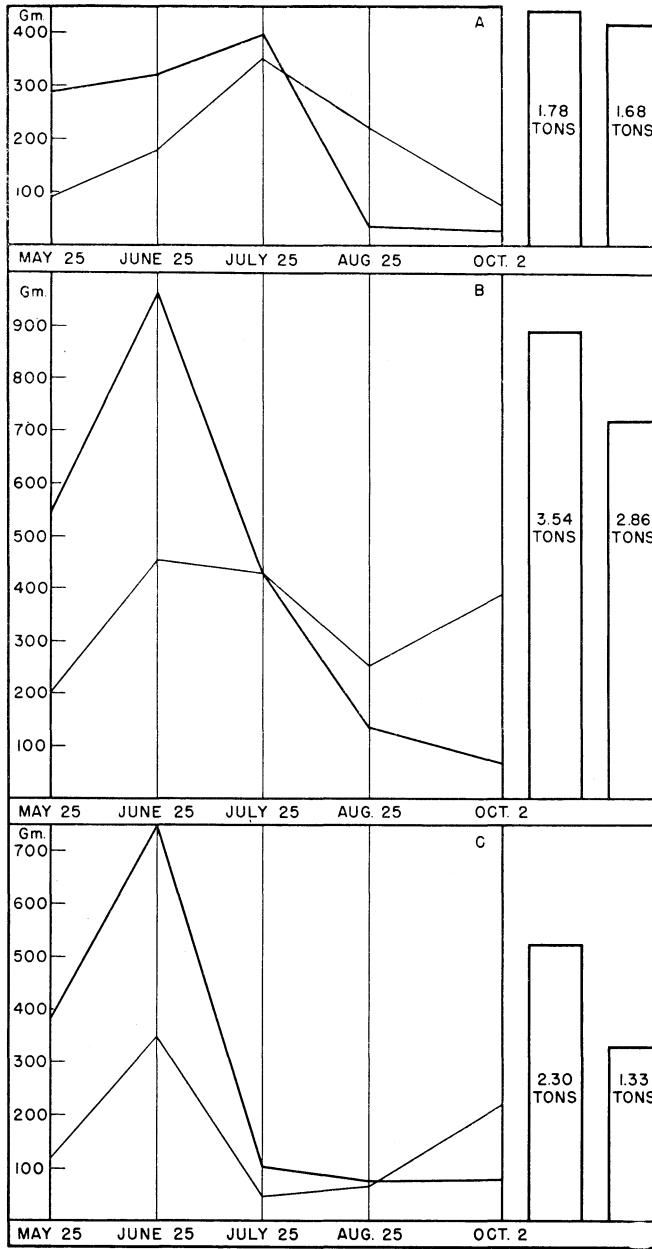


Fig. 12.—Graphs showing average yield (heavy line) and average consumption (light line) in grams per unit area in 1943. (A) bluegrass, (B) prairie grass, and (C) wheat grass type. Yield from roughs is not included. Seasonal yield and consumption are shown in tons per acre.

Climatic Factors, Consumption and Yield

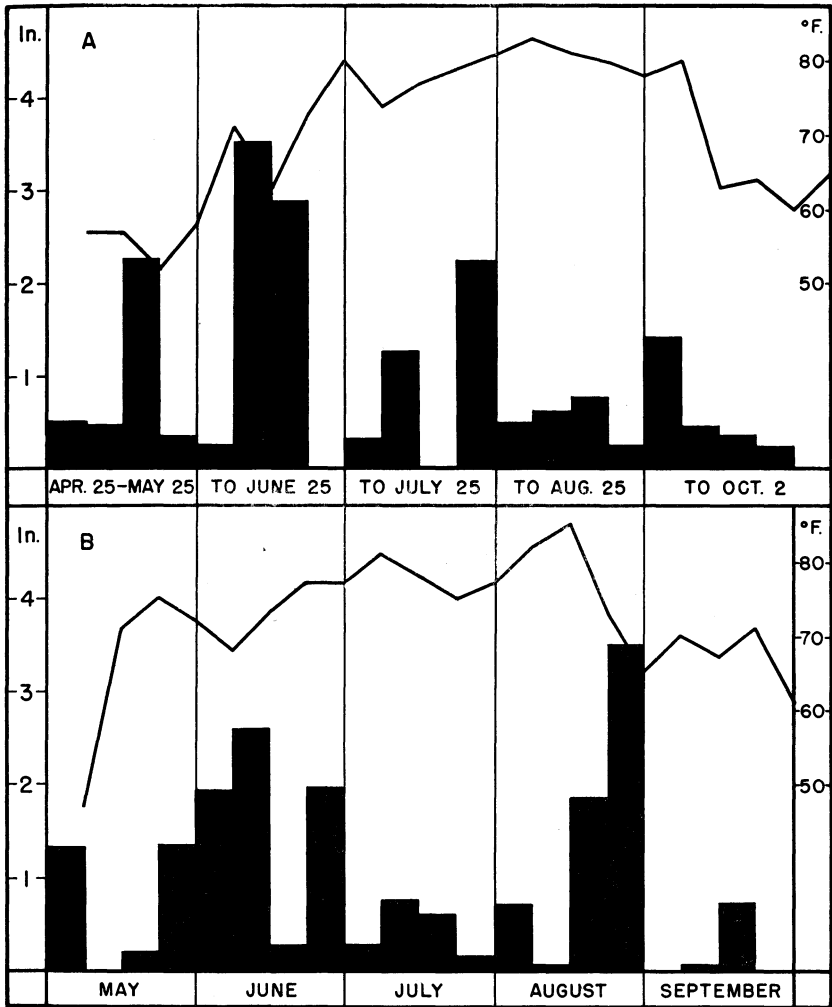
Yields as well as consumption of forage are very markedly affected by the climatic factors of rainfall and temperature. The general statement that graphs showing yield have a tendency to parallel those of rainfall, is borne out by a comparison of Figures 12-A and 12-B with 13-A. The chief correlation of yield of wheat grass (Fig. 12-C) was that production was almost confined to the periods of lower temperatures of spring and fall. Fuelleman and Burlison (1939), working with bluegrass, brome grass, and various other grasses, state that "consumption curves ordinarily do not fluctuate widely during the fore part of the grazing season. There is a tendency on the part of livestock, however, to graze more heavily during the latter part of the season, usually beginning about the first of September." They ascribe this trend to several causes, as more moderate temperatures, an increase in rainfall, decrease in troublesome insects, and, what may be more important, an apparent increase in palatability. Figure 12 shows that there is a marked increase in the consumption of both wheat grass and prairie grasses during the last period. Lack of increased consumption of bluegrass was due to the fact that the cattle consumed all that was available. During the summer the cattle had increased considerably in size and each animal now probably required one-third to one-half more forage than in early spring. Moreover, the forage was older and more fibrous, and it was necessary to consume larger quantities because of this lower forage value.

GRAZING AND YIELDS IN 1944

Spring was cool, moist, and fully two weeks later than normal. June was also a cool month with high rainfall, Fig. 13-B. The summer was warm but not hot, with average weekly temperatures mostly less than 80° Fahrenheit. Soil moisture was plentiful except for a dry period in August. Late fall was also dry. It was an unusually favorable season for the growth of grasses.

The enclosures were uniformly distributed over the whole pasture in 1944. Four were used in the bluegrass type, one being kept in the extensive bluegrass rough where there was an open overstory of slough grass and tall panic grass. Five were main-

tained in the relict prairie type, and four in the wheat grass. In addition a fourteenth enclosure was placed in an area of little barley in May and June, in an alterne of wheat grass in July, but in bluegrass during August and September. One was in Kochia.



DEL. V. J. BARTLING

Fig. 13.—Total rainfall in inches by weeks and average weekly temperatures in degrees Fahrenheit, during the growing season (A) of 1943 and (B) 1944. Intervals between clippings are separated by vertical lines.

Spring Grazing

Thirty-eight yearling steers were placed in the pasture late in April. This number was increased by the addition of 5 cows and 4 calves about June 15. These constituted the herd throughout the grazing season. When the cattle began grazing only the earlier grasses showed much development. By May 1, the blue-stems were just appearing above ground where last year's vegetation had been closely grazed and the soil was warm. But needle grass, penn sedge, and June grass which had begun growth early were being grazed back to 1 to 2 inches. This was true also of the new growth of prairie dropseed and slender rush (*Juncus tenuis*). Likewise, patches of little barley and downy brome were sought and grazed closely.

Bluegrass was green and inviting wherever it grew in the formerly closely grazed area; where it occurred intermixed with the old foliage of prairie grasses some of this was removed in securing the bluegrass.

Wheat grass was more advanced. Leaves of the new shoots were 4 to 6 inches high both in places that previously had been clipped or grazed and in the large patches where even late fall grazing had been very high. The standing stems and debris of last year's crop were still conspicuous even near the windmill. Places with wheat grass were used exclusively as bedding grounds; here much trampling also occurred. But where the old wheat grass had lodged close to the soil or bedding down had done away with old stems, the cattle were grazing the young wheat grass. Grazing occurred also in formerly grazed patches. Where there had been little forage removed the preceding year even the lodged wheat grass formed so much debris that the new growth did not attract the cattle. In other places where the old tops had been grazed from the wheat grass, a common grazing height of the new foliage was 8 to 10 inches. The patches of little barley which were prominent locally were in some places intermixed with the wheat grass. They were being sought and grazed regularly. At this time of year the cattle showed a high preference for it. It was an interesting phenomenon to observe the cattle graze such new green growth a little way into the wheat grass, then stop abruptly and go elsewhere to continue grazing.

Monthly Consumption of Forage

Because of former close grazing and the late spring, the amount of bluegrass consumed in May was small (80 to 140 grams), Table 3. Even less was taken from the rough (Exclosure 4). The amount of prairie grasses consumed was greater. But here grazing was much more irregular since certain controls (Numbers 6 and 7) were scarcely grazed at all. The amount of wheat grass eaten in May was greater than that of bluegrass and relict prairie combined. Nearly all of this (222 to 591 grams) was taken from three of the four control areas. The amounts are greater because, unlike bluegrass or well-grazed prairie grasses, some old material was also consumed since it was intermixed with the new growth. For unlike 1943, both the exclosures and control areas were in wheat grass that had been only partly removed or trampled the preceding year. From the exclosure placed in an area of nearly pure little barley (Table 3), a crop of 443 grams was harvested when the grass averaged 9 inches in height. The control had been grazed, like the larger area of which it was a part, to 4.5 inches; 206 grams or an amount exceeding that from a similar area of bluegrass, had been consumed. This amount was also much larger than the average weight of grass (144 grams) removed from a similar area of prairie.

At the June clipping the amount of bluegrass consumed was greater than that in May, Fig. 14. Since grazing was no closer than formerly, this meant that the amount of available forage was greater, as is shown by the weight of grass clipped from the exclosures. June was warmer than May and moisture relations were very favorable. A large amount of bluegrass was also removed from the rough. With a single exception, amount of prairie grasses consumed was much greater and the average was twice as great as in May, Fig. 15. Examination of the amount of wheat grass consumed shows that the herd ate only a small portion of this grass, which was rapidly maturing. That is, grazing had definitely shifted away from wheat grass. Table 3 shows that a small amount of grass was also consumed in the patch of little barley. Actually it became inedible early in June, and 55 per cent of this yield was from other grasses, chiefly Scribner's panic grass.

Supplementary forage of some importance was furnished by Kochia which grew on the lowland near Stevens Creek. It was

about an inch high when the control was selected and the enclosure placed on May 29. Plants outside the enclosure were repeatedly grazed to a height of 4.5 inches. In the enclosure a

Table 3.—Air-dry weight in grams of vegetation from the enclosures and controls, and the amounts consumed each month by the stock in 1944. Figures in parentheses are average heights of grazing in the plots, the smaller number indicates the closest general grazing and the one following the dash the average height in ungrazed to moderately grazed parts of the plot.

	BLUEGRASS 1	BLUEGRASS 2	BLUEGRASS 3	BLUEGRASS 4	BLUEGRASS 14
May 29					
Enclosure	354 (4 14*)	353 (3 14*)	300 (3 13*)	643 (8 17*) ¹	
Control	214 (2.5)	216 (2.5)	220 (2.5)	629 (7 16*) ¹	
Consumed	140	137	80	14	
June 29					
Enclosure	575 (5 14*)	519 (5 13*)	453 (5 13*)	1,269 (10 24*)	
Control	433 (2.5-3)	349 (1.5-5)	258 (2-3)	808 (10 24)	
Consumed	142	170	195	461	
July 29					
Enclosure	458 (3-5)	712 (3-8)	478 (4)	1,681 (3-8 16*)	
Control	211 (1-2)	328 (1-5)	128 (.5-1.5)	1,548 (13 19*)	
Consumed	247	384	350	133	
August 29					
Enclosure	528 (2-4)	411 (5-6)	318 (2-3)	1,720 (2-16)	325 (2-3)
Control	255 (1-2)	143 (1-1.5)	104 (1-1.5)	1,320 (2-16)	106 (1-1.5)
Consumed	273	268	214	400	219
September 30					
Enclosure	312 (2-5)	259 (1-5)	238 (2-4)	1,708 (10-15)	289 (2-3)
Control	150 (1-1.5)	153 (.5-1.5)	132 (1-1.5)	1,430 (3-12)	121 (.5-1.5)
Consumed	162	106	106	278	168
	PRAIRIE 5	PRAIRIE 6	PRAIRIE 7	PRAIRIE 8	PRAIRIE 9
May 29					
Enclosure	675	386	538	528	332
Control	394	340	505	311	187
Consumed	281	46	33	217	145
June 29					
Enclosure	980	1,053	903	829	656
Control	824	470	741	560	150
Consumed	156	583	162	269	506
July 29					
Enclosure	877	910	770	622	577
Control	432	455	479	264	155
Consumed	445	455	291	358	422
August 29					
Enclosure	687	626	494	528	378
Control	232	242	118	314	127
Consumed	455	384	376	214	251
September 30					
Enclosure	386	410	389	363	371
Control	208	353	270	137	186
Consumed	178	57	119	226	185

Table 3.—Continued.

	WHEAT GRASS 10	WHEAT GRASS 11	WHEAT GRASS 12	WHEAT GRASS 13	WHEAT GRASS 14
May 29					
Exclosure	875 (16)	1,042 (16)	962 (16)	809 (14)	
Control	847 (8-16)	451 (11)	482 (6-15)	587 (4-11)	
Consumed	28	591	480	222	
June 29					
Exclosure	1,178 (22 33*)	1,250 (23 39*)	1,338 (20 33*)	1,140 (20 32*)	
Control	1,148 (22 33*)	1,179 (22 39*)	1,245 (20 33*)	1,075 (20 32*)	
Consumed	30	71	93	65	
July 29					
Exclosure	1,204 (20 32*)	1,413 (24 28*)	1,494 (20 27*)	1,310 (18 30*)	977 (20)
Control	1,198 (20 32*)	1,380 (24 28*)	1,456 (20 27*)	1,159 (18 32*)	863 (20)
Consumed	6	33	38	151	114
August 29					
Exclosure	1,260 (20 38*)	1,358 (20 30*)	1,520 (18 lodged)	1,192 (18 33*)	
Control	1,249 (20 38*)	1,284 (20 30*)	1,423 (18-20)	1,054 (18 33*)	
Consumed	11	74	97	138	
September 30					
Exclosure	1,599 (25 32*)	1,662 (10 lodged) ²	1,782 (10 lodged) ²	1,410 (15 32*)	
Control	1,307 (15 20) ²	1,294 (lodged) ²	1,444 (lodged) ²	1,155 (14 30) ²	
Consumed	292	368	338	255	
Kochia scoparia					
	MAY 29	JUNE 29	JULY 29	AUGUST 29	SEPT. 30
Exclosure		1,127 ³ (30)	1,353 ³ (36)	907 (24)	990 (8)
Control		190 (4.5)	340 (3.5)	323 (4)	543 (4)
Consumed		937	1,013	584	447
Hordeum pusillum					
	MAY 29	JUNE 29			
Exclosure	443 (9)	417 (7)			
Control	237 (4.5)	339 (6)			
Consumed	206	78			

* Height of flower stalks. In ungrazed parts of bluegrass roughs in all the controls in late May and June they were 12-15 inches.

¹ Tall panic grass and slough grass in this rough had the following heights at each clipping, respectively: 10-17, 26-30, 24-30, 12-30, and 9-18 inches.

² New shoots of wheat grass were 10-12, 4-6, 6-8, and 10-12 inches tall; variations are due to amount grazed where old plants lodged.

³ The woody bases of the control plants were cut off at a height of 1 foot in June and at 1.5 feet in July, and discarded.

height of 30 inches was attained. After the woody bases of the stems were removed to a height of one foot, the air-dry yield was 1,127 grams, and the amount consumed per unit area was 937 grams. Thus, a large increment of forage amounting to 1.55 tons per acre was removed in June from this otherwise waste land.

July was a month with plentiful soil moisture, and the temperature was moderate. It was during this month that consumption of bluegrass was highest. Grazing of bluegrass had become somewhat closer, mostly .5 to 2 inches, and from 247 to 384 grams of

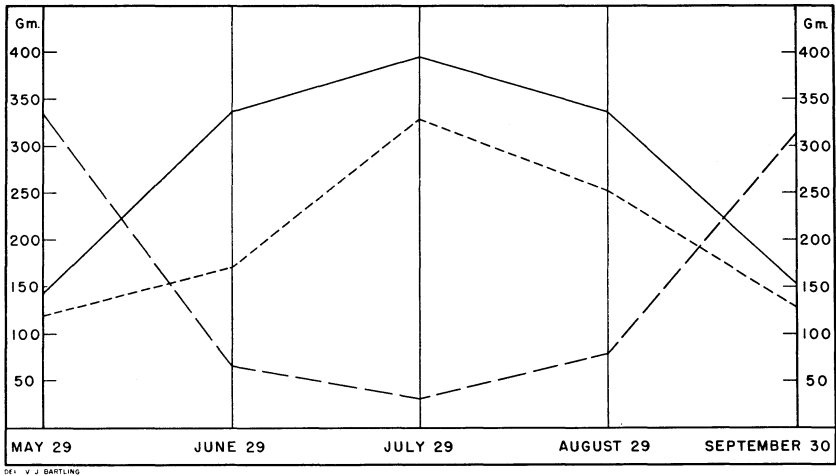


Fig. 14.—Average amount of forage in grams consumed per unit area of 29 square feet in the bluegrass type (short broken lines), prairie type (continuous line), and wheat grass type (long broken lines) each month as indicated in 1944.

forage were consumed. In fact, it was nearly twice as great as in June. Little grazing had occurred in the rough. More prairie grass than bluegrass was eaten. Consumption of prairie grass increased 18 per cent over that of the preceding period. This was due not to a greater abundance of forage but to closer grazing. Amount of wheat grass consumed was indeed small, 6 to 151 grams. This amount could have been the original difference between enclosure and control, despite the extreme care in selecting uniform stands. At least repeated observations revealed no grazing in any of the controls until late in August.

Even a larger amount of Kochia (1,013 grams) had been consumed than that in June. Moreover, the plants were also being eaten back a little closer. They were green and succulent and much relished as a supplement to the diet.

Drought beginning late in July was coupled with high temperatures the first half of August. But ample rain fell the third and fourth weeks. Grazing became a little closer and more uniform. Average amount of bluegrass consumed was reduced about 23 per cent and that of prairie grass 15 per cent. Since there was little evidence of grazing of wheat grass, the remainder of the forage necessary to satisfy the herd was taken largely from



Fig. 15.—Growth of prairie grasses, mostly big bluestem, under Exclosure 8 (which had just been removed) during June, 1944. Note moderately close grazing about the enclosure, and the wheat grass rough in the background.

roughs. The bluegrass rough showed that 400 grams had been removed, a phenomenon which later became not only general but pronounced. Production of Kochia fell to about half the yield in August (584 grams) but the stock kept it closely grazed.

In September much less bluegrass was produced where this type was closely grazed than during either of the two preceding months. Although the grass was repeatedly grazed to .5 to 1 inch, yet the amount consumed averaged only about half that eaten in August. The amounts that grew in the exclosures were also small. Even grazing in bluegrass roughs was now to a height of only 3 to 12 inches. Consumption of prairie grass was reduced in September even more than that of bluegrass, despite close grazing (.5 to 5 inches).

Much wheat grass had been consumed during September. Fall growth had begun and during the first week the new shoots were

4 to 8 inches high. Many of the old leaves were still one-third green and the tops of the plants were eaten. In addition there was an understory of little barley or hairy chess in some places; their presence also induced grazing. The large amounts of rather low grade, bulky forage being consumed was clearly shown in the greatly increased amount of dung. Although now growing much slower, considerable amounts of Kochia (447 grams per unit area) were still consumed.

Although there were no further clippings, the cattle were still in the pasture on November 1 when further studies were made. Since the exclosures had been placed in new locations on October 2, the amount of forage produced beneath them was carefully observed. There was little rain in October, and one had to look closely to find any differences in development of the bluestems inside and outside the exclosures. In the exclosures of prairie grass only a very little growth had been made, and this was nearly always by needle grass, which was 3 to 4 inches high. Conditions in the exclosures of wheat grass and those outside appeared identical, with one exception. Although the new growth of wheat grass was now 10 to 12 inches high, it was so intermixed with the dried stems of spring, where they remained standing, that it was not consumed. The cattle were eating nearly dry forage in roughs and grazed much more closely than formerly about the dung. Grazing in October had been largely from bluegrass roughs and patches of needle grass and other prairie grasses. These had been greatly reduced in height and extent. Bluegrass under the buckbrush had been grazed. The annual bromes and little barley had received much attention, and lastly wheat grass, especially where it had been grazed previously or had lodged, was a final source of supply.

Total Yields

The growth of bluegrass, prairie grasses, and wheat grass as expressed in total yield is shown by graphs in Figure 16. The method is the same as that used the preceding year. The cool-season bluegrass made its most rapid growth in May. It was only slightly less in June and July. Growth continued, although at a slightly decreased rate, during the relatively cool month of August. It declined sharply thereafter, and was poor throughout September.

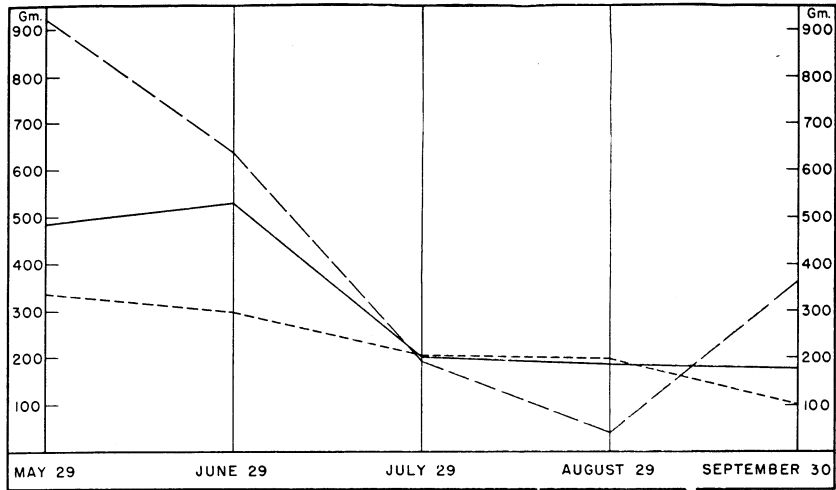


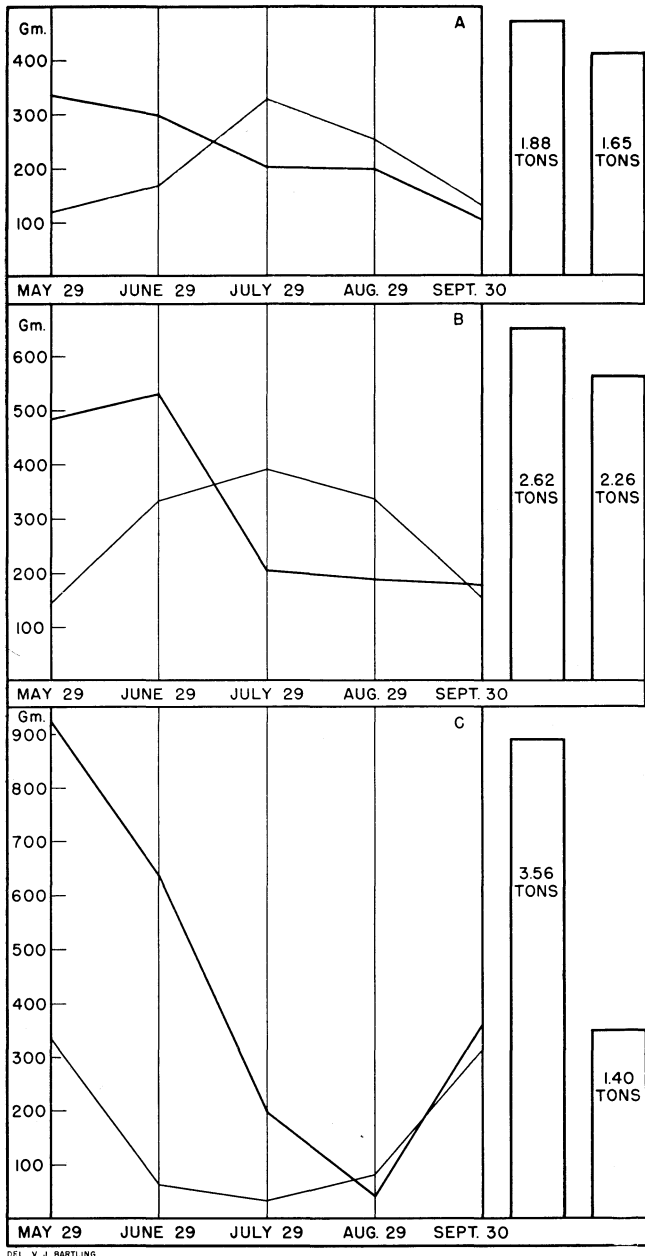
Fig. 16.—Average yield in grams per unit area (29 square feet) in the bluegrass type (short broken lines), prairie type (continuous line), and wheat grass type (long broken lines) each month as indicated in 1944. Yield from roughs is not included.

The bluestems and other warm-season grasses gave an excellent yield in May and June. Yield decreased to less than half this rate thereafter but was maintained throughout September.

Yield of forage in wheat grass was very high in May, and nearly twice that of prairie grasses. It decreased nearly one-third during June; later yields were small. Probably no growth occurred during August. In September the development of new shoots (and frequently an understory of little barley or downy brome) greatly increased the yield in the enclosures over that of the controls, since some old forage was removed in obtaining the new growth.

Relation Between Consumption and Yield

The relation between growth of forage and amount consumed in the bluegrass type is shown in Figure 17-A. Only about a third of the bluegrass which grew in May was consumed, and only slightly more than half in June. Despite the unusually favorable season for bluegrass, consumption during the remainder of the year somewhat exceeded current growth. Total annual yield was 1.88 tons per acre, nearly all of which (1.65 tons) was consumed.



DEL. V. J. BARTLING

Fig. 17.—Graphs showing average yield (heavy line) and average consumption (light line) in grams per unit area (29 square feet) in (A) blue-grass, (B) prairie grass, and (C) wheat grass type in 1944. Data from roughs are not included. Seasonal yield and consumption are shown in tons per acre.

Less than a third of the yield of prairie grasses in May was consumed in that month. In June consumption was increased to about two-thirds of the yield. But in July the amount of forage consumed was twice that of current production. This continued with a slight decrease in August, and only by the end of September when the stock had shifted back to wheat grass were consumption and yield about equal. Normally there is an increase in production of prairie grasses in autumn, but that did not occur during this dry fall. Moreover, several of the areas in which prairie grasses had appeared to dominate in spring had become heavily invaded by bluegrass. This tended to make the prairie graphs more like those of bluegrass. Of the 2.62 tons of prairie forage produced per acre, the cattle consumed 2.26 tons.

About one-third of the yield of wheat grass to May 29 was removed by the stock. Consumption decreased to about 10 per cent of the monthly yield in June and remained at a low level until September. Even by September 30, consumption was slightly exceeded by production. Thus, while the total amount of forage eaten was 1.40 tons per acre, the total amount produced was more than 2.5 times as great or 3.56 tons.

Comparisons with 1943

Similarities and differences in the graphs showing yields and consumption of bluegrass during the two years may be seen by comparing Figure 12-A with 17-A. The amounts of forage produced, 1.78 and 1.88 tons respectively, are nearly the same, as are also the quantities of forage consumed (1.68 and 1.65 tons). Production was at its maximum in May, June, and July, after which it declined, very rapidly in the dry late summer and fall of 1943. Consumption occurred at about the same rate each month during both years.

Yields of prairie grasses were much greater in 1943 during the first half of the season than in the following year, Figs. 12-B and 17-B. Trends of the graphs are the same, but here, as with bluegrass, late summer yields were depressed by drought. Causes of the decreased yield in the second year, which was more favorable to growth, were the very early grazing and the increased proportion of bluegrass intermixed with the prairie grasses as its invasion continued. Still another cause was the heavier grazing to which the prairie grasses were subjected in 1944 and conse-

quently the smaller chance for increased forage production. All of these factors are reflected in decreased yield, 2.62 tons as against 3.54 in 1943. Allowing for the later and wetter season in 1944, graphs of consumption show the same trends until late in August. In 1944 consumption exceeded current yield somewhat earlier, and no upward trend in forage consumed is shown simply because not enough forage was produced earlier in the year to permit an increased consumption. It is an interesting fact that in 1944 86.2 per cent of the yield was consumed, but in 1943 only 80.8 per cent.

Trends in the graphs of yield and consumption of wheat grass are remarkably similar after the end of June, Figs. 12-C and 17-C. In spring of 1944 there was a much greater production of dry matter in the wheat grass that had been ungrazed in previous years than in 1943 where the grass had been closely grazed previously. There was little yield in the dry fall of 1943, but a marked upturn in the graph (partly due to weedy annual grasses) in fall in 1944. Total yield was greater the second year, 3.56 tons as against 2.30 in 1943. Consumption in quantity continued longer in spring where the former growth did not hinder grazing. It was almost negligible during summer, but on both years increased greatly in fall with a renewal of growth. While 58 per cent of the moderate yield of 1943 was consumed, only 39 per cent of the much higher one in 1944 was eaten.

HEIGHT OF GRAZING AND BEHAVIOR OF CHIEF FORAGE SPECIES

A knowledge of the habits of growth of the individual grasses composing prairie and pasture is not only of much scientific interest but of great practical importance in range and pasture management and in general grassland agriculture. "Not only is grass important in pasture, in hay meadow, and on the range, but it can be expected to take an increasingly important place in actual farming operations. The incorporation of grass in the crop rotation in order to conserve the soil, increase fertility, and impart desirable physical properties to the soil is even now being practiced. Necessity may soon force a more or less universal adoption of the practice of using grass as a basic farm crop. Many believe that the United States is on its way toward a grassland agricul-

ture." (Whitman et al 1941). It has been estimated that approximately two million acres of land in Nebraska now under cultivation should be returned to grass (Frolik and Frolik 1941). Nebraska, a grassland state, is ideally adapted to take its place in the developing grassland agriculture of the nation. Grass, and particularly young grass, is the best feed for most livestock. It is palatable, highly digestible, and rich in proteins, minerals, and vitamins.

The height at which each of the most important species were grazed during the season is shown in parentheses after the yield of the control in Table 3. Here the first number is the general level of the well-grazed portion and the second and larger one is that of the highest grazing (remnants of roughs or bunches if any) in the control area. During the earlier part of the year bluegrass was consistently grazed to 1.5 to 2.5 inches (except in Exlosure 4 which was in a large rough). On July 29 and thereafter it was grazed 1 to 1.5 inches and sometimes even in the rough to 2 inches. Grazing of wheat grass was much higher (6 to 16 inches) even in May, and thereafter at a level of 18 to 20 inches or higher until September. Even then the lowest grazing was 14 to 20 inches.

Since several species were concerned in the relict prairie, heights of grazing are shown in a separate place, Table 4. In the control areas there was variable grazing of big bluestem (between 1 to 11 inches) until August, thereafter it was .5 to 6 inches. Needle grass was grazed more closely with the progress of the season and finally to 3 to 8 inches. Penn sedge was more or less uniformly grazed throughout the season where it was intermixed with other species, but closest in fall. Bluegrass was sought and grazed very closely after June, usually to .5 inch. Little bluestem was grazed 1.5 to 8 inches until grazing pressure increased after midsummer, when it was often reduced to a height of .5 inch. Thus, grazing intensity varied as the young stock became older and the total amount of forage decreased. This decrease was due partly to less vigorous growth later in the season resulting as a natural sequence in the growth cycle and accentuated by late July drought. It resulted in part from too frequent removal of the forage crop. Too close grazing of the more palatable species revealed the overwhelming effect of preference.

Table 4.—Height in inches of the most abundant grasses in the exclosures of relict prairie at the time of clipping in 1944. Heights in the control or grazed plots are in parentheses.

TIME	PLACE	BIG BLUESTEM	NEEDLE GRASS	PENN SEDGE	BLUE- GRASS	LITTLE BLUESTEM
May 29	Exclosure Control	5-14 (2-9)	13-16 (11-13)	6-7 (2-3.5)	5-11 (2-12)	6-7 (4-5)
June 29	Exclosure Control	10-20 (1.5-11)	20-22 (6-20)	8-10 (1-10)	7-18 (1-10)	6-8 (1.5-6)
July 29	Exclosure Control	7-24 (1-8)	12-23 (2-22)	5-10 (1-11)	5-12 (.5-7)	11-18 (1.5-8)
Aug. 29	Exclosure Control	4-12 (1-6)	8-24 (3-16)	5-8 (1-3)	2-8 (.5-5)	6-14 (.5-2)
Sept. 30	Exclosure Control	3-8 (.5-3)	4-14 (3-8)	2-3 (.5-5)	2-8 (.5-5)	3-4 (.5-1)

The following lists include the more abundant grasses, forbs, and weeds in the pasture. Infrequent species had little effect upon either quantity or quality of forage production. Grasses and sedges of each group are arranged approximately in order of their abundance. The groups of forbs are arranged according to their time of blossoming.

Table 5.—Species of native grasses, introduced weedy grasses, native forbs, and introduced weedy forbs occurring in the pasture. Occasional or rare species are not included. Chief native grasses are arranged in approximate order of their abundance; the forbs are listed according to their season of blossoming.

CHIEF NATIVE GRASSES	INTRODUCED WEEDY GRASSES	OTHER NATIVE GRASSES
Kentucky bluegrass (<i>Poa pratensis</i>)	Little barley (<i>Hordeum pusillum</i>)	Blue grama (<i>Bouteloua gracilis</i>)
Western wheat grass (<i>Agropyron smithii</i>)	Downy brome (<i>Bromus tectorum</i>)	Sand dropseed (<i>Sporobolus cryptandrus</i>)
Big bluestem (<i>Andropogon furcatus</i>)	Hairy chess (<i>Bromus commutatus</i>)	Side-oats grama (<i>Bouteloua curtipendula</i>)
Needle grass (<i>Stipa spartea</i>)	Barnyard grass (<i>Echinochloa crusgalli</i>)	June grass (<i>Koeleria cristata</i>)
Tall dropseed (<i>Sporobolus asper</i>)		Slender rush (<i>Juncus tenuis</i>)
Scribner's panic grass (<i>Panicum scribnerianum</i>)		Purple lovegrass (<i>Eragrostis spectabilis</i>)
Pennsylvania or penn sedge (<i>Carex pennsylvanica</i>)		Wilcox's panic grass (<i>Panicum wilcoxianum</i>)
Little bluestem (<i>Andropogon scoparius</i>)		Six-weeks fescue (<i>Festuca octoflora</i>)
Prairie dropseed (<i>Sporobolus heterolepis</i>)		Mead's sedge (<i>Carex meadii</i>)
		Nodding wild rye (<i>Elymus canadensis</i>)

Table 5.—Continued.

Slough grass (<i>Spartina pectinata</i>)		
Tall panic grass (<i>Panicum virgatum</i>)		
	NATIVE FORBS	
	Spring	Fall
	Summer	
Prairie cat's-foot ¹ (<i>Antennaria campestris</i>)	Yarrow ¹ (<i>Achillea occidentalis</i>)	Prairie mugwort ¹ (<i>Artemisia gnaphalodes</i>)
Golden corydalis (<i>Capnoides aureum</i>)	Lead plant* (<i>Amorpha canescens</i>)	Many-flowered aster ¹ (<i>Aster multiflorus</i>)
Showy dog's-tooth violet* (<i>Erythronium mesochoreum</i>)	Whorled milkweed ¹ (<i>Asclepias verticillata</i>)	Wavy-leaved thistle ¹ (<i>Cirsium undulatum</i>)
Narrow-leaved puccoon* (<i>Lithospermum linearifolium</i>)	Daisy fleabane ¹ (<i>Erigeron ramosus</i>)	Small-flowered gaura ¹ (<i>Gaura parviflora</i>)
Nyctelea (<i>Ellisia nyctelea</i>)	Prairie larkspur* (<i>Delphinium virescens</i>)	Upland prairie sunflower* (<i>Helianthus rigidus</i>)
Blue-eyed grass* (<i>Sisyrinchium angustifolium</i>)	Yellow woodsorrel ¹ (<i>Xanthoxalis stricta</i>)	Prairie false boneset* (<i>Kuhnia glutinosa</i>)
Bracted spiderwort* (<i>Tradescantia bracteata</i>)	Silver-leaved psoralea* (<i>Psoralea argophylla</i>)	Compass plant* (<i>Silphium laciniatum</i>)
	Prairie rose* (<i>Rosa arkansana</i>)	Ironweed ¹ (<i>Veronia baldwini</i>)
	INTRODUCED WEEDY FORBS	
Western ragweed (<i>Ambrosia psilostachya</i>)	Lamb's quarters (<i>Chenopodium album</i>)	Kochia or summer cypress (<i>Kochia scoparia</i>)
Hemp (<i>Cannabis sativa</i>)		Horseweed (<i>Leptilon canadense</i>)

Kentucky Bluegrass

Bluegrass ranks as one of the most palatable pasture grasses. It started growth early in spring and provided much tender, succulent forage for early grazing. Normally it becomes dormant during the heat of midsummer. This occurred in 1943, but during the following cooler, moister season it remained green. But even in 1943 it revived in fall and made a fair growth. Since it became green in spring earlier than most of the prairie grasses, it could be seen that it had become the most abundant species over approximately twice the area it occupied the preceding year. It is

because of this adaptability to grazing, its persistence and aggressiveness, that it is used for pasture eastward more than any other species (Fuelleman and Burlison 1939). Close grazing of the prairie grasses and weather conditions congenial to its growth, resulted in its constantly taking over more and more of the pasture area. This type of grazing is very injurious to seedlings of prairie grasses. They can not develop much above ground and the roots are relatively few and short, Fig. 18.

In late October of 1943 it was clear that the bluegrass type had greatly extended its territory since the preceding spring. It was now scattered thinly over much soil formerly concealed with the rank growth of horseweed, lamb's quarters, and other weeds but which were now dry and considerably trampled. It also dominated between relict areas of irregular patterns where grazing in preceding years had leveled off and partly destroyed the former prairie species. Although these relict grasses themselves had endured much recent grazing, they appeared as light-colored

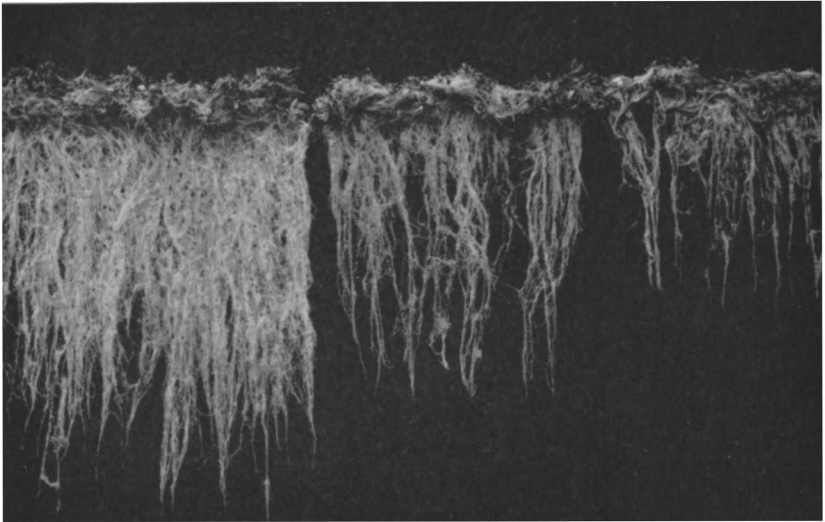


Fig. 18.—An illustration of the injurious effects of too close utilization of seedling grasses. Equal amounts of side-oats grama were planted on May 1 in three plots kept under very favorable conditions for growth. One lot of plants (left) was unclipped; the others were clipped on alternate weeks and a total of eight times by September 1. Clipping was at 4 inches height (center) and at 2 inches (right). Dry weight of roots freed from all soil was, from left to right, 60.5, 20.3, and 13.1 grams.

patches or islands in the sea of invading dark-green bluegrass.

Where it was protected by last year's weeds or dry prairie grasses, bluegrass was 6 inches high on May 1. But elsewhere it was nearly all grazed to 1 or 2 inches. This early growth of bluegrass is so attractive to cattle in spring that they consume considerable portions of bunches of dry prairie grasses of the previous year in the process of eating the bluegrass. Once the old bunch is eaten, the new growth of prairie grass, whether blue-stem or prairie dropseed, is usually grazed closely again and again, much to its detriment if not its complete destruction. When bluegrass put forth flower stalks in May and early June, a habit which reduces its palatability, the 12- to 15-inch stems grown under protection were in striking contrast to the 2- to 5-inch flower stalks where the grass was weakened in overgrazed areas.

Grazing was very general over all types of forage in May. This permitted bluegrass to produce considerable foliage which was not immediately removed. Although spotted, grazing of bluegrass was moderate. In general the sod was dense, except in the many places where bluegrass had only recently invaded. In the formerly weed-infested, broken area, few ruderals appeared, and the patches of bluegrass enlarged rapidly. Many coalesced to form a continuous sod. In late May and June blossoming of bluegrass was marked over much of the pasture.

In July bluegrass remained green. But even where protected by the exclosures it grew slowly and cattle consumed much bluegrass in roughs that had heretofore been grazed but little if at all. Thus, consumption began to exceed production.

In September growth of bluegrass was renewed as was also that of wheat grass. The whole pasture was green, but bluegrass was growing slowly. But as the cattle grew they required and consumed more and more grass. All areas of bluegrass previously grazed were again regrazed even more closely than before. Moreover, these areas were expanded. Many roughs of bluegrass and prairie grass disappeared. Even where a rank growth of bluegrass had lodged, it was grazed to 3 to 4 inches in height, since it was still green. Even the grass about deposits of dung were removed to a height of about 5 inches. In fact, the rough and irregular appearance of the vegetation, except for wheat grass, was being leveled off to a smooth sward as is characteristic of well-grazed bluegrass pastures.



Fig. 19.—A patch of wheat grass showing sharp boundary between it and the prairie type in the foreground. Grazing ceased abruptly at the boundary between these types.

Western Wheat Grass

Enough debris remained from the fall grazing of wheat grass to prevent early grazing in the spring. Only in a few marginal areas was the previous year's growth removed and the space left fairly clean. Despite some early grazing of this grass, its patches whether large or small remained with very distinct boundaries, Fig. 19. Exceptions were places where bluegrass had made slight invasions. Where the stand was dense, much green foliage 18 to 24 inches high remained undisturbed late in May. Other areas furnished much forage, considerable old, dried grass necessarily being consumed with the new growth. Many patches were grazed over a third to a half of their area, the rest remained almost untouched. In some places there was little surface mulch and the black soil was clearly revealed between the stems, Fig. 3. But usually there was a continuous mat of debris at least 1 to 2 inches deep. Spikes began to appear the first week in June; the foliage



Fig. 20.—Typical ungrazed wheat grass near the windmill in which Exclosure No. 14 was maintained during July. There was practically no green foliage below 8 inches. Photo July 27, 1944.

was mature and very little further grazing occurred. The stems of wheat grass are very stiff and the spikes are hard; there was no evidence of the cattle eating them.

Early in June about half of the wheat grass became lodged at a height of 4 or more inches; although it was two-thirds green, practically none was eaten. On the remainder green leaves were infrequent below a height of 8 inches. Figure 20 is typical of places where the grass was almost ungrazed. Indeed, some areas were scarcely entered during summer. Although wheat grass surrounded the windmill for many rods, some trampling but no grazing occurred. Indeed, much-used paths led in all directions from the tank, where salt also was to be had, to other portions of the pasture. Fully two-thirds of the wheat grass type remained remarkably pure, since this grass if it occurred at all was nearly always densely aggregated. Exceptions were found where bunches of other grasses, chiefly big bluestem, had remained alive



Fig. 21.—Appearance of repeatedly grazed stand of big bluestem viewed from above on July 1, 1944. There is much foliage near the ground which with the dead debris furnishes good protection to the soil.

through the drought or recovered when good rains came after several years of dormancy. Thus, bunches, streaks, and patches of prairie grasses were also found in wheat grass. Where these were sought and grazed, always only lightly or moderately, considerable trampling of wheat grass occurred. In fact, the wheat grass type was used regularly as the bedding ground and consequently much trampling was a result. Where big bluestem was lodged with wheat grass, it was not utilized.

Early in September new green shoots 2 to 4 inches high with 1 or 2 leaves became common. Also enough seedlings of little barley of about the same height appeared through the now closely lodged wheat grass and enticed the cattle to graze. The old, lodged grass was mostly dry and gray; green leaves were rare. In places the erect, old stand remained unmolested. But where the upper leaves were still partly green they were nipped back a little. This occurred first near the borders between bluegrass

or relict prairie and wheat grass. But with the progress of the season and a general reduction in the total growth of forage, grazing of mature grasses, including wheat grass, became gradually more pronounced. But matured, green bluegrass and half-cured prairie grasses were preferred to the old, nearly dry leaves of wheat grass. Nearly always too much debris occurred to encourage general grazing of the new undergrowth. Thus, at the end of the season dense mats of lodged wheat grass or thick stands of erect stems, nearly always 10 to 12 inches and often 20 inches high, encumbered the soil and remained to hinder the grazing of the crop of the following year.

Prairie Grasses and Forbs

Native true prairie has the distinct advantage over bluegrass and wheat grass types of having a variety of palatable grasses and forbs that contribute toward a balanced diet for livestock. About 250 species of plants have been recorded in a single square mile of native prairie near Lincoln. Of these the grasses, legumes, and composites contributed the largest numbers.

Chief Native Grasses

In the pasture, big bluestem was by far the most abundant prairie grass and the one that furnished the most and best-liked forage. Both big bluestem and little bluestem are warm-season species. In 1944 they were fully 3 weeks late in renewing growth and were just appearing above ground about May 1. Where bluestems had previously been grazed, the prominence of stems disappeared, the plants became much more leafy at the base, and like bluegrass were grazed closely. When the foliage was grazed off it was quickly replaced, at least during the first half of the growing season. When the grazing height was 1.5 inches, ungrazed, nearly horizontally placed leaves 2 to 4 inches long were not uncommon near the soil surface, Fig. 21. In midsummer of 1943 it was observed here, as in many other prairies and pastures, that some bunches of big bluestem were appearing in wheat grass after living several years below ground in a condition of dormancy. Bunches of big bluestem were also often protected, since they grew very close to the ungrazed tall dropseed. But cattle discerned this species and grazed it, leaving the dropseed. In prairie, this grass practically completes its vegetative development late in July but remains green until early fall. Under graz-

ing, however, growth from vigorous plants normally is renewed after each successive grazing, and some forage was produced even in September.

Needle grass, like bluegrass, penn sedge, and June grass, is of northern extraction, that is, of northern ancestry. Migration into true prairie has been from the boreal region (Clements 1942). Needle grass began growth very early in spring and, like wheat grass, was far ahead of the bluestems in development, Fig. 22.



Fig. 22.—Relative development of cool-season grasses above (needle grass at left and wheat grass at right, both 3 feet high) and warm-season grasses below (little bluestem at left and big bluestem at right, both about 10 inches high). All plants taken from a prairie and photographed in a season with normal spring, May 18, 1942.



Fig. 23.—Abundance of needle grass glistening in the sun among other prairie grasses in a scattered rough on October 6, 1944.

Needle grass renewed growth with lowering of temperature in fall. It sometimes remained partly green all winter. Plants previously grazed were again grazed when the new leaves appeared early in spring; ungrazed bunches had retained much coarse foliage which discouraged early grazing. Much grazing occurred at a height of about 2 inches. Some plants which were overlooked were only 5 inches tall on May 1 compared with a 10-inch height of new leaves of ungrazed bunches. Moreover, only a few new leaves grew from the grazed plants. Thus, the weakened condition was shown both by numbers and height. This explained why needle grass was much less abundant in 1944.

Needle grass seeded late in May and it was grazed but little until fall, except plants previously closely and regularly eaten. But when green foliage became scarcer and the demands for it were higher, old plants were eaten, often to a 2-inch stubble. It was also selected and eaten in quantity where it grew in roughs,

Fig. 23. Here much of it was grazed to 4 or 5 inches. Plants intermingled with bunches of the far less preferred tall dropseed were grazed higher, if at all.

Tall dropseed was an abundant grass in this pasture. Its importance was due not to its grazing value, which is small, but rather to its effect in protecting other prairie grasses and thus creating roughs and hindering uniform grazing. Like several other species, tall dropseed became much more abundant during the dry cycle. It is a coarse-stemmed bunch grass with leaves so tough that they are never eaten by preference. It did not occur in wheat grass except where it survived drought and dust burial, and was absent or nearly so in old, closely grazed bluegrass simply because it had finally been eaten. But elsewhere the bunches occurred thinly to thickly, and over a few square rods they formed the bulk of the vegetation. Thus, it was the nucleus of many roughs and furnished refuge for much palatable vegetation. It and wheat grass were the two great barriers to uniform grazing.

When tall dropseed was grazed, usually 10 to 14 inches of the base was left intact. Isolated bunches were far more apt to be

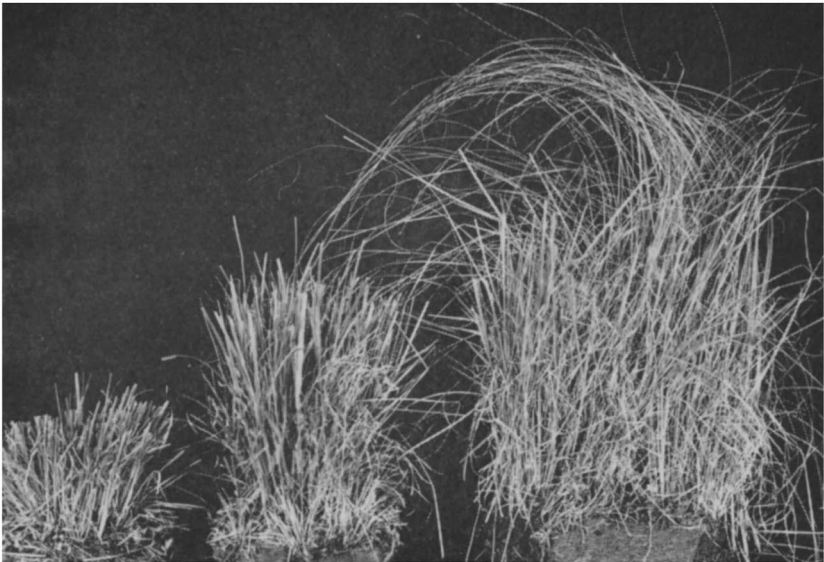


Fig. 24.—Bunches of tall dropseed grazed at heights of about 5, 18, and 23 inches in September, 1944. Leaves are so few near the base that bunches kept grazed back to less than 10 inches may die.

grazed than closely spaced ones where debris was plentiful. Such bunches were 9 to 13 inches wide across the leafy top after such high grazing. Hidden between the bunches if aggregated, or growing very close to them if isolated, were needle grass, June grass, prairie dropseed, and many other highly palatable grasses. By midsummer the cattle began to seek these out and graze them between the bunches of tall dropseed. At first such grazing was high, but once exposed they were grazed again and again, each time closer to the soil. Tops of the tall dropseed were also removed by this grazing. Where this process had occurred the previous year and bunches of the tall dropseed were thus isolated, the new tops were invariably eaten and by this process the grazing level was lowered. In spring, needle grass, June grass, and later bluegrass, all several inches tall, occurred intermingled on the periphery of the bunches of tall dropseed. In grazing them the stock also reduced the size of the unwanted dropseed. Repetition of this finally greatly reduced the old bunch. Thus, series of bunches grazed high, moderately, or closely, were always found, Fig. 24. Seedlings, of course, were readily eaten, but grazing at a height of even 4 to 5 inches caused the death of tall dropseed. It was in this way that this grass finally disappeared.

Scribner's panic grass is a low-growing plant of the understory. It had increased greatly as a result of bare areas being created by dust deposits. It was widely and often thickly distributed except in dense bluegrass sod or in wheat grass; often it constituted half of the vegetation locally. Although late in resuming growth from the winter rosettes it remained green all summer and furnished much forage. When protected it reached a height of a foot and bore much seed late in June. But where grazed to .5 to 2 inches, as was common, many of the short, broad leaves of the rosette remained intact, practically lying on the soil surface, where it formed a high percentage of basal cover, Fig. 25.

Pennsylvania sedge, a regular constituent of native prairie, became unusually abundant here, as in other grasslands, as a result of the drought. A few patches, 33 by 50 paces in extent, of a nearly pure stand were observed. Usually it was intermixed with prairie grasses, and where it occurred in bluegrass, even if in small amounts, it showed plainly where the bluegrass sod had replaced the other species. It grew rapidly in early spring, was grazed to within an inch of the soil, and furnished considerable



Fig. 25.—Vertical view of closely grazed Scribner's panic grass. The broad leaves lie so close to the soil that many remained despite the closest grazing by cattle.

forage. When closely grazed many leaves grew very near the soil surface, but the plants were green and growth continued more or less throughout the summer. In roughs where no grazing occurred until fall, it attained a height of 6 to 8 inches.

Little bluestem is almost like big bluestem in its period of growth. These two grasses furnished the great bulk of the once famous Kansas and Nebraska prairie hay. On upland the little bluestem type with a 15 to 20 per cent mixture of big bluestem composed most of the remaining upland prairie when it was surveyed over an area of 60,000 square miles preceding the drought (Weaver and Fitzpatrick 1934). But little bluestem was also commonly intermixed with big bluestem on lower ground. Little bluestem disappears after only a few seasons of very close grazing such as occurs in the bluegrass type, Fig. 26. Where bluegrass is present it establishes a sod around and close to the bunch. Later rhizomes grow through the crown at a shallow depth and shoots of bluegrass may appear in its dead center. Little bluestem is much more weakened than is bluegrass by close grazing. The sod-mat of bluegrass spreads over the entire crown, and finally

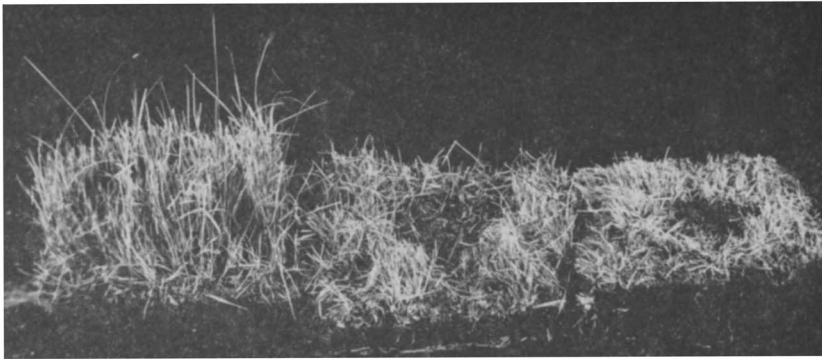


Fig. 26.—Three heights of grazing of little bluestem. The moderately grazed bunch on the left is filled with leafy stems throughout. The open center and weakened foliage of the one on the right furnish excellent conditions for the invasion of bluegrass or weeds.

only a few little bluestem leaves are found, if indeed all have not died. This also happens to most other prairie bunch grasses and even to big bluestem. Finally, the bluegrass sod becomes practically pure (Weaver and Hansen 1941a).

Prairie dropseed is a bunch grass. The fact that it is among the first to disappear from prairie under grazing is an expression of its high palatability. Like nearly all bunch grasses it can not survive under such close grazing as the sod-forming bluegrass where the stems are so short that the leaves may appear to come directly from the soil. Thus, once the prairie sod is well opened and bluegrass thickens its stand, the subsequent close grazing is not only highly detrimental to prairie dropseed, but it is soon fatal. The bunches disappear in the same manner as described for little bluestem. Experiments have shown that when bunches of this grass were clipped 1.5 inches high three times in summer, the next season's yield was very greatly reduced although the tops were removed but twice. In October of the second year all had died (Weaver and Hansen 1941).

Slough grass and tall panic grass were abundant in only a few places. These tall, coarse grasses were grazed mostly after July in 1943. The dense mat of bluegrass, 5 to 7 inches deep, beneath them was due to the protection afforded by their thick stems. They had been grazed high the preceding year and were again reduced mostly to the 16- to 20-inch level in late fall. Only in a few places, where these tall grasses were sparse, was bluegrass

grazed at all closely; indeed, much of it was not grazed at all. By June 1, 1944, the new growth of the tall grasses was 18 to 24 inches high. This was eaten back in places to 12 inches in July, and by September to 8 to 18 inches. Also much of the bluegrass was nipped back to 6 to 8 inches. Later in fall it was reduced further, but much debris remained to prevent early grazing. On the margins of this rough, however, it was being grazed more and more. In some small, isolated patches, slough grass had been reduced to a height of 5 to 12 inches.

Other Native Grasses

Blue grama, a short grass of tremendous importance westward, was found only in small patches. It did not become green until late in spring, and was grazed only moderately and occasionally.

Sand dropseed occurred on the tops of some dust mounds, on bared banks of the ravine, and also in places occupied by little barley or six-weeks fescue. Open ground was rapidly being seeded to sand dropseed. It also sometimes occurred in the wheat grass, but the total amount was small. Sand dropseed furnished an excellent example of past grazing activities influencing animal preferences. Once closely grazed it was kept very short by repeated grazing; stock showed a distinct preference for it compared with blue grama, wheat grass, and certain other species. The increase of sand dropseed in pastures of eastern Nebraska during the great drought has been described elsewhere (Weaver and Hansen 1939). Occurring only rarely and sparingly in native pastures before 1934, it has since increased so rapidly that it is now one of the most abundant and important pasture grasses and therefore deserves special comment. This species, of wide distribution westward, renews growth in early spring, develops rapidly, and is not readily injured by close grazing. It is a prolific seeder and under proper grazing soon reclaimed pastures where bluegrass and little bluestem died. It is highly resistant to drought. It is of good to high palatability in eastern Nebraska, produces much forage, and is efficient in protecting the soil against loss by erosion. For these reasons and the fact that it intermixes readily with many other excellent forage grasses it is considered by the writers as a much more desirable species for eastern Nebraska pastures than is wheat grass.

Only small amounts of side-oats grama and June grass, both excellent pasture grasses, were found. Slender sedge was abundant locally. It is readily grazed in spring often to less than an inch, but it is of small forage value when it dries in June. Other prairie grasses were of even less abundance.

Introduced Weedy Grasses

Little barley and downy brome were highly preferred early in the grazing season and in late fall when the new crop of these winter annuals appeared. When they ripened seed and dried they were not eaten, and they also discouraged grazing in areas where they were intermixed with sand dropseed or other later maturing grasses. Little barley occurred in several large patches scattered over a portion of the pasture, but it also was found elsewhere. It was grazed to a height of 2 to 3 inches in spring, but this grass and all the vegetation in which it grew thickly was avoided even before the little barley began to dry. Even when the spikes were still green they were not relished by cattle. It continued to hinder grazing even of the most palatable grasses often into July or at least until they had grown well above the little barley which lodged after heavy rains. Also much of it was left ungrazed.

Downy brome was less abundant than little barley, neither was it so much grazed. Like the preceding, it was scattered widely and often in wheat grass. It was tall enough to graze the first week in May, and it put forth its panicles by the middle of the month. When dry, it prevented grazing. But the new growth in late fall was readily eaten after a height of 3 or more inches had been attained.

Hairy chess was very common throughout prairie sod opened by the drought during the late thirties, and in 1940 to 1942. It differed from downy brome in occupying the smaller bare spots in the sod. Hence, its distribution was more general but it was less abundant. Barnyard grass is a rank, succulent, edible weed. There were only very small amounts of other weedy grasses.

Native Forbs

Prairie plants other than grasses constitute a long list of species. Practically all are perennials, the annuals and biennials constituting only about 5 per cent. Among them are legumes, nearly

all of which are valuable as forage. Forbs often contribute 10 to 16 per cent of the total prairie yield (Weaver and Albertson 1943). They provide a valuable variety in the diet of livestock grazing native prairie, and deserve much more consideration than they have received in the past.

A large decrease in number of forbs occurred during the great drought. A comprehensive record of their weakening and death shows that their decrease was not gradual but sporadic, corresponding with the severity of the drought. Many shallowly rooted plants were nearly all killed the first year, more deeply rooted ones often persisted for several years, and some very deeply rooted forbs lost most heavily near the end of the drought (Weaver and Albertson 1943). Further studies extending to 1943, or three years after the drought, showed that forbs recovered and increased much more slowly than the grasses (Weaver and Albertson 1944). Thus, when grazing began in this prairie after 1939, forbs were at a low ebb.

The fact that only widely scattered remnants of the more palatable forbs were found may be accounted for in part, on this low ground, by their being repeatedly grazed as soon as they were observed by the cattle, Fig. 27. In the lists of forbs in Table 5, those that regularly decrease under grazing are marked by an asterisk. The second group of plants includes those that usually increase as a result of grazing. These are designated by a superior 1. This results from the repeated removal of the foliage of the grasses which decreases the shade and reduces the amount of water used, thus leaving more for these plants which are either entirely uneaten by stock or grazed so sparingly that they are not much handicapped. Golden corydalis and *Nyctelea* are native species but usually occur only in waste places.

Only one of the 45 or more species of forbs occurring in this pasture became an abundant weed. This was the ironweed which is both native and perennial and spreads by underground stems. It formed patches in which the woody stems mostly occurred singly and from 2 inches to 2 feet apart. These weeds were usually 16 to 24 inches tall by June, and in full bloom at 3 to 4 feet early in July. Beneath them there was nearly always a good stand of bluegrass or bluegrass intermixed with prairie grasses. Large bunches with scores of densely aggregated stems which occur in old pastures and under which even bluegrass can not thrive had



Fig. 27.—Lead plant or prairie shoestring, the most abundant prairie forb, showing effects of grazing on a very palatable legume. The tallest plant, about 18 inches high and almost in bloom, is from ungrazed prairie; the smaller ones from the pasture had escaped spring and early summer grazing. Photo June 25.

not yet developed. As forage became scarcer in fall there was much more trampling, and many of the stems, like those of horseweed, were broken off near the soil surface.

Buckbrush is unpalatable to cattle and except for slight injury by trampling it is unaffected by grazing. Since it hinders grazing and even shades out the grass where it occurs in thick stands, it often becomes a serious pasture weed. Two species here formed small open patches, *Symphoricarpos orbiculatus* or red coralberry, and *S. occidentalis* or wolfberry, a species with white fruits.

Introduced Weedy Forbs

Western ragweed was a potential menace not only because it was not grazed but also because it spreads rapidly by underground stems and forms dense patches. It occurred in only a few

bared places. Hemp was abundant along the upper banks of the stream which were free of perennial plants because of periodic inundations. It also grew scatteringly over much of the five-acre tract that had been plowed. Under it everywhere, and to a minor extent scattered throughout the disturbed parts of the prairie, there occurred continuous to scattered stands of Kochia. Although this weedy annual began growth rather late in May it grew very rapidly, and the bushy plants provided much forage. This different forage and the protection from flies and sun afforded by the much branched plants of hemp, which became 6 to 13 feet tall, caused the cattle to spend several hours a day here. Only one cow was observed eating the leaves of hemp.

Horseweed was eaten only when other forage was scarce, except as young plants were consumed with bluegrass or in a sod of bluestems. When grazed off at the top, the plant produced 8 to 18 branches, varying with the water available for growth, and formed a bushy top. Mature plants 2 to 3 feet high interfered with grazing and promoted the formation of roughs. This weed was very abundant in 1942, less so in 1943, and not at all abundant the next year. But by midsummer it became prominent locally where the sod was not yet continuous. Practically none were found in the wheat grass sod. Extensive studies over the western ranges have shown that horseweed is distinctly cyclic in appearance, sometimes failing to occur where dead stems revealed that the plant had been abundant the preceding season. It disappeared entirely only where perennial grasses gained possession of the soil.

The land formerly cultivated was in a weed stage of succession in 1942-43. The chief species were horseweed and Kochia. Horseweed was not intentionally eaten and the old stems were 2 to 3.5 feet tall. Nor were the tufts and small patches of bluegrass beneath it much grazed since the stand of weeds was unusually dense. But in 1944 when Kochia was much more sparse in the area and there were few horseweeds, the bluegrass flourished, spread rapidly, and, although closely grazed by fall, it had sodded over fully half to two-thirds of the entire area. The size of the plants and the density of the stand revealed at some distance the degree of local disturbance of the cover. In the bluegrass sod where open spots were small and distantly placed, the weeds were widely spaced. Six to 8 plants per square foot when full stature was attained prevented grazing, or at least close grazing, even of bluegrass.

Lamb's quarters grew thickly only the first year. Unlike horseweed, it occurred only where there was considerable open ground. This plant was consumed in considerable amounts in the spring.

As a whole the pasture was remarkably free of weeds. Those that were present were due primarily to the disturbances caused by drought and dusting rather than to the opening of the cover as a result of too early and too heavy grazing.

ROUGHS

Places in the pasture where the forage had not been removed for a year or more either because of the presence of weeds, dung, an abundance of less palatable species, or for other reasons, gave the vegetation a very irregular and uneven appearance. These have been designated as roughs. Sometimes they occupied only a few square feet, areas of a few square yards were perhaps more common, but often they were larger. Bluegrass and all species of



Fig. 28.—Prairie rough composed of several species of grasses and accumulated debris. The light-colored grass with widely spreading leaves is tall dropseed.

prairie grasses were concerned, Fig. 28. Wheat grass roughs occurred almost throughout the area occupied by this species. Roughs are found in nearly all well-kept native pastures. It is assumed by some observant cattle raisers that these arise in new places as the older ones disappear and some believe that this is a method by which the much-grazed vegetation is permitted to recuperate. Certainly roughs are a prominent feature of most native pastures. Extended observation indicates that they become fewer even under long-continued moderate grazing.

Disappearance of Roughs

Roughs and ungrazed scattered bunches were a marked feature of the pasture in 1942, Fig. 29. Early in 1943 the periphery of 10 representative roughs varying in size from 18.5 to 161 square feet and of irregular shape were staked out in such a manner that their area could be re-determined. Four were in the bluegrass



Fig. 29.—Degeneration of relict prairie northeast of the windmill to closely grazed bluegrass. This occurred mostly since 1942. Bunches of various grasses remain, but chiefly tall dropseed, little bluestem, and needle grass.

type, 3 in prairie, and 3 in wheat grass. Each rough was examined twice each year and a map was made to scale of the ungrazed, moderately grazed, and closely grazed portions.

It was ascertained that of the 215 square feet of the four bluegrass roughs 89 per cent was closely (or a small part moderately) grazed in 1943. By October of the second year 75 per cent had again been grazed closely (or a part moderately), and probably more closely by November, since the cattle were making great inroads on bluegrass roughs everywhere, Fig. 30.

Grazing in roughs of relict prairie was similar to that in bluegrass. The first year 84 per cent of the 150 square feet was closely grazed and 87 per cent in 1944. The presence of tall dropseed hindered complete removal of one rough. Even dense stands of nearly mature plants of big bluestem, little bluestem, needle grass, and prairie dropseed much intermixed with the previous year's dried leaves and stems were grazed back to a height of 4 to 5 inches.

Results in wheat grass roughs were very different. Of the three totaling 314 square feet only 3 per cent had been closely



Fig. 30.—Bluegrass rough being removed under increased grazing pressure. This will add new territory for closer grazing next year. Photo October 6, 1944.

grazed late in 1943. Otherwise these roughs remained ungrazed or in a few places they were grazed to a height of 10 to 12 inches only. The next year only 8 per cent was closely grazed, 92 per cent remaining ungrazed except for a small amount grazed above 8 to 10 inches.

From these data, which are in accord with extensive observations, it may be seen that under the conditions of grazing in this pasture roughs composed of palatable grasses disappeared quickly and almost completely. But where less palatable forage composed the rough it remained essentially intact.

Formation of New Roughs

In order to determine whether or not new roughs were formed, an area of closely grazed pasture was selected and permanently marked out within a few feet of each of those discussed. These areas varied in size from 28 to 80 square feet. They were examined twice each year. The 190 square feet of bluegrass was kept closely grazed. Likewise, the prairie grass on the 150 square feet under observation was closely grazed. But the wheat grass areas totaling 200 square feet which had previously been grazed were either entirely unmolested or grazed to a height of 8 inches in 1943. The next fall 89 per cent remained ungrazed or was grazed to 8 to 10 inches in a few places.

At each harvest in 1943, places occupied by the enclosure were marked by stakes after clipping in such a manner that they could easily be found and the time of cutting ascertained. In no instance did roughs develop either year of the experiment in the bluegrass or prairie grass sod, although regeneration of the grasses was prompt and abundant. Little growth occurred in the enclosures of wheat grass clipped in May and practically none until fall where clipping occurred later. They were grazed a little in 1944, but by fall numerous dry stems were found. The bedding down of cattle in the ungrazed wheat grass flattened the stems to the ground where most of them died. In such spots there was no debris left above a height of 1 or 2 inches. These places where the herd rested sometimes aggregated a fourth of the area of the entire wheat grass alterne. In late fall and early spring when new shoots of wheat grass appeared, these places free from old stems were grazed at least for a time. The surrounding area with standing stems usually remained ungrazed

or was grazed very high, thus giving the pasture a very spotted appearance. Much dung accumulated here, however, and further grazing was hindered. New roughs were developed in many of these places.

A bluegrass rough of 100 square feet was cleared off early in spring. In it the new crop was very well utilized all summer. While the surrounding vegetation was regularly 7 inches tall, grass in this area never exceeded 2 inches. Here there was neither debris nor stiff protective stems of coarse grass to interfere with grazing. A similar rough of wheat grass was grazed both years, but considerable residue began to appear the second fall.

Summarizing, these experiments showed that where bluegrass or prairie grasses were once closely grazed such grazing was repeated, at least by fall. But where wheat grass was flattened in bedding grounds, grazed closely one year, or the old debris removed through clipping, there was no assurance that it would not revert into a rough after two or more years.

Fate of Marked Bunches

The grasses marked for study were either ungrazed, grazed high (above 6 inches), moderately grazed (between 3 and 6 inches), or closely grazed, that is, less than 3 inches in height and often to 1.5 inches.

Among the 39 bunches of needle grass, 7 ungrazed and 2 grazed high when marked were closely grazed thereafter. Five ungrazed bunches and 3 that were grazed high were all closely grazed and then permitted to recover; another was first moderately and then closely grazed. Ten moderately grazed bunches were repeatedly closely grazed after marking. Eight closely grazed bunches remained closely grazed continuously; one other bunch recovered from close grazing only again to be closely grazed. Thus, only one bunch remained entirely ungrazed and this was during the first year only. But another bunch was grazed high during both years. These 2 with 8 that recovered and grew up again constituted only 26 per cent of the group; the others seemed doomed to extinction.

Of 17 bunches of big bluestem, 5 grazed high and 11 grazed moderately, all were closely grazed thereafter. One closely grazed clump also remained closely grazed.

Seventeen of 39 bunches of little bluestem were ungrazed when marked. Eleven were closely grazed thereafter; 3 were grazed high or moderately and then closely; 2 were only moderately grazed; and 1 was closely grazed and then permitted to recover. Nine other clumps that had been grazed high were subsequently closely grazed; one was first moderately and then closely grazed. Nine moderately grazed bunches were closely grazed thereafter. Three closely grazed bunches were kept closely grazed. Thus, all but 3 of the 39 bunches became closely grazed, 2 of these three were grazed moderately, and only 1 had recovered.

Seven ungrazed bunches of prairie dropseed were marked. One was grazed high or moderately thereafter, one was closely grazed and recovered, the others were kept closely grazed. Two other bunches were grazed high and moderately, respectively, then both were closely grazed. Thus, the grazing trend was toward extinction of prairie dropseed.

Eleven ungrazed bunches of tall dropseed were grazed high after marking; 2 others remained ungrazed. Two ungrazed bunches were grazed closely during either the first or second summer, and one that had been grazed high was again grazed high each season. Clearly this grass was much less palatable than any of the preceding.

Even casual examination of the pasture in the fall of 1944 revealed that the decrease in isolated bunches of all prairie grasses, except tall dropseed, had been very great. This was in agreement with the 85 per cent loss among the 102 marked bunches.

SEASONAL RESIDUES AND GRAZING TRENDS IN THE SEVERAL TYPES

Proper management of range or pasture forage is largely determined by the amount of grass, forbs, or other vegetation that should be left on the ground. A certain amount, which varies with the species, must remain after grazing to maintain plant vigor and keep an effective stand in good condition. Under proper stocking the grasses will be more vigorous, growth will begin earlier in spring, and more forage will be produced. In addition, this unconsumed forage conserves moisture, adds organic matter to the soil, and protects the soil from the direct action of rain, wind, and other forces causing erosion of the soil or lowering its fertility. Forage residues are also essential in maintaining maxi-

imum forage yields. Experience has repeatedly shown that with proper rates of stocking, pastures and ranges will produce greater profits even for the current year than the heavier rates of stocking too often practiced (Costello 1944). Moreover, this permits a high level of livestock production in future years. Maximum number of animals is not necessary to produce maximum gains in beef and highest profits (Allred 1940).

Of the production of bluegrass in 1943, 1.68 tons were consumed and only .10 ton remained on October 2. This was only 5.6 per cent of the total yield. The next year the unconsumed yield amounted to 12 per cent. Among the prairie grasses, the residues on October 1 were 19.2 and 13.7 per cent respectively, but were undoubtedly much less after another month of grazing. Residues in the wheat grass type were very large, 42.1 and 60.7 per cent for the two years. Thus, the averages of unconsumed forage in the three grazing types in order were 8.8, 16.5, and 51.4 per cent.

Residues in Other Pastures

Practically all of the native pastures in the vicinity along Salt Creek have degenerated into shortgrass (mostly buffalo grass), western wheat grass, or a combination of the two. But in some there may be found, despite the drought, small areas of pure bluegrass, Fig. 31. But pastures of native prairie grass are now found only on the upland. Some information as to the percentage of the total yield consumed and the amount left after grazing may be gained from the following studies. Circular areas of 5 square feet were located at random in the several pasture types and the forage removed close to the soil. The data obtained are representative of the general conditions in the years of good rainfall, 1942 to 1944. In bluegrass, wherever found, the sod was grazed to approximately 0.5 inch. The residues, clipped at the soil surface, varied from 9.2 to 18.1 grams per unit area and averaged 13.4 grams. A few samples from roughs in moderately grazed pastures were also obtained. Assuming that this lightly grazed bluegrass (147.7 grams) represented 90 per cent of the average total yield (164.1 grams), the unconsumed bluegrass (actually an amount the grazing animals could not get) was only 8 per cent.

Table 6 presents similar data on wheat grass. The first 9 samples are from two different pastures both heavily stocked and greatly overgrazed. Unconsumed forage averaged 156.5 grams

per unit area. Samples 10 and 11 (taken April 2, but all others on August 3, 1943) are from similar low-lying pastures moderately grazed. The remainder are from pastures almost or entirely ungrazed that year. The average amount of unconsumed forage

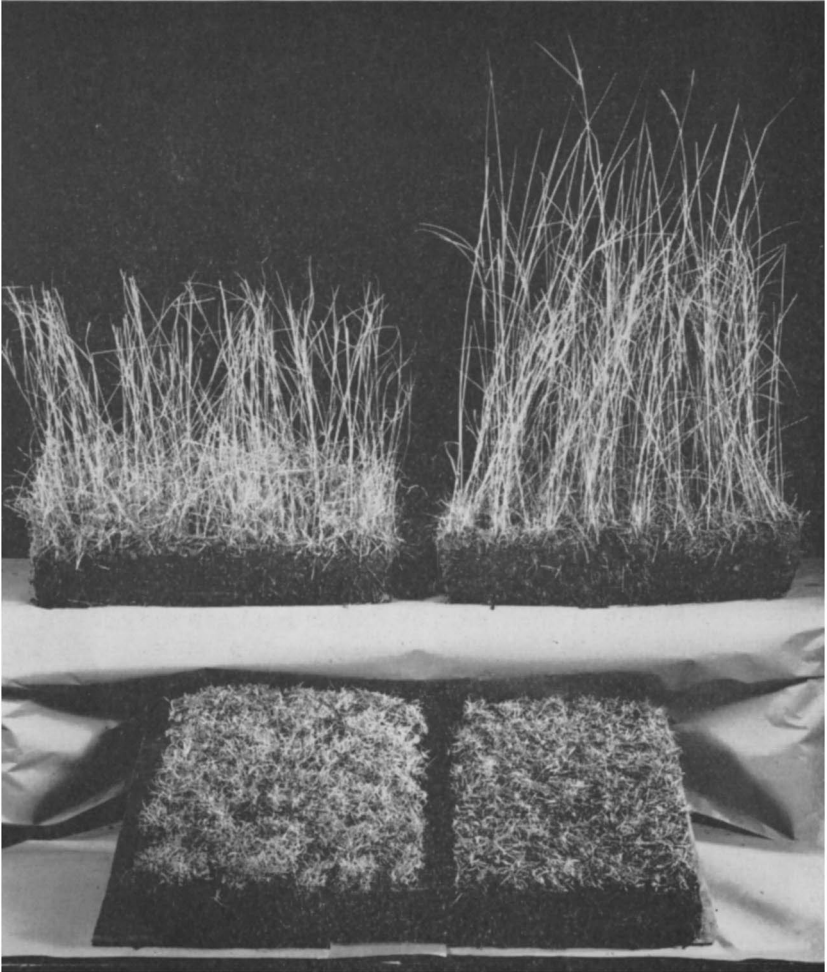


Fig. 31.—Representative blocks of sod from an unevenly grazed lowland pasture in early spring. Buffalo grass (left) and bluegrass (right) in the lower picture had been grazed to within three-fourths inch of the soil. The pure stand of wheat grass had been ungrazed, while that protecting an understory of buffalo grass 4 inches tall had been only slightly grazed.



Fig. 32.—Upland prairie, mostly big bluestem, being grazed at a height of 2.5 to 3 inches. Other grasses are little bluestem and side-oats grama.

(156.5 grams) was 65 per cent of the average total yield (239.1 grams). These are the conditions under overgrazing: all of the available bluegrass consumed but much more than half of the wheat grass trampled underfoot or left standing to encumber the land. With prairie grasses neither of these conditions maintained.

Clippings of prairie grasses were made in two pastures near Denton on rolling upland about 15 miles southwest of Lincoln. One pasture consisting of 425 acres was well stocked; the grazing animals, both cattle and horses, were turned in early, and grazing was fairly uniform except on certain steep hillsides. A second pasture, of 450 acres, adjoining the first was stocked so lightly in 1943 that it resembled undisturbed prairie and was used as a control. Clippings in both were made late in July, Table 6. One was impressed both by the marked uniformity of the bluestem prairie type and also by the uniform grazing, Fig. 32. Average amount of unconsumed forage was 34.8 grams per unit area. It consisted almost entirely of big bluestem, little bluestem, and

side-oats grama. The first three control samples (11, 12, and 13) are also from this pasture, but from a part infrequently grazed, since it was isolated by a deep ditch. The remainder are from the very similar but lightly grazed pasture across the road. If the average yield (192.4 grams) is considered total yield, then the percentage of unconsumed forage was 18.

Table 6.—Height and yield of ungrazed forage in closely grazed pastures (above the line) and ungrazed pastures (below the line) in two types of grassland. Each sample was from 5 square feet.

Western Wheat Grass			Prairie Grasses		
SAMPLE	HEIGHT INCHES	DRY WEIGHT GRAMS	SAMPLE	HEIGHT INCHES	DRY WEIGHT GRAMS
1	8	81.3	1	4.0	43.0
2	7	116.9	2	3.0	35.0
3	11	137.0	3	2.5	39.6
4	9	112.5	4	2.0	39.0
5	8	119.3	5	2.0	36.7
6	12	272.3	6	1.5	29.3
7	9	192.9	7	1.5	28.0
8	10	193.3	8	2.0	36.9
9	11	182.9	9	2.0	29.9
10	21	208.6	10	1.5	30.8
11	13	118.5	11	9.0	174.7
12	27	203.8	12	10.5	168.4
13	27	207.1	13	10.0	226.4
14	26	300.6	14	11-14	192.2
15	28	396.3	15	12-14	166.5
			16	12-16	166.3
			17	13-14	242.2
			18	12-14	202.5

Grazing Trends

From the preceding data it may be seen that bluegrass was greatly overgrazed in all of the pastures where it occurred. Instead of 20 to 25 per cent of the forage being left in the pasture, as is commonly advocated by range examiners, usually much less than half of this amount remained. In the pastures where about 18 per cent of prairie grasses were left intact no increase in bluegrass had occurred. The significance of a moderately low residue (16.5 per cent) or, technically, a too high utilization of the blue-stems in the experimental pasture, coupled with the rapid spread of bluegrass, is convincing evidence that there the trend is distinctly toward a type of pasture of lower productivity.

Only 49 per cent of the crop of wheat grass was utilized. Unfortunately there is little known about its proper utilization in eastern Nebraska, since it is almost entirely a drought invader. But studies in drier areas southwestward indicate that 52 per cent

of the weight of this species is approximately its correct utilization (Crafts 1938). Under very close grazing in the Salt Creek valley wheat grass has been largely replaced by short grasses. Since the preceding data were obtained on good years, similar grazing on drought years would result in even more rapid deterioration. Under no plan of stocking at a constant level is it possible to prevent excess use in parts of the year nor an accumulation of unused forage on better years. The latter may be beneficial, since it may add to the vigor of the plants and allow them to recover from damage inflicted during the dry years (Stoddart and Smith 1943).

Replacement of prairie grasses by bluegrass seems inevitable under the present grazing practice. This has been the regular fate of much native prairie both upland and lowland in eastern Nebraska before the drought. Fate of the wheat grass seems less certain.

If the wheat grass were replaced by warm-season grasses and grazing in too early spring discontinued, there would be an excellent opportunity still to save and improve this native-grass pasture. With spring mowing to check the growth of wheat grass, and seeding even superficially with side-oats grama, buffalo grass, or blue grama the area would be closely grazed and the wheat grass would tend to disappear. Spot sodding with buffalo grass, even if the sods were widely placed, would bring about the same result. Successful invasion of all these grasses into wheat grass has been repeatedly observed. Even the disking in of seed of big bluestem might prove successful on this low ground if the growth of wheat grass were suppressed by proper mowing. Thus far wheat grass has been taken for granted; its general invasion from the dry west into this region of moderate precipitation is so recent that little is known about its behavior. This plan would necessitate the use in early spring of a brome grass pasture or a temporary pasture as winter rye. Of course it may be the plan on this fertile lowland to stock the pasture heavily until it is "grazed out" and then to break the sod for production of crops.

DISCUSSION

The grazing trends, and especially their modification by deferred grazing or other management practice, are complicated because of the presence of the wheat grass type. Aldous (1938)

in his discussion of the management of bluestem pastures in Kansas points out that there has been a steady decline in their grazing capacity. "Prior to 1900 most of the pastures were stocked at the rate of 2 acres for a cow or mature steer. The average has been gradually decreased until in 1933, or before the present dry cycle started, the best pastures were carrying one mature animal to 4 acres, while the average for the bluestem region as a whole was 5 acres per head for the summer grazing period. During the past two years (1936-37) the average grazing capacity has been 7 acres for a cow or a 3-year-old steer." This deterioration was due primarily to too close grazing.

After years of experiment in an endeavor to increase the carrying capacity of bluestem ranges, the best method was found to be deferred grazing. Keeping the cattle from the grass until about June 15 and repeating this period of protection every two or three years, was found to be sufficient to maintain the normal stand and vigor of the vegetation in Kansas. The result of the deferred system of grazing gave an increase of approximately 25 per cent in carrying capacity and 33 per cent increase in the gains in pounds of livestock per acre over that in pasture lands grazed the season long (Aldous 1938). "As a result of spring protection, stands of grass on the deferred pasture have been maintained in better condition in spite of the fact that it had been subjected to much harder use. At the end of each grazing season it has had a better cover of grass to afford protection against runoff and erosion during winter and spring" (Anderson 1940).

Should such deferred grazing be practiced here the crop of wheat grass would be entirely unused until fall, and even then the denser growth due to lack of some grazing in spring would hinder fall grazing as well. Moreover, the bluegrass crop comes on early. Its period of greatest apparent palatability is in late March and during April. Consequently its loss in the bluestem pastures is probably not too serious, since it is not considered a particularly valuable addition to the vegetation of bluestem prairie. Its growing season is early spring and late fall; usually it becomes semidormant in midsummer. It does not fit into the grazing season of the bluestems. In fact, the loss of bluegrass is considered by many cattlemen to have benefited native pastures.

Conversely, should the present method of yearlong, heavy grazing result in the replacement of the prairie type with one of blue-

grass—as seems inevitable—this will be accompanied by a great loss in forage production. Weaver and Hougen (1939) have shown that where lowland bluestem prairie degenerated to bluegrass the forage yield measured in fall was reduced to 39 per cent, and where clipping to simulate close grazing was practiced the yield was reduced to 67 per cent of that of bluestems. In the present study, if the average consumption of prairie grasses over the two years is considered as 100, then that of bluegrass is 65.

Not only is the consumption of wheat grass much less than that of prairie grasses, but in quality this forage increment is certainly inferior. Moreover, the bulk of the wheat grass and early yield of bluegrass as well is being consumed in spring at a time when the grazing and trampling of the bluestems is most harmful. Again in fall the wheat grass is consumed only after both bluegrass and prairie grasses are grazed too closely and when grazing of the bluestems should normally be terminated.

That the total yield of wheat grass in this pasture exceeded that of the prairie grasses was not due to its better yielding qualities, but to the fact that the bluestems had been grazed. Extensive experiments have been conducted to ascertain relative production of big bluestem and western wheat grass growing in adjacent areas where it had invaded uplands. Whether these grasses were harvested once, twice, or three times per season in eastern Nebraska and Kansas, the yield was only 47 to 66 per cent as much as that produced by the bluestem similarly treated. Where wheat grass and big bluestem were growing in alternate patches on level land on the Salt Creek flood plain near Lincoln, the yield of wheat grass in August before the bluestem had produced flower stalks was only one-third that of bluestem (Weaver and Albertson 1944). These authors state: "wheat grass is less palatable than most other grasses in true prairie, even including sand dropseed. Its earlier growth in spring and late development in fall does extend the length of the grazing period. But under normal conditions the same end is attained by growing Kentucky bluegrass. Soil under wheat grass tends to lose the good tilth it had when it was covered with big bluestem. For these reasons encouragement of the planting or growing of western wheat grass in true prairie is not in accord with the best grazing practice."

Too early grazing in spring and too frequent and close removal of the herbage, commonly designated as overgrazing, are both

faulty practices that are never economical. They are usually unintentional on the part of the farmer or the range operator, simply because he is unfamiliar with the fundamental physiological activities of plants. When prairie hay is fed to stock in winter, the owner realizes that when the stack is gone he must provide more forage. But when the better grasses are grazed in fall to a degree where the remainder should be left and where its removal damages the plants greatly, or in extreme cases causes their death, the presence of this herbage and of unpalatable weeds often gives the false impression that there is still plenty of forage.

Early spring grazing of prairie grasses before the plants are 4 to 5 inches tall is very injurious. Unlike animals, plants make their own food. The green shoots in spring are produced from food stored in the roots and crowns which, unlike the parts above ground, did not die. This early growth draws heavily upon these food reserves, and to this extent the plant is weakened. Grazing at this time is very detrimental, since remaining foods must then be used in producing a second crop of new shoots. If these are also eaten the plant may ultimately succumb to starvation. But once the new growth—the food-making factory—is made, a new supply of food is manufactured, growth continues vigorously, and the storage organs are replenished. Hence, removal of a part of the top, as in moderate grazing, is not very harmful; the grass will still thrive. Although plants that are grazed early do not produce as much forage as do plants that are grazed later, the young foliage is more nutritious and is sought by grazing animals. Since the volume available is smaller the result is increased damage by trampling, especially if the soil is wet.

Under heavy clipping, to simulate grazing that occurred in adjacent pastures, yields from plots of bluestem prairie clipped frequently during two years were much lower than those from plots similarly clipped for only a single year. In little bluestem the yield was 60 per cent less, in big bluestem 37 per cent, and in mixed bluestems 51 per cent less. Where clipping was continued in the same plots for a period of three years, yields were further reduced. When compared with those of plots frequently clipped two years they were found to be 42 and 23 per cent less, respectively (Weaver and Hougén 1939). Thus, there is a rapid decrease in yield following too close utilization of forage.

Under heavy grazing vegetation is more susceptible to drought injury. On some ranges depletion of forage was found to be proportional to the degree of grazing during spring (Craddock and Forsling 1938). Decrease in production of blue grama and buffalo grass on the Great Plains under periods of drought were found to be almost directly proportional to the intensity of grazing (Savage 1937, Albertson and Weaver 1944). Why heavily grazed ranges are more susceptible to drought can better be understood when it is known that such grazing results both in a decrease of the depth of the roots and the volume of root production.

Many years ago Ellett and Carrier (1915) found that on permanent bluegrass sod, the total yield of dry matter varied inversely with the number of times the grass was cut during the growing season. While much larger current production of bluegrass has been obtained with frequent and close defoliations than by clipping high at the same time and frequency, the following year the closely clipped grass was less productive and weeds were 5 to 7 times more abundant (Graber 1933). Thus, delays in recovery from close removal of tops even for a single summer may greatly limit subsequent yields. Biswell and Weaver (1933) have shown the harmful effect of frequent clipping upon the development of both tops and roots of numerous grasses in prairie sod.

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SUMMARY

The monthly and seasonal yields and consumption of forage were ascertained in three grazing types in a level, lowland pasture on Wabash silt loam soil near Lincoln, Nebraska. This lowland was formerly native true prairie consisting largely of bluestem grasses mowed annually for hay. Damage by drought and burial by wind-blown dust permitted the establishment of western wheat grass (*Agropyron smithii*) in patches and alternes so extensive that they occupied approximately a third of the area. Three years of grazing had permitted the spreading of Kentucky bluegrass (*Poa pratensis*) to form a distinct and extensive bluegrass type. The remaining one-third of the 50-acre pasture consisted of native prairie.

There were about 45 species of native non-grasslike plants or forbs. Most of these were eaten and, with certain introduced

weedy forbs as summer cypress (*Kochia scoparia*), provided a valuable variety in the diet of the livestock. Only one, ironweed (*Vernonia baldwini*), had become a weed. Horseweed (*Leptilon canadense*) was the chief introduced weed. The presence of the numerous species of palatable native forbs and the scarcity of introduced weedy forbs and grasses indicated that this was a pasture of high grade.

Yields were obtained by monthly hand-clipping of the vegetation in portable exclosures, 15 in number and each 29 square feet in area. They were widely spaced throughout the several types. They were placed in the pasture when grazing began and a very similar control area was selected near each exclosure. Exclosures were transferred to new but adjacent locations after each clipping and new controls were marked out. The yield for June, for example, was the weight of forage harvested in an exclosure minus the weight of the unconsumed vegetation in the (grazed) control at the end of May. Consumption was ascertained by subtracting the weight of the ungrazed forage in the 29-square-foot control from the amount produced in the exclosure.

This highly productive pasture supported 45 head of yearling steers from April 22 to November in 1943, and 38 steers, 5 cows, and 4 calves over an approximately similar period in 1944.

Spring was late both years and moderate drought in August occurred in 1943. The following year was cool and moist, although fall was dry, and bluegrass remained green all summer. Western wheat grass produced its greatest yield in May and early June. Little or no growth occurred thereafter in 1943 and almost none until early fall in 1944. Total yield was 2.30 and 3.56 tons per acre, respectively. Yield of native prairie grasses was high in May, but highest in June. It decreased greatly in July, and much more (1943) or but little (1944) thereafter. Total yield was 3.54 and 2.62 tons per acre, respectively. Much bluegrass had invaded the prairie type the second year. This and too close previous grazing account for the decrease in yield. Yield of bluegrass was high in May, June, and July but decreased thereafter, very greatly in 1943. Total yield was 1.78 and 1.88 tons per acre, respectively.

Lower yield of bluestems than of wheat grass was not due to their poorer yielding qualities, but to the fact that the bluestems had been grazed. Extensive experiments have shown clearly that the yield of wheat grass compared with that of adjacent ungrazed big bluestem is only 32 to 66 per cent as great.

Yield of wheat grass far exceeded consumption during the first half of the grazing season, but thereafter consumption was nearly equal to or exceeded current yield. Total consumption of this coarse and only seasonally palatable grass was 1.33 and 1.40 tons during the two years, respectively, or 58 and 39 per cent of the yield. In the relict prairie type, yield of forage was exceeded by the amount consumed after July. The consumption in fall increased considerably after September 1 in 1943 at a time when yields of prairie grass were decreasing. Total consumption was high, 2.86 and 2.26 tons per acre or 80.8 and 86.2 per cent of the yield during 1943 and 1944.

In the closely grazed bluegrass type yields in May and June and even in the relatively cool month of July (1943) considerably exceeded consumption. But the amount eaten in July (1944) and thereafter both years exceeded but decreased with the current yield. There was no increase in consumption in fall simply because there was no excess of bluegrass, so close was the grazing. Total consumption, 1.68 and 1.65 tons, respectively, averaged 91.2 per cent of the yield. *Kochia scoparia* or summer cypress along the banks of the stream was consumed at the average rate of 1.6 tons per acre in June and July and of .8 ton in August and September.

Early spring grazing consisted largely of wheat grass, bluegrass, penn sedge (*Carex pennsylvanica*), and needle grass (*Stipa spartea*), as well as weedy grasses such as little barley (*Hordeum pusillum*) and downy brome (*Bromus tectorum*). Much damage was done by too early grazing of bluestems and other warm-season grasses. Wheat grass was scarcely grazed after June 20 until its new growth and that of weedy, winter-annual grasses under it appeared in September. Bluegrass was too closely grazed, except in spring. The old growth was consumed with the new in fall. Too close grazing of prairie grasses resulted in their gradual replacement by bluegrass.

Big bluestem, needle grass, tall dropseed (of small forage value), Scribner's panic grass, and little bluestem were the chief forage grasses. All except tall dropseed were grazed (except in roughs) to a height of 2 to 6 inches in spring and early summer and much closer (.5 to 3 inches) in fall. Grazing of needle grass occurred mostly in spring and fall. Tall dropseed was a barrier to uniform grazing. Much of it was finally removed by stock by their grazing

back of the tops in eating bluestems and other grasses growing near or in the bunches of tall dropseed.

Wheat grass was usually grazed back to a height of 4 to 11 inches in May, 10 to 22 early in June, and 12 to 20 inches in fall. Conversely, bluegrass was grazed to 1.5 to 3 inches before mid-summer and then more closely and often uniformly to .5 to 1.5 inches in fall.

Ungrazed patches of mature forage in each of the several types were mapped early in 1943 and their persistence ascertained. All were grazed closely and repeatedly except those in wheat grass which remained essentially intact. A series of marked, well-grazed plots revealed that where bluegrass or prairie grasses were once closely grazed such grazing was repeated in subsequent years. But where wheat grass was cleared of mature forage and debris either by grazing or otherwise there was no assurance that the place would not revert into a rough after two or more years. Of several score of marked bunches of various prairie grasses 85 per cent were closely grazed or had disappeared by the end of the second year.

Residues of unutilized current forage early in October amounted to 51 per cent of the yield of wheat grass but only 16.5 per cent of the prairie grasses, and 8.8 per cent of the yield of bluegrass. Too early removal and too close utilization of the prairie forage resulted in the rapid replacement of prairie by bluegrass and a consequent reduction of about 35 per cent in annual yield of forage.

The difficulties of range management favorable to the native prairie type so long as the wheat grass type remains are pointed out. Suggestions are offered for the replacement of wheat grass, much of which is not eaten, by bluestems or other warm-season grasses. This would increase the productivity of the highly preferred, original, native grasses, and tend to decrease the amount of bluegrass.

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