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Comparative Yields of Seven Native Grasses Growing in An Ungrazed Mixed Prairie

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being

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ABSTRACT OF THESIS

A study was made to determine the average monthly and seasonal yields of seven native grasses as they grew in pure stands in an ungrazed mixed prairie near Hays, Kansas. The study was conducted for two growing seasons (1952-1953) on the upland, gentle hillside, steep hillside, and lowland. The study area consisted of 320 acres with gently rolling hills and steep hillsides broadening at their bases to form ravines and a broad lowland.

Grasses which were studied on the upland were blue grama (Bouteloua gracilis (H. B. K.) Lab.), buffalo grass (Buchloe dactyloides (Nutt.) Englem.), side-oats grama (Bouteloua curtipendula (Michx.) Torr.), big bluestem (Andropogon gerardi, Vitman), and western wheatgrass (Agropyron smithii, Rydb.).

On the gentle hillside, yields were ascertained for buffalo grass, blue grama, side-oats grama, big bluestem, and little bluestem (Andropogon scoparius, Michx.). Grasses on the steep hillsides from which yields were taken were side-oats grama, big bluestem, and little bluestem.

On the lowland yields were obtained from big bluestem, switchgrass (Panicum virgatum L.), and western wheatgrass.

Randomly located square-foot quadrats were used to determine basal cover and yields. Fifteen or more square-foot quadrats were clipped each month (June to September) at

the top of underlying mulch to determine yields of each species of grass on each site. The clipped forage was air dried, weighed and computed to pounds per acre. Average basal cover was determined for each species by many individual measurements.

Height of growth was determined at each clipping period. Measurements were made of new growth prior to clipping the quadrats and also of unclipped growth outside the quadrats.

Soil moisture was determined every 2 weeks to a depth of 4 feet on the upland and lowland. Samples were taken in duplicate and an average percent moisture for the two samples was recorded for each depth.

Climate for the two seasons was characterized by low, uneven distribution of rainfall, deficiency of soil moisture and accompanying high temperatures and wind velocities. The two growing seasons were abnormally dry, each receiving about 11 inches of rainfall.

Production of grasses usually reached a peak in late spring or early summer and then declined during the latter part of the growing season. Generally more forage was produced by June 15 than thereafter. Height of growth and yield were greatest when soil moisture became deficient. During the latter part of both seasons, except for sporadic greening, most grasses were in semi-dormancy with their leaves either rolled or folded.

Generally the amount of forage produced was greatest

from species which occupied the mesic areas and lowest from those of more xeric ones. The tall-grasses, while occupying less surface area than the short grasses, produced larger amounts of forage due to their greater height and coarser growth.

On the upland habitat about 1,000 pounds of forage was produced by the short grasses each season, while the yield of side-oats grama was somewhat higher. Big bluestem which occurred only in isolated bunches produced slightly more than 3,500 pounds per acre. The yield of western wheatgrass was slightly more than 1,500 pounds the first season and somewhat less the second season.

On the gentle hillside habitat the two short grasses were again low producers. However, buffalo grass produced slightly more forage than blue grama and side-oats grama each season. The yield of little bluestem and big bluestem was somewhat comparable each season, each producing more than 2,000 pounds.

Big bluestem produced the greatest yield followed by little bluestem and side-oats grama in that order on the steep hillside habitat. Big bluestem produced less forage on this habitat than on other sites while the yields of side-oats grama and little bluestem were somewhat higher.

On the lowland habitat big bluestem produced about 6,013 pounds in 1952 followed by switchgrass (5,872 pounds)

and western wheatgrass (4,940 pounds). 1953 yields were considerably less for each species.

The amount of forage produced by each species generally increased with an increase in basal area.

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INTRODUCTION

The western range area as it is now known covers about 728 million acres, nearly 40 percent of the total land area of the United States (U. S. Forest Service, 1936). Within this vast range area lies the mixed prairie, deriving its name from the intimate mixture of mid and short grasses. The former constitute the upper story and the short grasses the lower one. Clements (1920) first recognized the mixed prairie as a distinct plant association and described its nature, range and grouping of dominants. Since this time vast areas of grassland have been plowed or have deteriorated through unwise stocking rates of domestic animals.

The value of grasses in obtaining an adequate cover for eroding land as well as providing pasture, hay, or seed has received increased attention during the past few years. Because the grazing resources of this country are important to everyone, it is desirable that those who are interested in conservation of grasslands or range management should acquaint themselves with production of important range species.

Rangelands have multiple uses, but for the current operator their value is largely limited to what they will produce in livestock products. The task of maintaining grazing lands in a high state of productivity is fundamentally based upon a knowledge of production of native vege-

tation. Most range operators find balancing numbers of range animals with their food supply a difficult problem since little has been known about the growth habits and production of the individual range species.

The purpose of this study was to determine average monthly and seasonal yields for the most common grasses on an ungrazed mixed prairie near Hays, Kansas, during the growing seasons of 1952 and 1953.

RELATED STUDIES

The great drought of the "thirties" served as a motivation for conservationists and range operators to begin focusing their attention on deterioration on grassland resources. A number of our universities and experiment stations have fostered studies which have resulted in a greater knowledge of our native vegetation.

Albertson (1937) divided the mixed prairie near Hays, into three types. The short-grass type occupies the high level land; little bluestem and its associates are most common on the hillsides, and the big bluestem type dominates the lowland and ravines. Riegel et al (1950) worked on yield and consumption of vegetation on these different habitat types in a typical pasture in a mixed prairie.

Several studies have been made in relation to the life history and growth habits of native grasses. Hopkins (1941),

Riegel (1941), and Webb (1941) worked with side-oats grama, blue grama, and buffalo grass, respectively. Weaver (1942) discussed the growth habits of western wheatgrass. Cornelius (1947) reported on the effect of the source of seed of little bluestem on growth, adaptation, and use in revegetation. Anderson and Aldous (1938) working with little bluestem growing from seeds produced in different localities found considerable variation in growth. Riegel (1940) made a study of the variation in growth of blue grama grass from seed produced in various sections of the Great Plains Region. Wenger (1943) reported on the yield of seed and forage of selected strains of buffalo grass, artificially established and irrigated. He also reported yield from native buffalo grass sod under different intensities of clipping. Newell and Keim (1947) studied several grasses (established artificially) adapted to the region of eastern Nebraska as they grew in pure stands. Yields were compared under two frequencies of harvesting by mowing to simulate haying and grazing conditions. Yields were collected for four years (1939-1943).

Studies of the effect of different intensities of clipping on growth of short grasses over a period of 6 years near Hays, were made by Albertson et al (1953). Aldous (1930) observed that clipping at short intervals caused greater decrease in density of grasses than did clipping

at longer intervals. Riegel (1947) found that tall native grasses were more susceptible to clipping damage than short grasses. When grasses were clipped for several months there was an increase in total height but a decrease in weight. Tomanek (1948) studied 5 short-grass pastures in western Kansas where grazing intensity had been different during the previous 15 years. He discovered that the moderately-grazed pasture had a yield significantly greater than either the ungrazed or heavily-grazed pastures. Lacey (1942), examining short-grass pastures, observed that moderate grazing maintained constant forage yield, except under adverse conditions when a considerable decrease was noted.

Albertson and Weaver (1944) reported the effect of drought, dust, and different intensities of grazing upon the yield of short-grass pastures. To measure recovery, studies were made on increase in basal cover of perennial grasses and amount of forage produced.

Hopkins et al (1952) examined the effects of rainfall, soil moisture, protein content and utilization of vegetation on the production of beef for a period of four years. The role of soil moisture was found to be most important in carrying out a successful livestock program.

Kinsinger (1953) investigated the effect of different intensities of clipping on the yield of several grasses in a mixed prairie near Hays. He also reported the effect of

clipping intensities on the storage of carbohydrate reserves followed a pattern closely related to the growth cycle of the grasses.

Dietz (1953) made a study of yields of grasses on various habitats of a mixed prairie. He reported yields in relation to the density of growth.

STUDY AREA AND VEGETATIVE TYPES

The study was conducted on a prairie lying about 1.5 miles west of the dam along the north shore of Cedar Bluff Reservoir. The 320-acre range is located in the southeast corner of Trego County, approximately 35 miles southwest of Hays. This area was a part of the Ryan Ranch before it and adjoining ranges were purchased by the government for the reservoir site. No grazing has been permitted since the purchase by the government. Since water sources were located nearly 2 miles away, the area has always been lightly grazed.

Topography of the range is characterized by rolling hills gradually sloping to the center of the area and forming a large ravine. Several tributaries empty into this (large) ravine which gives a rough, broken appearance (Fig. 1).

Figure 1.--View showing the topography of the area studied. Note rolling hills and many ravines.

The range was surveyed in early May, 1952 and was divided into upland, gentle hillside, steep hillside, and lowland. Seven grasses were studied as they grew and produced in pure stands. On the upland sites investigations were conducted on buffalo grass (Buchloe dactyloides (Nutt.) Englem.), blue grama (Bouteloua gracilis (H.B.K.) Lab.), side-oats grama (Bouteloua curtipendula (Michx.) Torr.), big bluestem (Andropogon gerardi, Vitman), and western wheatgrass (Agropyron smithii, Rydb.) (Fig. 2).

The most important grasses occurring on the gentle hillsides were buffalo grass, blue grama, side-oats grama, big bluestem, and little bluestem (Andropogon scoparius, Michx.) (Fig. 3). The steep hillsides included slopes which were significantly steeper than the gentle hillsides. Grasses found on these sites were side-oats grama, big bluestem, and little bluestem (Fig. 4).

The lowland was clothed with a tall-grass complex, located in a broad ravine which received runoff water from the surrounding area. Grasses studied here were big bluestem, western wheatgrass and switchgrass (Panicum virgatum, L.) (Fig. 5).

METHODS OF STUDY

The seasonal rainfall and daily temperatures were obtained from records which were collected at the Cedar Bluff

Figure 2.--View of the upland showing big bluestem (upper left), western wheatgrass (upper right), and short grasses (foreground).

Figure 3.--View of a gentle hillside showing side-oats grama, big bluestem (light color) and short grasses (dark).

Figure 4.--View of steep hillside showing little bluestem (dark bunches) and big bluestem. Note how little bluestem is most common near the rim line at top of hillside.

Figure 5.--View of lowland showing the cover of big bluestem (dark foreground) and switchgrass (light center).

weather station. The mean temperature for each month was computed and compared with the average mean for that period.

The principal limiting factor in the growth of vegetation in the Great Plains area is the frequent deficiency of soil moisture (Weaver and Albertson, 1944). Total amount of soil moisture was determined every two weeks to a depth of four feet by the use of a geotome. Samples were taken in duplicate and an average percent moisture for the two samples was recorded for each depth.

Fifteen or more randomly located square-foot quadrats, similar to those described by Voigt and Weaver (1951), were used to determine yield and basal cover of each species of grass occurring on the four sites (Fig. 6). New quadrats were selected for determining yields the second season.

To determine monthly and seasonal yields during the growing seasons, vegetation on each quadrat was clipped at the top of underlying mulch on the 15th day of each month (except when no growth occurred) from June to September inclusive. The clipped forage was air dried, weighed and converted to pounds per acre.

Average percent basal cover for each species was determined from many individual measurements. These included the clipped square-foot quadrats and fifty or more random samples.

Growth increment was determined at each clipping period.

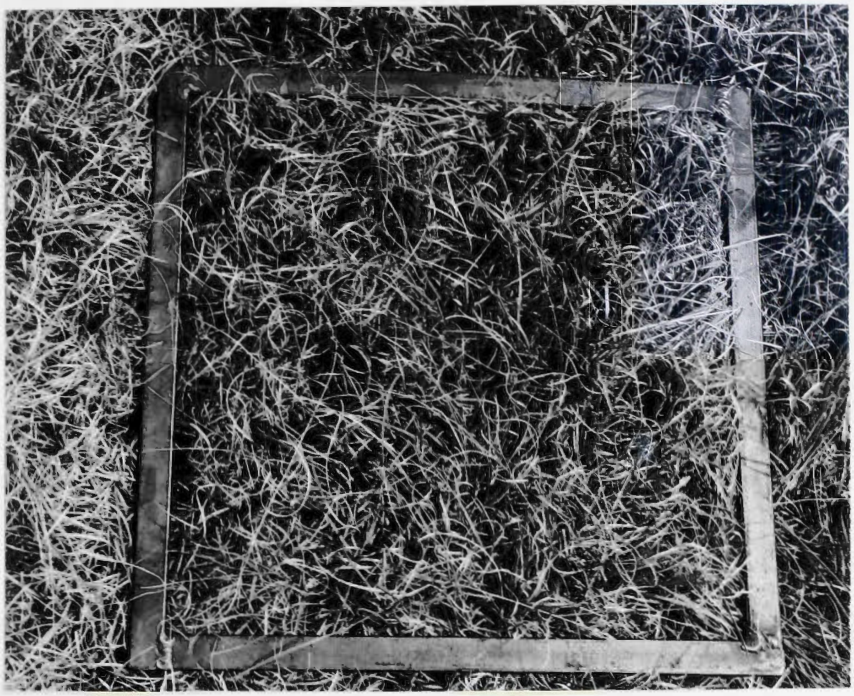

Figure 6.--A typical square-foot quadrat used to determine yield and basal cover.

The height of new growth was measured prior to clipping and measurements were also taken on unclipped growth outside of the clipped quadrats.

ENVIRONMENTAL FACTORS

Climate for the two seasons was characterized by low, uneven distribution of rainfall, deficiency of soil moisture and accompanying high temperatures and wind velocity.

Total precipitation during the 1952 growing season (April-September) was 11.27 inches, nearly 5.84 inches below average and 19.35 inches below that for the preceding period in 1951 (Table I). For the 1953 growing season, it was 10.9 inches or 6.2 inches below average. More than one-half of the total precipitation for 1952 fell before the first clipping date (June 15) while less than one-third of the 1952 moisture was received during the same period.

Above average temperatures occurred from June throughout the remaining 1952 growing season and also during June and September of 1953. It is significant that during periods of high temperatures, precipitation was below average, creating a condition not conducive to good growth (Table I).

Good rains were received and moisture was abundant during the early portion of the growing season of 1952 (Table I). Therefore, growth was rapid during the early part of the growing season. Bunch grasses had many new tillers

TABLE I. Rainfall and temperature with deviation from normal during the growing seasons 1952 and 1953*.

	April	May	June	July	August	September
Precipitation (Inches)						
1952	4.00	2.00	0.78	1.90	2.15	0.44
Normal	2.18	3.07	3.82	2.92	2.69	2.43
Deviation	+1.82	-1.07	-3.04	-1.02	-0.54	-1.99
1953	2.43	1.24	1.55	4.06	1.33	0.29
Normal	2.18	3.07	3.82	2.92	2.69	2.43
Deviation	+0.25	-1.83	-2.27	+1.14	-1.36	-2.14
Temperature (Degrees F.)						
1952	50.1	62.1	80.3	79.3	78.8	70.1
Normal Mean	53.0	62.4	72.4	78.7	77.6	69.0
Deviation	-02.9	-00.3	+07.9	+00.6	+01.2	+01.1
1953	48.3	60.6	79.9	78.2	76.2	71.2
Normal Mean	53.0	62.4	72.4	78.7	77.6	69.0
Deviation	-04.7	-01.8	+07.5	-00.5	-01.4	+02.2

*This table prepared from records obtained at Cedar Bluff weather station.

protruding from the old remnants of previous year's growth and the cool season western wheatgrass had made enormous growth by early May. It was 15 inches tall on the upland and nearly 18 inches on the lowland. As the season progressed temperatures climbed above average and precipitation decreased this causing a diminished growth rate of vegetation.

Total moisture in 1952 varied from 9 to 17 percent on the upland as compared with 7 to 21 percent on the lowland (Figs. 7 and 8). Very little difference in amount was found at the various depths on the upland, but on the lowland there was considerably more in the first 6 inches.

There were no rains in the early part of 1953 growing season and very little soil moisture was found in the first two feet from the previous year. Moisture was therefore low in the spring, but mid-summer rains caused a temporary increase in July. Early season growth of most grasses was greatly retarded with the cool season wheatgrass being less than half as tall as it was the preceding season.

Total amount of moisture in 1953 on upland varied from a low of 6 percent to a high of 24.5 percent (Fig. 7) and on lowland from 8.6 to nearly 29 percent (Fig. 8). Generally the greatest amount of moisture was found in the upper 12 inches and least in the lower 2 feet of the samples.

In the latter part of May of both seasons the decrease in soil moisture, due to scanty rainfall, high wind velocities

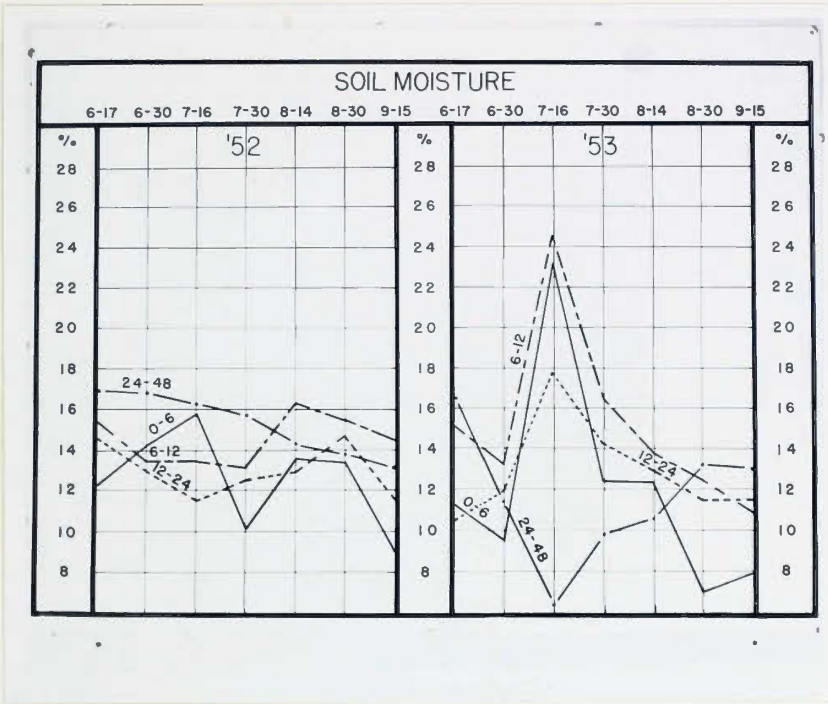

Figure 7.--Average percent soil moisture on upland to depths of 48 inches taken semi-monthly (June 17-September 15 inclusive) for two growing seasons.

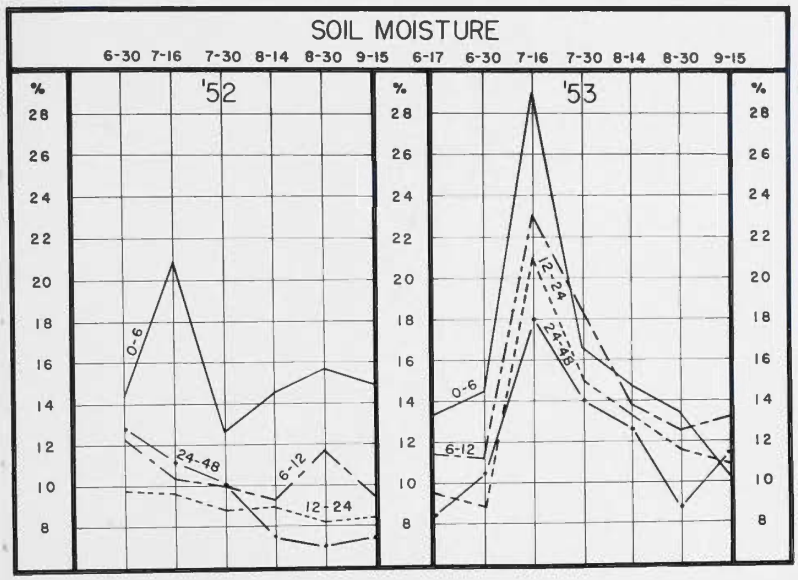

Figure 8.--Average percent soil moisture on lowland to depths of 48 inches taken semi-monthly (June 17-September 15 inclusive) for two growing seasons.

and rising temperatures, caused the vegetation to begin to show effects of drought. The plants growing in less mesic habitats were forced into semi-dormancy. Only grasses in the lowland and more favorable sites continued growth, but at reduced rates. As the season progressed and below average rainfall prevailed, species in the more favorable habitats also began to succumb to the effects of drought, and forage production was greatly reduced. Occasional showers and periods of normal temperatures were sufficient to prolong growth in some grasses for short periods, after which they resumed their semi-dormant characteristics.

RESULTS

Determinations of basal cover, before the first harvest in 1952, and clippings and measurements made the 15th of June to September inclusive during 1952 and 1953 are discussed under upland, gentle hillside, steep hillside, and lowland.

Upland

Yields and Cover: Considerable variation was noted in yields and basal cover for the grasses studied.

The two short grasses, blue grama and buffalo grass, were the dominant grasses of the upland. Buffalo grass produced 1,252 pounds per acre of air dry forage during 1952 and

1,018 pounds in 1953 (Table II). This sod forming grass had a basal cover of 75.4 percent which produced only 16.6 and 13.5 pounds of air dry forage per acre per one percent cover, respectively, for the two growing seasons.

Blue grama produced slightly more forage than its co-dominant each season. In the 1952 growing season 1,336 pounds of forage were harvested and only 1,217 pounds in 1953. Density of growth of this grass was considerably less than that of buffalo grass. Basal cover was only 50.6 percent. The yield was 26.4 pounds of air dry forage per one percent cover in 1952, with only a slight decrease in 1953.

These upland dominants had a greater percentage of their forage harvested after the initial clipping than other grasses of this habitat.

Side-oats grama ranked third in seasonal yields with a production of 1,677 pounds of forage per acre in 1952 but only 1,258 pounds in 1953. Nearly half of the seasonal yields each year was produced prior to the first clipping. The average basal cover (33.8 percent) was much higher than other mid-grasses growing on the habitat. However, the yield per one percent cover was much lower.

Big bluestem, the only tall grass studied on the upland habitat, had a yield each season of nearly 3,600 pounds of forage per acre which was about a ton more than that produced by the dominant short grasses. Big bluestem, however, is only

TABLE II. Monthly yield, seasonal yield, basal cover, and yield per one percent cover for grasses on the upland for 2 seasons.

1952

	Bda*	Bgr	Bcu	Age	Asm
June 15	543.5	707.8	1,009.4	2,293.2	2,096.8
July 15	275.9	205.5	329.7	1,032.4	
August 15	226.6	254.5	210.2	194.9	
September 15	206.8	169.0	127.7	83.5	
Seasonal Yield	1,252.8	1,336.8	1,677.0	3,604.0	2,096.8
Basal Cover	75.4	50.6	33.8	28.0	11.8
Lbs. per 1% Cover	16.6	26.4	49.6	128.7	177.7

1953

	Bda	Bgr	Bcu	Age	Asm
June 15	697.1	562.1	562.2	2,357.9	1,544.0
July 15	208.9	360.4	315.2	816.1	
August 15	202.4	294.9	280.6	610.8	
September 15				8.7	72.3
Seasonal Yield	1,018.4	1,217.4	1,258.0	3,793.5	1,616.3
Basal Cover	75.4	50.6	33.8	28.0	11.8
Lbs. per 1% Cover	13.5	24.2	37.2	135.4	136.9

*Symbols for each grass species are taken from the first letter of each genus and the first two of the species. These symbols occur in all tables used throughout this paper. Bda.--buffalo grass, Bgr.--blue grama, Bcu.--side-oats grama, Age.--big bluestem, Asm.--western wheatgrass, Asc.--little bluestem, Pvi.--switchgrass.

a minor grass on the upland habitat. Nearly a ton of forage was produced each season prior to the initial clipping; however, decrease in yield was rapid thereafter. Average basal cover for this sod-forming tall grass was 28 percent and, it produced 128.7 and 135.4 pounds per acre per one percent cover for the 1952 and 1953 growing seasons, respectively.

Western wheatgrass was second in per acre production with a yield of 2,096 pounds of forage per acre during 1952 and only 1,666 pounds during the 1953 growing season. Nearly all the forage of this cool-season grass was produced prior to the June clipping. This species had a sparse cover (11.8 percent) which yielded 177.7 and 136.9 pounds of forage per acre per one percent cover, during the growing seasons 1952 and 1953, respectively.

Growth Height of Upland Grasses: Considerable variation in total increment of growth was noted; however, every species produced more growth before the June clipping than during any other period and progressively less was recorded at each clipping thereafter. Clipping stimulated growth in some species but inhibited it in others. For example, big bluestem, blue grama, and buffalo grass had more total growth on the clipped areas than on undisturbed areas (Table III).

Buffalo grass, varied from 11.5 to 6.5 inches on the clipped and unclipped quadrats, respectively, during the

1952 growing season, and 9.5 to 6.5 inches for 1953. Blue grama had an increment of 11.5 and 9.5 inches on the clipped and unclipped areas, respectively, in 1952 and 12.7 and 9.0 inches in 1953. Very little difference was noted in the growth height of side-oats grama under these two treatments. Big bluestem was stimulated by clipping as shown by heights of 26.5 and 27.8 inches, respectively, during the 1952 and 1953 growing seasons on the clipped areas, and only 24 and 23 inches on the unclipped areas. Clipping inhibited the growth of western wheatgrass during both seasons. Considerably more difference was found in the 1952 and 1953 heights of wheatgrass than in any of the other species.

TABLE III. Seasonal growth height of grasses in inches on clipped (C) and unclipped (Uc) upland areas for 2 seasons.

Grass	Bda		Bgr		Bcu		[illegible]ge		Asm	
	C	Uc	C	Uc	C	Uc	C	Uc	C	Uc
1952	11.5	6.5	13.5	9.5	17.5	20.0	26.5	24.0	20.5	22.5
1953	9.5	6.5	12.7	9.0	17.8	19.5	27.8	23.0	16.0	20.5

Gentle Hillside

Yields and Cover: The five grasses which were studied on the gentle hillsides showed considerable variation in yield and basal cover.

Yield of buffalo grass was significantly higher than blue grama both seasons. Buffalo grass produced 1,548 pounds during 1952 and 1,231 pounds during 1953. Nearly half the seasonal yield was harvested at the first clipping. Basal cover of buffalo grass was quite dense (65.8 percent) thus resulting in a relatively low yield per one percent cover.

Blue grama had the lowest yield of all species on the hillside habitat. The 1952 seasonal yield was 979 pounds per acre while the 1953 yield was 1,022 pounds (Table IV). Average basal cover was 44 percent which produced a low yield of 22.3 and 23.2 pounds per one percent cover during the two seasons, 1952 and 1953, respectively.

Side-oats grama, a sod-former, produced slightly more than 1,000 pounds of forage per acre for each season. The initial clipping during both seasons accounted for nearly half the total yield. Growing in pure stands side-oats grama formed a basal cover of 23.9 percent and produced 49.6 and 47.2 pounds of forage per one percent cover for 1952 and 1953, respectively.

Big bluestem produced more than a ton of forage per acre during both abnormally dry seasons. More than two-thirds of the 1952 yield was harvested at the initial clipping. However, during 1953 more than half the yield was produced after the June clipping. Average basal cover for big bluestem was 24.4 percent. Nearly 100 pounds of air dry

TABLE IV. Monthly yield, seasonal yield, basal cover and yield per one percent cover for grasses on the gentle hillside.

1952

	Bda	Bgr	Bcu	Age	Asc
June 15	776.9	519.1	767.3	1,629.2	1,623.3
July 15	274.1	168.8	134.3	462.9	362.5
August 15	185.1	116.2	150.1	202.9	242.5
September 15	312.5	175.4	134.4	115.2	177.7
Seasonal Yield	1,548.6	979.5	1,186.1	2,410.2	2,406.0
Basal Cover	65.8	44.0	23.9	24.4	35.7
Lbs. per 1% Cover	23.5	22.3	49.6	98.8	67.4

1953

	Bda	Bgr	Bcu	Age	Asc
June 15	558.7	509.9	583.6	1,129.9	979.5
July 15	452.1	235.6	285.3	671.4	336.0
August 15	200.2	232.6	243.5	415.7	704.7
September 15	20.7	44.6	15.1	61.8	27.6
Seasonal Yield	1,231.7	1,022.7	1,1_7.5	2,278.8	2,047.8
Basal Cover	65.8	44.0	23.9	24.4	35.7
Lbs. per 1% Cover	18.7	23.2	47.2	93.4	57.4

forage was produced per acre per one percent cover each growing season.

Little bluestem yielded somewhat less than big bluestem, averaging slightly more than a ton of forage per acre for each season. More than half of the 1952 yield was produced prior to the first clipping, but in 1953 more than half was harvested after the June clipping. Little bluestem had a higher basal cover (37.7 percent) than did big bluestem, and produced 67.4 and 57.4 pounds of forage per acre for each percent of cover during the two seasons.

Growth Height of Gentle Hillside Grasses: Considerable difference in total growth height was recorded. Generally, growth progressively decreased after the initial clipping. However, some grasses responded to occasional short periods of increased precipitation.

The two short grasses, blue grama and buffalo grass, responded to clipping with increased growths on clipped areas both seasons (Table V). Buffalo grass was stimulated more by clipping than blue grama showing an increase of more than 5 inches on the clipped quadrats during the 1952 growing season. Blue grama had more total growth each season, but less difference was noted between the two treatments.

Side-oats grama had a growth height of 18 and 15 inches on clipped and unclipped areas, respectively, for the

1952 growing season. Slightly less total growth was recorded during 1953, but the same difference occurred between the two treatments.

Big bluestem produced the most growth of all species on the clipped areas. A clipping stimulus was evidenced by the fact that nearly 10 inches more growth was found on the clipped areas than was recorded on the undisturbed areas during 1953. Growth of little bluestem was apparently inhibited by clipping since nearly 2 inches less growth occurred on the clipped areas than on the undisturbed areas both seasons.

TABLE V. Seasonal growth increment of grasses in inches on clipped (C) and unclipped (Uc) gentle hillside areas for 2 seasons.

Grass	Bda		Bgr		Bcu		Age		Asc	
	C	Uc	C	Uc	C	Uc	C	Uc	C	Uc
1952	12.7	7.0	13.0	9.0	18.0	15.0	27.0	22.5	25.0	27.0
1953	9.2	6.5	11.6	8.5	17.5	14.5	27.2	17.0	21.3	23.7

Steep Hillside

Yields and Cover: Three species of grass were studied on the steep slopes. There was significant variation in yield and cover among these grasses.

Side-oats grama, a xeric, sod-forming grass, produced

1,440 pounds of forage per acre during 1952 and a much lower yield of 782 pounds during 1953 (Table VI). More than half of the seasonal yields was produced prior to the initial clipping. This sod-former had a sparse cover of only 16.9 percent which yielded 85.2 and 46.3 pounds per acre per one percent cover for the 1952 and 1953 growing seasons, respectively.

Big bluestem was the highest yielder for both seasons. 3,852 pounds of forage were produced in 1952; however, only 2,534 pounds were produced during the 1953 growing season. Nearly half of the 1952 and 1953 seasonal yield was produced following the initial clipping. The average basal cover of 26.3 percent was the highest of the three grasses studied on this habitat. For each percent of cover 146.5 and 96.4 pounds of forage per acre was harvested during 1952 and 1953, respectively.

Little bluestem, a bunch-grass ranked second in yield, producing 2,500 and 1,738 pounds per acre for the two growing seasons, respectively. The monthly yield of this species was higher than other grasses during the droughty months late in the growing seasons. Basal cover of little bluestem also ranked second (18.2 percent) resulting in 137.3 and 95.5 pounds of forage per one percent cover.

Growth Height of Steep Hillside Grasses: Some clipping stimulation was noted for all species studied on the habitat. Total recorded growth height of big bluestem

TABLE VI. Monthly yield, seasonal yield, basal cover, and yield per acre per one percent cover on the steep hillside.

1952

	Bcu	Age	Asc
June 15	912.3	1,816.6	1,436.3
July 15	273.2	1,491.9	625.3
August 15	122.2	382.4	266.7
September 15	132.7	161.5	174.9
Seasonal Yield	1,440.4	3,852.5	2,503.2
Basal Cover	16.9	26.3	18.2
Lbs. per 1% Cover	85.2	146.5	137.5

1953

	Bcu	Age	Asc
June 15	491.2	1,157.2	738.5
July 15	200.7	539.2	361.5
August 15	90.7	828.0	599.4
September 15			39.4
Seasonal Yield	782.6	2,534.4	1,738.8
Basal Cover	16.9	26.4	18.2
Lbs. per 1% Cover	46.3	96.4	95.5

was 25.5 and 23.5 inches on the clipped and unclipped areas, respectively, in 1952 and nearly 6 inches more growth was produced on the clipped areas during 1953 (Table VII). Little bluestem grew 24 and 22.5 inches on the clipped and undisturbed areas, respectively, in 1952. Considerably more growth was also recorded on the clipped (26.8) than on the unclipped (21.7) areas during the 1953 growing season. Side-oats grama had a growth height of 17 and 16 inches on the clipped and unclipped areas, respectively, during 1952. The 1953 growing season had less total growth but there was slightly more variation between the two treatments.

TABLE VII. Seasonal growth increment of grasses in inches on clipped (C) and unclipped (Uc) steep hillside areas for 2 seasons.

Grass	Age		Bcu		Asc	
	C	Uc	C	Uc	C	Uc
1952	25.5	23.5	17.0	16.0	24.0	22.5
1953	25.8	20.5	15.8	14.0	26.8	21.7

Lowland

Yields and Cover: The highest yielding grass in the lowland was again big bluestem. It produced 6,013 pounds of forage during 1952 but only 3,900 pounds during 1953 (Table VIII). More than half the total yield was harvested prior

TABLE VIII. Monthly yield, seasonal yield, basal cover, and yield per acre per one percent cover for two seasons on the lowland.

1952

	Age	Asm	Pvi
June 15	3,598.4	4,940.8	5,067.3
July 15	1,163.9		645.5
August 15	1,163.9		141.9
September 15	87.4		18.2
Seasonal Yield	6,013.6	4,940.8	5,872.9
Basal Cover	34.7	18.1	34.3
Lbs. per 1% Cover	173.3	272.9	171.2

1953

	Age	Asm	Pvi
June 15	2,090.1	1,913.9	2,636.5
July 15	850.6		513.8
August 15	837.7		664.5
September 15	123.4	72.0	144.0
Seasonal Yield	3,901.8	1,985.9	3,978.8
Basal Cover	34.7	18.1	34.3
Lbs. per 1% Cover	112.4	109.7	116.0

to the first clipping, but more forage was obtained at later clippings than from other species. This sod-forming grass had a basal cover of 34.7 percent and 173.3 and 112.4 pounds were produced for each percent of cover during 1952 and 1953 growing seasons, respectively.

Western wheatgrass had the lightest yield of the three species. Nearly 4,940 pounds were harvested in 1952, but slightly less than a ton was produced in 1953. Western wheatgrass had a sparse cover 18.1 percent, which produced the amazing yield of 272.9 pounds per one percent cover in 1952 and 109.7 pounds in 1953.

Switchgrass ranked second in yield with a production of 5,872 and nearly 4,000 pounds per acre for the two seasons 1952 and 1953, respectively. The initial clipping produced nearly 2.5 tons of forage in 1952, while more than half the 1953 yield was collected by this early date. The basal cover for switchgrass (34.3 percent) was nearly the same as it was for big bluestem. The yield per one percent cover was 171.2 and 116.0 pounds per acre for the two growing seasons, respectively.

Growth Height of Lowland Grasses: Three species of grass were studied on the lowland, two warm-season species and the other cool-season. It is very evident the warm-season grasses accumulated more growth than the cool-season western wheatgrass. The largest amount of growth was found

prior to the first clipping (Table IX).

Big bluestem grew 34.5 inches on the clipped areas and 31 inches on the undisturbed areas in 1952. Growth during 1953 was 7 inches more on the clipped areas than on the unclipped areas.

Clipping inhibited growth of western wheatgrass. There were 21.5 inches recorded on the clipped areas while 25 inches were measured on the undisturbed areas during the 1952 growing season. The clipped quadrats in 1953 had a growth of 16.4 inches and the undisturbed areas 22.5 inches.

The clipping stimulation on the growth of switchgrass amounted to 4.5 inches in 1952 and 6.7 inches in 1953.

TABLE IX. Seasonal growth increment of grass in inches on clipped (C) and unclipped (Uc) lowland areas for 2 seasons.

Grass	Age		Asm		Pvi	
	C	Uc	C	Uc	C	Uc
1952	34.5	31.0	21.5	25.0	44.5	40.0
1953	36.0	29.0	16.4	22.5	46.2	39.5

DISCUSSION

The two growing seasons during which the study was conducted were abnormally dry, each receiving about 11 inches of rainfall. Other climatic conditions which aided in making conditions unfavorable for plant growth were high temperatures

and frequent winds. However, sporadic rainfall followed by cool temperatures, provided favorable growing conditions for brief periods (Table I). Yields given in this paper could not be taken as representative of production during a normal year but rather of seasons drier than usual.

Growing conditions of the clipped areas seemed to be adversely affected by removal of the clipped forage and the consequent disappearance of mulch by decomposition and erosion. Loss of forage and mulch increases soil temperature and surface evaporation, thus fostering a condition unfavorable to plant growth.

The principle limiting factor in the growth of vegetation in a mixed prairie is the amount of available soil moisture (Weaver and Albertson, 1944). Shively and Weaver (1939) in their investigations of the plains region observed that yields decreased directly in proportion to available water content of the soil. Soil water is lost primarily by transpiration from leaves of growing plants and by evaporation from soil surface.

Production of native grasses usually reached a peak in late spring or early summer and then declined during the typical summer droughts. During the latter part of both seasons, except for sporadic greening, most of the grasses were in semi-dormancy with their leaves either rolled or folded. Costello and Turner (1944) reported that with ample supply of

moisture in the latter part of the growing season short grasses will continue growth. Other grasses may respond in the same manner.

Monthly yields generally followed trends of soil moisture. During the early portion of the growing season (April-June) soil moisture was relatively ample for growth and most all grasses produced the major portion of their forage before the initial clipping. As the season progressed and rainfall diminished, monthly yields decreased significantly (Fig. 9). Some grasses responded to late summer rain more rapidly than others. These species usually produced their yields in the month which the rains fell while slower responding grasses tended to produce yields in the succeeding month. The delayed response of some species to heavy rains is shown in the August 1953 yield which was heavy as a result of July rains. The more mesic condition of the lowland provided for more continuous growth of the species found there in comparison to the same species on more xeric habitats.

Yields for nearly all grasses were highest during 1952 (Fig. 9). Big bluestem studied on all four habitats was the highest producer except on the lowland where it was second to switchgrass in 1953. Yields of the two short grasses did not vary significantly on the upland. On the hillside, however, buffalo grass produced the greatest amount of forage. Yield of side-oats grama was ascertained on the upland,

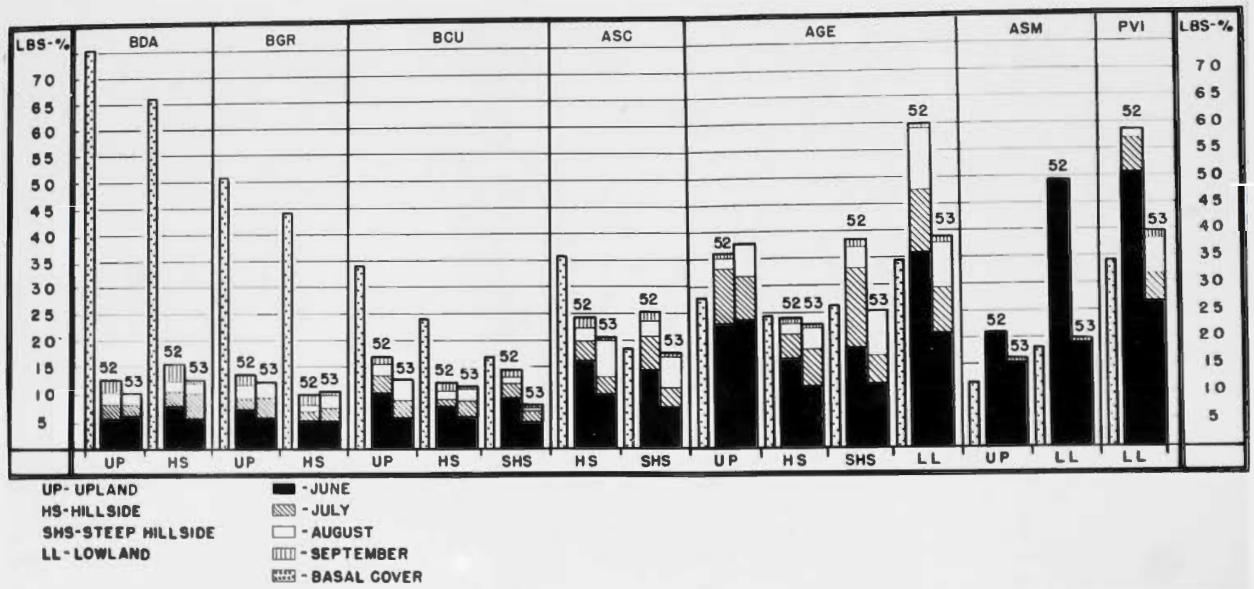

Figure 9.--Forage yields in hundreds of pounds per acre and percent basal cover for each species on its respective habitats.

Symbols for each grass species are taken from the first letter of each genus and the first two of the species name. Bda--Buffalo grass, Bgr--Blue grama, Bcu--Side-oats grama, Asc--Little bluestem, Age--Big bluestem, Asm--Western wheatgrass, and Pvi--Switchgrass.

gentle hillside, and steep hillside and production of this xeric midgrass was not significantly greater than that of the short grasses. On the gentle hillside it produced even less forage than buffalo grass. The cool-season western wheatgrass produced significantly more forage on the lowland than on the upland each season. It was second highest producer on the upland and third on the lowland habitat. Nearly all of its forage was harvested prior to the first clipping. No significant variation was found in yield of little bluestem on gentle hillside and steep hillside during the first season but the yields of the second season varied considerably. Switchgrass was the second highest forage producer, but was found in abundance only on lowlands and ravines.

Several reasons may be advanced for variation in growth and yield of these species growing on different habitats (Fig. 9). Some areas are more mesic than others due to the edaphic conditions of the habitats. Albertson (1937) found that run-off water percolated more rapidly into porous soils of the rocky hillsides than on other areas. Density of growth may also have contributed to the variation in yield. On areas where the mulch accumulated year after year the basal cover decreased significantly which may lower the yield. Weaver and Rowland (1952) have reported that excessive mulch greatly retards yield of prairie species by delaying the time of starting spring growth. It also has been recognized

that more moisture enters the soil on which it falls and evaporation is retarded if the ground has a dense cover and sufficient debris and mulch to absorb the water and retard run-off. A good soil mulch occurred on all habitats, especially tall grass areas. On the tall grass lowland, where considerable mulch had accumulated, the surface soil had significantly more moisture than areas of short grass (Fig. 7 and 8). By assuming that different species inhabit soils on which they are best adapted, the species present may be used as an indicator of varying soil conditions. It may then be stated that grasses are limited in production by the edaphic conditions of their habitat.

Grasses of the clipped areas appeared more succulent than the nonclipped grasses during periods of summer drought. Long leaves of the unclipped grasses died back from the tips to a greater extent than was observed on the clipped areas. This is in agreement with the work of Albertson et al (1953).

Comparative study of the seasonal yield and the seasonal height of growth showed only general correlations between the two factors. During early part of the growing season many new tillers were formed which increased the yield, but may have reduced the average height. In the latter part of the clipping period the number of tillers decreased which would have the reverse effect on the two factors. During the period of seed production many of the sparsely distributed

tillers formed flower heads which would tend to raise height of increment in relation to the amount of yield. This was particularly true of switchgrass, side-oats grama, and little bluestem. The 2 short grasses flowered much earlier and often buffalo grass burs increased the monthly yield. The greatest portion of the growth as well as the major portion of the yield in most all grasses occurred before the initial clipping. Generally height of growth and yield were greatest when soil moisture was plentiful and decreased as the soil moisture became deficient.

The tall grasses, while occupying much less surface area than the short grasses, produced larger amounts of forage due to their greater height and coarser growth. The short foliage of the short grass permits more light to penetrate, thus permitting a denser growth at the ground surface. The growth of the taller grasses shade the soil and the number of tillers produced is somewhat reduced.

Growth habits of the species on various areas influenced the amount of forage received at each clipping. It was observed that basal cover of buffalo grass decreased nearly 10 percent from the upland to the hillside where it produced the greater yield (Fig. 9). Generally the amount of forage produced by each species increased with an increase in basal cover. The number of tillers produced after each clipping greatly influenced the amount of forage produced

per acre. It was observed on the more xeric areas that many tillers either became dormant or died during the latter part of the growing season, leaving the remaining tillers more sparsely distributed and resulted in a lower yield.

Forage yields per unit of area were quite varied among the grasses. Sparsely populated sod-forming grasses such as western wheatgrass, big bluestem and switchgrass produced significantly greater yields per unit of area than the dense low growing short grasses. However, short grasses normally have a basal ground cover of 40 to 90 percent while midgrasses seldom exceed 35 percent.

Total yield is only one of the factors which should be used in evaluating a given grass species. Probably the most important factors next to those of adaptation and total yield are those of quality and palatability of grasses as forage.

SUMMARY

A field study was made to determine the average monthly and seasonal yields of seven native grasses as they grew and produced in pure stands in an ungrazed prairie. The study was conducted for two growing seasons (1952-1953) on the upland, gentle hillside, steep hillside, and lowland on a prairie near Hays, Kansas. The study area was an ungrazed range with gentle rolling hills and steep hillsides broadening at their bases forming ravines and a broad lowland.

Grasses which were studied on the upland were blue grama (Bouteloua gracilis (H.B.K.) Lab.), buffalo grass (Buchloe dactyloides (Nutt.) Engelm.), side-oats grama (Bouteloua curtipendula (Michx.) Torr.), big bluestem (Andropogon gerardi, Vitman, and western wheatgrass (Agropyron smithii, Rydb.).

On the gentle hillside, yields were ascertained for buffalo grass, blue grama, side-oats grama, big bluestem, and little bluestem (Andropogon scoparius, Michx.). Grasses on the steep hillsides from which yields were taken were side-oats grama, big bluestem, and little bluestem.

The fourth area studied was the lowland which was clothed with tall grasses, big bluestem and switchgrass (Panicum virgatum L.). Yield was also taken from western wheatgrass which occupied the disturbed places on this site.

Fifteen or more randomly located square-foot quadrats were used to determine the yield of each species of grass occurring on the four habitats. These quadrats were clipped when growth occurred near the fifteenth day of each month throughout each growing season (June-September inclusive). Clipped forage was air dried, weighed, and computed to pounds per acre.

The average basal cover for each species was determined from many individual measurements. These included readings of the clipped square-foot quadrats besides fifty

or more random samples.

Height of growth was determined at each clipping period. Measurements were made of new growth prior to clipping the quadrats and also of unclipped growth outside the quadrats.

The total amount of soil moisture was determined with a geotome every two weeks to a depth of four feet on the upland and lowland. Samples were taken in duplicate and an average percent moisture for the two samples was recorded for each depth.

Climate for the two seasons was characterized by low, uneven distribution of rainfall, deficiency of soil moisture and accompanying high temperatures and wind velocity. The two growing seasons were abnormally dry with each receiving about 11 inches of rainfall.

Production of native grasses usually reached a peak in late spring or early summer and then declined during the latter part of the growing season. Generally more forage was produced at the initial clipping when monthly rate of growth was at its maximum. Height of growth and yield were greatest when soil moisture was plentiful and decreased as the soil moisture became deficient. During the latter part of both seasons, except for sporadic greening, most grasses were in semi-dormancy with their leaves either rolled or folded. It was observed that more continuous growth occurred on the mesic lowland than on the other, more xeric habitats.

Generally the amount of forage produced was greatest from species which occupy the mesic areas and lowest from those of more xeric areas.

On the upland habitat only slightly more than 1,000 pounds per acre of air dry forage was harvested from buffalo grass each season. On the hillside, however, considerable more forage was produced than on the upland, but buffalo grass is only a minor species on this habitat.

Blue grama produced nearly 1,300 pounds of forage per acre on the upland which was slightly more than its co-dominant, buffalo grass. On the hillside the amount of air dry forage produced was nearly 1,000 pounds per acre for each season.

Production of side-oats grama was not significantly greater than the yields of short grasses. Yields varied from 800 pounds per acre on the steep hillside to nearly 1,700 pounds on the upland. Side-oats grama, however, is not an important grass on the upland, but is most abundant on the hillsides.

Forage produced by little bluestem did not vary significantly between the two habitats. On the steep hillside 2500 pounds of air dried forage was produced in 1952 and only 1700 pounds per acre was harvested in 1953. Amount of forage produced on the gentle hillside, where greater density of growth occurred, was slightly more than 2,000 pounds per

acre per season.

Yields of big bluestem were harvested on each habitat studied. The greatest amount of forage (6,000 pounds) was produced on the lowland and the lowest yield (2,300 pounds) per acre was harvested on the gentle hillside. Although big bluestem was not an important species on the upland, the small islands of this grass that did occur produced nearly 3,600 pounds of forage per acre each season. On the steep hillside forage production varied from 3,800 pounds per acre in 1952 to 2,500 pounds harvested in 1953.

Yield of western wheatgrass was harvested on the upland and lowland. On the upland it occupied the mesic swails and produced 2,096 pounds per acre in 1952 but only 1,600 pounds in 1953. On the lowland, western wheatgrass occupied the areas which had been disturbed and produced nearly 6,000 pounds of forage per acre in 1952 but less than 4,000 pounds was harvested in 1953. Nearly all the forage produced by this cool-season grass was harvested at the initial clipping.

Switchgrass was abundant only on the lowland and ravines. Amount of forage produced was not greatly different from that produced by its associate, big bluestem. Almost 5,900 pounds of forage per acre was harvested in 1952, and nearly 4,000 pounds during the 1953 growing season. Switchgrass produced a greater portion of its yield prior to the initial clipping than big bluestem.

The tall grasses, while occupying less surface area than the short grasses, produced larger amounts of forage due to their greater height and coarser growth. However, the amount of forage produced by each species generally increased with an increase in basal cover.

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