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184**

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**Effect of Time of
Cutting on Yield
and Botanical
Composition of
Prairie Hay in
Southeastern Nebraska**

**by
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Vincent H. Arthaud**

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SUMMARY

The effects of five cutting treatments on the yield and botanical composition of prairie hay from a native meadow in Gage County, Nebraska, were studied during the eight-year period 1945-1952. The cutting treatments involved early, midseason, and late cutting each year and early and midseason cutting in alternate years during the six-year period 1945-1950. In five of the six years an aftermath crop was harvested in mid-September from the plots cut early that year. All the plots were cut in midsummer in 1951 and 1952 to determine the cumulative effects of the cutting treatments on yield and botanical composition.

The average yields of hay from the midseason and late cuttings were 1.35 and 1.28 tons per acre, respectively, for the six-year period. The average yield from the early cutting was 0.93 ton per acre, but when this was combined with the aftermath crop harvested from the same plots, the total was 1.40 tons per acre. The combined yield of early cutting and aftermath from plots cut early in alternate years averaged 1.53 tons per acre. The midseason harvest from the same plots in the other years averaged 1.26 tons per acre.

The crude protein content of the hays decreased with the later cuttings each year. Variations in ether extract, crude fiber, nitrogen-free extract, and calcium and phosphorus were not consistent. Generally, the chemical composition of the aftermath hay approximated that of the midseason-cut hay of the same year.

Many of the important broadleaved species in the meadow were reduced in vigor and abundance by early cutting. The total forb population decreased 19 per cent under six years of early cutting as compared with increases of 49 and 87 per cent under midseason and late cutting, respectively.

Psoralea floribunda, the most abundant and conspicuous forb in the meadow at the beginning of the study, appeared to be affected by time of cutting more than any other species. A marked reduction in size of the plants was noted in 1947, after only two years of early cutting. In 1951, the average weights per stem following six years of early, midseason, and late cutting were 1.04, 2.72, and 2.90 grams, respectively.

Other important forb species which were reduced in size and abundance by early cutting are *Aster multiflorus*, *Helianthus rigidus*, and *Gaura biennis*. The populations of *Amorpha canescens* in the transects remained relatively constant, but the average weight per stem was reduced 52 and 28 per cent under early and midseason cutting, respectively, as compared with late cutting each year.

The average density of the grass and grass-like vegetation increased approximately 25 per cent during the six-year period 1946-1951. There

were no significant changes in total density due to the cutting treatments. *Poa pratensis* increased markedly under all the cutting treatments. *Sporobolus heterolepis* decreased 60, 34, and 19 per cent under early, midseason, and late cutting, respectively. Important increases in the density of *Andropogon scoparius* occurred under early and mid-season cutting, and of *Bouteloua curtipendula* under early cutting.

Early cutting and the removal of an aftermath crop in mid-September reduced the vigor of the grasses the following spring as compared with midseason cutting. The average yield of hay in 1951 from the 10 plots which were cut twice in 1950 was 1.08 tons per acre as compared with 1.41 tons per acre from the 10 plots cut once in midseason the preceding year. In 1952, following one year of uniform cutting, the average yields were 1.08 and 1.12 tons per acre respectively.

Delaying the time of harvesting the aftermath in fall increased the yield of the grasses the following summer.

Effect of Time of Cutting on Yield and Botanical Composition of Prairie Hay in Southeastern Nebraska

ELVERNE C. CONARD AND VINCENT H. ARTHAUD

APPROXIMATELY three and one-third million acres of native prairie are harvested annually in Nebraska for hay. In the four-year period 1948-1951, the State ranked first in wild hay production with an average yield of more than two and one-quarter million tons per year. This crop is an important natural resource in Nebraska's livestock industry.

Wild hays differ greatly in feeding value. These differences depend primarily on the botanical composition of the vegetation, the soil, stage of maturity at which the hay is cut, and the manner in which it is handled in harvesting. Several studies have shown that prairie hay cut early in the season generally has a higher protein and phosphorus content and a higher total digestible nutrient value than hays cut in midseason or later. The superior feeding value of early-cut hay has been demonstrated through feeding trials with livestock.

Good management of a permanent hay meadow requires the adoption of practices that will give maximum feeding value per acre of hay consistent with the maintenance or improvement of the stand and vigor of the more desirable plants. Deterioration of prairie vegetation due to time of cutting or other management practices may be very gradual. Nevertheless, any practice which decreases the vigor of the important grasses and legumes or causes them to give way to less desirable species will eventually result in lower yields and poorer quality of hay.

Studies were initiated in 1945 to determine the effects of time of cutting on the yield and feeding value of prairie hay in southeastern Nebraska. The yields and results of feeding trials obtained during the first three years of the experiment have been reported (Baker and others, 1951). The studies were continued through the summer of 1952 to determine the effects of different cutting treatments on the vigor and botanical composition of the vegetation. A separate study was initiated in 1948 and continued through 1952 to determine the effect of time of harvesting the aftermath crop in the fall on the yield of hay the following summer.

REVIEW OF LITERATURE

Generally, hay harvested early in the season is more palatable and has a greater feed value than similar hays cut later. In Oklahoma, prairie hay cut during the third week in June had a higher average protein and phosphorus content and a higher total digestible nutrient

(T.D.N.) value than hay cut in July, August or September (Briggs, Gallup and Darlow, 1948). The T.D.N. value of August-cut hay was below that of hays cut in the other months. July-cut prairie hay produced the greatest yield of total digestible nutrients because hay cut in that month had the largest average yield and also had a high feeding value per pound.

Similar results have been obtained in Nebraska (Baker and others, 1951). Prairie hays cut in early July, early August and mid-September were fed alone and with two levels of protein supplement as a wintering ration for growing calves. In general, as the maturity of the grasses increased, the amount of hay consumed by the calves decreased, a larger portion of the hay was refused, and the average daily gains of the calves decreased. These trends were evident whether the hay was fed with or without supplement. The feed required per unit of gain increased as the maturity of the hay increased.

In the Nebraska studies, average hay yields for 1945 to 1947 from early, midseason, and late cutting were 1.03, 1.32, and 1.22 tons per acre, respectively. Nevertheless, more pounds of gain per acre of hay were obtained from early-cut hay than from midseason- or late-cut hays when fed alone or with about $\frac{1}{2}$ pound of protein supplement per head daily. When fed with 1 pound of soybean oil meal or equivalent protein supplement per head daily, the calves receiving the midseason-cut hay made greater average gains than those receiving either of the other hays. In every comparison the late-cut hay produced fewer pounds of gain per acre of hay than either the early-cut or midseason-cut hay, regardless of whether protein supplement was fed. Calves fed the late-cut hay without supplement lost weight in each of the three trials.

Wild meadow hay in Nevada, consisting principally of red clover and wire grass with smaller amounts of timothy and broadleaved plants, was harvested July 10 to 12 and September 10 to 14 (Shipley and Headley, 1948). The early-cut hay contained almost twice as much crude protein and phosphorus as the late-cut hay and slightly less calcium and crude fiber. When fed to yearling steers for a 100-day period, the average daily consumption of early- and late-cut hay was 15.7 and 11.9 pounds, respectively. The steers fed the early-cut hay gained an average of 1.50 pounds per head daily while those fed the late-cut hay lost an average of 0.02 pound daily.

There has been considerable research to determine the effects of different intensities of harvesting on the growth and production of forage plants. Most of the studies have involved clipping several times during the growing season.

When the native prairie vegetation in the Flint Hill Region of Kansas was clipped at two-week intervals for three seasons, the density of the vegetation decreased about 60 per cent (Aldous, 1930). Clipping

at three-week intervals resulted in only a 13 per cent reduction in stand.

Clipping four to six times each season during a three-year period, in prairie near Lincoln, Nebraska, reduced the yields of little bluestem and mixed bluestems 68 and 56 per cent, respectively, as compared with clipping only once each season (Weaver and Hougen, 1939). Generally, quadrats cut at frequent intervals for the first time yielded more than those cut only once that year.

Removal of the herbage of forage species in Utah four or more times in a season resulted in a sharp decline in yield and in a marked reduction in longevity of the vegetation (Sampson and Malmsten, 1926).

Frequent removal of the tops of the prairie grasses usually results in decreased root development as well as decreased forage production. When transplanted sods of several perennial prairie grasses were clipped at 14-day intervals during the growing season, the total dry weight of roots ranged from 2.6 to 20.6 per cent of that of the same species unclipped (Biswell and Weaver, 1933). The dry weight of tops from the clipped plants varied from 13.1 to 47.5 per cent of the dry weight of tops from the unclipped controls. This type of study has been repeated many times with similar results (Weaver and Darland, 1947).

Numerous studies have been reported in the literature which show that frequent clipping is detrimental to the growth and production of forage plants (Graber, 1931; Canfield, 1939; Stoddart, 1946; Carter and Law, 1948; and others). All of these have been designed to determine the effects of clipping to stimulate different degrees of grazing upon the growth and production of the plants. No studies, so far as the writers are aware, have been made to determine the effects on prairie plants of cutting only once or twice each season at different stages of maturity.

EXPERIMENTAL AREA

The meadow where the studies described in this bulletin were conducted is located in southeastern Nebraska near the eastern border of Gage County. It includes approximately 300 acres in the west half of the Dalbey Section, which is a 640-acre tract of virgin prairie. The section was given to the University of Nebraska Foundation in 1943 by Dwight S. Dalbey as a memorial to his wife, Hannah Virginia Lewis Dalbey, and her father, Ford Lewis. The area is representative of much of the native hayland in eastern Nebraska.

The topography is gently rolling, the hills separated by well drained ravines. The soils are relatively deep silty clay and clay loams developed on glacial drift. On the relatively level ridge tops the soil is Carrington silty clay loam. The very dark granular surface layer is 12 to 15 inches thick. The upper subsoil is brown or slightly reddish-

brown, moderately heavy, though fairly friable. On the lower slopes the soil is Burchard silty clay loam. This differs from the Carrington in this area only in the highly calcareous layer at a depth of 36 to 44 inches. Often the two soils merge along the middle to upper slopes. In other places there is a band of Pawnee clay loam between. This soil has a very dark brown or almost black surface layer 8 to 15 inches thick. The upper part of the subsoil is a dark brown to almost black dense clay 10 to 20 inches thick.

The vegetation is typical upland true prairie, consisting principally of tall and midgrasses intermixed with several sedges and rushes and many forb species. It has been undisturbed for the past 40 years or longer except for annual mowing in late summer or early fall for hay. *Andropogon gerardi* Vitman, *A. scoparius* Michx., *Sporobolus heterolepis* (A. Gray) A. Gray, and *Poa pratensis* L. are the most abundant grasses. *Psoralea floribunda* Nutt. and *Amorpha canescens* Pursh. are the most abundant and conspicuous forb species.

CLIMATE

The 60-year average annual precipitation in eastern Gage County is 30 inches, with about 75 per cent falling during the growing season, April through September. The average mean temperature for the 60-year period is 52° F. and varies from 24.7° F. for January to 77.9° F. for July. The summers are characterized by frequent periods when the maximum daily temperature exceeds 90° F. and occasional days with temperatures above 100° F. For the most part, the winters are relatively moderate, although at times the temperature drops well below zero. Usually the soil freezes to a depth of 10 inches or more for at least a part of the winter. In some years the frost may extend to a depth of 36 to 40 inches.

It was not feasible to obtain climatological data at the meadow during the course of this experiment. Accordingly, data on the average monthly and annual precipitation from three nearby stations, with departures from the normal, are presented for the eight-year period 1945 through 1952 (table 1).¹ At Beatrice, 15 miles west northwest of the Dalbey Section, the average annual precipitation is 27.96 inches; at Pawnee City, 19 miles east southeast, it is 31.12 inches; and at Tecumseh, 21 miles northeast, it is 31.04 inches.

The years 1946 and 1948 were relatively dry throughout most of the growing season. During 1947, rainfall was plentiful in April and June but the remainder of the summer was extremely dry and little growth occurred after mid-July. Spring and summer rainfall during 1945, 1949, and 1951 was above normal and growing conditions were favorable for near maximum production. Although the total annual precipitation during 1950 and 1952 exceeded the normal, limited rain-

¹ From Annual Reports of the U. S. Weather Bureau, Lincoln, Nebraska.

TABLE 1.—Monthly and annual precipitation, in inches, with departures from the normal for the years 1945 to 1952, inclusive. Amounts are the averages for three stations: Beatrice, Pawnee City, and Tecumseh, Nebraska, as reported by the United States Weather Bureau at Lincoln, Nebraska.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1945 Precip.	0.55	1.96	1.68	5.10	6.89	4.76	3.59	2.84	4.29	0.19	0.54	1.63	34.02
Depart.	-0.16	0.92	0.21	2.41	2.74	0.16	0.01	-0.79	0.83	-2.06	-0.87	0.71	4.11
1946 Precip.	0.81	0.06	3.38	0.85	2.74	4.00	2.42	2.91	5.47	3.57	2.13	0.10	28.44
Depart.	0.10	-0.98	1.91	-1.85	-1.41	-0.60	-1.16	-0.72	2.02	1.32	0.71	-0.82	-1.48
1947 Precip.	0.43	0.24	1.46	4.67	3.47	9.23	2.20	1.08	1.41	1.34	0.87	2.09	28.49
Depart.	-0.28	-0.80	-0.02	1.98	-0.69	4.63	-1.39	-2.55	-2.05	-0.91	-0.54	1.17	-1.45
1948 Precip.	0.75	2.32	2.88	1.53	1.55	4.58	2.99	3.81	3.49	1.75	2.40	1.58	29.63
Depart.	0.04	1.28	1.40	-1.17	-2.61	-0.11	-0.54	0.24	-0.07	-0.46	1.00	0.65	-0.35
1949 Precip.	3.63	0.64	1.83	1.79	6.10	9.35	4.72	4.57	4.22	1.23	0.13	0.55	38.76
Depart.	2.93	-0.38	0.32	-0.95	1.94	4.66	1.18	1.01	0.66	-0.99	-1.27	-0.38	8.73
1950 Precip.	0.34	1.06	1.02	1.24	7.51	1.93	6.41	6.64	3.04	4.26	0.55	0.06	34.06
Depart.	-0.36	0.04	-0.49	-1.50	3.35	-2.77	2.88	3.08	-0.52	2.04	-0.86	-0.87	4.02
1951 Precip.	0.49	1.76	2.81	3.99	7.03	11.89	6.38	7.25	4.56	1.93	0.75	0.44	49.28
Depart.	-0.22	0.75	1.30	1.25	2.86	7.19	2.85	3.69	1.00	-0.28	-0.65	-0.50	19.24
1952 Precip.	0.38	1.09	3.46	3.91	4.00	3.40	5.40	9.84	1.01	0.00	2.89	1.17	36.55
Depart.	-0.33	0.08	1.94	1.17	-0.16	-1.29	1.87	6.27	-2.55	-2.22	1.49	0.24	6.51

fall during the spring and early summer and high temperatures in June resulted in limited growth of the prairie vegetation.

EXPERIMENTAL METHODS

Plan of the Haying Experiment

Five series of five plots each, totaling approximately 150 acres, were laid out in the meadow. All the plots were 20 rods wide, but they varied from 34 to 54 rods in length. The plots in each series were of the same size and were located so that they were similar in soil, topography, and vegetative composition. The five plots in each series were assigned at random to five cutting treatments as follows:

1. Early cutting each year.
2. Early cutting in alternate years beginning in 1945; midseason cutting in the other years.
3. Midseason cutting each year.
4. Midseason cutting in alternate years beginning in 1945; early cutting in the other years.
5. Late cutting each year.

In five of the six years, 1945-1950, the early cutting was completed during the period July 5 to 12. In 1946, the hay was cut during the last week of June. Midseason cutting was during the period August 4 to 15 every year, and late cutting from September 10 to 15. An aftermath crop was harvested in mid-September from all early-cut plots each year, except in 1947 when the aftermath crop was too short to harvest.

After partial curing in the swath, the hay was raked with a side-delivery rake and the curing completed in the windrow. The hay was baled from the windrow with a pickup baler, loaded onto trucks, and hauled to Lincoln and weighed. Three bales were taken at random from each load and a sample was taken from each for the determination of moisture content. Each sample, consisting of approximately 10 pounds of hay, was put into a cloth sack and weighed immediately. The samples were dried at 220° F. for 72 hours, weighed again, and the original moisture content was calculated.

Chemical analyses of the hays from the different dates of cutting were made each year by the Department of Agricultural Chemistry, University of Nebraska. All the moisture samples from each date of harvest were mixed thoroughly, ground with a small hammermill, mixed again, and an aliquot part was retained for analysis.

All of the plots were harvested at about the same time (July 21 to August 4) in 1951 and 1952 in order to measure the cumulative effects of the different cutting treatments on the yield and botanical composition of the hay. Curing, raking, and baling were handled as in the other years. As soon as the hay on a plot was baled, approximately one fourth of the bales were picked up at random over the plot and weighed individually in the field. The average weight per bale multi-

plied by the total number of bales gave the yield of hay per plot. Samples were taken from five bales from each plot for determining the moisture content of the hay.

All hay yields were calculated in tons per acre at 12 per cent moisture content. These data were subjected to analysis of variance according to the methods given by Snedecor (1946).

Vegetational Studies

Forbs and shrubs. Permanent belt transects (Weaver and Clements, 1938, page 33) were used to study the effects of the different cutting treatments on the forb and shrub species in the meadow. One transect 12 inches wide was located in each plot in the spring of 1946. The transects extended up and down the slopes and across the ridge-tops the full length of the plots. One side of each belt (transect) was permanently marked with a $\frac{3}{4}$ -inch iron pipe stake at each end and small wooden stakes, $1 \times 1\frac{1}{2} \times 10$ inches, at 100-foot intervals along the line. All stakes were driven down flush with the soil surface and their exact location indicated on a map of the plots.

All the broadleaved plants occurring within each 25-foot segment of the transects were counted in June or early July each year, 1946-1949, and in 1951. Because some species tend to branch more profusely than others, individual stems or rosettes were counted at approximately $\frac{1}{2}$ inch above the soil surface.

In order to count the plants in a transect, a 100-foot steel measuring tape was stretched between two of the permanent stakes in the line, and the area was divided into four 25-foot segments by placing wire stakes at the 25-, 50-, and 75-foot points. The wire stakes were so placed that they helped to hold the tape from being pushed out of line while the operator was counting the plants in the transect. The person counting the plants used a 12-inch ruler to measure the width of the belt to determine whether borderline plants were inside or outside the transect area.

The cumulative effects of time of cutting on the vigor (size) of *Amorpha canescens* and *Psoralea floribunda*, the two most important legumes in the meadow, were measured in 1951, following six years of the early-, midseason-, and late-cutting treatments. Each large hay plot was divided into five equal subplots. Two small sampling areas, 12 inches by 20 feet, were located at random in each subplot. Thus there were 10 of the small sample areas in each large hay plot and a total of 50 sample areas in the five hay plots receiving one of the major cutting treatments. All the stems of *Amorpha* and *Psoralea* in each sample area were cut off at the soil surface, counted, dried for 48 hours at 220° F., and weighed. Then the average dry weight per stem was calculated.

Grasses, sedges, and rushes. Permanent meter-square quadrats and "line" transects were used to study the effects of the different cutting

treatments on population changes among the grasses, sedges, and rushes. The line-transect method used was a modification of that described by Parker and Savage (1944).

Twenty-four permanent meter-square quadrats were established in June, 1946, on selected sites judged to be representative of several of the different habitat and vegetative conditions in the meadow. Eight quadrats were located in plots that were cut early each year, eight in plots cut at midseason, and eight in plots cut late each year. Stem counts of all the plants in each quadrat were made in June and early July, 1946, and again in 1952.

The density and botanical composition of the grass and grass-like vegetation following six years of early cutting each year as compared with late cutting annually was determined by the line-transect method in June, 1951. Each large hay plot was divided into four subplots, and four transects were located at random in each quarter-plot. Thus, 80 transects were read in the five plots which had been subjected to each cutting treatment. The transects were 1 centimeter wide by 5 meters long.

Botanical composition of the hay. The botanical composition of the hay on a weight basis was determined in 1951 and 1952 by sorting in the swath immediately after cutting. Each plot was divided into four strata and two samples were taken at random in each stratum. A sample consisted of all the green hay in an area approximately 7 feet wide (one mower cut) by 10 feet long. Hay from each sample was sorted into five components: *Amorpha canescens*, *Psoralea floribunda*, all other legumes, other forbs, and grasses and grass-like species (figure 1). The different components were bagged, dried at 220° F. for 48

FIGURE 1.—Sorting a sample of green hay into five components; i.e., *Amorpha canescens*, *Psoralea floribunda*, other legumes, all other forbs, and grasses and grasslike species. Note that the sorters always work in the direction opposite to that in which the mower traveled in cutting the hay.

hours, weighed, and the percentage composition calculated. It was found that the sorting was not difficult if done immediately after cutting while the plants were still green and turgid. As the plants began to wilt, the leaves curled and separation of the different species became increasingly difficult and time-consuming.

Effect of Time of Cutting the Aftermath on the Vigor and Yield of Prairie Grasses

Results obtained in the first four years, 1945-1948, indicated that the amount of regrowth following early and midseason cutting and the removal of aftermath from the early-cut plots were important factors affecting the vigor of the grasses. Therefore, a separate experiment was initiated in the fall of 1948 to study the effect of date of harvesting the aftermath in the fall on the yield of the grasses the following summer.

Five blocks of six plots each were established in September, 1948, on an area which had been cut in early July that year. Prior to 1948, the area had been harvested in mid-August to early September each year. Two series (12 plots) were located on Pawnee clay loam soil on a west-facing slope and three series on Carrington silty clay loam across a relatively level ridge-top. The plots were 8 x 30 feet in size. An area 34 inches wide by 30 feet long was harvested from the center of each plot to measure yield.

Six treatments, involving three dates of cutting the aftermath with and without a hay mulch left on the ground over winter, were assigned at random to the six plots in each series. The different dates of aftermath harvest were: mid-September; early October, before the first killing frost; and late October, after all the foliage had been frozen.

All plots were harvested in early July each year from 1949 to 1952. The hay from each plot was sorted into two parts: the forbs, and the grasses and grass-like species. These were dried for 48 hours at 220° F., weighed, and the yields calculated in tons per acre at 12 per cent moisture content. No significant differences were obtained between the yields from mulched and non-mulched plots in the first two years. Therefore, the mulching treatments were discontinued in the fall of 1950.

RESULTS

Effect of Time of Cutting on Yield

The yields of hay from the different cutting treatments during the six years, 1945-1950, are presented in table 2. Analyses of the variance of the yields by years are summarized in table 3. The average yields of hay from cutting in early August (midseason) and in mid-September (late) each year were 1.35 and 1.28 tons per acre, respectively, for the six-year period. The average yield from cutting in late June or early July (early) each year was only 0.93 ton per acre. In five of the six

TABLE 2.—Effect of time of cutting on the yield of prairie hay in eastern Gage County, Nebraska, during the period 1945 to 1950.

Cutting treatment	Kind of hay	Yield in tons per acre (12% moisture content)						
		1945	1946	1947	1948	1949	1950	Average
Cut early each year	Early-cut	1.15	0.70	1.15	0.94	0.85	0.82	0.93
	Aftermath	0.46	0.52	0.00*	0.89	0.43	0.51	0.47
	Total	1.61	1.22	1.15	1.83	1.28	1.33	1.40
Cut early in alternate years ¹	Early-cut	1.08	0.85	1.20	0.76	1.23	1.17	1.05
	Aftermath	0.42	0.53	0.00*	0.81	0.49	0.61	0.48
	Total	1.50	1.38	1.20	1.57	1.72	1.78	1.53
Cut midseason each year	Midseason	1.37	1.08	1.51	1.20	1.69	1.23	1.35
Cut midseason in alternate years ²	Midseason	1.49	0.99	1.45	1.36	1.35	0.93	1.26
Cut late each year	Late-cut	1.51	0.95	1.18	1.54	1.31	1.20	1.28

* The aftermath crop in 1947 was too short to harvest.

¹ Cut only once, in midseason, in the other years. Yields are from treatment 2 in 1945, 1947, and 1949, and from treatment 4 in 1946, 1948 and 1950.

² Cut twice, early plus an aftermath harvest, in the other years. Yields are from treatment 4 in 1945, 1947, and 1949, and from treatment 2 in 1946, 1948, and 1950.

TABLE 3.—Analyses of variance of prairie hay yields by years, 1945 to 1950 inclusive.

Source of variation	Degrees of freedom	Mean square					
		1945	1946	1947	1948	1949	1950
For first cutting only							
Total	24	.....	.....	.....	.....	.....	.....
Replications	4	.0080	.0115	.0077	.0024	.0029	.0195*
Treatments	4	.1888**	.1045**	.1417**	.5069**	.4492**	.1647**
Error	16	.0116	.0104	.0042	.0084	.0072	.0050
For total annual yields ¹							
Total	24	.....	.....	.....	.....	.....	.....
Replications	4	.0110	.0194	.0077	.0042	.0016	.0296*
Treatments	4	.0375*	.1549**	.1417**	.2831**	.2324**	.4776**
Error	16	.0120	.0175	.0042	.0129	.0089	.0071

* Indicates an F value which exceeds the .05 level of significance.

** Indicates an F value which exceeds the .01 level of significance.

¹ Aftermath yields were added to yields of early cuttings for total yields in 1945, 1946, 1948, 1949, and 1950. The aftermath was not harvested in 1947.

years, an aftermath crop was harvested from the plots cut early that year. Combined yields of aftermath and early-cut hay averaged 1.40 tons per acre for the six-year period.

The yields of hay fluctuated considerably from year to year and within the seasons, apparently due to fluctuations in weather. In half the years there were marked differences in yield of hay between the early August and mid-September cuttings. Variations in temperature and distribution of rainfall during the growing season appeared to affect the yields more than did total seasonal or annual precipitation. Drought periods of two weeks or more duration during the summer months usually resulted in reduced yields of hay. This reduction was particularly noticeable when the dry periods were accompanied by high temperature. The vegetation rapidly depleted the available moisture supply in the soil. The grasses and forbs wilted, their leaves became dry and brittle, and many were broken off by the wind. Thus, actual losses in yield sometimes occurred. The hay yields from mid-season cutting exceeded those from late cutting in 1947 and 1949. The differences, 0.33 and 0.38 ton per acre, respectively, are significant at the .01 level of probability.

The average yields of aftermath hay from all plots cut early in 1948, 1949, and 1950 were 0.85, 0.46, and 0.56 ton per acre, respectively (table 2). Regrowth following midseason cutting in those years was light to moderate, estimated to be the equivalent of about 0.15 to 0.25 ton of hay per acre. This second growth on the midseason-cut plots was not harvested in any year of the test.

The two cutting treatments involving early and midseason cutting in alternate years (treatments 2 and 4) were the same except that the plots receiving one treatment (treatment 2) were cut early in the odd-numbered years and midseason in the even-numbered years while those receiving the other (treatment 4) were cut in midseason in the odd-numbered years and early in the even-numbered years. These two treatments provided information on the effects of early cutting plus the removal of an aftermath crop as compared with midseason cutting in one year on the yield of hay the following year (table 4).

In 1949, 1950, and 1951, the grasses on the plots which had been cut twice the previous year were noticeably less vigorous than those on the plots which had been cut only once in midseason. Total hay yields from the plots cut early each year (treatment 1) were 0.44, 0.45, and 0.17 ton less per acre, respectively, than the total yields from early cutting of plots which had been harvested in midseason the previous year (treatments 2 and 4). Similarly, midseason yields from plots harvested twice the preceding year were 0.34, 0.30, and 0.19 ton less per acre, respectively, than from plots cut midseason each year (treatment 3). These differences are significant at the .01 level of probability. Similar trends occurred in 1946 and 1947. The five-year mean differ-

TABLE 4.—Comparative hay yields in each of six years, 1946-1951, as affected by midseason versus early cutting and removal of an aftermath crop in the preceding year.

Cutting treatment	Total annual yield in tons per acre (12% moisture content)						
	1946	1947	1948	1949	1950	1951	Average, ¹ 5 years
<i>Total yields from two cuttings (early plus an aftermath)</i>							
Cut early each year ²	1.22	1.15	1.83	1.28	1.33	1.00	1.20
Cut early in alternate years ³	1.38	1.20	1.57	1.72	1.78	1.17	1.45
Difference	0.16	0.05	-0.26	0.44	0.45	0.17	0.25
<i>Yields from a single cutting in midseason</i>							
Cut midseason each year ³	1.08	1.51	1.20	1.69	1.23	1.51	1.40
Cut midseason in alternate years ²	0.99	1.45	1.36	1.35	0.93	1.32	1.21
Difference	0.09	0.06	-0.16	0.34	0.30	0.19	0.19
Least significant difference between cutting treatments:							
at P = .05	.18	.09	.15	.13	.11	.07	.13
at P = .01	.24	.12	.21	.18	.16	.09	.17

¹ Yields for 1948 are omitted from the average because the aftermath was not cut the preceding year.

² Plots cut twice the preceding year; in early July and again in mid-september.

³ Plots cut only once the preceding year; in early August.

ences of 0.25 and 0.19 ton per acre in favor of midseason cutting the preceding year are highly significant (table 4).

The summer of 1947 was very dry with approximately 45 per cent of the normal rainfall during the three months July through September (table 1). Plots cut early that year produced a light aftermath growth which was not harvested. Plots cut at midseason produced very little regrowth. By mid-June, 1948, it was apparent that the grasses on the plots cut early in 1947 were making a more vigorous growth than those on the plots cut in midseason. Average yield differences of 0.26 and 0.16 ton per acre were obtained in early July and early August, respectively, in favor of early cutting as compared with midseason cutting the previous year (table 4).

The results summarized in table 4 indicate that the removal of the aftermath crop in mid-September was an important factor affecting the vigor and yield of the vegetation the following year.

Chemical Analyses of the Hays

The chemical analyses of the hays from the four dates of cutting each year, 1945-1950, are given in table 5. In each of the six years, the crude protein content of the hay decreased as the maturity of the

TABLE 5.—Chemical analyses of the prairie hays harvested 1945-1950.¹

Year	Time of cutting	Crude fat	Crude fiber	Crude protein	Nitrogen-free extract	Ca	P
		<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
1945	Early	1.5	28.5	7.2	44.8	0.39	0.09
	Midseason	1.3	30.9	5.7	44.1	0.47	0.08
	Late	1.3	29.7	4.1	45.6	0.47	0.07
	Aftermath	1.3	28.4	5.3	46.3	0.36	0.08
1946	Early	1.8	27.9	6.5	44.9	0.52	0.07
	Midseason	1.7	28.3	5.5	44.6	0.57	0.08
	Late	1.7	28.2	4.7	45.5	0.53	0.07
	Aftermath	1.2	27.3	5.7	46.5	0.43	0.08
1947	Early	1.2	28.8	6.4	46.4	0.36	0.07
	Midseason	1.3	30.3	5.2	45.1	0.41	0.07
	Late	1.4	30.3	4.0	46.6	0.32	0.05
1948	Early	1.9	28.2	6.5	45.8	0.66	0.06
	Midseason	1.6	28.5	6.2	45.5	0.48	0.07
	Late	1.5	28.4	5.0	45.8	0.45	0.07
	Aftermath	1.4	27.9	6.0	45.2	0.38	0.07
1949	Early	1.8	34.2	6.6	39.5	.....	.....
	Midseason	1.5	29.0	6.2	44.3	.....	.....
	Late	1.3	31.2	5.2	43.5	.....	.....
	Aftermath	1.5	27.2	6.0	46.1	.....	.....
1950	Early	1.8	28.8	6.7	44.6	0.47	0.06
	Midseason	1.7	30.4	6.2	43.3	0.53	0.06
	Late	1.5	32.0	5.5	41.9	0.49	0.05
	Aftermath	1.3	29.6	6.6	43.2	0.37	0.07
Ave.	Early	1.7	29.4	6.7	44.3	0.48	0.07
	Midseason	1.5	29.6	5.8	44.5	0.49	0.07
	Late	1.4	30.0	4.8	44.8	0.45	0.06
	Aftermath	1.3	28.1	5.9	45.5	0.39	0.07

¹ Analyses by Department of Agricultural Chemistry, Nebraska Agricultural Experiment Station; 12 per cent moisture basis.

vegetation increased. The average crude protein content for the six-year period of the early-, midseason-, and late-cut hays was 6.7, 5.8, and 4.8 per cent, respectively. Variations in either extract, crude fiber, nitrogen-free extract, calcium, and phosphorus were not consistent. Generally, the chemical composition of the aftermath hay approximated that of the midseason-cut hay of the same year. The phosphorus content of the hays varied from 0.05 to 0.09 per cent. These amounts are considerably less than the recommended minimum allowances for beef cattle.

Effect of Time of Cutting on the Vegetation

Forbs and Shrubs

The forb and shrub populations in the permanent belt transects were determined each year, 1946-1949 and in 1951. Data for the three principal treatments—early, midseason, and late cutting each year—are given in table 6.

TABLE 6.—Populations of broad-leaved species as affected by time of cutting during the six-year period, 1945-1950. Number of stems per 100 square feet in permanent 12-inch belt transects in June or early July each year, 1946-1949 and 1951.

Species	Time of cutting each year	Number of stems per 100 sq. ft. ¹				
		1946	1947	1948	1949	1951
<i>Amorpha canescens</i>	Early	44.6	34.4	44.2	43.4	37.1
	Midseason	37.0	36.2	41.4	39.9	40.7
	Late	36.0	36.5	36.9	39.8	36.4
<i>Psoralea floribunda</i>	Early	59.5	64.0	51.8	48.0	41.9
	Midseason	58.9	87.1	67.8	52.1	48.7
	Late	58.3	78.7	81.3	67.9	66.2
Miscellaneous legumes ²	Early	7.1	9.9	9.4	9.3	7.3
	Midseason	11.0	16.3	23.5	24.1	26.7
	Late	6.4	10.9	13.6	11.8	18.4
<i>Aster multiflorus</i>	Early	4.7	4.9	6.0	6.9	7.3
	Midseason	7.7	14.3	23.5	38.6	68.5
	Late	11.8	16.8	27.7	32.7	66.0
<i>Helianthus rigidus</i>	Early	9.6	5.9	2.9	1.6	0.2
	Midseason	25.7	11.0	6.6	4.3	3.4
	Late	20.5	9.7	5.7	9.1	45.8
Other forbs	Early	59.1	79.4	43.2	64.4	55.8
	Midseason	47.6	68.9	60.8	67.7	91.8
	Late	37.5	67.0	59.6	58.7	85.6
<i>Rosa arkansana</i>	Early	.....	5.0	5.4	5.2	4.3
	Midseason	.....	4.6	6.0	5.9	6.1
	Late	.....	2.5	2.3	2.2	2.6

¹ Data are the averages of five transects 475 to 650 feet long.

² *Desmodium illinoense* Gray, *Lespedeza capitata* Michx., *Petalostemum* spp.

***Psoralea floribunda*.** *Psoralea* was the most abundant and conspicuous forb in the meadow at the beginning of the experiment. It is a deep-rooted perennial legume with coarse, woody stems and sparse foliage. In full bloom by early July, it generally attains an average height of 22 to 26 inches, nearly twice that of the dominant grasses at that season. The plants mature rapidly. Usually the seed has

ripened and fallen and the leaves have withered by early to mid-August. Soon thereafter the dried stems break away near the crown of the plant and are tumbled about by the wind. In 1945, the first year of this experiment, *Psoralea floribunda* made up 11.3 per cent of the early-cut hay, but only 5.4 per cent of the midseason and 1.6 per cent of the late-cut hays. The presence of this species in any appreciable amount in prairie hay is objectionable because livestock refuse to eat it. However, under the common practice in southeastern Nebraska of harvesting prairie hay in late August or early September, the species has little effect on hay quality because most of the plants are blown out of the meadows before the hay is cut.

The number of stems of *Psoralea floribunda* in the permanent belt transects averaged 58.9 per 100 square feet in 1946 (table 6). Increases of 8, 48, and 35 per cent occurred in 1947 under early, midseason, and late cutting, respectively. These increases were due primarily to new seedlings rather than to an increase in the number of stems per plant. The numbers of stems decreased markedly from 1947 to 1949 under both early and midseason cutting and slight additional losses occurred thereafter (figure 2). Under late cutting, the average number of stems per 100 square feet increased from 78.7 in 1947 to 81.3 in 1948 and then dropped to 67.9 in 1949. In 1951, after six years of early, midseason, and late cutting, the populations were approximately 70, 83, and 113 per cent, respectively, of those present in 1946.

This species appeared to be affected by time of cutting more than any other in the meadow. A marked reduction in vigor (size) was

TABLE 7.—Cumulative effects of early, midseason, and late cutting each year during a six-year period, 1945-1950, on the vigor of *Psoralea floribunda*, July 16-18, 1951.¹

Previous cutting treatment	Average weight per stem ²	
	<i>Psoralea floribunda</i>	<i>Amorpha canescens</i>
	Grams	Grams
Cut early each year	1.04	1.10
Cut midseason each year	2.72	1.66
Cut late each year	2.90	2.32

Analyses of Variance

Source of variation	D.F.	Mean squares	
		<i>Psoralea</i>	<i>Amorpha</i>
Total	14	.....	.....
Replications	4	0.4691	0.1921
Treatments	2	5.2520**	1.8702**
Error	8	0.1380	0.2058

** Indicates an F value which exceeds the .01 level of significance.

¹ Data are the averages of 50 samples (10 samples from each of five plots), each sample consisting of all the plants from an area 1 x 20 feet in size.

² Oven-dry weight.

FIGURE 2.—Changes in the density of *Psoralea floribunda* Nutt. in relation to time of cutting during the five-year period, 1946 to 1951.

noted in 1947 following only two years of early cutting (figure 3). The average height was reduced 19 per cent and the average weight per stem 44 per cent as compared with midseason and late cutting (Baker and others, 1951). The average weight per stem in 1951, following six years of early cutting, was only 36 per cent of that of plants cut late each year (table 7).

***Amorpha canescens*.** Although shrubby under natural growth conditions, this species behaved much as an herbaceous forb under annual mowing. Generally, all growth of the current season was removed when the hay was cut. Any short basal portions of the new branches left attached to the main stems usually died before spring. Hence, new top growth was produced each year from buds on the main stems

FIGURE 3.—Effect of time of cutting on the vigor and density of *Psoralea floribunda*. The plot on the right was cut in early July, 1945, and late June, 1946; the one on the left in mid-September each year. Photographed May 25, 1947.

or primary branches below the point where they were cut off in harvesting the preceding year.

The population of *Amorpha canescens* in the permanent belt transects remained relatively constant throughout the course of the experiment (table 6 and figure 4). No differences in vigor under the different cutting treatments could be seen until 1950. In that year, it was noted that the plants on the plots cut early each year were somewhat smaller in size and five to seven days later in developing flower buds than the plants on the midseason- and late-cut plots. In 1951, following six years of early and midseason cutting each year, the average weight per stem was reduced 52 and 28 per cent, respectively, as compared with late cutting each year (table 7). Plants on the early-cut plots bloomed approximately five days later than on the other plots. No differences in date of bloom could be observed between midseason and late cutting.

Other native legumes. Four species are included in this group; *Desmodium illinoense* Gray, *Lespedeza capitata* Michx., *Petalostemum candidum* (Willd.) Michx., and *P. purpureum* (Vent.) Rydb. These forbs were relatively scarce in most of the meadow, numbering only 8.2 stems per 100 square feet as an average for all the transects in 1946. However, on certain sites, one or more of these species occurred in relative abundance. There was little change in population from year to year under early cutting (table 6 and figure 4). There was a more or less consistent increase in numbers under midseason and late cutting. Most of the increase was due to increases in size of individual plants (number of stems per crown) of the *Petalostemum* species.

FIGURE 4.—Changes in the density of *Amorpha canescens* and other legume species in relation to time of cutting during the five-year period, 1946 to 1951. The other legumes are *Desmodium illinoense*, *Lespedeza capitata*, and *Petalostemum* spp.

Legumes which were found only as occasional plants in the meadow are: *Astragalus crassicaarpus* Nutt., *Baptisia leucophaea* Nutt., *Psoralea argophylla* Pursh., and *Psoralea esculenta* Pursh.

***Aster multiflorus*.** The average population of *Aster multiflorus* Ait. in all the transects in 1946 was 8.1 stems per 100 square feet. The number increased steadily under midseason and late cutting to an average of 67.2 stems per 100 square feet in 1951 (table 6 and figure 5). This population increase amounted to 590 per cent in five years. Under early cutting the population remained relatively constant.

***Helianthus rigidus*.** The populations of *Helianthus rigidus* (Cass.) Desf. in the transects decreased steadily under early and midseason

FIGURE 5.—Changes in the density of *Aster multiflorus* in relation to time of cutting during the five-year period, 1946 to 1951.

cutting each year until the species had almost disappeared by 1951 (table 6 and figure 6). The few remaining plants were short, slender, and scarcely visible among the grasses as compared with the relatively robust plants on the late-cut plots (figure 7). Under late cutting each year the density of this species decreased to an average of 5.7 stems per 100 square feet in 1948, and then increased rapidly. In 1951 the average population in the transects on the late-cut plots was 45.8 stems per 100 square feet, more than twice that in 1946.

Other forbs. The total population of other forbs in the belt transects varied considerably from year to year (table 6). Much of this variation was due to the changes in numbers of biennial species, particularly *Erigeron strigosus* Muhl., *Gaura biennis* L., and *Senecio plattensis* Nutt. Many first-year rosettes of these species occurred in

FIGURE 6.—Changes in the density of *Helianthus rigidus* in relation to time of cutting during the five-year period, 1946 to 1951.

years when conditions in the spring were favorable for germination and seedling establishment. In other years, only an occasional rosette could be found. Likewise, relative survival until the second year varied considerably. There appeared to be no general relationship between cutting treatments and establishment of biennial species except as time of cutting affected seed production. Both first- and second-year plants of *Gaura* were relatively abundant in the meadow in 1945. The second-year plants were in the bud to early bloom stage in early July; in the late bloom stage with a few seeds mature in early August; and mature with the seed shattering in mid-September. This species decreased rapidly in all the plots until only an occasional first-year rosette could be found in 1948 and 1949. Apparently many of the seeds which ripened on the late-cut plots in 1945 and 1946 remained dormant but

FIGURE 7.—*Gaura biennis*, *Helianthus rigidus*, and *Psoralea floribunda* growing vigorously in large numbers on a plot (right) which was cut late each season for six years, 1945 to 1950. Only a few small plants of these species remained after six years of early cutting each season (left). Photographed July 25, 1952.

viable until the very wet spring and summer of 1951. Many rosettes were found on these plots that year which developed into large, vigorous plants in 1952 (figures 7 and 8). Only an occasional plant was found on the other plots.

FIGURE 8.—Looking northwest across a part of the Dalbey meadow, July 25, 1952. Early cutting each season for six years, 1945 to 1950, (foreground) reduced the size and number of forbs as compared with late cutting each year (background).

Many rosettes of *Senecio* were found on certain sites in some years, but very few survived until the second year. A few plants bloomed each spring, but in no year was this species abundant enough to be of any importance.

The number and relative survival of first-year rosettes of *Erigeron* varied considerably from year to year under the various cutting treatments. Large numbers of second-year plants bloomed profusely in June, 1948, on plots cut early each of the three preceding years (Baker and others, 1951). However, in the later years of the experiment, there were no important differences in the abundance of this species under the various cutting treatments.

Forb species of minor importance which appeared to be unaffected, or only slightly so, by the different cutting treatments include: *Achillea millifolium* L., *Artemisia gnaphalodes* Nutt., and *Solidago* spp.

Rosa arkansana. *Rosa arkansana* Porter, although relatively scarce, was distributed rather uniformly over the meadow. Like *Amorpha*, this shrub behaved much as an herbaceous forb under annual mowing. The average population of this species remained practically unchanged in the permanent transects throughout the course of the experiment (table 6).

Grasses, Sedges, and Rushes

PERMANENT QUADRATS. The total plant population increased in all of the quadrats from 1946 to 1952. Average increases of 20, 24, and 27 per cent occurred under early, midseason, and late cutting, respectively (table 8). It is doubtful that the small differences in total populations among the three treatments are significant since the quadrats with the lowest average density in 1946 showed the greatest increase in 1952 and vice versa.

Poa pratensis increased markedly in all the quadrats. The numbers of stems increased 322, 265, and 355 per square meter under early, midseason, and late cutting, respectively. On a percentage basis, the increases under midseason and late cutting are greatly overemphasized because of the small numbers of this species present in those quadrats in 1946.

Sporobolus heterolepis was the only grass of major importance which decreased in density. Over the period of the experiment, early cutting each year was particularly harmful. The numbers of stems decreased 60, 34, and 19 per cent, respectively, under the three cutting treatments.

Significant increases in the population of *Andropogon scoparius* occurred under early and midseason cutting, and of *Bouteloua curtipendula* under early cutting.

Since the permanent quadrats were not distributed at random, the data are not adapted to statistical analysis.

TABLE 8.—Grasses, sedges, and rushes in the permanent meter-square quadrats and changes in plant populations from 1946 to 1952 under three different cutting treatments.

Species ³	Cut early each year ¹			Cut midseason each year ²			Cut late each year ²		
	Number of stems			Number of stems			Number of stems		
	1946	1952	Per cent change	1946	1952	Per cent change	1946	1952	Per cent change
Age, Snu	646	935	45	385	665	73	386	445	21
Ppr	318	650	104	30	295	883	75	430	473
She, Sas	654	260	-60	880	585	-34	769	625	-19
CAR, JUN	244	290	19	351	440	25	296	350	18
Asc	106	235	122	36	150	317	103	115	12
Bcu	36	85	136	33	55	67	29	40	38
Kcr	34	25	-26	74	75	1	38	30	-21
Pvi	5	0	-100	1	0	-100	10	35	250
Ssp	16	5	-69	3	5	67	7	10	43
Esp	25	20	-20	62	20	-68	17	10	-41
PAN	69	75	9	128	170	33	70	180	157
Total	2153	2580	20	1983	2460	24	1782	2270	27

¹ Average of eight quadrats.² Average of seven quadrats.³ Age—*Andropogon gerardi*; Snu—*Sorghastrum nutans*; Ppr—*Poa pratensis*; She—*Sporobolus heterolepis*; Sas—*S. asper*; CAR—*Carex* spp.; JUN—*Juncus* spp.; Asc—*Andropogon scoparius*; Bcu—*Bouteloua curtipendula*; Kcr—*Koeleria cristata*; Pvi—*Panicum virgatum*; Ssp—*Stipa spartea*; Esp—*Eragrostis spectabilis*; PAN—*Panicum* spp.

LINE-TRANSECTS. The basal density and botanical composition of the grass and grass-like vegetation following six years of early cutting and late cutting each year were determined by the line-transect method in June, 1951. The data are summarized in table 9.

The transect data for the four major species or groups; i.e., *Andropogon gerardi*—*Sorghastrum nutans*, *Poa pratensis*, *Sporobolus heterolepis*, and *Carex-Juncus* species, were tested by analysis of variance. The data were transformed according to the method described by Snedecor (1946, page 446) for purposes of analysis. The mean squares shown in table 10 are from the transformed data.

The basal densities of the *Andropogon-Sorghastrum* group, *P. pratensis*, *A. scoparius*, and *Bouteloua curtipendula* were greater in the early-cut plots than in those cut late each year. Conversely, *Sporobolus heterolepis* showed a marked reduction in density and in percentage of the total vegetation under early cutting as compared with late cutting. In general, these results are similar to those obtained in permanent meter-square quadrats.

TABLE 9.—Cumulative effects of early versus late cutting each year for six years on the botanical composition and basal density of the "grass" vegetation as determined by the line-transect method in 1951.¹

Species ²	Cut early each year		Cut late each year	
	Botanical composition	Basal density	Botanical composition	Basal density
	Pct.	Pct.	Pct.	Pct.
Age, Snu	31.30	4.18	25.88	3.59
Ppr	23.49	3.14	18.35	2.54
She	7.54	1.01	17.64	2.45
CAR, JUN	13.74	1.84	22.02	3.05
Asc	8.34	1.11	3.68	0.51
Bcu	5.98	0.80	1.97	0.27
Kcr	2.58	0.35	1.64	0.23
Pvi	0.75	0.10	0.77	0.11
Ssp	0.16	0.02	0.41	0.06
PAN	2.99	0.40	5.10	0.71
Other grasses	3.13	0.42	2.54	0.35
Total	100.00	13.37	100.00	13.87

¹ Data are the averages of 80 line transects five meters long (16 transects distributed at random in each of five replicate plots).

² Age—*Andropogon gerardi*; Snu—*Sorghastrum nutans*; Ppr—*Poa pratensis*; She—*Sporobolus heterolepis*; Sas—*S. asper*; CAR—*Carex* spp.; JUN—*Juncus* spp.; Asc—*Andropogon scoparius*; Bcu—*Bouteloua curtipendula*; Kcr—*Koeleria cristata*; Pvi—*Panicum virgatum*; Ssp—*Stipa spartea*; Esp—*Eragrostis spectabilis*; PAN—*Panicum* spp.

TABLE 10.—Analyses of variance of transformed line-transect data.¹

Source of variance	D.F.	Mean squares			
		Age Snu	Ppr	She	CAR JUN
Total	159				
Replications	4	0.1777	1.0607	0.9694	0.8298
Treatments	1	5.1373*	9.5013**	53.6270**	29.6356**
Error	154	0.7742	1.1034	1.3969	0.4365

* Indicates an F value which exceeds the .05 level of significance.

** Indicates an F value which exceeds the .01 level of significance.

¹ Data transformed for analysis according to the method of Snedecor (1946), page 446.

The transect data show a highly significant decrease in the density of the *Carex* and *Juncus* species under early cutting as compared with late cutting, while only slight differences were found in the quadrats. This discrepancy between the two methods cannot be accounted for.

Cumulative Effects of the Cutting Treatments on Yield in Subsequent Years

All the plots were cut at approximately the same time in 1951 and 1952 to determine the cumulative effects of the different cutting treatments on the vegetation. The harvesting was completed during the two-week period July 20 to August 3 in both years. The yields of hay are given in table 11. The botanical composition of the hay was determined by sorting in the swath as it was cut. Data on composition of hay were secured for all five of the treatments in 1951 and for the three main cutting treatments (early, midseason, and late cutting each year) in 1952. The estimated yields per acre of the various components for the two years, based on percentage composition and total hay yields, are shown in tables 12 and 13, respectively.

In 1951, the average yields of hay following six years of early, midseason, and late cutting each year were 1.00, 1.51 and 1.56 tons per acre, respectively. The lower yield from the early-cut plots was due to lower yields of all the components of the hay (table 12). Of the two

TABLE 11.—Cumulative effects of different cutting treatments during a six-year period, 1945-1950, on the yield of prairie hay when cut uniformly in subsequent years. All plots harvested during the two-week period, July 20-August 3, in 1951 and in 1952.

Previous cutting treatment	Yield per acre ¹	
	1951	1952
	Tons	Tons
1. Cut early (early July) each year ²	1.00	1.07
3. Cut midseason (early August) each year	1.51	1.14
5. Cut late (mid-September) each year	1.56	1.26
2. Cut early in alternate years, 1945, 1947, 1949; midseason in 1946, 1948, 1950	1.32	1.10
4. Cut midseason in alternate years, 1945, 1947, 1949; early in 1946, 1948, 1950	1.17	1.09

Analyses of Variance

Source of variation	D.F.	Mean squares	
		1951	1952
Total	24	.....	.....
Replication	4	0.0506**	0.0187
Treatments	4	0.2788**	0.0297*
Error	16	0.0024	0.0081

* Indicates an F value which exceeds the .05 level of significance.

** Indicates an F value which exceeds the .01 level of significance.

¹ Data are the averages of five replications; calculated on the basis of 12% moisture content.
² An aftermath crop was harvested in mid-September from all plots cut early (early July) that year except in 1947 when the aftermath growth was too short to harvest.

TABLE 12.—Cumulative effects of different cutting treatments during a six-year period, 1945-1950, on the botanical composition of prairie hay in the seventh year. All plots were cut during the two-week period July 20 to August 3, 1951.

Previous cutting treatment	Estimated yield per acre in 1951 (12% moisture) ¹				
	<i>Amorpha canescens</i>	<i>Psoralea floribunda</i>	Other ² legumes	Other forbs	Grasses
	Lbs.	Lbs.	Lbs.	Lbs.	Tons
1. Cut early each year	59	26	10	29	0.93
3. Cut midseason each year	113	88	45	113	1.33
5. Cut late each year	109	113	37	169	1.35
2. Cut early in alternate years beginning in 1945; midseason in other years.	83	65	11	74	1.21
4. Cut midseason in alternate years beginning in 1945; early in other years.	85	78	25	53	1.04

Analyses of Variance

Source of variation	D.F.	Mean squares				
		<i>Amorpha canescens</i>	<i>Psoralea floribunda</i>	Other ² legumes	Other forbs	Grasses
Total	24	.....	.....	.....	.....	.....
Replications	4	934	1857	1070	1854	.0471**
Treatments	4	2405	5141**	1219	15011**	.1651**
Error	16	1480	732	699	1779	.0034

** Indicates an F value which exceeds the .01 level of significance.

¹ Yields based on average data for eight samples from each of five replicate plots receiving the same cutting treatment. Each sample included all the hay from an area approximately 7 by 10 feet, sorted in the swath immediately after it was cut.

² Includes all legumes except *Amorpha* and *Psoralea*.

TABLE 13.—Cumulative effect of different cutting treatments during a six-year period, 1945-1950, on the botanical composition of prairie hay in the second year of uniform cutting; all plots cut July 21 to August 1, 1952.

Previous cutting treatment	Estimated yield per acre in 1952 (12% moisture) ¹					
	<i>Amorpha canescens</i>	<i>Psoralea floribunda</i>	Other ² legumes	<i>Gaura</i>	Other forbs	Grasses
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Tons
Cut early each year	30	14	15	4	53	1.01
Cut midseason each year	82	89	49	6	139	0.96
Cut late each year	97	85	39	90	165	1.02

Analyses of Variance							
Source of variation	D.F.	Mean squares					
		<i>Amorpha canescens</i>	<i>Psoralea floribunda</i>	Other ² legumes	<i>Gaura</i>	Other forbs	Grasses
Total	14	.....					.....
Replications	4	70	2717*	1935	1660	6241	.0146
Treatments	2	6128**	8966**	1527	12100*	17109	.0060
Error	8	359	453	1411	1503	2027	.0104

* Indicates an F value which exceeds the .05 level of significance.

** Indicates an F value which exceeds the .01 level of significance.

¹ Yields based on average data for eight samples from each of five replicate plots receiving the same cutting treatment. Each sample included all the hay from an area approximately 7 by 10 feet, sorted in the swath.

² Includes all legumes except *Amorpha* and *Psoralea*.

treatments involving early and midseason cutting in alternate years, the plots which were cut twice in 1950 (treatment 4: cut early July and mid-September) produced an average of 1.17 tons of hay per acre in 1951 as compared with 1.32 tons from plots which were cut only once in 1950 (treatment 2: cut in early August). This difference of 0.15 ton per acre, which is significant at the .01 level of probability, was due to a difference in productivity of the grasses.

In 1952, the second year of uniform cutting, the average yields of the grass component from the plots which had been subjected to the three principal cutting treatments were practically the same. Plots which had been cut late each year produced an average of 1.26 tons of hay per acre; 0.12 to 0.19 ton per acre more than the average yields from the plots which had been subjected to the other treatments (table 11). These differences are significant at the .05 level of probability and apparently are due to the larger amounts of forbs, particularly *Gaura*

TABLE 14.—Effect of time of cutting the aftermath crop each fall on the yield of prairie grasses the following summer, 1949-1952.

Time of cutting aftermath the preceding fall	Yield of grasses in early July ¹				
	1949	1950	1951	1952	Average
	Tons	Tons	Tons	Tons	Tons
Mid-September	0.96	0.73	0.93	0.60	0.80
Early October	1.12	0.89	1.00	0.81	0.95
Late October	1.27	0.98	1.19	1.01	1.11

Analysis of Variance		
Source of variation	D.F.	Mean square
Total	119	
Replications	4	0.0436
Cutting treatments	2	0.9325**
Error A	8	0.0245
Years	3	0.6348**
Treatments x years	6	0.0201
Error B	36	0.0127
Plots within reps. (samples)	60	0.0052

** Indicates an F value which exceeds the .01 level of significance.

¹ Yields, in tons per acre at 12% moisture, are the averages of ten plots.

TABLE 15.—Chemical analyses of the grass component of aftermath hay cut at three different dates in 1948 and 1951.¹

Year	Date cut	Crude fat	Crude fiber	Crude protein	Nitrogen-free extract	Ca	P
		Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
1948	Sept. 20	1.4	28.7	5.9	44.4	0.36	0.08
	Oct. 4	1.5	27.8	4.9	45.5	0.40	0.08
	Oct. 27	1.4	29.3	3.5	45.3	0.44	0.06
1951	Sept. 15	2.3	27.8	6.4	43.6	0.38	0.18
	Oct. 11	1.9	28.0	5.1	44.8	0.42	0.08
	Oct. 30	2.0	29.1	3.6	44.8	0.40	0.05

¹ Analyses by Department of Agricultural Chemistry, Nebraska Agricultural Experiment Station; 12 per cent moisture basis.

and *Helianthus*, in the hay from the late-cut plots (table 13). Differences among the yields of hay following the various early and mid-season cutting treatments (.01 to .07 ton per acre) are not statistically significant.

Effect of Time of Cutting the Aftermath on the Yield of Prairie Grasses

The yields of grass obtained, as influenced by the time of cutting the aftermath the preceding fall, are shown in table 14. Average yields following the mid-September, early-October, and late-October cutting of the aftermath were 0.80, 0.95, and 1.11 tons per acre, respectively, for the four-year period. In every instance, delaying the time of cutting the aftermath crop in the fall gave highly significant increases in the yields of the prairie grasses the following summer.

The forb yields are not reported. Most of these species made little or no regrowth following early cutting; consequently, they were not greatly affected by time of cutting the aftermath crop.

Chemical analyses of the grass components of the aftermath hay from the three dates of cutting in 1948 and 1951 are shown in table 15. The crude protein content of the grasses decreased rapidly from mid-September to late October in both years. Only minor changes occurred in the relative amounts of the other constituents.

DISCUSSION

The severe drought of 1934-1939 and the years of above normal precipitation which followed brought about many major changes in the composition and structure of the prairie vegetation. These changes have been described by Weaver and Albertson (1939, 1944). There was a general thinning of the stands as certain species disappeared entirely or remained only in small amounts on the more favorable sites. *Andropogon scoparius*, formerly one of the most abundant species on the upland, was reduced to only a few widely scattered plants in many of the prairies in southern Nebraska. *Poa pratensis* and *Sorghastrum nutans* disappeared from many pastures, but small amounts remained in most of the meadows.

Andropogon gerardi and *Sporobolus heterolepis*, though severely reduced in vigor and abundance, remained rather uniformly distributed over large areas of upland as well as on the lower, more favorable sites. With the return of abundant moisture, these grasses increased rapidly by vegetative spread and by seed. Soon they became the dominant species on large areas of upland where *Andropogon scoparius* had formerly been the major grass.

The vegetation on the Dalbey meadow in 1945, when this study was initiated, was very similar to that of many other prairies in southern Nebraska as described by Weaver and Albertson (1944). *Andropogon gerardi* and *Sporobolus heterolepis* were the dominant grasses on most of the meadow. Together they comprised more than

60 per cent of the basal cover. *Andropogon scoparius* was of only minor importance. It made up less than 5 per cent of the total population of grasses and grass-like plants and was found only in limited areas on the upper slopes. Forbs were moderately abundant. When in full bloom, in early July, *Psoralea floribunda* dominated the landscape, but at all other times the dominant life form was that of the grasses.

The total population of the grasses, sedges, and rushes increased approximately 25 per cent from 1946 to 1952. The greatest increases were made by *Poa pratensis* under all cutting treatments and by *Andropogon scoparius* and *Bouteloua curtipendula* under early and midseason cutting. *Sporobolus heterolepis* decreased in density under all cutting treatments, but suffered the greatest loss (60 per cent) under early cutting each year.

The total forb population increased 87 and 49 per cent under late and midseason cutting, respectively, from 1946 to 1951, and decreased 19 per cent under early cutting. The different species varied considerably in their reactions to the different cutting treatments, but the general trend was for the populations to remain fairly constant or to increase under late cutting.

Harvesting in mid-September apparently has little effect on the growth and development of prairie vegetation. Most of the species have completed their annual growth cycle and the removal of their foliage at that time does not greatly affect their growth and reproduction the following spring and summer.

Many of the farmers in southeastern Nebraska harvest their prairie hay during the period from mid-August to early September. This practice fits well into their schedule of farm operations. Some of them contend that the more mature hay is a "stronger feed"; that it has more "substance." Also, they recognize that the *Psoralea* is not a problem under late harvesting because it usually is blown out of the meadows by that time.

The results of this study indicate that the yields of prairie hay in southeastern Nebraska would be as great or greater, on the average, and the quality would be better if the hay were harvested two to four weeks earlier than is generally done. In three of the six years, the largest yields of hay were obtained from the early August cutting; in two of the years, the yields from late cutting exceeded those from midseason; and in one year there was no difference in yield between the two dates. Usually the vegetative growth of most of the important species was completed by early August. Increased yield after that time was due to the production of seed stalks by the grasses and the enlargement of the stems of the various forbs. Both of these factors tend to decrease the quality of the hay. Feeding trials and chemical analyses have shown rather conclusively that September-cut hay is lower in nutritive value than hay cut earlier in the season.

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APPENDIX

Scientific and Common Names of Plants Included in this Study

Grasses and grasslike plants

		Symbol
Andropogon gerardi.....	Big bluestem	Age
Andropogon scoparius.....	Little bluestem	Asc
Bouteloua curtipendula.....	Side-oats grama	Bcu
Carex spp.	Sedges	CAR
Eragrostis spectabilis	Purple lovegrass	Esp
Juncus spp.	Rush	JUN
Koeleria cristata.....	Junegrass	Kcr
Panicum virgatum.....	Switchgrass	Pvi
Panicum spp.	Panic grasses (small).....	PAN
Poa pratensis.....	Kentucky bluegrass	Ppr
Sorghastrum nutans	Indiangrass	Snu
Sporobolus asper.....	Tall dropseed	Sas
Sporobolus heterolepis.....	Prairie dropseed	She
Stipa spartea	Porcupinegrass, Needlegrass.....	Ssp

Legumes

Amorpha canescens.....	Leadplant	Aca
Astragalus crassicaupus.....	Groundplum, Buffalo bean.....	Acr
Baptisia leucophaea.....	False indigo	Ble
Desmodium spp.	Tickclover	DES
Lespedeza capitata.....	Roundhead lespedeza	Lca
Petalostemum candidum.....	White prairieclover	Pca
Petalostemum purpureum.....	Purple prairieclover	Ppu
Psoralea argophylla.....	Silverleaf scurfpea.....	Par
Psoralea esculenta	Indian breadroot	Pes
Psoralea floribunda.....	Many-flowered scurfpea.....	
	Wild alfalfa	Pfl

Other forbs and shrubs

Aster multiflorus	Many-flowered aster	AST
Achillea millifolium.....	Yarrow	ACH
Artemisia spp.	White prairie sage	
	Cudweed sage	ART
Erigeron strigosus.....	Daisy fleabane	ERI
Gaura biennis	Biennial Gaura	GAR
Helianthus rigidus.....	Sunflower	HEL
Rosa arkansana.....	Wild rose	ROS
Senecio plattensis.....	Prairie groundsel	SEN
Solidago spp.	Goldenrod	SOL