Bulletin 260—Technical JULY, 1932

EFFECT OF WEATHERING AND STAGE OF MATURITY

ON THE

PALATABILITY AND NUTRITIVE VALUE OF PRAIRIE HAY

F. W. CHRISTENSEN and T. H. HOPPER

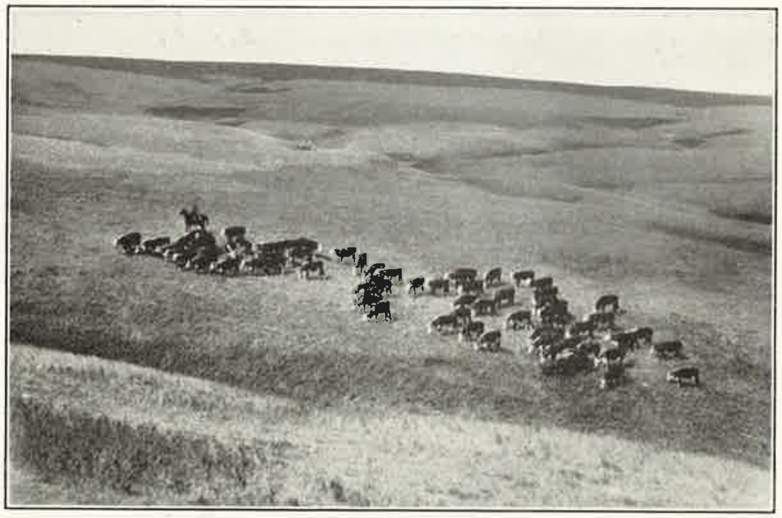

Photo U.S.D.A.
Native grass land, Northern Great Plains Field Station

AGRICULTURAL EXPERIMENT STATION
NORTH DAKOTA AGRICULTURAL COLLEGE
FARGO, NORTH DAKOTA

CONTENTS

Effect of Weathering and Stage of Maturity on the Palatability and Nutritive Value of Prairie Hay

F. W. CHRISTENSEN[1]

T. H. HOPPER[2]

THERE is a general opinion among stockmen in the range region of North Dakota that the matured, dry grasses are more nutritious than the fresh, succulent growth produced earlier in the season. The stockmen believe that cattle put on their best finish while grazing the matured grasses in the fall, and presumably, also make their best gains at that time.

That the matured and dried grasses possess considerable nutritive value is evident from the fact that in years past, vast herds of bison depended on these grasses for food thru the winter season and the further fact, that at present, it is not an uncommon practice for farmers to turn their horses out on the open range to shift for themselves during the winter. Cattle and sheep, likewise, must frequently depend on the range grasses, wholly or in part, for their winter's supply of food. But these facts do not show how the grasses at the height of the growing season, compare in nutritive value with the matured grasses and with the matured grasses after exposure to the weather thruout the winter.

To obtain some information on this point, a series of digestion trials were undertaken to study the effect of stage of maturity, weathering and system of haying upon the palatability and nutritive values of hays made from the grasses.

DESCRIPTION AND SOURCE OF HAYS, AND CLIMATIC NOTES

The hays for the digestion trials were obtained in connection with the Cooperative Grazing Experiment which is conducted by the North Dakota Agricultural Experiment Station and the United States Department of Agriculture at the Northern Great Plains Field Station, Mandan, North Dakota. J. T. Sarvis, Associate Agronomist, and others at the Field Station cooperated in furnishing the different cuttings of hay.

Three lots of hay were obtained in 1920 and two lots in 1923.

The first lot of hay, Trial I, consisted of dried grass grown in 1919 which had been exposed all winter and was cut April 8 and 9, 1920, before the new growth had started.

---

[1]F. W. Christensen, Animal Nutritionist.
[2]T. H. Hopper, Agricultural Chemist*

* The chemical work in Trial I was started by L. T. Anderegg and completed by the junior author. Mr. L. L. Nesbitt assisted in the chemical work of Trials IV and V.

The second lot of hay, Trial II, was cut at the height of the growing season, July 16 and 17, 1920, from two plots containing no old growth from the previous season.

For the third lot, Trial III, the intention was to obtain a hay representing the season's growth of grass at maturity, but, thru a misunderstanding, this hay was cut October 16 from a plot that had not been cut the preceding year, and consequently it contained considerable amounts of old grass residues of the previous year's growth and possibly some residues from earlier years. The amount of old growth in this particular lot of hay is not known but from observations on clipped quadrats, extending over several years, Sarvis[1] estimates that the amount of old growth in the hays from the plots cut biennially generally varies from 30 to 45 percent of the total weight, depending on the season.

The season of 1919 was uniformly dry.[1] The total precipitation for the year was 13.48 inches or 3.69 inches below the 45-year mean of 17.17 inches. The plant growth was light and dried up in July. The grasses were revived somewhat by rains in August but dried up later in the month with practically no growth in September. A snow early in October which melted largely in November, was followed by a rather long winter. A heavy snow and blizzard occurred in the middle of March which may have caused some

Photo U.S.D.A.

Figure 1. VIEW OF MOWING EXPERIMENT
Northern Great Plains Field Station, Mandan, at time of cutting 1925. Units cut every year on right; units cut every other year on left.

[1]The notes on the climatic and vegetative conditions are gathered from the annual reports of J. T. Sarvis on the Cooperative Experiments.

leaching when the snow thawed. On the whole it appears that this grass had not been subjected to severe weathering altho it had been exposed all winter.

The 45-year mean frost-free period at Mandan up to 1920 was 127 days, but in that year the frost-free period was 155 days, which exceeded all previous records for that region. The season of 1920 was again uniformly dry with a shortage of 3.52 inches of rain during April, May and June as compared to the 45-year average. The growth was light and began drying up the latter part of June. By August the prairie was brown and practically no growth occurred after August first.

It is a rather common practice in some parts of the state to cut the grass lands for hay only on alternate years, because it is a common belief that larger yields of hay are obtained by this method than where the grass is cut annually. When cut every year the grass is frequently too short to gather up satisfactorily with the ordinary rakes. It was thought worth while, therefore, to obtain some data on the digestibility of the hays and the digestible nutrients produced per acre under the two systems. Accordingly, arrangements were made with Sarvis for two additional lots of hay cut under comparable conditions from the plots of the mowing experiment started in 1919. One of these, here designated as the "biennial cutting" was cut from a plot that had been cut on alternate years only and, therefore, contained the remaining growth of the previous year and the other, here designated as the "annual cutting", was from a plot cut annually, thus consisting only of the current season's growth. Both hays were cut August 20, 1923.

The summer of 1922 was uniformly warm and the plant growth, tho not heavy, was somewhat better than the growth of the two or three preceding seasons. The growth in August was very light.

The frost-free period from April 25 to September 24 was 165 days compared to the 10-year average of 134 days at the station and the 45-year average of 128 days for this section.

The precipitation for the year (1922) was 17.35 inches. This was slightly above the 45-year average of 17.17 inches. Of the total rainfall 1½ inches fell in November after the growing season.

The hay in the 1-year units was much better than in the 2-year units. It contained less of the coarse weeds of which the commonest was the green sage. The uncut 2-year units of 1922 furnished the "biennial" cutting of 1923.

Measurements of the height of individual plants of the green sage (*Artemisia dracunculoides*) in 10 quadrats in both the 1-year and 2-year units gave average heights of 369 millimeters for the 1-year units and 475.5 millimeters for the 2-year units. This is a good index of the growth of this plant in the two units.

The winter of 1922-23 was cold, the minimum temperatures for January and February being below the average minimum for this area. A moderate amount of snow fell. The total precipitation for the year was 14.41 inches, compared to the 49-year average of 16.98 inches and 17.35 inches in 1922. The rains during April and May were not sufficient to give the grass a good start but growth started at about the usual time. The frost-free period was 133 days, compared to the 49-year average of 130 days.

In the mowing experiment, the average yield per acre of air dried hay was 660 pounds for the 2-year units and 247 pounds for the 1-year units; a difference of 2.67 to 1 this year compared to the usual difference of 2 to 1. This difference is no doubt due to the good growth in 1922 compared to the smaller growth in 1923.

The weeds were coarser in the 2-year units than in the 1-year units. Measurements on the green sage (*Artemisia dracunculoides*) in 10 quadrats in the two units gave the following results:

	Number of plants	Height mm.	Diameter mm.	Number of stalks
2-year units	4.7	326.5	42.7	7.0
1-year units	4.5	187.4	19.7	3.8

NOTE:—Plants less than 100 mm. high were not considered.

It will be observed that the growth was much greater on the 2-year units. The hay from the 2-year units contained more dust and dirt and apparently about one-third was old growth.

A record of the rainfal during the growing season for the years 1920 to 1923 is given in Table 1.

All the hays were cut under favorable weather conditions, packed into wool sacks and shipped to the Experiment Station at Fargo where the digestion trials were made.

TABLE 1. RAINFALL AT THE NORTHERN GREAT PLAINS FIELD STATION AND AT PASTURES DURING THE GROWING SEASON. (INCHES)

	1920		1921		1922		1923	
	Pasture	Station	Pasture	Station	Pasture	Station	Pasture	Station
May	(a)	......	3.29(b)	3.05	2.08	2.05	1.47	1.18
June	1.90	1.85	0.72	0.82	2.80	3.43	2.37	1.94
July	2.51	2.68	1.67	3.38	3.06	3.17	3.58	4.12
August	1.67	1.81	0.34	0.25	0.25	0.32	0.66	1.15
September	0.90	1.29	1.67	1.58	2.46	2.31	2.49	2.31
Total	6.98	7.63	7.69	9.08	10.65	11.28	10.57	10.70

(a) Records incomplete for May.
(b) Gauge was not set up at pasture until May 11, 0.56 recorded at Station. May 8, 9, 10 is included in 3.29. Rain the last of July recorded 1.98 inches at Station and 0.75 at the pasture.

BOTANICAL COMPOSITION OF HAYS

The native vegetation at Mandan has been fully described by Sarvis (2, 3) elsewhere and need not be given in detail here. For the purpose of this publication Sarvis has kindly furnished the following list of species found in the first lot of hay which, it appears, is adequate for our purpose.

LIST OF SPECIES ESTIMATED IN PERCENTAGE OF THE TOTAL GRASS IN THE HAY
J. T. Sarvis

	Field 1	Field 2
Agropyron caninum (bearded wheat grass)	T	T
Agropyron smithii (western wheat grass)	1	1
Andropogon furcatus (big bluestem)	T	1
Andropogon scoparius (little bluestem)	T	3
Aristida longiseta (wire grass)	T	T
Bouteloua gracilis (blue grama)*	T	T
Bouteloua curtipendula (tall grama)	T	T
Koeleria cristata (prairie June-grass)	5	2-3
Stipa comata (western needle grass)	50-75	40-50
Stipa spartea (porcupine grass)	T	5
Stipa viridula (feather bunch-grass)	2	5
Calomovilfa longifolia (big sand grass)	5**	T
Other plants make up the remainder.		

T Indicates trace.
* Short growing varieties.
** The hay from field 1 contained a little more big sand grass than is commonly found on the prairie.

Plants other than grasses which include the three common sages; *Artemisia dracunculoides, Artemisia frigida* and *Artemisia gnaphalodes,* and the two sedges *Carex filifolia* (bull sod-sedge) (nigger wool)* and *Carex heliophila* (western prairie sedge)* made up the remainder of the hay. As high as 50 or more different kinds of plants may enter into the hay. The species indicated as a trace (T), many of which are considered weeds and wasted in feeding the hay, make up varying amounts.

It is a common practice to speak of hay as grass. In these hays, the data from the clipped quadrats show that *Stipa Comata* made up from *50 to 75 percent of the total weight of the grasses* and the other grasses from 25 to 50 percent. This does not include *Bouteloua gracilis* as only a small amount of this enters into the hay. **Other plants made up about 50 percent by weight of the "hay."**

The foregoing botanical analysis applies particularly to the hay cut in April from two different fields but according to Sarvis this analysis may be considered typical of the others also. The hay from Field 1, as indicated by the double asterisk (**), contained a little more of the big sand grass than is commonly found on the prairie. For practical purposes, however, the hays from Fields 1 and 2 may be considered alike.

As indicated by the botanical analysis, the prairie hays are mixtures of a number of grasses and a few other plants. These vary greatly in their characteristics. Some are quite short and are not present in any appreciable quantity in the hays, but are valuable for grazing purposes. Others are tall and are present in the hays to a greater extent, tho they may not be present to such an extent as to be of large value for either grazing or haying. As the hays are mixtures of a number of species they contain plants of a number

* The species marked with an asterisk (*) are short growing varieties which largely escape the mowing machine, and consequently, only small percentages of them are obtained in the hay. Nevertheless, it has been estimated that these grasses furnish more than 50 percent of the feed for grazing cattle.

Photo U.S.D.A.

Figure 2. A CLOSE VIEW OF NATIVE VEGETATION
Northern Great Plains Field Station, July 28, 1915.

of stages of maturity. The height and maturity characteristics of the grasses and plants indicated in the botanical analysis are given in Table 2. All of these grasses and plants are perennials and where their maturity is early enough they should make some second growth and supply some young material late in the season. Such young growth should aid in keeping up the quality of the late cut hays. This is particularly true of western needle grass, which is present in the largest amounts in the hays.

Blue grama and western needle grass are the most palatable grasses, according to Sarvis, tho for 2 or 3 weeks when the needles are being formed and dropped, the stock will avoid the western needle grass. The palatability of the species *Carex* is good while young. When *Carex filifolia* becomes old it is tough, and *Carex heliophila* dries up as it gets old, thus becoming unpalatable. *Artemisia frigida* is the least palatable of the three.

CHEMICAL COMPOSITION OF INDIVIDUAL SPECIES

Samples of the several species of plants indicated in the botanical classification have been analyzed at this station (4). Table 2 gives data on the height and maturity of the plants and Table 3 gives the chemical composition, calculated to a moisture-free or dry basis. These samples were collected by J. T. Sarvis of the Northern Great Plains Field Station at Mandan and by Leroy Moomaw of the Dickinson Substation.

TABLE 2. HEIGHT AND MATURITY OF THE PRAIRIE GRASSES AND PLANTS IN THE HAYS

Species	Common Name	Height	Height Inches	Maturity
Agropyron canium	Bearded wheat grass	Tall	12-36	July-Aug.
Agropyron smithii	Western wheat grass	Tall	18-36	July-Aug.
Andropogon furcatus	Big bluestem	Tall	30-48a	Aug.-Sept.
Andropogon scoparius	Little bluestem	Medium	12-24	Aug.-Oct.
Aristida longiseta	Wire grass	Short	6-12	July-Aug.
Bouteloua gracilis	Blue grama	Short	1-4b	July-Sept.
Bouteloua curtipendula	Tall grama	Medium	12-20	July-Sept.
Koeleria cristata	Prairie June grass	Medium	6-15	June-July
Stipa comata	Western needle grass	Medium	12-24	July
Stipa spartea	Porcupine grass	Tall	12-48	July-Aug.
Stipa viridula	Feather bunch grass	Tall	18-36	July-Aug.
Calomovilfa longifolia	Big sand grass	Tall	30-60	July-Sept.
Artemisia dracunculoides	Green sage	Medium	12-24	Sept.-Oct.
Artemisia frigida	Pasture sage	Short	10-20	Aug.-Sept.
Artemisia gnaphalodes	White sage	Short	10-20	Sept.-Oct.
Carex filifolia	Nigger wool (sedge)	Short	4-8	May
Carex heliophila	Western prairie sedge	Short	4-10	May-June

a Under favorable conditions on the river bottoms this grass will reach a height of 5 or 6 feet.

b This applies to the undergrowth. When it is headed out it will run 6 - 12 inches or more.

TABLE 3. COMPOSITION OF SOME SPECIES OF PRAIRIE GRASSES AND PLANTS
Dry Basis

Species	Stage of Growth	Date	Ash %	Crude protein N x 6.25 %	Crude fiber %	Nitrogen free extract %	Ether extract %
Agropyron canium	Past bloom	Aug. 7, 1925	7.13	7.14	41.31	42.56	1.69
Agropyron tenerum	Full bloom	July 9, 1925	7.82	12.69	36.47	41.24	1.74
Agropyron tenerum	Before heading	July 5, 1920	10.27	21.99	25.99	39.77	1.94
Agropyron tenerum	Bloom	July 29, 1920	9.46	13.69	34.74	40.20	1.88
Agropyron tenerum	Bloom	July 25, 1921	9.80	10.56	34.39	42.61	2.61
Agropyron tenerum	Seed maturing	Aug. 7, 1920	13.28	12.44	32.22	39.33	2.69
Andropogon furcatus	Full bloom	Aug. 14, 1925	7.66	6.52	36.42	47.09	2.31
Andropogon scoparius	Full bloom	Aug. 19, 1925	4.68	4.18	41.62	47.26	2.26
Aristida longiseta	Past bloom	Aug. 8, 1925	6.69	5.82	40.32	49.51	1.26
Bouteloua gracilis	Before heading	June 30, 1925	11.95	11.24	30.13	44.48	2.20
Bouteloua gracilis	After heading	July 20, 1925	11.06	11.47	27.87	47.45	2.15
Bouteloua gracilis	Early bloom	July 24, 1925	9.24	11.87	32.74	44.71	1.44
Bouteloua gracilis	Past bloom	Aug. 9, 1925	8.18	9.76	33.82	46.76	1.57
Bouteloua gracilis	Mature	Aug. 22, 1925	10.62	8.70	31.00	47.20	2.48
Bouteloua curtipendula	Full bloom	Aug. 4, 1925	8.30	8.13	36.22	46.04	1.31
Koeleria cristata	Full bloom	July 1, 1925	9.70	9.16	37.29	41.98	1.87
Stipa comata	Early bloom	June 30, 1925	10.54	11.43	31.02	43.35	3.66
Stipa comata	Full bloom	July 8, 1925	6.09	6.75	41.81	43.98	1.37
Stipa comata	Mature	Aug. 20, 1925	6.45	4.75	39.26	46.89	2.56
Stipa spartea	Full bloom	July 9, 1925	8.41	5.67	41.81	43.16	0.95
Stiua viridula	Full bloom	July 12, 1925	6.98	7.70	40.65	43.58	1.09
Calomovilfa longifolia	Full bloom	Aug. 18, 1925	5.47	5.83	37.77	49.06	1.87
Artemisia frigida	Max. growth	July 10, 1925	7.94	14.03	35.54	36.29	5.20
Artemisia frigida	Full bloom	Sept. 2, 1925	6.43	9.40	33.24	48.94	1.99
Artemisia dracunculoides	Max. growth	July 30, 1925	6.14	9.78	22.27	59.43	2.38
Artemisia gnapholodes	Max. growth	July 30, 1925	10.04	12.37	31.54	42.25	3.80
Carex filifolia	Seeds soft dough	June 2, 1925	8.01	14.57	26.99	48.14	2.29
Carex heliophila	Past bloom	May 29, 1925	7.71	15.87	22.47	51.59	2.36

SCHEDULE OF DIGESTION TRIALS: PRAIRIE HAYS

Trial I. April cutting, 1920. (April 8 and 9).
Preliminary period, May 30 to June 8, inclusive.
Digestion trial, June 9 to 18, inclusive.

Trial II, July cutting, 1920. (July 16 and 17).
Preliminary period, Sept. 30 to Oct. 9, inclusive.
Digestion trial, Oct. 10 to 19, inclusive.

Trial III, October cutting, 1920. (October 16).
Transitional period, Oct. 20 and 21, fed same hay as in Trial I.
Oct. 22 to morning of 27 fed some prairie hay from horse barn while

waiting to receive hay from Mandan.
Preliminary period, beginning with evening feeding Oct. 27 to Nov. 1, inclusive.
Digestion trial, Nov. 2 to 11, inclusive.

Trial IV, Biennial cutting, 1923. (August 20).
Preliminary period, Oct. 9 to 23, inclusive.
Digestion trial, Oct. 24 to Nov. 2, inclusive.

Trial V, Annual cutting, 1923. (August 20).
Transitional period, Nov. 3 to Nov. 28, inclusive, during which the steers were dehorned and fed on a ration of alfalfa hay and corn meal.
Preliminary period, Nov. 29 to Dec. 10, inclusive.
Digestion trial, Dec. 11 to 20, inclusive.

The foregoing schedule shows that in Trials I and II, preliminary feeding periods of 10 days were observed but in Trial III the preliminary period was only 6 days because the amount of hay available would not permit a longer period. The intention was to start feeding the third lot of hay immediately following the close of Trial II, but, owing to a delay in shipment, the hay was not received until several days later. During the intervening period a somewhat similar prairie hay was fed and consequently it is thought that no serious error resulted from the shorter preliminary period in Trial III.

In Trials IV and V the preliminary periods were 15 and 12 days respectively.

ANIMALS USED

In the trials of 1920, four young Hereford or grade Hereford steers were used. They were in good thrifty condition but not fat, and were free from disease. They had been used previously in metabolism trials, were very tame and gentle in disposition, and were not visibly disturbed by the attendants collecting the excreta. These steers were approximately 12 to 13 months of age at the time of the first trial and 16 to 18 months of age at the time of Trials II and III.

The steers used in Trials IV and V were likewise of Hereford breeding with some Shorthorn blood. In age they ranged from about 17 to 20 months at the time of the trials. These steers had also been used previously in metabolism trials and were not disturbed by the routine of the trials.

During Trial IV it was found that the horns on the steers had grown to such size as to be troublesome and since the steers were to be used in other digestion trials later on it seemed best to dehorn them before the onset of cold weather. This was done between Trials IV and V.

RATIONS FED AND OBSERVATIONS ON PALATABILITY

The rations for the entire digestion trial were weighed into bags for each steer in advance. Approximately one-half of the day's ration was fed in the morning and the remainder in the evening. The hay was fed unchopped, just as received from Mandan, and

the aim was, so far as possible, to feed all the hay the steers would consume.

Digestion Trial I—April cutting. After a few days it became evident that the steers would consume less than 10 pounds per head daily of the dried weathered grass, that is, the April cutting, but it was hoped that by fixing the amounts at 8 or 9 pounds practically all the hay offered would be consumed. However, the hay proved unpalatable and considerable amounts were refused as is shown in Table 4. The steers consumed on the average 7.49 pounds per day, per head.

Digestion Trial II—July cutting. The hay of the July cutting possessed a fragrant aroma and appeared very palatable. It was expected, therefore, that larger amounts would be consumed and this proved true. Reference to Table 4 shows that the four steers consumed on the average 15.12 pounds of the July cutting compared

Photo U.S.D.A.

Figure 3. GENERAL VIEW OF NATIVE VEGETATION
Northern Great Plains Field Station, July 28, 1915.

to 7.49 pounds of the April cutting. Had more hay been available, we believe that even larger amounts would have been consumed since the very small amounts refused consisted almost entirely of coarse, woody stems and weeds. Obviously, the hay of the July cutting was decidedly more palatable than the dried, weathered grass of the April cutting.

Digestion Trial III—October cutting. The hay fed in this trial consisted of the matured grass of the season's growth together with the old growth of the previous year. It appeared less palatable than the hay of the July cutting and, therefore, smaller amounts were offered. However, the hay proved even less palatable than we anticipated. None of the steers ate all the hay offered. Table 4 shows that the four steers, on the average, consumed 12.49

pounds of this hay compared to 15.12 pounds of the more palatable July cutting.

As several months had elapsed between digestion Trial I and Trials II and III the steers had grown in size and, doubtless, had developed greater capacities for feed consumption and also greater maintenance requirements which, evidently, accounts in part for the greater feed consumption in these trials. While this fact must be borne in mind, we believe that the differences in the amounts of hay consumed may be considered a fair index of the relative palatability of the different hays.

Digestion Trial IV—Biennial cutting. Probably because the steers had been on pasture during the summer or because they were accustomed to more palatable feeds, they did not take to this hay very eagerly. At first 8 pounds per head daily were offered and most of this was refused during the first 3 or 4 days. After the sixth day the amounts offered were increased from day to day until three of the four were receiving 14 pounds per head which it was expected they would readily clean up, but they failed to do so as is clearly shown in Table 4. For some unaccountable reason steer C-22 would not eat as much as the others in this trial.

The actual average consumption of all four steers was 11.41 pounds per head, daily, but if steer C-22 which ate only about one-half as much as the others is omitted, the average for the remaining three is 12.97 pounds.

Digestion Trial V—Annual cutting. This hay contained no old growth from the preceding year and appeared more palatable than the biennial cutting. The steers were started at 8 and 10 pounds per head daily and the amounts increased from time to time as they would take more but again they failed to consume the anticipated amounts of hay. The four steers consumed an average of 13.87 pounds of the hay, per head daily, compared to 12.97 pounds of the biennial cutting by the steers in Trial IV, if steer C-22 is omitted. Since steer C-22 was not eating well in Trial IV it would seem that comparisons of palatability should be confined to the average of the other three.

In summarizing the observations on palatability it is obvious that of the first three hays the July cutting was the most palatable, the October cutting consideraly less palatable and the April cutting decidedly the least palatable. A similar conclusion is reached by comparing the dry or water-free substance consumed per 1000 pounds live weight. These amounts are: July cutting, 21.87 pounds, October cutting, 17.10 pounds and April cutting, 12.48 pounds.

As different steers were used in Trials IV and V, and the hays were grown in different years, a strict comparison between the first three and the last two trials cannot be made. Naturally, the growth of the different species of plants will vary, depending on seasonal conditions, so that the proportions of the plants composing the hays and their maturity may be quite different one year with another. This, in turn, will influence both the nutritive values and palatability of the hays.

TABLE 4. HAY FED, HAY REFUSED AND HAY CONSUMED PER DAY AND HEAD, AND HAY CONSUMED PER 1000 POUNDS LIVE WEIGHT

	Hay offered	Hay refused	Hay consumed	Dry matter consumed: Per head	Dry matter consumed: Per 1000 lbs. live weight
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Trial I—April cutting, 1920 (Growth of 1919).					
Steer A-19	9.00	1.18	7.82	7.08	11.46
Steer B-19	9.00	1.31	7.69	6.96	12.49
Steer C-19	8.00	.53	7.47	6.73	13.99
Steer D-19	8.00	1.11	6.89	6.24	12.31
Average	8.50	1.03	7.49	6.75	12.48
Trial II—July cutting, 1920					
Steer A-19	16.00	.07	15.93	14.93	20.79
Steer B-19	15.00	.24	14.76	13.83	21.21
Steer C-19	15:00	.06	14.94	14.00	22.73
Steer D-19	15.00	.14	14.86	13.92	23.01
Average	15.25	.13	15.12	14.17	21.87
Trial III—October cuting, 1920					
Steer A-19	14.00	1.13	12.87	11.54	15.77
Steer B-19	14.00	1.42	12.58	11.28	17.12
Steer C-19	14.00	.69	13.31	11.90	18.95
Steer D-19	14.00	2.81	11.19	10.14	16.76
Average	14.00	1.51	12.49	11.22	17.10
Trial IV—Biennial cutting, 1923					
Steer A-22	14.00	.84	13.16	11.58	13.03
Steer B-22	14.00	.45	13.55	11.91	13.83
Steer C-22	8.00	1.28	6.73	5.92	7.46
Steer D-22	14.00	1.80	12.20	10.79	13.73
Average	12.50	1.09	11.41	10.05	12.06
Average A, B, D.	14.00	1.03	12.97	11.43	13.72
Trial V—Annual cutting, 1923					
Steer A-22	18.00	3.15	14.85	13.26	15.03
Steer B-22	12.00	.53	11.47	10.14	12.04
Steer C-22	16.00	1.12	14.88	13.17	16.55
Steer D-22	16.00	1.70	14.30	12.71	15.09
Average	15.50	1.63	13.87	12.32	14.84

However, if we assume that the hays are comparable, it appears, on the basis of pounds consumed per head, that the biennial cutting of 1923 and the October cutting of 1920, which was also a "biennial" cutting, were about equally palatable since nearly the same amounts were consumed per head. But when the comparison is on the basis of dry matter consumed per 100 pounds live weight the October cutting appears to be the more palatable. Of the "biennial" cutting, the steers consumed on the average 12.06 pounds but if steer C-22 is omitted, the amount is 13.72 pounds, which is 3.38 pounds less than was consumed of the October cutting.

The "annual" cutting of 1923 was cut about a month later than the "annual" cutting of July, 1920, and proved less palatable. The steers consumed 13.87 pounds of the "annual" cutting of 1923 as compared to 15.12 pounds of the July cutting.

A similar but more pronounced result is obtained by comparing the hay consumed in proportion to live weight. Of the annual cutting the steers consumed 14.84 pounds of dry matter per 1000 pounds live weight compared to 21.84 pounds of the July cutting. On this basis not only does the annual cutting of 1923 appear distinctly less palatable than the July cutting of 1920 but it and the biennial both appear less palatable than the October cutting of 1920.

Obviously, it is impossible to classify the hays in the order of their palatability except that the "annual" cutting of each year was more palatable than the "biennial" cutting of the same year and that the April cutting was the least palatable of all the hays.

Some additional information on the relative palatability of hays from the 1-year and 2-year units is furnished by Mr. Sarvis. In a letter of April 14, 1930, he writes:

> "In the fall of 1928 we fed the two lots of hay to a team of horses. There were 835 pounds of hay from the 1-year units. The horses ate all of this without waste. There were 2410 pounds of hay from the 2-year units. The horses ate all of this except 80 pounds which was waste. This of course was very little waste or about 3.3 percent. This of course was only one trial and might be much different under other conditions and years.
>
> "It is safe to say that usually there will be little or no waste in feeding hay from the 1-year units, while there will be waste in feeding the hay from the 2-year units, depending upon the amount of old material in it."

GAINS AND LOSSES IN LIVE WEIGHT

The steers were weighed daily during the preliminary feeding period and from 3 to 5 days following each trial but they were not weighed during the digestion trials. The averages of three or five weights on successive days at the beginning and end of each trial, the gain or loss in weight and the "average" weight for the periods are given in Table 5.

The apparent gains and losses show considerable irregularities and seeming inconsistencies, doubtless due in part to the shortness of the experimental period and in part to unavoidable errors in the weights themselves. Lush et. al. (5) in a study of the accuracy of cattle weights, found that the probable error of a gain when the initial and final weights were each the average of three-day weights

TABLE 5. AGE AND LIVE WEIGHTS OF STEERS

	Approximate age in months	Average live weight: Before trial (a)	Average live weight: After trial (b)	Gain (+) or loss (–) (c)	Average live weights (d)
Trial I—April cutting		Lbs.	Lbs.	Lbs.	Lbs.
Steer A-19	13	629	607	–22	618
Steer B-19	13	558	558	0	558
Steer C-19	12	479	482	+3	481
Steer D-19	12	507	507	0	507
Trial II—July cutting					
Steer A-19	17	715	721	+6	718
Steer B-19	17	657	647	–10	652
Steer C-19	16	612	619	+7	616
Steer D-19	16	599	610	+11	605
Trial III—October cutting					
Steer A-19	18	738	725	–13	732
Steer B-19	18	656	662	+6	659
Steer C-19	17	623	632	+9	628
Steer D-19	17	616	593	–23	605
Trial IV—Biennial cutting					
Steer A-22	18	888	889	+1	889
Steer B-22	18	864	858	–6	861
Steer C-22	17	824	773	-51	794
Steer D-22	17	802	775	-27	786
Trial V—Annual cutting					
Steer A-22	20	894	872	-22	882
Steer B-22	20	848	836	–12	842
Steer C-22	19	793	798	+5	796
Steer D-22	19	796	803	+7	800

(a) Average of weights on three successive days before the trial in Trials I, II and III; and five days in Trials IV and V.
(b) Average of weights on three successive days after the trial in Trials I, II and III; and five days in Trials IV and V.
(c) Gain or loss during 13 days in Trials I, II and III; and 18 days in Trials IV and V.
(d) Average of (a) and (b) in Trials I, II and III but in Trials IV and V the "average live weight" has been computed from (a) and (b) for the 6th to 15th days inclusive, that is, for the digestion period proper.

would be approximately 3.3 to 6.5 pounds. Similarly, they found that the probable error of the difference in gains of two steers weighed three successive days at the beginning and end of the experiment, would be from 4.7 to 9.2 pounds. When the shortness of the feeding period and the magnitude of the probable errors are considered the apparent gains and losses observed in these trials are of doubtful value as a measure of the relative nutritive values of the hays. However, a few comments on the apparent gains and losses in weight appear worth while.

On the April cutting, two of the steers just maintained their weights, C-19 showed a gain of 3 pounds, and A-19 showed a loss in weight of 22 pounds. Reference to Table 4 shows that A-19 consumed the least amount of hay in proportion to live weight, C-19 the most, and the other two consumed approximately equal amounts. The gains and losses in this trial appear to be related to the feed consumption, and further, that about 12.5 pounds of this hay per

1000 pounds live weight were sufficient for a maintenance ration.

Unfortunately, the weights of the steers on the July cutting are not so consistent. B-19 showed a loss of 10 pounds in weight but the other three showed gains of 6, 7 and 11 pounds. B-19 consumed proportionately more feed than A-19 but somewhat less than the other two, and therefore, aside from the possible errors previously mentioned no satisfactory explanation for this can be offered. Certain contributory factors, however, may be mentioned. Reference to the original records shows that one of the weights on the three days immediately before the trial was distinctly higher than the other two and was notably higher than any of the weights on the nine days preceding it. Furthermore, B-19 was more irregular than the others in his drinking habits, especially toward the latter part of the period. The records show that on the fifth and eighth days he refused water entirely but on the following days; namely, the sixth and ninth he drank 63.9 and 63.1 pounds respectively. On the seventh day he drank 22.0 pounds and 21.3 pounds on the tenth. Records of water drunk were kept only during the digestion trial, making it impossible to consider the water consumption on the days when the live weights were taken.

Altho the results are not entirely consistent, it appears that three of the four steers showed a tendency to gain in weight on the amount of hay consumed.

On the October cutting, the two steers which ate the larger amounts of hay made gains while the other two showed losses in weight but the gains and losses do not closely follow the amounts of feed eaten. All the steers were irregular in the amounts of water drunk from day to day and all showed a tendency to drink decreasing amounts of water as the period advanced, especially during the last three days. D-19 showed a more or less regular decrease in water consumption as the trial progressed and also showed the largest decrease in live weight.

Because of these factors and the mixed character of the results, no definite conclusions can be drawn from the apparent gains and losses in weight, as to the relative value of the October cutting in comparison with the April and July cuttings.

All the steers were irregular in their daily water consumption during the digestion trial on the biennial cutting. On next to the last day of the trial the steers drank an average of 52.1 pounds of water, the largest amount for any day of the trial, but on the last day the average was only 16.6 pounds—the average for the period being 27.5 pounds. On the last day of the trial C-22 drank only 8.1 pounds of water and D-22 none at all.

Since C-22 consumed, in proportion to weight, only about one-half as much hay as the other steers, the apparent loss of 51 pounds in weight might be due largely to the smaller feed consumption. But the remaining three steers consumed nearly equal amounts of

hay, and therefore, the apparent loss in weight by D-22 does not seem related to the feed consumption.

During the trial on the annual cutting the steers were much more regular in their water consumption than on the biennial cutting, but apparently there is no direct relation between the observed gains and losses in live weight and the amounts of hay eaten by the steers in this trial. It is rather curious that C-22 and D-22 which showed the largest losses on the biennial cutting made small gains on the annual cutting; and that A-22 which showed a small gain on the biennial cutting and B-22 which showed only a small loss, both showed considerable losses in weight on the annual cutting.

Evidently the gains and losses indicated by changes in the live weights of the steers, on the different lots of hay, are not sufficiently consistent or closely related to the amounts consumed to serve as a satisfactory measure of the nutritive value of the hays.

WATER INTAKE DURING DIGESTION TRIALS

Table 6 presents the principal data on the water intake during the trials.

Table 6 shows that the steers were very irregular in their water consumption from day to day. This undoubtedly influenced the live weights of the steers and in turn the apparent gains and losses. It is interesting to note that the ratios of dry matter to water drunk and to total water intake are fairly uniform in the different trials.

METHOD OF CONDUCTING THE DIGESTION TRIALS

Samples for chemical analysis were taken by putting aside portions of the hay from time to time as the rations were weighed into the bags. The portions of hay thus set aside were run thru a feed cutter and cut into lengths of about three-fourths of an inch, thoroly mixed, and the sample drawn from the mixture.

The uneaten feed residues for the entire 10-day periods, likewise were weighed, run thru the feed cutter and sampled for chemical analysis.

During the first three trials attendants were always on hand to collect the feces as they were voided. Large scoop shovels were used for this purpose and the droppings were immediately transferred to 50-pound lard cans with tight fitting covers. As some difficulty was experienced in securing dependable help, just when needed; and the further fact, that the constant presence of the attendants and the necessity of keeping the lights on thruout the night, might have a disturbing influence on the steers, and affect the results; it was decided to adapt the stalls to the use of rubber ducts for collecting the feces. Except for this change, Trials IV and V were carried out in the same way as those of 1920.

TABLE 6. WATER INTAKE DURING DIGESTION TRIALS

	Water drunk per day			Water in feed	Total water intake	Ratio of dry matter to water intake, 1:	
	Minimum	Maximum	Average			Water drunk	Total water
Trial I—April cutting	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Steer A-19	0.0	37.2	20.92	.89	21.81	3.0	3.1
Steer B-19	0.0	42.6	19.75	.88	20.63	2.8	3.0
Steer C-19	11.3	23.2	17.58	.85	18.43	2.6	2.7
Steer D-19	0.0	27.5	15.75	.79	16.54	2.5	2.7
Average	2.83	32.63	18.50	.85	19.35	2.7	2.9
Trial II—July cutting							
Steer A-19	23.4	60.0	40.08	1.07	41.15	2.7	2.8
Steer B-19	0.0	63.9	33.63	.99	34.62	2.4	2.5
Steer C-19	22.5	57.7	39.83	1.00	40.83	2.8	2.9
Steer D-19	30.9	55.8	42.38	1.00	43.38	3.0	3.1
Average	19.20	59.35	38.98	1.02	40.00	2.7	2.8
Trial III—October cutting							
Steer A-19	9.0	43.4	24.42	1.56	25.98	2.1	2.3
Steer B-19	0.0	44.2	21.47	1.52	22.99	1.9	2.0
Steer C-19	0.0	41.5	24.92	1.61	26.53	2.1	2.2
Steer D-19	3.0	35.0	20.35	1.35	21.70	2.0	2.1
Average	3.0	41.03	22.79	1.51	24.30	2.0	2.2
Trial IV—Biennial cutting							
Steer A-22	0.0	55.5	23.13	1.80	24.93	2.0	2.2
Steer B-22	1.5	57.3	35.97	1.86	37.83	3.0	3.2
Steer C-22	0.0	54.1	23.57	.92	24.49	4.0	4.1
Steer D-22	0.0	55.6	27.17	1.67	28.84	2.5	2.7
Average	.38	55.63	27.46	1.56	29.02	2.9	3.1
Trial V—Annual cutting							
Steer A-22	24.6	35.7	30.08	1.99	32.07	2.3	2.4
Steer B-22	3.3	56.2	31.06	1.54	32.60	3.1	3.2
Steer C-22	19.5	48.6	32.62	1.99	34.61	2.5	2.6
Steer D-22	19.8	43.9	31.71	1.92	33.63	2.5	2.6
Average	16.80	46.10	31.37	1.86	33.23	2.6	2.7

The urines were collected in 5-gallon glass bottles by means of the usual rubber funnels and tubes.

Both feces and urines were weighed at 24-hour intervals and samples taken for analysis. Nitrogen determinations were made daily on the fresh materials but aliquot portions of the daily excretions were also set aside for composite samples which were analyzed at the close of the trial. The samples were protected against fermentation and putrefaction by keeping them cold and by the use of suitable preservatives.

The official methods of the Association of Official Agricultural Chemists were used in making the analyses.

CHEMICAL COMPOSITION OF HAYS

The hay fed in Trial I was cut from two different plots. Each lot of hay was sampled and fed separately to two pairs of steers. On analysis, the hays proved to be so nearly alike that the average of the two analyses was used in the computations of digestibility and is the one given in Table 7.

TABLE 7. CHEMICAL COMPOSITION OF PRAIRIE HAYS

Year of trials	1920			1923	
Trial No.	I	II	III	IV	V
Cutting	April	July	October	Biennial	Annual
	%	%	%	%	%
Dry matter	89.75	93.70	89.19	87.94	88.18
Composition of dry matter					
Organic matter	93.38	92.11	91.29	92.65	91.78
Ash	6.62	7.89	8.71	7.35	8.22
Crude protein (N.X6.25)	3.91	9.58	4.16	7.16	7.34
Crude fiber	36.75	28.19	35.89	32.73	33.00
Nitrogen-free extract	49.13	50.71	46.77	48.12	47.58
Ether extract	3.59	3.63	4.47	4.64	3.86
Total nitrogen	0.625	1.532	0.665	1.146	1.174
Protein nitrogen				0.896	1.069
Non-protein nitrogen				0.250	0.105

From Table 7, it is apparent that the hays of the April and October cuttings did not differ greatly in composition. The October cutting contained about 2 percent more ash, slightly more crude protein, and about 0.9 percent more ether extract than the April cutting. On the other hand, the April cutting contained slightly more crude fiber and about 2.3 percent more nitrogen-free extract than the October cutting. The hay of the July cutting differs from the April and October cuttings principally in its higher content of protein and nitrogen-free extract and its lower crude fiber content. The percentages of ash and ether extract fall between the April and October cuttings. From the standpoint of composition, therefore, the July cutting is the best hay.

A comparison of the biennial and annual cuttings in 1923 shows that they were very similar in composition. The biennial cutting contained slightly less ash, protein and crude fiber than the annual cutting but slightly more nitrogen-free extract and ether extract. The differences in each case are less than 1 percent.

When the hays of 1923 are compared with the hays of 1920, it is observed that, in general, the percentages of the various nutrients lie between those of the July and October cuttings. It should be noted that the protein content of the hays of 1923 are considerably higher than those of the April and October cuttings in 1920 but considerably lower than the protein content of the July cutting. These differences in composition will be considered more particularly in connection with the results of the digestion trials.

COMPOSITION OF THE DRY MATTER CONSUMED

As has already been pointed out, and is clearly shown in Table 4, the steers refused considerable amounts of hay in all the trials, except of the July cutting. Feed residues are very undesirable in tests of this kind because a question always arises as to whether or not the portion of the ration consumed is the same or similar in composition to the feeds sampled for analyses. For instance, one steer may consume all of the feed offered him and a second steer refuse considerable amounts. If the feed refused consists largely of coarse, unpalatable materials, the portion of the ration actually consumed would naturally differ considerably in composition from the ration consumed by the first steer. Table 8 shows that apparently there were no very large differences in the nature of the rations actually consumed, due to the feed residues. In other words, the rations consumed by the steers were comparable.

TABLE 8. COMPOSITION OF DRY MATTER CONSUMED

	Organic matter	Ash	Crude protein	Crude fiber	Nitrogen-free ext.	Ether extract
Trial I—April cutitng	%	%	%	%	%	%
Steer A-19	94.44	5.56	3.67	37.41	49.59	3.77
Steer B-19	94.53	5.47	3.64	37.42	49.72	3.75
Steer C-19	93.96	6.04	3.73	37.17	49.45	3.61
Steer D-19	93.77	6.23	3.67	36.93	49.59	3.58
Average	94.18	5.82	3.68	37.23	49.59	3.68
Trial II—July cutting						
Steer A-19	92.18	7.81	9.57	28.26	50.73	3.63
Steer B-19	92.35	7.65	9.56	28.37	50.77	3.64
Steer C-19	92.16	7.84	9.57	28.22	50.73	3.64
Steer D-19	92.19	7.81	9.53	28.26	50.76	3.63
Average	92.22	7.78	9.56	28.28	50.75	3.64
Trial III—October cutting						
Steer A-19	91.76	8.25	4.00	36.56	46.65	4.54
Steer B-19	91.77	8.23	4.02	36.44	46.74	4.56
Steer C-19	91.62	8.38	4.09	36.16	46.85	4.52
Steer D-19	91.90	8.10	4.05	36.37	46.80	4.68
Average	91.76	8.24	4.04	36.38	46.76	4.58
Trial IV—Biennial cutting						
Steer A-22	92.51	7.49	7.30	32.09	48.35	4.77
Steer B-22	92.54	7.46	7.23	32.29	48.29	4.73
Steer C-22	92.68	7.32	6.90	33.13	48.04	4.61
Steer D-22	92.47	7.53	7.08	32.49	48.07	4.83
Average	92.55	7.45	7.13	32.50	48.19	4.73
Trial V—Annual cutting						
Steer A-22	91.67	8.33	7.32	32.95	47.56	3.84
Steer B-22	91.68	8.32	7.37	32.76	47.68	3.87
Steer C-22	91.69	8.31	7.40	32.63	47.76	3.90
Steer D-22	91.60	8.40	7.35	32.70	47.69	3.86
Average	91.66	8.34	7.36	32.76	47.67	3.87

DIGESTIBILITY OF THE HAYS

The coefficients of digestibility obtained in the several trials are summarized in Table 9. The detailed data on the intake, excretion and digestibility of the different feed components are given in the appended tables.

TABLE 9. DIGESTIBILITY OF HAYS

	Dry matter	Organic matter	Ash	Crude protein	Crude fiber	Nitrogen-free ext.	Ether extract
Trial I—April cutting	%	%	%	%	%	%	%
Steer A-19	49.99	57.67	Neg.	3.46	66.10	55.89	50.09
Steer B-19	48.77	55.48	Neg.	0.40	64.33	53.97	40.51
Steer C-19(a)	44.93	50.35	Neg.	Neg.	57.50	52.09	9.03
Steer D-19	49.28	54.53	Neg.	Neg.	61.48	55.59	25.00
Average(b)	48.25	54.56	Neg.	Neg.	62.44	54.38	32.06
Ave. A, B, D(b)	49.35	55.95	Neg.	1.34	64.07	55.14	39.49
Triall II—July cutting							
Steer A-19	61.78	65.32	20.05	52.32	67.63	68.34	39.30
Steer B-19	60.47	64.27	14.65	52.74	67.12	67.32	29.56
Steer C-19	57.17	61.27	9.02	47.20	61.82	65.51	34.97
Steer D-19	59.34	63.35	12.05	51.31	65.49	66.66	31.62
Average	59.72	63.58	14.04	50.99	65.55	66.98	33.96
Ave. A, B, D	60.56	64.33	15.70	52.22	66.77	67.46	33.63
Trail III—October cutting							
Steer A-19	47.15	52.54	Neg.	9.44	59.82	51.93	38.17
Steer B-19	46.10	51.38	Neg.	10.93	57.96	50.78	40.89
Steer C-19	40.09	45.79	Neg.	5.20	53.14	44.80	33.83
Steer D-19	48.56	54.29	Neg.	16.58	62.67	52.10	43.58
Average	45.33	50.86	Neg.	10.33	58.23	49.78	38.73
Ave. A, B, D	47.22	52.68	Neg.	12.22	60.06	51.58	40.79
Trial IV—Biennial cutting							
Steer A-22	50.31	53.78	7.43	39.31	55.16	56.84	35.68
Steer B-22	51.65	55.12	8.62	39.38	56.33	58.16	39.95
Steer C-22	51.11	57.77	Neg.	35.69	59.17	61.21	45.01
Steer D-22	47.45	51.57	Neg.	36.10	52.42	54.63	38.09
Average	50.06	54.17	Neg.	37.96	55.38	57.27	38.87
Trial V—Annual cutting							
Steer A-22	51.48	56.59	Neg.	40.44	60.66	59.10	21.29
Steer B-22	53.70	59.14	Neg.	39.98	62.94	62.15	26.24
Steer C-22	53.73	58.37	2.52	43.55	62.67	60.65	22.81
Steer D-22	51.76	56.15	3.95	40.02	61.15	58.65	13.52
Average	52.61	57.48	Neg.	41.10	61.79	60.02	20.72

(a) Note: Steer C-19 gave uniformly lower digestive coefficients in these trials and also in two others in which these same steers were used, and therefore an average is given in which the results from this steer are omitted.
(b) Weighted averages are given for each lot of hay.

Digestibility of the Dry Matter. Obviously, steer C-19 possessed somewhat lower digestive powers than the other three used in 1920. Therefore, in comparing the results obtained on the different hays it becomes a matter of choice as to whether the averages from all steers should be used or simply the averages of the three, with C-19 omitted. In either case the general conclusions will be the same altho the actual figures will differ slightly.

Considering all four steers, the average digestibility of the dry matter, arranged in order of increasing digestibility, was 45.33 percent for the October cutting, 48.25 for the April cutting and 59.72 for the July cutting. If steer C-19 is omitted, the corresponding results are 47.22, 49.35 and 60.56, respectively. Contrary to expectations, the digestibility of the dry matter of the April cutting was higher than in the October cutting by 2 percent or more. No really satisfactory explanation for this is apparent.

Undoubtedly, differences in the proportions, development and maturity of the different plants in the hays, and the extent to which these have been affected by weathering, are important factors but no definite conclusions can be drawn from the data available.

It is, of course, well known that the apparent digestibility of mixed rations is higher at, or slightly below, the maintenance level than at higher planes of intake. But such differences have not generally been observed when roughages alone are fed, altho Armsby (6) cites three experiments on each of two steers on submaintenance rations of timothy hay in which the coefficients ranged from 1.0 to 2.7 percent higher on the submaintenance than on the maintenance rations in five out of six cases. Benedict and Ritzman (7) obtained somewhat higher digestibility on some submaintenance rations as compared to full maintenance but they state: that, "in general the profound curtailment of the hay ration did not measurably affect the coefficients of digestibility, and the conclusion is reached that the digestibility of a single feed stuff, like hay, constituting the sole ration, is practically unaltered either by the amount of hay fed within wide limits, or by the nutritive plane of the animal."

In these trials, there appears to be no consistent relation between the amount of hay consumed and the digestibility of the dry matter, altho in a few instances higher coefficients were obtained on the lighter rations.

The average difference in digestibility of the dry matter between the April and October cuttings is 2.92 percent if all steers are considered or 2.13 with C-19 omitted. The difference between the October cutting and the July cutting is 14.39 percent with all steers or 13.34 percent with C-19 omitted. Whichever values are used in the comparison, the July cutting is distinctly more digestible than the other two hays.

As previously stated, a strict comparison cannot be made between the hays of 1920 and those of 1923 since the hays were grown in different years and different steers were used. While individual differences in digestive powers may occur, as for instance in the case of steer C-19, no other consistent differences were observed, and, therefore, in view of these results and those obtained by others, it seems justifiable to assume that the digestive powers of different, healthy individuals are sufficiently alike to permit comparisons of this kind.

The average digestibility of the dry matter of the biennial cutting of 1923 was 50.06 percent compared to 52.61 percent for the annual cutting, a difference of 2.55 percent in favor of the annual cutting. However, the July or annual cutting of 1920 was approximately 8 percent more digestible than the annual cutting of 1923 which was made about a month later than the July cutting of 1920. Consequently, the grasses and other plants composing the hay were cut at a later, more mature stage and naturally contained more fiber which would, at least in part, account for the lower digestibility of this hay.

The five hays arranged in order of increasing digestibility of dry or water-free matter, based on the averages of all steers, are as follows: October cutting, 45.33; April cutting, 48.25; biennial cutting, 50.06; annual cutting, 52.61, and July cutting, 59.72 percent.

The digestibility of the organic matter is slightly higher, but shows in general the same kind of variations altho the order is slightly different.

Digestibility of the Ash. It is a matter of common experience to observe great variations in the apparent digestibility of the ash in trials of this kind. This is due to a variety of factors, but in part, to the fact that in herbivorous animals certain mineral elements, particularly calcium and phosphorus are largely excreted in the feces. In spite of this, the results obtained in these trials merit some consideration.

Reference to Table 9 shows that negative coefficients of digestibility of the ash were obtained with all steers on the April and October cuttings and that on the July cutting positive coefficients were obtained ranging from 9.02 to 20.05 percent. On the biennial and annual cuttings the results are mixed in character. Steers A-22 and B-22 gave positive coefficients on the biennial cutting but negative coefficients on the annual cutting in contrast to steers C-22 and D-22 which gave negative coefficients on the biennial cutting but positive coefficients on the annual cutting.

Gains or losses of ash. To bring out more clearly the significance of the results obtained on the digestibility of the ash, the data have been arranged in tabular form in Table 10 showing the amount of crude ash in the feed consumed and in the corresponding feces, and the difference. This table does not show a complete balance and, therefore, what is indicated as a "gain" simply means that less ash was excreted in the feces than was contained in the ration consumed and a "loss" means that more ash was excreted in the feces than the feed contained.

TABLE 10. RELATION BETWEEN ASH CONSUMED AND ASH EXCRETED IN THE FECES—DAILY

	Amount consumed	Amount in feces	Difference	
			Gain	Loss
	Lbs.	Lbs.	Lbs.	Lbs.
Trial I—April cutting				
Steer A-19	0.394	0.710	....	0.317
Steer B-19	0.381	0.637	....	0.256
Steer C-19	0.406	0.566	....	0.160
Steer D-19	0.388	0.504	....	0.116
Average	0.392	0.604	....	0.212
Trial II—July cutting				
Steer A-19	1.167	0.933	0.234	....
Steer B-19	1.058	0.903	0.155	....
Steer C-19	1.098	0.999	0.099	....
Steer D-19	1.087	0.956	0.131	....
Average	1.103	0.948	0.155	....
Trial III—October cutting				
Steer A-19	0.952	1.074	....	0.122
Steer B-19	0.928	1.047	....	0.119
Steer C-19	0.997	1.218	....	0.221
Steer D-19	0.821	0.956	....	0.135
Average	0.925	1.074	....	0.149
Trial IV—Biennial cutting				
Steer A-22	0.868	0.803	0.065	....
Steer B-22	0.889	0.812	0.077	....
Steer C-22	0.433	0.578	....	0.144
Steer D-22	0.812	0.838	....	0.026
Average 4 steers	0.751	0.758	....	0.007
Average A, B, D.	0.856	0.818	....	0.038
Trial V—Annual cutting				
Steer A-22	1.104	1.157	....	0.053
Steer B-22	0.844	0.897	....	0.053
Steer C-22	1.095	1.067	0.028	....
Steer D-22	1.067	1.025	0.042	....
Average	1.028	1.037	....	0.009

Altho the data on apparent "gains" and "losses" of ash are incomplete and do not show what particular elements are concerned, it seems significant, that appreciable "losses" occurred on the April and October cuttings in marked contrast to the appreciable "gains" on the July cutting. Of course, the ash intake was not the same in all trials, due to differences in the amounts of hay consumed and differences in their ash content. Furthermore, in the data of

Table 10, no account is taken of the minerals, calcium, magnesium, etc. contained in the water drunk. These were not determined in connection with the trial as it was not planned to make a mineral balance. The water used was from the Fargo City filtration plant, and analyses at different times of the year show considerable constancy in the values at corresponding periods. These analyses indicate that the general conclusions would not be altered by including the minerals contained in the water.

It seems safe to conclude that cattle feeding upon hays like the April and October cuttings or upon similar dried grasses, would be depleting their mineral reserves unless they consumed considerably larger amounts of hay than in these trials. Long continued feeding upon limited amounts of these hays would surely tend to weaken the skeleton and affect the health and vigor of the animals.

On the other hand, cattle feeding upon hays like the July cutting would probably eat enough of the hays, if available, to maintain a normal mineral balance or even replenish depleted mineral stores in the body.

The data on the hays of 1923, while not consistent for the two hays, would seem to indicate that these hays, in the amounts here consumed, would approximately meet the needs of the animals. If larger amounts had been eaten, probably some storage of ash would have occurred in all cases.

The data suggest differences in the availability of the ash as is evident from a comparison of the July cutting with the annual cutting of 1923. Simply eating more hay, therefore, would not necessarily insure a sufficiency of ash or minerals for the body. Fortunately, animals such as cattle, under favorable conditions, can store up a supply of minerals in their skeletons sufficient to carry them thru considerable periods of under-supply without serious injury. The young growing grasses usually furnish minerals in available forms and contain the vitamin or vitamins necessary for their absorption and utilization. The summer season, with the green growing grasses, upon which the cattle are grazing, therefore, favors the storage of minerals in the body against a time of shortage. The extent to which cattle can protect themselves in this way depends upon a variety of factors, among which are; the fertility of the soil, the kind of vegetation and its stage of growth, rainfall, age of animals, etc.

Altho under normal conditions cattle may build up a sufficient mineral reserve to withstand, without apparent permanent injury, the strain and hardships of the winter season while subsisting on hays and grasses such as these; it is, nevertheless, well to recognize the possibility of injury from a lack of minerals, especially in years of scanty vegetation and limited feed supply. Under such conditions the stock may approach the winter season without a sufficient reserve of minerals to endure its hardships.

Digestibility of the Crude Protein. Some striking differences in the apparent digestibility of the crude protein in the different hays are evident. On the April cutting, steer A-19 gave a digestion coefficient for crude protein of only 3.46 percent and B-19 only 0.40 percent. The other two steers gave negative coefficients. The average coefficient of all four steers is negative but, if steer C-19 is omitted, the average is 1.34 percent.

The coefficients for crude protein in the July cutting, in striking contrast to those of the April cutting, range from 47.20 to 52.74 percent, making an average of 50.99 for all four steers and 52.22 percent if C-19 is omitted.

The digestibility of the crude protein in the hay of the October cutting ranged from 5.20 to 16.58 percent with all four steers or from 9.44 to 16.58 percent with steer C-19 omitted. Altho this is considerably better than in the April cutting, it is still much below that of the July cutting.

For the hays of 1923 the digestibility of the crude protein in the biennial cutting was 37.96 and in the annual cutting 41.10 percent. This is considerably better than in the April and Ocotber cuttings of 1920 but is about 10 to 13 percent below the July cutting.

The average coefficients of digestibility of the crude protein in the five hays, arranged in order of increasing digestibility, are as follows: April cutting, 0.0; October cutting, 10.33; biennial cutting, 37.96; annual cutting, 41.10; and the July cutting, 50.99 percent.

From the data, as presented, it would appear that the crude protein in the April cutting was indigestible and of no value in furnishing protein for replacing the daily "wear and tear" on body protein, to say nothing of furnishing protein for growth. But this does not necessarily follow. The usual method of determining the digestibility of protein consists in subtracting the protein of the feces from the protein of the feed and considering the differences between the two as representing the protein digested; or by subtracting the fecal nitrogen from the feed nitrogen and computing the difference to equivalent protein. It is well known that this method may, under certain conditions, be subject to considerable errors due to the presence in the feces of nitrogenous substances which have not come directly from the feed. The presence of the non-feed or so-called "metabolic" nitrogen in the feces has the effect of decreasing the difference between the feed nitrogen and the fecal nitrogen thus decreasing the "apparent" digestibility of the protein. The magnitude of the error thus introduced may be comparatively small in some instances and considerable in others.

Influence of "metabolic" nitrogen on apparent digestibility of protein. Mitchell (8), in 1926, published the results of a critical study of the factors influencing the determination of the protein requirements of animals and of protein values. He showed clearly

the marked influence of the so-called "metabolic"[1] nitrogen of the feces on the apparent digestibility of protein, and also showed that the amount of metabolic nitrogen appears to be closely related to the amount of dry matter consumed and to the amount of indigestible non-nitrogenous material in the ration. In other words, the metabolic nitrogen is essentially a wastage of nitrogen incident to the digestion of the feed, and therefore, is equivalent to reducing the digestible feed protein by a corresponding amount.

Mitchell applied his method of correcting for metabolic nitrogen to two series of digestion trials on low and high-protein rations which showed an average difference in "apparent" digestibility of 11 percent. On applying the correction, the digestibility of the protein in the low-protein rations was increased from 57.8 to 90.3 percent and in the high-protein rations from 68.7 to 90.1 percent. The application of the correction for metabolic nitrogen, therefore, not only increased the percentage digestibility but gave almost identical coefficients of digestibility for the proteins in the two series.

In the same year, 1926, Titus (9) published the results of a series of metabolism trials in which alfalfa hay alone was fed, followed by other trials in which a portion of the alfalfa was replaced with cellulose, practically free from protein, in the form of filter paper pulp. He found that the apparent digestibility of the nitrogen in the alfalfa hay when fed alone was 72.0 percent and that the percentage digestibility decreased with increasing proportions of cellumass. In 1927, Titus (10) published the results of a more critical study of the data with special reference to the nitrogen metabolism. He observed an apparent relationship between the weight of the metabolic nitrogen in the feces on the one hand, and the weight of the digested dry matter and the weight of water in the feces on the other. He also observed a relationship between the metabolic nitrogen, and the dry matter consumed and water in the feces. By a mathematical treatment of the data he derived two formulas for correcting for metabolic nitrogen in the feces of cattle. The results of this study are briefly indicated as follows:

Experiment No.	1	2	3	4	5
Alfalfa in ration, percent	100	85	70	55	40
Paper pulp (cellumass) percent	.....	15	30	45	60
Digestibility of nitrogen, percent					
"Apparent"	72.0	68.1	64.2	53.6	38.4
"True" or corrected	88.0	88.3	88.7	87.7	88.0

For the purpose of comparing the results obtained by applying the methods proposed by Mitchell and by Titus, one of us, Chris-

[1]Altho the term "metabolic" nitrogen is a misnomer, at least in part, it is here used for lack of a better term.

tensen,[1] has applied these three methods of correction for metabolic nitrogen to groups of trials involving a total of 115 individual digestion trials, exclusive of the prairie hay trials, in which there has been considerable variety in the feeds and rations. The rations have consisted of alfalfa hay alone and in combination with different silages and with a variety of grains or concentrate mixtures in varying proportions. The results of these computations indicate tha tapproximately the same results are obtained by Mitchell's method and the second formula proposed by Titus.

In 50 trials the difference between the two methods was less than 1 percent; in 32 other trials the difference lay between 1 and 2 percent; and in 17 trials the difference was between 2 and 3 percent. In the remaining 16 cases extreme variations from 3 to 4.7 percent occurred. Altho Mitchell's method tended to give slightly higher coefficients than the method of Titus, the results were not consistent but in many instances the two were practically identical. It appears that the nature of the ration has some influence on the results.

The standard deviations of the coefficients of digestibility of protein, both corrected and uncorrected, were determined in the 115 trials. It was found that when corrections were made for metabolic nitrogen, not only were the deviations greatly reduced, but the coefficients obtained by correcting according to Mitchell or the second formula of Titus, showed practically the same standard deviations. It seems rather significant that these two methods, arrived at in entirely different ways, should yield such concordant results.

If we apply to the prairie hays the corrections for metabolic nitrogen proposed by Mitchell; and by Titus, formulas I and II; we get the average results presented in Table 11.

TABLE 11. A COMPARISON OF DIFFERENT METHODS OF ESTIMATING THE "TRUE" DIGESTIBILITY OF PROTEIN

	Percentage digestibility by different methods			
	Usual or "apparent"	Mitchell's method	Titus' formula I	Titus' formula II
Trial I, April cutting	Negative	84.8	66.2	80.8
Trial II, July cutting	50.9	81.6	77.9	81.5
Trial III, October cutting	10.3	87.7	65.5	80.4
Trial IV, Biennial cutting	38.0	81.6	68.2	75.6
Trial V, Annual cutting	41.1	83.9	77.0	80.8

A comparison of the results in Table 11 show a striking difference between the "apparent" digestibility and the corrected or "true" digestibility computed by the different methods. Also it will be noted, that there are considerable differences in the corrected digestibilities depending on the method used.

[1]Unpublished data.

If we assume that the corrected digestibility of the protein, using Mitchell's method, is approximately the "true" digestibility, it is evident from Table 11 that the corrected values show comparatively small differences among the several hays, in marked contrast to the values for "apparent" digestibility. Furthermore, the April and October cuttings show as high or higher digestibility than the July cutting.

These results signify that while the protein of the April cutting appeared indigestible, it was apparently as digestible as the others and in reality contributed in part toward the protein requirements of the steers. It was, therefore, not wholly useless, but owing to the low protein content of the hay, the digestible protein in it was barely sufficient to cover the protein wastage incident to the digestion of the hay, leaving nothing additional for other protein needs.

For this reason, the relative values of the different hays as sources of this additional protein are indicated better by the "apparent" digestibility than by the "true" digestibility inasmuch as the coefficients of "apparent" digestibility indicate the amount of digestible protein available above the wastage due to digestion.

From this viewpoint, the comparisons already made furnish an index of the relative values of the different hays as sources of protein altho the "apparent" digestibility is probably not the "true" digestibility.

Digestibility of Crude Fiber. The old growth in the April and October cuttings, which had grown toward maturity and had been weathered thru the winter season had the effect of lowering the digestibility of the crude fiber below that of the July cutting. This was expected but it was not expected that the October cutting which consisted of the season's growth together with the carry over from the previous year, would show lower digestibility of the crude fiber than the April cutting in which all the growth had been exposed during the winter season. The average digestibility of the crude fiber in the October cutting was 58.23, in the April cutting 62.44 and in the July cutting 65.55 percent, with all steers, or 60.06, 64.07 and 66.77 percent, respectively, if the results of steer C-19 are omitted. In the hays of 1923, the digestibility of the crude fiber was 55.38 percent in the biennial cutting and 61.79 percent in the annual cutting. Altho there is no consistent relation between the percentage of crude fiber in the hay consumed and the percentage digestibility, the results are consistent in showing that the crude fiber of the annual cutting of each year was more digestible than in the other hays.

Digestibility of the Nitrogen-free Extract. The average percentages of nitrogen-free extract in the dry matter consumed (Table 8) for the different hays was; April, 49.59; July, 50.75; October, 46.76; biennial, 48.19 and annual, 47.67. As the nitrogen-free extract composed nearly one half of the dry matter, its digestibility has an important bearing on the nutritive value of the hays. The average coefficients for all four steers (Table 9) arranged in order of increasing digestibility are: October, 49.78; April, 54.38; biennial, 57.27; annual, 60.02; and July, 66.98 percent. With steer C-19 omitted the coefficients for the first three hays are 51.58, 55.14 and 67.46 percent, respectively.

Using the averages of all four steers, the difference in digestibility of the nitrogen-free extract between the October and April cuttings is 4.6 percent and between the April and July cutting 12.6 percent, making a total difference between October and July of 17.2 percent. The difference between the biennial and annual cuttings is only 2.75 percent. The nitrogen-free extract of the annual cutting 1923 was about 7 percent less digestible than in the July cutting 1920 but both are superior to the other hays. Considerable variations in the individual coefficients exist, and it is well to note, that the highest coefficient on the October cutting is practically identical with the lowest on the April cutting; that two of the coefficients on the April cutting are higher than the lowest on the biennial cutting, and finally, that the highest coefficient on the biennial cutting is higher than three of the coefficients on the annual cutting. The coefficients on the July cuttings are all distinctly above the others. In spite of these irregularities it seems that the averages indicate in a general way the relative digestibility of the nitrogen-free extract of the hays.

Digestibility of the Ether Extract. As frequently happens, rather wide variations occur in the coefficients of the ether extract. In this series the variation is greatest on the April cutting where it ranges from 9.03 to 50.09 percent, a difference of 41.06 percent. If steer C-19 is omitted, the difference is reduced to about 25 percent. In the other trials the differences between the highest and lowest range between 9 and 15 percent. Because of the small amounts of ether extract in the hays, these variations are of less significance than they would be otherwise.

It is rather curious that the "annual" and "July" cuttings which showed the highest average coefficients for all constituents, excepting crude fiber in the April cutting, have the lowest coefficients for the ether extract. The differences among the averages for the different groups show a maximum of 18.15 percent when all steers are included and 20.07 percent with C-19 omitted. When the low average of the annual cutting is omitted the maximum differences are 6.81 with all steers and 7.12 percent with C-19 omitted. The averages among the different groups, therefore, show in general, smaller differences than the coefficients of individuals within the groups. When compared with the results of digestion trials by others on similar hays and grasses, the coefficients agree fairly well but tend to be a little lower. Apparently the digestibility of the ether-extract of these hays was about the same as others have found for similar hays.

AMOUNTS OF DIGESTIBLE NUTRIENTS IN THE HAYS

The nutritive values of the hays are dependent on the composition or amounts of the different nutrients in the hays and their energy content on the one hand, and the extent to which these nutrients can be utilized by the body on the other. The relative values of the hays are, therefore, indicated by the amounts of digestible nutrients they contain and by their energy values. Since the hays differ somewhat in their water content, a better comparison is obtained by making the comparison on a dry or water-free basis.

When the data for the different hays are compared, some striking differences are observed. The dry matter and the digestible nutrients in the different hays are shown in Table 12. This table gives the amount of digestible nutrients in 100 pounds of hay as fed and also in 100 pounds of dry or water-free substance in these hays.

TABLE 12. DRY MATTER AND DIGESTIBLE NUTRIENTS IN HAYS
Average results with four steers in each trial

		In 100 lbs. of hay as fed Digestible nutrients				In 100 lbs. dry matter Digestible nutrients			
	Dry matter Lbs.	Crude protein Lbs.	Carbo-hydrates Lbs.	Ether extract Lbs.	Total, (fat x 2.25)	Crude protein Lbs.	Carbo-hydrates Lbs.	Ether extract Lbs.	Total, (fat x 2.25)
Expts. of 1920									
Trial I April cutting[1]..	89.75	......	44.57	1.03	46.90	......	49.66	1.15	52.26
Trial II July cutting[1]....	93.70	4.57	49.16	1.14	56.29	4.88	52.46	1.22	60.08
Trial III Oct. cutting[1]....	89.19	0.38	39.40	1.54	43.24	0.43	44.18	1.73	48.50
Expts. of 1923									
Trial IV Biennial cutting[2]	89.94	2.39	40.18	1.58	46.14	2.72	45.69	1.80	52.46
Trial V Annual cutting[2]	88.18	2.66	43.16	0.71	47.42	3.02	48.95	0.80	53.77

[1]April cutting, 8 and 9; July cutting, 16 - 17; October cutting, 16.
[2]Hays cut August 20.

Digestible Protein. From Table 12, it will be seen that per 100 pounds of dry matter, the April cutting contained no digestible crude protein, the October cutting only 0.43 pound; the biennial cutting, 2.72 pounds; the annual cutting 3.02 pounds; and the July cutting 4.88 pounds. As a source of digestible crude protein, therefore, the July cutting is distinctly superior to the others. The April and October cuttings have little or no value as sources of protein and the biennial and annual cuttings furnish only about three-fifths as much digestible protein as the July cutting.

The data show clearly that the amount of digestible protein is less in the hays containing residues of old growth from the previous year than the hays which consist only of the season's growth. Evidently, exposure of the old growth to the effects of snow, rain, wind, sun and other conditions had the effect of leaching out or destroying a part of the digestible protein. Altho this undoubtedly accounts in a large measure for the lower amounts of digestible protein in the hays containing the old growth, seasonal differences influence markedly the relative rate of growth of plants, thus changing the proportions of the different species found in the hays not only from year to year but from time to time during the same season. Due to these differences, the stage of maturity of the different plants composing the hays will vary from year to year even if the hays are cut on a definite date. These different factors cannot be controlled nor can their effects be definitely measured.

Total Digestible Nutrients. A comparison of the different hays on the basis of total digestible nutrients shows less striking differences than in the case of digestible protein. The term "total digestible nutrients" is here used in the ordinary sense to indicate the sum of the digestible crude protein, digestible carbohydrates and digestible fats (ether extracts) multiplied by 2.25 to express the fats in terms of equivalent carbohydrates.

The hays arranged in the order of increasing amounts of digestible nutrients are: October cutting, 48.50; April cutting, 52.26; biennial cutting, 52.46; annual cutting, 53.77; and July cutting, 60.08 pounds per 100 pounds of dry matter. It seems a little strange that the April cutting should contain more digestible nutrients than the Ocober cutting. From observations of the grasses on the range, it appears that there is comparatively little decay during the winter season and that most of the decay occurs during the spring and summer. If that is true, the grass may come thru the winter without much loss in digestible nutrients as compared to the losses in the old growth remaining at the end of the summer season. If this old growth formed a considerable part of the hay at the end of the growing season, it would undoubtedly have the effect of measurably lowering the digestibility of the hay.

Our records fail to show whether or not the October cutting contained residues of grass from more than one year prior to cutting and, consequently, it is impossible to state whether or not the old growth is limited to one season or more. If this hay contained residues of old growth from more than one season, the effect of course would be to depress the digestibility below what it would otherwise be.

The data show that the April cutting contained practically as much digestible nutrients as the biennial cutting of 1923. This is a little surprising, since the biennial cutting of 1923 contained the new growth of the season as well as the residues from the previous year. One would expect that this hay would contain more digestible nutrients than the April cutting. The difference between the two, however, is insignificant.

The digestible nutrients of the annual cutting 1923, were only 1.31 percent higher than the biennial cutting of the same year and considerably lower than the July cutting of 1920.

The annual cutting and the July cutting are not strictly comparable because the July cutting was made on the 16 and 17 of July in 1920 and the annual cutting of 1923 was made about a month later, that is, August 20. Naturally, the grasses and other plants composing the hays of 1923 were more mature and, consequently, contained larger amounts of crude fiber which would tend to lower the digestibility as compared to the July cutting. The July cutting contained somewhat more digestible protein than the hays of 1923, probably due to having been cut at an earlier stage of maturity. Undoubtedly, this explains in part the larger amounts of digestible nutrients in the July cutting as compared to the others, altho the digestible carbohydrates are also higher in the July cutting.

Considering the hays as a whole, it seems evident that the October cutting was the least digestible, probably due to the maturity of the plants as well as the more advanced decay of the old growth in comparison with the biennial cutting of 1923 or the April cutting of 1920. The April cutting of 1920 apparently came thru the winter in good condition, furnishing considerable amounts of digestible nutrients but no digestible crude protein. The annual cutting of 1923 ranks next to the July cutting in total digestible nutrients but furnishes 6.3 pounds less digestible nutrients per 100 pounds than the July cutting and only 1.3 pounds more digestible nutrients than the biennial cutting of the same year. It is, therefore, not much superior to the biennial cutting of the same year from the standpoint of digestible nutrients.

NUTRITIVE VALUE OF RATIONS

In considering the digestibility of the different hays it was pointed out that in a number of instances the rations consumed did not supply sufficient minerals for the needs of the steers. Also attention was directed to the low digestibility of the protein in some lots of hay. It is of interest, therefore, to consider how nearly the rations consumed came to meeting the needs of the animals.

Gains and losses of protein. It has already been shown that the April cutting furnished but little or no digestible protein; the October cutting only 0.43 pound in 100 pounds of dry matter; the biennial and annual cuttings 2.72 and 3.02 pounds respectively; and the July cutting 4.88 pounds. Obviously, rations made up of these hays will differ greatly in their value as sources of protein as is clearly shown by the nitrogen balances in Table 13.

TABLE 13. NITROGEN BALANCES—DAILY

	Amount consumed	Amount in feces	Amount in urine	Amount of outgo	Amount of gain	Amount of loss
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Trial I, April cutting						
Steer A-19	0.0415	0.0402	0.0327	0.0729	....	0.0314
Steer B-19	0.0405	0.0404	0.0345	0.0749	....	0.0344
Steer C-19	0.0401	0.0417	0.0279	0.0696	....	0.0295
Steer D-19	0.0366	0.0369	0.0285	0.0654	....	0.0288
Average	0.0397	0.0398	0.0309	0.0707	....	0.0310
Trial II, July cutting						
Steer A-19	0.2285	0.1091	0.0991	0.2082	0.0203	....
Steer B-19	0.2115	0.0999	0.0908	0.1907	0.0208	....
Steer C-19	0.2144	0.1133	0.0914	0.2047	0.0097	....
Steer D-19	0.2123	0.1033	0.0803	0.1836	0.0287	....
Average	0.2166	0.1064	0.0904	0.1968	0.0198	....
Trial III, October cutting						
Steer A-19	0.0737	0.0668	0.0327	0.0995	....	0.0258
Steer B-19	0.0736	0.0645	0.0323	0.0968	....	0.0232
Steer C-19	0.0778	0.0737	0.0307	0.1044	....	0.0266
Steer D-19	0.0657	0.0548	0.0277	0.0825	....	0.0168
Average	0.0727	0.0649	0.0309	0.0958	....	0.0231
Trial IV, Biennial cutting						
Steer A-22	0.1352	0.0821	0.0751	0.1572	....	0.0220
Steer B-22	0.1378	0.0835	0.0769	0.1604	....	0.0226
Steer C-22	0.0654	0.0421	0.0607	0.1028	....	0.0374
Steer D-22	0.1222	0.0782	0.0609	0.1391	....	0.0169
Average	0.1151	0.0715	0.0684	0.1399	....	0.0248
Trial V, Annual cutting						
Steer A-22	0.1551	0.0925	0.0780	0.1705	....	0.0154
Steer B-22	0.1193	0.0718	0.0518	0.1236	....	0.0043
Steer C-22	0.1559	0.0880	0.0576	0.1456	0.0103	....
Steer D-22	0.1494	0.0898	0.0616	0.1514	....	0.0020
Average	0.1449	0.0855	0.0623	0.1478	....	0.0029

Table 13 shows that all the steers gained nitrogen while fed the July cutting but lost nitrogen in all the other trials, except C-22 in Trial V on the annual cutting (1923). Also the losses were least on the annual cutting (1923) with the losses increasing in order thru the biennial, October and April cuttings. These gains and losses are brought out more clearly in Table 14.

TABLE 14. GAIN OR LOSS OF PROTEIN PER 1000 LBS. LIVE WEIGHT, PER DAY

	Average live wt. (a)	Approximate age in months	Crude protein consumed per 1000 lbs. live weight: Total	Crude protein consumed per 1000 lbs. live weight: Digestible	Crude protein consumed per 1000 lbs. live weight: Estimated minimum required (b)	Gain of protein per 1000 lbs. live wt.: Normal	Gain of protein per 1000 lbs. live wt.: Observed N x 6.25	Digestible feed protein above (+) below (–) maintenance requirements
	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Trial I, April cutting								
Steer A-19	618	13	.420	.015	.93	.33	–.32	–.59
Steer B-19	558	13	.454	.002	.93	.33	–.39	–.60
Steer C-19	481	12	.521	......	.95	.35	–.40	–.60
Steer D-19	507	12	.452	......	.95	.35	–.36	–.60
Average			.462	.004	.940	.34	–.37	–.60
Trial II, July cutting								
Steer A-19	718	17	1.990	1.041	.85	.25	+.17	+.44
Steer B-19	652	17	2.028	1.070	.85	.25	+.20	+.47
Steer C-19	616	16	2.175	1.027	.87	.27	+.10	+.43
Steer D-19	605	16	2.193	1.126	.87	.27	+.30	+.53
Average			2.096	1.066	.860	.260	+.19	+.47
Trial III, October cutting								
Steer A-19	732	18	.630	.059	.84	.24	–.22	–.54
Steer B-19	659	18	.687	.075	.84	.24	–.23	–.52
Steer C-19	628	17	.774	.040	.85	.25	–.27	–.56
Steer D-19	605	17	.679	.113	.85	.25	–.18	–.49
Average			.693	.072	.845	.245	–.22	–.53
Trial IV, Biennial cutting								
Steer A-22	889	18	.950	.374	.84	.24	–.16	–.23
Steer B-22	861	18	1.000	.394	.84	.24	–.16	–.21
Steer C-22	794	17	.515	.184	.85	.25	–.29	–.42
Steer D-22	786	17	.972	.351	.85	.25	–.13	–.25
Average			.859	.326	.845	.245	–.19	–.27
Trial V Annual cutting								
Steer A-22	882	20	1.100	.445	.82	.22	–.11	–.16
Steer B-22	842	20	.888	.355	.82	.22	–.04	–.25
Steer C-22	796	19	1.224	.533	.83	.23	+.08	–.07
Steer D-22	800	19	1.168	.467	.83	.23	–.01	–.13
Average			1.095	.450	.825	.225	–.02	–.15

(a) Average of three weights on successive days immediately before the trial and three similar weights immediately following the trial in trials I, II, and III, and an average of five successive weights in trials IV and V.

(b) Estimated at 0.6 pound[1] crude protein for maintenance + normal growth of protein estimated according to the formula suggested by Armsby[2].

[1]U. S. Dept. Agr., Bureau Animal Industry Bulletin 108 (1908) p. 19.

[2]U. S. Dept. Agr., Bureau Animal Industry Bulletin 143 (1912) p. 94.

Table 14 gives the average live weight of the steers on the several trials, their approximate age, the total and digestible protein in the rations, the estimated minimum of digestible protein required for maintenance and normal growth, the estimated normal gain of protein together with the observed gains or losses and the amount of digestible feed protein supplied above the requirements for maintenance alone.

The estimated minimum required is .6 pound of digestible crude protein per 1000 pounds live weight plus an amount of digestible protein equal to the normal gain of protein by steers of the respective ages according to Armsby's estimates. These estimated requirements are considerably lower than those specified in the Armsby feeding standards but are not as low as the minimum requirements recently proposed by Mitchell (11). The differences between the estimates of Armsby and of Mitchell are due chiefly to the lower maintenance requirements proposed by Mitchell, altho the figures for "normal growth" of protein also differ slightly. The minimum maintenance requirements of Armsby are closer to the commonly used standards and since the primary object of the comparison is to show differences in the hays as sources of protein this method appears to be satisfactory.

A comparison of the digestible protein consumed with the estimated minimum required, shows it was only on the July cutting that the steers received enough digestible protein for the estimated minimum requirements. This holds true even with Mitchell's estimates. He estimates that the daily requirements of digestible protein for growing Hereford-Shorthorn calves range from 0.60 pound at 500 pounds to 0.55 pound at 900 pounds which is equivalent, respectively, to a range of 1.20 down to 0.61 pounds per 1000 pounds live weight. On the July cutting B-19 gained slightly less than the estimated "normal" and D-19 slightly more; while of the remaining two steers, one gained a little less and the other a little more than one-half of the estimated "normal".

The annual cutting (1923) came next to the July cutting in the amount of digestible protein supplied. On this hay C-22 showed a small gain of protein but the other three showed small losses. Steer C-22 received only 0.53 pound of digestible protein compared to the estimated requirements of 0.70 pound by Mitchell and 0.83 by Armsby. The observed gain, therefore, may have been accidental. In all the other trials the protein was insufficient and losses of body protein occurred.

Altho there are some apparent inconsistencies in the data, it seems rather significant that on the July cutting all the steers gained amounts of protein equal to or approaching the "normal"; that on the annual cutting the protein was nearly sufficient to prevent a loss of body protein, but was insufficient for gains; and that on all the other hays the amounts of protein were inadequate, and consequently, protein losses occurred which increased as the protein of the rations decreased.

The gain or storage of protein by animals is not dependent alone on the amount of digestible protein in the ration but also depends on the total digestible nutrients or available energy. Therefore, if more hay is eaten, both factors would be increased and in this way protein losses might be avoided. It is conceivable that cattle, such as these, under different conditions might be induced to eat enough more of the annual, and possibly of the biennial cuttings (1923), to prevent losses of protein and even enough for some gains.

To fully meet both the maintenance and growth reqirements for protein as estimated by Armsby, it would be necessary for the steers to eat nearly twice as much of the annual cutting, and approximately two and one-half times as much of the biennial cutting (1923), as they did. It is hardly to be expected that they would do this.

It is inconceivable that the steers either would or could eat enough of the April cutting to fully supply their protein needs since it furnished little or no digestible protein; and of the October cutting it would be necessary to eat more than 11 times as much as was eaten, in order to supply sufficient protein.

The steers used in these trials ranged in age from about 12 to 20 months. Since older cattle have somewhat lower and calves higher protein requirements, these hays would be slightly more valuable for older cattle but less valuable for young calves. In general, this would also apply to horses and sheep at corresponding stages of maturity.

Total digestible nutrients in rations. The gains and losses in live weight, ash, and protein are related not only to the amounts of the individual nutrients but also to the total intake of digestible nutrients or energy producing materials. Table 15 gives the digestible nutrients in the rations consumed by the individual steers and the average for each trial and lot of hay.

TABLE 15. TOTAL DIGESTIBLE NUTRIENTS IN RATIONS PER 1000 POUNDS LIVE WEIGHT OF STEERS

	Steers A-19 & A-22	Steers B-19 & B-22	Steers C-19 & C-22	Steers D-19 & D-22	Average
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Trial I, April cutting	6.51	6.78	6.69	6.44	6.61
Trial II, July cutting	12.89	12.87	13.19	13.77	13.18
Trial III, October cutting	7.94	8.47	8.31	8.79	8.38
Trial IV, Biennial cutting	6.76	7.39	4.19	6.86	6.30(a)
Trial V, Annual cutting	7.95	6.68	9.04	8.27	7.99

(a) Average omitting steer C-22 is 7.00 lbs.

Owing to the variations in the apparent gains and losses in live weight by individuals, only the "average" rations by groups will be considered. Previously, in discussing the feed consumption in relation to gains and losses in live weight, it was stated that about 12.5 pounds of the April cutting per 1000 pounds live weight appeared to be about enough for maintenance. Since our feeding standards are not in agreement as to what constitutes a maintenance ration, a comparison will be made only with the Haecker and the Armsby standards, both of which are commonly used in this country.

Haecker (12) gives 0.7 pound of digestible crude protein and 7.925 pounds of total digestible nutrients as the daily requirement for the maintenance of a 1000-pound cow. Armsby (6) stated the requirement of cattle, per 1000 pounds live weight as 0.5 pound of digestible "true" protein or 0.6 pound of digestible crude protein and 6.0 therms of net energy. For younger cattle weighing less than 1000 pounds Armsby decreases the protein in direct proportion to the decrease in weight but the energy varies with the two-thirds power of the live weight and not directly with the weight. He gives the maintenance requirement of a 500-pound steer as 3.78 therms and for a 750-pound steer 4.95 therms of net energy. Per 1000 pounds live weight this is equivalent to 7.56 and 6.6 therms respectively.

As these standards are stated in different terms, they cannot be compared directly. However, Hills (13) in his extensive study of "The Maintenance Requirement of Dairy Cattle", "converted" the Armsby standard to "crude protein" and "digestible nutrients" and concludes from his study: "that the Haecker, Savage, modified Wolff-Lehmann (Morrison) and Woll-Humphrey standards for maintenance (0.7 pound digestible protein, 7.93 pounds total digestible nutrients) are over-statements; and that the Armsby and Eckles standards in the form stated (0.5 pound digestible true protein, 6.0 therms energy) or as "converted" (0.595 pound digestible crude protein and 6.48 pounds of total digestible nutrients) provide a sufficiency of digestible protein and total digestible nutrients for the maintenance of 1000-pound dry, non-pregnant cows."

Armsby's standards apply to mature cattle generally and if it is assumed that Haecker's standards for dairy cows also apply to cattle in general, comparisons are possible.

On the basis of the Haecker standard, it is evident from Table 15 that the digestible nutrients in the rations of the April and biennial cuttings were inadequate for maintenance. The average of the rations on the annual cutting furnished just enough for maintenance and somewhat more than a maintenance ration was consumed, of the October cutting. The nutrients in the rations of the July cutting were distinctly above the maintenance needs and were sufficient for some gains. With the exception of the July cutting, therefore, the steers did not receive enough digestible nutrients in the rations consumed to permit any material gains.

Metabolizable and net energy in hays and rations. Table 16 gives the estimated metabolizable energy in the April, July and October cuttings; the determined values for the annual and biennial cuttings; and the estimated net energy values for all the hays.

TABLE 16. METABOLIZABLE AND NET ENERGY IN HAYS PER 100 POUNDS DRY MATTER

	Organic matter	Digestible organic matter	Metabolizable energy (a)	Estimated net energy (b)
	Lbs.	Lbs.	Therms	Therms
Trial I, April cutting	93.38	50.95	75.05	41.9
Trial II, July cutting	92.11	58.56	86.26	53.1
Trial III, October cutting	91.29	46.43	68.39	35.2
Trial IV Biennial cutting	92.65	50.19	71.55	38.4
Trial V, Annual cutting ..	91.78	52.76	79.83	46.6

(a) The metabolizable energy in the biennial and annual cuttings of 1923 was determined by use of the oxygen bomb calorimeter. The metabolizable energy per pound of digestible organic matter was found to be 1.432 therms for the biennial cutting and 1.514 therms for the annual cutting. The average of these two values, 1.473, was used in estimating the metabolizable energy in trials I, II and III according to the method of Armsby (6, p. 648).

(b) The net energy was estimated by deducting the heat increment, 33.2 therms per 100 pounds of dry matter, from the metabolizable energy. This is the heat increment found by Armsby and Fries as revised by Forbes and Kriss (14).

The **net energy** of a feed is the energy that is available for **productive purposes** after all the expenditures or losses incident to the digestion and utilization of the feed have been deducted. The net energy values, therefore, furnish another method of comparing the relative values of feeds and rations.

According to the net energy system, the different hays, arranged in order of increasing energy values are; October cutting, 35.2; biennial, 38.4; April, 41.9; annual, 46.6 and July, 53.1 therms per 100 pounds of dry matter. This order differs from the arrangement on the basis of digestible nutrients, chiefly in placing the biennial cutting below the April cutting. Both comparisons show the July cutting highest in nutritive value with the annual cutting next in order.

The net energy values of the rations consumed in the several trials have been computed and are given in Table 17.

TABLE 17. ESTIMATED NET ENERGY IN RATIONS PER 1000 POUNDS LIVE WEIGHT

	Steers A-19 & A-22	Steers B-19 & B-22	Steers C-19 & C-22	Steers D-19 & D-22	Average
	Therms	Therms	Therms	Therms	Therms
Trial I, April cutting	5.39	5.50	5.09	5.19	5.29
Trial II, July cutting	11.55	11.50	11.36	12.15	11.64
Trial III, October cutting ..	5.96	6.21	5.41	6.76	6.09
Trial IV, Biennial cutting ..	4.84	5.52	3.39	4.67	4.61[a]
Trial V, Annual cutting	6.68	5.83	8.25	7.00	6.94

a Average, omitting steer C-22 is 5.01 therms.

On the basis of 6.0 therms of net energy per 1000 pounds live weight as the maintenance requirement, it is evident from Table 16 that on the April and biennial cuttings, none of the steers ate enough hay for full maintenance; that on the October cutting, one steer ate slightly less and the other three ate enough or slightly more than a maintenance ration; that on the annual cutting, one steer ate less and the other three somewhat more than the maintenance requirement; while on the July cutting, all the steers ate considerably more than was necessary simply for maintenance.

As previously stated, the Armsby standard specifies more net energy in proportion to live weight for cattle weighing less than 1000 pounds and since these steers ranged in weight from about 500 to nearly 900 pounds, it is obvious that the estimated maintenance requirement of 6 therms is low rather than too high.

When the rations are compared on the basis of net energy the results agree with the comparison on the basis of digestible nutrients, in showing, that the July cutting was the only hay that was eaten in sufficient amounts to furnish a material surplus for gains. Of the other hays, the amounts eaten were approximately sufficient for maintenance or less.

Obviously, differences in the palatability of the hays largely determined the consumption, and in turn, the adequacy or inadequacy of rations. In satisfying the energy needs, the palatability of the hays appears to be as important, if not more important, than the differences in their net energy values.

YIELDS OF HAY AND DIGESTIBLE NUTRIENTS IN ANNUAL AND BIENNIAL CUTTINGS

Since these digestion trials were made, considerable data have been collected at the Northern Great Plains Field Station on the yields of hay when the grasses are cut annually and when cut only once in two years or biennially. From the yields per acre the digestible crude protein and total digestible nutrients have been computed by using the digestion coefficients for the "annual" and "biennial" cuttings as determined in the digestion trials.

The data of Table 18 show great variation in the yields of hay from year to year. Furthermore, it is clear that the yield of hay from the plots cut only once in two years was usually twice, or more than twice, the yield obtained from the plots cut each year. The ratio of annual to biennial cutting, for the 11-year average, is 1:2.35; but extreme variations of 1:1 in 1927 and 1:16.6 in 1926 may be noted.

Due to the great variations in growth from year to year, the proportion of old growth residues in the biennial cuttings also varies and this, of course, in turn affects the palatability and nutritive value of the hays. In making the computations for the yields of digestible crude protein and total digestible nutrients, it has been

TABLE 18. ACRE YIELDS OF HAY, DIGESTIBLE CRUDE PROTEIN, AND TOTAL DIGESTIBLE NUTRIENTS
When cut annually and biennially

Year	Hay cut each year: Yield per acre (a)	Hay cut each year: Digestible Crude protein	Hay cut each year: Digestible Total nutrients	Hay cut once in 2 years: Yield per acre (a)	Hay cut once in 2 years: Digestible Crude protein	Hay cut once in 2 years: Digestible Total nutrients	Ratio annual to biennial 1:	Old growth (b)
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.		%
1921	308	8.2	146	610	14.6	281	1.98	29
1922	452	12.0	214	928	22.2	428	2.05	26
1923	247	6.6	117	660	15.8	304	2.67	45
1924	652	17.3	309	1385	33.1	639	2.12	34
1925	212	5.6	101	827	19.8	382	3.90	49
1926	29	.8	14	480	11.5	221	16.55	49
1927	628	16.7	298	655	15.7	302	1.04	27
1928	278	7.4	132	833	19.9	384	3.00	39
1929	172	4.6	82	568	13.6	262	3.30	36
1930	137	3.6	65	557	13.3	257	4.07	38
1931	232	6.2	110	348	8.3	161	1.50	29
Average	304	8.1	144	714	17.1	329	2.35	36.5

(a) Air dried weights. Yield is the average of three one-acre plots. Data from reports of Sarvis on the Cooperative Grazing Experiment: North Dakota Agricultural Experiment Station and United States Department of Agriculture.

(b) The percentage of old growth is based on the clipped quadrats which are cut at the same time as the hay land.

assumed, that all the hays were similar to the annual and biennial cuttings of 1923. It is realized that this is only approximately correct but it is, apparently, the best estimate that can be made from the available data.

The amounts of digestible protein produced per acre, on the average, are approximately the same under either system of haying but considerable variations are observed from year to year.

On the average, more digestible nutrients are produced when the grass is cut only once in two years than by cutting every year. This supports the view of farmers who believe they obtain more hay or feed from an acre of grass land by cutting only every two years and to this extent justifies the practice. It does not, however, take into account differences in palatability.

VALUE OF THE GRASSES FOR GRAZING

The results of the digestion trials apply only in part to grazing conditions. It has been estimated that 50 percent or more of the feed obtained by grazing cattle in the Plains region is furnished by certain species of grasses that are too short to be reached by the mower, or if cut by the mower, are too short to be gathered with an ordinary rake. Of these blue grama *(Bouteloua gracilis)* is the most important. Buffalo grass, *(Bulbilis dactyloides)* is similar to blue grama but is not important in Western North Dakota. Both of these grasses come on late in the spring, dry cure and give excellent late fall and winter pasturage.

The chemical composition of these two grasses and, for comparison, the composition of the July cutting is given in Table 19. The data include analyses of samples collected by Sarvis and analyzed at this Station together with analyses from other sources. All analyses have been calculated to a uniform moisture content of 15 percent.

TABLE 19. COMPOSITION OF BLUE GRAMA AND BUFFALO GRASS

Sample No.	Description	Moisture	Ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract
	Blue Grama	%	%	%	%	%	%
25–12–254	Before heading June 30	15.00	10.16	9.55	25.61	37.81	1.87
255	After heading July 20	15.00	9.40	9.75	23.69	40.33	1.83
227	Early bloom July 24	15.00	7.85	10.09	27.83	38.01	1.22
228	Past bloom Aug. 9	15.00	6.95	8.22	28.75	39.75	1.33
257	Past Bloom Aug. 22	15.00	9.03	7.40	26.35	40.11	2.11
21– 1–14	Early cutting	15.00	8.69	8.22	24.94	41.38	1.77
15	Late cutting	15.00	9.55	4.78	25.41	43.60	1.66
25–12–27	Growth to Aug. 3	15.00	9.67	6.23	25.05	42.22	1.83
	Analyses by others						
	Cut Sept. 10[1]	15.00	6.84	7.99	31.60	35.61	2.96
	Cut July 10[2]	15.00	7.39	7.74	26.69	41.33	1.85
	In bloom[3]	15.00	4.13	7.00	29.48	43.17	1.22
	Early bloom[4]	15.00	7.30	6.86	30.20	39.40	1.24
	Buffalo Grass						
25–12–230	Full bloom July 28	15.00	8.87	9.99	22.86	41.27	2.01
	Analyses by others						
	Average of 7[5]	15.00	8.93	6.25	21.50	46.53	1.79
	July cut Prairie hay	15.00	6.71	8.14	23.96	43.11	3.08

[1]Pammel, L. H., Weems, J. B., and Lamson-Scribner, F. Pasture and Meadow Grasses of Iowa. Iowa Agr. Expt. Sta. Bul. 56, 1901.
[2]Shepard, J. H., and Williams, T. A. Native and Introduced Forage Plants of S. Dak., S. Dak. Agr. Expt. Sta. Bul. 70, 1906.
[3]Knight, H. G., Hepner, F. E., and Nelson, Aven. Wyoming Forage Plants and Their Chemical Composition, No. 2, Wyo. Agr. Expt. Sta. Bul. 70, 1906.
[4]Knight, H. G., Hepner, F. E., and Nelson, Aven. Wyoming Forage Plants and Their Chemical Composition, No. 4, Wyo. Agr. Expt. Sta. Bul. 87, 1911.
[5]Griffiths, D., Bidwell, G. L., and Goodrich, C. E. Native Pasture Grasses of the United States. U. S. Dept. of Agr. Bul. 201 (Professional paper) 1915.

The samples of blue grama do not vary extremely in composition. The late cut sample gave the lowest percentage of crude protein. Buffalo grass is quite similar to blue grama in composition and both species are similar to the July cutting of prairie hay. It is seen in Table 19 that blue grama varies some with respect to stage of maturity, and that it dry cures without extreme changes in composition. Exposure to unfavorable weather conditions will, of course, reduce its value, depending on the severity of the exposure.

The coefficients of digestibility determined on the hays apply only approximately to the grasses eaten by cattle when grazing; because cattle will avoid certain of the less palatable and less digestible plants, unless forced to eat them on account of pasture shortage. It would seem likely, therefore, that the grasses actually eaten would probably have somewhat higher digestibility than is indicated by the results of the digestion tests.

Nevertheless the results of the digestion trials do have a direct bearing on the relative values of the grasses during the growing season, at maturity, and after weathering to a greater or less extent. The tests show that the grasses contain more crude protein during the earlier stages of growth than at maturity and that the grasses at this stage are more digestible. There is no evidence that the grasses are more nutritious at maturity than they are earlier in the season, in fact, our results indicate that the very opposite is true. Since the young succulent grasses carry more water than the more mature grasses, cattle must eat more pounds of green grass than of dry or nearly dry grass to obtain the same amounts of nutrients. Possibly, this is a factor which lends support to the belief that the matured grasses are more nutritious than the more succulent growth.

SUMMARY

1. Digestion trials were made on five different hays as follows:

- I. April cutting. Old dried grass of the previous season's growth cut before the new growth started.
- II. July cutting. Hay from grass cut at the height of the growing season.
- III. October cutting. Hay from grass cut at the close of the growing season, but also containing residues from previous years.
- IV. Biennial cutting. Hay from a plot cut only once in two years.
- V. Annual cutting. Hay from a plot cut every year.

2. Botanically, western needle grass, *Stipa comata*, made up from 50 to 75 percent of the grasses in the hay, by weight, and the other grasses and weeds from 25 to 50 percent. Some 50 or more species of plants may enter into the hay. Normally, about 50 percent of the hay by weight, consists of grasses and the remainder of other plants.

3. It has been estimated that the short grasses which do not enter into the hay furnish 50 percent or more of the feed for grazing cattle. Of these, blue grama, *Bouteloua gracilis*, is the most important and most palatable.

4. Of the grasses entering into the hay western needle grass is the most palatable.

5. Data are presented on the height of plants, and the chemical composition of several species of plants at different stages of

growth and maturity. These data show, among other things, that the grasses have a high protein content during the early growing stages which decreases toward maturity.

6. Marked differences in palatability of the hays were observed. Of the first three hays the July cutting was the most palatable, the October cutting was next and the April cutting the least palatable.

The annual cutting was more palatable than the biennial cutting but as different steers were used and the hays were cut in different years they cannot be directly compared with the other hays.

The "annual" cuttings of each year were more palatable than the other cuttings.

7. Due to the size of the inherent experimental errors in weighing cattle, particularly when applied to short periods of 1 or 2 weeks; irregularities in water drunk, and the mixed character of the results, no definite conclusions can be drawn from the apparent gains and losses in live weight as to the relative nutritive values of the hays.

8. The data on water drunk during the trials show generally rather uniform water consumption in proportion to the dry matter consumed. The average water drunk per pound of dry matter in the ration, by groups, was: April cutting, 2.7; July cutting, 2.7; October cutting, 2.0; biennial cutting, 2.7; and the annual cutting, 2.5 pounds. Similar, tho slightly higher figures are obtained when the water in the feed is included.

9. In chemical composition the April and October cuttings were similar. The October cutting contained slightly more ash, crude protein and ether extract, and slightly less crude fiber and nitrogen-free extract.

The July cutting differed from the foregoing chiefly in its higher content of protein and nitrogen-free extract, and its lower content of crude fiber.

The biennial and annual cuttings of 1923 were similar in composition. Both hays contained notably more crude protein than the April or October cuttings, but considerably less than the July cutting. In general, the percentages of the several nutrients in the two hays lie between those of the October and July cuttings.

10. The average percentage digestibility of the dry matter arranged in order of increasing digestibility of the different hays was: October, 45.33; April, 48.25; biennial, 50.06; annual, 52.61; and July, 59.72.

11. The percentage digestibility of the ash was negative in the April and October cuttings; negative with two steers and positive with two steers on each of the annual and biennial cuttings but was positive for all steers on the July cutting.

12. On the April and October cuttings all steers voided more ash materials than the feed contained: on the annual and biennial cuttings one-half of the steers showed retention of ash and the other half showed losses, but on the July cutting all steers showed ash retention.

13. Wide differences appear in the percentage digestibility of the crude protein in the different hays. The average coefficients arranged in order of increasing digestibility for the five hays are as follows: April, 0.0; October, 10.33; biennial, 37.96, annual, 41.10; and July, 50.99.

14. If the coefficients of digestibility of crude protein are corrected for "metabolic" nitrogen according to the methods of Mitchell or Titus, the differences largely disappear. The coefficients for the different cuttings, corrected according to Mitchell's method, are: April, 84.8; July, 81.6; October, 87.7; biennial, 81.6; annual, 83.9.

15. The digestibility of the crude fiber shows less variation than the crude protein, ranging from 55.38 in the biennial cutting to 65.55 percent in the July cutting.

16. The average coefficients of digestibility of the nitrogen-free extract arranged in increasing order are: October, 49.78; April, 54.38; biennial, 57.27; annual, 60.02; July, 66.98.

17. The coefficients of digestibility of the ether extract show large variations within the groups and among the groups. Arranged in order of increasing digestibility, by groups, they are: annual, 20.72; April, 32.06; July, 33.96; biennial, 38.87; October, 38.73.

18. The digestible crude protein per 100 pounds dry matter in the different cuttings was: April, 0.0; October, 0.43; biennial, 2.72; annual, 3.02; July, 4.88 pounds. Obviously weathering of the old growth reduced the digestible protein.

19. The "total digestible nutrients" per 100 pounds dry matter in the different cuttings were; October, 48.50; April, 52.26; biennial, 52.46; annual, 53.77 and July, 60.08 pounds.

20. The nitrogen balances show that all the steers gained nitrogen on the July cutting but lost nitrogen on all the other hays, except for a slight gain by C-22 on the annual cutting. Except on the July cutting the amounts of digestible protein consumed were less than the estimated requirements.

21. On the basis of Haecker's standard, the steers consumed less than a maintenance ration of the April and biennial cuttings, just a maintenance ration of the annual cutting, a little more than maintenance of the October cutting and considerably above maintenance of the July cutting.

22. Similar results are obtained by comparing the rations on the net energy basis and Armsby's standards, showing that only on the July cutting was enough feed eaten to permit material gains.

23. The yield of hay on the plots cut annually during seasons of 1921 to 1931 inclusive ranged from 29 pounds in 1926 to 652 in 1924 with an average of 304 pounds. On the plots cut only once in two years the yields ranged from 348 pounds in 1931 to 1385 pounds in 1924 with an average of 714 pounds.

24. The yield of digestible crude protein during the same period on the one-year units, ranged from 0.8 pound per acre in 1926 to 17.3 pounds in 1924 with an average of 8.1 pounds, and, on the two-year units, from 8.3 pounds in 1931 to 33.1 pounds in 1924 with an average of 17.1 pounds.

25. The yield of total digestible nutrients on the one-year units ranged from 14 pounds in 1926 to 309 pounds in 1924 with an average of 144 pounds, and on the two-year units, from 161 pounds in 1931 to 639 pounds in 1924 with an average of 329 pounds.

26. The ratio of annual to biennial cuttings, for the 11-year average was 1:2.35 but extremes of 1:1 in 1927 and 1:16.6 in 1926 occurred.

Over a period of years, therefore, somewhat more hay is obtained by cutting only once in two years, but the digestion trials and practical feeding tests show that the hay produced under the system of cutting biennially is less digestible and has lower palatability than the hay from the plots cut annually.

ACKNOWLEDGMENTS

The authors hereby express their appreciation and thanks to all who have contributed to the completion of this project. Professor J. H. Shepperd, as Chairman of the Department of Animal Husbandry, suggested the project and gave it wholehearted support. J. T. Sarvis, Associate Agronomist, in addition to furnishing the hays for the digestion trials furnished data on the vegetation and in other ways assisted in preparing the material for publication.

LITERATURE CITED

1. Sarvis, J. T., Personal communication July 23, 1925.
2. Sarvis, J. T.
   1923. Effects of different systems and intensities of grazing upon the native vegetation at the Northern Great Plains Field Station. U. S. Dept. Agr. Bul. 1170, 45 p. illus.
3. Sarvis, J. T.
   1920. Composition and density of the native vegetation in the vicinity of the Northern Great Plains Field Station. Jour. Agr. Research, Vol. 19, page 65.
4. Hopper, T. H. and Nesbitt, L. L.
   1930. The chemical composition of some North Dakota Pasture and hay grasses. N. Dak. Exp. Sta. Bul. 236.
5. Lush, J. L., Christensen, F. W., Wilson, C. V. and Black, W. H.
   1928. The accuracy of cattle weights. Jour. Agr. Res. 36.
6. Armsby, H. P.
   1917. The nutrition of farm animals, Macmillan.

7. Benedict, Francis G. and Ritzman, Ernest G.
   1923. Undernutrition in steers: Its relation to metabolism, digestion and subsequent realimentation. Carnegie Institution of Washington, Publication No. 324.
8. Mitchell, H. H.
   1926. The determination of the protein requirements of animals and of the protein values of farm feeds and rations. Bul. Natl. Res. Council, 11, pt. I, No. 55.
9. Titus, Harry W.
   1926. I. Crude fiber. The digestibility of rations containing varying amounts of alfalfa and paper pulp. New Mex. Exp. Sta. Tech. Bul. 153, p. 52.
10. Titus, Harry W.
   1927. The nitrogen metabolism of some steers on rations containing alfalfa as the sole source of nitrogen. Jour. Agr. Res. 31, pp. 49 - 58.
11. Mitchell, H. H.
   1929. The minimum protein requirement of cattle. Bul. 67, Natl. Res. Council.
12. Haecker, T. L.
   1918. Feeding dairy cows. Minn. Exp. Sta. Bul. 130. Revised and enlarged.
13. Hills, J. L.
   1922. The maintenance requirement of dairy cattle, Vt. Exp. Sta. Bul. 226.
14. Forbes, E. B. and Kriss, Max
   1925. Revised net energy values of feeding stuffs for cattle. Jour. Agr. Res. 31.

Appendix

Tables 20 to 26 inclusive

TABLE 20. DIGESTIBILITY OF PRAIRIE HAY, APRIL CUTTING—DIGESTION TRIAL I
Daily average for 10-day Period

	Fresh weight	Dry matter	Organic matter	Ash	Crude protein	Crude fiber	Nitrogen free extract	Ether extract
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
STEER A-19								
Feed	9.000	8.078	7.543	.535	.316	2.969	3.969	.290
Residue	1.176	.999	.858	.141	.056	.320	.458	.023
Total eaten	7.824	7.079	6.685	.394	.260	2.649	3.511	.267
Feces	14.093	3.540	2.830	.710	.251	.898	1.549	.133
Digested		3.539	3.855	....	.009	1.751	1.962	.134
Percentage Digestibility		49.99	57.67	....	3.46	66.10	55.88	50.19
STEER B-19								
Feed	9.000	8.078	7.543	.535	.316	2.969	3.969	.290
Residue	1.313	1.115	.961	.154	.063	.363	.507	.029
Total eaten	7.687	6.963	6.581	.381	.253	2.606	3.462	.261
Feces	13.470	3.567	2.930	.637	.252	.930	1.593	.155
Digested		3.396	3.651	....	.001	1.676	1.869	.106
Percentage Digestibility		48.77	55.48	....	0.40	64.31	53.98	40.61
STEER C-19								
Feed	8.000	7.180	6.705	.475	.281	2.639	3.528	.258
Residue	.534	.454	.385	.069	.030	.138	.201	.015
Total eaten	7.466	6.726	6.320	.406	.251	2.501	3.327	.243
Feces	14.195	3.704	3.138	.566	.261	1.063	1.594	.221
Digested		3.022	3.182	....	....	1.438	1.733	.022
Percentage Digestibility		44.93	50.35	....	....	57.50	52.09	9.05
STEER D-19								
Feed	8.000	7.180	6.705	.475	.281	2.639	3.528	.258
Residue	1.107	.940	.853	.087	.052	.334	.433	.034
Total eaten	6.893	6.240	5.852	.388	.229	2.305	3.095	.224
Feces	12.558	3.165	2.661	.504	.231	.888	1.374	.167
Digested		3.075	3.191	....	....	1.417	1.721	.056
Percentage Digestibility		49.28	54.53	....	....	61.48	55.57	25.00

TABLE 21. DIGESTIBILITY OF PRAIRIE HAY, JULY CUTTING—DIGESTION TRIAL II
Daily average for 10-day Period

	Fresh weight	Dry matter	Organic matter	Ash	Crude protein	Crude fiber	Nitro-gen free extract	Ether extract
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
STEER A-19								
Feed	16.000	14.992	13.809	1.183	1.436	4.226	7.603	.544
Residue	.066	.062	.046	.016	.007	.007	.029	.002
Total eaten		14.930	13.763	1.167	1.429	4.219	7.574	.542
Feces	25.726	5.706	4.773	.933	.681	1.365	2.398	.329
Digested		9.224	8.990	.234	.748	2.854	5.176	.213
Percentage Digestibility		61.78	65.32	20.05	52.34	67.63	68.34	39.30
STEER B-19								
Feed	15.000	14.055	12.946	1.109	1.346	3.962	7.128	.510
Residue	.241	.225	.174	.051	.024	.038	.106	.006
Total eaten		13.830	12.772	1.058	1.322	3.924	7.022	.504
Feces	23.073	5.468	4.565	.903	.625	1.290	2.295	.355
Digested		8.362	8.207	.155	.697	2.634	4.727	.149
Percentage Digestibility		60.47	64.26	14.65	52.72	67.12	67.32	29.56
STEER C-19								
Feed	15.000	14.055	12.946	1.109	1.346	3.962	7.128	.510
Residue	.061	.057	.046	.011	.006	.012	.027	.001
Total eaten		13.998	12.900	1.098	1.340	3.950	7.101	.509
Feces	27.976	5.995	4.996	.999	.707	1.508	2.449	.331
Digested		8.003	7.904	.099	.633	2.442	4.652	.178
Percentage Digestibility		57.17	61.27	9.02	47.24	61.82	65.51	34.97
STEER D-19								
Feed	15.000	14.055	12.946	1.109	1.346	3.962	7.128	.510
Residue	.141	.132	.110	.022	.019	.027	.061	.004
Total eaten		13.923	12.836	1.087	1.327	3.935	7.067	.506
Feces	27.698	5.661	4.705	.956	.646	1.358	2.356	.346
Digested		8.262	8.131	.131	.681	2.577	4.711	.160
Percentage Digestibility		59.34	63.35	12.05	51.32	65.49	66.66	31.62

TABLE 22. DIGESTIBILITY OF PRAIRIE HAY, OCTOBER CUTTING—DIGESTION TRIAL III
Daily average for 10-day Period

	Fresh weight	Dry matter	Organic matter	Ash	Crude protein	Crude fiber	Nitro-gen free extract	Ether extract
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
STEER A-19								
Feed	14.000	12.487	11.399	1.088	.519	4.482	5.840	.558
Residue	1.127	.949	.813	.136	.058	.264	.457	.034
Total eaten		11.538	10.586	.952	.461	4.218	5.383	.524
Feces	21.914	6.098	5.024	1.074	.417	1.695	2.588	.324
Digested		5.440	5.562	....	.044	2.523	2.795	.200
Percentage Digestibility		47.15	52.54	....	9.54	59.82	51.92	38.17
STEER B-19								
Feed	14.000	12.487	11.399	1.088	.519	4.482	5.840	.558
Residue	1.416	1.209	1.049	.160	.066	.372	.569	.042
Total eaten		11.278	10.350	.928	.453	4.110	5.271	.516
Feces	19.848	6.079	5.032	1.047	.403	1.728	2.595	.305
Digested		5.199	5.318	....	.050	2.382	2.676	.211
Percentage Digestibility		46.10	51.38	....	11.04	57.96	50.77	40.89
STEER C-19								
Feed	14.000	12.487	11.399	1.088	.519	4.482	5.840	.558
Residue	.685	.591	.500	.091	.033	.180	.267	.020
Total eaten		11.896	10.899	.997	.486	4.302	5.573	.538
Feces	25.501	7.127	5.909	1.218	.461	2.016	3.076	.356
Digested		4.769	4.990	....	.025	2.286	2.497	.182
Percentage Digestibility		40.09	45.79	....	5.14	53.14	44.80	33.83
STEER D-19								
Feed	14.000	12.487	11.399	1.088	.519	4.482	5.840	.558
Residue	2.805	2.345	2.078	.267	.108	.793	1.094	.083
Total eaten		10.142	9.321	.821	.411	3.689	4.746	.475
Feces	17.521	5.217	4.261	.956	.343	1.377	2.273	.268
Digested		4.925	5.060	....	.068	2.321	2.473	.207
Percentage Digestibility		48.56	54.29	....	16.54	62.67	52.11	43.58

TABLE 23. DIGESTIBILITY OF PRAIRIE HAY, BIENNIAL CUTTING—DIGESTION TRIAL IV
Daily average for 10-day Period

	Fresh weight	Dry matter	Organic matter	Ash	Crude protein	Crude fiber	Nitrogen free extract	Ether extract
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
STEER A-22								
Feed	14.000	12.312	11.407	.905	.882	4.030	5.924	.571
Residue	.837	.733	.696	.037	.037	.314	.327	.018
Total eaten	13.163	11.579	10.711	.868	.845	3.716	5.597	.553
Feces	18.543	5.754	4.951	.803	.513	1.666	2.416	.356
Digested		5.825	5.760	.065	.332	2.050	3.181	.197
Percentage Digestibility		50.31	53.78	7.49	39.29	55.17	56.83	35.62
STEER B-22								
Feed	14.000	12.312	11.407	.905	.882	4.030	5.924	.571
Residue	.452	.397	.381	.016	.021	.182	.170	.008
Total eaten	13.548	11.915	11.026	.889	.861	3.848	5.754	.563
Feces	20.362	5.760	4.948	.812	.522	1.680	2.408	.338
Digested		6.155	6.078	.077	.339	2.168	3.346	.225
Percentage Digestibility		51.66	55.12	8.66	39.37	56.34	58.15	39.96
STEER C-22								
Feed	8.000	7.035	6.518	.517	.504	2.303	3.385	.326
Residue	1.275	1.114	1.030	.084	.095	.341	.541	.054
Total eaten	6.725	5.921	5.488	.433	.409	1.962	2.844	.272
Feces	9.110	2.895	2.318	.578	.263	.801	1.104	.150
Digested		3.026	3.170	....	.146	1.161	1.740	.122
Percentage Digestibility		51.11	57.76	....	35.70	59.17	61.18	44.85
STEER D-22								
Feed	14.000	12.312	11.407	.905	.882	4.030	5.924	.571
Residue	1.803	1.526	1.433	.093	.118	.525	.740	.050
Total eaten	12.197	10.786	9.974	.812	.764	3.505	5.184	.521
Feces	20.530	5.668	4.831	.838	.488	1.668	2.352	.323
Digested		5.118	5.143	....	.276	1.837	2.832	.198
Percentage Digestibility		47.45	51.57	....	36.13	52.41	54.63	38.00

TABLE 24. DIGESTIBILITY OF PRAIRIE HAY, ANNUAL CUTTING—DIGESTION TRIAL V
Daily average for 10-day Period

	Fresh weight	Dry matter	Organic matter	Ash	Crude protein	Crude fiber	Nitrogen free extract	Ether extract
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
STEER A-22								
Feed	18.000	15.872	14.568	1.305	1.165	5.238	7.552	.613
Residue	3.150	2.617	2.146	.201	.195	.871	1.247	.104
Total eaten	14.850	13.255	12.152	1.104	.970	4.367	6.305	.509
Feces	26.201	6.432	5.275	1.157	.578	1.718	2.579	.401
Digested		6.823	6.877	....	.392	2.649	3.726	.108
Percentage Digestibility		51.47	56.59	....	40.41	60.66	59.10	21.22
STEER B-22								
Feed	12.000	10.582	9.712	.870	.777	3.492	5.035	.408
Residue	.530	.440	.414	.026	.029	.169	.199	.016
Total eaten	11.470	10.142	9.298	.844	.748	3.323	4.836	.392
Feces	19.097	4.696	3.800	.897	.449	1.231	1.831	.289
Digested		5.446	5.498	....	.299	2.092	3.005	.103
Percentage Digestibility		53.70	59.13	....	39.97	62.96	62.14	26.28
STEER C-22								
Feed	16.000	14.109	12.949	1.160	1.036	4.656	6.713	.545
Residue	1.119	.939	.874	.065	.061	.359	.424	.031
Total eaten	14.881	13.170	12.075	1.095	.975	4.297	6.289	.514
Feces	25.667	6.093	5.026	1.067	.550	1.604	2.475	.397
Digested		7.077	7.049	.028	.425	2.693	3.814	.117
Percentage Digestibility		53.74	58.38	2.56	43.59	62.67	60.65	22.76
STEER D-22								
Feed	16.000	14.109	12.949	1.160	1.036	4.656	6.713	.545
Residue	1.700	1.401	1.308	.093	.101	.500	.653	.054
Total eaten	14.300	12.708	11.641	1.067	.935	4.156	6.060	.491
Feces	26.184	6.130	5.105	1.025	.560	1.615	2.506	.424
Digested		6.578	6.536	.042	.375	2.541	3.554	.067
Percentage Digestibility		51.76	56.15	3.94	40.11	61.14	58.65	13.65

TABLE 25. COMPOSITION OF FEED RESIDUES AND FECES

Steer	Feed Residues A-19	Feed Residues B-19	Feed Residues C-19	Feed Residues D-19	Feces A-19	Feces B-19	Feces C-19	Feces D-19
	%	%	%	%	%	%	%	%
TRIAL I—APRIL CUTTING								
Moisture	15.07	15.07	15.07	15.07	74.88	73.52	73.91	74.80
Dry matter	84.93	84.93	84.93	84.93	25.12	26.48	26.09	25.20
Composition of dry matter								
Organic matter	85.86	86.23	84.78	90.76	79.94	82.15	84.73	84.07
Ash	14.14	13.77	15.22	9.24	20.06	17.85	15.27	15.93
Crude protein	5.61	5.60	6.61	5.48	7.08	7.07	7.05	7.30
Crude fiber	32.06	32.55	30.48	35.55	25.36	26.06	28.69	28.05
Nitrogen-free extract	45.86	45.47	44.35	46.09	43.74	44.67	43.03	43.42
Ether extract	2.33	2.61	3.34	3.64	3.76	4.35	5.96	5.30
Nitrogen	0.898	0.897	1.057	0.877	1.133	1.131	1.128	1.168
TRIAL II—JULY CUTTING								
Moisture	6.02	6.75	6.32	6.52	77.82	76.30	78.57	79.56
Dry matter	93.98	93.25	93.68	93.48	22.18	23.70	21.43	20.44
Composition of dry matter								
Organic matter	73.36	77.33	81.06	83.61	83.64	83.49	83.33	83.12
Ash	26.64	22.67	18.94	16.39	16.36	16.51	16.67	16.88
Crude protein	11.61	10.66	10.31	14.31	11.94	11.42	11.80	11.41
Crude fiber	11.77	16.83	21.15	20.59	23.92	23.60	25.15	23.98
Nitrogen-free extract	46.76	47.15	47.27	45.97	42.01	41.98	40.86	41.62
Ether extract	3.22	2.69	2.33	2.74	5.77	6.49	5.52	6.11
Nitrogen	1.857	1.705	1.649	2.289	1.910	1.827	1.888	1.826
TRIAL III—OCTOBER CUTTING								
Moisture	15.85	14.62	13.74	16.38	72.17	69.37	72.05	70.22
Dry matter	84.15	85.38	86.26	83.61	27.83	30.63	27.95	29.78
Composition of dry matter								
Organic matter	85.68	86.74	84.56	88.63	82.38	82.77	82.91	81.67
Ash	14.32	13.26	15.44	11.37	17.62	17.23	17.09	18.33
Crude protein	6.13	5.47	5.57	4.62	6.85	6.64	6.47	6.57
Crude fiber	27.87	30.75	30.41	33.83	27.79	28.43	28.28	26.40
Nitrogen-free extract	48.11	47.06	45.28	46.64	42.34	42.69	43.18	43.57
Ether extract	3.57	3.47	3.30	3.54	5.31	5.01	4.99	5.13
Nitrogen	0.981	0.785	0.891	0.740	1.095	1.062	1.035	1.051
Steer	**A-22**	**B-22**	**C-22**	**D-22**	**A-22**	**B-22**	**C-22**	**D-22**
TRIAL IV—BIENNIAL CUTTING								
Moisture	12.44	12.15	12.67	15.36	68.97	71.71	68.22	72.39
Dry matter	87.56	87.85	87.33	84.64	31.03	28.29	31.78	27.61
Composition of dry matter								
Organic matter	94.93	95.94	92.47	93.90	86.04	85.90	80.05	85.22
Ash	5.07	4.06	7.53	6.10	13.96	14.10	19.95	14.78
Crude protein	5.01	5.19	8.52	7.72	8.91	9.06	9.08	8.61
Crude fiber	42.82	45.80	30.58	34.41	28.96	29.17	27.67	29.42
Nitrogen-free extract	44.59	42.85	48.56	48.47	41.99	41.80	38.12	41.50
Ether extract	2.51	2.10	4.81	3.30	6.18	5.87	5.18	5.69
Nitrogen	0.802	0.831	1.363	1.235	1.426	1.449	1.453	1.378

TABLE 25. COMPOSITION OF FEED RESIDUES AND FECES (Continued)

Steer	Feed Residues A-19	Feed Residues B-19	Feed Residues C-19	Feed Residues D-19	Feces A-19	Feces B-19	Feces C-19	Feces D-19
	%	%	%	%	%	%	%	%
TRIAL V—ANNUAL CUTTING								
Moisture	16.93	17.06	16.08	17.59	75.45	75.41	76.26	76.59
Dry matter	83.07	82.94	83.92	82.41	24.55	24.59	23.74	23.41
Composition of dry matter								
Organic matter	92.33	94.09	93.06	93.38	82.01	80.91	82.49	83.28
Ash	7.67	5.91	6.94	6.62	17.99	19.09	17.51	16.72
Crude protein	7.46	6.69	6.50	7.24	8.98	9.55	9.03	9.14
Crude fiber	33.27	38.54	38.17	35.70	26.71	26.22	26.33	26.34
Nitrogen-free extract	47.64	45.18	45.12	46.58	40.09	38.98	40.62	40.88
Ether extract	3.96	3.68	3.27	3.86	6.23	6.16	6.51	6.92
Nitrogen	1.194	1.071	1.040	1.159	1.437	1.528	1.445	1.463

TABLE 26. WEIGHTS AND NITROGEN CONTENT OF FRESH FECES AND URINES Daily Averages

	FECES Total	FECES Nitrogen	FECES Nitrogen	URINE Total[1]	URINE Nitrogen	URINE Nitrogen
	Lbs.	%	Lbs.	Lbs.	%	Lbs.
TRIAL I—APRIL CUTTING						
Steer A-19	14.093	0.285	0.0402	6.320	0.518	0.0327
Steer B-19	13.470	0.300	0.0404	6.220	0.555	0.0345
Steer C-19	14.195	0.294	0.0417	3.681	0.759	0.0279
Steer D-19	12.558	0.294	0.0369	2.450	1.164	0.0285
TRIAL II—JULY CUTTING						
Steer A-19	25.726	0.424	0.1091	11.959	0.829	0.0991
Steer B-19	23.073	0.433	0.0999	10.636	0.854	0.0908
Steer C-19	27.976	0.405	0.1133	11.828	0.773	0.0914
Steer D-19	27.698	0.373	0.1033	10.723	0.749	0.0803
TRIAL III—OCTOBER CUTTING						
Steer A-19	21.914	0.305	0.0668	7.856	0.416	0.0327
Steer B-19	19.848	0.325	0.0645	6.675	0.484	0.0323
Steer C-19	25.501	0.289	0.0737	4.879	0.629	0.0307
Steer D-19	17.521	0.313	0.0548	6.653	0.417	0.0277
TRIAL IV—BIENNIAL CUTTING						
Steer A-22	18.543	0.443	0.0821	12.664	0.593	0.0751
Steer B-22	20.362	0.410	0.0835	20.239	0.380	0.0769
Steer C-22	9.110	0.462	0.0421	17.380	0.349	0.0607
Steer D-22	20.530	0.381	0.0782	15.625	0.390	0.0609
TRIAL V—ANNUAL CUTTING						
Steer A-22	26.201	0.353	0.0925	7.789	1.001	0.0780
Steer B-22	19.097	0.376	0.0718	13.048	0.397	0.0518
Steer C-22	25.667	0.343	0.0880	10.326	0.558	0.0576
Steer D-22	26.184	0.343	0.0898	7.463	0.825	0.0616

[1]Corrected for any urine spilled and collected in drip pans under stalls.