John B. Rogers

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The Chemical Composition of Some North Dakota Pasture and Hay Grasses

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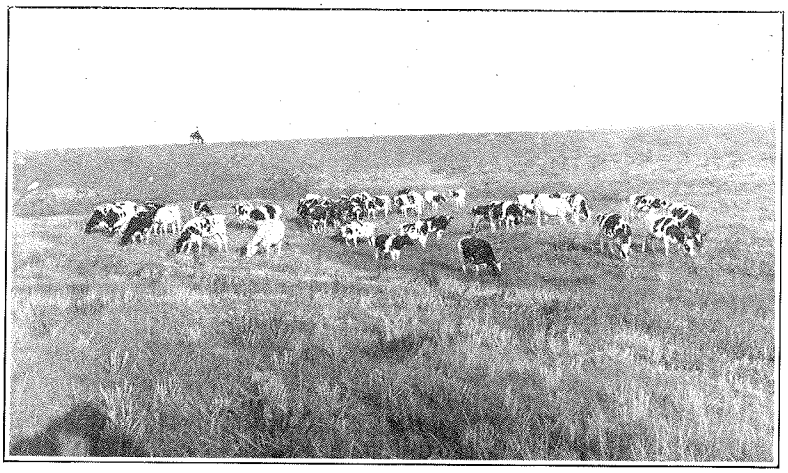

AGRICULTURAL EXPERIMENT STATION
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The Chemical Composition of Some North Dakota Pasture and Hay Grasses

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The grasses and grass-like forage plants have always been, are, and will continue to be an economic source of feed for live stock, when utilized as pasturage and hay. Leguminous plants, alfalfa and clover, because of their high protein content and of their nitrogen fixing characteristics, have replaced grasses as roughage for most types of live stock, tho, for horses and mules hay from grasses is usually preferred.

VALUE OF ANALYSES

In a study of the cultivation, management, and utilization of the different species of grasses, their chemical characteristics are important. The chemical analyses of feeds are used in the calculation of rations, and are relied upon by investigators in carrying out feeding, digestion, and metabolism experiments, and in the comparative studies of different feeding stuffs and their combinations in an animal's ration. They do not show all that may be desired, but when considered in connection with the facts covering the physical characteristics of the feed studied, and the possible presence of some chemical substances which may cause the feed to be unpalatable or to be poisonous to animals, they are important and enable one to make a rational comparison.

The standard feeding stuff analysis consists of the determinations of moisture, ash, crude protein, ether extract (crude fat), crude fiber, and nitrogen-free extract. The last two, crude fiber and nitrogen-free extract, are the carbohydrates, or starch-like substances of the feed. The coarser feeds, hay, straw, silage, and fodder, are high in percentage of crude fiber and low in their percentage of digestible matter, when compared with concentrates, such as grain feeds, which are of a condensed nature. In general, the higher the crude protein content, and the lower the crude fiber content, the higher is the value of a feed. Feeds of high value are commonly referred to as having narrow nutritive ratios.

Mature grasses and the hays made from them have wide nutritive ratios, and require a high protein feed to supplement them in a ration, so that sufficient protein will be available to meet the animal's requirements for production, reproduction, and growth. The young succulent grass which the animal

obtains from a heavily or a moderately grazed pasture has a narrow nutritive ratio and should be supplemented with starchy feeds such as cereal grains. The nutritive ratio is the ratio or proportion between the digestible protein and the combined digestible carbohydrates and fats, in which case the digestible fats are calculated to a carbohydrate equivalent basis (digestible fats x 2.25).

The greatest effect of a high crude fiber content is to reduce the digestibility of the feed, which essentially means that larger losses occur in the feces. Feeds that have a low digestibility have a low net energy value. The net energy of a feed is the energy remaining after all the losses have been deducted, that is, the losses occurring in the excreta (feces, urine, and combustible gases), and in the work of digestion (mastication, digestion, and assimilation). The net energy value of corn meal, timothy hay, and wheat straw is given (7) as 82.9, 43.0, and 10.1 therms, respectively. The average crude fiber content of these feeds is 2.0, 29.8 and 37.4 percent, respectively.

VARIATIONS IN COMPOSITION

The chemical composition, and consequently the nutritive value of grasses, like other plants, is known to vary widely. The variations are due to a number of factors, such as the species, stage of maturity, seasonal variations, fertility of the soil, elevation, and moisture content.

INFLUENCE OF SPECIES

Different species of grasses and grass-like plants have characteristically different chemical compositions. These depend on the inherent nature and to some extent upon the physical character of the plant. The larger the percentage of leaf to stem, the more favorable is the composition. The fineness and abundance of the bottom growth improves both the composition and quality. The leaf has a higher nutritive value than the stem.

INFLUENCE OF MATURITY

Probably the factor that influences the composition of a plant the most is the stage of its maturity when harvested. It is a well known fact that certain progressive changes in composition are incident to advancement in maturity. As ripening approaches the moisture content decreases and the dry substance content increases accordingly. In the dry substance the percentage of crude protein decreases, the percentage of crude fiber increases, the percentage of nitrogen-free extract generally increases, and the percentages of ash and ether extract (crude fat) remain about the same, altho they may be variable.

The best time to cut grass for hay is a few days after it has reached the stage of maximum flowering and before the seeds begin to form. At this stage the grass yields the greatest return of digestible nutrients per acre. A delay causes a deterioration in quality and possibly in quantity. To be sure, the quality of an earlier cut hay should be higher but the yield of digestible nutrients is not generally so large. The yields of dry matter and of digestible nutrients of timothy cut at different stages as reported by the Missouri Station (21) are given in Table 1.

TABLE 1. YIELDS OF TIMOTHY CUT AT DIFFERENT STAGES OF GROWTH (21).

Stage of maturity	Dry matter per acre	Digestible Nutrients per Acre			
		Crude protein	Carbohydrates	Crude fat	Total digestible matter
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Coming into blossom	3,411	135	1,676	43	1,908
Full bloom	3,964	147	1,867	44	2,113
Seed formed	4,089	113	1,802	51	2,030
Seed in dough	4,038	98	1,695	54	1,914
Seed ripe	3,747	92	1,576	38	1,754

The composition and characteristics of timothy, a typical and important grass, have been studied thoroly by the Missouri (19,21) and other stations. The average analyses of timothy (7) calculated to a uniform hay moisture content at several of its stages of growth are shown in Table 2.

For purposes of comparison all the analyses of grasses presented here are calculated to an air dry hay basis of a moisture content of 15 percent.

TABLE 2. COMPOSITION OF TIMOTHY AT DIFFERENT STAGES OF GROWTH (7).
(Calculated to contain 15 percent moisture)

No. of analyses	Stage of maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
7	Before bloom	15.00	6.04	8.98	2.93	25.74	41.31
50	Early full bloom	15.00	4.48	6.14	2.53	28.76	43.09
21	Late bloom to early seed	15.00	4.49	5.49	2.80	28.27	43.95
28	Nearly ripe	15.00	4.18	5.05	2.14	29.82	43.81
3	Rowen (aftermath)	15.00	6.91	14.42	4.40	24.33	34.93

The usual changes in composition with maturity are observed. As might be expected the rowen (second cutting, aftermath), containing a large proportion of young succulent bottom growth, contained a high percentage of crude protein and a low percentage of crude fiber.

The composition, of brome, slender wheat, and crested wheat grass at different stages of maturity is given in Tables 3, 4 and 5. The samples of these three grasses were from some clipping experiments conducted by Leroy Moomaw, Superintendent of the Dickinson Substation at Dickinson, North Dakota, during the 1928 season.

TABLE 3. COMPOSITION OF BROME GRASS AT DIFFERENT STAGES OF GROWTH.
(Hay basis—15 percent moisture)

Lab. No.	Date cut	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
28-11-57	April 10	15.00	10.18	11.02	1.51	27.00	35.29
58	April 25	15.00	8.98	13.23	1.99	24.16	36.64
59	May 10	15.00	11.87	18.51	2.75	20.43	31.44
60	May 25	15.00	10.83	19.93	2.87	19.71	31.66
61	June 10	15.00	6.14	14.57	2.43	22.89	38.97
62	June 25	15.00	9.96	11.94	2.24	22.92	37.94
63	July 10	15.00	8.05	11.68	2.20	26.63	36.44
64	July 25	15.00	5.71	9.20	1.97	24.80	43.32
65	Aug. 10	15.00	6.14	8.98	2.18	21.37	46.33

TABLE 4. COMPOSITION OF SLENDER WHEAT GRASS AT DIFFERENT STAGES OF GROWTH.
(Hay basis—15 percent moisture)

Lab. No.	Date cut	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
28-11-31	April 10	15.00	9.30	9.68	1.28	31.78	32.96
32	April 25	15.00	9.49	11.00	1.59	29.50	33.42
33	May 10	15.00	12.10	15.72	2.17	24.62	29.85
34	May 25	15.00	8.92	18.11	3.52	22.74	31.73
35	June 10	15.00	6.60	12.94	2.84	24.28	38.34
36	June 25	15.00	6.32	12.60	2.25	25.97	37.56
37	July 10	15.00	7.86	9.93	1.92	29.38	35.91
38	July 25	15.00	5.64	8.72	1.92	28.79	39.93
39	Aug. 10	15.00	5.80	6.31	2.12	30.27	40.50

TABEL 5. COMPOSITION OF CRESTED WHEAT GRASS AT DIFFERENT STAGES OF GROWTH.
(Hay basis—15 percent moisture)

Lab. No.	Date cut	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
28-11- 1	April 10	15.00	8.84	15.86	2.01	27.39	30.90
2	April 25	15.00	9.46	19.06	2.01	22.94	31.53
3	May 10	15.00	10.25	21.01	3.10	21.16	29.48
4	May 25	15.00	8.02	18.82	2.64	22.92	32.60
5	June 10	15.00	5.47	12.26	2.48	26.94	37.85
6	June 25	15.00	4.79	12.60	2.44	25.52	39.65
7	July 10	15.00	5.59	9.76	1.90	25.81	41.94
8	July 25	15.00	5.49	9.78	2.16	25.43	42.14
9	Aug. 10	15.00	5.25	9.05	2.27	25.61	42.82

The composition of the early cuttings of these grasses is influenced somewhat by the aftermath from the previous season's growth, as indicated by the protein and fiber contents of the samples collected on April 10. The composition of the late cuttings is influenced somewhat by the bottom growth which develops as the plant ripens its seeds. All three species reached the stage of highest nutritive value in May. They then attained their highest content of crude protein and their lower content of crude fiber.

The sugars in feeds are customarily included in the nitrogen-free extract in a feeding stuff analysis. By some students, a high sugar content is considered as enhancing the palatability of a feed. At maturity, when the content of crude fiber and higher forms of carbohydrates, such as starches increases, the percentage of sugar, both total and reducing, decreases. The percentages of these sugars in four species of grasses at three stages of growth are given in Table 6, calculated on the moisture free or dry basis.

TABLE 6. SUGAR CONTENT OF GRASSES.
(Calculated on the dry basis as dextrose)

Grass	Total sugars			Reducing sugars		
	Before heading	In blossom	Seeds ripe	Before heading	In blossom	Seeds ripe
	%	%	%	%	%	%
Brome	11.07	7.98	4.22	6.67	3.65	2.06
Timothy	13.56	7.77	3.80	8.52	5.60	1.49
Western wheat	8.22	4.14	4.83	5.35	2.41	1.50
Slender wheat	9.30	4.73	2.87	6.84	3.49	1.34
Average	10.54	6.16	3.93	6.84	3.79	1.60

It is reasonable to assume that the high sugar content of the younger grass is one of the factors that renders it more palatable and improves the quality of the hay made from the immature plant. Because of the solubility and ease with which it is fermented much of the sugar may be lost in curing grasses for hay under unfavorable conditions.

INFLUENCE OF GRAZING

The more heavily grasses are grazed, the leafier they become, and the greater is their value as a feed in so far as their chemical composition is an indication. Close grazing reduces the yield of dry matter, but that which is obtained is of a superior composition and higher value.

Several investigators have conducted clipping trials on grasses, aimed to represent the effects of grazing by clipping the grasses at regular intervals.

The results obtained at the Michigan Station by Crozier (2) indicates that the percentage of crude protein in the hay from the frequently cut grass is approximately three times as great as that in the nearly mature grass. But when the grass was not cut until it was approaching maturity it yielded the largest total amount of crude protein and almost four times as much dry matter.

Trials with 15 grasses conducted by Wolfe (22) indicated that the yield as pasture was from 40 to 65 percent of the yield when the grasses were cut in the usual manner for hay.

Ellett and Carrier (4) found that yields from permanent blue grass sod varied inversely with the number of times the grass is cut during the growing season. They concluded that the decrease in the percentage of protein when grass is allowed to mature is sufficient to more than counterbalance the increase in the weight of dry matter; and that the increase in weight of mature grass over frequently clipped grass must be crude fiber and other nitrogen-free substances. The data of their trials are given in Table 7.

TABLE 7. EFFECT OF CLIPPING ON THE YIELD OF PERMANENT BLUE GRASS SOD (4).

No. of plots	Frequency of cutting	Total air dry substance	Average crude protein	Total crude protein
		Pounds	%	Pounds
1	Every 7 days	111.3	15.58	17.4
3	Every 10 days	112.9	14.84	16.8
2	Every 20 days	114.9	14.43	16.6
1	Every 30 days	138.4	12.67	17.9
1	Once a year	197.2	8.25	16.3

Similar results have been obtained by Schutt (18) and his associates. The data of their trials are given in Table 8.

TABLE 8. INFLUENCE OF FREQUENT CUTTING OF GRASS, CHIEFLY MEADOW FOXTAIL (18).

Frequency of cutting	Total yield of dry matter	Total yield of crude protein	Crude protein	Crude fiber
	Pounds	Pounds	%	%
Every week	2918	439	21.20	19.38
Every 2 weeks	3344	466	18.60	20.50
Every 3 weeks	4304	571	17.17	22.06
Once a year	5311	520	10.16	28.65

Woodman and his associates (23-24-25) have conducted a thoro investigation of the nutritive value of grasses. They found the frequently cut grass to be characterized by containing a high percentage of crude protein and a low percentage of crude fiber in comparison with hay. The yields obtained by cutting the grass for hay at the proper time were more than twice that obtained by the system of frequent clipping, representing pasturing. The seasonable production of digestible protein and nutritive matter was calculated in terms of starch equivalent. They found that altho for hay the hay produced a greater weight of dry matter per acre, the weight of starch equivalent thus obtained was no greater than that obtained in the frequent cuttings from the pasture plot.

Woodman and his associates also conducted digestion trials with sheep on their clippings of grass. They found that in the frequently cut grass 80 percent of the organic matter was digestible, indicating in respect to digestibility, that well grazed grass compares favorably with concentrates, and is far superior to meadow hay of best quality. The digestion coefficient of the crude fiber in the closely grazed grass was approximately 80 percent, a value just slightly lower than the corresponding value for the carbohydrate in the grass.

The effect of clipping on the composition of three species namely, brome, slender wheat, and crested wheat grass, is shown in Tables 9, 10, and 11, which give the analysis of the samples from the grass clipping trials conducted by Moomaw. In these trials the grass plots were clipped on the 10th and 25th of the months of the growing season. A complete report of the experiments will be given in another publication. The analysis in any instance is that of the growth made between the date of the cutting and that of the previous cutting.

TABLE 9. COMPOSITION OF BROME GRASS FROM CLIPPED PLOTS.
(Hay basis—15 percent moisture)

Lab. No.	Date of cutting	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
28-11-57	April 10	15.00	10.18	11.02	1.51	27.00	35.29
66	April 25	15.00	9.46	22.36	2.64	16.97	33.57
67	May 10	15.00	11.53	26.49	4.07	16.37	26.54
68	May 25	15.00	10.87	24.61	3.17	19.38	26.97
69	June 10	15.00	7.93	22.87	2.39	20.71	31.10
70	June 25	15.00	18.89	23.31	2.29	17.60	22.91
71	July 10	15.00	21.60	20.36	2.40	18.28	22.36
72	July 25	15.00	10.62	22.86	3.45	19.08	28.99
73	Aug. 10	15.00	11.08	22.98	2.98	17.08	30.88
74	Aug. 25	15.00	7.93	26.19	2.98	15.47	32.43
75	Sept. 10	15.00	8.50	28.03	2.67	15.87	29.93
76	Sept. 25	15.00	8.49	24.76	3.45	14.95	33.35

TABLE 10. COMPOSITION OF SLENDER WHEAT GRASS FROM CLIPPED PLOTS.
(Hay basis—15 percent moisture)

Lab. No.	Date of clipping	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
28-11-31	April 10	15.00	9.30	9.68	1.28	31.78	32.96
40	April 25	15.00	9.38	23.32	2.61	19.30	30.39
41	May 10	15.00	10.68	27.21	3.96	17.50	25.65
42	May 25	15.00	9.15	24.54	3.47	20.39	27.45
43	June 10	15.00	8.43	21.59	2.88	20.26	31.84
44	June 25	15.00	10.34	23.72	2.06	20.42	28.46
45	July 10	15.00	16.86	24.16	3.35	17.73	22.90
46	July 25	15.00	10.35	21.25	3.52	20.86	29.02
47	Aug. 10	15.00	8.63	18.90	3.14	22.48	31.85
48	Aug. 25	15.00	10.04	18.72	3.32	21.44	31.48
49	Sept. 10	15.00	8.37	20.95	4.35	19.79	31.54
50	Sept. 25	15.00	9.57	22.18	3.08	18.41	31.76

TABLE 11. COMPOSITION OF CRESTED WHEAT GRASS FROM CLIPPED PLOTS.
(Hay basis—15 percent moisture)

Lab. No.	Date of clipping	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
28-11- 1	April 10	15.00	8.84	15.86	2.01	27.39	30.90
10	April 25	15.00	9.60	25.16	2.72	19.45	28.07
11	May 10	15.00	9.94	27.43	4.47	18.54	24.62
12	May 25	15.00	9.44	24.79	2.44	20.97	27.36
13	June 10	15.00	8.64	21.88	1.78	21.20	31.50
14	June 25	15.00	10.27	28.73	2.65	19.92	23.43
15	July 10	15.00	19.12	20.88	2.31	19.77	22.92
16	July 25	15.00	10.89	27.87	2.84	18.98	24.42
17	Aug. 10	15.00	9.51	24.24	3.20	18.48	29.57
18	Aug. 25	15.00	9.70	24.50	3.48	18.02	29.30
19	Sept. 10	15.00	8.54	25.91	3.76	18.34	28.45
20	Sept. 25	15.00	9.81	24.75	3.42	17.97	29.05

Comparison of the data in Tables 9, 10, and 11 with that in Tables 3, 4 and 5 indicates the same conclusion arrived at by others, that frequent clipping, representing grazing, maintains a young succulent grass growth that is high in crude protein content and low in crude fiber content. The effect of clipping on the percentage content of ash, crude protein, crude fiber, and nitrogen-free extract is shown in Figures 1, 2, 3 and 4, in which the values given in Tables 3, 4 and 5 for the unclipped grasses, and in Tables 9, 10, and 11 for the clipped grasses are represented graphically.

It may be seen that in the frequently clipped grasses the ash content is generally higher. During the rainy part of the season, when a rapid growth occurred, accompanied by a high rate of respiration, it is noted that there was a high accumulation of ash or mineral matter in the frequently clipped grasses. The highest ash content, 21.60 percent, was found in the brome grass, on July 10.

The percentage of protein in the frequently clipped grasses averaged approximately twice that in the unclipped. This is what one would expect since the growth on the frequently clipped plots was young and succulent, and being less abundant would have more soil nitrogen available in proportion to the yield than the crop on the unclipped plots. Also, the percentage of protein in a grass plant decreases as maturity is approached.

The grass obtained from the frequently clipped plots uniformly contained a lower crude fiber percentage content than that harvested from the unclipped plots. As a grass plant matures the percentage content of crude fiber increases.

The percentage of nitrogen-free extract content in the grass from the unclipped plots was uniformly higher than that in the grass from the frequently clipped plots. As the grass from the clipped plots contained a larger percentage of crude protein, somewhat less crude fiber, and about the same percentages of ash and ether extract, the percentage of nitrogen-free extract should be less than that in the grass from the unclipped plots. The percentages of all constituents must add up to 100 percent.

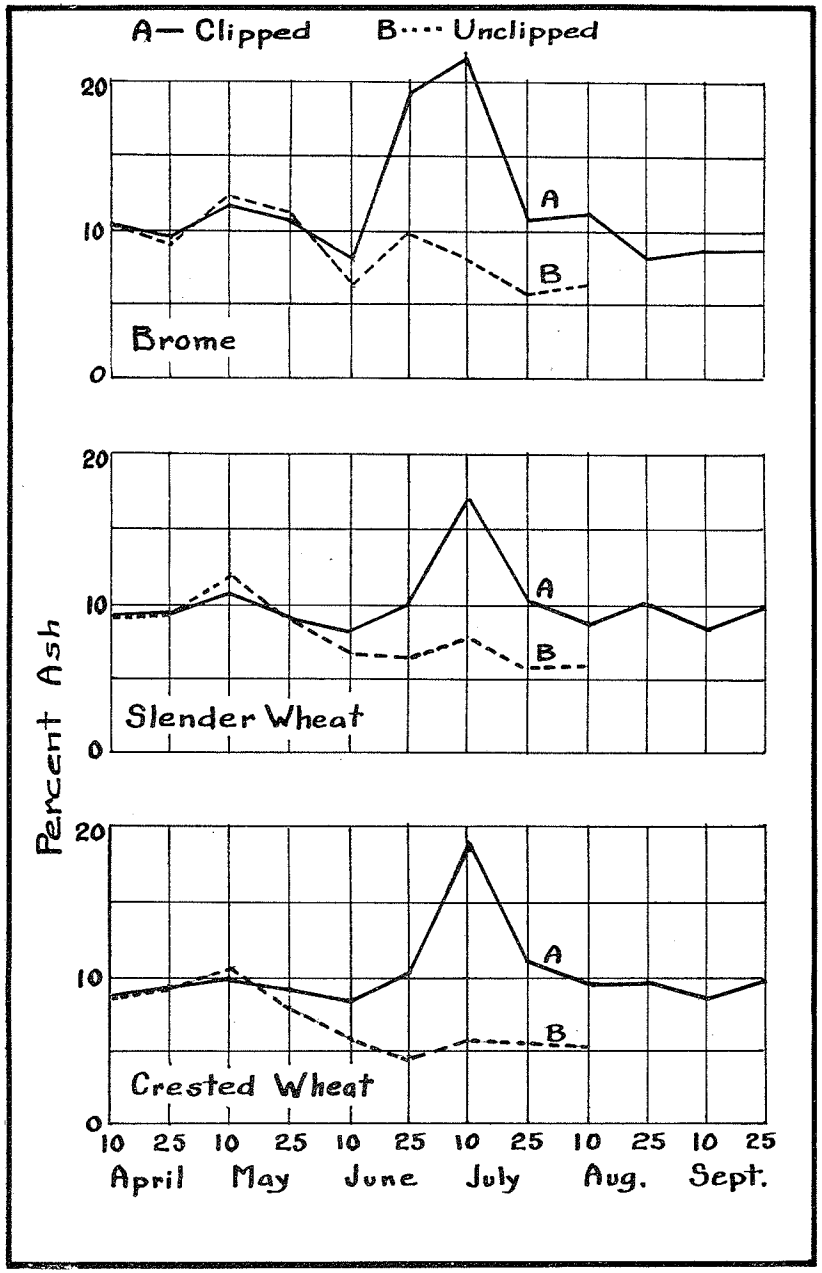

Figure 1. Effect of clipping on the ash content of grasses.

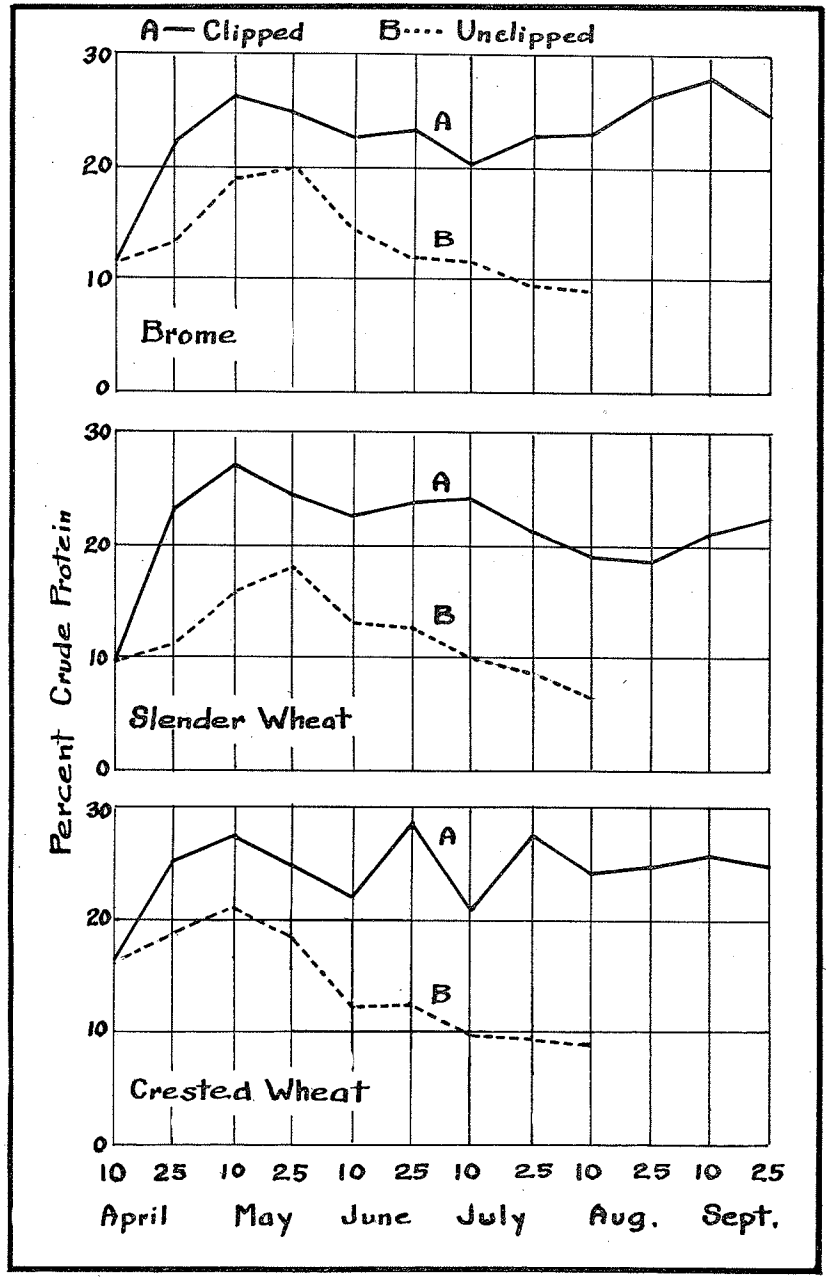

Figure 2. Effect of clipping on the protein content of grasses.

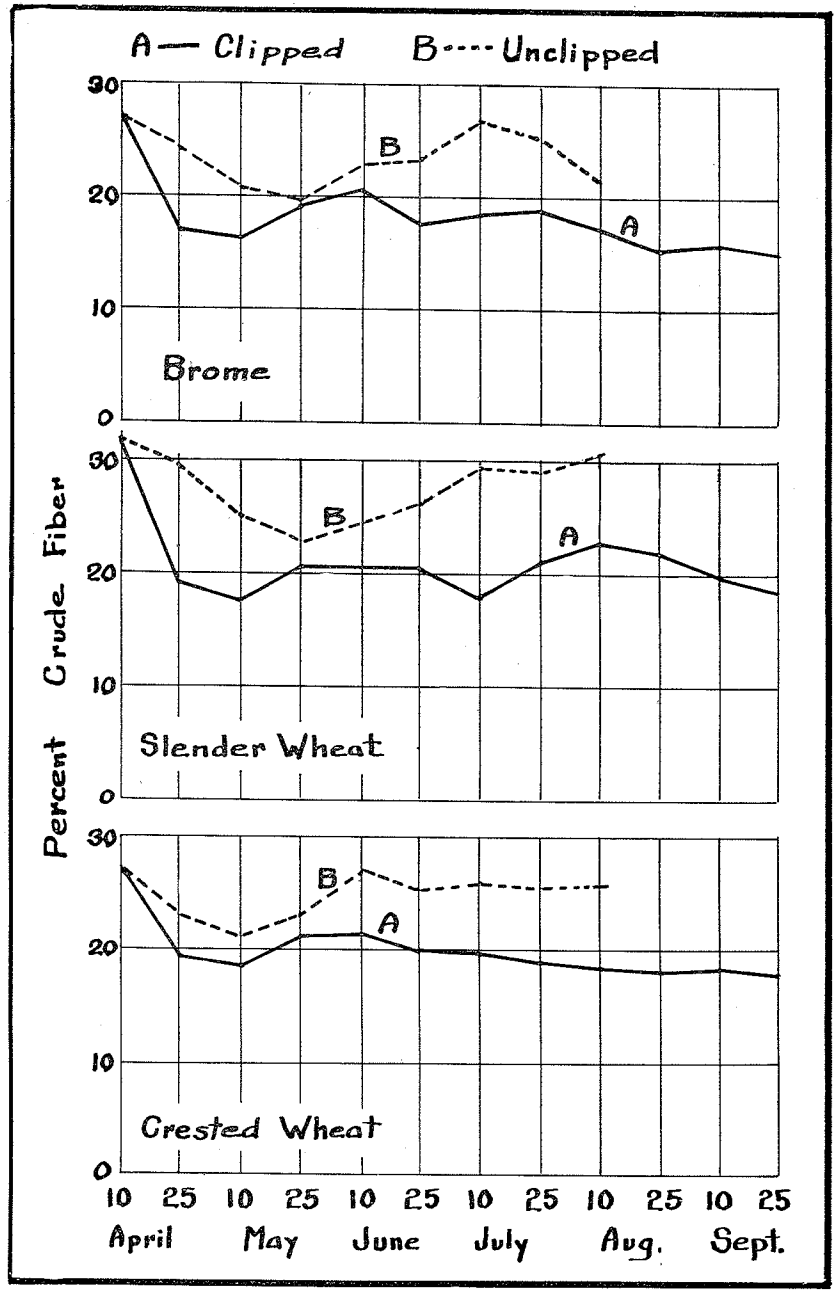

Figure 3. Effect of clipping on the crude fiber content of grasses.

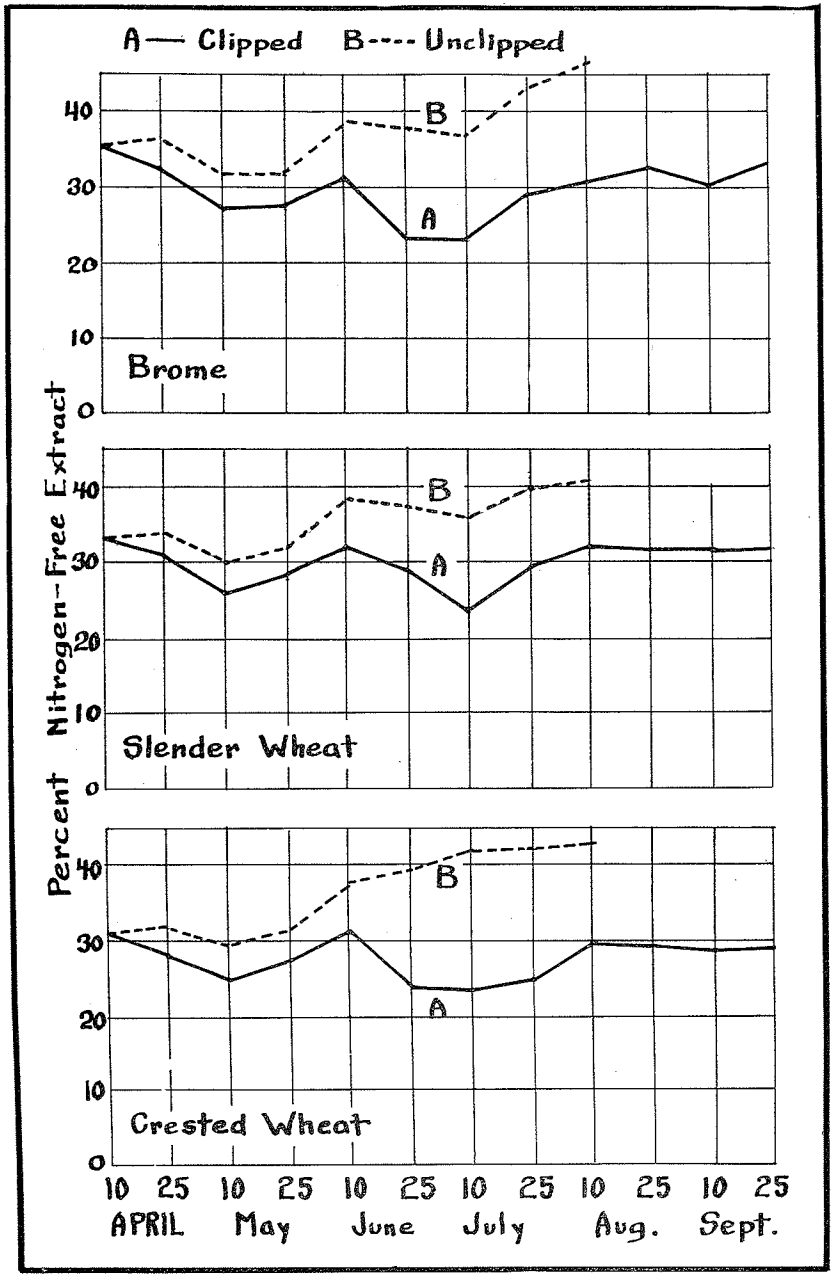

Figure 4. Effect of clipping on the nitrogen-free extract content of grasses.

The grass that an animal obtains from a closely or moderately grazed pasture has a narrow nutritive ratio, has a high digestibility, and may be considered a "watered" high protein concentrate. Its feeding value is really higher than generally assumed. On account of its low content of indigestible fiber, it should not be classed with the coarse fodders. As it provides an unbalanced ration, it should be supplemented (24) with some substance, like cereals, which are high in digestible carbohydrates.

INFLUENCE OF STRAIN

By selection and breeding it is possible to obtain strains of grasses of a given species which have improved characteristics. Strains of brome grass and their characteristics have been studied by Waldron of this Station (20). Two of the strains (A clone 14.24 and B clone 23.3B), which had quite different physical and chemical characteristics, are shown in Figure 5. Marked differences are noted in the tillering habits and in the amount and character of the foliage.

Marked differences in the chemical composition at the blossom stage of maturity of these two strains occurred as is shown in Table 12. Strain B was decidedly higher in percentage of ash and crude protein and lower in percentage of crude fiber. This is accounted for by the quantity and quality of the bottom growth. Strain B with the higher percentage of ash had uniformly the higher content of the principal ash or mineral constituents (Table 13).

TABLE 12. COMPOSITION OF TWO STRAINS OF BROME GRASS.
(Hay basis—15 percent moisture)

Lab. No.	Year	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
Strain A (clone 14.24)							
20- 7- 2	1919	15.00	6.86	6.08	1.67	33.29	37.10
21- 8-13	1921	15.00	7.43	7.03	1.81	32.14	36.59
	Average	15.00	7.14	6.56	1.74	32.72	36.84
Strain B (clone 23.3B)							
20- 7- 7	1919	15.00	10.06	13.59	2.39	26.46	32.50
20- 6-149	1920	15.00	10.32	12.06	1.50	23.99	37.13
21- 8-19	1921	15.00	10.90	11.52	2.40	28.15	32.03
	Average	15.00	10.43	12.39	2.10	26.20	33.88

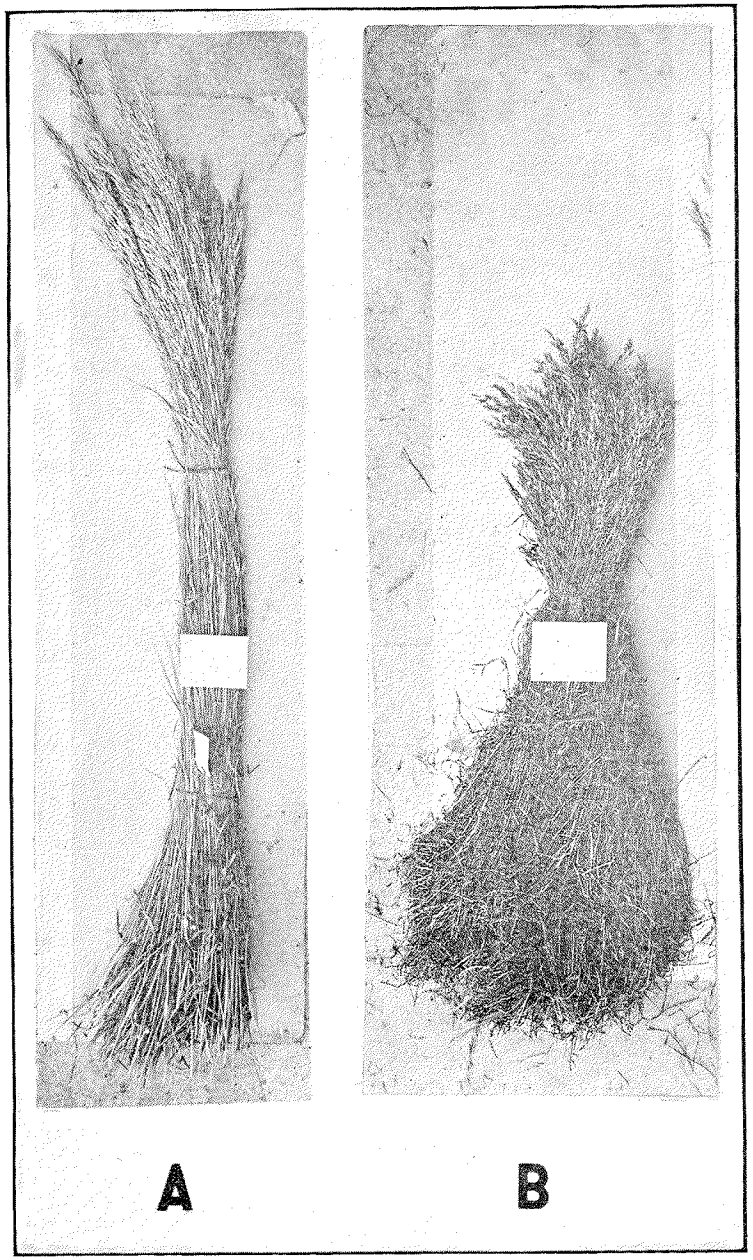

Figure 5. Two strains of brome grass.

TABLE 13. ASH OF MINERAL CONSTITUENTS IN TWO STRAINS OF BROME GRASS. (Hay basis—15 percent moisture)

Lab.No.	Year	Phosphoric acid (P_2O_5)	Potash (K_2O)	Soda (Na_2O)	Lime (CaO)	Magnesia (MgO)	Sulfur trioxide (SO_3)
		%	%	%	%	%	%
Strain A (clone 14.24)							
20-7-2	1919	.444	3.070	.541	.180	.234	.081
21-8-13	1921	.462	1.975	.801	.308	.269	.335
	Average	.453	2.522	.671	.244	.252	.208
Strain B (clone 23.3B)							
20-7-7	1919	.883	3.796	1.346	.280	.461	.280
21-8-19	1921	.710	2.462	.828	.388	.318	.240
	Average	.796	3.129	1.087	.334	.390	.260

INFLUENCE OF CLIMATE

With variable seasonal climatic conditions there is a variation in the composition of a given species from one year to another. This may be a result of the effect of the temperature, of the rainfall, of the length of the growing season, or of all combined on the proportion of leaf to stem, and possibly on the coarseness of both.

Armsby (1) has shown that fresh young grass and perfectly dried young grass have equivalent feeding value when compared pound for pound of dry matter. In actual hay making more or less of the finer portions is lost.

Climatic factors at the time of haying always influence the quality of hay produced more or less. The palatability is reduced by long exposure to the sun which bleaches the hay and causes a loss of aromatic substances. The dampening by dew causes injury and rains leach out some of the more soluble portions. It has been shown that 40 percent of the dry matter of red clover may be leached out by cold water and that from 12 to 20 percent of the dry matter may be lost from hay when cured under prolonged alternately wet and dry weather conditions.

The object sought in hay making is to obtain a hay of bright green color and of attractive aroma, with the retention of leaves and finer parts, and free from molds and dust.

INFLUENCE OF ALTITUDE

From their study of Wyoming forage plants and their chemical composition, Cundy (3) and Roberts (13) concluded that altitude affects the composition of grasses. They found that as grasses grew at higher altitudes there was generally a marked increase in the percentage of crude protein and at the same time an increase in the percentage of nitrogen-free extract.

Consequently they found that generally an increase in altitude showed a decrease in the percentage content of crude fiber. Thus it seems that the western forage plants increase in feeding value with an increase in the altitude at which they are grown.

Variations in altitude cannot alone be considered the cause of the variations in composition, but rather the variations in climate and soil that accompany variations in altitude.

INFLUENCE OF SHADE

It has been shown by Roberts (13) that shading causes an increase in the crude protein content and a decrease in the nitrogen-free extract content of grasses. The effect on the crude fiber as recorded was not so consistent. Brome, orchard, and western wheat grasses were increased in crude fiber by shading, but that in timothy was decreased, and that in red top variant.

INFLUENCE OF MOISTURE CONTENT

The moisture content of feeds is of prime importance in comparing their value, and in the calculation of rations. This is a factor that is frequently overlooked. As already mentioned a change in moisture content is incident to maturity. The moisture content of a plant decreases as the plant matures. It has been observed that in the case of corn (8) there is a close relation between the moisture content and the stage of maturity. Observations made on the moisture content of four species of grasses are given in Table 14.

TABLE 14. MOISTURE CONTENT OF GRASSES AT DIFFERENT STAGES OF GROWTH.

Species	Before heading	Full blossom	Seeds mature
	%	%	%
Brome grass—Plot A	71.51	63.69	57.13
Brome grass—Plot B	73.21	66.56	55.53
Brome grass—Plot 7-4	82.58	65.98	60.81
Average	75.77	65.41	57.82
Timothy—Plot 2-2	78.48	67.22	49.88
Western wheat grass—Plot 11-5	75.88	70.71	57.42
Slender wheat grass—Plot 12-5	76.99	71.11	47.15
Average of 4 species	76.78	68.61	53.07

How much the moisture content (11) may influence the value of a feed is shown in Table 15, which can be used as a moisture conversion table. Variations in the moisture contents of the higher ranges give the larger variations in the values of substances as feeds. The value of a feed is entirely in its dry or solid matter. By use of the table it is seen that in order to make a comparison apply to equal amounts of dry substances, for instance, it is necessary to compare 100 pounds of substance containing 80 percent moisture with 67 pounds of the same or a similar substance containing 70 percent moisture. Or, it is necessary to compare 100 pounds of a substance containing 70 percent moisture with 150 pounds of the same or similar substance containing 80 percent moisture.

TABLE 15. CONVERSION OF 100 POUNDS OF SUBSTANCE AT A GIVEN MOISTURE* CONTENT TO THE POUNDS WEIGHT AT A DIFFERENT MOISTURE CONTENT.

Known Moisture		Sought, pounds at different percents of moisture content																				
Lbs.	%	0%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
100	0	100	105	111	118	125	133	143	154	167	182	200	222	250	286	333	400	500	667	1000	2000
100	5	95	100	106	112	119	127	136	146	158	173	190	211	238	271	317	380	475	633	950	1900
100	10	90	95	100	106	113	120	129	138	150	164	180	200	225	257	300	360	450	600	900	1800
100	15	85	89	94	100	106	113	121	131	142	155	170	189	213	243	283	340	425	567	850	1700
100	20	80	84	89	94	100	107	114	123	133	146	160	178	200	229	267	320	400	533	800	1600
100	25	75	79	83	88	94	100	107	115	125	136	150	167	188	214	250	300	375	500	750	1500
100	30	70	74	78	82	88	93	100	108	117	127	140	155	175	200	233	280	350	467	700	1400
100	35	65	68	72	76	81	87	93	100	108	118	130	144	163	186	217	260	325	433	650	1300
100	40	60	63	67	71	75	80	86	92	100	109	120	133	150	171	200	240	300	400	600	1200
100	45	55	58	61	65	69	73	79	85	92	100	110	122	138	157	183	220	275	367	550	1100
100	50	50	53	56	59	63	67	71	77	83	91	100	111	125	143	167	200	250	333	500	1000
100	55	45	47	50	53	56	60	64	69	75	82	90	100	113	129	150	180	225	300	450	900
100	60	40	42	44	47	50	53	57	62	67	73	80	89	100	114	133	160	200	267	400	800
100	65	35	37	39	41	44	47	50	54	58	64	70	78	88	100	117	140	175	233	350	700
100	70	30	32	33	35	38	40	43	46	50	55	60	67	75	86	100	120	150	200	300	600
100	75	25	26	28	29	31	33	36	38	42	46	50	55	63	71	83	100	125	167	250	500
100	80	20	21	22	24	25	27	29	31	33	36	40	44	50	57	67	80	100	133	200	400
100	85	15	16	17	18	19	20	21	23	25	27	30	33	38	43	50	60	75	100	150	300
100	90	10	11	11	12	13	13	14	15	17	18	20	22	25	29	33	40	50	67	100	200
100	95	5	5.3	5.6	5.9	6.3	6.6	7.1	7.7	8.3	9.1	10	11	13	14.3	16.7	20	25	33	50	100

*Method of use: Find the weight of 100 pounds of substance containing 80 percent moisture when the moisture content has been reduced to 50 percent, the amount of dry substance remaining the same. Under the division headed "known" run down the moisture percentage column to 80 and then read across the division headed "sought" to the intersection with the column headed 50 percent. The weight sought is seen to be 40 pounds.

If it is assumed that the feeding value of the dry substance of the grasses is the same at the several stages of growth, 100 pounds of the grass when the seeds are ripe (Table 14) containing 53.07 percent moisture are equivalent to 150 pounds of the fresh grass in the full bloom stage containing 68.61 percent moisture, and is equivalent to 202 pounds of the grass before the heading stage containing 76.78 percent moisture.

NATIVE VEGETATION

The native vegetation of the prairies of North Dakota consists of a large number of species of plants. For the Mandan area, Sarvis (15) has identified over 300 different species. About 50 to 60 of these are grasses. In any given area but about 25 to 30 species are important from the standpoint of grazing, even a smaller number are important from the standpoint of haying.

Sarvis says in regard to the importance of a given species for grazing (16): "The value of a given species for grazing purposes depends upon (a) its abundance, (b) whether it is relished by stock, (c) its length of growing season, (d) its ability to withstand trampling and to recover readily from grazing, and (e) its adaption to drought conditions."

For the Mandan area he writes (16): "According to these requirements, *Bouteloua gracilis* (Blue grama) would take first rank and *Stipa comata* (Western needle grass) would be of second importance."

The native plants of the Mandan area have been arranged by Sarvis (16) in the following list in order of their abundance. "The order of the dominant species was determined by measurements from quadrat maps and in the field. The order of the primary species, other than grasses, was determined by count. The secondary species are listed in the estimated order of their abundance (16)."

DOMINANT SPECIES

Bouteloua gracilis
Stipa comata
Carex filifolia
Carex heliophila

PRIMARY SPECIES

Artemisia gnaphalodes
Koeleria cristata
Solidago pulcherrima
Agropyron smithii
Artemisia dracunculoides
Psoralea argophylla
Andropogon scoparius
Artemisia frigida
Stipa viridula
Eschinacea angustifolia
Aristida longiseta
Polygala alba
Stipa spartea
Ratibida columnaris

SECONDARY SPECIES

Muhlenbergia cuspidata
Lacinaria punctata
Calamovilfa longifolia
Agropyron caninum
Bouteloua curtipendula
Comandra pallida
Aster multiflorus
Petalostemon purpureum
Petalostemon candidum
Lactuca pulchella
Vicia sparsifolia
Agropyron tenerum

Qualitative and quantitative botanical analyses of the native vegetation of other areas would no doubt indicate other species in the highest rank and of the greater importance. Important species greatly relished by stock are:

Bouteloua gracilis—(Blue grama)
Stipa comata—(Western needle grass)
Andropogon furcatus—(Big blue stem)
Bulbilis dactyloides—(Buffalo grass)
Agropyron smithii—(Western wheat grass)
Koleria cristata—(Prairie June grass)
Bouteloua curtipendula—(Tall grama)
Andropogon scoparius—(Little blue stem)
Muhlenbergia cuspidata—(Prairie rush grass)
Calamovilfa longifolia—(Big sand grass)
Stipa spartea—(Porcupine grass)
Aristida longiseta—(Wire grass)

The sages (*Artemisia*) are the lowest in palatability. *Artemisia frigida* is bitter and the least palatable of all. Stock will not begin to eat it until other grasses become scarce. An increase in the number of *Artemisia frigida* per given area is an indication of over grazing (15). As cattle do not relish it, it is able to take advantage of the weakened condition of the other plants and increase in number and size.

The germination of the seed of the native prairie plants is generally low. The germination of the seed of 40 species as reported by A. W. Sampson (14) varies from 2 to 90 percent, 31 of the instances having values or average values below 50 percent. The values may be generally low, due to the lack of complete knowledge of the optimum germination conditions for each of the several species.

It has been frequently shown that the problem of maintaining the native vegetation on the range is one of management. The present range lands are those which for reasons of topography, shortage of rainfall, or isolation have not been suitable for tillage. For reasons of low germination, low seed productivity, and the inability of some to withstand heavy grazing, the grass species in the native vegetation are not very prolific. Hence the study of the life characteristics and chemical composition of the native plants is important in the consideration of range management.

Tho prairie grass hay may be in any instance composed of a large number of species, in any particular case the large percentage of the grass in the hay will be of a few species. Which ones they are will depend on the abundance of those species which are large enough in stature to be cut and collected by haying equipment. Some of the more important species, from the standpoint of grazing, are of but little importance from the standpoint of haying.

In the case of five lots of prairie hay received from the Northern Great Plains Field Station at Mandan for digestibility studies. J. T. Sarvis indicated that half or more than half of the grass in the different lots of hay was western needle grass (*Stipa comata*). (The results of these digestion trials are to be reported in a separate publication.) The analyses of these lots of hay are presented in Table 16.

TABLE 16. COMPOSITION OF PRAIRIE HAY*.
(Hay basis—15 percent moisture)

Lab. No.		Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
20-10- 64	Lot 1	15.00	4.94	3.26	3.35	31.67	41.78
65	Lot 1	15.00	6.32	3.38	2.76	30.80	41.74
20-10-179	Lot 2	15.00	6.71	8.14	3.08	23.96	43.11
20-11- 93	Lot 3	15.00	7.40	3.54	3.80	30.51	39.75
23-10- 4	Lot 4	15.00	6.25	6.09	3.94	27.82	40.90
23-12- 1	Lot 5	15.00	6.99	6.24	3.28	28.05	40.44

*The hay samples and those of most of the grass species later reported were collected in connection with the Cooperative Grazing Experiment conducted jointly by the North Dakota Agricultural Experiment Station and the United States Department of Agriculture, Bureau of Plant Industry, Office of Dry-Land Agricultural Investigations.

Lot No. 1 Cut April 1920.
Lot No. 2 Cut July 1920.
Lot No. 3 Cut October 1920.
Lot No. 4 Biennial cutting, August 1923.
Lot No. 5 Annual cutting, August 1923.

From these anlyses it is apparent that the hays from the April and October cuttings are very similar. The hay from the July cutting is distinctly superior, as it contains more than twice as much crude protein, some more nitrogen-free extract, and much less crude fiber.

The chemical analyses indicates that annual and biennial cuttings are similar.

The analyses of grass from native sod plots at Dickinson (1928) at four different dates thru the season are given in Table 17. The protein content is the highest on July 25th, when the general run of the several species are making their most rapid growth.

TABLE 17. COMPOSITION OF NATIVE SOD GRASS.

Lab. No.		Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
28-11-84	May 25	15.00	7.47	11.87	2.06	23.70	39.90
85	June 25	15.00	9.46	18.70	1.71	23.66	31.47
86	July 25	15.00	7.80	9.66	2.15	25.28	40.11
87	Aug. 25	15.00	10.12	8.18	1.61	23.59	41.50

CHEMICAL COMPOSITION OF SPECIES

The chemical analyses of the species of grasses and of grass-like plants given in the following pages are of samples collected here at Fargo in the course of various investigations, and at Mandan by J. T. Sarvis. The samples of the native species were collected by J. T. Sarvis. For uniformity and to enable direct comparison, the analyses are all calculated to a uniform moisture content of 15 percent. Both the common and the botanical name of the grasses are given together with some notes on the physical characteristics of the species and their general value.

For the purpose of comparison, analyses by other chemists are given. Those indicated by literature reference No. 6 are the average of a number of analyses by various workers.

1. BEARDED WHEAT GRASS

Bearded wheat grass (*Agropyron caninum*) is a bunch or tufted grass which grows from 1 to 4 feet in height. It makes considerable leafy growth early in the season and matures in July or August. It is coarser than slender wheat grass and its bearded heads make it less desirable for hay. It grows naturally on river bottoms and prefers a light sandy soil.

COMPOSITION OF BEARDED WHEAT GRASS.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-211	Past bloom Aug. 7	15.00	6.21	6.07	1.44	35.11	36.17
Analyses by others							
	Cut June 3 (12)	15.00	9.95	12.41	4.62	28.06	29.96
	Cut June 15 (12)	15.00	9.72	10.18	4.23	27.94	32.93
	Cut July 18 (12)	15.00	7.24	4.22	1.63	37.32	34.59

2. CRESTED WHEAT GRASS

Crested wheat grass (*Agropyron cristatum*) is a tall grass which matures in July or August. It was first introduced from Russia by the United States Department of Agriculture in about 1898. It is a long lived perennial bunch grass which is usually ready to cut for hay during the latter part of June or early in July. It makes hay of excellent quality and is especially relished by horses. It will usually outyield brome grass or slender wheat grass in Western North Dakota.

COMPOSITION OF CRESTED WHEAT GRASS

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-222	Early bloom July 8	15.00	8.48	11.86	1.29	33.14	30.23
25- 7- 5	Bloom July 17	15.00	5.71	6.33	1.38	31.88	39.70
25- 7- 6	Bloom July 17	15.00	5.71	8.41	1.43	33.98	35.47
Analyses by others							
	Before heading (13)	15.00	6.04	9.06	3.37	21.38	45.15
	Near bloom (13)	15.00	5.88	7.76	1.83	30.94	38.59
	Near bloom (13)	15.00	5.22	8.63	2.08	31.06	38.01
	Past bloom (13)	15.00	5.07	6.78	2.17	29.49	41.49
	Cut July 6 (3)	15.00	7.09	7.86	1.70	33.26	35.09
	Cut August 11 (3)	15.00	5.55	6.52	2.01	33.33	37.59

3. WESTERN WHEAT GRASS

Western wheat grass (*Agropyron smithii*) is tall grass, which grows from 18 to 48 inches in height and matures in July or August. It is a sod-forming species, which makes a rather dense sod. Like quack grass, to which it is closely related, it is benefitted by partial cultivation. In general it reproduces naturally by running rootstocks. Under cultivation its seed production is abundant, but only during favorable years will it produce an

abundant seed crop under natural conditions. The percentage germination of its seed is usually low. It appears that the analyses of the Western wheat grass seed herewith reported is the only one that has been made.

Western wheat grass is considered one of the alkali tolerating grasses, but it will make larger growth on the better soils with sufficient supply of moisture. It produces hay of high quality, which ranks first of the native species for the plains area. It easily out ranks timothy and has very little waste in feeding. Western wheat grass hay has been given a special grade in the U. S. standards, and brings $2 or $3 a ton more than other prairie hays on the market. It is favored around stockyards as the stock will clean it up thoroly. In certain sections of the country large amounts of it are cut, baled and shipped. Western wheat grass is much better for hay than slender wheat grass, but crested wheat grass is about equal to it. It must be cut early enough to avoid ergot.

COMPOSITION OF WESTERN WHEAT GRASS.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-223	Full bloom July 9	15.00	6.65	10.79	1.48	31.01	35.07
20- 6- 4	Before heading	15.00	8.73	18.70	1.65	22.10	33.82
20- 6-128	Bloom	15.00	8.04	11.64	1.60	29.54	34.18
21- 8- 8	Bloom	15.00	8.33	8.98	2.22	29.24	36.23
20- 8- 20	Seed maturing	15.00	11.29	10.58	2.29	27.40	33.44
	Average of 20 others (6)	15.00	7.00	8.20	2.46	29.16	38.18

The increase in the protein content of the sample taken when the seeds were maturing is due to the development of a young succulent bottom growth at this stage of maturity.

COMPOSITION OF WESTERN WHEAT GRASS SEED.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-264	Mature	12.00	5.55	12.28	1.64	20.06	48.47

FERTILITY AND MINERAL CONSTITUENTS OF WESTERN WHEAT GRASS.

Sample Number	21-8-8
Maturity	Blossom
Moisture	15.00 percent
Ash	8.33 percent
Nitrogen	1.436 percent
Phosphoric acid (P_2O_5)	.482 percent
Potash (K_2O)	2.704 percent
Soda (Na_2O)	.584 percent
Lime (CaO)	.320 percent
Magnesia (MgO)	.229 percent
Sulfur troxide (SO_3)	.269 percent

4. SLENDER WHEAT GRASS

Slender wheat grass (*Agropyron tenerum*) is a bunch forming c tufted type of grass which grows 18 to 24 inches in height and matur in July or August. It prefers light, well drained soils, and under favorab conditions makes large yields. It is quite tolerant to alkali, but not to suc an extent as Western wheat-grass. Considerable attention has been give it as a cultivated grass. Its yields are equal to those of timothy which surpasses in nutritive value.

COMPOSITION OF SLENDER WHEAT GRASS.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen free extract
		%	%	%	%	%	%
25-12-224	Full bloom July 10	15.00	6.43	5.75	1.22	36.40	35.20
20- 6- 3	Before heading	15.00	8.17	19.90	1.43	19.37	36.13
20- 6-127	Bloom	15.00	7.63	12.51	1.62	30.27	32.97
21- 8- 9	Bloom	15.00	7.15	11.05	2.88	30.25	33.67
20- 7- 47	Seed mature	15.00	7.40	11.78	2.24	30.26	33.32
	Analyses by others						
	Average of 10 (6)	15.00	6.02	6.74	1.90	29.70	40.64

COMPOSITION OF SLENDER WHEAT GRASS SEED.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen free extract
		%	%	%	%	%	%
25-12-265	Mature	12.00	5.51	6.30	2.15	28.26	45.78

FERTILITY AND MINERAL CONSTITUENTS OF SLENDER WHEAT GRASS.

Sample Number	21-8-9
Maturity	Blossom
Moisture	15.00 percent
Ash	7.15 percent
Nitrogen	1.767 percent
Phosphoric acid (P_2O_5)	.642 percent
Potash (K_2O)	2.741 percent
Soda (Na_2O)	.951 percent
Lime (CaO)	.317 percent
Magnesia (MgO)	.337 percent
Sulfur trioxide (SO_3)	.242 percent

5. BIG BLUE STEM

Big blue stem (*Andropogon furcatus*) is an important grass of th prairie region of the Great Plains. It grows from 36 to 72 inches height and matures in August or September. It is high in palatability, an is grazed with extreme relish by cattle during the early part of the seaso In the spring it is tender, juicy, sweet, and has a pleasant odor. By fa it becomes harsh and woody, and has lost its palatable characteristics.

thrives best along river bottoms and occurs in small ravines. It withstands burning better than most grass species. It is a minor ingredient of most lots of prairie hay.

COMPOSITION OF BIG BLUE STEM.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-231	Full bloom Aug. 14	15.00	5.61	5.54	1.96	30.96	40.03
	Analyses by others						
	Average of 20 (6)	15.00	5.66	5.94	2.71	28.74	41.95

6. LITTLE BLUE STEM

Little blue stem (*Andropogon scoparius*) is similar in type to Big blue stem, but has a greater tendency to grow in bunches and is smaller in stature rarely attaining a height of more than 3 feet. It matures late, August-October. Cattle will graze on it before it begins to head, but later it gets woody. Even early in the season cattle somewhat avoid it, partly because the old stems are stiff and protect the young spring growth. This species is not very important as an ingredient of prairie hays.

COMPOSITION OF LITTLE BLUE STEM.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-232	Full bloom Aug. 19	15.00	3.98	3.55	1.92	35.38	40.17
	Analyses by others						
	Average of 19 (6)	15.00	5.14	5.07	1.95	29.23	43.61

7. ROUGH HAIR GRASS

Rough hair grass (*Agrostis hyemalis*) is sometimes called tickle grass or dog-hair. It grows from 12 to 48 inches in height and matures in July or August. It is not an important species and is generally regarded as a weed, tho not a bad one. It is light in weight, transient in character, and forms but a small part of the native vegetation. In pastures and open range cattle graze it down closely with apparent relish. It likes low wet places and comes on after the spring water recedes. Its tops break off and blow around badly, and will get into the wool of sheep.

COMPOSITION OF ROUGH HAIR GRASS.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-225	Past bloom July 23	15.00	7.62	6.77	2.77	29.90	37.94
	Analyses by others						
	Cut Aug 19 (17)	15.00	9.63	7.51	2.64	27.42	37.80
	Cut June 29 (10)	15.00	5.66	6.98	2.01	27.96	42.39

8. WIRE OR POVERTY GRASS

Wire or poverty grass (*Aristida longiseta*) is a small wiry specie which grows about a foot high and matures in July or August. Cattle wil graze on it when the range is short. Its palatability is low. The awns o this grass, developed when the plants mature, are very sharp and are no dropped as readily as in the case of those of the species of Stipa or tru needle grasses.

COMPOSITION OF WIRE OR POVERTY GRASS.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-233	Past bloom Aug. 8	15.00	5.69	4.95	1.07	34.27	39.02
234	Mature fall	15.00	7.38	6.43	1.35	33.62	36.22
	Analyses by others						
	Average of 4 (6)	15.00	6.88	6.32	1.21	31.34	39.25

9. *ARTEMISIA DRACUNCULOIDES* (SAGE)

Artemisia dracunculoides is one of the well known prairie sages. I may grow to a height of 4 feet and matures from July to October. It ha a slightly bitter or aromatic taste, hence is low in palatability, and is some what avoided by cattle both on the range and in prairie hay, tho they d not hesitate in grazing this plant on a range that is fairly well stocked.

COMPOSITION OF ARTEMISIA DRACUNCULOIDES.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-235	Maximum growth July 30	15.00	5.22	8.31	2.02	18.93	50.52

10. *ARTEMISIA FRIGIDA* (SAGE)

Artemisia frigida is possibly the most prominent of the common sage: It grows to a height of from 10 to 20 inches and matures July or Augus Having a bitter taste its palatability is low, almost the lowest of any c the prairie plant species. Cattle will eat it on the range or in hay onl when other feed is scarce. This sage is possibly the best indicator of ove grazing of native vegetation pasture or range (15). As cattle do not lik it, it is able to take advantage of the weakened condition of the othe plants, and increase in size and number per unit area.

COMPOSITION OF ARTEMISIA FRIGIDA.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-236	Max. growth July 10	15.00	6.75	11.92	4.42	31.06	30.85
25-12-237	Full bloom Sept. 2	15.00	5.46	7.99	1.69	28.25	41.61

11. *ARTEMISIA GNAPHALODES*
(SAGE)

Artemisia gnaphalodes is another of the common sages. It grows from 12 to 48 inches in height and matures from August to October. Like the other sages it is bitter and low in palatability. It is closely grazed down by cattle in small pastures.

COMPOSITION OF ARTEMISIA GNAPHALODES.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-238	Max. growth July 30	15.00	8.53	10.51	3.23	26.81	35.92

The fact that plants may not be liked by stock on the range does not mean that they won't be eaten in the hay. Stock will eat these species of Artemisia in the form of hay more readily than they will eat them on the range.

12. BROME GRASS

Brome grass (*Bromus Inermis*) is an introduced species valuable for grazing and haying. It reproduces largely by rootstocks and spreads badly. It grows from 30 to 48 inches in height and matures in June or July. It generally makes considerable second growth and bottom growth. By selection and breeding important strains of it have been developed (20). These strains vary widely in physical and chemical characteristics.

Brome grass is equal to timothy in feeding value, is one of the most palatable of pasture grasses, and will endure heavy grazing. It seems to withstand drought well and is an excellent grass for permanent pasture.

COMPOSITION OF BROME GRASS.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-229	Full bloom July 10	15.00	8.18	7.79	1.36	34.76	32.91
	Before heading (average of 7)	15.00	9.38	15.14	1.62	23.56	35.30
	Blossom (average of 22)	15.00	8.16	8.80	1.93	29.96	36.15
	Seed maturing (average of 4)	15.00	9.83	8.97	1.93	25.50	38.77
	Analyses by others						
	Average of 60 (7)	15.00	7.43	10.52	3.21	25.74	38.10

FERTILITY AND MINERAL CONSTITUENTS OF BROME GRASS.

Number of analyses	9
Maturity	Blossom
Moisture	15.0 percent
Nitrogen	1.385 percent
Phosphoric acid (P_2O_5)	.618 percent
Potash (K_2O)	2.726 percent
Soda (Na_2O)	.733 percent
Lime (CaO)	.269 percent
Magnesia (MgO)	.282 percent
Sulfur trioxide (SO_3)	.220 percent

Side Oats

13. TALL GRAMA GRASS

Tall grama or side oat grass (*Bouteloua curtipendula*) is one of the most widely distributed species of our native grasses. It grows to a height of about 3 feet and matures in July or August. It is a conspicuous and important grass on the rougher portions of the plains. Its palatability is high and it makes an excellent ingredient in prairie hay. Some efforts to domesticate it have met with more or less success (12). If furnished an adequate supply of moisture it has the ability to adjust itself to almost all other conditions.

COMPOSITION OF TALL GRAMA GRASS.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-226	Full bloom Aug. 4	15.00	7.06	6.91	1.11	30.79	39.13
	Analyses by others						
	Average of 6 (6)	15.00	8.18	5.39	1.65	27.93	41.85
	Before bloom (9)	15.00	8.49	6.03	1.67	28.02	40.79

14. BLUE GRAMA

Blue grama (*Bouteloua gracilis*) is one of the important grasses of the plains. It is sometimes erroneously called Buffalo grass. It is a short grass, rarely growing over one foot in height, and then only in favorable seasons when it forms abundant flower stalks. It matures in July or August. It is recognized as possibly the most palatable of the prairie grasses. It produces green foliage early, and the cattle do not hesitate to graze on it at any time during the season, even after it is mature. It dry cures and furnishes excellent winter grazing. Because of its height but little of it occurs in prairie hay.

COMPOSITION OF BLUE GRAMA.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-254	Before heading June 30	15.00	10.16	9.55	1.87	25.61	37.81
255	After heading July 20	15.00	9.40	9.75	1.83	23.69	40.33
227	Early bloom July 24	15.00	7.85	10.09	1.22	27.83	38.01
228	Past bloom Aug. 9	15.00	6.95	8.22	1.33	28.75	39.75
257	Past bloom Aug. 22	15.00	9.03	7.40	2.11	26.35	40.11
21-1-14	Early cutting	15.00	8.69	8.22	1.77	24.94	41.38
15	Late cutting	15.00	9.55	4.78	1.66	25.41	43.60
25-12-27	Growth to Aug. 3	15.00	9.67	6.23	1.83	25.05	42.22
	Analyses by others						
	Cut Sept. 10 (12)	15.00	6.84	7.99	2.96	31.60	35.61
	Cut July 10 (17)	15.00	7.39	7.74	1.85	26.69	41.33
	In bloom (10)	15.00	4.13	7.00	1.22	29.48	43.17
	Early bloom (9)	15.00	7.30	6.86	1.24	30.20	39.40

15. BUFFALO GRASS

The true Buffalo grass is *Bulbilis dactyloides*. It generally grows from 2 to 4 inches in height, tho in the southern part of the Great Plains it may reach a height of 12 inches. It is an early grass and matures in June or July. It is very palatable both in the fresh and dry condition. On the Plains it dry cures and furnishes excellent winter grazing where there is little or no snow cover. Because of its height it has no importance except as a pasture plant.

Popularly the true Buffalo grass has been confused with the Blue grama grass (*Bouteloua gracilis*) to which at early stages of maturity it is similar. In regard to this Griffith (6) says—"*Bouteloua gracilis*, especially when not in head is very similar and frequently mistaken for it. On this account the true Buffalo grass is very much overestimated in importance, because there are so many things included with it in the popular mind. Much of the credit given this species is due to the gramas, which in age especially look very much like it. On the other hand, the species is an important one thruout its range."

In feeding value and palatability Buffalo grass is classed as equal to the Blue grama. Buffalo grass is not abundant in western North Dakota. It occurs frequently from Mandan westward but does not replace Blue grama in dominence except in very limited areas.

COMPOSITION OF BUFFALO GRASS.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-230	Full bloom July 28	15.00	8.87	9.99	2.01	22.86	41.27
	Analyses by others						
	Average of 7 (6)	15.00	8.93	6.25	1.79	21.50	46.53

16. BIG SAND GRASS

Big sand grass (*Calamovilfa longifolia*) is a coarse and harsh grass of low palatability which grows at its best upon moist or saline sandy soils. It grows from 12 to 36 inches in height and matures in July, August or September. It reproduces mainly by large, strong, scaly, creeping rootstocks and readily spreads thru loose types of soils forming a tough hard sod. Stock eat it but sparingly while young and as hay even if it has been cut before it is fully mature.

COMPOSITION OF BIG SAND GRASS.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-239	Full bloom Aug. 18	15.00	4.65	4.96	1.59	32.10	41.70
	Analyses by others						
	Average of 4 (6)	15.00	5.43	5.15	1.55	33.65	39.22

17. BULL SOD-SEDGE

Bull sod-sedge or nigger wool (*Carex filifolia*) is a densely tufted perennial which grows from 3 to 14 inches in height and seeds freely. It matures early and in the Mandan area usually matures its seed by the first of June. Frequently its flowers are injured by late frosts. It forms a tough dense sod and the black roots rot slowly after breaking. Its palatability is high early in the season, but as it becomes dry and tough it becomes pratically nothing by the end of the season. It is too short to be of any importance in prairie hay.

COMPOSITION OF BULL SOD-SEDGE

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-240	Seeds-dough-June 2	15.00	6.81	12.38	1.95	22.94	40.92
25-12-258	Growth to Aug. 22	15.00	10.46	5.60	2.24	26.68	40.02

18. WESTERN PRAIRIE SEDGE

Western prairie sedge (*Carex heliophila*) reproduces by rootstocks, grows from 6 to 16 inches in height, and matures in June. Its palatability is high early in the season but is not avoided by cattle at the end of the season. It is too short to be of much importance in prairie hay. This sedge grows later and furnishes feed longer than nigger wool.

COMPOSITION OF WESTERN PRAIRIE SEDGE.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-241	Past bloom May 29	15.00	6.55	13.49	2.01	19.10	43.85

19. ALKALI GRASS

Alkali or salt grass (*Distichlis spicata*) is a distinctive grass of alkali areas. It grows fairly well where alkali salts are present in the soils to such an extent that other grasses can not thrive at all. It likes moisture but can withstand considerable drought. It spreads by means of a scaly rootstock and forms a close harsh sod. The alkali grass may grow to a height of 2 feet and matures in July or August. Its value as a forage plant depends on the location and the relative amounts of other grasses of high value. It dry cures and furnishes some winter forage. In general its palatability is low and cattle do not care much for it.

Composition of Alkali Grass.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-242	Full bloom Aug. 1	15.00	8.91	8.11	1.50	26.53	39.95
	Analyses by others						
	Average of 11 (6)	15.00	8.59	7.05	1.93	24.30	43.13

20. RYE GRASS

Rye or nodding wild-rye grass (*Elymus canadensis*) in many localities forms a large part of the native forage. It is a large species, growing from 2 to 5 feet in height, and matures in July or August. Its seed habits are good but it ergots badly. It is usually found growing in moist ravines and on stream banks. While young it is relished by stock, and to obtain the best quality of hay it must be cut before it becomes woody. The mature stems are tough and woody. At best it is a coarse grass and its value depends on the relative amounts of other valuable grasses available for grazing and haying.

Composition of Rye Grass.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-243	Past bloom July 23	15.00	6.61	6.23	1.55	34.32	36.29
	Analyses by others						
	Average of 5 others (6)	15.00	6.77	8.10	2.39	32.10	35.64
	Average of 10 others (7)	15.00	6.96	6.76	1.81	24.87	44.60

21. JUNE GRASS

June grass (*Koeleria cristata*) is one of the important, common, and early species of the prairies. It is a tufted grass, very leafy at the base, grows to a height of from 12 to 30 inches and matures in July. Its palatability is high and few species are more readily eaten. It is often found in dry situations but generally matures before the driest part of the season. If moisture is available it makes some second growth. Following maturity it dries up, but little is left for winter grazing. It makes hay of only medium quality as many of the root leaves are lost in the cutting and handling of the hay. June grass is one of the most common of the grasses found all over the prairie. Common but not as abundant as many of the others.

Composition of June Grass.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-244	Full bloom July 1	15.00	8.24	7.79	1.59	31.70	35.68
	Analyses by others						
	Average of 10 (6)	15.00	6.33	7.31	2.58	28.85	39.93

22. PRAIRIE RUSH GRASS

Prairie rush grass (*Muhlenbergia cuspidata*) thrives on a variety of soils but prefers that of the drier draws and swales. This species has a well developed root system and is valuable for holding soils in place. It is only valuable for forage where better grasses do not thrive. It grows from 12 to 24 inches in height and matures in August or September. As in the case of other coarse grasses it is more palatable during its earlier stages of growth.

Composition of Prairie Rush Grass.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-245	Full bloom Aug. 5	15.00	8.86	6.32	1.56	28.54	39.72
	Analyses by others						
	Cut Aug. 10 (17)	15.00	4.44	5.93	1.97	26.97	45.69

23. SWITCH-GRASS

The common switch grass (*Panicum virgatum*) is a familiar and conspicuous species of large stature which matures in August or September. It is considered a valuable native grass. This species is widely distributed, prefers moist rich soils and is found near streams, ponds and lakes, but is frequently found on sandy or gravelly drifts. It grows in large, strong tufts and spreads by creeping rootstocks. It furnishes good pasturage, but is preferably more valuable for haying. For hay it should be cut when in bloom, as at maturity it becomes harsh and woody and loses its palatability.

Composition of Switch-Grass.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-246	Full bloom Aug. 9	15.00	6.43	8.05	1.22	31.75	37.55
	Analyses by others						
	Average of 17 (6)	15.00	5.32	5.48	1.91	28.49	43.80

24. FALSE RED TOP

False red top or fowl meadow grass (*Poa palustris*), a close relative of Kentucky blue grass, is a tall grass which matures in July or August. It is found in low native meadows and produces a forage of excellent quality. Unlike many other grasses it remains of high quality even after it has matured its seed. It is considered an excellent grass for meadows that are occasionally overflown. Its seed production is abundant and its hay as palatable as upland hay.

Composition of False Red Top.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-247	Full bloom July 9	15.00	8.27	7.65	1.36	33.96	33.76
25-12-248	Past bloom July 23	15.00	6.53	5.44	1.43	31.88	39.72
	Analyses by others						
	Average of 5 (7)	15.00	6.88	9.37	2.58	27.54	38.63
	Cut July 15 (17)	15.00	6.79	7.99	2.30	27.77	40.15

25. EARLY BUNCH GRASS

Early or prairie bunch grass (*Sphenopolis obtusata*) is a tufted perennial species which grows as high as 30 inches and matures in June, July or August. It grows fairly well on nearly all dry soils but thrives best on the moister prairies, on bottom lands, or along streams. It is one of the earliest of the native species and wherever it occurs in any considerable quantity it is valuable for both grazing and haying.

Composition of Early Bunch Grass.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-249	Past bloom July 26	15.00	8.36	5.69	4.31	29.32	37.32—
	Analyses by others						
	In bloom July 18 (9)	15.00	7.81	8.09	2.06	30.73	36.31
	Cut in August (17)	15.00	11.70	6.45	2.19	27.81	36.85

26. WESTERN NEEDLE GRASS

Considering all factors, J. T. Sarvis (16) places Western Needle Grass (*Stipa Comata*) as second in importance and value among the native forage plants of the Mandan area. It reaches a height of from 12 to 24 inches and matures in June or July. As its palatability is good it is eaten readily by stock even after it has become dry except for the time when the needles form, become sharp, and drop. This grass starts early in the spring and grows late in the fall, producing some green feed after other grasses have ceased growth. It is present in comparatively large proportions in strictly prairie hay. For hay it should be cut before the needles are formed or after they have dropped.

Composition of Western Needle Grass.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-259	Early bloom June 30	15.00	8.96	9.72	3.11	26.37	36.84
250	Full bloom July 8	15.00	5.18	5.74	1.16	35.54	37.38
251	Mature Aug. 20	15.00	5.56	4.04	2.18	33.37	39.85
260	Biennial clip Aug. 21	15.00	6.98	7.18	4.85	25.98	40.01
261	Annual clip Aug. 22	15.00	7.56	6.88	5.29	26.02	39.25
	Analyses by others						
	Average of 9 (6)	15.00	5.70	5.83	1.96	29.24	42.27
	Average of 9 (7)	15.00	4.94	7.00	.72	30.52	40.93

27. PORCUPINE GRASS

Porcupine grass (*Stipa spartea*) is larger in stature than Western Needle grass. It may grow to a height of 4 feet and matures in June or July. The general characteristics and values of this species are similar to those of Western Needle grass with which it is somewhat confused. It is not so prominent a grass and its needle-like seeds are more troublesome. It does not grow commonly on the prairies, but likes the more favored places such as ravines and the lower areas.

Composition of Porcupine Grass.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-252	Full bloom July 9	15.00	7.15	4.82	.81	35.54	36.68
	Analyses by others						
	Cut May 7 (12)	15.00	9.87	13.11	3.04	24.75	34.23
	Cut May 21 (12)	15.00	7.85	7.23	2.70	32.23	34.99
	Cut May 26 (12)	15.00	6.39	7.65	1.01	33.34	36.61
	Cut June 8 (12)	15.00	6.98	7.93	1.92	26.32	41.85
	Cut June 30 (17)	15.00	5.12	7.14	2.21	30.12	40.41

28. FEATHER BUNCH GRASS

Feather bunch grass (*Stipa viridula*) is closely related to the other species of Stipa, namely, Western Needle grass and Porcupine grass. It grows from 1 to 3 feet in height and matures in July or August. It is commonly found in large bunches on dry soils and prefers soils that have been disturbed by scanty cultivation. Stock graze on it readily and it is a good pasture grass when kept closely grazed. Hay made from it appears to be of good quality.

The needles of this Stipa are not as sharp as in the case of the other two species of Stipa described. The seeds are short and blunt. They have a high percentage germination, but the awns do not allow the seeds to be readily handled. That is, the seeds mass up and cannot be readily sown.

COMPOSITION OF FEATHER BUNCH GRASS.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
25-12-253	Full bloom July 12	15.00	5.93	6.54	.93	34.55	37.05
	Analyses by others						
	Average of 5 (6)	15.00	6.83	7.40	2.22	26.24	42.31

29. TIMOTHY

Since the characteristics of timothy (*Phleum pratense*) are so generally well known, no discussion of them is considered necessary. Analyses of timothy have been used in the forepart of this bulletin, as an illustration of the effect of maturity on the composition of grasses.

COMPOSITION OF TIMOTHY.

Lab. No.	Maturity	Moisture	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
		%	%	%	%	%	%
20- 6- 5	Before heading (1920)	15.00	7.05	12.81	2.19	20.68	42.27
20- 7- 10	In bloom (1919)	15.00	5.54	7.09	2.46	30.86	39.05
20- 6-129	In bloom (1920)	15.00	5.98	5.90	1.62	29.32	42.18
21- 8- 10	In bloom (1921)	15.00	6.06	5.29	2.06	29.80	41.79
	Average	15.00	5.86	6.09	2.05	29.99	41.01
20- 7- 51	Seeds maturing (1920)	15.00	5.79	5.84	1.99	27.82	43.56

FERTILITY AND MINERAL CONSTITUENTS OF TIMOTHY.

Sample No.	20-7-10	21-8-10	Average
Season	1919	1921	.....
Maturity	Blossom	Blossom	Blossom
Moisture	15.00%	15.00%	15.00%
Ash	5.54%	6.06%	5.80%
Nitrogen	1.130%	.846%	.988%
Phosphoric acid (P_2O_5)	.492	.413	.452
Potash (K_2O)	2.377	2.210	2.294
Soda (Na_2O)	.379	.934	.656
Lime (CaO)	.181	.276	.228
Magnesia (MgO)	.244	.200	.222
Sulfur trioxide (SO_3)	.045	.171	.108

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