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Bulletin No. 385 - Comparitive Nutritive Value and Palatability of Some Introduced and Native Forage Plants for Spring and Summer Grazing

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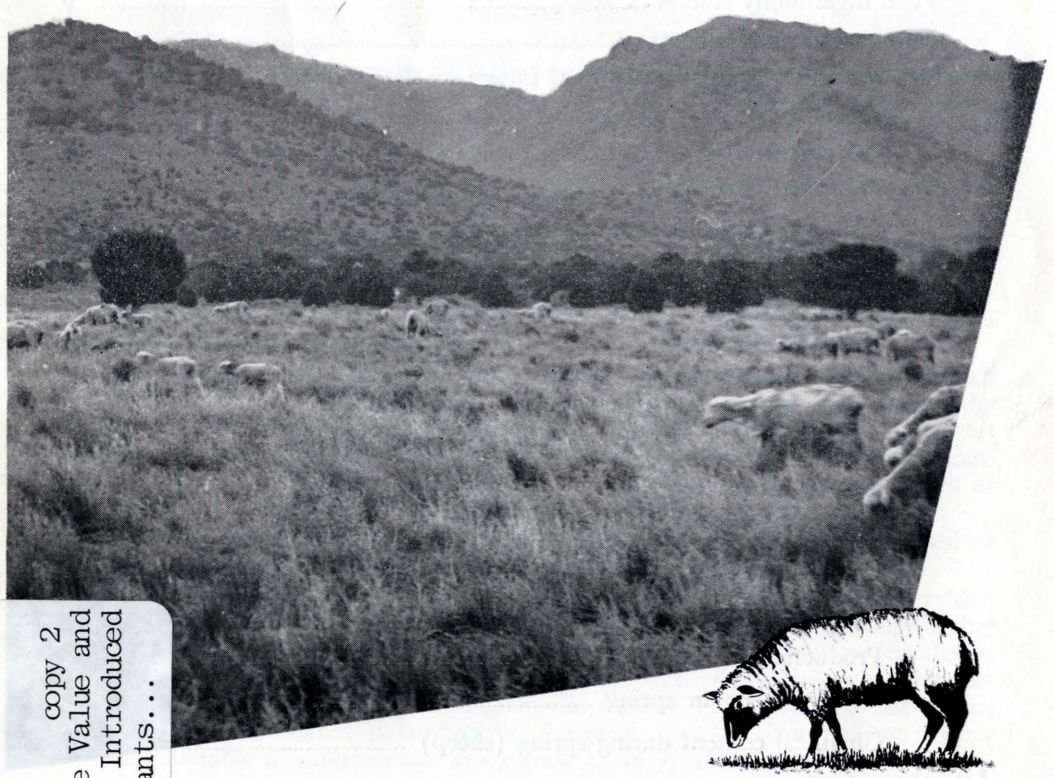

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SUMMARY

From 1952 to 1954 studies were conducted on foothill ranges of central Utah to determine the forage production, palatability, and nutritive value of some of the more important native and introduced species used for spring and summer grazing.

Plants studied were four introduced wheatgrasses (crested, tall, pubescent, and intermediate), four native grasses (western wheatgrass, beardless wheatgrass, squirreltail grass, and Indian ricegrass), and two introduced annual forbs (Russian-thistle, and smother weed).

Field digestibility trials were conducted to determine the nutrient content by the lignin-ratio technique. In addition, both sheep and cattle preferences were studied on areas where both introduced and native species were planted.

Crested wheatgrass produced spring growth in advance of other introduced wheatgrasses and native grasses by about one and one-half weeks and matured at a much faster rate. Both crested and pubescent wheatgrass started growth relatively early and matured rather rapidly compared to other grasses. Tall, intermediate, beardless, and western wheatgrass started growth at about the same time but tall and intermediate matured much more slowly.

Most species showed a steady decrease in digestible protein, phosphorus, and gross energy as maturity advanced, whereas ether extract, ash, lignin, and cellulose showed a general increase.

Digestibility of protein, cellulose, gross energy, and other carbohydrates decreased with increased maturity.

Intermediate, tall, beardless, and western wheatgrass appeared to furnish ample nutrients to meet the energy requirements for lactating ewes during the spring grazing season (May 1 to July 1). However, crested and pubescent wheatgrass were slightly deficient or borderline late in the season. Russian-thistle and smother weed were marginal to decidedly low in energy values at all seasons and were always less valuable than grasses in furnishing energy.

Only Russian-thistle, smother weed, and intermediate wheatgrass furnished adequate protein for lactating ewes during advanced stages of growth.

Intermediate wheatgrass was the most palatable and western wheatgrass was the least palatable. Crested wheatgrass was highly palatable in early spring but became relatively unpalatable late in the season. Pubescent wheatgrass was eaten as readily as crested wheatgrass early in the season but was considerably more palatable than crested late in the season. Pubescent and tall wheatgrass increased in relative palatability as the grazing season advanced but neither was as palatable as intermediate wheatgrass at any period.

During early spring, grazing animals preferred introduced species to native species. Squirreltail grass was used lightly early and preference increased as the season advanced. Beardless wheatgrass was used only slightly until late in the season at which time it was more palatable than both crested and tall wheatgrass. Indian ricegrass and western wheatgrass were used only lightly and this occurred late in the season.

This study suggests that it would be better to graze the introduced species separately from native species and from each other for best management of

both plants and animals. It was evident that intermediate wheatgrass in a mixture would soon be destroyed if moderate use was made of other species.

Chemical analysis of the entire plant compared to portions representing material consumed showed that both sheep and cattle select the more nutritious portions. This preference became more pronounced as plant maturity increased. In general, protein, phosphorus, cellulose, and gross energy were higher in forage being consumed than in total current growth. These differences were more pronounced for sheep than cattle.

When planted and grown under similar conditions, native wheatgrasses (beardless and western) produced more forage per acre than the four introduced wheatgrasses.

COMPARATIVE NUTRITIVE VALUE AND PALATABILITY OF SOME INTRODUCED AND NATIVE FORAGE PLANTS FOR SPRING AND SUMMER GRAZING

C. Wayne Cook, L. A. Stoddart, and Lorin E. Harris

Introduction

Improvement of depleted foothill ranges in the Intermountain Region offers a solution to the shortage of spring and early summer forage. The question of whether to seed these ranges artificially to obtain increased forage or to attempt improvement by management and natural seeding is difficult to answer with present knowledge. Certainly foothill ranges with little or no native perennial grasses remaining can best be improved through seeding. If the stand of perennial grass is sufficient to show rapid response to protection and conservative use, it may be more economical to increase production in this way.

With increased interest in improving range conditions there is need for knowledge of forage production, palatability, and nutritive value of species available for seeding in order to compare these to the native species now present or once inhabiting the area.

Studies were started in 1952 in central Utah to determine (1) the chemical composition, digestibility, and metabolizable energy and (2) the forage production and palatability of some native and introduced species used for spring and early summer grazing.

The plants studied were crested wheatgrass (*Agropyron cristatum*), tall wheatgrass (*Agropyron elongatum*), intermediate wheatgrass (*Agropyron intermedium*), pubescent wheatgrass (*Agropyron trichophorum*), beardless wheatgrass (*Agropyron inerme*), western wheatgrass (*Agropyron smithii*), squirreltail grass (*Sitanion hystrix*), Indian ricegrass (*Oryzopsis hymenoides*), Russian-thistle (*Salsola kali* var. *tenuifolia*), and smother weed (*Bassia hyssopifolia*). The first four are introduced perennial grasses. The next four are native perennial grasses and the last two are introduced annual forbs.

The ranges studied were formerly occupied by sagebrush, juniper, and annual weeds although they were highly variable in vegetation, topography, and soil type.

Precipitation averages from 12 to 15 inches annually and occurs principally as winter snows and early spring rains. Summers are characterized by long periods of hot, dry weather, and winters are cold, with subzero temperatures occurring frequently.

Review of Literature

Animal production is influenced by the quantity and quality of the forage the animals consume. The quantity an animal will consume depends upon palatability and amount available. Quality of forage depends upon nutritive content and portions of the plant selected in natural grazing. Grazing animals tire frequently of diets composed of a single species and

decreased consumption results (Cook and Harris 1950a, 1952).

Stage of plant growth influences consumption. Woodman *et al.* (1937a) reported that sheep consume more when on green pasture than when on dry forage because the appetite is stimulated by green leafy herbage. Cook and Harris (1952) found that the quantity of cheatgrass (*Bromus tectorum*) consumed by sheep decreased with increased maturity accompanied by decreased palatability.

Measuring the nutritive value of range forage by chemical analysis alone is not reliable (Cook and Harris 1950a). However, chemical analyses provide a comparison among forage species as to the effect of stage of growth, climatic conditions, and soil variability on the value of forage.

Comparative chemical composition of range forage species has been studied widely (Clarke and Tisdale 1945, Crampton and Forshaw 1940, Forbes and Garrigus 1950, Hart *et al.* 1932, Patton 1943, Ritzman and Benedict 1930, Woodman *et al.* 1937a). Several studies (Dutoit *et al.* 1935, Kik 1943, Waldron 1921, Woodman *et al.* 1937b) have shown that different species, and even varieties of the same species, when grown on the same soil and under the same climatic conditions may differ in nutritive value at comparable stages of development. Variation may result from differences in methods of plant collection and chemical analysis (Norman 1939). Data for the same species vary as a result of stage of maturity, soil, or current weather conditions (Cook and Harris 1950 b). Chemical changes as a result of advancing stage of growth have been found greater than those arising from any other factor (Cook and Harris 1950b, Dutoit *et al.* 1935, Hart *et al.* 1932).

The nutritive content of the animal's diet varies with chemical content of the plant material eaten (Cook and Harris 1950a). However, the nutritive value of the diet can be determined only when the digestibility of the nutrients in the forage is known. Like chemical content, digestibility for any plant species varies. Digestibility for any particular constituent may be affected by animal selectivity, species and age of animal, plane of nutrition, and nutritive balance of the ration. Regardless of these variabilities, digestibility coefficients are a practical means of comparing the nutritive values and predicting nutritive deficiencies of range forage (Cook *et al.* 1954).

Some authors believe that lignin has an adverse affect on the digestibility of other plant constituents. Digestibility of nitrogen-free-extract, crude fiber, cellulose, and other carbohydrates decreases as the lignin values increase (Patton 1943). However, this is true only for a single species in different stages of growth and does not hold true when comparing lignin content and digestibility among different species (Phillips and Loughlin 1949). Little can be found in literature dealing with the nutritive value of the introduced wheatgrasses. Crested wheatgrass appears to be excellent forage during immature stages but loses much of its nutritive value as it matures. During the early growing season it has been found to contain as much as 20.59 percent crude protein, but by September it contained only 3.22 percent. Ash, crude fiber, and nitrogen-free-extract increased slightly with maturity but phosphorus showed a gradual decline (Sotola 1941).

Field digestibility trials with crested wheatgrass showed no definite trend in digestibility with increased maturity because animals selected the more tender and nutritious parts of the plant (Cook and Harris 1952a).

Chemical analysis of current year's growth of crested wheatgrass, tall wheatgrass, intermediate wheatgrass,

and pubescent wheatgrass differed little between June 19 and July 6 (Cook and Stoddart 1951).

Palatability of a forage species is a relative matter and may be high or low, depending upon the total effect of many factors. Certain plants are grazed uniformly throughout the year, whereas others are subject to seasonal preference (Cook and Harris 1950b, Dutoit *et al.* 1935, Hart *et al.* 1932). Both stage of growth and floral composition of the range influence palatability (Davies 1925). Sheep have been shown to consume a greater quantity of grass leaves than stems even though stems outweigh leaves three to one (Stapledon and Jones 1927). Palatability of a species is not the same for cattle and sheep. Preference ratings change for both classes of livestock at various seasons and under different conditions (Schmantz 1954, U. S. Forest Service 1953).

Method and Procedure

Field digestibility studies

Digestibility studies were conducted during the spring and summer months of 1953 and 1954 on foothill ranges in four counties in central and northern Utah, Cache, Box Elder, Tooele, and Juab.

The lignin-ratio technique was used for determining feed intake, digestibility, and metabolizable energy under range conditions (Cook *et al.* 1952). Wether sheep of mixed breeds (Rambouillet, Hampshire, Columbia, and Targhee) ranging from one to six years of age and averaging 130 pounds in weight were used. They were equipped with specially constructed bags for col-

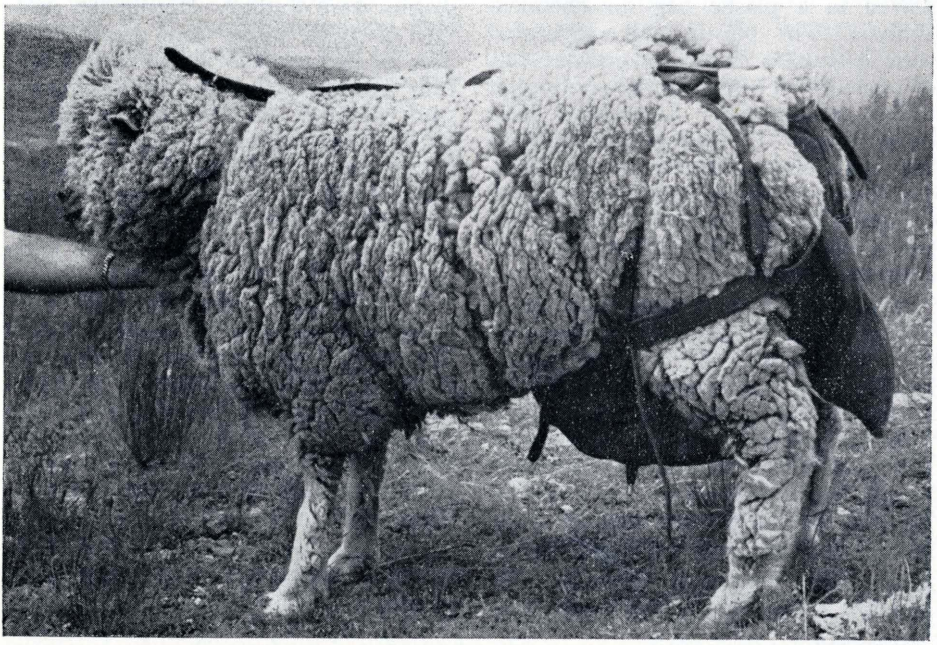

Fig. 1. Wether sheep equipped with collection bags for studying digestibility of range plants

lecting feces and urine and allowed to graze in temporary enclosures (fig. 1).

Five to seven sheep were used in each trial. The number varied according to size of the area and growing conditions at the time of the trials.

The wethers were allowed an 8-day preliminary grazing period for each trial to empty their digestive systems and to adjust them to the species being tested. This was followed by a 6-day collection period during which time the animals were equipped with bags to collect feces and urine.

Collection bags were emptied twice daily. The feces from each sheep were placed in a separate five-gallon can with a tight lid. The material was glazed with a solution of 97 percent alcohol and 3 percent hydrochloric acid to prevent mold and decomposition. At the end of the collection period, total fecal material was weighed and a composite sample for each sheep was placed in a plastic bag for chemical analysis. The plastic bag was sealed with a rubber band to prevent loss of moisture. These samples were stored under refrigeration. Later they were dried at 65° C. and ground to pass through a one-millimeter screen. Moisture loss from the samples was recorded to permit calculation of dry matter present in fecal material for the entire collection period.

A sample of urine from each sheep was obtained by placing one tenth of the daily output in a quart plastic bottle. The remainder was placed in a three-gallon galvanized can with a tight lid and retained until the collection period was terminated. To each sample bottle was added 3.6 grains of mercury bichloride and enough hyrochloric acid to make the urine slightly acid. This prevented decomposition and loss of nitrogen. The sample was stored under refrigeration and later analyzed for nitrogen, phosphorus, and gross energy.

One day prior to the beginning of and throughout the collection period, individual animals were observed for four to five hours daily while grazing to determine the portion of the plant consumed. Comparable samples of the material actually being consumed by the sheep were hand-plucked in duplicate throughout the area. These samples were dried, ground to pass through a one-millimeter screen, and later chemically analyzed.

Palatability and production studies

In another phase of this study cattle and sheep were grazed on areas where both native and introduced grasses were planted. Production, palatability, and chemical content of the various species were studied. During the summer of 1954, cattle were grazed from July 22 to August 24 on an area where four introduced species of wheatgrass were planted. During the spring of 1955, sheep and cattle were grazed on areas where both native and introduced grasses were planted. Cattle grazed one area from May 5 to July 1 and sheep grazed another area from June 1 to July 1. At frequent intervals utilization determinations were made and samples of plant material consumed from each species were obtained for chemical analysis. In addition, total current year's growth was collected to compare with material representing ingested forage at various periods throughout the grazing season. At the end of the growing season, protected plots were clipped to determine the dry matter production for each species.

Results and Discussion

Forage growth and consumption

Digestion trials were made on each of four introduced wheatgrasses at four stages of growth and on each of two native wheatgrasses and two forbs at three stages of growth. All species were studied from early growth until seed was formed. Each was measured for height and observed for comparative stage of growth during each trial (table 1).

At the beginning of the first collection period May 9, 1953, crested wheatgrass was approximately two weeks ahead of tall wheatgrass in development. Tall wheatgrass was as high as crested wheatgrass but had fewer leaves. Pubescent and intermediate wheatgrass were similar in height and stage of growth and were one week behind crested wheatgrass. As the season progressed, pubescent wheatgrass matured more rapidly than intermediate wheatgrass. Tall wheatgrass developed at a much slower rate than intermediate wheatgrass and at the end of August was approximately one month behind crested wheatgrass.

The development was somewhat different in 1954. Crested wheatgrass and tall wheatgrass were about ten days earlier, intermediate wheatgrass about one week later, and pubescent wheatgrass was about the same.

During early growth stages the animals consumed the entire herbage of all species. During later stages they preferred leaves over stems (table 1). Such selection was not noted in tall wheatgrass and intermediate wheatgrass until the plants were in anthesis or dough stage. It was displayed earlier in the case of pubescent and crested wheatgrass.

During 1954 western wheatgrass started growth a week later than beardless wheatgrass and developed much more slowly. Crested and pubescent wheatgrass produced earlier growth than either western or beardless wheatgrass and matured in shorter time. Tall and intermediate wheatgrass started the same time as western and beardless wheatgrass, however, tall wheatgrass matured much more slowly than the others. Intermediate wheatgrass matured slightly more rapidly than beardless wheatgrass and beardless wheatgrass more rapidly than western wheatgrass.

During early growth stages significantly more crested wheatgrass was consumed daily than for other species, however, during advanced stages of growth significantly greater quantities of intermediate wheatgrass were consumed.

Average daily dry matter consumption and confidence interval in pounds for each species for all trials were: crested wheatgrass 3.6 ($\pm$ .37), pubescent wheatgrass 3.1 ($\pm$ .24), tall wheatgrass 3.5 ($\pm$ .26), intermediate wheatgrass 3.9 ($\pm$ .21), beardless wheatgrass 3.0 ($\pm$ .28), western wheatgrass 2.9 ($\pm$ .50), Russian-thistle 3.3 ($\pm$ .21) and smother weed 3.3 ($\pm$ .27).

More dry matter was consumed early in the growing season. This is of extreme importance since decreased consumption combined with reduced nutritive value intensified the inadequacy of the diet late in the season.

Decrease in amount consumed as the season advanced was most rapid for crested wheatgrass. In early growth, consumption per sheep was 4.6 pounds per day compared to 3.3 pounds per day later in the season. Consumption of intermediate wheatgrass remained nearly constant and that of tall, pubescent, beardless, and western wheatgrass declined only slightly.

Daily intake of Russian-thistle decreased as the season progressed while there was a slight increase for smother weed.

Table 1. Growth stage and utilization of pure stands for various species during digestion trials with sheep

Date	Species	Stage of growth and height	Part of plant eaten*	Percent utilization†
5/9/53	Crested wheatgrass	Fifth leaf, 7 inches, green and succulent	Entire plant to 2 inches above ground	85
6/8/53	Crested wheatgrass	Early head, 18 inches, green and succulent	Entire plant, preference for leaves	65
6/16/54	Crested wheatgrass	Anthesis, 20 inches, green and succulent	Entire plant, preference for leaves	50
7/10/54	Crested wheatgrass	Soft dough, 20 inches, leaves brown, culms green	Leaves and few immature stems	40
5/15/53	Pubescent wheatgrass	Fifth leaf, 10 inches, green and succulent	Entire plant to 3 inches above ground	80
6/15/53	Pubescent wheatgrass	Early head, 16 inches, leaves turning to brown	Entire plant to 3 inches above ground	75
6/22/54	Pubescent wheatgrass	Preanthesis, 18 inches, leaves green but drying on tips	Entire plant, preference for leaves and heads	60
7/16/54	Pubescent wheatgrass	Soft dough, 20 inches, leaves brown, culms green	Heads and leaves and few stems	50
5/22/53	Tall wheatgrass	Fourth leaf, 10 inches, green and succulent	Entire plant to 3 inches above ground	80
6/22/53	Tall wheatgrass	Sixth leaf, 24 inches, green and succulent	Entire plant to 3 inches above ground	75
6/28/54	Tall wheatgrass	Early head, 26 inches, leaves green but drying on tips	Entire plant to 2 inches above ground	60
7/28/54	Tall wheatgrass	Anthesis, 26 inches, green but leaves drying at tips, few seed stalks	Entire plant to lower node, preference for leaves under light use	45
5/28/53	Intermediate wheatgrass	Sixth leaf, 10 inches, green and succulent	Entire plant to 2 inches above ground	85
6/28/53	Intermediate wheatgrass	Early anthesis, 20 inches, green and succulent	Entire plant to 2 inches above ground	80

Table 1. (Cont.)

Date	Species	Stage of growth and height	Part of plant eaten	Percent utilization
7/4/54	Intermediate wheatgrass	Late anthesis, 20 inches, green and succulent	Entire plant to 2 inches above ground	65
7/28/54	Intermediate wheatgrass	Hard dough, 20 inches, green but leaves drying at tips	Entire plant, preference for leaves under light use	60
5/15/54	Beardless wheatgrass	Four-leaf, plant green and growing rapidly, 8 to 10 inches.	Entire plant 4 inches above ground level.	70
6/13/54	Beardless wheatgrass	Boot, plant green and succulent, 16 to 20 inches high	Entire plant, preference for leaves	40
8/29/54	Beardless wheatgrass	Late seed shattering, green only at the base of leaves and stems	Dry and green leaves	45
6/1/54	Western wheatgrass	Four-leaf, plant green and growing rapidly, 3 to 5 inches	Entire plant 1.5 inches above ground level	80
6/23/54	Western wheatgrass	Boot, plant green and succulent, 6 to 9 inches high	Preference for leaves	75
8/4/54	Western wheatgrass	Mature seed, green only at base of leaves and stems	Dry and green leaves	50
7/27/54	Russian-thistle	Flower, plant green and succulent, 4 to 6 inches high	Entire plant, excepting lower and coarser stems	40
8/16/54	Russian-thistle	Seed stage, plant particularly coarse	Lower branches and upper 6 inches of stems	20
8/19/54	Russian-thistle	Seed stage, plant coarse throughout	Upper 6 inches of seed stalks and lower branches	30
8/3/54	Smother weed	Early flower, plant green and succulent, 12 to 24 inches high	Heads, flowers and green leaves, upper portion	35
8/22/54	Smother weed	Late flower, plant green but coarse and stemmy	Seeds, leaves, and finer stems	20
8/26/54	Smother weed	Early seed, plant green but exceedingly rank and coarse	Leaves, seeds, and some coarser stem material	25

*Areas were not grazed uniformly after the first trials.

†Estimate of percent utilization based on weight of herbage produced above 1 inch stubble height.

Nutritional requirements

The National Research Council's recommended nutrient allowances for sheep (1949) allow for a margin of safety for all nutrients. These recommendations for maximum animal production often are not economically justified under range conditions where costly supplements are required to meet these standards.

According to the Research Council's calculations for a 130-pound lactating ewe consuming 4.3 pounds of dry matter, the daily ration should contain 6.8 percent digestible protein, 64 percent total digestible nutrients, 0.30 percent calcium, and 0.22 percent phosphorus.

By use of a transposed regression formula metabolizable energy (Calories per kilogram) = (TDN - a)/b. In the present study a = 13.51 and b = 0.0217. Thus, if 64 percent TDN is used as the standard energy requirement (64 - 13.51) / 0.0217 = 2367 Calories per kilogram of feed intake or about 1074 Calories per pound as the metabolizable energy requirement for lactating ewes.

Only during the early growth stages when plants were in the fourth to fifth leaf stage did they meet the energy requirements suggested by the National Research Council. However, ewes with 3- to 6-week-old lambs in the experimental areas gained weight during all periods during spring grazing. This suggests that the recommendations of the National Research Council are somewhat higher than necessary for range ewes during lactation.

In order to compare the nutritive value of the plants studied with amounts of nutrients required by lactating ewes under spring grazing conditions, the following evaluations have been made. It has been assumed that wether sheep digest feed to about the same extent as lactating ewes.

From this study it would appear that about 900 Calories per pound or about 2,000 Calories per kilogram of feed intake would at least meet the minimum requirements for a 130-pound lactating ewe during spring grazing.

Thus, if 2,000 Calories per kilogram of feed intake is used as the standard energy requirement, percent TDN = 13.51 + (.0217) (2000) or 57 percent.

According to Maynard (1947) the recommended requirement for digestible protein for a lactating ewe should include about 128 percent of the protein secreted in milk in addition to an allowance of 0.7 pounds of digestible protein per 1,000 pounds of live weight for maintenance.

Studies with common breeds of range sheep in United States and Australia show that the average 130-pound ewe produces about 2.3 pounds of milk daily during the first seven weeks of lactation (Bonsma 1939, Shrewsbury *et al.* 1942). Therefore, assuming 5.5 percent protein content in milk, the digestible protein requirement would be about 5.9 percent if the ewe consumed an average of 4.3 pounds of dry matter daily. This calculation agrees with work in Canada (Slen and Whiting 1952) which stated that this allowance gave satisfactory response for lamb production. This is somewhat lower than the National Research Council's recommendation, but appears to be a more reasonable requirement for range ewes during spring grazing.

All grasses studied in the digestion trials except crested wheatgrass and pubescent wheatgrass appeared to meet the energy requirements for lactating ewes throughout the spring grazing season. Crested wheatgrass was somewhat low in energy-supplying constituents after the fifth leaf stage and remained relatively low. Pubescent wheatgrass was considered low in energy after it reached anthesis.

Description and nutritive value of forage species studied in digestion trials

Chemical composition at the various stages of growth is shown in table 2. These values represent only forage material actually ingested by the grazing sheep and not entire current year's growth. As a result of the animal's preference for more nutritious parts, changes in composition with maturity are not as pronounced as in total current year's growth.

Total protein, which was high early in the growing period in most species, decreased rather rapidly at first and then more gradually later in the season.

Most species showed a steady decrease in phosphorus and gross energy as the season advanced, whereas, ether extract, lignin, and cellulose increased somewhat.

During advanced stages of growth all species except smother weed failed to meet the recommended level of phosphorus for lactating ewes. There was no deficiency of calcium indicated in any species and no decrease occurred in advanced growth stages.

The digestion coefficients for total protein, cellulose, gross energy, and other carbohydrates except in intermediate wheatgrass declined with increased maturity, particularly during early growth (table 3). During later stages of maturity, digestible protein for lactating ewes was inadequate in all species except intermediate wheatgrass, Russian-thistle, and smother weed. Digestibility of protein decreased as content of crude protein decreased. This agrees with the findings of Mitchell (1942).

Russian-thistle and smother weed were decidedly low in energy values at all seasons and were always less valuable than grasses in furnishing energy.

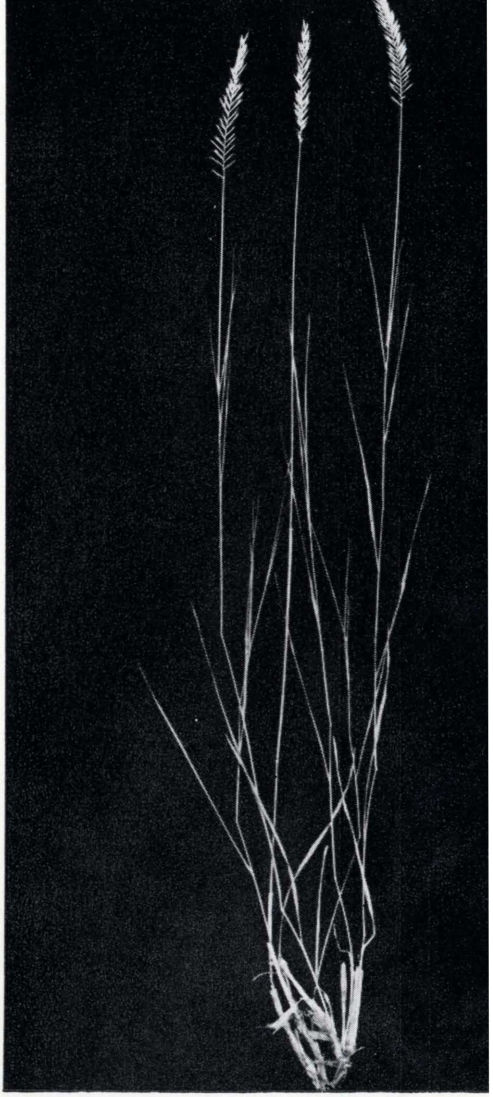

Fig. 2. A portion of a crested wheatgrass plant which shows the characteristic broad, flattened seed head

Crested wheatgrass Crested wheatgrass is a perennial bunchgrass, native to the cold dry plains of Siberia and Russia (fig. 2). It was introduced into the United States in 1898. It can grow at low temperatures and makes rapid growth early in the spring but becomes dormant during summer. Its forage is nutritious in early spring while

Table 2. Chemical composition of sheep forage intake by species during spring and summer on an air-dry weight basis

Species and stage of growth	Date	Ether extract	Total protein	Ash	Lignin	Cellulose	Other carbohydrates	Phosphorus	Calcium	Gross energy
						percent				*cal./lb.*
Crested wheatgrass										
fifth leaf	5/ 9/53	3.3	20.3	8.7	3.3	19.0	45.4	.27	.54	2050
early head	6/ 8/53	2.3	12.6	7.3	7.4	30.6	39.0	.23	.40	1986
anthesis	6/16/54	2.4	10.7	5.7	7.3	30.9	42.8	.18	.36	1946
mature seed	7/10/54	3.5	9.3	7.2	7.3	28.4	44.1	.14	.41	1999
Average		2.9	18.4	7.2	6.3	27.2	42.8	.20	.42	1995
Pubescent wheatgrass										
fifth leaf	5/15/53	3.4	16.5	11.5	3.7	20.6	44.2	.24	.42	1936
early head	6/15/53	2.9	11.1	10.2	5.2	33.3	36.1	.18	.41	1909
paranthesis	6/22/54	2.8	9.7	10.1	5.9	27.6	42.7	.16	.53	1905
soft dough	7/16/54	3.4	7.3	10.9	7.8	31.2	39.1	.11	.60	1878
Average		3.1	11.8	10.7	5.6	28.2	40.5	.17	.49	1907
Tall wheatgrass										
fourth leaf	5/22/53	3.3	16.8	11.0	4.6	26.5	37.8	.21	.47	2027
sixth leaf	6/22/53	3.6	13.8	10.5	6.3	31.9	34.9	.16	.43	1950
early head	6/28/54	4.7	10.9	8.8	6.2	24.8	44.4	.16	.43	1932
anthesis	7/22/54	6.5	8.5	11.6	6.6	30.7	36.4	.12	.62	1941
Average		4.5	12.5	10.5	5.9	28.4	38.4	.16	.49	1962
Intermediate wheatgrass										
sixth leaf	5/28/53	3.5	13.9	9.9	5.3	25.0	42.5	.23	.43	1977
anthesis (early)	6/28/53	4.4	10.4	9.3	5.6	32.3	37.8	.19	.42	1982
anthesis (late)	7/ 4/54	5.4	11.0	9.5	6.1	24.4	44.0	.16	.52	1968
hard dough	7/28/54	5.5	10.1	10.8	5.4	30.4	37.5	.16	.55	1973
Average		4.7	11.3	9.9	5.6	28.0	40.4	.18	.48	1975

Table 2. (Cont.)

Species and stage of growth	Date	Ether extract	Total protein	Ash	Lignin	Cellulose	Other carbohydrates	Phosphorus	Calcium	Gross energy
						percent				*cal./lb.*
Beardless wheatgrass										
fourth leaf	5/15/54	2.4	14.1	8.5	6.2	31.6	37.1	.26	.68	1995
boot	6/13/54	2.6	10.4	7.1	7.3	35.1	37.5	.16	.64	1968
mature seed	8/29/54	3.8	5.9	10.4	6.6	32.8	40.5	.15	.76	1891
Average		2.9	10.1	8.7	6.7	33.2	38.4	.19	.69	1951
Western wheatgrass										
fourth leaf	6/ 1/54	3.6	9.4	7.2	5.2	36.2	38.5	.20	.68	1982
boot	6/23/54	2.3	15.0	8.0	5.9	31.0	35.2	.26	.57	1968
mature seed	8/ 4/54	5.9	7.0	10.1	6.1	32.8	38.1	.09	.79	1968
Average		3.9	10.4	8.4	5.7	33.3	37.3	.18	.68	1972
Russian-thistle										
early flower	7/27/54	1.1	18.0	25.5	3.8	16.4	35.1	.20	2.18	1464
early seed	8/18/54	1.1	15.5	22.5	4.1	16.1	41.1	.15	1.80	1578
late seed	8/19/53	1.7	10.2	20.1	5.6	20.6	41.8	.18	2.20	1578
Average		1.3	14.6	22.7	4.5	17.7	39.3	.18	2.06	1540
Smother weed										
early flower	8/ 3/54	1.5	18.2	20.6	4.0	20.6	35.0	.28	1.24	1669
late flower	8/22/54	2.1	15.8	19.2	5.4	20.0	37.6	.34	1.20	1659
early seed	8/26/53	2.6	16.1	15.8	5.2	20.0	40.4	.33	.82	1796
Average		2.0	16.7	18.5	4.8	20.2	37.7	.32	1.08	1708

Table 3. Apparent digestibility coefficients and limits of error for nutrients shown in table 2*

Species and stage of growth†	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	Digestible protein	Total digestible nutrients	Metabolizable energy
				percent digested		*percent*		*Cal./lb.*
Crested wheatgrass								
fifth leaf	55.3	79.7	80.3	89.3	76.9	16.1	76.1	1324
	2.5	3.3	1.6	1.2	3.5	.4	3.1	26
early head	0.0	52.4	63.1	62.8	49.9	6.6	50.7	831
	20.2	3.6	5.1	4.7	3.3	.5	7.0	61
anthesis	-20.4	54.5	57.4	66.2	50.6	5.8	52.3	886
	8.5	4.1	6.9	4.1	3.4	.4	10.4	59
mature seed	36.4	59.0	57.5	72.5	55.4	5.5	56.8	913
	5.0	1.7	5.7	2.2	2.8	.2	7.0	67
Average	17.8	61.4	64.6	72.7	58.2	8.5	59.0	988
	9.1	3.2	4.8	3.1	3.2	.4	6.9	54
Pubescent wheatgrass								
fifth leaf	46.8	72.1	78.1	84.9	73.1	11.9	69.4	1158
	1.9	3.2	2.4	.6	8.4	.5	3.6	60
early head	27.4	61.2	74.5	72.2	63.0	6.8	59.5	936
	16.9	1.6	3.5	4.8	3.9	.6	6.1	109
preanthesis	2.1	62.4	70.7	74.2	60.4	5.8	58.1	942
	9.5	6.7	3.7	2.4	2.3	.2	4.6	50
soft dough	14.8	51.8	66.4	63.4	51.7	3.8	50.7	846
	9.1	3.4	2.5	5.6	3.5	.2	9.5	62
Average	22.6	61.9	72.4	73.7	62.0	7.0	59.4	953
	9.3	3.7	3.0	3.4	4.6	.4	5.9	71
Tall wheatgrass								
fourth leaf	43.7	69.5	75.6	73.6	65.3	11.6	62.9	1008
	3.5	1.9	3.5	3.8	5.6	.2	6.3	95
sixth leaf	17.0	64.6	68.1	70.1	56.9	8.9	56.5	894
	7.4	1.1	4.5	2.5	3.1	.1	6.1	56
early head	38.8	65.5	66.4	72.1	60.0	7.1	59.8	947
	9.4	4.7	6.1	5.7	5.2	.4	14.2	99
anthesis	40.9	55.2	76.5	64.9	57.9	4.7	57.9	946
	3.8	2.1	2.1	3.0	2.9	.1	7.2	67
Average	35.1	63.7	71.7	70.2	60.0	8.1	59.3	937
	6.0	2.4	4.1	3.7	4.2	.2	8.4	79

Table 3. (Cont.)

Species and stage of growth†	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	Digestible protein	Total digestible nutrients	Metabolizable energy
				percent digested			*percent*	*Cal./lb.*
Intermediate wheatgrass								
sixth leaf	26.8	56.0	75.8	77.2	63.7	7.7	61.7	933
	17.9	8.1	6.7	5.9	9.8	1.0	12.3	264
anthesis (early)	20.9	57.7	75.1	75.6	60.3	6.0	60.9	930
	6.0	4.3	3.1	2.5	.6	.4	.9	55
anthesis (late)	38.4	66.2	71.3	75.1	62.3	7.3	62.6	1022
	6.0	1.5	2.8	2.2	2.5	.2	5.8	53
hard dough	33.0	63.6	75.5	68.6	60.5	6.4	59.4	1001
	4.0	1.5	4.5	1.9	1.9	.3	6.1	57
Average	29.8	60.8	74.4	74.1	61.7	6.8	1.2	1072
	3.4	3.8	4.3	3.1	3.7	.5	6.3	123
Beardless wheatgrass								
fourth leaf	47.4	69.8	76.1	76.3	68.3	9.9	64.8	1142
	6.7	2.2	4.3	2.8	2.6	.2	2.0	41
boot	13.2	50.1	68.7	68.5	57.0	5.2	55.8	877
	5.1	5.7	4.8	1.9	4.9	.6	3.7	88
mature seed	28.1	40.6	69.4	73.9	58.9	2.4	57.5	916
	5.7	5.8	4.2	2.6	2.4	.3	7.0	41
Average	29.6	53.5	71.4	72.9	61.4	5.8	59.4	978
	5.8	4.6	4.4	2.4	3.3	.4	4.2	57
Western wheatgrass								
fourth leaf	38.9	53.4	78.8	78.8	66.2	5.0	67.0	1068
	8.3	3.8	3.3	1.4	3.0	.4	2.1	71
boot	12.9	73.8	64.0	72.8	61.2	11.1	57.6	948
	4.0	.0	2.1	1.7	1.5	.1	1.7	34
mature seed	45.7	55.6	76.4	73.6	64.8	3.9	63.1	1077
	11.1	4.1	6.6	7.8	2.7	.2	19.7	113
Average	32.5	60.9	73.1	75.1	64.1	6.6	62.6	1031
	7.8	2.6	4.0	3.6	2.4	.2	7.8	73

Table 3. (Cont.)

Species and stage of growth†	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	Digestible protein	Total digestible nutrients	Metabolizable energy
				percent digested			*percent*	*Cal./lb.*
Russian-thistle								
early flower	43.7	86.3	71.1	79.3	74.0	15.5	56.2	856
	56.5	9.5	11.9	18.5	14.4	1.7	18.6	278
early seed	40.0	83.4	59.2	73.6	69.8	12.9	53.7	910
	7.3	1.8	3.0	5.9	1.8	.3	6.8	46
late seed	19.7	67.1	57.6	69.4	60.1	6.8	48.5	764
	7.3	2.0	3.0	1.5	1.1	.2	6.4	25
Average	34.5	78.9	62.6	74.1	67.9	11.7	52.8	844
	23.7	4.4	5.9	8.6	5.8	.4	10.6	117
Smother weed								
early flower	-68.6	80.6	59.0	75.2	61.1	14.7	53.2	817
	43.1	1.0	4.4	1.0	3.2	.2	1.2	41
late flower	-44.1	75.7	52.3	75.4	55.8	11.9	50.7	746
	23.5	1.8	3.5	2.0	2.1	.3	1.4	45
early seed	10.4	72.8	53.4	71.0	60.3	12.8	52.7	900
	6.3	1.5	4.4	3.3	2.1	.2	2.5	88
Average	-34.1	76.4	54.9	73.9	59.1	13.1	52.2	821
	24.3	1.4	4.1	2.1	2.5	.2	1.7	58

* Limit of error is shown below average and when added to or subtracted from the average will give 95 percent confidence interval.
† See table 2 for dates.

succulent, but fails to meet the requirements for lactating animals in digestible protein and phosphorus after heading. It is a good source of energy only during early growth. The forage is relatively high in gross energy but digestibility of this constituent is low after early growth (tables 2 and 3). Daily gains of 0.6 to 1.8 pounds per day were made by wether sheep grazing the plant.

Consumed parts of crested wheatgrass were high in protein at the beginning of the growing season with 20.3 percent as late as the fifth leaf stage. Protein decreased to 9.3 percent when the plant was setting seed.

Crested wheatgrass is one of the best of introduced grasses for early spring range in the Great Basin area. It is highly palatable early in the spring and furnishes good forage. It is relatively unpalatable to both sheep and cattle after it approaches maturity and it loses its nutritive content rapidly.

Pubescent wheatgrass This grass, sometimes called stiffhair wheatgrass, is a sod forming, cool-weather perennial grass introduced during the 1930's from Russia (fig. 3).

The plant begins growth early in the spring and produces a large amount of leafy foliage which is taken readily by all range animals during most of the spring grazing period.

Pubescent wheatgrass forage is slightly higher than crested wheatgrass in ash and cellulose, but is lower in other carbohydrates, gross energy, protein, and phosphorus. The content of energy-furnishing constituents was considered adequate for lactating animals until seed was formed, but deficiency of phosphorus occurred before the plant headed. The plant became deficient in digestible protein for lactating ewes soon after seed was produced. Average daily gains of 0.4 to 1.4 pounds per day were recorded even though the amount consumed per day was low.

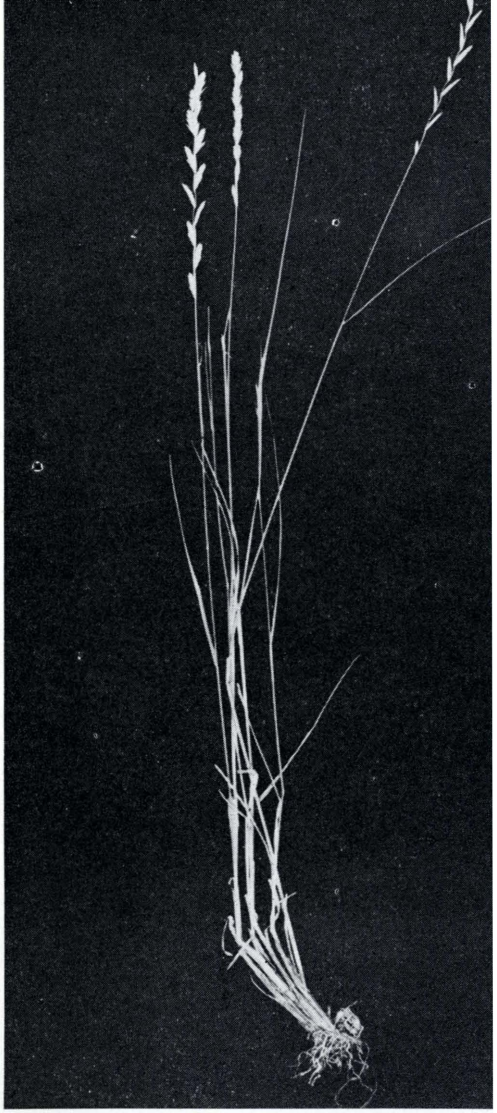

Fig. 3. A portion of pubescent wheatgrass plant in full head. The heads as well as leaves are covered with soft, short hairs (pubescence)

Tall wheatgrass This species is a coarse, perennial bunchgrass native of southern Europe and Asia Minor where it grows on saline meadows and seashores (fig 4). It was introduced into the United States early in the 1930's

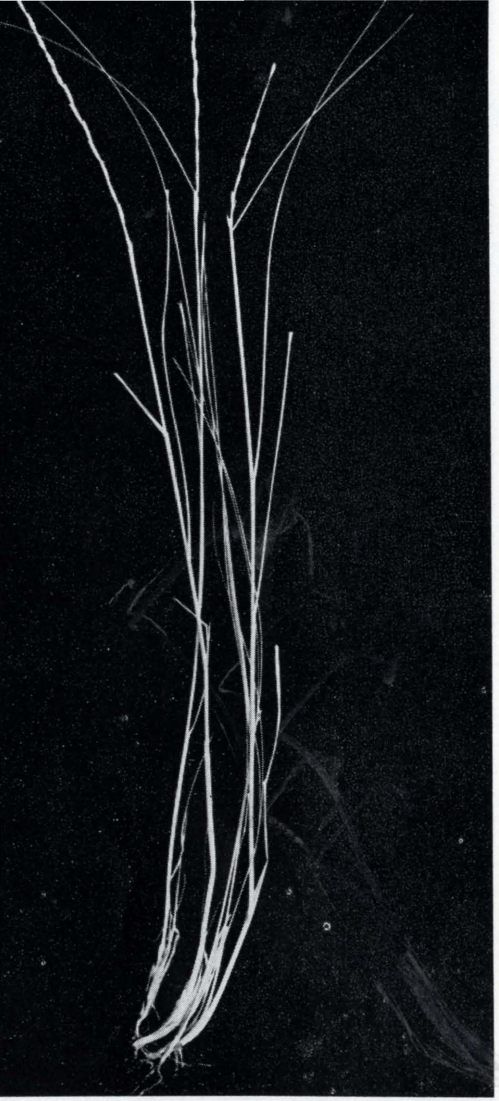

Fig. 4. A few stems of tall wheatgrass showing the long, coarse leaves and comparatively large, robust seed heads. These heads are 8-12 inches long

and has shown several outstanding qualities.

It possesses larger seeds than the other wheatgrasses, and where moisture is reasonably favorable it is easy to establish good stands. The grass starts moderately early, remains green longer, and matures later than most other wheatgrasses. Tall wheatgrass produces well on ground too alkaline to grow common cultivated crops. Despite its coarseness, the grass is grazed reasonably well by livestock when in pure stands. Cattle make much better use of tall wheatgrass than sheep, especially late in the season.

Chemical analysis of tall wheatgrass showed it to be a good source of protein when young but deficient for lactating animals when the plant headed. Energy sources were relatively high throughout the season but phosphorus was deficient before the plant reached the fourth-leaf stage.

Tall wheatgrass matures rather slowly and as a result furnishes desirable forage for late spring and summer grazing, especially where areas are too alkaline for other forage crops.

Intermediate wheatgrass This grass is a sod-forming perennial introduced into the United States in the 1920's from Russia and Europe (fig. 5). It grows on well-drained soils receiving 12 to 15 inches of precipitation annually. The plant starts early in spring though not as early as crested wheatgrass. Growth stops during hot dry summers but resumes when fall rains come. The forage is of excellent quality and is highly palatable throughout the spring and summer to all grazing animals.

Intermediate wheatgrass consumed was somewhat higher in lignin and somewhat lower in protein than other grasses during early stages of growth. This is a result of animals eating the entire plant of intermediate wheatgrass with little or no preference for leaves over stems. Thus a plant that is readily eaten may be lower in nutrient intake than one less palatable where greater preference for various portions of the plant is displayed.

The protein content remained high throughout the spring grazing season.

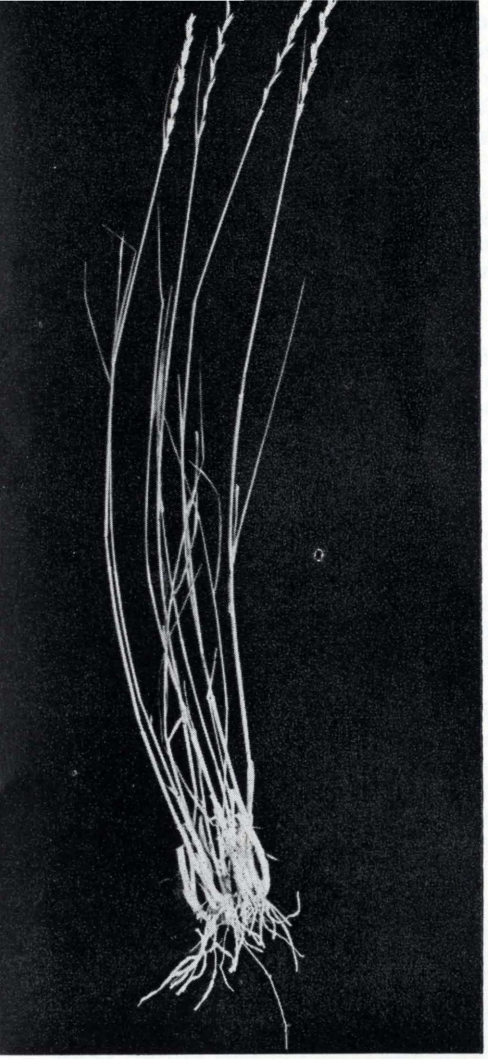

Fig. 5. A portion of an intermediate wheatgrass plant. It resembles pubescent wheatgrass except neither heads nor leaves have the abundance of short hairs

Digestible protein content was 6.4 percent even as late as hard-dough stage. Since it matures later than crested wheatgrass or pubescent wheatgrass, the nutritive value remains high for a longer period of time. Intermediate wheatgrass was relatively high in digestible protein and energy throughout the spring grazing season; however, it became deficient in phosphorus soon after the head stage was reached.

Beardless wheatgrass Beardless wheatgrass is a drought resistant native perennial bunchgrass which dominates wide areas of the Great Basin (fig. 6). It is found on lower foothills associated with sagebrush. The forage is readily consumed by livestock during spring.

Digestible protein (table 3) was sufficient for lactating animals only dur-

Fig. 6. A beardless wheatgrass plant. These plants grow in a distinct bunch and the heads are much more slender and delicate than the other wheatgrasses

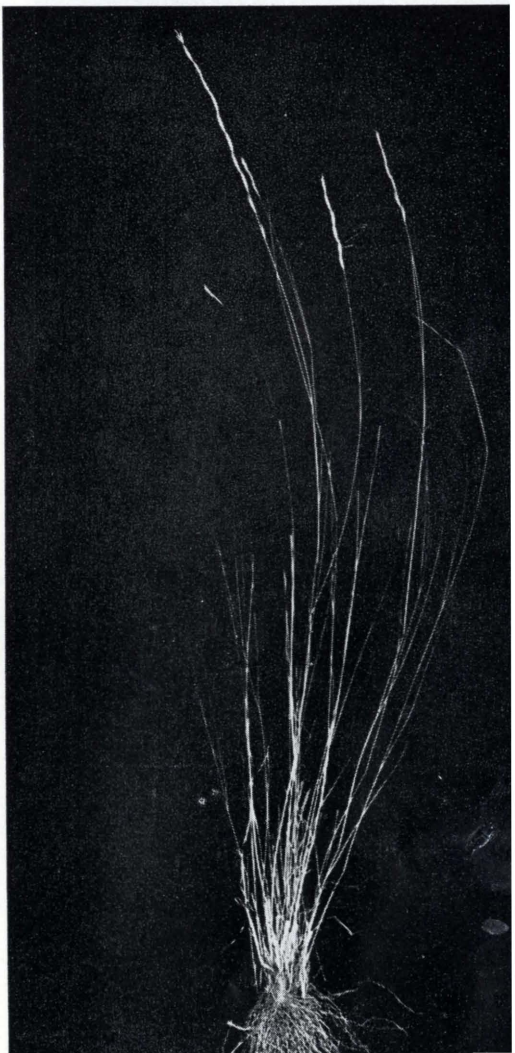

Fig. 7. A few stems of western wheatgrass and connecting underground stems or rhizomes. Western wheatgrass is often bluish-green in color and it produces individual stems or tufts rather than bunches

ing early spring. Thereafter, it became markedly deficient. Metabolizable energy values were considered adequate throughout the spring and summer. Adequate phosphorus was available only during early spring. This may be of considerable importance for ewes with sucking lambs, since low phosphorus intake causes decreased milk production.

Western wheatgrass Western wheatgrass (fig. 7) sometimes known as bluestem because of the bluish color of the leaves and stems, is a drought-resistant native perennial. This plant possesses underground stems (rhizomes) hence it grows as single stems or open sod.

Western wheatgrass occurs over extensive areas of the Great Basin and on a wide variety of soils. It is frequent where soils are high in sodium salts but also on well drained and sandy soils. Although fair forage in early spring, it is grazed reluctantly by sheep during summer because the foliage is stiff and coarse.

Chemical analysis of western wheatgrass (table 2) showed wide variation. Total protein and phosphorus increased from early to late spring then decreased to the lowest values during the summer. Cellulose, other carbohydrates, and calcium showed a trend somewhat opposite to that of total protein and phosphorus. Gross energy values did not vary much, whereas lignin progressively increased.

Coefficients of digestibility (table 3) were relatively high for all nutrients. However, wide fluctuations were noted between seasons.

Digestible protein (table 3) was adequate in early summer although lower than expected during early stage of growth. This was believed a result of the animal's consuming much of the leaf sheath in addition to blades. By late spring or early summer, while in the boot stage, digestible protein value was more than adequate. During the summer after maturity digestible protein content became decidedly deficient. Metabolizable energy (table 3) was considered adequate throughout the season. Phosphorus in early spring was slightly deficient. In late spring it

was adequate but by the time the plant reached the seed stage, it was again deficient.

Russian-thistle Russian-thistle, or tumbleweed, is an introduced annual with somewhat spiny leaves (fig. 8). It is found in abundance on abused ranges and abandoned fields. Forage production of Russian-thistle is extremely variable. However, with sufficient summer rainfall, growth is luxuriant and dense.

Sheep readily consume early growth, but consumption rapidly decreases as the plant becomes coarse and spiny. Continuous feeding for about two weeks causes the animals to become scoured, and further use may cause physiological disturbances. In early spring it was necessary to eliminate some of the sheep from grazing trials because of extreme scouring. Therefore, digestion coefficients obtained from this trial may not be as reliable as those obtained in other periods where a larger number of animals were used.

Russian-thistle (table 2) showed a steady decrease in total protein, total ash, and phosphorus as the plant matured, whereas lignin, cellulose, and other carbohydrates progressively increased.

Digestibility of ether extract, total protein, cellulose, other carbohydrates, and gross energy showed an orderly decrease as the plant matured (table 3). Digestible protein was adequate at all times during the summer. This factor may be of considerable importance to livestock operators since lactating ewes and growing lambs require a high intake of digestible protein.

Metabolizable energy of Russian-thistle (table 3) during early and mid-summer appeared adequate, but during late summer it was decidedly deficient.

Throughout the summer, Russian-thistle contained insufficient phosphorus. Milk flow of ewes and growth of lambs may be affected because of this deficiency if animals are restricted to Russian-thistle.

Smother weed Smother weed is an introduced annual (fig. 9) growing abundantly on abandoned fields, alkali lands, semi-swamp lands, and disturbed range areas. Animals readily consume smother weed throughout the summer when other forage is comparatively dry.

As a source of feed it is not reliable because production fluctuates in accordance with amount of summer precipitation. If eaten continuously for a two-week period, this plant causes sheep to scour.

The percentage of phosphorus, ether extract, lignin, other carbohydrates, and gross energy increased with ad-

Fig. 8. A young Russian-thistle plant at the time of flowering

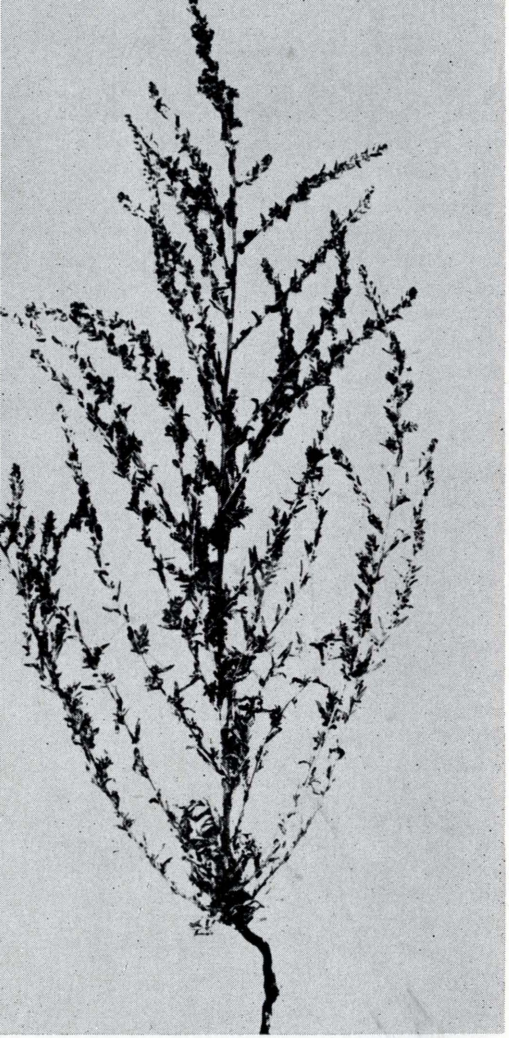

Fig. 9. A young smother weed in the preflower stage. This plant is not prickly like the Russian-thistle

vancing growth, whereas, total protein, total ash, and calcium decreased.

Digestibility of protein and other carbohydrates showed an orderly decrease as maturity advanced.

Smother weed more than met the digestible protein requirements (table 3) for lactating ewes during the entire summer. Since protein is the nutrient most likely to be deficient in range forage during late summer, smother weed, which supplies digestible protein in an amount sufficient to meet the animal's requirements, is important to the livestock operator.

Metabolizable energy was somewhat low during early and midsummer, however, in late summer it increased slightly. Phosphorus was adequate throughout the summer. Smother weed was the only plant studied which could be considered an excellent source of phosphorus during summer.

Grazing Studies with Cattle and Sheep

In 1954 cattle were grazed from July 22 to August 24 on an area consisting of plots planted to the four introduced wheatgrasses (*A. cristatum, A. elongatum, A. intermedium,* and *A. trichophorum*). Within this area were 300 small plots of an acre or less in size and ten 40-acre plots planted to each species alone and to a mixture of the four in two replications. These plots were not separated by fence, hence it was possible to determine comparative degree of utilization.

At the time the cattle were turned into the area, crested wheatgrass was in the seed shattering stage, pubescent wheatgrass was in mature seed stage, tall wheatgrass was in anthesis, and intermediate wheatgrass was in dough stage.

Use by cattle in summer Use of crested and pubescent wheatgrasses was spotty. Animals concentrated on swales where the grasses were greener. They had a tendency to graze plants that were grazed the year before and hence were less stemmy and coarse.

In many areas crested wheatgrass plants were eaten only slightly, the use varying from none to as much as 50 percent, the average being about 10 percent. Pubescent wheatgrass was utilized only moderately. Few plants were used more than 25 to 30 percent and many were untouched. The use of

the area of pubescent wheatgrass was more uniform than in the case of crested wheatgrass. However, animals showed preference for plants that were greener and less stemmy. Average utilization of pubescent wheatgrass was about 18 percent.

Tall wheatgrass was used heavily and uniformly. Areas where it grew in dense stands and was not robust and stemmy were utilized much the closest. Average use under all conditions was about 75 percent.

Intermediate wheatgrass was eaten readily under all conditions and was utilized heavily on all plots. All plants were grazed to a uniform height of about 1½ to 2 inches. Average utilization was about 80 percent. Native species (western wheatgrass, beardless wheatgrass, squirreltail grass, and Indian ricegrass) were virtually ungrazed.

On the large plots where species grew in pure stands of considerable size, grazing was lighter. After two weeks of grazing, crested wheatgrass and pubescent wheatgrass were used only about 1 percent. Tall wheatgrass and intermediate wheatgrass were utilized 15 and 12 percent, respectively. At the close of the grazing season, crested wheatgrass and pubescent wheatgrass were used at about 5 and 8 percent, respectively, whereas tall wheatgrass was utilized about 38 percent and intermediate wheatgrass about 52 percent (table 4).

Chemical content during summer grazing (cattle) Plant samples representing material consumed by cattle were collected from each species two weeks and four weeks after grazing started (table 5). There was little difference between the species in total protein and gross energy. However, crested wheatgrass was higher in lignin and other carbohydrates and lower in cellulose than the other three species. This does not explain differences in palatability among the species. Higher lignin content in crested wheatgrass might indicate coarseness. However, high carbohydrate content should increase palatability. Physical character of the plant may influence palatability more than chemical content.

Steers grazing the areas made an average daily gain of 2.2 pounds—exceptionally good for late summer.

Use by cattle in spring In the spring of 1955, cattle were placed on the same plots that were grazed the

Table 4. Estimated degree of utilization by cattle for four wheatgrass species on 40-acre pastures at the end of two weeks of grazing, August 5, at the end of three weeks' grazing, August 12, and at the end of the grazing period, August 24*

Species	Date		
	8/5	8/12	8/24
		percent utilization	
Crested wheatgrass	1	3	5
Pubescent wheatgrass	1	6	8
Tall wheatgrass	15	27	38
Intermediate wheatgrass	12	30	52

*Percent utilization was based upon total production on ungrazed plots on date estimates were made.

Table 5. Chemical content of wheatgrass forage consumed by cattle after two weeks of grazing and after four weeks of grazing in summer.

Species and stages of growth	Date	Ether extract	Total protein	Ash	Lignin	Cellulose	Other carbohydrates	Calcium	Phosphorus	Gross energy
					percent					*cal./lb.*
Crested wheatgrass										
seed shattering stage—stems and leaves with	8/12	3.32	7.56	9.70	8.28	27.8	43.34	.49	.10	1936
few heads eaten	8/25	3.15	7.62	9.74	8.19	28.1	43.20	.47	.10	1936
Average		3.23	7.59	9.72	8.23	27.9	43.27	.48	.10	1936
Pubescent wheatgrass										
mature seed stage—stems and leaves with few	8/12	3.36	8.00	11.4	7.58	32.0	37.66	.63	.10	1891
heads eaten	8/25	3.33	7.87	11.8	7.42	32.1	37.48	.63	.10	1882
Average		3.34	7.93	11.6	7.50	32.0	37.57	.63	.10	1886
Tall wheatgrass										
early head stage—entire plant to 6 inch	8/12	2.49	8.25	10.24	6.72	33.6	38.70	.47	.11	1922
stubble eaten	8/25	3.78	8.25	9.87	7.80	31.8	38.50	.49	.10	1936
Average		3.13	8.25	10.05	7.26	32.7	38.60	.48	.10	1929
Intermediate wheatgrass										
early seed stage—entire plant to 3 inch	8/12	4.05	7.37	8.81	6.47	33.5	39.53	.45	.10	1959
stubble height eaten	8/25	3.89	7.06	8.82	6.91	33.3	40.02	.45	.11	1959
Average		3.97	7.21	8.81	6.82	33.4	39.77	.45	.10	1959

previous year during the summer. All species were in the vegetative stages (third to fifth leaf stages.) On May 15, after two weeks of grazing, observations showed a decided preference for introduced grasses over the native grasses. On all species animals ate upper portions of the young plants and avoided old growth. At the beginning of grazing, intermediate wheatgrass was used heaviest, followed closely by crested wheatgrass and pubescent wheatgrass (table 6). Tall wheatgrass was grazed only slightly.

On May 30 most species were either in or approaching the boot stage. Only western wheatgrass, tall wheatgrass, and intermediate wheatgrass were still in earlier stages. At this time only squirreltail grass of the native grasses had been grazed. Of the introduced species intermediate wheatgrass was heaviest utilized (25 percent), however both crested and pubescent wheatgrasses were being eaten readily. Tall wheatgrass was still only slightly used.

By mid June all grasses except western wheatgrass and tall wheatgrass were in early head stage. Tall wheatgrass was still in the pre-boot stage and western wheatgrass was in late boot. Intermediate wheatgrass was utilized more than twice as heavily as any of the others. Pubescent wheatgrass was more preferred than crested wheatgrass and use of tall wheatgrass had increased materially. Squirreltail grass and beardless wheatgrass were as palatable as pubescent wheatgrass and more palatable than crested wheatgrass.

At the end of grazing, June 29, all plants were in the head stage except tall wheatgrass which was still in the boot. Crested wheatgrass, Indian ricegrass (fig. 10), and squirreltail grass (fig. 11) were in the dough stage and others were between anthesis and milk stage. Intermediate wheatgrass was being utilized heavily. Use of pubescent wheatgrass had increased but was still moderate (55 percent). Tall wheatgrass and crested wheatgrass were both used about 25 percent. Squirreltail grass and beardless wheatgrass were more palatable than crested wheatgrass or tall wheatgrass, however, they were less palatable than pubescent or intermediate wheatgrass.

Table 6. Estimated degree of utilization of grasses by grazing intervals for cattle from May 15 to June 29*

Species	Date						
	5/15	5/21	5/30	6/7	6/15	6/21	6/29
	percent utilization						
Crested wheatgrass	10	20	10	7	15	25	25
Pubescent wheatgrass	10	15	15	7	25	40	55
Tall wheatgrass	2	2	5	9	11	18	25
Intermediate wheatgrass	20	25	35	40	55	67	80
Indian Ricegrass	0	0	0	5	10	15	20
Squirreltail grass	3	20	15	25	30	30	40
Beardless wheatgrass	0	0	2	5	20	30	30
Western wheatgrass	0	0	0	0	5	7	10

*Percent utilization was based upon total production on ungrazed plots on the date estimates were made.

Table 7. Chemical content of introduced wheatgrasses during spring based on samples of the entire plant to crown level, Benmore, Utah

Species and stage of growth	Date	Ether extract	Total protein	Ash	Lignin	Cellulose	Other carbohydrates	Calcium	Phosphorus	Gross energy
					percent					*cal./lb.*
Crested wheatgrass										
fourth leaf	5/ 9/55	2.49	15.81	15.68	5.41	21.42	39.19	.66	.27	1886
fifth leaf	5/15/55	2.55	15.55	14.05	4.18	26.39	37.28	.62	.25	1882
early boot	5/21/55	2.28	16.76	11.69	5.57	26.39	37.31	.50	.26	1904
late boot	5/30/55	2.06	12.58	11.83	3.60	28.99	40.94	.56	.23	1963
early head stage	6/ 7/55	1.58	10.61	10.28	6.10	28.11	43.32	.48	.20	1863
anthesis	6/15/55	2.05	9.42	9.29	7.75	34.55	37.14	.47	.22	2018
milk	6/22/55	2.07	7.39	7.85	8.28	30.23	44.18	.35	.20	1940
early dough	6/29/55	2.13	6.47	7.81	7.30	33.75	42.54	.36	.18	1972
Average		2.15	11.81	11.06	6.02	28.70	40.24	.50	.22	1927
Pubescent wheatgrass										
third leaf	5/ 9/55	1.80	19.97	17.41	3.82	19.75	37.25	.58	.26	1850
fourth leaf	5/15/55	2.70	13.48	18.72	4.76	24.43	35.91	.60	.15	1836
fifth leaf	5/21/55	2.31	17.39	12.91	3.80	26.58	37.01	.47	.26	1859
early boot	5/30/55	1.83	11.78	14.94	5.08	27.03	39.34	.50	.21	1877
late boot	6/ 7/55	2.06	8.88	14.43	6.00	29.80	38.83	.56	.16	1895
early head	6/15/55	2.09	9.60	9.28	7.20	34.75	37.08	.39	.17	1940
anthesis	6/22/55	2.02	8.19	9.08	8.28	32.81	39.62	.36	.15	1909
milk stage	6/29/55	3.40	6.58	10.96	8.17	31.28	39.61	.51	.18	1918
Average		2.28	11.98	13.46	5.89	28.30	38.08	.47	.19	1886

Table 7 (Cont.)

Species and stage of growth	Date	Ether extract	Total protein	Ash	Lignin	Cellulose	Other carbohydrates	Calcium	Phosphorus	Gross energy
					percent					*cal./lb.*
Tall wheatgrass										
third leaf	5/ 9/55	1.89	21.27	18.58	3.86	24.37	30.03	.57	.28	1859
fourth leaf	5/15/55	1.83	16.74	17.53	5.84	24.30	33.76	.55	.21	1841
fifth leaf	5/21/55	2.04	18.00	11.11	4.23	31.66	32.96	.47	.20	1845
fifth leaf	5/30/55	1.28	12.89	13.23	5.61	30.18	36.81	.50	.19	1850
sixth leaf	6/ 7/55	1.72	10.15	12.82	6.52	29.50	39.29	.52	.21	1836
sixth leaf	6/15/55	1.91	9.97	10.33	5.75	32.16	39.88	.47	.19	1877
early boot	6/22/55	2.01	8.94	10.32	7.20	33.46	38.07	.41	.16	1941
boot	6/29/55	2.27	7.81	10.90	5.45	31.21	42.36	.40	.16	1891
Average		1.85	13.22	13.10	5.56	29.60	36.64	.48	.20	1868
Intermediate wheatgrass										
third leaf	5/ 9/55	2.48	17.37	18.81	5.34	21.27	34.73	.36	.26	1836
fourth leaf	5/15/55	2.32	14.54	19.89	4.76	21.47	37.02	.63	.24	1832
fifth leaf	5/21/55	2.37	16.36	12.03	3.80	23.85	41.59	.41	.24	1977
sixth leaf	5/30/55	1.87	11.23	15.72	6.31	25.25	39.62	.53	.17	1863
early boot	6/ 7/55	1.65	10.31	13.50	5.14	29.26	40.14	.48	.17	2027
late boot	6/15/55	2.80	9.12	10.95	7.41	28.67	41.05	.35	.16	1873
early head	6/22/55	2.05	7.97	10.74	7.62	34.04	37.58	.33	.21	1950
anthesis	6/29/55	1.81	6.68	11.55	8.13	34.34	37.49	.36	.18	1882
Average		2.17	11.69	14.15	6.06	27.27	38.65	.44	.20	1904

Table 8. Chemical content of forage representing portions of plants consumed by cattle during spring, Benmore, Utah

Species and portion eaten	Date	Ether extract	Total protein	Ash	Lignin	Cellulose	Other carbohydrates	Calcium	Phosphorus	Gross energy
					percent					*cal./lb.*
Crested wheatgrass										
young plants	5/15/55	3.11	21.24	11.33	4.23	21.81	38.28	.51	.29	1954
young plants	5/21/55	2.24	19.25	12.13	4.43	21.73	40.22	.55	.26	1918
small plants & basal leaves on others	5/30/55	2.55	17.07	11.19	6.45	30.60	32.14	.48	.30	1995
same as above	6/ 7/55	2.20	12.39	8.80	6.61	30.89	39.11	.40	.25	1909
same as above	6/15/55	2.50	12.91	8.21	7.20	34.27	34.91	.38	.25	1959
same as above	6/22/55	3.01	12.36	9.83	6.20	33.04	35.56	.50	.25	1909
same as above	6/29/55	2.99	10.73	8.98	7.42	33.63	36.25	.46	.22	1986
Average		2.68	15.13	10.07	6.08	29.42	36.64	.47	.26	1945
Pubescent wheatgrass										
new growth on all plants	5/15/55	2.83	19.46	15.73	3.72	25.19	33.07	.77	.22	1872
upper portions	5/21/55	2.89	19.45	11.77	5.13	22.89	37.87	.47	.26	1986
upper portions	5/30/55	2.44	14.90	11.44	4.45	25.97	40.80	.46	.23	1904
upper portions	6/ 7/55	2.19	13.92	9.86	4.77	29.38	39.88	.48	.22	1877
upper portions	6/15/55	2.13	11.68	8.15	6.05	34.30	37.69	.38	.21	1972
stems avoided	6/22/55	2.75	11.22	11.83	8.13	29.38	36.69	.51	.19	1886
stems avoided	6/29/55	3.60	9.88	13.60	6.80	27.50	38.62	.65	.16	1995
Average		2.69	14.36	11.77	5.58	27.80	37.80	.53	.21	1927

Table 8. (Cont.)

Species and portion eaten	Date	Ether extract	Total protein	Ash	Lignin	Cellulose	Other carbohydrates	Calcium	Phosphorus	Gross energy
					percent					*cal./lb.*
Tall wheatgrass										
leafy material of young plants	5/15/55	2.40	23.21	14.35	3.85	23.56	32.63	.53	.26	1395
leafy material only	5/21/55	2.37	21.07	13.23	5.54	27.20	30.59	.52	.24	1954
upper portions of leaves	5/30/55	2.77	20.26	13.63	5.26	27.17	30.91	.51	.23	1891
same as above	6/ 7/55	2.22	17.60	11.05	4.99	31.25	32.89	.47	.21	1945
same as above	6/15/55	2.91	16.30	10.79	5.00	31.21	33.79	.42	.22	1954
same as above	6/22/55	2.69	13.63	9.64	7.83	28.71	37.50	.34	.20	1891
same as above	6/29/55	2.96	11.79	10.04	7.01	32.80	35.40	.34	.20	1904
Average		2.62	17.69	11.82	5.64	28.84	33.39	.44	.22	1918
Intermediate wheatgrass										
new growth	5/15/55	2.85	21.15	12.50	4.85	23.28	35.37	.45	.26	1927
primarily leafy material	5/21/55	2.85	18.59	13.55	4.05	29.44	31.52	.53	.24	1922
All of plant without old growth	5/30/55	2.63	17.20	11.99	4.90	29.88	33.40	.44	.25	1868
all of plant without old growth	6/ 7/55	2.03	14.75	10.02	4.65	30.70	37.85	.38	.28	1945
entire plant to 4 inches	6/15/55	2.60	12.02	10.63	5.66	31.53	37.56	.42	.17	1909
entire plant to 3 inches	6/22/55	2.19	12.31	11.07	7.45	30.45	36.53	.39	.26	1900
same as above	6/29/55	2.37	10.00	13.99	7.36	33.00	33.28	.52	.23	1832
Average		2.50	15.14	11.96	5.56	29.75	35.07	.44	.24	1900

Fig. 10. Indian ricegrass in seed-shattering stage late in summer. The seeds are hard, round, and blackish, with a tuft of white hairs at the base

Chemical content during spring (cattle) From May 15 to June 29 plant samples were collected for chemical analyses. Total current year's growth was collected from each of the introduced wheatgrasses (table 7) and, in addition, portions representing material being consumed by the cattle were collected (table 8).

As would be expected, protein and phosphorus decreased with plant maturity. Lignin, cellulose, and other carbohydrates increased (tables 7 and 8). Protein and phosphorus were higher in forage actually being consumed than in total current growth (tables 7 and 8). Lignin and other carbohydrates were lower in the portion consumed. Cellulose and gross energy were about the same. In general cattle selected the more nutritious portions of the grasses. This was particularly true for protein and phosphorus. In advanced growth stages preference for certain portions of the plants was more obvious. Increase of lignin content with advancing maturity is not so pronounced in the forage consumed as in total current growth.

Tall wheatgrass was relatively high in protein and intermediate wheatgrass was relatively high in cellulose. Late maturity may account for some of the differences, however, even in early growth stages these species were comparatively high in these constituents. There appeared to be little difference in chemical content between the other two introduced wheatgrasses.

Two-year-old steers and heifers from May 15 to June 29 gained an average of 3.34 pounds daily which is an excellent gain.

Production Data on these plots showed that native wheatgrasses (beardless and western) yielded significantly more forage per acre than the introduced species (table 9). Indian ricegrasses and squirreltail grass yielded slightly more than tall wheatgrass, however, the differences were not statistically significant. This would indicate that most native grasses would yield about as well as the introduced wheatgrasses if given the same opportunity.

Use by sheep in spring During June 1955, sheep were grazed on large plots near Eureka, Utah, composed of pure stands of tall wheatgrass, intermediate wheatgrass, crested wheatgrass, and mixtures of all three. They had access to a 70-acre area of each species in a pure stand and in addition a 70-

Table 9. Production of airy dry material per acre for native and introduced grasses on experiemental plots when clipped to 1 inch stubble height*

Species	Pounds per acre	Confidence interval (t.05 Sx)
Crested wheatgrass	225.9	±20
Pubescent wheatgrass	212.6	±16
Intermediate wheatgrass	201.0	±12
Tall wheatgrass	161.5	±15
Beardless wheatgrass	320.1	±32
Western wheatgrass	290.0	±22
Indian ricegrass	173.3	±21
Squirreltail grass	180.0	± 8

*The introduced species were seeded in 1950 and 1951 and were ungrazed until after production was obtained in the fall of 1953 and 1954. The native species were seeded in 1940 and were ungrazed until after production was obtained in the fall of 1953 and 1954. All old growth was removed from material at the time of weighing.

acre area in a mixture of the three; they also had access to some native range. Use of the various species by sheep was similar to that by cattle. Intermediate wheatgrass was always the most preferred by sheep and western wheatgrass least preferred. Preference for the introduced species over native species was pronounced (table 10). Native species were untouched until after three weeks of grazing. At this time use of intermediate wheatgrass was heavy and crested wheatgrass was becoming stemmy and mature. Even under these conditions only light use was made of the native species. Crested wheatgrass was only lightly used when intermediate wheatgrass was heavily grazed. Tall wheatgrass was used only when crested wheatgrass became more mature and intermediate wheatgrass became scarce. It was evident that intermediate wheatgrass in a mixture would soon be destroyed if moderate use of other species was obtained.

Fig. 11. Squirreltail grass during July. This head breaks apart readily and scatters seeds which have long, stiff awns

Chemical content during spring (sheep) The chemical content of the three introduced wheatgrasses was determined on the entire plant from crown level and also on portions repre-

Table 10. Estimated utilization of grasses grazed by sheep from June 1 to July 1, 1955*

Species	Date			
	6/7	6/14	6/21	6/28
	percent utilization			
Crested wheatgrass	2	10	15	15
Tall wheatgrass	0	1	5	10
Intermediate wheatgrass	5	20	60	85
Western wheatgrass	0	0	0	0
Beardless wheatgrass	0	0	1	5
Indian ricegrass	0	0	3	5
Squirreltail grass	0	0	5	10

*Percent utilization was based upon forage production on ungrazed plots on the date estimations were made.

senting material actually being consumed by sheep (tables 11 and 12). In addition, analyses of the entire plant of four native species were made on total current growth collected on the same dates (table 13).

When comparing the chemical content of the entire plant of the three introduced wheatgrasses with the content of material being consumed, it was noted that sheep, like cattle, selected nutritious portions and selection was more pronounced as the stage of growth advanced.

The differences between nutritive content of the entire plant and portions eaten were greater for sheep than for cattle, suggesting that sheep show more selectivity for nutritious portions than cattle. This agreed with observations, which showed that sheep nibble the leaves and sheathes from the stem whereas cattle wrapped the tongue around the more leafy portion and pulled it from the plant.

The chemical content of forage consumed by sheep (table 12) showed that most constiuents changed little with advanced growth. However, some constituents changed rather noticeably with maturity when the entire plant was analyzed (table 11). Lignin and ether extract increased, whereas protein and ash decreased.

Ewes with three-week to six-week-old lambs gained an average of 0.17 pounds per day from June 1 to July 29 on these pastures. Lambs gained an average of 0.47 pounds per day.

There appeared to be little difference in chemical content of the entire plant of introduced grasses compared to native grasses (tables 11 and 13). Seasonal changes appear to be somewhat more pronounced in the introduced species.

Table 11. Chemical content of introduced wheatgrasses during spring based on samples of the entire plant to crown level, Eureka, Utah

Species and portion eaten	Date	Ether extract	Total protein	Ash	Lignin	Cellulose	Other carbohydrates	Calcium	Phosphorus	Gross energy
					percent					*cal./lb.*
Crested wheatgrass										
late boot	5/30/55	2.11	11.22	11.33	5.40	28.80	41.14	.54	.22	1891
early head	6/ 7/55	2.14	11.66	13.96	5.71	27.72	38.81	.68	.14	1977
anthesis	6/14/55	2.30	8.05	11.50	7.98	28.54	41.63	.43	.17	1827
milk	6/21/55	2.51	9.06	10.77	7.68	26.35	43.63	.52	.16	1968
early dough	6/28/55	2.47	8.03	7.92	7.65	28.38	45.55	.42	.21	2004
Average		2.30	9.60	11.09	6.88	27.96	42.15	.52	.18	1931
Tall wheatgrass										
fifth leaf	5/30/55	1.71	12.29	12.48	6.13	32.90	34.49	.43	.17	1863
fifth leaf	6/ 7/55	1.83	10.90	15.35	5.00	30.61	36.31	.70	.13	1809
sixth leaf	6/14/55	2.11	11.49	13.25	6.09	31.42	35.64	.48	.20	1850
sixth leaf	6/21/55	2.24	10.38	13.21	7.96	29.20	37.01	.40	.17	1854
boot	6/28/55	2.57	9.51	11.73	6.10	33.18	36.91	.43	.16	1913
Average		2.11	10.83	12.87	6.53	31.09	36.55	.47	.17	1854
Intermediate wheatgrass										
sixth leaf	5/30/55	2.31	12.10	14.40	5.29	25.70	40.20	.49	.19	1832
early boot	6/ 7/55	2.44	8.91	12.37	4.97	31.84	39.41	.43	.18	1863
late boot	6/14/55	2.30	8.92	12.99	5.90	31.46	38.43	.41	.19	1832
early head	6/21/55	2.60	7.18	10.15	6.23	33.24	40.60	.37	.19	1900
anthesis	6/28/55	3.28	9.72	12.57	7.14	32.19	35.10	.45	.21	1877
Average		2.59	9.36	12.49	5.91	30.89	38.75	.43	.19	1859

Table 12. Chemical content of forage representing portions of plants consumed by sheep during spring, Eureka, Utah

Species and portion eaten	Date	Ether extract	Total protein	Ash	Lignin	Cellulose	Other carbohydrates	Calcium	Phosphorus	Gross energy
					percent					*cal./lb.*
Crested wheatgrass										
early head	6/ 7/55	3.42	11.20	11.18	6.75	31.96	35.49	.59	.21	1945
anthesis	6/14/55	2.30	10.54	10.06	5.73	29.31	42.06	.54	.20	1872
milk	6/21/55	2.20	10.91	9.06	6.31	34.74	36.78	.35	.21	1850
dough	6/28/55	3.22	9.61	11.03	6.68	32.36	37.10	.50	.18	1954
Average		2.78	10.56	10.33	6.37	32.09	37.86	.49	.20	1904
Tall wheatgrass										
fifth leaf	6/ 7/55	3.28	15.56	11.33	6.70	30.89	32.24	.48	.20	1954
sixth leaf	6/14/55	2.81	12.98	10.48	5.19	31.05	37.49	.41	.18	1927
sixth leaf	6/21/55	3.35	13.93	12.00	5.41	29.62	35.69	.47	.18	1959
boot	6/28/55	3.74	12.34	12.49	5.55	30.97	34.91	.42	.21	1936
Average		3.29	13.70	11.57	5.71	30.63	35.08	.44	.19	1945
Intermediate wheatgrass										
early boot	6/ 7/55	3.13	11.19	12.13	4.55	29.08	39.92	.49	.22	1918
late boot	6/14/55	2.68	9.87	11.45	5.90	29.49	40.61	.44	.24	1882
early head	6/21/55	2.36	10.33	10.07	5.83	30.52	40.89	.40	.24	1940
anthesis	6/28/55	3.61	11.33	12.09	5.50	31.19	36.28	.43	.23	1882
Average		2.94	10.68	11.43	5.44	30.07	39.42	.44	.23	1904

Table 13. Chemical content of native grasses during spring based upon samples of the entire plant to crown level, Eureka, Utah

Species and portion eaten	Date	Ether extract	Total protein	Ash	Lignin	Cellulose	Other carbohydrates	Calcium	Phosphorus	Gross energy
					percent					*cal./lb.*
Western wheatgrass										
fourth leaf	5/30/55	2.04	10.04	12.99	5.50	33.44	35.99	.53	.17	1891
fifth leaf	6/ 7/55	2.58	11.36	10.13	4.96	35.72	35.25	.50	.20	1990
boot	6/14/55	2.94	13.87	9.46	4.37	34.99	34.37	.43	.22	1954
early head	6/21/55	3.07	9.55	9.47	6.79	29.62	41.50	.41	.20	1927
anthesis	6/28/55	3.51	12.34	12.63	6.47	33.98	31.07	.64	.13	1927
Average		2.83	11.43	10.93	5.62	33.55	35.63	.50	.18	1936
Beardless wheatgrass										
fifth leaf	5/30/55	1.76	11.06	12.27	7.89	28.06	38.96	.53	.19	1845
boot	6/ 7/55	2.25	10.98	13.34	6.88	19.40	47.15	.77	.13	1863
early head	6/14/55	2.73	9.53	14.60	6.70	30.40	36.04	.65	.16	1863
anthesis	6/21/55	2.21	8.48	9.25	10.17	28.51	41.38	.44	.12	1891
milk	6/28/55	3.57	9.41	11.76	7.10	31.58	36.58	.65	.14	1850
Average		2.50	9.89	12.24	7.75	27.59	40.02	.61	.15	1863
Indian ricegrass										
boot	5/30/55	1.49	9.37	10.35	10.14	30.23	38.42	.45	.14	1850
early head	6/ 7/55	1.77	9.63	11.65	7.77	33.49	35.69	.64	.12	1832
anthesis	6/14/55	1.46	9.06	9.45	8.62	33.45	37.96	.52	.15	1895
milk	6/21/55	1.62	9.32	8.00	9.74	34.73	36.59	.46	.18	1954
dough	6/28/55	1.64	9.21	7.93	8.00	31.37	41.85	.48	.12	1963
Average		1.59	9.32	9.48	8.85	32.65	38.10	.51	.14	1900
Squirreltail grass										
boot	5/30/55	2.63	10.69	14.37	5.70	28.22	38.39	.49	.20	1827
early head	6/ 7/55	2.28	10.84	6.50	6.49	26.41	47.48	.60	.22	2013
anthesis	6/14/55	3.33	9.72	13.87	6.45	30.92	35.71	.52	.19	1863
milk	6/21/55	2.83	10.53	13.50	8.37	26.48	38.29	.45	.19	1868
late dough	6/28/55	2.61	10.26	8.82	5.83	27.98	44.50	.47	.14	1954
Average		2.73	10.41	11.41	6.57	28.00	40.87	.50	.19	1904

Literature Cited

1. Bonsma, F. N. Factors influencing the growth and development of lambs with special reference to cross-breeding of Merino sheep for fat lamb production in South Africa. Pretoria Univ. Pub. Series 1 (Agriculture) 48. 1939.
2. Clarke, S. E., and E. W. Tisdale. The chemical composition of native forage plants of southern Alberta and Saskatchewan in relation to grazing practices. Canada Dept. Agr. Tech. Bul. 54. 1945.
3. Cook, C. Wayne and Lorin E. Harris. The nutritive content of the grazing sheep's diet on summer and winter ranges in Utah. Utah Agr. Exp. Sta. Bul. 342. 1950.
4. Cook, C. Wayne and Lorin E. Harris. The nutritive value of range forage as affected by vegetation type, site and stages of maturity. Utah Agr. Exp. Sta. Bul. 344. 1950.
5. Cook, C. Wayne and Lorin E. Harris. A comparison of the lignin-ratio technique and the chromogen method of determining digestibility and forage consumption of desert range plants by sheep. Jour. Anim. Sci. 10 (3): 565-573. 1951.
6. Cook, C. Wayne and Lorin E. Harris. Nutritive value of cheatgrass and crested wheatgrass on spring ranges in Utah. Jour. Range Mgt. 5: 311-337. 1952.
7. Cook, C. Wayne, L. A. Stoddart, and Lorin E. Harris. Measuring consumption and digestibility of winter range plants by sheep. Jour. Range Mgt. 4: 335-346. 1951.
8. Cook, C. Wayne, L. A. Stoddart, and Lorin E. Harris. Determining the digestibility and metabolizable energy of winter range plants by sheep. Jour. Anim. Sci. 11 (3): 578-590. 1952.
9. Cook, C. Wayne, L. A. Stoddart, and Lorin E. Harris. The nutritive value of winter range plants in the Great Basin as determined with digestion trials with sheep. Utah Agr. Exp. Sta. Bul. 372. 1954.
10. Cook, C. Wayne and L. A. Stoddart. Survival of wheatgrasses on sagebrush range depends on methods of seeding as well as weather conditions. Utah Agr. Exp. Sta. Farm and Home Sci. (12) 3: 43+. 1951.
11. Crampton, E. W., and R. P. Forshaw. Pasture Studies. XVI. The nutritive value of Kentucky bluegrass, red top, and bromegrass with particular reference to the relation between the chemical composition of the herbage and the live weight gains made by the animals subsisting thereon. Jour. Nutr. 19:161-172. 1940.
12. Culley, M. J. Grazing habits of range cattle. Southwestern For. and Range Exp. Sta. Res. Note 21. 1937.
13. Davies, W. The relative palatability of pasture plants. Gt. Brit. Min. Agr., Jour. 32:106-116. 1925.
14. Doran, C. W. Activities and grazing habits of sheep on summer ranges. Jour. Forestry 41:253-258. 1943.
15. Dutoit, P. J., J. G. Louw, and A. I. Malan. The influence of season and frequency of cutting on the yield, persistency, and chemical composition of grass species. Onderstepoort Jour. Vet. Sci. and Anim. Indus. 5:215-270. 1935.
16. Ellis, H. H., G. Matrone, and L. A. Maynard. A 72 percent H_2SO_4 method for determination of lignin and its use in animal nutrition studies. Jour. Anim. Sci. 5: 285-297. 1946.
17. Forbes, R. M. and W. P. Garrigus. Some relationships between chemical composition, nutritive value, and intake of forages grazed by steers and wethers. Jour. Anim. Sci. 9(3):354-362. 1950.
18. Gordon, A., and A. W. Sampson. Composition of common California foothill plants as a factor in range management. Calif. Agr. Exp. Sta. Bul. 627. 1939.
19. Hart, G. H., H. R. Guilbert, and H. Goss. Seasonal changes in the chemical composition of range forage and their relation to nutrition of animals. Calif. Agr. Exp. Sta. Bul. 543. 1932.

20. Kik, M. C. Nutritive studies of forage plants. Ark. Agr. Exp. Sta. Bul. 434. 1943.

21. Maynard, Leonard A. Animal nutrition. 2nd ed. New York, McGraw-Hill Book Co., 1947.

22. McCall, R. Seasonal variation in composition and digestibility of certain species of range bunch grasses. Amer. Soc. Anim. Prod. Proc. 25:95-100. 1932.

23. McCall, Ralph, R. T. Clark, and A. R. Patton. The apparent digestibility and nutritive value of several native and introduced grasses. Mont. Agr. Exp. Sta. Bul. 418. 1943.

24. Mitchell, H. H. The evaluation of feeds on the basis of digestible and metabolizable nutrients. Jour. Anim. Sci. 1:159-173. 1942.

25. Morrison, Frank B. Feeds and feeding. 20th ed. New York, The Morrison Pub. Co., 1947.

26. National Research Council. Recommended nutrient allowances for domestic animals. No. V. Recommended nutrient allowances for sheep. A report of the committee on animal nutrition. 1949.

27. Norman, A. G., Biochemical approach to grass problems. Amer. Soc. Agron. Jour. 31: 751-760. 1939.

28. Ostle, Bernard. Statistics in research. Ames, Iowa, Iowa St. College Press. 1954.

29. Patton. A. R. Seasonal changes in the lignin and cellulose content of some Montana grasses. II Jour. Anim. Sci. 2:59-62. 1943.

30. Phillips, T. G. and M. E. Loughlin. Composition and digestible energy of hays fed to cattle. Jour. Agr. Res. 78:389-395. 1949.

31. Richardson, A. E. V., H. C. Trumble, and R. E. Shapter. The influence of growth stage and frequency of cutting on yield and composition of a perennial grass (*Phalaris tuberosa*). Australia Counc. Sci. Indus. Res. Bul. 66. 1932.

32. Ritzman, E. G. and F. G. Benedict. The energy metabolism of sheep. New Hampshire Agr. Exp. Sta. Tech. Bul. 43. 1930.

33. Schmantz, Jack E. Grass-cafeteria style in southwestern Montana. Intermountain For. Range Exp. Sta. Research Note 12. 1954.

34. Shrewsbury, C. L., Claude Harper, F. N. Andrews and M. R. Zelle. The limitations of oat straw as a roughage for maintenance, lactation and growth in sheep. Jour. Anim. Sci. 1 (2):126-130. 1942.

35. Slen, S. B., and F. Whiting. Lamb production as affected by level of protein in the ration of the mature ewe. Jour. Anim. Sci. 11(1): 166-173. 1952.

36. Sotola, Jerry. The chemical composition and apparent digestibility of nutrients in crested wheatgrass harvested in three stages of maturity. Jour. Agr. Res. 61:303-311. 1941.

37. Stapledon, R. G., and M. G. Jones. The sheep as a grazing animal and as an instrument for estimating the productivity of pastures. Welsh Plant Breeding Sta., Aberystwyth, Bul. Ser. (H):42-54. 1927.

38. U. S. Forest Service. Preference of sheep and cattle for grasses. Intermountain Forest and Range Experiment Station. Annual Report. 1953.

39. Waldron, L. R. Some physical and chemical studies of certain clones and sibs of bromegrass. N. Dak. Agr. Exp. Sta. Bul. 152. 1921.

40. Woodman, H. E., R. E. Evans, and A. Eden. Sheep nutrition II. Determination of amounts of grass consumed by sheep on pasture of varying quality. Jour. Agr. Sci. 27(2): 212-223. 1937.

41. Woodman, H. E., R. E. Evans, and A. Eden. Sheep nutrition I. Measurement of the appetite of sheep on typical winter rations together with a critical study of the sheep feeding standards. Jour. Agr. Sci. 27:191-211. 1937.