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Bulletin No. 372 - The Nutritive Value of Winter Range Plants in the Great Basin as Determined with Digestion Trials with Sheep

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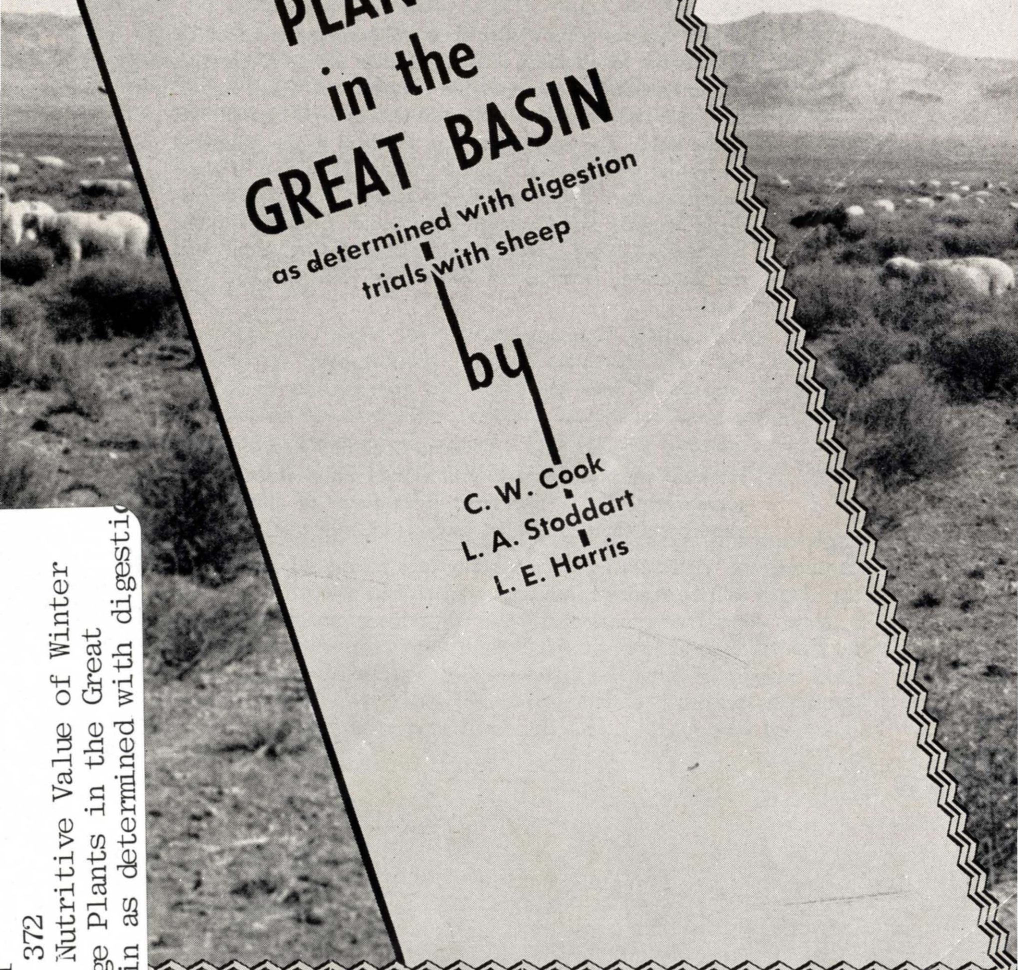

The NUTRITIVE VALUE of WINTER RANGE PLANTS in the GREAT BASIN

as determined with digestion trials with sheep

by

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The details of the feeding tests mentioned on page 12 will be reported in a later publication.

Summary

DURING the winter grazing seasons from 1946 to 1953, studies were carried on throughout the desert ranges of western Utah to determine nutritive content and digestibility of range forage plants.

These desert areas receive about 7 inches of precipiation annually and the vegetation consists, chiefly, of saltbush and sagebrush types.

The average floral composition of the desert areas studied was about 74 percent browse, 25 percent grass, and 1 percent forbs. However, on some areas there was more grass than browse and, on still others, large quantities of forbs were present, primarily Russian-thistle.

Digestion trials were carried out under normal range conditions by the use of the lignin-ratio method. Desert ranges in winter were found to be from borderline to decidedly deficient in digestible protein, phosphorus, and metabolizable energy. Diets containing appreciable quantity of browse furnished more than 10 times the minimum requirement of carotene, whereas, grass ranges were decidedly deficient in this respect.

The diet varied from area to area and was influenced by site, weather conditions, species present, and intensity of use. Of these, intensity of use was of most importance. As degree of utilization increased, the content of desirable nutrients in the diet decreased, and the digestibility was decidedly lowered. In addition, animals consumed less forage daily with increased degree of use.

In general, browse plants meet recommended standards for protein requirements and are exceptionally high in carotene. They are, however, slightly deficient in phosphorus and decidedly low in energy furnishing constituents. Grasses are markedly deficient in protein, phosphorus, and carotene but are good sources of energy. Therefore, a mixture of browse and grass in the diet more nearly balances the ration than either forage class alone.

Most desert ranges of the Great Basin area can be classed into three broad groups. Some are predominantly grass, whereas others are predominantly browse. The browse may consist primarily of species of sagebrush or primarily of salt-desert shrubs. If the range forage is largely grass, a supplement high in digestible protein and phosphorus should be fed in the winter; whereas, if the range forage is largely sagebrush species, feeds high in energy should be fed. However, if the browse is composed mainly of saltbush species, a supplement of intermediate nature should be fed.

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as determined with digestion trials with sheep

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

Introduction

THE desert ranges of the Great Basin area are composed primarily of browse species, growing in association with various amounts of grasses. Generally these ranges furnish forage to grazing animals for about five months during the winter.

Range forage, unlike most cultivated crop feeds, is harvested by the grazing animal in an assortment of species and portions of plants determined by the selectivity of the animal. This selectivity may be influenced by kind of animal, intensity of grazing, plant species present, stage of growth, abundance of forage, and general climatic conditions. As a result of this selection, it is difficult to evaluate the nutritive content of the diet. Evaluation of range forage is further complicated by many variable factors that affect chemical composition of forage plants. This may be affected by soil type, site, stage of growth, and degree of weathering. In the same way diet may vary widely, thereby exerting a profound influence on the actual intake of nutrients by the grazing animal.

To evaluate the nutritive intake by grazing animals it is necessary to determine the digestibility of the ingested nutrients. This is necessary to calculate the quantities of the various plant constituents actually available for animal use.

Digestion coefficients are considered a direct means of determining availability of nutrients. They may vary greatly, however, according to age and species of animal, and the nutrient composition of the forage or forages being tested. Individual plant species differ in chemical composition and when eaten in various combinations their digestibility may be different than when eaten separately. Therefore, such information, even when the diet and the digestibility are accurately determined, provides only an approximate index to the quality of the range herbage.

The majority of the animals grazing the desert ranges of the Great Basin area receive no supplement during the winter. A few livestock receive supplemental feed only during severe winter weather and others receive a supplement only late in the season when feed is short and regrowth is delayed.

A high rate of return from capital investment in land and livestock is dependent upon high producing efficiency of the livestock grazing the lands which, in turn, is dependent upon properly nourished animals and well managed ranges. For this reason, it is of great importance to know the nutrient value of the native forage plants and their contribution to the grazing animal's diet so that deficiencies can be corrected.

During the winter grazing seasons from 1947 to 1953, a study was conducted to determine the nutritive value of native forage on the desert ranges throughout western Utah and the benefits to be derived by feeding supplements to balance the range ration when deficiencies occur.

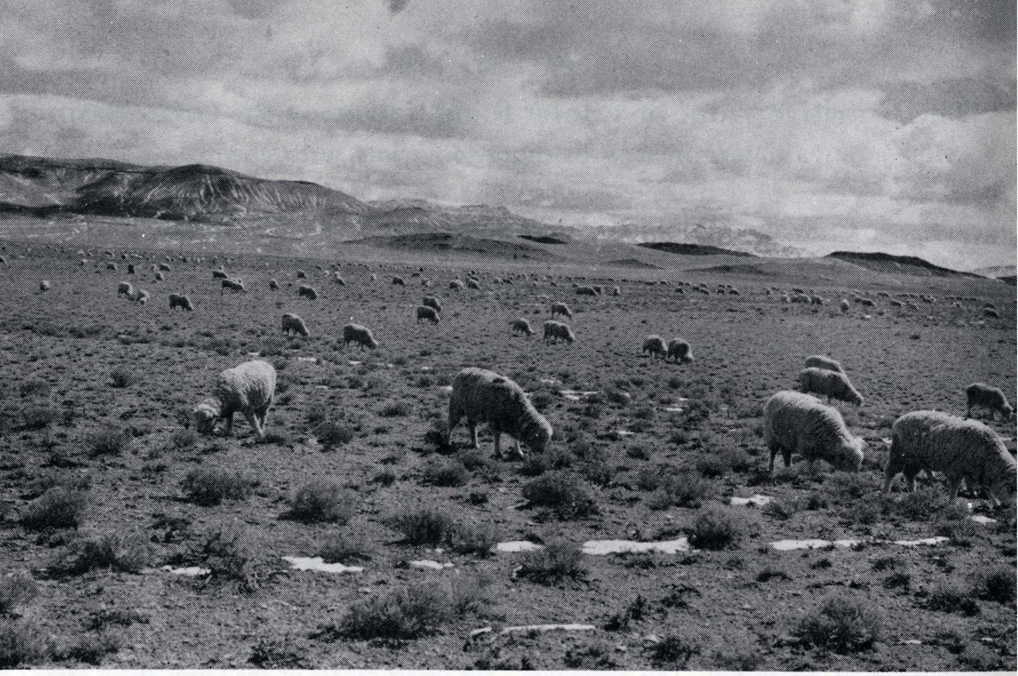

Fig. 1. Sheep grazing a typical salt-desert shrub range in west central Utah. Photo courtesy U. S. Forest Service

Description of the Area

THE desert ranges of western Utah receive an average precipitation of approximately 7 inches annually. About 40 percent of the annual precipitation is received as snow during the winter months and about 60 percent as rain during the early spring and fall.

The general physical characteristics of this region include small plateaus, foothills of low mountain chains, and broad desert basins. The soils are derived chiefly from dolomite and limestone sedimentary rock. The salt content of the soil is high in some localities and varies with the topography and general soil characteristics of the area.

The vegetation consists mainly of saltbush and sagebrush types of the northern-desert shrub formation. Dominant plant species covering extensive areas are shadscale (*Atriplex confertifolia*), winterfat or white sage (*Eurotia lanata*), Nuttall saltbush (*Atriplex nuttallii*), big sagebrush (*Artemisia tridentata*), and black sage (*Artemisia nova*). In addition to the dominants each type supports a variety of associated plant species, namely: desert molly (*Kochia vestita*), yellowbrush (*Chrysothamnus stenophyllus*), bud sage (*Artemisia spinescens*), squirreltail grass (*Sitanion hystrix*), needle-and-thread grass (*Stipa comata*), Indian ricegrass (*Oryzopsis hymenoides*), galleta or curlygrass (*Hilaria jamesii*), sand dropseed grass (*Sporobolus cryptandrus*), western wheatgrass (*Agropyron smithii*), beardless wheatgrass (*Agropyron inerme*), alkali sacaton grass (*Sporobolus airoides*), giant wild rye grass (*Elymus cinereus*), and Russian-thistle (*Salsola kali* var.

tenuifolia). The diversity in soil types, topography, and salt content of the soil solution causes great variability of native forage even on local areas. Forage types vary from a few acres dominated by a single species to large areas of complex mixtures (fig. 1).

These desert plants produce most of their growth during the spring months because they are dormant during the cold winters, and the hot and dry summers. Occasionally late summer or fall rains produce some regrowth which increases the nutrient value of the forage at least during the early part of the winter.

The average composition of the salt-desert vegetation in western Utah is about 74 percent browse, 25 percent grasses, and 1 percent forbs. However, on some areas grasses make up as much as 90 percent of the available forage and occasionally forbs occupy as much as 50 percent. The floral composition of the valley basin floor is generally different from that of foothills or adjacent gentle slopes. Therefore, when animals are restricted in area they are likewise restricted in variety of vegetation and nutrient intake.

Review of Literature

ONLY a limited number of studies have been devoted to determining the digestibility of the nutrients in range forage. The first work of this nature was carried on in Nevada (Kennedy and Dinsmore 1909). The authors found that sheep, when fed forage collected from the range, did not show normal selectivity for the plants or portions of the plants and frequently did not eat adequate amounts for a maintenance ration.

Feeding trials in California (Hart *et al.* 1932) dealing with digestibility of mature range forage, gave extremely low digestibility coefficients for crude protein, and lambs did not eat adequate amounts to maintain their weight.

McCall (1940), McCall *et al.* (1943) and Guilbert and Goss (1944) found that animals ate some range plants more readily than others and that species differed materially in digestibility of the various constituents. They found that many range plants having high palatability were sometimes comparatively low in nutritive value. Catlin (1925) summarized reports on digestion trials dealing with mature range grasses and forbs which indicated that these plants were inferior to alfalfa and grass hays in feeding value.

It has long been recognized that one of the best ways to measure the nutritive value of native forage plants is to carry out digestion trials under range conditions where the animal is allowed to select the forage in a normal manner. In order to accomplish this it has been necessary to find a plant constituent that appears normally in the forage and is indigestible so that it can be recovered in the feces. Animals can then be equipped with specially designed bags for collecting the solid excreta and allowed to graze normally without restriction.

For practical purposes, lignin meets this requirement, as shown by Ellis *et al.* (1946), Forbes and Garrigus (1948), and Forbes *et al.* (1946). By collecting all the fecal material voided and determining the quantity of lignin, it is possible to calculate the quantity of feed an animal must have consumed to excrete that quantity of lignin. However, some controversy has arisen over the validity of the assumption that lignin is not digested (Bondi 1948, Crampton and Maynard 1938, Csonka *et al.* 1929, Davis *et al.* 1947, Forbes *et al.* 1948). Reports by Ellis *et al.* (1946) stated that many of the discrepancies concerning the digestibility of lignin might be attributed to the chemical procedures used to isolate it from the feeds and feces, and failure to analyze material comparable to that actually being consumed by the animal. In the studies by Ellis *et al.* (1946), Forbes *et al.* (1946), and Chi (1951) it was shown that the digestibility of lignin fluctuated slightly above and below zero and the average approached zero.

Reid *et al.* (1950) suggested that chromogens (plant pigments absorbing light at a wavelength of 406 milimicrons) could be used as indicator substances for certain plant species. However, studies in Utah (Cook *et al.* 1951) showed that this method was unsatisfactory for desert range plants, especially those high in ether extract and essential oils. Fecal material from these plants contained considerably less chromogen substance than the original plant which in turn indicated a negative digestion coefficient for all nutrients.

Although the recovery or forage lignin in the feces shows slight variability, the lignin-ratio technique is sufficiently accurate to make it of practical value for determining digestibility of range forage. Digestion coefficients for any particular species of plant vary with environmental conditions, stage of plant maturity, animal selectivity, site and soil conditions, species of animal, age of animal, plane of nutrition, and nutritive balance of the ration. In spite of these variabilities, digestion coefficients are considered the most feasible means of obtaining information on nutrient value of native forage plants and predicting nutritive deficiencies of range forages. It should, however, be remembered that even a highly nutritious plant is of little value unless it is readily eaten by livestock. The palatability and abundance of the various species determine the botanical composition of the grazing animal's diet (Cook *et al.* 1953, Stapledon *et al.* 1927).

Most studies of the nutrients supplied by range forage have dealt with chemical analyses of herbage collected from the range and as such are not reliable indexes to availability of most nutrients to grazing animals. However, a knowledge of the chemical composition of the forage may prove useful to measure the effect of stage of growth, climatic conditions, and soil variability on apparent nutritive value of forage. Chemical analyses of forage, likewise may serve as an index to the identification of areas producing mineral deficient forage or elements causing toxicity (Ahlgren 1947, Norman 1939).

Knowledge of the nutritive value is important to the livestock operator so that he may provide a variety of desirable species and feed supplements best suited to his range and type of management.

Method and Procedure

Method for determining the digestibility and metabolizable energy of native forage under range conditions was developed and used in obtaining the data presented in this publication.

Wether sheep equipped with specially constructed fecal bags and urinals were allowed to graze enclosures typical of the vegetations being studied (fig 2). These animals were allowed to select forage in a normal manner, and by the lignin-ratio technique, the rate of consumption and digestibility coefficients were determined.

The wethers varied from 2 to 6 years

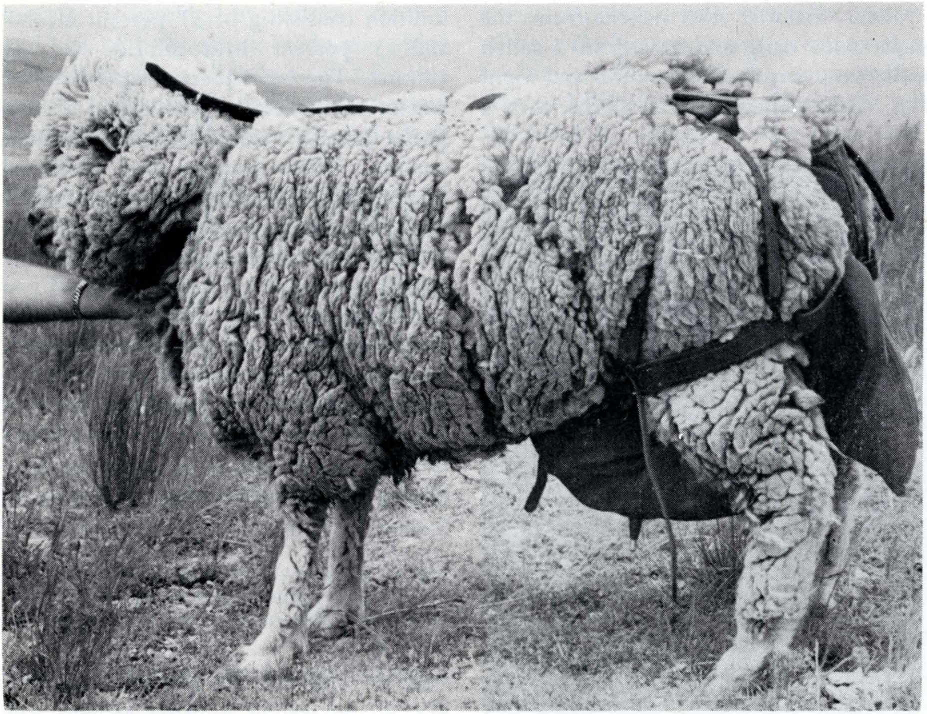

Fig. 2. A wether sheep equipped with specially designed fecal bag and urinal for collecting both the solid and liquid excreta from sheep while they graze in a normal manner

of age, averaged 140 pounds and represented various degrees of Rambouillet, Columbia, and Hampshire breeding. All animals used were raised on the range from birth and were allowed to graze with the range herds during periods when they were not being used in the experiment.

The procedure consisted of collecting feces and urine from wethers that grazed temporary enclosures. These areas were grazed by 7 wethers at a time and averaged from four to eight acres in area depending on the abundance of vegetation and the intensity of grazing desired. Frequently half of the area was used for a preliminary grazing period, during which time the stomach was emptied of other types of plant material, and the remaining half was used for running the digestion trial.

The wethers were allowed an eight-day preliminary grazing period followed by a six-day collection period. During the collection period, forage samples were taken daily by observing individual animals from four to six hours while grazing and hand plucking forage comparable to the material actually being consumed by the sheep. Many small random plucks were taken over the area as the sheep were normally grazing. When studying areas composed of complex mixtures, the method presented by Cook *et al.* (1950, 1951) was used. All forage samples were composited in duplicate for the entire period and chemically analyzed.

Fecal material was taken from the bags twice daily and placed in 5-gallon milk cans with wide mouths and tight lids. Each collection was glazed with a solution consisting of 97 percent alcohol and 3 percent hydrochloric acid by volume. The feces were weighed at the end of the collection period and a composite sample was taken for chemical analysis. These samples were preserved by freezing until dried. They were dried at 65° C. and ground through a Willey mill to pass through a one millimeter screen.

The urinals were likewise emptied daily and placed in airtight containers. Urine samples for analysis were accumulated for the period by taking 1/10 of the output from each sheep daily. These samples for analysis were placed in quart plastic bottles containing 3.6 grains of

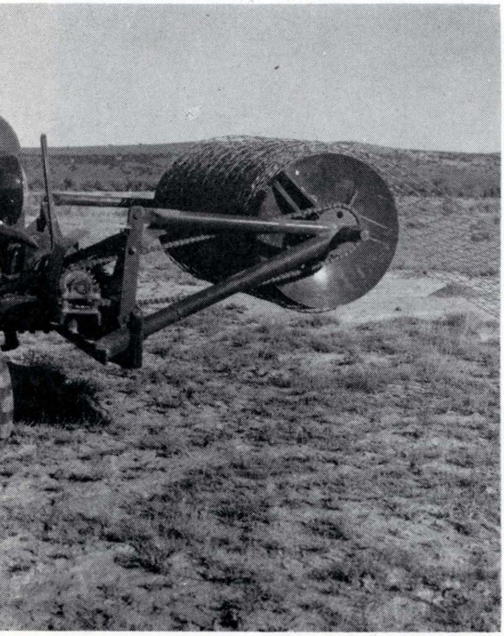

Fig. 3. A power-driven wire roller for moving woven wire fence. This device can be operated by one man from the front end of the truck

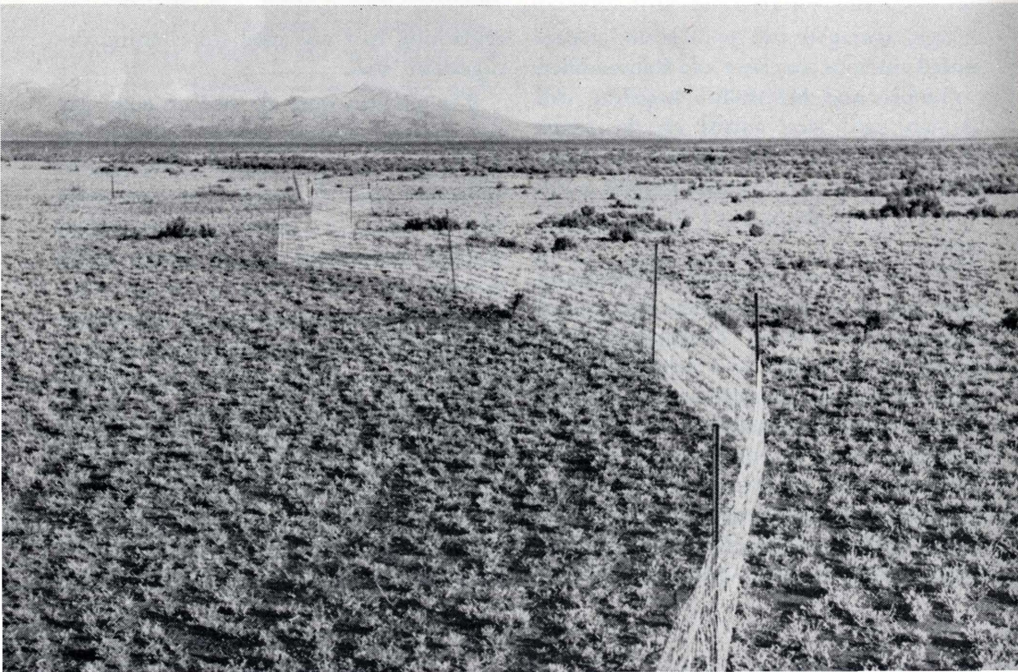

Fig. 4. An area of winterfat enclosed with triangle-mesh woven wire held upright by zigzagging steel posts on opposite sides

mercury bichloride. In addition, from 2 to 25 cc. of hydrochloric acid were added to keep the urine slightly acid. All urine samples were kept under refrigeration until analyzed for nitrogen and gross energy.

Both plant and fecal material was chemically analyzed according to the modified method of proximate analyses and for gross energy (Cook *et al.* 1951). In addition, many plant samples were collected exclusively for carotene analyses. Carotene was determined by the official method reported by the Association of Official Agricultural Chemists (1950).

From eight to sixteen 9-rod rolls of triangle-mesh fence were used to enclose each area grazed by the experimental sheep. A power-driven wire roller mounted on a Dodge power wagon was used to facilitate moving fence from one grazing area to another (fig. 3). The fence was tightened by zigzagging steel posts alternately on opposite sides of the fence (fig. 4).

Two grazing areas and two groups of sheep were operated simultaneously so that one trial was being completed each week. Sufficient fencing material was available so that one pasture could be moved and established while two others were being grazed.

Utilization, in most cases, was moderate or somewhat conservative except when trials were carried on to compare heavy use with moderate or light use.

Results and Discussion

Energy Values of Range Forage

DATA calculated from digestion experiments by conventional methods may not properly evaluate the energy supplying qualities of many shrubby range plants because they do not consider energy lost through gasses and the excretion of urine (Cook *et al.* 1952). Commonly-used indexes for evaluating the energy yielding qualities of forage such as total digestible nutrients and digestible energy consider only the loss of energy through the feces and therefore may be subject to error.

Losses through gas result from fermentation in certain segments of the digestive tract. These losses resulting from the formation of methane can be determined directly only in a respiration chamber; however, such losses can be estimated by formulas obtained from carefully controlled metabolism trials using the respiration calorimeter. Calculations for such losses were made according to the procedure outlined by Cook *et al.* (1952).

Metabolizable energy is calculated by subtracting from the gross energy of the forage, loss of energy in the feces, in the urine, and in gas. It is considered the best estimate of energy available for animals on winter range and is used herein as the index to energy-furnishing qualities of the plant.

The losses of energy through urine and gas are extremely variable for forage species found on desert ranges of the Great Basin area. Many species of browse are high in ether extract which, in turn, is high in essential oils. By conventional analyses, these oils appear to yield high digestible energy and total digestible nutrient values but actually are of relatively low feed value as shown by metabolizable energy measurements. These low metabolizable energy values are obtained because the oils are not used by the animal but are lost through the urine.

Therefore, an acurate appraisal of the nutritive energy furnished by many range plants can be assessed only by determining their metabolizable energy values.

In order to place energy values commonly used for domestic feed crops upon a comparable basis with range forage, the ether extract material would have to be broken down into its various constituents so that the fatty acid content could be determined.

Evaluating Nutrient Deficiencies

To predict nutrient deficiencies and make practical recommendations for supplementing the basal ration received from range forage, it is important to establish a recommended level for critical nutrients for optimum production and greatest economic return. This can be done only when cost-return relations have been determined by actual feeding tests.

Such a study was carried on in conjunction with the plant investigation work on the desert areas of western Utah. The nutritive content of the range forage consumed by sheep indicated deficiencies of phosphorus, protein, and energy-supplying constituents. In view of these deficiencies it was desirable to determine whether the production of range ewes could be increased by feeding supplements to furnish these nutrients. Feeding tests for a period of 3 years were started in the fall of 1947. These trials were begun soon after the sheep arrived on the winter range in November and were continued until they left in April. Results were measured in terms of body weight, wool production, and lamb crop.

Sheep fed supplements maintained their weight throughout the winter better than ewes receiving only range forage. Animals receiving supplements produced 0.3 of a pound more clean wool than sheep receiving no supplement. In addition to increased wool yield the lamb crop of the supplemented sheep was approximately 10 percent greater than the unsupplemented group. During the last two years of the feeding tests, the supplements consisted of 3 levels of high energy feed (barley), 3 levels of high protein feed (soybean oil meal), and 3 3 levels of phosphorus (monosodium phosphate). These were fed separately and in all possible combinations. The quantity of the various nutrients giving greatest economical return per unit of increased cost of supplement was the intermediate level and is shown in table 1.

Table 1. ***Calculated optimum intake* of digestible protein, metabolizable energy, and phosphorus for greatest economic return under winter range conditions of the Great Basin area***

	Intake oven dry basis	Digestible protein		Metabolizable energy		Phosphorus	
		in ration	per sheep	in ration	per sheep	in ration	per sheep
	lbs.	*%*	*lbs.*	*Cal./lb.*	*Calories*	*%*	*oz.*
Range forage	3.30	2.6	.09	577	1,904	0.09	.05
Supplement	0.29	23.0	.07	1,638	475	1.08	.05
Range forage and supplement	3.59	4.4	.16	663	2,379	0.17	.10

* Per day for 130-pound ewe during winter grazing season November until April.

The most important nutrients to be considered in appraising the nutrient value of desert range forage of the Great Basin area are: (a) digestible protein, (b) energy supplying constituents, and (c) phosphorus. These nutrients are most often the ones deficient and any one or all may be limiting factors of production. As shown in table 1, digestible protein should be maintained at about 4.5 percent of the ration, phosphorus at about 0.17 percent, and metabolizable energy at about 665 Calories per pound of feed intake.

Carotene analysis of the forage indicated no vitamin A deficiency. The carotene intake averaged 7.72 milligrams per pound of forage in the diet. This is more

Table 2. ***Average degree of utilization from average range under average conditions calculated from all study areas where a mixed flora was present***

	1	2	3	4
Species	Plant composition	Preference index	Column 1 x 2	Diet*
	percent	*percent*		*percent*
Black sage (*Artemisia nova*)	10	50	500	17
Bud sage (*Artemisia spinescens*)	5	40	200	7
Big sage (*Artemisia tridentata*)	11	15	165	5
Shadscale (*Atriplex confertifolia*)	13	20	260	9
Nuttall saltbush (*Atriplex nuttallii*)	8	35	280	9
Yellowbrush (*Chrysothamnus stenophyllus*)	5	10	50	2
Winterfat (*Eurotia lanata*)	12	40	480	16
Desert molly (*Kochia vestita*)	10	15	150	5
Browse total	74	28	-----	70
Western wheatgrass (*Agropyron smithii*)	3	30	90	3
Beardless wheatgrass (*Agropyron inerme*)	3	40	120	4
Giant wild-rye grass (*Elymus cinereus*)	1	10	10	0
Galleta or curlygrass (*Hilaria jamesii*)	2	25	50	2
Indian ricegrass (*Oryzopsis hymenoides*)	6	45	270	9
Squirreltail grass (*Sitanion hystrix*)	3	50	150	5
Alkali sacaton grass (*Sporobolus airoides*)	1	10	10	0
Sand dropseed grass (*Sporobolus cryptandrus*)	2	10	20	1
Needle-and-thread grass (*Stipa comata*)	4	40	160	5
Grass total	25	29	-----	29
Russian-thistle (*Salsola kali* var. *tenuifolia*)	1	20	20	1
Grand total	100		2,865	100

* The product for each species, column 3, is divided by the sum of the products, column 3, to obtain the percent floral composition of the diet.

than ten times that required for normal growth and reproduction. Feeding tests with dehydrated alfalfa high in carotene showed no advantage over sun cured alfalfa hay or supplements supplying no vitamin A, thus confirming the high carotene content of the plant material in the diet. The accepted minimum vitamin A level for optimum growth as well as freedom from clinical symptoms is about 1.5 milligrams of carotene per 100 pounds of body weight or about 0.5 milligrams per pound (1.1 parts per million) of the ration of forage (Guilbert and Loosli 1951). This allows only a slight margin of safety for reproduction, however.

Utilization and Diet of the Grazing Animal

Utilization varies widely among species; however, if a large variety of both browse and grass is available, both forage classes are utilized to about the same degree. The floral composition of the diet frequently is in direct proportion to the abundance of the forage species available. This is not, however, the case unless there is a variety of species, especially browse species. A more accurate estimation of the diet is obtained by weighting the percentage floral composition of the range by the anticipated degree of utilization or a preference index for each species. The average degree of utilization (preference index) for each species arrived at during this study is shown in table 2. These indexes are averages under usual plant associations and are subject to wide variation depending on the many factors affecting the palatability of forage.

The actual floral composition of the diet will vary widely from area to area; however, for practical purposes in calculating the diet on an allotment, where degree of utilization is unknown at the beginning of the grazing season but where floral composition can be determined, the procedure shown in table 2 can be used.

Effects of Intensity of Grazing Upon Nutritive Content of the Diet

Experiments have shown that animals on moderately used ranges make considerably better gains than animals on heavily used ranges (Clark 1937, Costello 1944, Harris *et al.* 1950, Woolfolk and Knapp 1949). These unfavorable responses of livestock resulting from heavy utilization of range have long been recognized but never fully explained.

Table 3. ***Chemical composition of two important desert forage plants and of a mixed diet under two intensities of utilization***

Forage species and degree of utilization	Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Phosphorus	Gross energy
				percent			*Cal./lb.*
Shadscale							
0 to 20% use	2.4	8.7	11.2	17.5	34.8	.095	1,678
21 to 50% use	2.6	8.1	13.5	14.2	35.2	.074	1,613
Black sage							
0 to 30% use	10.3	8.5	15.6	25.6	33.9	.166	2,346
31 to 55% use	8.4	7.8	18.2	23.7	33.7	.120	2,258
Mixed diet							
0 to 18% use	1.5	5.4	7.6	26.7	41.4	0.09	1,693
19 to 40% use	2.4	4.3	8.7	26.5	41.5	0.09	1,587

Table 4. *Dry matter consumed daily and digestibility of the nutrien's for the two forage species and the mixed diet under two intensities of utilization as shown in table 3*

	Degree of utilization	Dry matter consumed	Percent digested: Dry matter	Ether extract	Total protein	Cellu-lose	Other carbo-hydrates	Gross energy	Digest-ible protein	Metabo-lizable energy
	percent	*pounds*	*percent*							*Cal./lb.*
Shadscale	0-20	3.5	47.8	44.6	61.4	37.7	61.3	37.7	5.3	399
	20-50	3.2	42.3	38.2	59.1	12.3	56.1	33.3	4.8	363
Black sage	0-30	2.9	41.1	63.5	54.5	35.9	58.2	43.6	4.6	476
	30-55	2.4	34.1	56.2	53.9	24.5	55.3	35.9	4.2	386
Mixed diet	0-18	3.6	52.0	33.0	40.6	48.8	63.0	48.5	2.2	567
	18-40	3.5	48.3	41.0	36.4	44.0	61.6	42.9	1.6	499

The present studies on desert ranges indicate that these differences result largely from quantity and quality of ingested material. Animals normally prefer leaves and tender stems and reject the tougher and more fibrous parts of the plant. However, with heavier utilization, they are forced to consume coarser and less nutritious portions of the plants and as a result the diet contains a smaller percentage of the more desirable nutrients.

In addition to decreased content of desirable nutrients accompanying heavy utilization, overall digestibility of these nutrients is materially reduced.

The effect of close utilization upon nutritive content of the diet is shown in table 3. The content of protein, phos-

Table 5. ***Major winter forage plants of the Great Basin and average content of the more critical nutrients under moderate utilization for winter grazing***

Species	Phosphorus	Carotene	Digestible protein	Metabolizable energy
	percent	*mg./lb.*	*percent*	*Cal./lb.*
Black sage *(Artemisia nova)*	.14	7.90	4.4	510
Bud sage *(Artemisia spinescens)*	.33	10.80	13.7	911
Big sagebrush *(Artemisia tridentata)*	.18	7.30	5.4	575
Shadscale *(Atriplex confertifolia)*	.09	8.90	4.3	399
Nuttall saltbush *(Atriplex nuttallii)*	.12	8.60	3.4	599
Yellowbrush *(Chrysothamnus stenophyllus)*	.10	2.10	3.1	760
Winterfat *(Eurotia lanata)*	.12	7.60	6.9	594
Desert molly *(Kochia vestita)*	.12	8.20	5.5	863
Browse average*	.12	7.20	4.7	614
Western wheatgrass *(Agropyron smithii)*	.06	0.10	0.2	1,120
Beardless wheatgrass *(Agropyron inerme)*	.06	0.45	0.0†	903
Giant wild-rye grass *(Elymus cinereus)*	.06	0.05	0.0†	658
Galleta curlygrass *(Hilaria jamesii)*	.07	0.18	1.4	595
Indian ricegrass *(Oryzopsis hymenoides)*	.06	0.41	0.3	733
Squirreltail grass *(Sitanion hystrix)*	.07	0.45	1.1	732
Alkali sacaton grass *(Sporobolus airoides)*	.08	0.30	0.0†	750
Sand dropseed grass *(Sporobolus cryptandrus)*	.06	0.27	1.9	939
Needle-and-thread grass *(Stipa comata)*	.07	0.23	1.2	747
Grass average	.07	0.23	0.2	800
Russian-thistle *(Salsola kali var. tenuifolia)*	.16	4.10	9.7	807
Alfalfa hay	.21	7.90	10.5	899
Recommended requirement	.17	0.80	4.5	665

* Bud sage is not included in the average because it is eaten only in the early spring when green.
† These were determined as slight negative values but for practical use in calculating the nutritive content of the diet zeros are presented.

phorus, cellulose, and metabolizable energy in the forage decreased with heavier utilization whereas lignin increased. As utilization increased, digestibility of protein and cellulose decreased (table 4). This decrease in digestibility with increased intensity of grazing resulted in even greater reduction of available protein and energy for animal use. The differences in some cases are of sufficient magnitude that degree of utilization alone can be responsible for nutritional deficiencies. Under moderate use, range forage may furnish an adequate diet, whereas, with heavy use many deficiencies may exist.

In addition to the decreased content of the more desirable nutrients and the decreased digestibility of these nutrients with increased degree of utilization, the animals actually consume less feed per day on areas utilized heavily compared to areas utilized moderately (table 4).

Effect of Class of Forage on Nutritive Content of the Diet

According to data shown in table 5, browse plants of the desert ranges in the Great Basin are of higher quality than grass and generally contribute a greater amount to the grazing animal's diet because of greater abundance. Browse plants are higher in protein, phosphorus, and carotene (vitamin A), whereas grasses are superior only in energy yielding qualities (metabolizable energy). Browse plants generally are adequate or borderline in meeting the recommended standards for protein, exceptionally high in carotene, slightly deficient in phosphorus, and decidedly low in energy-

Table 6. *Nutrient content and digestibility of range forage when various percentages of browse and grass were eaten**

Forage class	Percent of diet	Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Calcium	Phosphorus
					percent			
Chemical content								
Browse	78	1.7	6.4	8.3	17	42	1.2	.10
Grass	22							
Browse	20	1.3	4.3	7.4	36	40	0.4	.08
Grass	80							
Browse	51	1.6	4.9	8.0	27	41	0.7	.09
Grass	49							
Digestibility								
Browse	78	29	52	0	29	62		
Grass	22							
Browse	20	19	30	0	68	64		
Grass	80							
Browse	51	30	34	0	52	63		
Grass	49							

Nutritive content	Percent of diet	Digestible protein *percent*	Digestible organic matter *percent*	Carotene *mg./lb.*	Metabolizable energy *Cal./lb.*
Browse	78	3.3	35	7.0	504
Grass	22				
Browse	20	1.3	51	1.9	743
Grass	80				
Browse	51	2.0	45	4.4	661
Grass	49				

* Forage species consisted largely of shadscale, winterfat, curly grass, and Indian ricegrass with minor quantities of 10 other species of both browse and grass.

Table 7. *A saltbush range area showing the actual calculations involved in determining the nutritive content of the diet for various nutrients*

	1	2	3	4	5	6	7
Species	Diet	Phosphorus content in plants	Phosphorus in diet 1 x 2	Digestible protein content in plants	Digestible protein in diet 1 x 4	Metabolizable energy in plants	Metabolizable energy in diet 1 x 6
	percent	*percent*	*percent*	*percent*	*percent*	*Cal./lb.*	*Cal./lb.*
Black sage	5	0.14	.0070	4.4	.220	510	25.50
Shadscale	35	0.09	.0315	4.3	1.505	373	130.55
Winterfat	15	0.12	.0180	6.9	1.035	594	89.10
Nuttall saltbush	15	0.12	.0180	3.4	.510	599	89.85
Indian ricegrass	25	0.07	.0175	0	.000	686	171.50
Squirreltail grass	5	0.07	.0035	1.1	.055	732	36.60
Total	100		.0955		3.325		543.10

furnishing constituents. Grasses are markedly deficient in protein, phosphorus, and carotene but are rather good sources of energy (table 5). Browse species are lower than grasses as a source of energy, mainly because of their relatively low content of cellulose and high content of lignin.

If animals are expected to subsist during the winter on range forage alone, a mixture of browse and grass would more nearly meet the requirements of a balanced ration than either class alone. A good salt-desert shrub range under good management frequently furnishes an adequate diet, and supplementing to correct nutritional deficiencies on deteriorated ranges is a poor and costly substitute for good range management.

Digestion trials to show the effect of percentage of browse and grass in the diet are presented in table 6. Sagebrush species were not abundant on these areas and shadscale, which was abundant, was low in nutrients after the seeds were shattered during the latter part of the grazing season; therefore, digestible protein was lower in most cases than would be expected on desert ranges where some sagebrush is present. Areas supporting the various percentages of grass and browse (table 6) were all adjacent and were located on gentle slopes between the foothills of low mountain chains and the valley floor in west central Utah.

In the first case (table 6), it is shown that the diet composed of 78 percent browse and 22 percent grass was somewhat deficient in digestible protein, phosphorus, and energy supplying constituents (metabolizable energy). Therefore, a supplement should include materials supplying all three of these constituents to correct the deficiencies. Carotene or vitamin A was adequate in all cases, indicating that a diet containing even relatively small quantities of browse will furnish ample amounts of this constituent. However, diets containing largely grass were extremely deficient in digestible protein and phosphorus, but were more than adequate sources of energy. Therefore, in this case, a supplement to correct nutritional deficiencies would necessarily have to be high in both phosphorus and protein.

The primary consideration in balancing the range ration is the percentage of browse and grass in the diet. The quantity of the individual species actually constituting the diet is of importance also but is of primary concern only when a variety of species is lacking. Generally speaking, if there is a variety of both browse and grass species, particularly browse species, the ration can be balanced on the basis of percentage of browse and grass on the range. However, if the variety of forage is limited, then it would be desirable to calculate the diet more precisely in order to evaluate the deficiencies and prepare a supplement to fit such cases.

Compounding Supplements for Various Range Types

As shown in table 2 the floral composition of the diet can be determined if the approximate vegetation composition of the range is known. Even if only the percentages of the major species eaten are known, it is relatively easy to calculate the approximate nutrient content of the diet.

For practical purposes in calculating the adequacy of the diet, it is not necessary to use more than the four nutrients listed in table 5. In determining the nutritive content of the diet, the percentage of each species in the diet is multiplied by the average content of any particular nutrient for that species (table 5) and the product

Table 8. ***Average vegetation composition of the grazing animal's diet and content of the critical nutrients used in appraising nutrient value of desert ranges of the Great Basin for the three major range types***

Species	Predominately grass range				Predominately saltbush range				Predominately sagebrush range			
	Vegetative composition of diet	Dig. protein	Phosphorus	Metabolizable energy	Vegetative composition of diet	Dig. protein	Phosphorus	Metabolizable energy	Vegetative composition of diet	Dig. protein	Phosphorus	Metabolizable energy
	percent	*percent*	*percent*	*Cal./lb.*	*percent*	*percent*	*percent*	*Cal./lb.*	*percent*	*percent*	*percent*	*Cal./lb.*
Black sage (*Artemisia nova*)	2	4.4	.14	510	1	4.4	.14	510	12	4.4	.14	510
Bud sage (*Artemisia spinescens*)	....	....	....	......	1	13.7	.33	911	2	13.7	.33	911
Big sagebrush (*Artemisia tridentata*)	3	5.4	.18	575	....	....	....	......	35	5.4	.18	575
Shadscale (*Atriplex confertifolia*)	3	4.3	.09	399	25	4.3	.09	399	5	4.3	.09	399
Nuttall saltbush (*Atriplex nuttallii*)	....	....	....	......	10	3.4	.12	599	....	....	....	......
Yellowbrush (*Chrysothamnus stenophyllus*)	2	3.1	.10	760	6	3.1	.10	760	8	3.1	.10	760
Winterfat (*Eurotia lanata*)	10	6.9	.12	594	10	6.9	.12	594	3	6.9	.12	594
Desert molly (*Kochia vestita*)	1	5.5	.12	863	3	5.5	.12	863	....	....	....	......
Misc. species	3	4.7	.12	614	5	4.7	.12	614	5	4.7	.12	614
Browse average	24	4.9	.12	616	61	4.6*	.12*	619*	70	4.8*	.12*	575*

Table 8 (Continued). *Average vegetation composition of the grazing animal's diet and content of the critical nutrients used in appraising nutrient value of desert ranges of the Great Basin for the three major range types*

Species	Predominately grass range				Predominately saltbush range				Predominately sagebrush range			
	Vegetative composition of diet	Dig. protein	Phosphorus	Metabolizable energy	Vegetative composition of diet	Dig. protein	Phosphorus	Metabolizable energy	Vegetative composition of diet	Dig. protein	Phosphorus	Metabolizable energy
Western wheatgrass *(Agropyron smithii)*	3	0.2	.06	1,120	----	----	----	------	2	0.2	.06	1,120
Beardless wheatgrass *(Agropyron inerme)*	1	0.0	.06	903	----	----	----	------	7	0.0	.06	903
Giant wild-rye grass *(Elymus cinereus)*	----	----	----	------	----	----	----	------	1	0.0	.06	658
Galleta curlygrass *(Hilaria jamesii)*	7	1.4	.07	595	3	1.4	.07	595	4	1.4	.07	595
Indian ricegrass *(Oryzopsis hymenoides)*	20	0.3	.06	733	12	0.3	.06	733	3	0.3	.06	733
Squirreltail grass *(Sitanion hystrix)*	10	1.1	.07	732	3	1.1	.07	732	4	1.1	.07	732
Alkali sacaton grass *(Sporobolus airoides)*	----	----	----	------	3	0.0	.08	750	----	----	----	------
Sand dropseed grass *(Sporobolus cryptandrus)*	15	1.9	.06	939	4	1.9	.06	939	3	1.9	.06	939
Needle-and-thread grass *(Stipa comata)*	17	1.2	.07	747	8	1.2	.07	747	2	1.2	.07	747
Misc. species	3	0.2	.07	800	6	0.2	.07	800	4	0.2	.07	800
Grass average	76	0.8	.06	821	39	0.9	.07	757	30	0.7	.06	803
Diet average	100	2.1	.08	737	100	3.1*	.10*	628*	100	3.7*	.12*	619*

* Bud sage not included because it was used only in the late winter or early spring while green.

is divided by 100. This gives a weighted figure representing the average percentage intake for the nutrient. These weighted percentages can be compared with the recommended standards presented at the bottom of table 5. An example of these calculations is shown in table 7. This area is deficient in all three of the nutrients. Therefore, a supplement containing appropriate amounts of each of these to balance the ration should be fed.

Each grazing allotment will differ in nutrients furnished by the forage, however, most ranges of the Great Basin fall into three broad classes. Some desert ranges are predominantly grass, whereas, others are predominantly browse and produce a large variety of species. Browse ranges can further be divided into sagebrush and saltbush types. The species composition of browse range is of great importance since species vary widely in nutritive content. Grasses differ in nutritive content but the variability is not as great as in browse. If browse species are mainly sagebrush, energy supplying constituents should be emphasized in a supplement with only small amounts of phosphorus and protein. However, if the browse is saltbush, a supplement containing moderate amounts of protein and phosphorus should be fed. If the range is mainly grass, supplements high in protein and phosphorus are better. The

Table 9. *Three suggested pellet supplements containing different protein levels and recommended for various range types found on the winter desert ranges of the Great Basin**

Main groups	Sub groups	Feedstuff	Proportions of feeds in pellet: high protein	medium protein	low protein
			percent	*percent*	*percent*
Protein supplements	Protein feeds	Cottonseed meal	73	42	10
		Linseed oil meal	....	....	....
		Soybean oil meal	20	10	5
		Safflower meal	....	....	....
		Urea—not over 30 percent of protein equivalent in pellet. For every pound of urea added, 6 pounds of corn or barley should be substituted for protein feeds			
Energy	Grains	Barley	....	23	55
		Corn	3	10	7
		Wheat	....	....	....
		Milo	....	....	....
Energy	Mill feeds	Shorts	....	....	....
		Molasses	....	5	10
		Beet pulp (dried)	....	....	....
Mineral supplements		Bone meal	3	3	2
		Defluorinated phosphate	....	....	....
		Monosodium phosphate	....	....	....
		Salt or trace mineralized salt	1	1	1
Roughage		Sun-cured alfalfa meal	....	6	10
TOTAL			100	100	100
Suggested composition of supplement					
Total crude protein, percent			41.0	28.0	16.0
Digestible protein, percent			34.0	23.0	13.0
Phosphorus, percent			1.3	1.0	0.7

* These supplements are calculated on the basis that about 0.25 of a pound per day will be fed to sheep and about 1.5 pounds will be fed to cattle.

average vegetation composition of the diet and the content of the critical nutrients for the three range types in the Great Basin area are presented in table 8.

Supplements for feeding on these general range types are shown in table 9. The supplement high in protein, containing about 41 percent crude protein and 1.3 percent phosphorus, would be suitable under most conditions for areas with large quantities of grass and would meet the requirements of animals grazing ranges comparable to the grass range shown in table 8. The supplement low in protein, containing about 16 percent crude protein and 0.7 percent phosphorus, would be most suitable on areas supporting largely sagebrush species. The intermediate supplement, containing 28 percent crude protein and 1 percent phosphorus would be appropriate on ranges where the majority of the vegetation consists of saltbush and associated species.

Description and Nutritive Content of the Dominant Forage Plants

Black Sage. Black sage (*Artemisia nova*) is sometimes referred to as dwarf sage because it is small compared to big sagebrush. It is closely related to big sagebrush but differs in size and also in color of the leaves. Black sage has leaves that are shorter and greener than leaves of big sagebrush but they also have the three notches or teeth at the tip of the leaf. The seed stalks have sparse foliage and extend well above the main body of the plant (fig. 5). It occurs widely in the Great Basin area on deserts and plains especially on gravelly and rocky slopes along the foothills. It is an excellent plant and is grazed readily by stock during the winter especially in mixed stands. Black sage may occur as a dominant or it may be associated with a large variety of species of both grasses and shrubs.

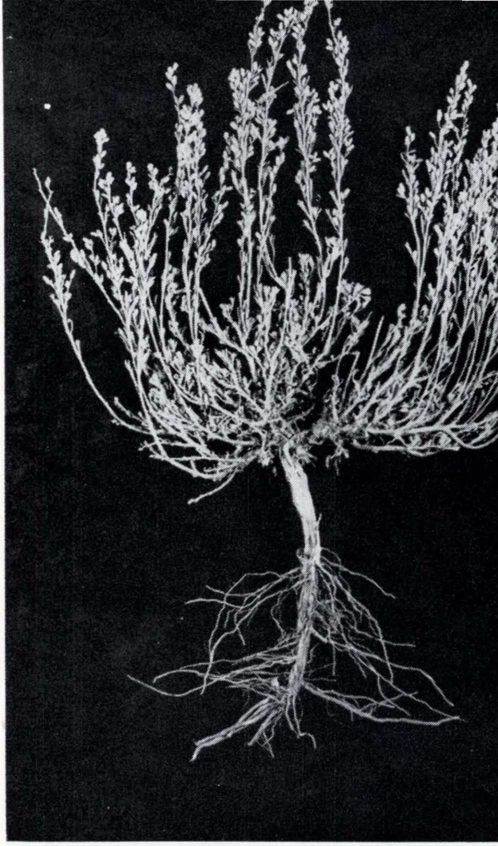

Fig. 5. Black sage plant showing characteristic form of growth and three-notched leaf tips. Flower heads are usually reddish-brown in winter and are larger than those of big sagebrush

The chemical composition of black sage (table 10) is similar to that of big sagebrush (table 12) and, like big sagebrush, is a good source of phosphorus and vitamin A. The dates shown in table 10 represent separate trials on separate areas which are, in most cases, several hundred miles apart. Therefore, wide variability in chemical content among trials is largely a result of site influence and character of growth. The digestibility coefficients (table 11) are, likewise, comparable with big sagebrush (table 13). The average digestible protein was 4.4 percent which

Table 10. *Nutrient content of black-sage seed stalks and current year's growth when grazed at different dates and intensities on various areas throughout the Great Basin area of Utah*

Date	Intensity of use	Chemical composition of plants: Ether extract	Total protein	Lignin	Cellu-lose	Other carbo-hydrates	Total ash	Calcium	Phos-phorus	Gross energy	Carotene
	percent				*percent*					*Cal./lb.*	*mg/lb.*
12-16-50	30	11.1	8.2	16.1	25.4	34.1	5.2	.32	.15	2,341	12.8
1-27-51	50	5.6	7.9	18.8	24.7	38.0	5.0	.60	.19	2,238	7.3
3-24-51	65	8.1	9.8	15.7	19.0	41.7	5.7	.55	.14	2,278	5.1
9-28-51	30	10.4	8.7	15.0	17.7	42.2	6.0	.80	.18	2,350	......
10-27-51	25	9.4	8.0	15.5	23.1	37.5	6.5	.58	.16	2,286	6.6
10-16-52	20	11.5	8.2	13.6	19.8	38.5	8.5	.72	.14	2,282	......
Average	37	9.4	8.5	15.8	21.6	38.7	6.2	.60	.16	2,296	8.0

Table 11. *Daily dry matter consumption and digestibility of black sage forage during winter when grazed in pure stands*

Date	Dry matter consumed daily	Percent digested: Dry matter	Organic matter	Ether extract	Total protein	Cellu-lose	Other carbo-hydrates	Gross energy	T. D. N. in diet	Digest-ible energy	Digestible protein in diet	Metabo-lizable energy
	pounds				*percent*				*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
12-16-50	3.24	40.7	42.5	68.2	54.1	45.7	56.0	44.9	51.8	1,050	4.4	......
1-27-51	2.53	32.7	31.8	57.2	54.8	16.6	53.3	32.9	35.8	736	4.3	......
3-24-51	2.41	36.5	40.3	55.0	53.6	32.2	58.8	39.7	45.9	904	5.2	474
9-28-51	2.10	41.6	41.5	58.9	54.9	25.2	60.8	41.9	49.2	983	4.8	470
10-27-51	2.30	36.8	37.9	59.8	46.8	30.2	57.4	37.5	44.5	865	3.7	385
10-16-52	2.89	43.5	45.1	74.6	50.9	36.0	65.6	49.3	55.8	1,124	4.2	711
Average	2.58	38.6	39.9	62.3	52.5	31.0	58.7	41.0	47.2	944	4.4	510
Limit of error*		2.4	2.2	4.4	3.3	5.1	4.0	3.4	2.4	149	0.5	177

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

is considered adequate in meeting the requirements; however, energy-furnishing constituents are decidely deficient. Digestible energy and total digestible nutrients are comparatively high which generally indicates high energy values; however, the ether extract fraction of this species contains considerable quantities of essential oils which are not true energy-supplying substances and are suspected of being toxic when consumed in large quantities over extended periods of time. Therefore, this plant actually is a poor energy feed (table 11).

Black sage meets most of the nutrient requirements except for energy which is only about two-thirds the recommended standard (table 5).

Big Sagebrush. Big sagebrush (*Artemisia tridentata*) is a large shrub, usually from 2 to 5 feet high, with silvery wedge-shaped leaves having three triangular teeth at the apex (fig. 6). Clusters of small, inconspicuous flower heads are produced late in the summer. This plant covers extensive areas throughout the Great Basin. The altitudinal range varies from 2,000 to 10,000 feet and it is found on a large variety of soils but is not tolerant of excessive salinity or wet soils. At higher elevations on summer ranges where succulent forage is plentiful, this plant is little grazed but on the lower desert ranges it is a valuable forage plant for sheep. Big sagebrush generally grows in association with a limited quantity of desert grasses and occasionally with other desert shrubs such as black sage, winterfat (*Eurotia lanata*), and rabbitbrush (*Chrysothamnus* spp.). However, sheep graze many winter ranges composed of almost pure stands of big sagebrush from 5 to 7 months during the winter.

On winter range, big sagebrush furnishes adequate phosphorus and carotene

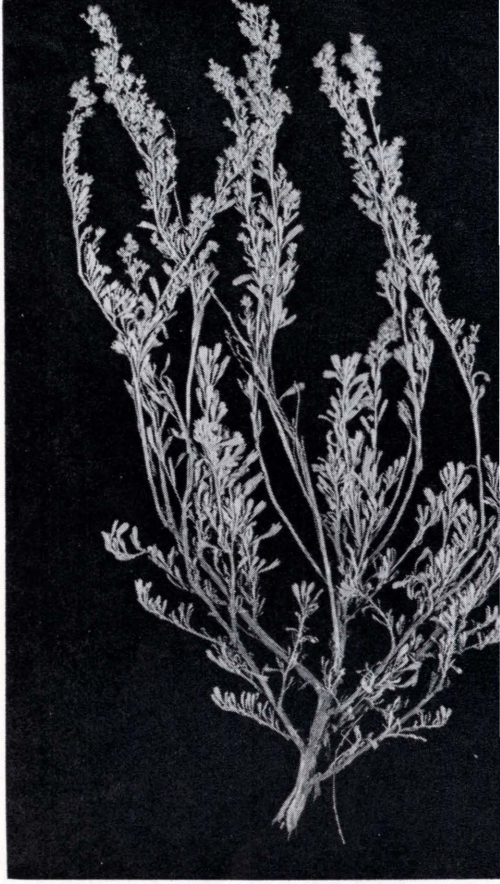

Fig. 6. A branch of big sagebrush showing the characteristic flower cluster and three-notched leaf tip

(table 12) and apparent digestion coefficients are high for most nutrients (table 13). Digestible protein in some cases was almost twice the recommended allowance and in others it was decidedly deficient; however, the average for all trials more than met the requirements (table 5). Like black sage, the energy-furnishing qualities of big sagebrush are rather poor and are somewhat below the recommended standard. The average metabolizable energy values were only 575 Calories per pound of feed intake, whereas it requires about 665 to meet the suggested requirements.

Table 12. *Nutrient content of seed stalks and current year's growth of big sagebrush which was eaten by sheep on winter ranges*

Date	Intensity of use	Chemical composition of plants: Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Total ash	Calcium	Phosphorus	Gross energy	Carotene
	percent	*percent*								*Cal./lb.*	*mg/lb.*
11- 4-50	27	17.5	10.9	11.9	17.5	37.3	4.9	.24	.24	2,486	9.1
12-30-50	16	12.7	11.5	13.2	19.5	38.7	4.4	.66	.17	2,427	......
2-23-51	15	6.9	9.2	19.7	24.6	33.8	5.8	.59	.14	2,270	......
10- 5-51	10	8.2	9.0	16.6	18.5	38.1	9.7	.93	.21	2,191	7.6
11- 2-51	10	8.5	8.5	16.8	24.0	36.0	6.7	.80	.18	2,263	......
1- 1-52	20	6.8	7.3	18.6	25.5	36.5	5.1	.78	.14	2,250	5.0
Average	16	10.1	9.4	16.1	21.3	37.1	6.1	.67	.18	2,314	7.3

Table 13. *Daily dry matter consumption and digestibility of big sagebrush forage during winter when grazed in pure stands*

Date	Dry matter consumed daily	Percent digested: Dry matter	Organic matter	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	T. D. N. in diet	Digestible energy	Digestible protein in diet	Metabolizable energy
	pounds	*percent*							*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
11- 4-50	3.28	50.4	54.8	91.2	72.9	37.8	65.1	61.2	73.3	1,520	8.0	......
12-30-50	3.93	52.7	52.2	87.6	74.4	35.3	66.3	56.8	66.1	1,381	8.5	......
2-23-51	1.96	28.2	29.5	67.2	53.9	29.6	48.6	31.8	39.2	723	5.0	513
10- 5-51	2.29	30.5	36.6	66.1	42.3	44.2	50.5	40.4	43.4	884	3.8	513
11- 2-51	2.75	33.4	41.0	69.6	44.2	46.6	56.8	44.1	47.9	999	3.8	767
1- 1-52	2.51	30.2	32.3	66.0	40.7	28.8	48.0	33.7	38.0	759	3.0	508
Average	2.79	37.6	41.1	74.6	54.7	33.7	55.9	44.7	50.7	1,045	5.4	575
Limit of error*		2.0	1.4	3.7	3.6	4.6	3.3	2.1	1.6	112	0.3	148

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

Big sagebrush from the standpoint of nutrient content furnishes an adequate diet for pregnant ewes on winter range except in the case of energy (table 5).

It was noted that sheep never preferred a diet of any single range shrub for extended periods of time as evidenced by their tendency to graze closely any occasional inferior plant which occurred in almost pure types. Big sagebrush was one of the least palatable of the desert species studied but was good winter feed when occurring with the normally associated grasses and shrubs. Big sagebrush plants of lower stature on poor sites or on heavily grazed areas were more readily eaten than robust ones on favorable sites. This was believed a result of stem-leaf ratio which affects the concentration of volatile oils of the forage eaten. The leaves are extremely high in oils and frequently animals eat dry stems by choice along with current growth in order to reduce what is believed to be a burning taste caused by the oils in foliage.

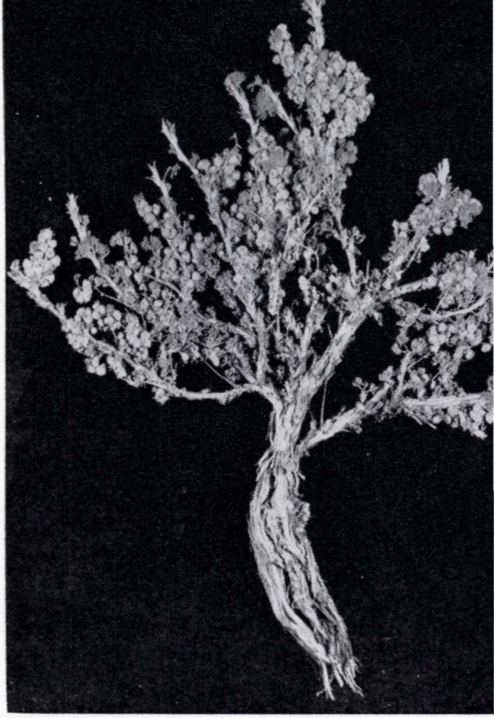

Fig. 7. A bud sage plant showing finely dissected leaves and buttonlike cluster of flower heads

Bud Sage. Bud sage (*Artemisia spinescens*) is sometimes referred to as button sage because of the conspicuous bud or buttonlike cluster of flower heads. This plant is a low-growing spiny-twigged shrub (fig. 7) with typical sage odor and occurring rather commonly throughout the salt-desert shrub association of the Great Basin area. This plant also occurs in association with big sagebrush in limited quantities and in almost pure stands in local areas of Nevada and southern Idaho.

Bud sage is one of the earliest feeds to renew growth in the late winter or early spring. The dark green delicately dissected foliage and tender young stems are highly relished by livestock in early spring. Later in the spring the volatile oils increase and livestock avoid the plant. Likewise, it is not readily eaten during the fall and winter because only a few dry leaves remain, leaving only the spiny twig and woody base available to grazing animals.

Experimental trials on this plant were run while the plant was in the early growth stages during late winter. Therefore, some of the chemical constituents appear unusually high compared to other browse species studied. As shown in table 14, bud sage was high in both phosphorus and carotene. Likewise, most of the digestion coefficients in table 15 appear high. As would be expected of green forage the digestible protein and metabolizable energy values were well above the suggested requirement (table 5).

Shadscale. Shadscale (*Atriplex confertifolia*) is a spiny shrub usually 1 to 2 feet in height, with numerous stiff

Table 14. *Nutrient content of green spring growth of bud sage on winter ranges*

Date	Intensity of use	Chemical composition of plants									
		Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Total ash	Calcium	Phosphorus	Gross energy	Carotene
	percent	*percent*								*Cal./lb.*	*mg/lb.*
3-20-53	70	4.9	17.3	8.4	18.1	29.9	21.4	.97	.33	1,923	10.8

Table 15. *Daily dry matter consumption and digestibility of bud sage*

Date	Dry matter consumed daily	Percent digested							T. D. N. in diet	Digestible energy	Digestible protein in diet	Metabolizable energy
		Dry matter	Organic matter	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy				
	pounds	*percent*							*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
3-20-53	4.20	55.3	46.2	72.3	79.1	58.1	61.7	60.3	50.6	1,160	13.7	911
Limit of error*		0.3	1.6	2.4	1.8	1.4	5.2	0.9	1.6	49	0.6	64

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

branches forming a rounded top (fig. 8). It tolerates large amounts of salt and is often found in almost pure stands on valley bottom soils. Shadscale is abundant on dry sites throughout the Great Basin. It is good forage and sheep graze pure stands without becoming dissatisfied over relatively long periods. This shrub produces an abundance of seed and foliage especially during early winter. The naked spiny branches which persist for several years provide protection for this plant against heavy use. Utilization under moderate stocking seldom averages more than 30 or 40 percent of the current year's growth at the end of the winter grazing season.

The chemical content of shadscale (table 16) shows that it is not outstandingly high in any nutrients except carotene which is more than 10 times the requirement. Likewise, digestion coefficients are low for most nutrients (table 17). As a result, shadscale is seriously deficient in both phosphorus and energy. This plant furnishes about 50 percent of the phosphorus requirement and only about 55 percent of the energy requirement on winter ranges (table 5).

Fig. 8. A branch of shadscale showing the abundance of foliage available during early winter grazing. Dead spiny stems intermingled with new growth is characteristic of this plant

Fig. 9. Plant of Nuttall saltbrush showing the woody base and the leafy herbaceous growth above

Nuttall Saltbush. Nuttall saltbush (*Atriplex nuttallii*), sometimes referred to as salt sage or mound sage, is a low, leafy, silvery colored plant with a woody base (fig. 9) which occurs in abundance on saline plains and clay bottoms throughout the deserts of the Great Basin. This plant is highly relished by grazing animals during winter and range managers should be concerned in maintaining it in a high state of vigor because it is adapted to local situations not occupied by other forage plants. Intensive use reduces the stand

Table 16. *Nutrient content of shadscale consumed by sheep which included current year's growth and seed on winter ranges*

Date	Intensity of use	Chemical composition of plants: Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Total ash	Calcium	Phosphorus	Gross energy	Carotene
	percent	*percent*								*Cal./lb.*	*mg/lb.*
11-11-50	20	2.5	7.6	12.4	16.1	36.1	25.3	1.21	.09	1,681	8.9
1- 6-51	50	2.8	8.9	12.5	15.0	35.0	25.8	2.54	.07	1,637	8.2
3- 7-51	50	2.9	8.6	13.9	12.5	37.0	25.1	1.92	.08	1,675	4.3
10-12-51	35	2.2	5.6	11.8	17.7	37.1	25.6	2.27	.08	1,538	12.0
11- 8-51	20	2.0	8.6	13.4	23.9	31.6	20.6	1.96	.11	1,760	11.3
12-24-51	30	2.1	7.1	14.7	21.7	34.6	19.9	2.36	.09	1,696	8.3
12-23-53	40	2.4	7.4	12.5	16.2	38.9	21.8	3.04	.06	1,547	......
Average	35	2.4	7.7	13.0	17.6	35.7	23.4	2.53	.09	1,648	8.9

Table 17. *Daily dry matter consumption and digestibility of shadscale forage*

Date	Dry matter consumed daily	Percent digested: Dry matter	Organic matter	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	T. D. N. in diet	Digestible energy	Digestible protein in diet	Metabolizable energy
	pounds	*percent*							*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
11-11-50	2.93	48.6	32.3	37.0	61.2	26.1	62.4	41.1	33.4	690	4.6	......
1- 6-51	3.94	46.3	28.0	46.6	67.1	10.1	55.0	34.0	29.6	570	6.0	......
3-17-51	2.80	38.4	28.4	42.6	59.1	7.2	57.1	31.7	30.0	527	5.1	384
10-12-51	3.42	46.8	31.7	7.2	40.4	39.1	60.2	34.8	31.9	536	2.3	369
11- 8-51	2.77	35.1	30.5	36.7	48.3	49.7	43.6	36.9	31.4	650	4.2	......
12-24-51	3.56	36.9	24.4	31.7	53.2	22.6	43.7	27.0	25.3	457	3.8	365
12-23-53	3.89	46.2	34.2	27.1	58.4	28.1	63.2	35.9	35.0	555	4.32	478
Average	3.33	42.6	29.9	32.7	55.4	26.1	55.1	34.5	31.0	570	4.3	399
Limit of error*		2.8	2.6	6.1	3.2	6.1	4.7	3.4	2.7	128	0.3	176

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

Table 18. ***Nutrient content of current year's growth of Nuttall saltbush which was consumed by sheep on winter ranges***

Date	Intensity of use	Chemical composition of plants: Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Total ash	Calcium	Phosphorus	Gross energy	Carotene
	percent				*percent*					*Cal./lb.*	*mg/lb.*
11-24-50	70	1.6	6.6	10.1	19.8	39.7	22.2	1.39	.09	1,627	11.5
11-23-51	70	2.6	8.8	9.3	14.9	42.4	22.0	3.14	.14	1,715	8.1
2-15-52	45	2.4	6.2	10.2	23.0	38.0	20.2	2.11	.12	1,687	6.3
Average	62	2.2	7.2	9.9	19.2	40.0	21.5	2.21	.12	1,676	8.6

Table 19. ***Daily dry matter consumption and digestibility of Nuttall saltbush***

Date	Dry matter consumed daily	Percent digested: Dry matter	Organic matter	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	T. D. N. in diet	Digestible energy	Digestible protein in diet	Metabolizable energy
	pounds				*percent*				*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
11-24-50	3.79	26.7	35.1	—75.3	36.7	63.2	52.4	36.0	35.7	585	2.4	......
11-23-51	3.38	42.4	37.9	—1.4	52.7	38.3	65.0	44.7	37.8	767	4.6	623
2-15-52	4.35	46.0	33.2	54.1	50.4	36.1	53.9	40.3	34.8	679	3.2	576
Average	3.84	38.4	35.4	—7.5	46.6	45.9	57.1	40.3	36.1	677	3.4	599
Limit of error*		1.7	1.1	3.4	2.6	5.3	2.6	1.2	1.1	85	0.2	52

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

Table 20. ***Nutrient content of portion of plant eaten by sheep which included mature current year's growth except for seed heads of yellowbrush on winter ranges***

Date	Intensity of use	Ether extract	Total protein	Lignin	Cellu-lose	Other carbo-hydrates	Total ash	Calcium	Phos-phorus	Gross energy	Carotene
		Chemical composition of plants									
	percent	*percent*								*Cal./lb.*	*mg/lb.*
10-31-52	75	14.4	7.4	11.8	19.0	39.9	7.7	1.95	.12	2,304	2.1
12-11-53	65	10.0	5.7	14.9	24.7	35.7	9.0	1.86	.08	2,141	......
Average	70	12.2	6.6	13.3	21.8	37.8	8.4	1.90	.10	2,223	2.1

Table 21. ***Daily dry matter consumption and digestibility of yellowbrush***

Date	Dry matter consumed daily	Dry matter	Organic matter	Ether extract	Total protein	Cellu-lose	Other carbo-hydrates	Gross energy	T. D. N. in diet	Digest-ible energy	Digestible protein in diet	Metabo-lizable energy
		Percent digested										
	pounds	*percent*							*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
10-31-52	4.11	38.5	40.6	82.5	54.9	31.0	47.3	47.3	55.3	1,090	4.0	839
12-11-53	2.73	33.4	36.0	66.8	39.0	35.1	51.6	44.4	44.4	960	2.2	682
Average	3.42	35.9	38.3	74.6	46.9	33.1	49.4	45.8	49.8	1,025	3.1	760
Limit of error*		3.9	2.5	3.2	5.2	7.6	2.0	3.0	2.4	146	0.6	162

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

materially because the foliage is readily available and can be easily cropped excessively by foraging animals. When animals graze pure stands of this plant over extended periods of time, they become scoured and may develop physiological disturbances unless other feed is available.

In winter, Nuttall saltbush is comparatively low in most desirable constituents other than carotene which is more than 10 times the minimum requirement (table 18). The digestion coefficients for most nutrients are also low (table 19) resulting in low digestible protein and metabolizable energy values. Nuttall saltbush is deficient in phosphorus, digestible protein, and energy yielding constituents but adequate in meeting the carotene or vitamin A requirements (table 5).

Yellowbrush. Yellowbrush (*Chrysothamnus stenophyllus*) is a low growing shrub with narrow, linear leaves and light colored stems (fig. 10). It produces bright yellow flower clusters in late summer (never early). This plant is rather common on most desert range and in some cases represents more than a third of the vegetation cover. The use of yellowbrush appeared to be determined by site. On gentle alluvial slopes or plateaus use was generally light or negligible; however, on rocky foothills it was frequently heavy and sometimes destructively so. Animals preferred mature or partially mature plants to green immature ones. Because of its low palatability on most sites, it is frequently abundant on overgrazed ranges.

This plant is considered relatively high in carotene but somewhat low in phosphorus and protein (tables 20 and 21). The energy values were higher than for most shrubs, a result of considerable green growth being eaten along with the mature material.

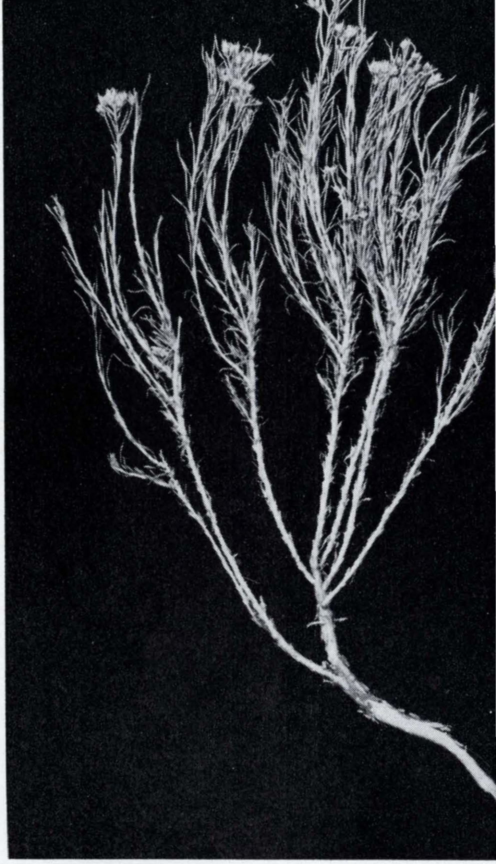

Fig. 10. A branch of yellowbrush showing the rather sparse covering of threadlike leaves and terminate flower heads

Winterfat. Winterfat (*Eurotia lanata*) also known as white sage, is a low, silvery white plant with a woody base (fig. 11). It is not really a sage and has no sage odor. The herbage is covered with short whitish hairs, giving the plant a fuzzy appearance. Also, in fall it has abundant woolly-white seed clusters. This plant is one of the most common species of the salt-desert types of the Great Basin. However, many extensive areas are greatly depleted because of the high preference and close utilization by livestock. Winterfat is known as a superior winter feed for grazing animals, hence the name winterfat.

Table 22. ***Nutrient content of current year's growth with some woody material of winterfat which was eaten by sheep on winter ranges***

Date	Intensity of use	Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Total ash	Calcium	Phosphorus	Gross energy	Carotene
		Chemical composition of plants									
	percent				*percent*					*Cal./lb.*	*mg/lb.*
11-18-50	55	2.5	9.8	8.1	21.9	32.7	25.0	1.24	.15	1,622	8.6
3-31-51	55	2.1	11.8	8.5	17.4	30.7	29.5	2.78	.15	1,454	5.7
11-29-51	65	2.8	10.7	9.0	27.2	36.4	14.0	2.60	.12	1,882	7.9
12-18-51	40	3.2	10.6	8.6	29.6	35.4	12.6	2.38	.12	1,928	8.1
10- 9-52	35	2.7	12.2	9.0	28.3	36.2	11.7	1.68	.08	1,950	......
Average	50	2.7	11.0	8.6	24.9	34.3	18.6	2.14	.12	1,767	7.6

Table 23. ***Daily dry matter consumption and digestibility of winterfat***

Date	Dry matter consumed daily	Dry matter	Organic matter	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	T. D. N. in diet	Digestible energy	Digestible protein in diet	Metabolizable energy
		Percent digested										
	pounds				*percent*				*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
11-18-50	3.16	33.5	33.8	38.4	64.9	43.6	52.9	45.3	35.0	734	6.3	......
3-31-51	2.44	28.2	27.0	13.6	66.4	35.1	41.8	32.8	27.3	476	7.8	......
11-29-51	2.52	26.3	31.7	21.7	55.7	28.6	47.7	36.3	32.5	684	6.0	553
12-18-51	2.79	39.5	42.7	48.7	61.5	48.1	56.8	47.7	44.1	919	6.5	742
10- 9-52	2.10	27.3	27.4	14.8	65.8	22.6	44.3	36.9	27.9	682	8.0	488
Average	2.60	31.0	32.5	27.4	62.9	35.6	48.7	39.8	33.4	699	6.9	594
Limit of error*		4.0	2.5	6.8	2.8	5.8	4.5	2.7	2.7	133	0.5	182

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

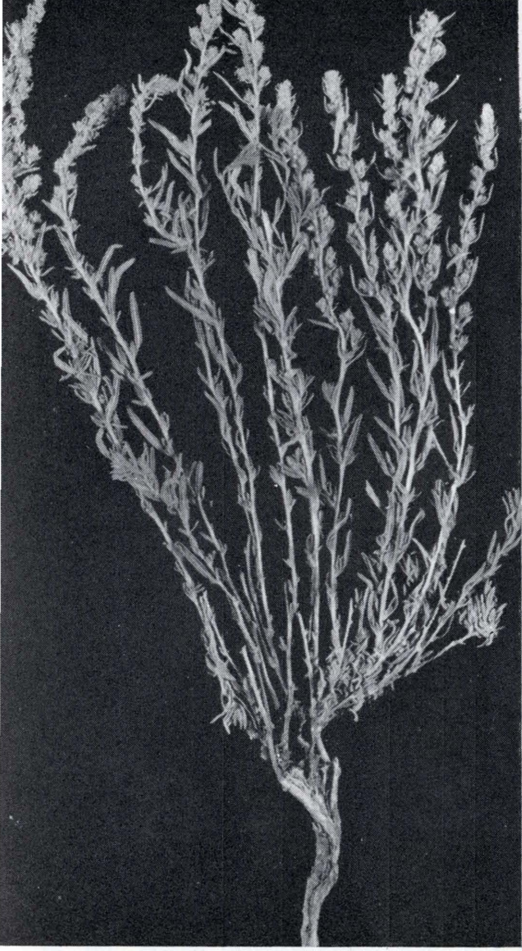

Fig. 11. A plant of winterfat showing the characteristic linear leaves and the fuzzy cluster of flowers terminating each stem arising from the woody base

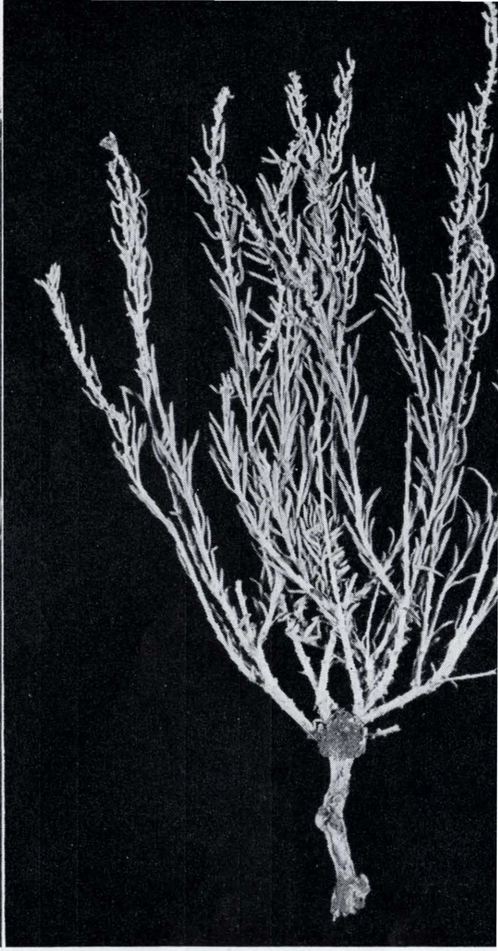

Fig. 12. A plant of desert molly, a small shrub with a woody base and herbaceous stems supporting numerous linear leaves

This species is primarily found in the lower plains and valleys on dry soils containing moderate amounts of salt. On such sites it frequently occurs over extensive areas in almost pure stands. It is also found growing along with other desert shrubs and associated grasses.

Winterfat is valuable because it furnishes both palatable and nutritious forage. It is relatively high in nutrients with the exception of cellulose and ether extract as shown in table 22. Likewise, the digestion coefficients for all constituents except cellulose and ether extract were relatively high (table 23). The energy-yielding values of winterfat are low, being about 600 Calories per pound of feed intake, whereas 665 is considered necessary. This species is a good source of digestible protein and vitamin A but is slightly deficient in phosphorus and energy yielding constituents (table 5).

Desert Molly. Desert molly (*Kochia vestita*) is a small shrub with a woody

Table 24. *Nutrient content of current year's growth of desert molly which was consumed by sheep on winter ranges*

Date	Intensity of use	Chemical composition of plants: Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Total ash	Calcium	Phosphorus	Gross energy	Carotene
	percent				*percent*					*Cal./lb.*	*mg/lb.*
9-14-52	85	3.8	12.7	7.3	10.7	46.2	23.9	2.17	.08	1,783	10.6
11-15-52	60	3.3	6.9	9.7	14.8	41.6	23.7	2.71	.06	1,601	5.8
11-24-53	70	5.3	7.5	5.9	12.8	41.5	26.9	2.22	.22	1,497	.....
Average	72	4.1	9.0	7.6	12.8	43.1	24.8	2.37	.12	1,627	8.2

Table 25. *Daily dry matter consumption and digestibility of desert molly*

Date	Dry matter consumed daily	Percent digested: Dry matter	Organic matter	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	T. D. N. in diet	Digestible energy	Digestible protein in diet	Metabolizable energy
	pounds				*percent*				*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
9-14-52	5.95	59.0	48.0	69.9	77.9	36.8	73.4	62.5	48.4	1,114	9.9	981
11-15-52	5.42	52.5	39.6	67.4	52.5	43.3	65.7	49.0	42.4	785	3.6	686
11-24-53	6.98	74.15	53.2	79.8	76.7	62.7	84.7	69.2	58.6	1,036	5.7	923
Average	6.09	61.9	46.9	72.4	69.0	47.6	74.6	60.3	49.8	978	5.5	863
Limit of error*		4.9	3.2	6.0	5.0	5.0	4.4	2.5	1.4	89	0.8	115

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

base and somewhat fleshy, round, linear leaves which are about one-half to three-fourths of an inch in length and covered with short white or grayish hairs (fig. 12). During growth the plant appears grayish blue in color but after killing frosts in early winter it turns grayish brown, suggesting the name of "brown sage" which is sometimes used locally. The plant is moderately palatable and when grazing pure stands of the species, sheep ate it readily and consumed 5.6 pounds of dry matter daily. However, when desert molly was grazed in mixtures with other grasses or shrubs, its palatability was generally secondary and utilization was not heavy.

Desert molly occurs on salty plains and valleys, frequently in association with winterfat, bud sage, shadscale, and other shrubs and grasses. Occassionally almost pure stands are found where other plants have been reduced by grazing.

Desert molly is high in total protein during the fall of the year before killing frosts turn the plant brown but later in the season it is not a good source (table 24). This is, likewise, true of digestible protein (table 25) and as a result, late in the season digestible protein was decidedly deficient. It is not a good source of phosphorus even when green and is deficient during the entire winter.

Desert molly is a good source of carotene even after it turns partially brown and as a source of energy it appears to meet the needs of the grazing animal during most of the season (table 25).

Fig. 13. A few stems of western wheatgrass and connecting underground stems. The leaves are rather coarse and rather sparse on the upper portion of the seed stalks which is characteristic of this grass

Western Wheatgrass. Western wheatgrass (*Agropyron smithii*) is sometimes referred to as bluestem wheatgrass or bluejoint wheatgrass (fig. 13) because of the bluish color of the stems and leaves. This plant is a sod grass, possessing underground stems (rhizomes), hence it grows as single stems or small tufts and does not form a bunch. However, it does not form a dense sod under arid or semi-desert conditions.

Western wheatgrass is widespread throughout the Great Basin area and

Table 26. *Nutrient content of portion of plant eaten by sheep which included most of the current year's growth of western wheatgrass on winter ranges*

Date	Intensity of use	Chemical composition of plants: Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Total ash	Calcium	Phosphorus	Gross energy	Carotene
	percent				*percent*					*Cal./lb.*	*mg/lb.*
11- 6-53	65	8.27	2.40	6.59	36.27	36.48	9.99	.74	.06	1,973	0.10

Table 27. *Daily dry matter consumption and digestibility of western wheatgrass*

Date	Dry matter consumed daily	Percent digested: Dry matter	Organic matter	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	T. D. N. in diet	Digestible energy	Digestible protein in diet	Metabolizable energy
	pounds				*percent*				*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
11- 6-53	4.72	59.8	56.8	65.8	6.4	81.7	70.1	64.3	63.6	1,267	0.2	1,120
Limit of error*		1.6	8.1	8.0	6.5	1.8	3.8	2.4	8.7	108	0.1	116

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

occurs on a wide variety of soils. This species is drought resistant and withstands grazing well. It is most commonly found on open plains, hillsides, benchlands, and well-drained bottomlands. It is alkali tolerant. On heavy clay soils in valley bottoms extensive areas of almost pure stands are found but it is most often subdominant in sagebrush-grass associations and is an important constituent on many winter ranges. The foliage becomes stiff and coarse with maturity; however, livestock usually graze it readily. This grass withstands grazing rather well and is considered good winter forage by livestock operators. The chemical composition and digestibility of this plant under winter range conditions are shown in tables 26 and 27.

Beardless Wheatgrass. Forms of beardless wheatgrass (*Agropyron inerme*) and bluebunch wheatgrass (*Agropyron spicatum*) grade into one another and in most cases plants of both species were present on study areas. Typically bluebunch wheatgrass (fig. 14) possesses a rough, strongly spreading, often twisted beard (awn) whereas beardless wheatgrass possesses a smooth head. However, these species have about the same geographic distribution, similar habitat or site requirements, and the same nutrient values as far as could be determined. Therefore, there is little need in distinguishing between the two for practical purposes. For presentation of data beardless wheatgrass is used but the information also applies to bluebunch wheatgrass.

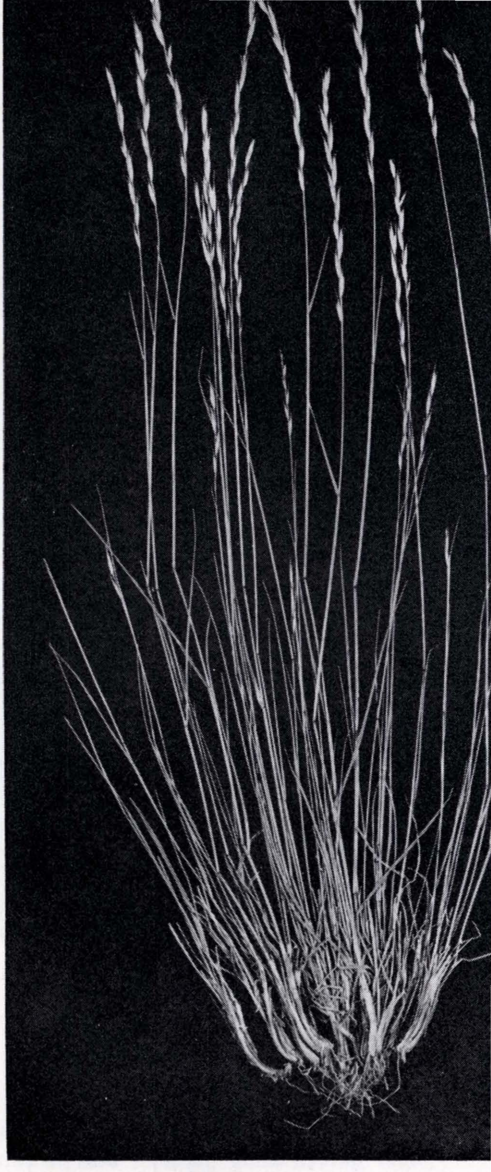

Fig. 14. A plant of bluebunch wheatgrass showing fine leaves and slender stems

Beardless wheatgrass is a perennial, often exhibiting a bluish color when growing. Leaves are narrow, often rolled and the plant grows as a distinct bunch. This plant, a drought-hardy grass, is typically a foothill species, and is a dominant of the palouse prairie. It is generally found in abundance on lower foothill areas adjacent to the broad desert basins and is commonly associated with sagebrush. The grass is highly relished by livestock during all seasons. Frequently late summer or fall rains cause renewed growth in the base of the clump, causing

Table 28. *Nutrient content of consumed material which included all of the current year's growth of beardless wheatgrass on winter ranges*

Date	Intensity of use	Chemical composition of plants: Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Total ash	Calcium	Phosphorus	Gross energy	Carotene
	percent	*percent*								*Cal./lb.*	*mg/lb.*
12-14-52	30	5.1	2.8	7.3	34.9	39.0	11.0	.50	.05	1,937	0.5
11-13-53	60	3.1	3.4	8.4	42.0	33.0	10.2	.48	.06	1,873	......
Average	45	4.1	3.1	7.8	38.4	36.0	10.6	.49	.06	1,905	0.5

Table 29. *Daily dry matter consumption and digestibility of beardless wheatgrass*

Date	Dry matter consumed daily	Percent digested: Dry matter	Organic matter	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	T. D. N. in diet	Digestible energy	Digestible protein in diet	Metabolizable energy
	pounds	*percent*							*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
12-14-52	3.50	47.3	56.9	69.0	—11.9	79.9	58.2	59.4	61.3	1,151	—0.3	946
11-13-53	3.09	45.0	52.6	44.7	0	73.0	61.9	54.5	54.3	1,012	0.2	859
Average	3.30	46.2	54.8	56.9	—6.0	76.4	60.0	56.9	57.8	1,081	0.0	903
Limit of error*		3.7	1.9	6.9	9.3	4.7	4.1	1.8	1.6	76	0.6	79

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

close utilization in an effort to obtain the green forage.

Beardless wheatgrass during the winter grazing season is an excellent source of energy but like other grasses, it is deficient in the other three critical nutrients (table 5). The chemical composition is shown in table 28 and the digestibility in table 29.

Giant Wild-rye Grass. Giant wild-rye grass (*Elymus cinereus*) was formerly referred to taxonomically as *Elymus condensatus* in the Great Basin area. This plant is a robust bunchgrass generally found in dense clumps on moderately favorable sites. It is the West's tallest range grass. Big bunches may vary from 3 to 5 feet high. It is not a dominant species of either the sagebrush or the salt-desert shrub association but occurs in ravines, along drainages in the foothills, in saline bottomlands, along ditch banks, and canyons.

Giant wild-rye grass is coarse and tough when mature (fig. 15) and as a result is relatively unpalatable to livestock during most of the winter grazing season. However, when snow has covered other grasses and low shrubs, giant wild-rye grass may be utilized closely. Cattle eat the leaves and the smaller stems, whereas sheep eat mostly the leaves and only a few of the more tender stems and seed heads.

In some localities giant wild-rye is a valuable winter feed. This is particularly true for cattle where a concentrate supplement is fed.

Giant wild-rye grass is not high in any desirable nutrients and is seriously deficient in phosphorus, carotene, and digestible protein (tables 30 and 31). Grasses as a group are good sources of energy but giant wild-rye grass rates low in this respect late in the season (table 31).

Galleta Grass. Galleta grass (*Hilaria jamesii*) also known as curly grass is a mat or sod forming grass having underground rhizomes. This plant grows on desert or semidesert plains and foothills where moisture is limited. It often grows in small erect tufts in relatively sparse stands rather than a dense sod (fig. 16). It may occur with other species or in almost pure stands. The plant is especially abundant on well-drained gravelly slopes adjacent to salt deserts.

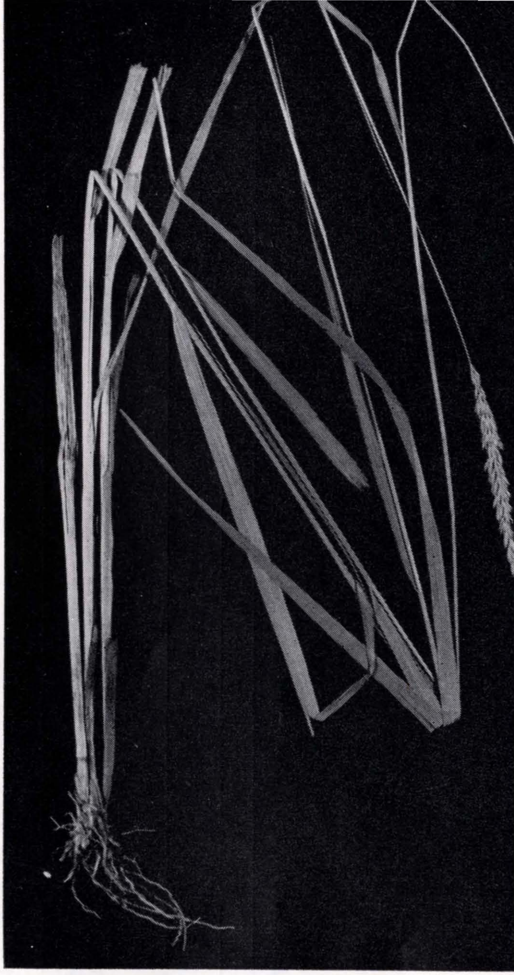

Fig. 15. A portion of a clump of giant wild-rye showing characteristic coarse stems and leaves and tall stature. This plant frequently 3-5 feet tall is the largest of western range grasses

Table 30. *Nutrient content of leaves and terminal stems of giant wild-rye grass which was eaten by sheep on winter ranges*

Date	Intensity of use	Chemical composition of plants: Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Total ash	Calcium	Phosphorus	Gross energy	Carotene
	percent				*percent*					*Cal./lb.*	*mg/lb.*
2- 7-52	30	4.0	3.0	9.4	37.4	33.5	12.6	.93	.06	1,869	0.0
9-21-53	55	2.5	3.3	6.7	41.4	36.5	9.7	.37	.05	1,846	......
Average	42	3.2	3.2	8.0	39.4	35.0	11.6	.66	.06	1,857	0.0

Table 31. *Daily dry matter consumption and digestibility of giant wild-rye grass*

Date	Dry matter consumed daily	Percent digested: Dry matter	Organic matter	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	T. D. N. in diet	Digestible energy	Digestible protein in diet	Metabolizable energy
	pounds				*percent*				*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
2- 7-52	2.02	33.9	35.1	29.1	—37.4	50.7	48.1	35.4	36.6	662	—1.1	507
9-21-53	3.01	54.4	50.8	—32.3	1.2	66.3	63.7	53.3	50.8	1,186	0.2	808
Average	2.51	44.2	42.9	—1.6	—18.1	58.5	55.9	44.4	43.7	924	—0.4	658
Limit of error*		3.5	5.2	8.0	8.6	8.8	4.6	3.2	5.3	784	0.3	141

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

Table 32. *Nutrient content of current year's growth of galleta (curly) grass which was consumed by sheep on winter ranges*

Date	Intensity of use	Chemical composition of plants: Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Total ash	Calcium	Phosphorus	Gross energy	Carotene
	percent	*percent*								*Cal./lb.*	*mg/lb.*
9- 3-52	80	2.1	5.6	7.5	26.9	40.7	17.3	1.03	.07	1,728	0.2
11-11-52	40	1.5	5.4	7.2	27.1	43.4	15.4	1.19	.08	1,751	0.1
11-30-53	75	2.5	5.5	8.3	29.7	39.6	17.0	.92	.06	1,774	......
Average	65	2.0	5.5	7.7	27.9	41.2	16.6	1.05	.07	1,751	0.2

Table 33. *Daily dry matter consumption and digestibility of galleta (curly) grass*

Date	Dry matter consumed daily	Percent digested: Dry matter	Organic matter	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	T. D. N. in diet	Digestible energy	Digestible protein in diet	Metabolizable energy
	pounds	*percent*							*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
9- 3-52	2.12	30.7	31.8	—20.4	19.2	46.5	44.7	35.0	31.8	604	1.1	421
11-11-52	3.88	41.3	41.6	1.7	31.3	58.0	50.3	44.6	41.7	780	1.7	629
11-30-53	3.05	44.6	43.2	13.3	29.3	62.8	56.8	49.8	43.7	884	1.5	734
Average	3.02	38.9	38.9	—1.8	26.6	55.8	50.6	43.1	39.1	756	1.4	595
Limit of error*		4.4	3.9	7.1	4.2	4.8	6.4	5.2	3.9	204	0.6	204

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

Table 34. ***Nutrient content of consumed material which included the current year's growth of Indian ricegrass on winter ranges***

Date	Intensity of use	Chemical composition of plants									
		Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Total ash	Calcium	Phosphorus	Gross energy	Carotene
	percent	*percent*								*Cal./lb.*	*mg/lb.*
8-19-52	40	2.8	4.1	9.6	37.3	39.1	7.2	.65	.08	1,973	0.4
12- 6-52	50	2.3	2.8	9.5	35.6	42.9	6.8	.42	.06	1,928	0.0
11-19-53	55	3.1	3.7	9.4	39.8	35.9	8.2	.48	.05	1,926	......
Average	48	2.7	3.5	9.5	37.6	39.3	7.4	.52	.06	1,942	0.2

Table 35. ***Daily dry matter consumption and digestibility of Indian ricegrass***

Date	Dry matter consumed daily	Percent digested							T. D. N. in diet	Digestible energy	Digestible protein in diet	Metabolizable energy
		Dry matter	Organic matter	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy				
	pounds	*percent*							*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
8-19-52	2.49	39.9	43.2	0	12.2	64.5	47.8	40.0	43.2	790	0.5	621
12- 6-52	2.91	41.6	50.1	50.9	0	74.5	52.3	46.9	51.5	903	0	751
11-19-53	3.30	45.6	49.9	16.3	7.1	69.4	60.0	50.7	50.5	978	0.4	823
Average	2.90	42.4	47.7	22.4	6.4	69.5	53.4	45.9	48.4	890	0.3	733
Limit of error*		1.3	2.1	8.4	5.1	4.0	2.4	3.3	2.2	133	0.5	127

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

Fig. 16. A few tufts of galleta grass showing the underground stems and small delicate foliage concentrated in the lower portion of the plant. This plant is recognized by the tendency of seeds to fall off and leave a bare zigzag stem

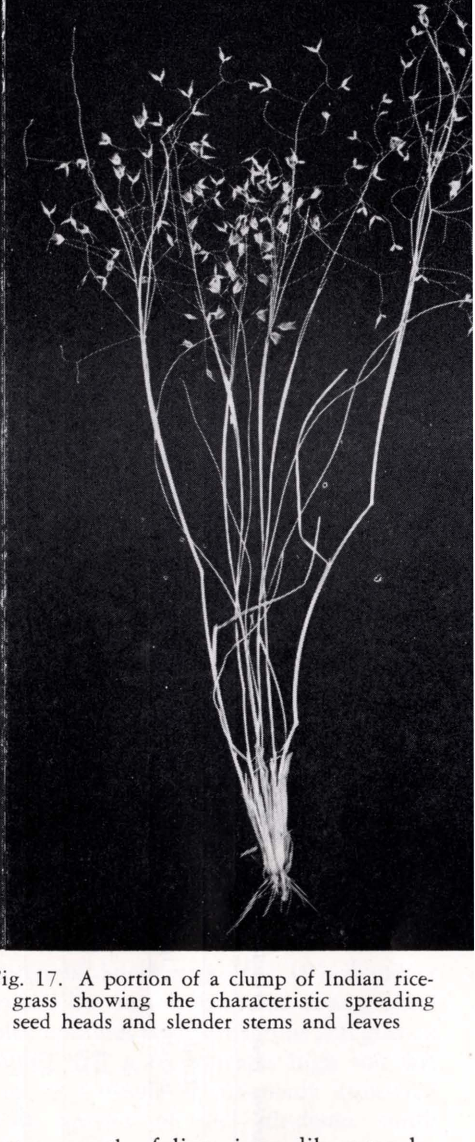

Fig. 17. A portion of a clump of Indian rice-grass showing the characteristic spreading seed heads and slender stems and leaves

Galleta grass is drought hardy and is one of the most grazing-resistant plants on the desert. It is often the only desirable plant remaining on stock trails or destructively used ranges. Galleta is relished by livestock during the early spring and summer but is only moderately palatable in the dry mature stage. The foliage may become harsh and tough in favorable growth years; however, in most years it remains fine and pliable. In the latter case the foliage is readily eaten by livestock. The forage cures rather well and as a result is relatively high in digestible protein under winter range conditions compared to most desert grasses (table 5). However, galleta grass like other desert grasses, is a relatively poor source of phosphorus, carotene, and digestible protein compared to browse plants (tables 5, 32, and 33). In addition, this grass is not as high in metabo-

Table 36. *Nutrient content of current year's growth of squirreltail grass which was consumed by sheep on winter ranges*

Date	Intensity of use	Chemical composition of plants								Gross energy	Carotene
		Ether extract	Total protein	Lignin	Cellu-lose	Other carbo-hydrates	Total ash	Calcium	Phos-phorus		
	percent				*percent*					*Cal./lb.*	*mg/lb.*
12-23-50	70	2.2	3.1	8.3	40.4	29.0	17.0	0.37	.06	1,717	0.5
12- 6-51	70	2.9	5.9	9.0	34.6	30.2	17.3	0.96	.08	1,742	0.4
Average	70	2.6	4.5	8.7	37.5	29.6	17.1	0.67	.07	1,730	0.5

Table 37. *Daily dry matter consumption and digestibility of squirreltail grass*

Date	Dry matter consumed daily	Percent digested							T. D. N. in diet	Digest-ible energy	Digestible protein in diet	Metabo-lizable energy
		Dry matter	Organic matter	Ether extract	Total protein	Cellu-lose	Other carbo-hydrates	Gross energy				
	pounds				*percent*				*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
12-23-50	4.36	48.7	48.1	39.1	—1.9	75.6	57.9	53.4	49.2	917	0.0	773
12- 6-51	3.90	40.8	41.1	52.6	36.7	69.1	44.7	47.0	43.1	818	2.2	691
Average	4.13	44.8	44.6	45.9	17.4	72.4	51.3	50.2	46.2	868	1.1	732
Limit of error*		1.4	1.1	2.6	4.1	1.8	3.1	1.9	1.1	57	0.7	71

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

lizable energy as most grasses. It furnishes only about 595 Calories per pound of feed intake compared to the average for grasses of 800 (table 5).

Indian Ricegrass. Indian ricegrass (*Oryzopsis hymenoides*) is a perennial bunchgrass (fig. 17) with widely spreading seed heads. The seeds are black at maturity and are surrounded by long white hairs. The plant is widely distributed throughout the Great Basin and is one of the most important forage plants for winter grazing.

Indian ricegrass is found growing in complex plant mixtures with species of sagebrush and also members of the salt-desert shrub association. It is moderately tolerant to alkali but requires well-drained soil. Occasionally the plant is found growing in almost pure stands on sandy soils and it may be dominant under juniper stands.

Indian ricegrass produces an abundance of forage and is highly palatable to all classes of livestock. This species may produce some green shoots in the fall but generally it remains dry until late winter or early spring before new growth is available. The lower portions of the stems may remain somewhat green during most of the winter which, of course, induces livestock to utilize the plant closely. The only protection against excessively close utilization is the old stubble from previous growth.

Indian ricegrass is seriously deficient in phosphorus, carotene, and digestible protein, but like most other desert grasses is a relatively good source of energy (tables 5, 34, and 35).

Squirreltail Grass. Squirreltail grass (*Sitanion hystrix*) is widely distributed on desert ranges of the Great Basin and is valuable because it generally furnishes some green growth during the winter season. The plant is a bristly headed, perennial bunchgrass (fig. 18) abundant locally but mainly scattered among complex mixtures of desert shrubs and grasses. Squirreltail grass tolerates high soil salt and as a result is commonly associated with species of the salt-desert shrub vegetation.

Fig. 18. A squirreltail grass plant showing characteristic growth habit and bristly head

During late summer or fall, most of the objectionable bristles fall from the plant, thereafter it is readily eaten. Early fall rains frequently produce new growth which remains green most of the winter. This makes the plant highly palatable and it often is able to grow only in the protection of thorny shrubs or cactus plants. On all study areas this plant was relished even when new growth was absent.

Table 38. *Nutrient content of consumed material of alkali sacaton grass which included most of the current year's growth on winter ranges*

Date	Intensity of use	Chemical composition of plants: Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Total ash	Calcium	Phosphorus	Gross energy	Carotene
	percent				*percent*					*Cal./lb.*	*mg/lb.*
10- 7-53	60	2.19	3.44	9.56	32.8	39.38	12.63	.67	.08	1,903	0.3

Table 39. *Daily dry matter consumption and digestibility of alkali sacaton grass*

Date	Dry matter consumed daily	Percent digested: Dry matter	Organic matter	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	T. D. N. in diet	Digestible energy	Digestible protein in diet	Metabolizable energy
	pounds				*percent*				*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
10- 7-53	3.00	42.6	34.9	—12.7	—7.0	45.5	50.8	46.8	35.0	891	0.0	750
Limit of error*		11.8	3.0	9.1	17.1	4.2	6.5	10.8	3.1	455	0.0	453

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

The chemical analyses of this plant (table 36) show relatively high cellulose but only average amounts of other nutrients. Squirreltail grass is a poor source of phosphorous, carotene, and digestible protein (tables 36 and 37). However, it is a good source of energy. The metabolizable energy values were 732 Calories per pound of feed intake compared to 665, the recommended requirement (table 5).

Alkali Sacaton Grass. Alkali sacaton grass (*Sporobolus airoides*), also known as finetop saltgrass (fig. 19), is a robust perennial bunchgrass found widely distributed throughout the Great Basin area, generally in slightly moist, alkaline bottoms. Scattered stands also may be found on rocky foothills or open plains of desert and semidesert areas.

Alkali sacaton may be found in almost pure stands and it produces an abundance of forage. During early spring the herbage is cropped closely; however, as it matures the foliage becomes coarse, tough, and unpalatable. In some areas this grass is used for winter feed where it is supplemented with concentrates such as cottonseed cake. Sheep utilize it lightly under normal winter range conditions but they occasionally utilize it rather heavily when there is a dearth of other forage because of drought or range abuse. The chemical content and digestibility of this plant are shown in tables 38 and 39.

Fig. 19. Portions of a clump of alkali sacaton grass showing the fine delicate seed head and basal foliage which is characteristic of this plant

Sand Dropseed Grass. Sand dropseed grass (*Sporobolus cryptandrus*) is a tufted perennial (fig. 20) of wide distribution throughout the Great Basin. It grows at lower elevations on foothills and benchlands on sandy or gravelly soils. The palatability depends on the plant association in which it occurs. In many localities on the desert range the plant renews growth because of rains during the fall. This new growth causes the stems at the base to remain green most of the winter and in addition new shoots are available within the old sheath. This green material makes the plant highly palatable and under these conditions it is readily eaten during the winter. On other areas where fall growth seldom occurs and the forage is composed largely of stems with relatively small leaves the plant is not readily eaten and may even increase with heavy grazing. This sometimes occurs along stock trails or around loading corrals.

Table 40. *Nutrient content of consumed material which included most of current year's growth of sand dropseed grass on winter ranges*

Date	Intensity of use	Chemical composition of plants: Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Total ash	Calcium	Phosphorus	Gross energy	Carotene
	percent	*percent*								*Cal./lb.*	*mg/lb.*
3-18-52	35	1.1	3.5	10.1	45.9	33.8	5.7	.59	.08	1,860	0.5
10-24-52	60	1.1	6.4	7.3	44.5	34.4	6.3	.52	.04	1,919	0.0
12-17-53	70	2.0	5.2	7.8	48.0	30.0	7.0	.61	.05	1,905	......
Average	55	1.4	5.0	8.4	46.1	32.7	6.3	.57	.06	1,895	0.2

Table 41. *Daily dry matter consumption and digestibility of sand dropseed grass*

Date	Dry matter consumed daily	Percent digested: Dry matter	Organic matter	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	T. D. N. in diet	Digestible energy	Digestible protein in diet	Metabolizable energy
	pounds	*percent*							*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
3-18-52	2.64	61.4	62.2	25.9	4.3	77.7	77.4	61.0	62.6	1,134	0.2	973
10-24-52	2.40	56.4	57.6	14.7	40.3	75.4	61.9	57.4	57.8	1,100	3.9	913
12-17-53	2.92	50.9	55.4	52.4	30.9	76.8	53.0	56.6	56.7	1,043	1.6	931
Average	2.65	56.2	58.4	31.0	25.2	76.6	64.1	58.3	59.0	1,093	1.9	939
Limit of error*		2.4	1.4	6.9	7.1	1.8	2.9	1.9	1.4	73	0.5	75

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

The grass is a prolific seeder and when protected reproduces rapidly. The uppermost leaf sheath partially encloses the seed head and as it weathers away seed is disseminated all year. Even after new growth begins the following year seeds can be found enclosed in the old sheath.

Fig. 20. A plant of sand dropseed which shows the short, sparse leaves and the contracted seed head partially enclosed in the sheath. This is characteristic of this grass in addition to the small tuft of hairs at the base of the leaf

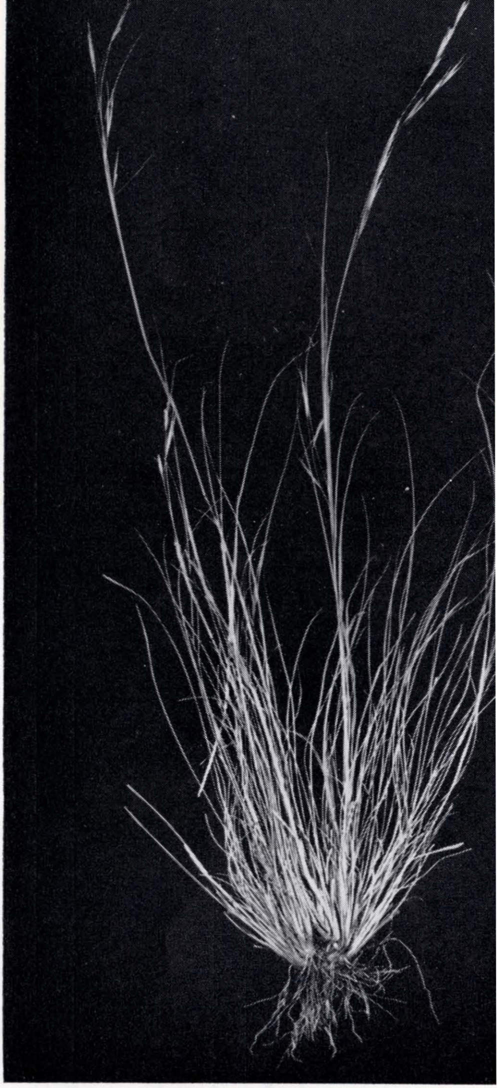

Fig. 21. A clump of needle-and-thread grass showing the characteristic basal leafiness and slender stems with fine pliable foliage. Seeds bear a long, twisted, thread-like awn about 3 inches long on their tips

From the standpoint of nutrient value, sand dropseed is one of the best grasses found on the desert ranges for winter grazing. However, like other desert grasses, it is deficient in phosphorus and carotene (table 40). It is also de-

Table 42. *Nutrient content of consumed material which included the current year's growth of needle-and-thread grass on winter ranges*

Date	Intensity of use	Chemical composition of plants: Ether extract	Total protein	Lignin	Cellu-lose	Other carbo-hydrates	Total ash	Calcium	Phos-phorus	Gross energy	Carotene
	percent	*percent*								*Cal./lb.*	*mg/lb.*
8-13-52	65	4.4	4.9	7.9	34.2	34.4	14.4	.68	.08	1,860	0.2
10-16-53	40	5.4	3.2	7.5	31.4	31.4	21.1	1.08	.06	1,692	......
Average	52	4.9	4.0	7.7	32.8	32.9	17.8	.88	.07	1,776	0.2

Table 43. *Daily dry matter consumption and digestibility of needle-and-thread grass*

Date	Day matter consumed daily	Percent digested: Dry matter	Organic matter	Ether extract	Total protein	Cellu-lose	Other carbo-hydrates	Gross energy	T. D. N. in diet	Digest-ible energy	Digestible protein in diet	Metabo-lizable energy
	pounds	*percent*							*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
8-13-52	2.85	46.4	44.1	14.6	29.1	70.6	52.1	45.3	44.9	842	1.5	671
	4.63	53.4	46.1	34.6	26.0	68.8	69.5	56.1	48.5	949	0.8	823
Average	3.74	49.9	45.1	24.6	27.6	69.7	60.8	50.7	46.7	895	1.2	747
Limit of error*		4.2	2.5	8.1	8.3	2.9	4.4	3.2	2.8	66	0.8	113

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

ficient in digestible protein (table 41) but is better in this respect than most other grasses. Sand dropseed grass furnishes 939 Calories per pound of feed intake which is considerably higher than the recommended requirement (table 5).

Needle-and-thread Grass. Needle-and-thread grass (*Stipa comata*) sometimes referred to as needlegrass is an erect leafy bunchgrass 1 to 2 feet high (fig. 21). It is identified by a long curling awn 2 to 3 inches long on the end of each seed. Needle-and-thread grass is found throughout the desert and foothill ranges of the Great Basin and is valuable because it is palatable and frequently produces new growth for winter grazing following favorable fall rains. The foliage cures well and is readily eaten even when dry.

Many desert ranges in good condition produce large quantities of this grass. It may compose as much as 25 percent of the total forage but in most cases the quantity has been reduced because of heavy use. In some small areas, usually sandy soil, where utilization has not been abusive, the plant may be present in almost pure stands. This grass like other desert grasses is low in phosphorus, carotene, and digestible protein during the winter grazing season (tables 42 and 43). However, it is adequate in energy (table 5).

Russian-thistle. Russian-thistle (*Salsola kali* var. *tenuifolia*), also known as tumbleweed, is an annual plant with fleshy spine-tipped leaves (fig. 22) found abundantly on abused ranges and abandoned fields throughout the Great Basin. Russian-thistle was introduced about 70 years ago from Eurasia in flaxseed shipped into South Dakota. Since then it has spread widely in the United States particularly in the Western States.

Rusian-thistle, like most annual plants, is not a reliable feed supply. During years

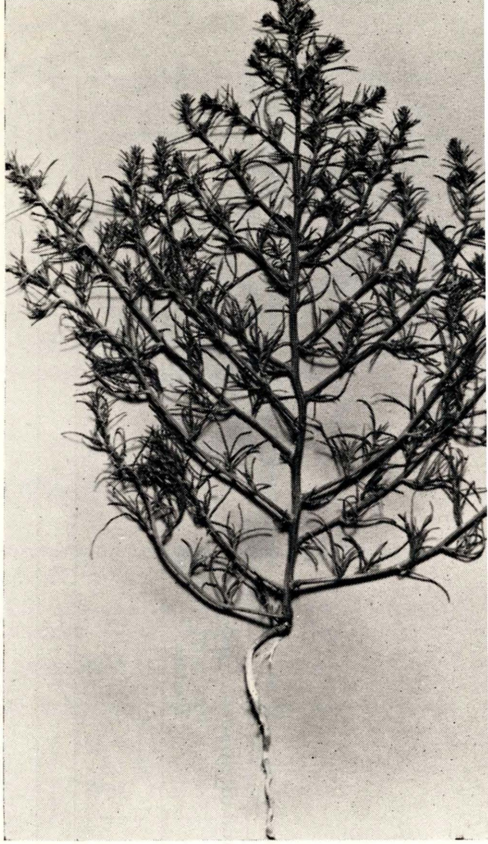

Fig. 22. A medium sized Russian-thistle plant showing general characteristics and stature on most desert ranges used for winter grazing. At maturity these plants are spiny and are round in shape

when summer rainfall is plentiful this plant flourishes on unoccupied areas throughout the desert. Generally the stands are so dense that the individual plants seldom attain a height over 10 inches and are small in diameter compared to plants in scattered stands. The plant becomes dark and dry by November when sheep arrive on the range; however, with intermittent snows and showers it becomes sufficiently moist that livestock often make full feeds on this plant for several days or weeks. Under these conditions it may produce a laxative effect and

Table 44. ***Nutrient content of consumed material which included most of the current year's growth of Russian-thistle on winter ranges***

Date	Intensity of use	Chemical composition of plants: Ether extract	Total protein	Lignin	Cellulose	Other carbohydrates	Total ash	Calcium	Phosphorus	Gross energy	Carotene
	percent				*percent*					*Cal./lb.*	*mg/lb.*
10-21-52	25	3.8	15.2	4.9	13.9	39.6	22.8	2.47	.22	1,533	4.1
12- 5-53	30	2.2	13.2	8.4	22.9	37.0	16.5	4.14	.09	1,694	......
Average	28	3.0	14.2	6.6	18.4	38.3	19.6	3.30	.16	1,614	4.1

Table 45. ***Daily dry matter consumption and digestibility of Russian-thistle***

Date	Dry matter consumed daily	Percent digested: Dry matter	Organic matter	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	T. D. N. in diet	Digestible energy	Digestible protein in diet	Metabolizable energy
	pounds				*percent*				*percent*	*Cal./lb.*	*percent*	*Cal./lb.*
10-21-52	3.47	63.7	51.7	80.5	81.9	52.5	73.0	65.0	55.6	997	12.4	827
12- 5-53	2.38	39.5	42.9	31.9	52.8	63.0	56.2	54.3	43.7	941	7.0	788
Average	2.92	51.6	47.3	56.2	67.4	57.8	64.6	59.6	49.6	969	9.7	807
Limit of error*		3.3	2.6	5.5	3.1	4.7	3.8	3.9	2.7	109	0.8	89

* Limit of error when added to and subtracted from the average percentage expresses the 95 percent confidence interval.

cause the animals to scour. This can be prevented if a supplement is added or animals alternate their feeding with native range forage. Livestock operators consider Russian-thistle an excellent feed to alternate with big sagebrush during winter grazing. Lambs entering the winter range for the first time sometimes develop sore mouth or lip ulceration from eating dry Russian-thistle which may cause them some discomfort for 2 or 3 weeks.

The chemical analysis of Russian-thistle (table 44) indicates a good source of both phosphorus and carotene (vitamin A) and as shown in table 45 it is likewise a good source of digestible protein and energy. The digestible protein is more than twice the recommended requirement and the metabolizable energy furnishes 807 Calories per pound of feed intake compared to 665 for the recommended allowance (table 5).

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