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UTILIZATION OF FORAGE PLANTS AND DIET OF SHEEP ON UTAH WINTER RANGE

by

Lisle R. Green

A thesis submitted in partial fulfillment of the requirements

For the degree of

MASTER OF SCIENCE

in

The School of Forest, Range, and Wildlife Management

Utah State Agricultural College

1948

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UTILIZATION OF FORAGE PLANTS AND DIET OF SHEEP ON UTAH WINTER RANGE

INTRODUCTION

Although there is an abundance of material available concerning forage consumption by livestock on pasture land and in the feed lot, there is relatively little known about the grazing habits and forage preferences of livestock under range conditions. There has been still less scientific effort expended toward solving the riddle of the grazing animal's diet under winter range conditions. Investigators have suggested means to determine the quantity of forage available on range areas, the carrying capacities of range lands, and methods of determining the degree to which forage has been utilized. The diet of the foraging animal is affected by the quantity of forage available, and the capacity of range lands to support grazing and the degree to which various species are utilized are directly dependent upon the diet, yet virtually nothing is known about the actual composition of this diet as selected by the animal on the range.

There is need for additional scientific information concerning choice of species by the foraging animal and the factors which affect this selection. Basic information of this nature must be known before scientific range management can be applied. Sheep are known to prefer certain plants, and likewise certain portions of these plants. In addition weather, stage of maturity, intensity of use, and plant associations all affect the sheep's diet, and make interpretations and calculations still more complex.

This study was designed to determine on the winter range the quantity of forage available to grazing animals, the species composition of the animal's diet, and to evaluate, where possible, factors affecting the diet.

REVIEW OF LITERATURE

Early-day stockmen were the first to attempt the determination of range forage utilization, and their method was simply ocular examination. The experienced guess of the stockman was often good, but range conditions today testify that he seldom erred on the side of conservatism. Range planners early recognized the inadequacy of a mere ocular judgment, and set about devising more scientific approaches to the problem.

The first attempt to express utilization as a percentage figure was that of early forest rangers who believed that proper range use demanded that 15 to 20 percent of the forage be unused at the conclusion of the grazing season (27). From this belief came the idea that proper utilization allowed about 80 percent of the height growth to be taken. This was later modified to include the concept of leaving 20 percent of the seed stalks each season.

Lommasson and Jensen (19) reported a method which correlated weight and height. They cut samples of grasses at 1-inch intervals, and recorded the weight for each interval. Volume tables were constructed for different grass species, and a table was designed to convert height of stubble into percentage utilization. Crafts (10) similarly clipped and weighed, and perfected the system somewhat by developing the height-volume conversion tables. Costello and Turner (9) in the Central Great Plains have worked out the stubble-heights for the major grasses in their area which would leave as stubble approximately 50 percent of the total herbage weight produced. In checking utilization they walk through the area measuring or estimating stubble-heights at definite intervals, and determine utilization from an average of the measurements. Collins and Hurtt (5) and others have since used the method.

Beruldsen and Morgan (1) in Australia, Johnstone-Wallace and Kennedy (18) at Cornell University, and Stapledon and Jones (25) in

Wales measured utilization by using two sets of randomized plots or strips, one of which was harvested after grazing, and the other without grazing. The difference between the two clippings was attributed to grazing, and percentage utilization was calculated from the difference between the two yields. Fiero (15) determined production and utilization of forage plants on the Red Desert in Wyoming by clipping, sorting, and weighing the vegetation from sample plots of 100 square feet each at the start of the winter grazing season and again at its conclusion. This is one of the few attempts made to determine production by range species, but with this method considerable error may be involved because shattering of leaves and seeds and use by animals other than the grazing sheep may be considerable during the winter months. Cassady (4) has suggested a modification of the before and after method which is better adapted to range conditions. Plant units, consisting of portions or all of the plant and including all that is susceptible to destruction by grazing sheep, are collected over an area before and immediately after grazing, the difference being the amount consumed.

Pechanec and Pickford (23) have suggested a weight-estimate method involving the use of small randomized plots. The percentage utilization is determined by estimating the total weight remaining on the plot or the percentage by weight that has been grazed. Observers are trained by estimating on clipped plots, and then checking against the clipped and weighed herbage.

Stoddart (26) developed a system based on a simple count of grazed and ungrazed stalks of single stem grasses within regularly located quadrats. The percentage of stalks grazed gives an index to utilization, and by use of appropriate conversion factors, volume can be estimated (22).

The U. S. Bureau of Land Management has in use a system reported by Deming (12) which is based upon the principle of recording at the end of a season's use specific information about the plant species which carry the grazing load, and noting other factors that would affect range management. The investigator then decides into which of 9 use classes, ranging from no use to destructive use, the area should go.

Canfield (2 and 3) has suggested two possibilities. In the first of these (2), use is made of line transects 50 to 100 feet long, the length depending upon density of vegetation. All plants intercepted by the line transect are measured for height and lateral spread, and a utilization class number between 1, representing complete use, and 9, representing the ungrazed plant, is assigned depending upon the stubble-height from tables prepared for each species. In his second method of determining utilization Canfield (3) uses a system based upon the premise that the percentage of close grazing is proportional to the percentage of partly grazed and ungrazed forage. In use the investigator makes a measurement or ocular estimate of percentage plant cover, an estimate of the important grasses that are grazed to stubble 2 inches or less in height, and then reads the percentage utilization from a set of stubble-height distribution curves presented in chart form. The tables are prepared from statistical analysis of stubble-height measurements in repeated surveys.

Hormay and Fausett (17) on annual-plant ranges in California have photographed various degrees of use, and included with each photograph a written description of the degree of use plus notes on any other factors that the range manager should consider. In practice, the area in question is compared to the photographs and descriptions and assigned to the use class which it most nearly fits.

Numerous investigators have studied use of the plant in attempting to learn the grazing preferences and habits of foraging livestock, but others have worked directly with the animals.

Dixon (13) studied utilization by deer by watching through binoculars and recording the minutes spent in feeding upon each species. He also examined deer stomachs to determine forage consumed. Norris (21) examined sheep stomach contents after feeding a known diet and concluded that stomach analysis could be used to compile lists of plants eaten, but that the method is impractical when the percentage composition of the diet is desired.

Garrigus and Rusk (16) measured the consumption of various pasture species by collecting feces from the grazing steer and using the reasonably constant relationship between dry matter consumed and dry matter defiated to obtain the desired information. Woodman, et al. (28) measured pasture consumption by sheep in a similar manner. The daily output of feces was collected, weighed, and an aliquot reserved for analysis. At the same time the digestibility of the herbage was determined by digestibility trials using other sheep. From these data forage consumption in pounds was computed.

METHOD OF PROCEDURE

During the winter of 1946-47, near Milford, Utah, a study was conducted to obtain basic information concerning the foraging sheep's diet under typical winter range conditions. The study area consisted of two sheep allotments in Wah Wah, Pine, and Antelope valleys which are located in a region of low, roughly parallel mountain ranges separated by almost level desert basins. The mountain chains average seven or eight miles in width, are often steep, and contain numerous coves and canyons which furnish winter grazing to sheep (Plate 1). Basins are from 10 to 15 miles in width, rather flat near their centers, and slope

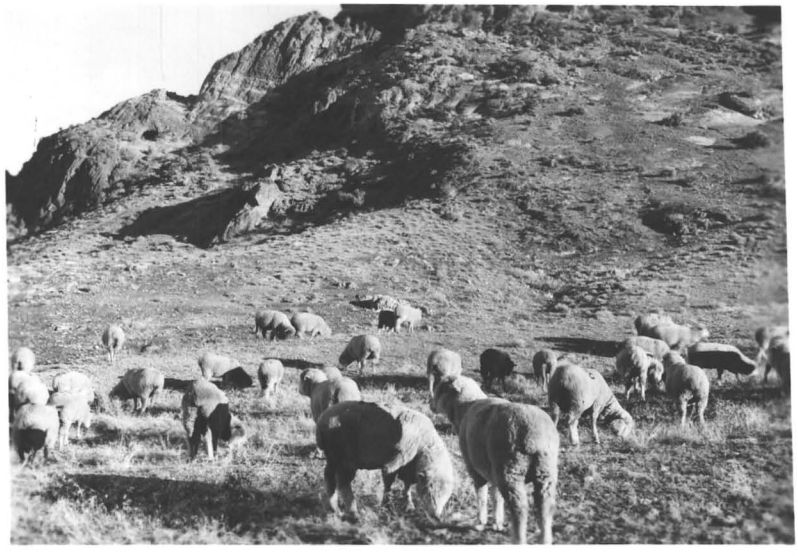

Plate 1. Sheep grazing on the winter range.

gently upward to the mountains which rise abruptly from the valley floor.

Soils are derived from marine sedimentary rocks, chiefly dolomite and limestone. Owing to the extremely dry climate and absence of any appreciable amount of leaching, salt content is relatively high at some point in the soil profile. As a result, vegetation is either salt tolerant or it roots above the region of greatest salt concentration.

Sheep graze the mountain slopes, canyons, and coves, as well as the broad alluvial fans which radiate from every canyon and form almost continuous alluvial slopes. Valley floors are generally reserved for grazing by cattle.

After consideration of the various methods of sampling vegetation, the "before and after" method advocated by Cassady (4) and used on Utah summer range by Cook, et al. (7) was adopted in the belief that it offered the most satisfactory means of determining the sheep's diet. Briefly, the method as used in this study consisted of sampling a certain number of plant "units" of each edible species both before and following grazing. Each sample was air dried and weighed. The difference in weight between the before-grazing and the after-grazing unit was a measure of the utilization of the forage.

The unit constituted the plant or portion of the plant which was collected and which collectively made up the composite sample used for determining before and after grazing weight differences. It was easily recognized, and was selected for uniformity of sampling so that a collector would take the same portion of the plant before and after grazing and in all collections of that species. The unit included sufficient plant material so that it was not destroyed by grazing, but was selected to include little or nothing not potentially edible under heavy grazing stress.

The unit varied with the plant species, and the nature of the unit was determined by the type of plant in each case. A twig comprised of the current years growth provided the most satisfactory unit for most browse species. In the case of some browse species which are half-shrub in nature such as snakeweed (Gutierrezia sarothrae), white sage (Eurotia lanata), and bud sage (Artemisia spinescens), the best unit proved to be the entire current years growth from one plant. For bunch grasses the entire bunch clipped to ground level was considered most satisfactory. In the case of turf forming grasses such as galleta (Hilaria jamesii) and blue grama (Bouteloua gracilis), a unit was the amount which filled a frame one-sixteenth of a square foot in size. However, in this regard it is suggested that individual tufts might make more definite and satisfactory units, especially in thin stands.

To avoid personal bias in the collection of units, use was made of what is called an "observation." An observation consisted of one unit when collecting bunch grasses and half-shrubs where the entire plant made up the unit. However, it was impossible to pick one unit from a browse species without some degree of personal selection, so the observation consisted of a major branch which included numerous units. These were later picked off, counted, and the woody material discarded.

Randomization of collection was obtained by sampling ahead of the sheep as they normally graze rather than by directing the herd to a sample area. In locating sampling areas the collector went to the herders and inquired where they intended to have their herds grazing the following morning. Upon learning where the sheep would be grazing, the collector went there and staked out transects, generally 300 yards in length, perpendicular to the direction of movement of the sheep and directly in their path.

A definite number of plant units of each edible species present in sufficient abundance to contribute significantly to the diet, was collected along a transect between stakes set at both ends of the sampling area. The number of unit s collected varied with the species, but was of sufficient quantity to give a statistically reliable index of the average weight of a unit before grazing. This number varied from 25 units of certain bunch grasses to 500 units of some browse species depending upon size and variability of the unit. The collector estimated the number of units required for a statistically reliable sample, and determined the number of observations he must take through the sampling transect to collect the necessary units. He then paced along the transect the determined number of paces, and collected the observation nearest to the toe of the right foot. He placed the sample in a bag and continued the process through the transect. Approximately the same number of observations were then collected back along the transect and placed in another bag for weight determination.

It is generally agreed among agronomists that a field sampling error * of 10 percent or less is within the limits of allowable error. Sufficient units were collected in the two samples to keep within this limit of error. The number of units necessary to do this varied with the species, and species themselves varied from one site to another.

Error of browse species having small units made up usually of a twig, generally fell under 10 percent if about 300 units were taken, and when this number was increased to more than 500 units, sampling error was consistently less than 5 percent. In the case of species where the unit was an entire clump, collections of fewer than 20 units were not reliable, but collections of from 20 to 30 units

* Sampling error is the standard error of the mean of the two samples divided by the mean.

consistently fell under 10 percent. Collections of more than 30 units averaged five percent or less. The average unit number collected and the average sampling error for the entire season for each species is presented in Table 1.

The sampling error for seasonal averages did not approach significance for any species as shown in Table 1. These seasonal averages considered all individual samples and generally included several individual collections. Even though a few of the differences between duplicates for individual collections were considerable, the seasonal averages for the species were reduced below significance by compensation from a number of samples. All utilization figures on a seasonal basis are considered directly or indirectly in total averages, consequently, the test for significance in Table 1 would be an index to the error that was included in sampling.

The "T" test and analysis presented in column 7 of Table 1 is the value of T for the number of areas sampled, and in column 8 is shown the difference necessary to be significant at the 5 percent level. This necessary difference for significance between the means of the duplicate samples for either the before-grazing or the after-grazing collections was far greater than any actually obtained for seasonal averages in all species. The T values presented are expressions of the sampling error for each species and were computed for the entire season for the total number of areas sampled for each species, respectively.

The actual sampling error involved for measuring utilization, which was the difference between the before-grazing weight and the after-grazing weight, would be still smaller than those presented because the two duplicate collections were composited for the total composite sample before-grazing, and likewise the total composite sample after-grazing. Thus the size of the sample is doubled and this

Table 1. Total number of areas on which species occurred in sufficient abundance to sample, average number of units collected per transect, average percent sampling error, average sample weights, and T analysis by species.

Species	No. of areas	Before Grazing: No. of units	Before Grazing: Sampling error	Before Grazing: Coll. A Gms.	Before Grazing: Coll. B Gms.	Before Grazing: T value	Before Grazing: Diff. for sig. at .05	After Grazing: No. of units	After Grazing: Sampling error	After Grazing: Coll. A Gms.	After Grazing: Coll. B Gms.	After Grazing: T value	After Grazing: Diff. for sig. at .05
Artemisia nova	7	585	5.21	66.15	64.30	0.462	2.571	560	5.19	40.05	39.61	0.284	2.571
Artemisia spinescens	2	282	10.61	36.51	31.59	0.117	12.706	357	1.93	54.27	52.05	0.072	12.706
Atriplex confertifolia	24	521	4.02	82.89	88.44	0.789	2.069	495	4.32	71.22	79.49	0.167	2.069
Chrysothamnus stenophyllus	20	501	5.29	46.02	48.60	0.577	2.093	539	6.62	37.36	37.80	0.094	2.093
Ephedra nevadensis	2	661	6.56	115.62	101.18	1.460	12.706	546	8.07	85.71	89.82	0.265	12.706
Eurotia lanata	14	34	6.16	172.20	179.06	0.141	2.160	30	5.13	69.70	70.41	0.065	2.160
Grayia spinosa	2	384	7.27	66.23	64.36	0.385	12.706	428	2.67	41.09	41.52	0.079	12.706
Gutierrezia sarothrae	5	26	3.71	82.23	78.23	0.513	2.776	25	10.07	68.20	65.92	0.209	2.776
Tetradymia spinosa	2	335	5.04	47.45	46.46	0.022	12.706	360	1.72	64.68	66.02	0.016	12.706
Agropyron spicatum	4	30	7.36	127.33	125.71	0.068	3.182	30	4.36	90.56	96.25	0.125	3.182
Aristida longiseta	1	20	4.55	46.00	42.00	- —	- —	25	15.38	60.00	44.00	- —	- —
Bouteloua gracilis	3	22	2.57	30.55	32.22	0.084	4.303	22	7.56	34.22	31.90	0.070	4.303
Hilaria jamesii	9	26	4.74	69.86	67.11	0.325	2.306	27	3.44	57.80	54.86	0.354	2.306
Oryzopsis hymenoides	15	30	3.09	118.58	118.22	0.016	2.145	30	7.38	60.35	59.96	0.054	2.160
Sitanion hystrix	2	25	7.53	43.29	37.71	0.340	12.706	28	10.32	18.18	20.12	0.459	12.706
Sporobolus cryptandrus	6	30	6.35	115.14	116.86	0.054	2.571	29	4.10	111.29	106.77	0.155	2.571

reduces the error proportionately to the square root of the number of samples taken.

As soon as possible after the animals had grazed through the area, samples were again collected along the same transect to determine the average after-grazing unit weight. Collection procedure was identical to that of the before-grazing collection, except that generally a greater number of units was required to obtain the same degree of sampling accuracy.

To know the quantity of each plant species in the sheep's diet it was necessary to determine, not only the percent of that species consumed, but also the quantity of each species on the range. To determine this quantity, 10 plots, each of 100 square feet area, were laid down equi-distant along the utilization transect. The number of square feet of each species was determined by use of a square-foot frame. By counting the number of units of each species within the 100 square foot area, and dividing by the number of square feet of that species present, the units per square-foot of vegetation of that species were approximated. This total, multiplied by the weight per unit, gave a weight for each species per square-foot of area. After the average square feet of each species per average 100 square-foot plot was calculated, the forage weight on any unit of land area represented by the sample areas could be determined.

All samples were stored until they reached a uniform air-dry weight, at which time they were weighed to determine the average weight per unit. The difference between the before-grazing and the after-grazing weights was assumed to be the weight consumed.

RESULTS AND DISCUSSION

The winter grazing season normally begins early in November, and sheep start to leave the winter range in late March, most herds having left the area by mid-April. Sampling followed this same schedule as closely as was possible, and was intensified during the months January, February, and March when feed was scarce. To facilitate study the sampling season was arbitrarily divided into nine periods averaging about 15 days per period. The first period included sampling accomplished between November 18 and November 30. Sampling was continuous between January 4 and March 17; the inclusive dates for these periods were as follows: second period, January 4 to January 14; third period, January 15 to January 27; fourth period, January 28 to February 9; fifth period, February 10 to February 16; sixth period, February 17 to February 28; and the seventh period, March 1 to March 14. During period 8, March 15 to April 8, and period 9, April 9 to April 25, sampling was intermittent.

Though utilization of certain grasses was light, all were subject to some grazing use. Some browse plants--Utah juniper (Juniperus utahensis), pinon pine (Pinus monophylla), desert thorn (Lycium andersonii), horse brush (Tetradymia spinosa), and other less important species--totaled 8.53 percent* of the species composition but are normally not grazed. These plants were sampled only occasionally, or not at all. Sampled forage, averaging 91.47 percent of the total plant composition, was calculated in all cases to represent over 95 percent of the forage contributing to the diet of the grazing sheep, and in many cases included all species that were grazed.

* This figure also includes edible species not present in sufficient quantity to sample.

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Forage production by forage class and by species.

Browse species produced 81 percent of the average total quantity of forage available to the foraging sheep throughout the winter season with grasses making up the remainder,** or about 19 percent (Table 2). These ratios were relatively constant throughout the winter, but varied from 70 to 93 percent for browse plants, and from 7 to 30 percent for grasses. Data in Table 2 show that white sage contributed 28 percent of the forage available to the grazing sheep, shadscale (Atriplex confertifolia) 27 percent, yellow brush (Chrysothamnus stenophyllus) 17 percent, and black sage (Artemisia nova) 5 percent of the available feed, respectively. The first three species listed contributed 87 percent of the production of browse and 71 percent of the total forage production. Four species contributed 98 percent of the grass production and this was 18 percent of the total forage production. Indian ricegrass (Oryzopsis hymenoides) was most important, comprising about 7 percent of the season-long forage production. Bunch wheatgrass (Agropyron spicatum) and sand dropseed (Sporobolus cryptandrus) each produced about 4 percent and galleta 3 percent of the available forage. Other species of both browse and grass contributed only minor quantities to the total forage production.

Data in Table 3 show that nine species of browse and seven species of grass produced the forage which was available for grazing use during the winter season. Of these species only one, shadscale, occurred in every period which indicates that it was present nearly everywhere. Production of shadscale varied by period from 5 to 51 percent of the available forage production. Yellow brush appeared in all but the first period, and likewise was abundant over most of the study area.

** Forbs totaled less than 1 percent of the total vegetation.

Table 2. Average percent seasonal production of forage by area and by weight, grams produced per square-foot, and available forage production in pounds per acre.

Species	Percent composition of forage		Wt. per sq. ft.	Production per acre
	By area	By wt.	Gms.	Pounds
Artemisia nova (black sage)	7.24	4.75	54.27	15.87
Artemisia spinescens (bud sage)	0.44	0.51	54.00	1.02
Atriplex confertifolia (shadscale)	27.55	26.75	52.64	89.26
Chrysothamnus stenophyllus (yellow brush)	15.14	16.60	52.82	55.45
Ephedra nevadensis (jointfir)	1.46	2.38	165.71	7.94
Eurotia lanata (white sage)	18.98	27.70	94.90	92.50
Grayia spinosa (hop sage)	0.24	0.15	55.00	0.53
Gutierrezia sarothrae (snakeweed)	1.88	1.75	67.55	5.85
Lycium andersonii (desert thorn)	0.95	- -	- -	- -
Tedradymia spinosa (horse brush)	1.14	1.05	66.80	3.43
All others	6.44	- -	- -	- -
Browse total or average	81.26	81.42	70.90	271.85
Agropyron spicatum (bunch wheatgrass)	2.50	3.51	69.91	11.71
Aristida longiseta (three-awn)	0.06	0.07	70.40	0.25
Bouteloua gracilis (blue grama)	0.74	0.19	26.67	0.65
Hilaria jamesii (galleta grass)	4.26	3.26	35.55	10.88
Oryzopsis hymenoides (Indian ricegrass)	4.44	7.44	76.00	24.85
Sitanion hystrix (squirreltail)	0.22	0.12	57.00	0.41
Sporobolus cryptandrus (dropseed)	3.05	3.99	78.21	13.32
All others	2.82	- -	- -	- -
Grass total or average	17.69	18.58	71.23	62.07
Forbs	0.85	- -	- -	- -
Total or average	100.00	100.00	59.02	333.92

Table 3. Average percent of total forage production, utilization, and composition of diet calculated by weight produced and consumed during the winter grazing season, November to May.

Species	Period 1			Period 2			Period 3			Period 4			Period 5		
	Prod.	Util.	Diet	Prod.	Util.	Diet	Prod.	Util.	Diet	Prod.	Util.	Diet	Prod.	Util.	Diet
Artemisia nova	- --	- --	- --	2.55	40.70	3.19	14.94	46.79	18.68	2.16	56.89	4.65	4.54	49.37	12.61
Artemisia spinescens	- --	- --	- --	1.25	66.19	2.62	- --	- --	- --	- --	- --	- --	- --	- --	- --
Atriplex confertifolia	5.53	0.00	0.00	34.12	17.38	19.12	27.08	33.93	24.22	10.63	-3.72	-1.55	23.11	21.29	27.12
Chrysothamnus stenophyllus	- --	- --	- --	9.44	20.90	5.92	24.82	37.93	24.37	15.12	24.62	15.90	30.22	19.88	33.80
Ephedra nevadensis	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	12.90	-1.41	-0.89
Eurotia lanata	77.00	68.70	98.25	42.87	45.66	59.80	- --	- --	- --	64.90	30.97	77.00	13.84	1.22	1.67
Grayia spinosa	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	1.23	9.98	0.70
Gutierrezia sarothrae	2.13	13.55	0.55	0.24	13.09	0.09	4.66	14.89	1.83	- --	- --	- --	5.58	32.14	9.96
Tetradymia spinosa	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --
Browse total	84.66	82.82	98.80	90.47	32.47	90.64	71.45	36.77	69.10	92.81	26.61	94.00	91.42	16.49	84.97
Agropyron spicatum	- --	- --	- --	- --	- --	- --	4.88	43.87	5.71	7.19	22.47	6.00	- --	- --	- --
Aristida longiseta	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --	- --
Bouteloua gracilis	- --	- --	- --	- --	- --	- --	1.28	-6.32	-0.23	- --	- --	- --	- --	- --	- --
Hilaria Jamesii	- --	- --	- --	- --	- --	- --	0.81	11.30	0.25	- --	- --	- --	3.87	11.11	2.32
Oryzopsis hymenoides	- --	- --	- --	2.01	55.65	3.47	18.99	50.02	25.33	- --	- --	- --	3.59	43.28	8.56
Sitanion hystrix	- --	- --	- --	0.06	50.00	0.09	0.35	48.44	0.47	- --	- --	- --	1.12	65.33	4.15
Sporobolus cryptandrus	15.34	2.91	1.20	7.46	24.81	5.80	2.24	-10.92	-0.63	- --	- --	- --	- --	- --	- --
Grass total	15.34	2.91	1.20	9.63	31.47	9.36	28.55	40.54	30.90	7.19	22.47	6.00	8.58	31.65	15.03
Total	100.00	85.62	100.00	100.00	32.37	100.00	100.00	37.85	100.00	100.00	26.31	100.00	100.00	17.79	100.00

Table 3. Average percent of total forage production, utilization, and composition of diet calculated by weight produced and consumed during the winter grazing season, November to May.

Species	Period 6			Period 7			Period 8			Period 9		
	Prod.	Util.	Diet	Prod.	Util.	Diet	Prod.	Util.	Diet	Prod.	Util.	Diet
Artemisia nova	- -	- -	- -	27.97	32.00	43.56	- -	- -	- -	- -	- -	- -
Artemisia spinescens	- -	- -	- -	- -	- -	- -	2.20	25.65	6.05	- -	- -	- -
Atriplex confertifolia	51.17	3.52	13.65	23.22	12.67	14.56	45.60	-3.51	-16.88	51.10	20.93	45.78
Chrysothamnus stenophyllus	6.44	-2.84	-2.36	18.97	22.59	20.73	6.30	-15.93	-10.30	14.75	18.77	11.77
Ephedra nevadensis	24.69	2.66	11.20	- -	- -	- -	- -	- -	- -	- -	- -	- -
Eurotia lanata	24.15	16.07	43.69	- -	- -	- -	5.88	14.62	9.01	- -	- -	- -
Grayia spinosa	- -	- -	- -	- -	- -	- -	- -	- -	- -	4.38	45.01	8.13
Gutierrezia sarothrae	0.14	6.97	0.13	- -	- -	- -	12.10	10.68	12.42	2.55	-5.83	-0.53
Tetradymia spinosa	- -	- -	- -	- -	- -	- -	6.25	5.92	3.40	- -	- -	- -
Browse total	86.59	6.24	66.31	70.16	23.06	78.84	76.33	0.72	3.68	72.56	21.09	65.15
Agropyron spicatum	- -	- -	- -	11.55	11.95	7.09	6.14	28.22	18.02	- -	- -	- -
Aristida longiseta	0.81	5.45	0.53	- -	- -	- -	- -	- -	- -	- -	- -	- -
Bouteloua gracilis	- -	- -	- -	0.89	12.12	0.52	- -	- -	- -	- -	- -	- -
Hilaria jamesii	7.27	20.81	17.48	2.35	26.93	3.18	8.44	37.50	32.98	25.02	28.00	31.15
Oryzopsis hymenoides	3.70	30.68	15.38	11.42	17.23	9.75	9.09	51.92	45.32	2.42	34.30	3.70
Sitanion hystrix	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Sporobolus cryptandrus	1.63	11.71	2.30	3.63	3.51	0.62	- -	- -	- -	- -	- -	- -
Grass total	13.41	21.50	33.69	29.84	14.15	21.16	23.67	40.63	96.32	27.44	28.56	34.85
Total	100.00	8.29	100.00	100.00	20.40	100.00	100.00	10.17	100.00	100.00	23.14	100.00

Where it occurred it produced not less than 6 percent of the available feed, and during one period comprised almost one-third of the forage. Snakeweed was present almost everywhere, but usually did not occur other than as a minority member of the flora. However, during one period in late winter when more preferred species had been closely grazed, it represented 12 percent of the forage then available to the grazing sheep. White sage was particularly abundant on the lower alluvial slopes, here occurring in extensive pure stands. Inasmuch as snow was the chief source of water for the sheep, use of these extensive areas of white sage depended, generally, upon the presence of snow. After a storm, the sheep left the shelter of the hills and went down onto the lower slopes, and often spent several days on almost pure stands of white sage before receding snow forced them up nearer the mountains. During such times the available forage production was weighted heavily to white sage. However, this species was also widely mixed with other members of the flora elsewhere and usually was available to grazing sheep. Black sage was available only in the mountains and seldom dominated any extensive area. However, in its dry rocky habitat it was an important species and as such produced a significant quantity of forage which was available to sheep through more than half the grazing season. During the grazing period when it was most abundant, it represented 28 percent of the forage production. Bud sage grew on the lower alluvial slopes and was never present in great abundance. Jointfir (Ephedra nevadensis) was present along rocky washes, and hop sage (Grayia spinosa) was also limited in extent, growing only in localized sections of the grazing allotments. Consequently, these plants did not contribute greatly to the available forage or to the diet.

Indian ricegrass was the most abundant grass species and was scattered over most of the area of the grazing allotments. Where the

species was present in sufficient quantity to sample, it made up from 2 to 19 percent of the available forage. Bunch wheatgrass occupied local areas within the foothill cedar belt, but during no grazing period did it represent more than 12 percent of the available feed. Sand dropseed was restricted, generally, to the higher alluvial slopes, and only during the first period did it comprise as much as 15 percent of the feed available. Other grass species were less abundant and, consequently, less important in the production of forage.

Production per square foot.

A factor which is frequently neglected when evaluating range production is the weight of forage produced per unit of area occupied. However, weight production is more important than is the area occupied by the various species. Data presented in Table 2 show that browse species as a group produced about the same weight per unit of land area occupied as did grasses, the production figures being 70.90 and 71.23 grams per square foot, respectively.

Jointfir appeared to yield more per square foot than any other species. This may be because it is a relatively tall species and produces more than a single layer of growth which has higher density than does growth of most other species. However, collections of the species were limited, and there was difficulty in differentiating current years growth from older growth, so production data for jointfir might justly be questioned. White sage produced more weight per square foot of vegetation than did any other dominant species, producing about 95 grams of edible feed per square foot. Snakeweed and horse brush followed in decreasing order with four other important species, black sage, bud sage, shadscale, and yellow brush following below these species with a seasonal average production of 53 to 54 grams of forage on each square foot of vegetation.

The taller bunch grass species generally produced more forage per square foot of ground cover than did sod grasses or tuft forming grasses, bunch wheatgrass being most notable in this respect with an average square foot production of 90 grams. Sand dropseed and Indian ricegrass followed with 78.21 and 76.00 grams per square foot, respectively. The tuft forming species, galleta and blue grama grass, produced less per square foot of ground cover, production being 35.55 and 26.75 grams, respectively.

Forage production per acre.

The pattern of grazing on the winter range consists of the sheep first passing over the entire allotment "topping" the feed or grazing to what might be described as conservative use. This was completed about January 31, when the sheep began a second systematic coverage of the allotments which was somewhat faster and was completed about the time spring growth became available in quantity, about mid-March. Much of the area was grazed a third time in search of the green spring growth which was by then about all the feed available, and certainly it was all that interested the sheep to any extent.

A determination of available forage produced per acre must be based on units which have not been grazed. This means that only before-grazing units collected during the first grazing* can be considered, because later units, having been grazed, would average less in weight. Forage production in pounds per acre based on these before-grazing collections is presented in the first column of Table 4 which shows that total forage available per acre at the start of the grazing season was 339 pounds. This production was computed by multiplying the average

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* By first grazing is meant the period November through January when sheep were passing over the grazing allotments the first time. Second grazing refers to the second coverage, and spring grazing refers to the use following March 15.

Table 4. Forage production and consumption in pounds per acre and forage utilization and diet in percent prior to spring growth.

Species	First Grazing				Second Grazing				Summary	
	Forage available	Utilization	Forage consumed	Diet	Forage available	Utilization	Forage consumed	Diet	Forage consumed	Diet
Artemisia nova	15.39	46.84	7.21	6.18	25.35	33.44	8.48	24.30	15.69	10.35
Artemisia spinescens	3.04	66.17	2.01	1.72	0.17*	— —	— —	— —	2.01	1.33
Atriplex confertifolia	73.93	18.13	13.40	11.48	58.33	7.89	4.60	13.18	18.00	11.87
Chrysothamnus stenophyllus	41.39	29.72	12.30	10.54	37.06	15.21	5.64	16.18	17.94	11.83
Ephedra nevadensis	3.41	0.00	0.00	0.00	21.57	1.61	0.35	1.00	0.35	0.23
Eurotia lanata	140.30	46.25	64.89	55.58	30.45	12.27	3.74	10.72	68.63	45.26
Grayia spinosa	— —	— —	— —	— —	0.53	9.93	0.05	0.14	0.05	0.03
Gutierrezia sarothrae	5.85	14.50	0.85	0.73	8.30	16.88	1.40	4.01	2.25	1.48
Tetradymia spinosa	0.20	0.00	0.00	0.00	10.97	-8.24	0.00	0.00	0.00	0.00
Browse total or average	283.51	35.50	100.66	86.23	192.73	12.69	24.26	69.52	124.92	82.38
Agropyron spicatum	9.57	30.71	2.94	2.52	10.96	15.96	1.75	5.01	4.69	3.09
Aristida longiseta	0.67	0.00	0.00	0.00	1.28	5.40	0.07	0.20	0.07	0.05
Bouteloua gracilis	1.53	-6.33	0.00	0.00	0.76	12.12	0.09	0.26	0.09	0.06
Hilaria jamesii	1.09	11.30	0.12	0.10	9.38	20.19	1.89	5.42	2.01	1.33
Oryzopsis hymenoides	20.12	50.76	10.21	8.75	19.78	29.30	5.80	16.62	16.01	10.56
Sitanion hystrix	0.41	48.66	0.20	0.17	1.25	65.36	0.82	2.35	1.02	0.67
Sporobolus cryptandrus	21.88	11.89	2.60	2.23	3.88	5.77	0.22	0.63	2.82	1.86
Grass total or average	55.27	29.08	16.07	13.77	47.29	22.50	10.64	30.49	26.71	17.62
Grand total or average	338.78	34.46	116.73	100.00	240.02	14.54	34.90	100.00	151.63	100.00

* Computed from first grazing and not sampled during second grazing.

production weight per square-foot of each species before grazing by the average number of square-feet of each species present on plots studied during the first grazing, November through January, and then totaling the production for each species. This total production, 339 pounds per acre, agrees closely with the total production for the winter season, 334 pounds per acre, presented in Table 2. This was computed by multiplying the before-grazing production weight per square-foot of each species by the average composition, or average number of square-feet present, on all plots studied throughout the entire winter season. Considering only total seasonal production, either figure gives an accurate index to the available forage. However, in the case of production by forage class or by species, the data presented in column 4 of Table 2 most nearly represent the average production of the grazing allotments. This is because these production figures are based upon the average composition of all plots studied throughout the season, while production figures presented in column 2 of Table 4 were based upon averages from the smaller number of plots studied during the forepart of the winter. Being based upon fewer plots, production data are weighted to species that sheep happened to be grazing most at that time. For example, sheep were grazing white sage more early in the grazing season than they did later. Proportionally more samples of white sage were taken at this time which tends to weight forage production during this early period to white sage. However, later in the year much less of this species was present where the sheep grazed, and by averaging the forage composition of plots studied season-long, white sage assumes its proper proportion in forage production.

Forage available at the start of the second grazing, 240 pounds per acre, represents the forage which was not grazed during the first grazing (Table 4), although some units were partially consumed. The

data on actual forage available differ somewhat from values which might be computed from first grazing production and consumption by multiplying pounds of each species present by the utilization recorded for the species, then subtracting the quantity grazed from the quantity originally present to give the quantity of forage available for grazing the second time sheep went over the allotment. For example, the average total available forage in the second grazing is about 18 pounds per acre in excess of the quantity computed; the actual weight of browse available during the second period is 20 pounds greater than the calculated value; and similar figures for grass show about 8 pounds available in excess of the calculated quantity. These differences between actual values obtained and calculated values are explained on the basis of variations in site productivity from place to place. During the first grazing, sheep grazed most heavily on the readily accessible areas, and these plants had had similar heavy use in previous years so that productivity and size of unit may have been somewhat reduced. During the second grazing, the best forage was in relatively inaccessible areas which had not received such close use during the first grazing, and had also had relatively lighter use during previous years. Soil and other factors contributed to the total of factors affecting site productivity, with the result that the available forage was greater than the calculated values. In the case of certain species, black sage being the most notable, there was, in addition to the effect of larger units available during the second grazing, a greater square foot density of the forage produced, with the result that more pounds of this species are shown to be available than were present at the start of grazing season. Had the same collection areas been considered in both grazings, these differences would not have appeared.

In addition to production available at the start of the grazing season, there was forage produced after spring growth started which was available for grazing (Table 5). This was difficult to determine quantitatively, since remnants of old units and new growth alike were subject to use and had to be sampled as one unit. However, growth was rapid after March 15, and after this date sheep grazed little of the old production except where it was supporting incipient growth and had to be eaten if new growth were to be taken. Thus, in Table 5, the 188 pounds of available forage per acre represent a mixture of the past year's and new spring production. The 31 pounds of forage consumed per acre represent most spring production.

Spring production varies from year to year. During the study period warm spring weather came in mid-March and there was considerable new production available before sheep left the winter range. During other years, spring is quite often later and the sheep have gone before the new growth becomes so important in their diet. Presumably the spring production would be available for sampling and grazing in November if it were not removed during March and April, and hence could be added to it for a total production of 366 pounds per acre. It is believed that this total production is conservative since sheep herders all testified that 1946-47 was a poor feed year, and that the following year, even with spring forage removed as indicated, was a good one.

Utilization and composition of the diet.

It is commonly assumed that sheep prefer browse to grass, but this study showed no decided preference for either class of forage. Browse species produced 81 percent of the available forage and grasses produced 19 percent (Table 2). Average utilization percentages were 43 and 45 (Table 6), respectively, both forage classes receiving approximately the same degree of use. The average percent of diet prior to

Table 5. Forage production and consumption in pounds per acre, forage utilization and diet in percent during the spring growing season, and seasonal summary.

	Spring grazing				Seasonal Summary	
Species	Forage available	Util.	Forage consumed	Diet	Total forage consumed	Diet
Artemisia nova	-- --	-- --	-- --	-- --	15.69	8.58
Artemisia spinescens	7.20	35.66	1.85	5.92	3.86	2.11
Atriplex confertifolia	92.51	8.93	8.26	26.44	26.26	14.36
Chrysothamnus stenophyllus	12.49	18.78	2.35	7.52	20.29	11.09
Ephedra nevadensis	-- --	-- --	-- --	-- --	0.35	0.19
Eurotia lanata	-- --	-- --	-- --	-- --	68.63	37.55
Grayia spinosa	3.56	44.18	1.57	5.03	1.62	0.89
Gutierrezia sarothrae	4.16	-5.83	0.00	0.00	2.25	1.23
Tetradymia spinosa	18.75	5.93	1.11	3.55	1.11	0.61
Browse total or average	138.67	10.92	15.14	48.46	140.06	76.59
Agropyron spicatum	-- --	-- --	-- --	-- --	4.69	2.57
Aristida longiseta	-- --	-- --	-- --	-- --	0.07	0.04
Bouteloua gracilis	-- --	-- --	-- --	-- --	0.09	0.05
Hilaria jamesii	41.23	32.26	13.30	42.58	15.31	8.37
Oryzopsis hymenoides	8.18	34.27	2.80	8.96	18.61	10.28
Sitanion hystrix	-- --	-- --	-- --	-- --	1.02	0.56
Sporobolus cryptandrus	-- --	-- --	-- --	-- --	2.82	1.54
Grass total or average	49.41	32.58	16.10	51.54	42.81	23.41
Grand total or average	188.08	16.61	31.24	100.00	182.87	100.00

spring growth was 82 percent browse, and 18 percent grass--almost directly proportional to available forage by forage classes. There was no significant difference in percentage use between grass and browse throughout the winter grazing season, but variation of use by forage classes between periods approached significance*. During some periods, particularly 1, 2, and 4, the diet was weighted to browse, and during one period, 8, the sheep grazed the fresh green grass almost exclusively. There were highly significant differences in use between species and also between forage classes where only the dominant forage producing species were considered. In this case grasses were used to a greater extent than were browse species. During the first grazing, browse species were utilized to a greater degree than were grasses (Table 4), but during the second period the use ratio was reversed to favor the grasses. During the third grazing (Table 5) new spring grass was grazed considerably heavier than was the green browse.

During two grazing periods sheep showed distinctly different dietary habits than they displayed during the rest of the grazing season, and these merit additional comment. During the first period the apparent high browse-use (Table 3) is due in part to the fact that a combination of weather and road conditions made it impossible to reach one of the two herds with which the collector worked most of the winter, so sampling was accomplished before and after two herds which were accessible but which were not used again. These were grazing a region which had little grass other than sand dropseed, but did have palatable browse, particularly white sage. The herders allowed the sheep to graze very slowly through the sampled areas, and a high

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* Significance at the .05 percent level is spoken of as "significant," and significance at the .01 percent level is spoken of as "highly significant."

Table 6. Comparison of average percent utilization computed by total forage produced and consumed and average percent utilization computed by averaging utilization percentages of individual samples.

Species	First Grazing		Second Grazing		Winter Summary	
	Util. by wt. produced and consumed	Util. by av. of individual samples	Util. by wt. produced and consumed	Util. by av. of individual samples	Util. by wt. produced and consumed	Util. by av. of individual samples
Artemisia nova	46.84	48.25	33.44	37.39	64.62	67.69
Artemisia spinescens	66.17	60.12	-- --	-- --	66.17	60.12
Atriplex confertifolia	18.13	11.66	7.89	8.05	24.59	18.77
Chrysothamnus stenophyllus	29.72	34.85	15.21	11.00	40.41	42.02
Ephedra nevadensis	0.00	0.00	1.61	1.25	1.61	1.25
Eurotia lanata	46.26	45.03	12.27	9.16	52.85	50.07
Grayia spinosa	0.00	0.00	9.93	9.98	9.93	9.98
Gutierrezia sarothrae	14.50	14.41	16.88	12.73	28.95	25.31
Tetradymia spinosa	0.00	0.00	-9.24	-9.24	-9.24	-9.24
Browse total	35.28	30.61	12.46	10.04	45.34	37.58
Agropyron spicatum	30.71	33.17	15.96	20.09	41.77	46.60
Aristida longiseta	0.00	0.00	5.40	5.45	5.40	5.45
Bouteloua gracilis	-6.83	-5.96	12.12	12.12	6.66	6.86
Hilaria jamesii	11.39	11.80	20.19	21.47	29.21	30.34
Oryzopsis hymenoides	50.76	51.07	29.30	40.62	65.19	70.95
Sitanion hystrix	48.66	49.22	65.38	66.55	82.25	82.59
Sporobolus cryptandrus	11.89	8.60	5.77	9.45	16.97	14.52
Grass total	29.93	24.07	21.56	24.93	45.04	42.00
Grand total	34.53	27.59	14.23	16.99	43.85	39.69

utilization resulted. During period 8, use of browse dropped to about 1 percent, and use of grass increased. This is explained by the fact that spring growth had started, particularly among the grasses. With a little green grass available, the sheep had little or no interest in anything else, but by period 9 green browse was available, and sheep were again eating both grass and browse.

The species content of the diet varied somewhat by periods, and to some extent reflected the effect of site, season, and particularly forage composition. The effect of plant composition is displayed during the first period and profoundly influenced the diet for that period. The two herds happened to be grazing a white sage type, and so the diet of this period is weighted to this species. Later in the winter lack of snow for sheep water tended to limit grazing to the foothills and white sage was a less important constituent of the diet, being absent in 3 periods. White sage is grazed considerably everywhere it occurs, but heavier use percentages were obtained when sheep grazed almost pure stands than when the plant occurred as part of a mixed flora. Herders believe that sheep get hungry for the species, and that when pure stands are grazed the sheep settle down and graze heavily for about two days, but after that they become restless and want to move onto other feed.

Weighted average utilization of white sage prior to spring growth was 55 percent, and 69 pounds of this species consumed per acre amounted to 45 percent of the winter diet (Table 4). White sage was not sampled after active spring growth started, yet it consitituted 38 percent of the average seasonal diet (Table 5).

Use of yellow brush appeared to be determined by site. When it occurred on the alluvial slopes, use was light and often negligible, and where the species was grazed it appeared to be the same plants

that were grazed year after year, neighboring plants not being touched. When the species occurred in the mountains, use was usually heavy, and often destructively so, with little but woody stumps remaining at the end of the grazing season. No explanation for this difference in palatability was discovered, but an interesting correlation in use between it and black sage which ties use of yellow brush to the mountainous areas can be noted from data in Table 5. Black sage occurred in quantity only in the foothills and furnished a prominent part of the diet when it was available. During the periods when black sage was lacking, indicating the sheep were grazing on the slopes where it was not available, yellow brush was not important in the diet even though it was available in considerable quantity. Black sage was preferred by the sheep, and, wherever it occurred, the species was closely used by the end of the winter grazing season. The weighted utilization, 64.62 percent, represents most growth not protected by woody branches.

Shadscale was quite prominent throughout the grazing allotment, but use was never heavy, weighted utilization for the winter season amounting to only 25 percent* (Table 6) of the current years growth. However, because of its abundance it made up about one-eighth of the seasonal diet. Use was heaviest during the fore-part of the winter grazing season before seeds and leaves began to shatter appreciably. Sheep grazed this species by biting off twigs, but often stripped off the seeds and leaves by running their teeth and lips up the stem. A bare sharp spine was left which suggested shattering rather than grazing by sheep. Later in the winter, use was lighter except when

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* This percentage includes any weight lost due to shattering between the before and after collections. This loss is believed to be negligible over a 3 to 6 day sampling period.

snow covered other species and no doubt softened the sharp spines. In the spring, use increased again as succulent shoots became available.

Bud sage was not present in great abundance due, probably, to its high palatability and utilization. Sheep grazed 66 percent of the available forage of this species during the first grazing period (Table 4). This represented all that they could readily take, and only stumps of shoots and the limited amount of photosynthetic tissue protected by coarse wood was left to supply plant needs. It formed no measurable portion of the diet again until short spring growth was available.

Hop sage did not grow widely, and was not important except in the spring, when most of its new growth was taken. Sanakeweed was lightly used throughout most of the season, but contributed only one percent of the average seasonal diet. Jointfir and horse brush were insignificant insofar as diet was concerned, but herders claimed that sheep make some use of jointfir late in the winter.

Indian ricegrass was the most preferred of the dominant grass species, and received an average winter use of 65 percent. Squirreltail grass was green most of the winter and was more heavily used, but only a small quantity was available, so it was not an important factor in the diet, while Indian ricegrass represented one-tenth. Bunch wheatgrass was moderately used where it appeared and represented 5 percent of the diet. Sand dropseed was never heavily used but was grazed when snow was on the ground. Observation and sampling both showed very little use of blue grama grass.

It has been pointed out that season-long utilization of grass and browse was approximately the same, and that diet was directly proportional to forage class abundance. When considering individual species this is not true, some species constituting a greater percent of the diet than their respective proportion of the forage production would suggest.

During the winter season, bud sage was most outstanding in this regard, producing only .31 percent of available forage but 1.33 percent of the diet (Tables 2 and 4). Black sage produced 5 percent of the forage and 10 percent of the diet. Other species with a similar but less marked ratio of available forage to percent of diet are white sage, Indian ricegrass, and squirreltail grass. Shadscale made up 27 percent of the forage but only 12 percent of the diet, yellow brush 17 and 12 percent, blue grama .19 and .06 percent, galleta 3.26 and 1.33 percent, and sand dropseed 4 and 1.86 percent available forage and diet, respectively. Other species produced available forage and entered into the composition of the diet in approximately equal proportion.

Data in Table 4 show that, during the first grazing, 117 pounds of forage per acre were harvested by the grazing sheep, and during the second grazing, 35 additional pounds per acre were consumed. At the conclusion of the second grazing an average of 152 pounds per acre had been harvested by the grazing sheep. This represents 45 percent of the total weight available at the start of the grazing season and was considered complete use, some species having been used rather heavily even at the end of the first grazing. All species that were used to a degree greater than 55 percent were scarce and in a weakened state of production even where present. The sheep herders agreed that feed was short at the conclusion of the second grazing, and ideally sheep should have been removed from the range.

During the latter part of March and the fore-part of April, much of the area was grazed a third time. Utilization was chiefly on the new growth although some old stems were consumed. During this period more galleta grass was eaten than had been taken previously, and there was considerable green Indian ricegrass available. Moderate to heavy

use of these two species weighted the spring forage consumption slightly to grass.

During the spring grazing period, there was succulent shadscale available amounting to almost 50 percent of the available edible forage. However, the species was still only lightly used and constituted only one-fourth of the diet. Bud sage, yellow brush, and hop sage contributed about equally to the diet, but hop sage was only locally abundant and was utilized much heavier.

Comparison of weighted utilization and average utilization.

Obtaining weight production and utilization of range species is a time consuming process that is seldom attempted, but where soil, exposure, topography, and other factors make production as erratic as in the case on range land, considerable error may be involved in utilization estimates if this is not done. In Table 6 are presented the two methods of determining utilization. The method generally employed, consisting of measuring individual plants and dividing by the number of samples, gives a distorted picture for it does not consider weight production which is necessary if an accurate calculation of average use is to be made. The actual use figures presented in column 1 in each case (first grazing, second grazing, and average winter use) were computed by dividing the total weight consumed of each species by the total weight produced. The second column in each case is based upon actual weight produced and consumed on each sample area, but utilization is averaged on the basis of number of areas sampled rather than by total weight of forage produced and consumed.

Differences are not great in any case, being less than 6 percent, which would not be important in general range management practice. However, such an error is important because it might be very different on other vegetation types, especially if utilization is not weighted by

forage production, but is merely an average of measurements taken at intervals through a range unit. Inasmuch as there is error involved in utilization determinations which are not weighted by production, it is important that utilization be so weighted, especially if production within large vegetation type areas differs, and utilization determinations are made by forage types or grazing allotments.

Utilization percentages compared with palatability ratings.

It is the practice of governmental agencies concerned with management of range lands to set up proper use or palatability ratings which mean the percent use a particular species will receive if the range is properly used. These species ratings are compiled by range managers who are familiar with the range and represent their best estimates of proper use.

In Table 7 is presented a comparison of inter-agency proper use factors and use percentages obtained at the conclusion of the winter grazing season when the range had received what was probably heavier than proper use. On the basis of utilization percentages obtained in this study, it is believed that certain inter-agency proper use figures are high and others somewhat low. Proper use figures for black sage, shadscale, and Indian ricegrass should probably be revised downward, for if animals were to graze 75, 40 and 75 percent, respectively, of the available forage production from these species, the best forage plants as a group would be grubbed and most certainly would be damaged or killed. Bud sage and squirreltail grass receive considerably more use than is recommended for them by the inter-agency tables, however, the use that they receive is too heavy. Bud sage is grubbed and squirreltail grass has been driven into the protection of thorny brush. Considerable discrepancy in use figures occurred in the case of blue grama. It has been given a proper use rating of 20, while actual use was about 7 percent.

Table 7. Comparison of utilization percentage figures with Inter-agency palatability ratings.

Species	Inter-agency use factor	Weighted average utilization prior to spring growth	Weighted average utilization of spring growth
Artemisia nova	75	64.62	-- --
Artemisia spinescens	30	66.17	26.68
Atriplex confertifolia	40	24.59	8.93
Chrysothamnus stenophyllus	20	40.41	18.78
Ephedra nevadensis	30	1.61	-- --
Eurotia lanata	60	52.85	-- --
Grayia spinosa	60	9.93	44.18
Gutierrezia sarothrae	10	28.93	-5.83
Tetradymia spinosa	10	-9.24	5.93
Agropyron spicatum	50	41.77	-- --
Aristida longiseta	10	5.40	-- --
Bouteloua gracilis	20	6.56	-- --
Hilaria jamesii	40	29.21	32.26
Oryzopsis hymenoides	75	65.19	34.27
Sitanion hystrix	50	82.23	-- --
Sporobolus cryptandrus	10	16.97	-- --

The use factors of two species, snakeweed and sand dropseed, might be revised upward. Use of these species was light but was greater than allowed by the inter-agency tables. Most use was made of sand dropseed when snow covered the ground, and snakeweed was used lightly throughout the year regardless of the quantity of other forage available.

Palatability tables too often assume that sheep consume a much greater percent of the plant than is shown to be the case, and that plants can endure removal of 75 percent or more of their annual production each year without damage. This is an erroneous assumption and results in poor vigor and scarcity of species which are most heavily utilized. Palatability tables should be adjusted to fit local areas or regions due to the many factors affecting preferences displayed by grazing animals as shown by this study.

Grazing capacity of the winter range.

It has been demonstrated that a 100 pound sheep consumes in the neighborhood of 2.2 pounds of dry matter daily (24) and that sheep averaging 130 pounds in weight consume 3.46 pounds of dry matter daily (29). Sheep on Utah winter range average near this latter weight. At the conclusion of the spring grazing the sheep had consumed 183 pounds of air-dry forage per acre (Table 5) or about 170 pounds, moisture free. Assuming that this is proper use of winter range forage, 1 acre would support 49 sheep days of grazing, and 3.3 acres would be required to carry each sheep through the winter grazing season of approximately 160 days.

CONCLUSION

Investigators have long been interested in determining the quantity of forage which is present on the range, the degree to which it is utilized, and factors affecting use of various species. Many methods of determining utilization of range forage species and the quantity of

forage present have been suggested, but most are based upon an estimate of the forage consumed rather than upon the actual species composition of the diet of the grazing animal on the range or the actual quantity of forage produced and consumed. This study attempted to determine actual forage production and consumption by naturally grazing sheep in a manner not previously attempted on winter range. The "before and after" method of sampling provides an accurate index to forage production because it considers actual production by weight of the individual species. The difference in weight of the before-grazing and the after grazing sample, weighted by pounds of forage produced by each species on the range, presents an accurate index to the diet of the naturally grazing sheep.

The study shows that the number of species contributing to the diet of the grazing sheep on Utah winter range is not large, that a very few species produce the bulk of the available forage, and that browse species are much more abundant and more important from the standpoint of forage production than are grasses. White sage, shadscale, and yellow brush are the dominant browse species, and Indian ricegrass, bunch wheatgrass, sand dropseed, and galleta the dominant grasses.

Winter range land is generally considered to be low producing. The average total production, 365 pounds per acre, in comparison with production figures obtained on summer range in Northern Utah where average production was 1,834 pounds of edible forage per acre (6), shows this forcibly. A productivity of only one-fifth as much as that found on summer range suggests the need for careful balance between the available forage and number of grazing livestock, especially in view of the fact that few studies have been conducted to determine proper use of winter range.

It is a common assumption that sheep prefer browse to grass, but this study indicates that on the winter range there is no forage class

preference. Average seasonal use of browse and grass was approximately equal, and composition of the diet was in direct proportion to the quantity of each class of forage present on the area. However, there were highly significant differences in use between species among both grasses and browse, some species of each being heavily used, while others were used but lightly. A fact that should be noted by managers of such range land is that species which were utilized in excess of 55 percent of the seasonal production were weak, unthrifty, and in some cases, were dying. Such species included bud sage, black sage, white sage, Indian ricegrass, squirreltail grass, and hop sage. Hop sage is highly preferred in the spring and at this time most of the available production is removed by the sheep. Partially or completely dead plants throughout the hop sage community testify that such use is much too severe, and that this species may be faced with extinction if present grazing practices continue. Species which were more lightly used included shadscale, yellow brush, and sand dropseed. These species appeared to be increasing at the expense of the more heavily used species.

On the basis of observations made in connection with this study it is believed that forage species, even though they may be dormant, cannot withstand removal of over half their seasonal production. This concept is directly opposed to the ideas of the past, and of current ideas voiced by those not familiar with the winter range.

SUMMARY

1. Because proper management of livestock and forage on the winter range demanded additional scientific information, a study was conducted during the winter of 1946-47 near Milford, Utah, to determine on the winter range the quantity of forage available to grazing animals, the composition of the grazing sheep's diet, and to evaluate, where possible, the factors which affect the diet.

2. The range forage was sampled by a "before and after" method of sampling not previously used on winter range. The method consisted of the random sampling of a determined number of plant "units" of all edible species both before and after grazing by sheep. Each sample was air dried and weighed, and the difference in weight between the before grazing and after grazing sample was a measure of the percentage utilization of each species.

3. Unless sampling error between duplicate samples fell under 10 percent, more units were collected. Error was within acceptable limits when 300 units were collected from those species where a twig of current years production comprised the unit, but increasing this to 500 units reduced the sampling error to less than 5 percent. When the unit was an entire clump, collections of 20 to 30 units gave an error of less than 10 percent, and collections in excess of 30 units averaged less than 5 percent sampling error.

4. Browse species produced over four-fifths of the forage available to sheep throughout the winter season. Grass and an occasional forb made up the remainder. Three browse species, white sage, shadscale, and yellow brush, constituted 87 percent of the available browse forage and 71 percent of the total forage production. Four grass species, Indian ricegrass, bunch wheatgrass, sand dropseed, and galleta, comprised 98 percent of the grass production, and 18 percent of the total production.

5. Jointfir appeared to be the most productive species per square foot of area occupied, but white sage was the most productive dominant species, producing 95 grams of forage per square foot. Snakeweed and horse brush followed in decreasing order, and black sage, bud sage, shadscale, and yellow brush produced 53 to 84 grams of forage on each square foot of area. The tall bunch grasses were most productive among the grasses. Bunch wheatgrass produced 90 grams, sand dropseed 78 grams, and

Indian ricegrass 76 grams respectively. Tuft forming species were least productive, galleta producing 36 grams and blue grama 27 grams per square foot of area occupied.

6. Production in pounds of available forage per acre was 334 prior to spring growth. During the spring season 31 additional pounds of new growth were consumed. This, plus the previous production, gave an average total yield of 365 pounds per acre.

7. Average utilization of browse was 43 percent, and use of grasses was 45 percent. The average percent of the grazing sheep's diet prior to spring growth was browse, 82 percent, and grass, 18 percent. Percent of diet by class was in almost direct ratio to amount of forage present. However, there were highly significant differences in use between species, certain grass species and some browse species receiving heavier use than others.

8. Certain species were preferred by the sheep which consumed over half of their annual forage production. These species, including bud sage, black sage, white sage, Indian ricegrass, and squirreltail grass, constituted a greater percent of the diet of the sheep than they did of the available forage production. Black sage, for example, constituted about 5 percent of the available forage, but because of heavy use made of this species, it constituted 10 percent of the diet prior to spring growth. Species which had less than half of their forage production removed were shadscale, yellow brush, blue grama grass, sand dropseed, and galleta grass. Shadscale and yellow brush were, generally, lightly used, but because of their great abundance, they were important components of the diet.

9. While sheep grazed over the allotments the first time, 117 pounds of forage per acre were harvested. During the second grazing which lasted until spring growth started, 36 additional pounds were consumed.

This totaled 45 percent of the total forage available at the start of the grazing season, and was considered complete use, some species having been heavily used. During the latter part of March and the fore-part of April, sheep grazed 31 pounds per acre which consisted mainly of new growth. Season-long, 183 pounds of forage were consumed per acre.

10. The method of measuring utilization by forage weight produced and consumed is compared with a modification of the method of measuring utilization which consists of averaging use estimates or measurements of a series of samples. The method used in this study gives a true picture of use, and showed that, on the range allotments studied, the other method gave errors as great as 6 percent.

11. Utilization percentages compared with inter-agency palatability tables indicate that adjustments should be made in the proper use factors for certain species. Values for several of the most palatable species should be revised downward.

12. Calculations indicate that an average acre of Utah winter range grazed as it was during 1946-47 supports 49 sheep days of grazing, and 3.3 acres are required to carry each sheep through the winter grazing season of approximately 160 days.

13. On the basis of observations made during the study it was concluded that forage plants, even though they are grazed during the winter while dormant, cannot withstand the continuous loss of over half their annual forage production. Species that were grazed to such an extent were in a weakened state of production, were unthrifty, and some were threatened with extinction. This suggests that better management of livestock and forage is needed on the Utah winter range.

LITERATURE CITED

1. Beruldsen, E. T. and Morgan, A. Notes on botanical analysis of irrigated pasture. Imp. Bur. Plant Genetics Herbage Pub. Ser. Bul. 14. 1934.

2. Canfield, R. H. Measurement of grazing use by the line interception method. Jour. of For. 42(3):192-194. 1944.

3. ---------- A short-cut method for checking degree of forage utilization. Jour. of For. 42(4):294-296. 1944.

4. Cassady, J. T. A method of determining range forage utilization by sheep. Jour. of For. 39(8):667-671. 1941.

5. Collins, R. W. and Hurtt, L. C. A method for measuring utilization of bluestem wheatgrass on experimental range pastures. Ecol. 24(1):122-125. 1943.

6. Cook, C. J. A study of the utilization of northern Utah summer range plants by sheep. Unpublished thesis. Range Management Department. Utah State Agricultural College. 1947.

7. Cook, C. W., Harris, L. E., and Stoddart, L. A. Measuring the nutritive content of a foraging sheep's diet under range conditions. Jour. of Animal Sci. In press.

8. Cory, V. L. Activities of livestock on the range. Texas Agr. Exp. Sta. Bul. 367. 1927.

9. Costello, D. F. and Turner, G. T. Judging condition and utilization of short-grass ranges on the Central Great Plains. U. S. D. A. Farmer's Bul. 1949. 1944.

10. Crafts, E. C. Height-volume distribution in range grasses. Jour. of For. 36(12):1182-1185. 1938.

11. Davies, W. The relative palatability of pasture plants. Jour. Min. Agr. 32(2):106-116. 1925.

12. Deming, M. H. A field method of judging range utilization. Mimeo. U. S. D. I., Div. of Grazing. 1939.

13. Dixon, J. S. A study of the life history and food habits of mule deer in California. Part II. Food Habits. Calif. Fish and Game 20(4):316-354. 1934

14. Doran, C. W. Activities and grazing habits of sheep on summer ranges. Jour. of For. 41(4):253-258. 1943.

15. Fiero, K. Utilization of range plants on Wyoming winter sheep ranges. Soil Conservation 7(11):281-284. 1942.

16. Garrigus, W. P. and Rusk, H. P. Some effects of the species and stage of maturity of plants on the forage consumption of grazing steers of various weights. Ill. Agr. Exp. Sta. Bul. 464. 1939.

17. Hormay, A. L. and Fausett, A. Standards for judging the degree of forage utilization on California annual-type ranges. Calif. For. and Range Exp. Sta. Tech. Note 21. 1942.

18. Johnstone-Wallace, D. B. and Kennedy, K. Grazing management practices and their relationships to the behavior and grazing habits of cattle. Jour. Agr. Sci. 34(4):190-197. 1944.

19. Lommasson, T. and Jensen, C. Grass volume tables for determining range utilization. Science 87(2263):444. 1938.

20. Milton, W. E. J. The palatability of the self-establishing species contributing to different types of grassland. Empire Jour. of Exp. Agr. 1(4):347-360. 1933.

21. Morris, J. J. Botanical analysis of stomach contents as a method of determining forage consumption of range sheep. Ecol. 24(2):244-251. 1943.

22. Peshanec, J. F. Comments on the stem-count method of determining the percentage utilization of ranges. Ecol. 17(2):329-331. 1936.

23. Peshanec, J. F. and Pickford, G. D. A weight-estimate method for the determination of range or pasture production. Jour. American Soc. Agron. 29(11):894-904. 1937.

24. Smuts, D. B. and Marais, J. S. C. The dry matter consumption of sheep on natural grazing in the Transvaal. Onderstepoort Jour. of Vet. Sci. and Animal Ind. 14(1 and 2):403-415. 1940.

25. Stapledon, R. G. and Jones, M. G. The sheep as a grazing animal and as an instrument for estimating the productivity of pastures. Univ. Col. Wales, Welsh Plant Breeding Sta. Ser. H. (5):42-54. 1925-26.

26. Stoddart, L. A. Range capacity determination. Ecol. 16(3):531-533. 1935.

27. Stoddart, L. A. and Smith, A. D. Range management. 1st ed. McGraw-Hill Book Co. New York. 1943. 547 pp.

28. Woodman, H. E., Evans, R. E. and Eden, A. Sheep nutrition. I. Measurement of the appetites of sheep on typical winter rations together with a critical study of the sheep feeding standards. Jour. Agr. Sci. 27(2):191-211. 1937.

29. Woodman, H. E., Evans, R. E., and Eden, A. Sheep nutrition. II. Determination of amounts of grass consumed by sheep on pasture of varying quality. Jour. Agr. Sci. 27(2):212-225. 1937.

INDEX TO COMMON AND SCIENTIFIC NAMES

Scientific Name	Common Name
Browse:	
Artemisia nova A. Nels.	Black sage
Artemisia spinescens Eat.	Bud sage
Atriplex confertifolia (Torr.) Wats.	Shadscale
Chrysothamnus stenophyllus (A. Gray) Greene	Yellow brush
Ephedra nevadensis S. Wats.	Jointfir
Eurotia lanata (Pursh) Moq.	White sage
Grayia spinosa (Hook.) Moq.	Hop sage
Gutierrezia sarothrae (Pursh) B. & R.	Snakeweed
Tetradymia spinosa H. & A.	horse brush
Grasses:	
Agropyron spicatum (Pursh) Rydb.	Bunch Wheatgrass
Aristida longiseta Steud.	Three-awn grass
Bouteloua gracilis (H.B.K.) Lag.	Blue grama grass
Hilaria jamesii (Torr.) Benth.	Galleta
Oryzopsis hymenoides (Roem. & Schult) Ricker	Indian ricegrass
Sitanion hystrix (Nutt.) J. G. Smith	Squirreltail
Sporobolus cryptandrus (Torr.) Gray	Sand dropseed