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Nutritive Value of Seasonal Ranges

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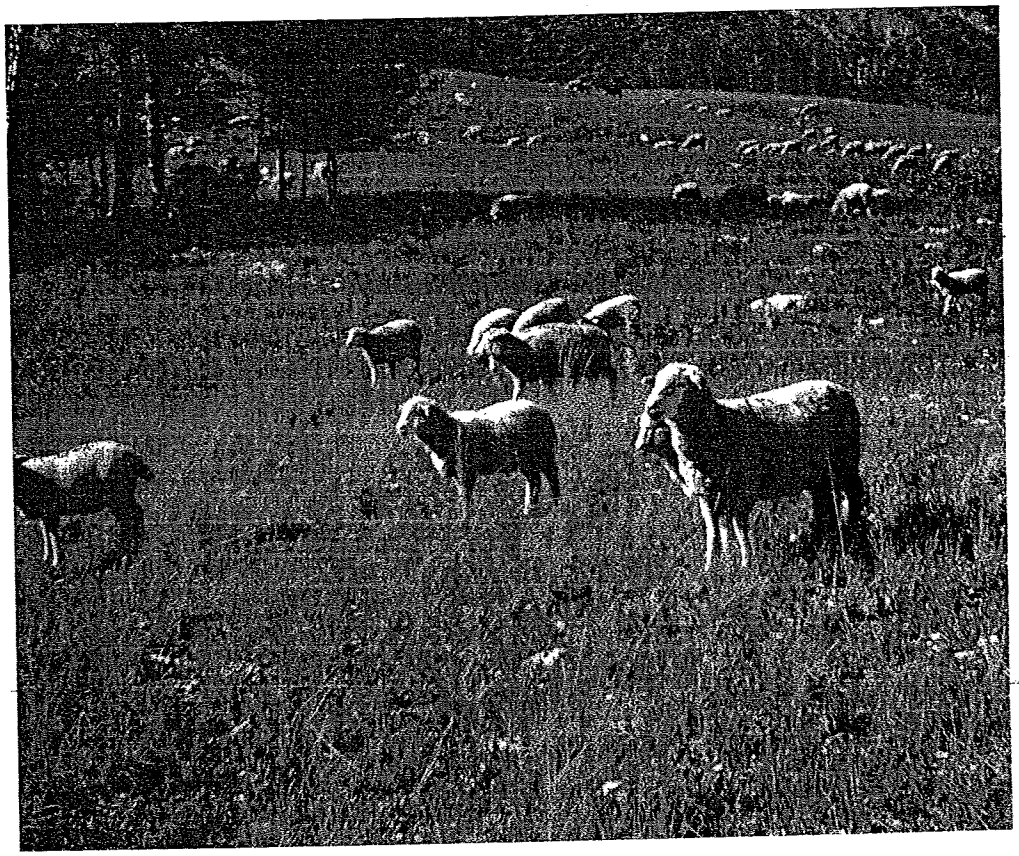

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NUTRITIVE VALUE OF SEASONAL RANGES

C. WAYNE COOK and LORIN E. HARRIS

INTRODUCTION

Considerable information has been presented on the nutritive value of domestic crops but little is known about the nutritive content of range forage. Such information is fundamental to the management of ranges for effective livestock production.

The shortage of suitable spring range in the Intermountain region has caused increased interest in seeding depleted foothill areas to supply more spring forage. Many native foothill ranges with established stands of perennial grasses sufficient to show rapid response to conservative use may be more economically developed through better management practices. In any event, knowledge of forage production, palatability, and nutritive value of both native foothill species and introduced species is needed.

It is generally believed that mountain ranges furnish adequate nutrients for the normal requirements of livestock throughout the summer except perhaps late in the season.

Desert ranges normally used for winter grazing are composed primarily of grass and browse species in varying quantities. Since these species are generally dormant during the winter, the nutritive value may be deficient in some essential nutrients.

NUTRITIONAL REQUIREMENTS OF RANGE LIVESTOCK

Adequate nutrition of range livestock includes protein for repairing worn out tissue and growth, fats and carbohydrates for production of heat and energy, minerals for bone building and general body functions, and vitamins for many important physiological processes.

Deficiencies most common on ranges of the West are protein, energy, phosphorus, and carotene (vitamin A). Such deficiencies are more apt to occur when forage is mature, during periods of drought, or when overgrazing occurs. These deficiencies may appear singly or in any combination.

To date there is no published data confirming that any mineral other than phosphorus is deficient in the diets of grazing animals in the Intermountain area. Likewise, vitamin A is the only vitamin that has been found deficient in the diets of range animals in the western range area.

Vitamin A is stored in the body, principally in the liver, and requires from 90 to 180 days for its depletion. Thus, animals coming from summer ranges where carotene content of the forage is high could subsist on substandard levels of carotene intake for 3 to 6 months without harm. If the diets consisted of dry grass for periods of 3 months or more, vitamin A supplements might be beneficial. However, if the diet consists of even relatively small quantities of browse or shrubs — 15 percent or more — there would be no reason to suspect a vitamin A deficiency since most browse species even during dormant periods in the winter, furnish as much carotene (vitamin A) as good suncured alfalfa hay.

Nutrient requirements for livestock vary according to the physiological function of the animal which includes maintenance and various phases of production such as gestation, growth, fattening and lactation. Therefore, the level of nutrients in the diet or the type of supplement needed will depend somewhat on the physiological functions of the animal.

Efficiency of livestock production in the West is closely correlated with ability of range forage to meet the grazing animal's nutritional requirements. Supplements are costly but sub-levels of required nutrients may limit production and result in substantially lower net income. In some cases even a costly supplement may be economically justified because of the increased production received from it.

It is not possible to make practical recommendations for supplementing the basal diet until specific nutrient requirements for range animals are known. This is true even when the availability of the various nutrients in the diet is known. Therefore, it is important to establish a *recommended* level for the more critical nutrients for optimum livestock production consistent with expected net returns to operations.

Farm animals frequently are fed given levels of nutrients in a balanced ration. Feed intake by range animals cannot be regulated with such precision since these animals consume forage according to their individual grazing efforts. The quantity of feed consumed by the grazing animal is influenced by physiological state of the animal, the plant species present, stage of growth, abundance of forage, and general climatic conditions. Therefore, the intake and composition of the diet varies from day to day and from one range to another.

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Past research in Utah has established recommended nutrient requirements for range animals during the winter grazing season (gestation period) and during the spring and summer grazing season (lactation period). These requirements are based on optimum production under average range conditions consistent with cost-return relations. Observed nutrient intakes are presented on a dry-matter basis for livestock during gestation, and early and late lactation (table 1). These data are based upon good ranges, moderately grazed. The forage plants are dormant during the animals' gestation period and are generally growing when the animals are lactating.

Some species of browse[1] and forbs[2] are high in ether-extract material (volatile oils, resins, and waxes) that is voided through the urine. Therefore, metabolizable energy measures the energy values of these plants much better than digestible energy or total digestible nutrients (Cook *et al.*, 1952). This is particularly true where sagebrush and rabbitbrush contribute substantially to the diet.

In range livestock management it is not economical to supplement the animals for maximum production since the increased costs are not commensurate with output in saleable animal produce. When feeding an average herd for maximum production, the majority of the herd receives a nutrient level higher than necessary for optimum production from the average herd potential. It pays to supplement only when the average animal will yield increased production to offset the increased feed cost.

METHODS AND PROCEDURES

Digestibility studies were conducted during the winter, spring and summer months on desert, foothill, and mountain ranges respectively, from 1951 to 1963. Temporary grazing paddocks were established on typical seasonal ranges throughout western and northern Utah to determine the nutritional value of range forage by field grazing trials. Paddocks varied from 5 to 11 acres in area depending upon the quantity of forage. During the first few years, forage samples representing ingested forage were hand plucked and during later trials forage samples were obtained by esophageal-fistulated animals (Cook, 1964).

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[1] Browse is a broad-leafed woody plant, a shrub, a bush, or a tree of small stature.
[2] A forb is a broad-leafed herbaceous plant commonly referred to as a weed by the layman.

Table 1. Recommended nutrient requirements for cattle and sheep under range conditions during gestation and lactation on a dry-matter basis[1]

Phase of production	Percentage of ration or amount/pound of feed					
	DP[2] (%)	TDN[3] (%)	DE[3] (kcal/lb)	ME[4] (kcal/lb)	P (%)	Carotene (mg/lb)
Gestation	4.4	46	830	665	0.17	0.6
Lactation						
First 8 weeks	5.4	57	1120	900	0.22	1.6
Last 12 weeks	4.5	49	880	700	0.20	1.6

1 Nutrient requirements are slightly higher for sheep because smaller animals have a somewhat higher metabolic requirement per unit of body weight

2 DP represents digestible protein

3 Calculated by deducting allowance for high ether extract in browse in the diet. TDN represents total digestible nutrients and DE represents digestible energy

4 ME represents metabolizable energy

Each trial period was preceded by a 6 to 7 day preliminary grazing period followed by a 6 to 7 day collection period. In most trials total fecal and urine collections were made from collection bags attached to harnesses on the grazing animals.

In some trials only grab samples of feces were obtained. These were collected by following animals and taking partial samples of each defacation from a rather large number of animals. In all cases, two or more individuals collected the grab samples.

Total daily forage intake and digestibility coefficients were determined by the lignin-ratio technique as described by Cook *et al.* (1951). Herbage production and diets were calculated by the method used by Edlefsen *et al.* (1960).

SEASONAL RANGES AND NUTRITIONAL PROBLEMS

Livestock operators of the Intermountain region make use of seasonal range lands by moving livestock from one geographical range to another. The desert ranges are used during the winter (November 1 to April 5) and the foothill or intermediate elevation ranges are used during the spring (April 5 to July 1) and some are used in the fall (October 1 to November 1). The mountain ranges are used during the summer from July 1 until about September 15. Livestock are frequently trucked or driven hundreds of miles to and from these seasonal ranges.

Of great importance is the comparative nutrient value of different forage plants during the various seasons and the ability of these forage species to meet the requirements for optimum livestock production.

It is common belief that animals do not need a supplement during the spring and summer grazing season because green plant growth from a wide variety of species adequately meets the demands of foraging animals in all phases of production. In like manner, it is generally believed that during the fall and winter, supplements are necessary to meet the requirements because the forage is dry and mature and inclement weather may seriously reduce daily intake. Research data do not confirm these beliefs for many areas and under various conditions.

SPRING RANGE

A scarcity of suitable spring range in the Intermountain area generally is a limiting factor for successful livestock production (figure 1).

Calculated by deducting [illegible] nutrients and DE represents digestible energy

4 ME represents metabolizable energy

During recent years, livestock men have shown increased interest in seeding depleted foothill range to provide more suitable forage for spring grazing.

Figure 1. Sheep grazing native sagebrush-grass foothill range during the spring lambing season.

Considerable uncertainty exists as to the relative grazing value of the species available for planting on arid ranges. Because of differences in palatability, nutritive value, and growth habits, all species are not equally valuable for the various grazing seasons and all kinds of livestock.

Many livestock operators have spent considerable time and effort in either natural or artificial rehabilitation of spring ranges through better management or by seeding introduced species of grasses. Most introduced wheatgrasses are considered better for spring forage than the native grasses because they grow earlier or because they are more nutritious over a longer period. As a result, many livestock producers have developed better spring grazing for their animals by seeding introduced grasses (figure 2).

Seeded species

It is important to know the difference in nutrient content among these introduced species, especially those that are being planted for spring forage. Crested wheatgrass and pubescent wheatgrass start growth relatively early but mature rather rapidly. Therefore they are best suited to early spring grazing.[3] Both of these grasses fail to meet the nutrient requirements (table 1) for lactating animals after about the first week in June (Cook *et al.*, 1956). Tall wheatgrass and intermediate wheatgrass start growth later in the spring and mature at a slower rate than either crested or pubescent wheatgrass. Russian wildrye is likewise late

[3] See table 27 for scientific names of species studied.

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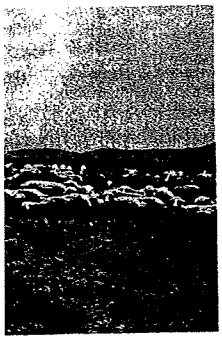

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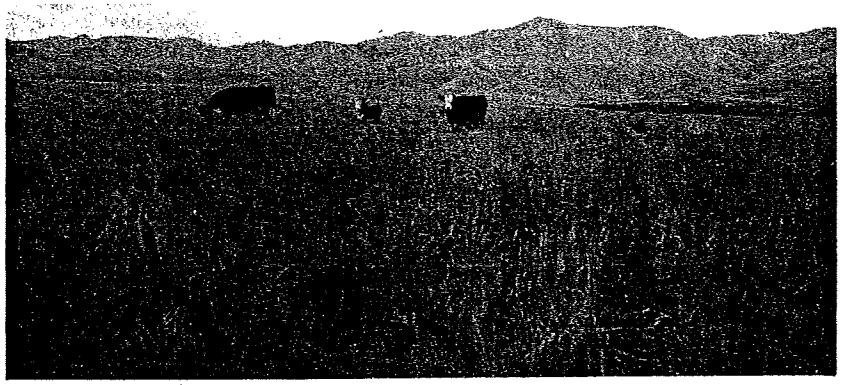

Figure 2. Cattle (above) and sheep (below) grazing seeded intermediate wheatgrass during the late spring June 8 to July 1.

maturing and retains its nutrient content well upon maturing. Therefore, tall and intermediate wheatgrass and Russian wildrye are better suited for later spring grazing. All three of these species meet the nutritional requirements for lactating animals except for phosphorus until about the first of July or later (table 2).

Even though the nutritive value of a species is high, it must be eaten readily if livestock are to benefit from its presence on the range. As an example, tall wheatgrass matures slowly and retains a comparatively high nutritive content until midsummer. However, sheep do not readily consume it after the first of June but cattle eat it, when in pure stands, with little discrimination for leaves over stems until the middle of the summer. Both intermediate wheatgrass and Russian wildrye are readily eaten by all range livestock throughout spring and early summer.

Averages of nutrient content for native and introduced grasses during early and late spring (May 1 to May 15 and June 15 to July 1) are shown in table 2. Samples representing early spring forage were collected at about the same stage of growth but, depending upon species, late spring samples varied in maturity from early anthesis to early seed formation. Digestible protein decreased from 11.8 to 3.1 percent for introduced species and from 7.4 to 4.6 percent for native foothill species. Phosphorus decreased from .19 to .12 percent for introduced species and from .23 to .18 percent for native species from early to late spring. The average content of digestible protein for both native and introduced

Table 2. Nutrient value for different stages of growth of introduced wheatgrasses compared to native foothill grasses and the recommended standard for females on the range during the first 8 weeks of lactation [1]

Species and season	Dig. protein (%)	Dig. energy (kcal/lb)	TDN (%)	P (%)
Crested wheatgrass				
early	10.6	1,578	69.2	.16
late	3.9	991	50.4	.12
Pubescent wheatgrass				
early	11.8	1,401	68.6	.18
late	3.1	1,078	55.2	.15
Tall wheatgrass				
early	11.7	1,325	62.8	.18
late	7.0	1,109	56.2	.16
Intermediate wheatgrass				
early	10.0	1,208	59.4	.19
late	5.4	1,169	59.6	.17
Russian wildrye				
early	8.1	1,172	59.6	.16
late	7.4	1,142	58.6	.15
Native foothill grasses				
early	7.4	1,396	65.9	.23
late	4.6	1,142	56.7	.18
Recommended	5.4	1,120	57.0	.22

[1] Early and late was May 1 to May 15 and June 10 to June 20 for all species except Russian wildrye which was June 15 to 20 and July 8 to 15

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TDN (%)	P (%)
69.2	.16
50.4	.12
68.6	.18
55.2	.15
62.8	.18
56.2	.16
59.4	.19
59.6	.17
59.6	.16
58.6	.15
65.9	.23
56.7	.18
57.0	.22

June 20 for all species
July 8 to 15

species meets the suggested range requirements for lactating animals during early spring but only a few of the introduced grasses meet the requirements late in the season. The average content of phosphorus for both groups is adequate early in the growing season but is deficient in most cases in late spring. Total digestible nutrients and digestible energy adequately meet the requirements throughout the spring grazing season. Carotene (vitamin A) is present in ample amounts the entire spring season since the forage never completely loses its green color.

When a particular spring forage does not meet the nutrient requirements, another type of range forage should be provided. Thus when crested wheatgrass or native foothill ranges become mature and deficient in nutrients, another forage such as intermediate wheatgrass or Russian wildrye should be developed for subsequent use. In the same manner when foothill ranges become dry and dormant, animals can be moved to higher elevation where feed is still green and growing. Providing range supporting forage types that meet the nutritional requirements is usually a more economical approach than supplemental feeding.

With increased knowledge of the nutritive value and palatability of spring forage, operators can provide the type of herbage that will furnish the nutritional requirements without feeding supplements on foothill ranges during spring grazing.

Crested wheatgrass is admirably suited for early spring grazing because it starts growth earlier than most other forage species. If not grazed too heavily, it can be grazed on lower foothill areas as early as April 15 during most years. For sheep, crested wheatgrass furnishes adequate nutrients for lactation until about June 8 and about 2 weeks longer for cattle. If crested wheatgrass is to be grazed in the spring from April 5 until the first week in June, there should be at least two pastures so that early and late spring grazing can be alternated.

As stated previously, intermediate wheatgrass and Russian wildrye are more suitable for late spring and early summer grazing than crested wheatgrass. Sheep, however, do not do well on foothill ranges after about the third week in June when forage begins to turn brown and daytime temperature increase. Cattle do well on intermediate wheatgrass or Russian wildrye until as late as August 1 unless the year is unusually dry. Intermediate wheatgrass will not maintain itself under grazing on lower foothill ranges where the precipitation is below about 13 inches annually, but Russian wildrye will grow in lower rainfall areas (Cook, 1966).

Seeded compared to native species

Digestion trials were conducted on four introduced wheatgrasses at four stages of growth, on two native wheatgrasses and two forbs at three stages of growth, and on Russian wildrye at eight stages of growth. All species were studied from beginning growth until after the seed was formed (table 3).

During early growth stages the animals consumed the entire plant growth of all species. During later stages they preferred leaves over stems. Such selection was not noted in tall wheatgrass, intermediate wheatgrass, and Russian wildrye until the plants were in the anthesis or dough stage. This selection of leafy over stemy material was displayed earlier in the case of pubescent and crested wheatgrass.

Western wheatgrass started growth a week later than beardless wheatgrass and developed much more slowly. Crested and pubescent wheatgrass produced earlier growth than either western or beardless wheatgrass and matured to the seed shattering stage in less time. Tall and intermediate wheatgrass and Russian wildrye started the same time as western and beardless wheatgrass. However, tall wheatgrass reached advanced growth stages much more slowly than the others. Intermediate wheatgrass matured slightly more rapidly than beardless wheatgrass which in turn matured more rapidly than western wheatgrass. Russian wildrye appeared to mature about the same time as intermediate wheatgrass but retained a higher nutrient level of the more desirable constituents.

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

More forage on a dry matter basis was consumed per animal early in the growing season. This is of extreme importance since decreased consumption combined with reduced nutritive value intensified any inadequacies of the diet late in the spring.

Decreased forage consumption as the season advanced was most rapid for crested wheatgrass. The consumption of intermediate wheatgrass remained nearly constant and that of the other species declined only slightly.

Chemical composition at various stages of growth is shown in table 3. These values represent only forage material actually ingested by the grazing animals and not the entire current growth of the plant. As a

Table 3. Chemical composition of material representing feed intake for each species grazed by sheep during spring and summer on a dry weight basis

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Table 3. Chemical composition of material representing feed intake for each species grazed by sheep during spring and summer on a dry weight basis

Species and stage of growth	Date	Ether extract (%)	Total protein (%)	Ash (%)	Lignin (%)	Cellu- lose (%)	Other carbo- hydrates (%)	Phos- phorus (%)	Gross energy (kcal/lb)
Crested wheatgrass									
fifth leaf	5/9/53	3.3	20.3	8.7	3.3	19.0	45.4	.27	2050
early head	6/8/53	2.3	12.6	7.3	7.4	30.6	39.0	.23	1987
anthesis	6/16/54	2.45	10.7	5.7	7.3	30.9	42.8	.18	1946
hard seed	7/10/54	3.56	9.3	7.2	7.3	28.4	44.1	.14	2000
Average		2.9	18.4	7.2	6.3	27.2	42.8	.20	1996
Pubescent wheatgrass									
fifth leaf	5/15/53	3.4	16.5	11.5	3.7	20.6	44.2	.24	1937
early head	6/15/53	2.9	11.1	10.2	5.2	33.3	36.1	.18	1909
preanthesis	6/22/54	2.87	9.7	10.1	5.9	27.6	42.7	.16	1905
soft dough	7/16/54	3.44	7.3	10.9	7.8	31.2	39.1	.11	1878
Average		3.15	11.8	10.7	5.6	28.2	40.5	.17	1907
Tall wheatgrass									
fourth leaf	5/22/53	3.3	16.8	11.0	4.6	26.5	37.8	.21	2027
sixth leaf	6/22/53	3.6	13.8	10.5	6.3	31.9	34.9	.16	1950

Table 3. (continued)

Species and stage of growth	Date	Ether extract (%)	Total protein (%)	Ash (%)	Lignin (%)	Cellulose (%)	Other carbohydrates (%)	Phosphorus (%)	Gross energy (kcal/lb)
early head	6/28/54	4.72	10.9	8.8	6.2	24.8	44.4	.16	1932
anthesis	7/22/54	6.51	8.5	11.6	6.6	30.7	36.4	.12	1941
Average		4.53	12.5	10.5	5.9	28.4	38.4	.16	1963
Intermediate wheatgrass									
sixth leaf	5/28/53	3.5	13.9	9.9	5.3	25.0	42.5	.23	1977
anthesis (early)	6/28/53	4.4	10.4	9.3	5.6	32.3	37.8	.19	1982
anthesis (late)	7/4/54	5.45	11.0	9.5	6.0	24.4	44.0	.16	1968
hard dough	7/28/54	5.58	10.1	10.8	5.4	30.4	37.5	.16	1973
Average		4.74	11.3	9.9	5.6	28.0	40.4	.18	1975
Russian wildrye									
fourth leaf	6/15/64	2.1	11.6	9.0	4.0	32.9	38.4	.16	1921
early head	7/8/64	2.4	10.2	13.2	4.8	30.3	39.0	.15	1903
hard seed	8/3/64	3.7	7.6	15.1	5.2	30.9	37.4	.12	1885
Average		2.7	9.8	12.6	4.0	31.0	38.3	.14	1902
Beardless wheatgrass									
fourth leaf	5/15/54	2.4	14.1	8.5	6.2	31.6	37.1	.26	1996

Table 3. (continued)

Species and stage of growth	Date	Ether extract (%)	Total protein (%)	Ash (%)	Lignin (%)	Cellulose (%)	Other carbohydrates (%)	Phosphorus (%)	Gross energy (kcal/lb)
boot	6/13/54	2.6	10.4	7.1	7.3	35.1	37.5	.16	1968
seed	8/29/54	3.8	5.9	10.4	6.6	32.8	40.5	.15	1891
Average		2.9	10.1	8.7	6.7	33.2	38.4	.19	1952

hard seed	8/3/64	3.7	7.6	15.1	5.2	30.9	37.4	.12	1885
Average		2.7	9.8	12.6	4.0	31.0	38.3	.14	1902
Beardless wheatgrass									
fourth leaf	5/15/54	2.4	14.1	8.5	6.2	31.6	37.1	.26	1996

Table 3. (continued)

Species and stage of growth	Date	Ether extract (%)	Total protein (%)	Ash (%)	Lignin (%)	Cellulose (%)	Other carbohydrates (%)	Phosphorus (%)	Gross energy (kcal/lb)
boot	6/13/54	2.6	10.4	7.1	7.3	35.1	37.5	.16	1968
seed	8/29/54	3.8	5.9	10.4	6.6	32.8	40.5	.15	1891
Average		2.9	10.1	8.7	6.7	33.2	38.4	.19	1952
Western wheatgrass									
fourth leaf	6/1/54	3.6	9.4	7.2	5.2	36.2	38.5	.20	1982
boot	6/23/54	2.3	15.0	8.0	5.9	31.0	35.2	.26	1968
seed	8/4/54	5.9	7.0	10.1	6.1	32.8	38.1	.09	1968
Average		3.9	10.4	8.4	5.7	33.3	37.3	.18	1973
Russian thistle									
early flower	7/27/54	1.1	18.0	25.5	3.8	16.4	35.1	.20	1465
early seed	8/18/54	1.1	15.5	22.5	4.1	16.1	41.1	.15	1579
late seed	8/19/53	1.7	10.2	20.1	5.6	20.6	41.8	.18	1578
Average		1.3	14.6	22.7	4.5	17.7	39.3	.18	1541
Smother weed									
early flower	8/3/54	1.5	18.2	20.6	4.0	20.6	35.0	.28	1669
late flower	8/22/54	2.1	15.8	19.2	5.4	20.0	37.6	.34	1660
early seed	8/26/53	2.6	16.1	15.8	5.2	20.0	40.4	.33	1796
Average		2.0	16.7	18.5	4.8	20.2	37.7	.32	1708

result of the animals' preference for more nutritious parts, changes in chemical composition with maturity are not as pronounced as might be expected if the analyses were based upon the entire plant production.

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

Most species showed a steady decrease in phosphorus and gross energy as the season advanced; whereas, ether extract, lignin, and cellulose increased somewhat. During advanced stages of growth all grass species, both introduced and native, failed to meet the recommended level of phosphorus for lactating animals.

The digestion coefficients for total protein, cellulose, gross energy, and other carbohydrates of nine grazed species except in intermediate wheatgrass and Russian wildrye declined with increased maturity, particularly during early growth (table 4).

Nutritional requirements

According to the recommended nutrient requirements for range animals during early lactation (table 1) digestible protein should be about 5.4 percent and digestible energy should be about 1,120 kilocalories per pound of air-dry forage eaten. Both protein and energy requirements for lactating animals were met for cattle and sheep during the entire spring grazing season by intermediate wheatgrass, tall wheatgrass, and Russian wildrye. Crested and pubescent wheatgrass and the native foothill species were deficient in energy and digestible protein during the latter part of the spring, however.

Annual forbs such as Russian-thistle and smother weed were decidedly low in energy values at all periods and were always less valuable than grasses in furnishing energy.

The phosphorus content should be at least 0.21 percent to meet the nutrient requirements for lactating animals. Thus, the introduced species were either deficient or borderline (table 4) during the latter part of the spring grazing season (after about June 1). Both cattle and sheep were supplemented with phosphorus while grazing seeded and native foothill pastures. One-half the pastures were supplemented with phosphorus by adding monosodium phosphate to the drinking water. Each year for 4 years (1960 through 1963), the supplement was rotated among pastures. During the 4 years, no detectable difference in weight gain was found between the phosphorus supplemented and unsupplemented animals.

Table 4. Apparent digestibility of nutrients shown in table 3 and metabolizable energy for each of the species grazed

Species	Digestion coefficients (percent)		Total digestible	Metabolizable
	Digestible	Other		

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quirements for range ani- protein should be about out 1,120 kilocalories per and energy requirements sheep during the entire ass, tall wheatgrass, and grass and the native foot- stible protein during the

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0.21 percent to meet the us, the introduced species ring the latter part of the oth cattle and sheep were eeded and native foothill nted with phosphorus by ; water. Each year for 4 s rotated among pastures. n weight gain was found unsupplemented animals.

Table 4. Apparent digestibility of nutrients shown in table 3 and metabolizable energy for each of the species grazed

Species and stage of growth	Digestion coefficients (percent) Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	Digestible protein (%)	Total digestible nutrients (%)	Metabolizable energy (kcal/lb)
Crested wheatgrass								
fifth leaf	55.4	79.7	80.3	89.4	77.0	16.2	76.1	1325
early head	0.0	52.5	63.1	62.8	49.9	6.6	50.7	683
anthesis	-20.5	54.5	57.5	66.3	50.7	5.9	52.3	751
hard seed	36.4	59.1	57.5	72.5	55.5	5.5	56.8	914
Average	17.8	61.4	64.6	72.7	58.3	8.5	59.0	918
Pubescent wheatgrass								
fifth leaf	46.8	72.2	78.1	85.0	73.1	11.9	69.4	1159
early head	27.5	61.2	74.5	72.3	63.0	6.8	59.5	937
preanthesis	2.2	62.4	70.7	74.2	60.4	5.8	58.1	943
soft dough	14.8	51.8	66.4	63.5	51.7	3.8	50.7	777
Average	22.6	61.9	72.4	73.7	62.1	7.1	59.4	954
Tall wheatgrass								
fourth leaf	43.8	69.5	75.7	73.7	65.4	11.7	62.9	1009
sixth leaf	17.1	64.7	68.1	70.1	56.9	8.9	56.5	850

Table 4. (continued)

Species and stage of growth	Digestion coefficients (percent)					Digestible protein (%)	Total digestible nutrients (%)	Metabolizable energy (kcal/lb)
	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy			
early head	38.9	65.6	66.4	72.1	60.0	7.2	59.8	947
anthesis	40.9	55.2	76.6	64.9	58.0	4.7	57.9	946
Average	35.2	63.7	71.7	70.2	60.1	8.1	59.3	938
Intermediate wheatgrass								
sixth leaf	26.8	56.0	75.8	77.3	63.7	7.79	61.7	934
anthesis (early)	21.0	57.7	75.2	75.6	60.4	6.0	60.9	930
anthesis (late)	38.4	66.2	71.4	75.2	62.4	7.3	62.6	1022
hard dough	33.0	63.6	75.5	68.6	60.6	6.4	59.4	1002
Average	29.8	60.9	74.5	74.2	61.7	6.9	61.2	972
Russian wildrye								
fourth leaf	-9.8	70.1	69.5	74.5	61.0	8.1	59.6	---
early head	-9.1	72.3	61.8	77.9	60.4	7.4	58.6	---
hard seed	44.9	68.3	70.4	74.5	64.5	5.2	58.5	---
Average	8.7	70.2	67.2	75.6	62.0	6.9	58.9	---
Beardless wheatgrass								
fourth leaf	47.4	69.8	76.1	76.3	68.3	9.9	64.8	1175

Table 4. (continued)

Species and stage of growth	Digestion coefficients (percent)					Digestible protein (%)	Total digestible nutrients (%)	Metabolizable energy (kcal/lb)
	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy			
							55.9	878

hard seed	44.9	68.3	70.4	74.5	64.5	5.2	58.5	---
Average	8.7	70.2	67.2	75.6	62.0	6.9	58.9	---
Beardless wheatgrass								
fourth leaf	47.4	69.8	76.1	76.3	68.3	9.9	64.8	1175

Table 4. (continued)

Species and stage of growth	Digestion coefficients (percent)					Digestible protein (%)	Total digestible nutrients (%)	Metabolizable energy (kcal/lb)
	Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy			
boot	13.2	50.1	68.7	68.5	57.0	5.2	55.8	878
seed	28.1	40.6	69.4	73.9	58.9	2.4	57.5	917
Average	29.6	53.5	71.4	72.9	61.4	5.8	59.4	979
Western wheatgrass								
fourth leaf	38.9	53.4	78.8	78.8	66.2	5.0	67.0	1068
boot	12.9	73.8	64.0	72.8	61.2	11.1	57.6	920
seed	45.7	55.6	76.4	73.6	64.8	3.9	63.1	1078
Average	32.5	60.9	73.1	75.1	64.1	6.6	62.6	1031
Russian thistle								
early flower	43.7	86.3	71.1	79.3	74.0	15.5	56.2	857
early seed	40.0	83.4	59.2	73.6	69.8	12.9	53.7	911
late seed	19.7	67.1	57.6	69.4	60.1	6.8	48.5	765
Average	34.5	78.9	62.6	74.1	67.9	11.7	52.8	844
Smother weed								
early flower	-68.6	80.6	59.0	75.2	61.1	14.7	53.2	817
late flower	-44.1	75.7	52.3	75.4	55.8	11.9	50.7	746
early seed	10.4	72.8	53.4	71.0	60.3	12.8	52.7	901
Average	-34.1	76.4	54.9	73.9	59.1	13.1	52.2	821

This was true for both sheep and cattle. Animals apparently used the phosphorus they retained in their bodies during the early spring to carry them over the deficient period in late spring. Longer periods of grazing into the summer may have shown a beneficial effect of phosphorus supplementation.

Livestock responses

Nutrient changes in the diets as the season advanced were probably the primary cause for the reduction in livestock gains from early to late spring season. Likewise, higher nutrient content probably caused intermediate and tall wheatgrass and Russian wildrye to produce better livestock gains in late season than crested and pubescent wheatgrass or the sagebrush-grass pastures. In a study by Cook and Stoddart (1961), lactating cows lost weight after June 29 on crested wheatgrass and gained only slightly on pubescent wheatgrass. However, lactating cows gained 1.8 and 0.9 pounds per day on tall and intermediate wheatgrass, respectively, from June 29 to July 19.

In the early grazing period, cows gained most (1.9 lb. per day) on pubescent wheatgrass, and least on native foothill grasses (1.0 lb. per day). During the late period, tall and intermediate wheatgrass produced the best gains for cattle but tall wheatgrass was not readily eaten by sheep (table 5). In general, intermediate wheatgrass and Russian wildrye were the best grasses during late grazing periods. For late spring grazing, pubescent and crested wheatgrass were both deficient in nutrients and produced poorer livestock gains compared to the other seeded species.

Calves showed much less variation in gain both from different grazing seasons and from different grass species than did cows (table 5). Apparently cows furnished a rather uniform supply of milk to the calves at the expense of body weight gain even though feed conditions become poorer. The uniformly high quality of intermediate wheatgrass and Russian wildrye grass as cattle forage was also reflected in better than average calf gains.

It should be pointed out that reduced gain as the season progresses is not only a result of lower nutrient content of the forage, but may also be a result of decreased daily forage intake. The livestock eat less because of decreased palatability caused by plant maturity (Cook *et al.*, 1956). Studies suggest that cattle make better use of seeded wheatgrass species than sheep. Lactating cows gained throughout the spring season but ewes lost weight on some seeded species late in the season. Cattle

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Table 5.

Species
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Pubescent wheatgr
Tall wheatgr
Intermedi wheatgr
Russian wildrye
Native foothill

sometimes continue to gain when grazing seeded species into the summer. Some of the difference in response between sheep and cattle on seeded foothill ranges may have been a result of high daytime temperatures during late spring.

Lamb and calf gains were less as the season advanced and as the plants became more mature (table 5). Both ewes and lambs gained more throughout the grazing season on intermediate wheatgrass than on tall or crested wheatgrass. Lactating ewes lost weight during the late spring on both crested and tall wheatgrass pastures and on native foothill range; whereas, they gained substantially on intermediate wheatgrass during all periods (table 5). Ewes, like cows, sacrifice body weight in an attempt to maintain milk flow for lamb welfare. Therefore, low nutrient intake may be reflected in ewe weights long before it is evident in lamb weights (table 5).

Cheatgrass range

The abundance of cheatgrass or downy brome on the foothill ranges throughout the Intermountain region makes it of concern to the livestock industry of this area. It is the most abundant forage plant on many spring ranges and perhaps contributes more feed for livestock than any other range species during this period. However, the forage production from cheatgrass fluctuates greatly from year to year, depending upon moisture and growing conditions. Therefore, many believe that cheatgrass should be replaced by introduced perennial grasses such as crested wheatgrass.

Table 5. Expected gain per day for sheep and cattle grazing introduced and native grasses on foothill areas during early and late spring

		Pounds per day gain			
		Sheep		Cattle	
Species	Period	Ewes	Lambs	Cows	Calves
Crested wheatgrass	Early	0.37	0.56	1.5	2.3
	Late	-0.25	0.39	0.3	1.6
Pubescent wheatgrass	Early	0.36	0.54	1.9	2.1
	Late	0.06	0.40	0.2	1.3
Tall wheatgrass	Early	0.26	0.53	1.2	2.3
	Late	-0.43	0.44	0.8	1.5
Intermediate wheatgrass	Early	0.28	0.66	1.6	2.2
	Late	0.22	0.52	0.5	1.7
Russian wildrye grass	Early	----	----	1.7	2.3
	Late	----	----	1.1	2.0
Native foothill grasses	Early	0.10	0.58	1.0	1.5
	Late	-0.12	0.53	0.1	1.1

Cheatgrass remains green only a relatively short time during the spring and soon after maturity becomes unpalatable. Sheep normally graze very little on cheatgrass after it becomes dry, but cattle graze mature cheatgrass late into the spring and even during the summer if there is little else to eat. As previously mentioned, the palatability of crested wheatgrass for both sheep and cattle decreases markedly as the plant matures. However, the crested wheatgrass remains green longer than cheatgrass and as a result is more palatable and more nutritious over a much longer period during the spring (Cook and Harris, 1952).

Both nutritive content and digestibility of the material consumed by sheep show marked downward trend for cheatgrass with advanced stages of growth (table 6). Selection of the more tender parts of the crested wheatgrass plant prevented a definite trend with increased maturity. Digestion coefficients for protein, cellulose, other carbohydrates, and gross energy of cheatgrass decreased markedly in advanced growth stages (table 7). In addition, the pounds of dry matter consumed daily per sheep decreased sharply with increased maturity of cheatgrass.

Cheatgrass was deficient in digestible protein and energy during the last week in May and all of June even on moderately high foothill ranges. Crested wheatgrass furnished considerably more digestible protein and digestible energy than cheatgrass throughout the spring season.

SUMMER RANGE

After animals leave the spring ranges about July 1 and move to high-elevation summer ranges, they are on vegetation that is less mature (figure 3). Nutrient levels, therefore, are higher and deficiencies are rare during early summer. However, if the grazing animals are confined to a few species of any one forage class or to only one vegetation type, deficiencies may develop as the plants mature. On most mountain ranges of the West this is not the case because the diet may be composed of as many as 100 separate species which represent several vegetation types and all three forage classes (grass, forbs, and browse).

Forage classes

As shown in table 8, the individual forage classes are inherently different in nutrient content. Likewise, each forage class shows characteristic seasonal changes among the separate nutrients with advancing stages of maturity. Grasses are lowest in protein and phosphorus but are the highest in energy-yielding cellulose. Browse plants are highest in protein and lowest in cellulose. Forbs are intermediate in most respects.

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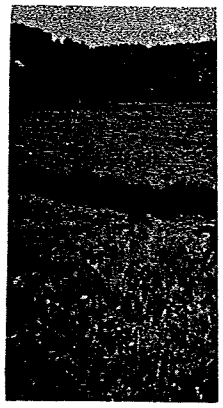

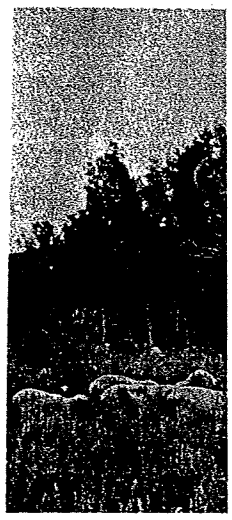

Figure 3. Cattle
summe
grass

Grasses lose about one-half their protein content and increase decidedly in lignin and cellulose with season advance. However, protein content of forbs and browse decreases only slightly and lignin and cellulose increase moderately as the season advances. For these reasons grazing animals more nearly satisfy their nutritional requirements when they have access to an assortment of plant species. The mountain range used in this research produced an average of 1,140 pounds of air-dry forage per acre, which included 304 pounds of grass, 270 pounds of forbs, and 566 pounds of browse. (table 9).

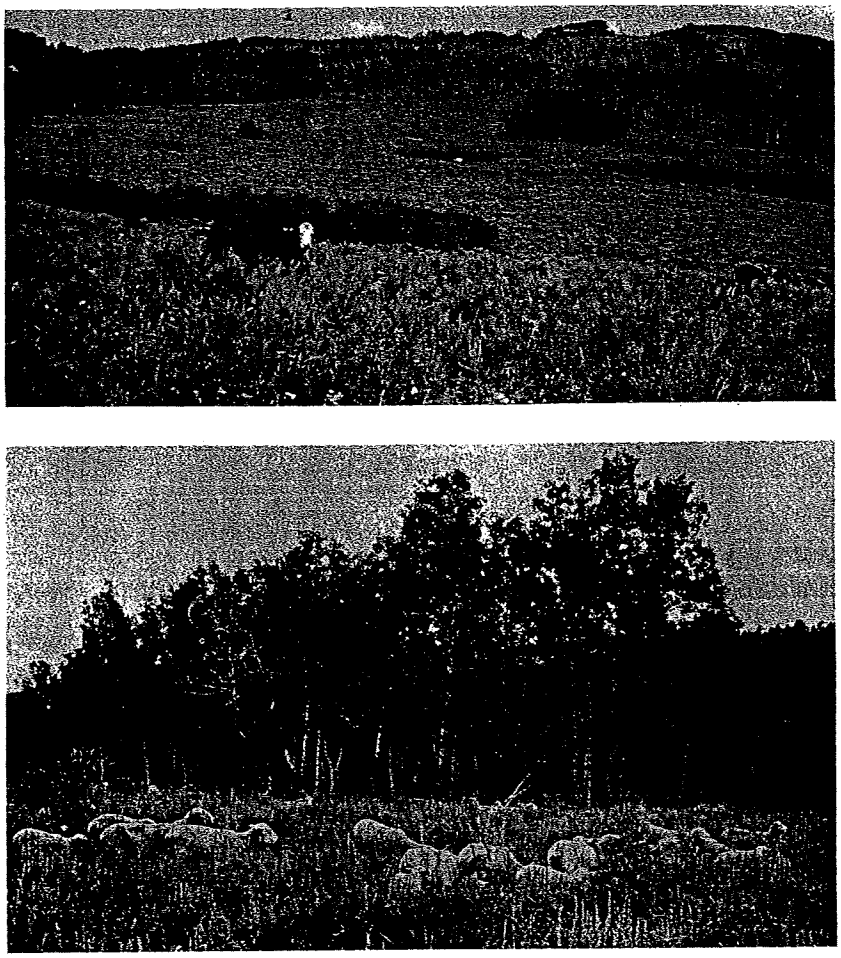

Figure 3. Cattle (above) and sheep (below) grazing mountainous summer range which consists of aspen and sagebrush-grass vegetation types.

Table 6. Chemical composition of the foraging sheep's diet while grazing cheatgrass and crested wheatgrass

Stage of growth	Ether extract (%)	Total protein (%)	Lignin (%)	Cellu-lose (%)	Other carbo-hydrates (%)	Total Ash (%)	Calcium (%)	Phos-phorus (%)	Gross energy (kcal/lb)
Cheatgrass									
boot	2.7	15.4	4.1	27.4	40.2	10.2	.64	.36	1964
head	2.1	11.1	4.4	30.6	41.5	10.3	.60	.32	1973
dough	1.8	8.2	6.3	33.4	39.8	10.5	.53	.27	1914
early seed	1.6	7.4	8.4	28.3	43.6	10.7	.51	.26	1805
late seed	1.3	6.1	10.4	32.4	38.8	11.0	.56	.21	1878
Crested wheatgrass									
boot	2.5	12.0	5.9	34.1	34.8	10.7	.63	.22	1959
head	2.8	11.0	6.0	33.8	38.4	8.0	.49	.21	2005
dough	2.7	10.5	5.9	35.3	36.2	9.4	.49	.21	1896
seed	3.4	10.8	6.1	32.1	37.1	10.5	.53	.21	1968

Table 7. Dry matter consumed daily, apparent digestibility and limit of error for nutrients in cheatgrass and crested wheatgrass in various stages of growth

	Dry matter	Digestion coefficients ( )

dough	2.7	10.5	5.9	35.3	36.2	9.4	.49	.21	1896
seed	3.4	10.8	6.1	32.1	37.1	10.5	.53	.21	1968

Table 7. Dry matter consumed daily, apparent digestibility and limit of error for nutrients in cheatgrass and crested wheatgrass in various stages of growth

Stage of growth	Dry matter consumed (lbs)	Digestion coefficients (percent)						Digestible protein (%)	Digestible energy (kcal/lb)	Total digestible nutrients (%)
		Ether extract	Total protein	Cellulose	Other carbohydrates	Dry matter	Gross energy			
Cheatgrass										
boot	3.3	24.8	67.9	77.9	83.5	67.4	70.8	10.5	1391	66.9
head	2.8	45.0	65.0	76.3	80.7	65.4	71.7	7.2	1415	66.2
dough	2.3	41.0	46.4	63.9	68.4	51.0	56.6	3.8	1083	54.0
early seed	2.1	16.0	38.3	47.8	73.6	46.4	47.9	2.8	865	49.0
late seed	2.0	12.6	16.1	51.3	58.5	38.7	44.4	1.0	834	40.7
Crested wheatgrass										
boot	2.4	20.3	59.8	64.5	67.4	53.0	55.1	7.2	1080	53.8
head	2.4	31.1	56.8	65.7	68.4	53.9	59.3	6.3	1188	56.7
dough	2.6	12.8	60.7	68.2	68.6	57.0	57.8	6.4	1096	56.1
seed	2.6	24.8	62.6	39.0	66.0	53.4	56.1	6.7	1098	52.1

Table 8. Average chemical content of grass, forbs, and browse[1] collected from typical mountain range during early summer (July 1 to July 15) and late summer (August 15 to September 1)

Forage class and season	Ether extract (%)	Total protein (%)	Lignin (%)	Cellulose (%)	Other carbohydrates (%)	Ash (%)	Phosphorus (%)
Grass							
Early summer	2.3	8.3	9.7	38.7	35.6	5.4	0.27
Late summer	2.4	4.2	12.3	44.5	31.4	5.2	0.21
Forbs							
Early summer	4.3	10.6	9.7	26.0	38.7	10.7	0.42
Late summer	3.1	8.8	11.6	29.1	38.6	8.8	0.32
Browse							
Early summer	4.2	12.3	15.6	20.5	41.0	6.4	0.31
Late summer	6.3	10.8	16.1	23.7	37.2	5.9	0.33

[1] Averages include 11 grasses, 25 forbs, and 7 browse species all of which are common on summer ranges of northern Utah

Table 9. Average production, utilization and diet for sheep and cattle on mountain range during early, mid and late grazing periods for the summer grazing season from June 10 to September 15 for 6 years, 1959 to 1964[1]

Animal and forage class	Early			Mid			Late		
	Production[2] (lbs/A)	Utilization (%)	Diet (%)	Production[2] (lbs/A)	Utilization (%)	Diet (%)	Production[2] (lbs/A)	Utilization (%)	Diet (%)
Sheep									

Late summer	6.3	10.8	16.1	23.7	37.2	5.9	0.33

[1] Averages include 11 grasses, 25 forbs, and 7 browse species all of which are common on summer ranges of northern Utah

Table 9. Average production, utilization and diet for sheep and cattle on mountain range during early, mid and late grazing periods for the summer grazing season from June 10 to September 15 for 6 years, 1959 to 1964[1]

Animal and forage class	Early			Mid			Late		
	Production[2] (lbs/A)	Utilization (%)	Diet (%)	Production[2] (lbs/A)	Utilization (%)	Diet (%)	Production[2] (lbs/A)	Utilization (%)	Diet (%)
Sheep									
Grass	208	39.0	28.9	344	26.0	34.3	318	31.9	34.6
Forbs	307	43.5	47.6	297	29.5	33.6	219	27.4	21.1
Browse	646	10.2	23.5	564	14.8	32.1	573	22.0	44.3
Total or average	1161	24.2	100.0	1205	21.6	100.0	1110	25.6	100.0
Cattle									
Grass	266	50.5	47.7	348	35.5	62.9	341	43.5	51.6
Forbs	216	29.7	22.8	307	18.0	28.2	275	24.5	23.5
Browse	788	10.5	29.5	451	3.9	8.9	377	18.9	24.5
Total or average	1270	22.1	100.0	1106	17.8	100.0	993	28.9	100.0

[1] Early season was from June 10 to July 15, mid-season from July 16 to August 9, and late from August 10 to September 15

[2] Does not include unpalatable species. Production of unpalatable material was approximately 31 percent of the total yield of herbage

Utilization and diet

As shown in table 9, both sheep and cattle changed forage preferences as the summer season advanced. For cattle, the grasses were relatively high in the diet during the entire summer. Forbs were highest in the diet of sheep early in the season but decreased as the season advanced. Sheep and cattle ate moderate amounts of browse during the late season. These changes were more pronounced for sheep than cattle. The percentage of forbs in the diet of cattle and the percentage of grass in the diet of sheep increased only slightly as the season advanced.

The changing preference for forage species and forage classes with the advancement of season emphasizes the importance of providing, when possible, a variety of forage for grazing animals.

Preference displayed for certain species and for certain portions of plants was perhaps the most important factor affecting the nutrient content of the diet in any given area. However, stage of growth, weathering, and relative abundance of forage species were of great importance.

It was found in an earlier study (Cook *et al.*, 1956) that during early summer, stems comprised 60.1 percent of the available forage, but only 34.0 percent of the diet, while leaves comprised 39.9 percent of the available forage, but 66.0 percent of the diet. These comparisons were still more pronounced late in the summer when there was a tendency for leaves to be increasingly preferred over stems. The quantity of stems, however, increased more in proportion to leaves as the season advanced.

The seasonal weighted-average use of summer range plants as shown in table 9 ranges from about 18 to 29 percent, yet the range was judged as moderately grazed. This can be explained by the abundance of less palatable species which received only light use.

Nutritive content of the diet

In addition to the variables occasioned by animal behavior, relative preference, and species composition of the range forage, there are other important factors such as stage of plant growth, and variable site conditions which influence the nutritive content of the grazing animal's diet.

Each forage species has its characteristic nutritive composition, yet the variation in chemical values from early to late summer is greater than that between species during any one period.

Browse and forbs furnish ample protein and phosphorus late in the season but are somewhat deficient in energy supplies, whereas most grasses are deficient in both protein and phosphorus late in the season

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The nutrient content among grass species varies widely depending upon the length of time required to mature. Cool weather grasses usually start growth in the fall and mature early in the summer while warm weather grasses grow most of the summer and mature and set seed in late summer or fall. As a result, the warm weather grasses are higher in nutrients during late summer (table 10) but the cool weather grasses are more suited to early summer and spring grazing because they start growth earlier and mature at a more rapid rate.

Fagan and Milton (1931) stated that the chemical composition of grasses varied with season largely because of change in stem-to-leaf ratio. As shown in a study by Cook *et al.* (1956), stems increased in weight in greater proportion than did leaves for all classes of forage. This accounted for part of the seasonal decrease in protein and phosphorus and, likewise, the increase in lignin and cellulose since stems are lower in protein and phosphorus and higher in lignin and cellulose than leaves. However, there was a general trend for both stems and leaves to decrease in both protein and phosphorus, and to increase in lignin as the season advanced. Leaves differed from stems in seasonal changes in cellulose content, because leaves showed little or no change with advancement of season, whereas stems showed a decided increase.

Seasonal changes in the chemical content of summer range plants showed that phosphorus and protein generally decreased for all forage classes whereas, lignin, cellulose and other carbohydrates increased. Browse plants changed least in nutrient content as the season advanced and grass changed the most. These changes, as the growth stages advanced, were affected by both changes in stem-leaf ratio and changes in chemical content of the plant parts themselves. Leaves for all forage classes were higher in ether extract, protein, phosphorus, and calcium and stems were higher in lignin and cellulose.

There was a decline of protein for all classes of forage from the beginning of the grazing season until grazing ceased. Browse had the highest protein content at all seasons and grass had the lowest. The protein content of forbs was intermediate, but much higher than grass and it approached the level of browse (table 8).

The phosphorus content of both grasses and forbs decreased as the season advanced, whereas the phosphorus content of browse had a slight tendency to increase. Grasses were decidedly lower in phosphorus than either forbs or browse during all periods of the summer (table 8).

Table 10. Average nutrient content of cool weather and warm weather grasses on mountain range during early (July 1) and late (September 1) summer

Forage type	Season	Digestible protein (%)	Cellulose (%)	Digestible energy (kcal/lb)	TDN (%)	P (%)
Cool weather	Early	6.9	40.3	1266	64.1	.24
grasses[1]	Late	2.4	44.5	959	53.2	.16
Warm weather	Early	8.8	38.5	1183	61.2	.30
grasses[2]	Late	4.7	40.6	1091	57.4	.23

1 Cool weather grasses consisted of mountain brome, slender wheatgrass, and blue wildrye grass

2 Warm weather grasses consisted of Kentucky bluegrass, green needle-and-thread grass and Idaho fescue

In most cases, there was an increase of both lignin and cellulose in all species as the plants matured (table 8). Browse had the highest content of lignin and the lowest content of cellulose, whereas grass had the highest content of cellulose and a comparatively low lignin content. Forbs were intermediate in cellulose and comparable to grass in lignin (table 8).

From the viewpoint of nutritive value, it appears that forbs and browse were superior to grass in phosphorus and protein but cellulose was decidedly higher in grass. Cellulose represents a considerable portion of the energy fraction available for the nutrition of ruminants.

Chemical analysis of the diets of both sheep and cattle showed that protein decreased and lignin increased from early to late season (table 11). The protein and phosphorus content of the diet was higher for sheep but cellulose was higher in the diet of cattle. This would be expected since sheep ate more browse and cattle ate more grass (table 9).

As shown in table 11, the phosphorus content of the diet on summer ranges was never below the requirement for lactating animals (0.21 percent). Digestibility of chemical constituents in the diet of both sheep and cattle decreased as the season advanced (table 12). Digestible protein was higher in the diets of sheep during the entire summer, but TDN and digestible energy were higher in the diets of cattle. This was perhaps a result of sheep being more selective for leaves over stems and the relatively higher quantity of browse in their diet. Even so, the digestible protein in the diet was deficient for both sheep and cattle during late summer (table 12). Energy requirements for lactation during the early summer were met. During mid-summer the energy furnishing constituents in the diet were borderline and during late summer they were slightly deficient. This deficiency was more pronounced for sheep than for cattle. This might be expected since cattle ate more grass which is higher in energy-supplying cellulose.

As noted in table 13, the gain of both sheep and cattle decreased as the season progressed. These data suggest that there were no weight losses of either ewes or cows during any period. This was not always the case, however. During dry years and during the first 2 weeks in September, it was not unusual for lactating animals to lose weight slightly.

Sagebrush and aspen types

During the summers of 1963 and 1964, the nutrient value of sagebrush and aspen types was studied for both sheep and cattle grazing.

Table 11. Average chemical content of diets of sheep and cattle on mountain range during early, mid and late grazing periods for summer grazing from June 10 to September 15 for 6 years, 1959 to 1964

Animal	Periods[1]	Ether extract (%)	Total protein (%)	Ash (%)	Lignin (%)	Cellu-lose (%)	Other CHO (%)	Phos-phorus (%)	Gross energy (kcal/lb)
Sheep	Early	3.1	13.8	11.3	8.4	23.1	40.3	.38	1943
	Mid	3.8	11.0	10.7	9.3	23.4	41.8	.34	1980
	Late	4.0	11.1	10.9	11.2	24.4	38.4	.35	1839
	Average	3.6	11.9	10.9	9.6	23.6	40.2	.36	1921
Cattle	Early	3.2	10.2	12.2	8.6	28.4	37.4	.30	1975
	Mid	3.5	8.9	10.7	8.5	29.5	38.9	.30	1984
	Late	3.6	8.4	9.5	10.4	29.4	38.7	.29	1946
	Average	3.4	9.2	10.8	9.2	29.1	38.3	.30	1968

[1] Early, mid, and late season corresponds to dates from June 10 to July 15, July 16 to August 9, and August 10 to September 10, respectively

Table 12. Average digestibility and nutrient intake for sheep and cattle grazing summer mountainous ranges during three periods for 6 years from 1959 to 1964

1 Early, mid, and late season corresponds to dates from June 10 to July 15, July 16 to August 9, and August 10 to September 10, respectively

Table 12. Average digestibility and nutrient intake for sheep and cattle grazing summer mountainous ranges during three periods for 6 years from 1959 to 1964

Animal	Periods[1]	Digestion coefficients (percent)					Digest. protein (%)	TDN (%)	Digest. energy (kcal/lb)
		Ether extract	Total protein	Cellulose	Other CHO	Gross energy			
Sheep	Early	-4.5	49.8	62.0	72.1	52.8	6.9	50.2	1026
	Mid	-5.1	43.4	54.9	68.0	47.9	4.8	46.0	949
	Late	-5.6	37.5	50.3	63.6	40.9	4.2	40.9	752
	Average	-5.1	43.8	55.7	67.9	47.2	5.3	45.7	907
Cattle	Early	0.1	48.2	67.2	65.6	49.8	4.9	49.5	983
	Mid	3.4	45.2	68.4	63.2	48.8	4.0	48.8	968
	Late	-1.4	35.2	67.6	61.2	41.8	3.0	46.6	814
	Average	3.0	42.9	67.7	63.3	46.8	4.0	48.3	921

1 Early, mid and late season corresponds to dates from June 10 to July 15, July 16 to August 9, and August 10 to September 15, respectively

Table 13. Average daily gain for sheep and cattle on mountain ranges during three periods during the summer grazing season[1]

Period	Pounds per day gain			
	Sheep		Cattle	
	Ewes	Lambs	Cows	Calves
June 8 to July 16	0.19	0.64	1.56	1.67
July 17 to August 5	0.15	0.60	1.00	1.42
August 6 to September 15	0.07	0.48	0.58	1.18

1 Lambs weigh an average of 71.1 and calves weigh an average of 351.2 pounds September 15 when removed from the summer range

Production — Sagebrush-grass areas produced an average of 1,104 pounds of air-dry forage per acre and aspen areas produced 987 pounds per acre. Grass species composed over half of the total herbage production on aspen range, but composed only about 35 percent of the composition by weight on the sagebrush-grass range. Forbs contributed 15 percent of the total production on sagebrush- grass and 40 percent on aspen range. Browse produced approximately 50 percent of the herbage on sagebrush-grass range, but only 9 percent on aspen range.

Flora of the sagebrush-grass areas included 16 species of grasses, 35 species of forbs, and 9 species of browse. Aspen area had 13 species of grasses, 42 species of forbs, and 10 species of browse.

Utilization — Livestock ate more per day on aspen areas than on sagebrush-grass types. This is perhaps a result of forage under aspen being more lush and in a cooler environment; consequently more palatable over a longer period.

Cattle grazed grasses and browse somewhat heavier on aspen range than on sagebrush-grass range. Sheep, however, utilized grasses and forbs more heavily on sagebrush-grass range than on aspen range.

The lower utilization of browse by cattle and sheep in sagebrush-grass enclosures resulted primarily from the relatively high quantity of the low palatable big sagebrush and little rabbitbrush.

The overall utilization of grass by sheep and cattle decreased and browse use increased as the season advanced (figure 4). Utilization of forbs increased rather markedly for cattle during early season; whereas, utilization of forbs by sheep was comparatively high during the entire season.

Forage composition of the diet — Diets of cattle were highest in

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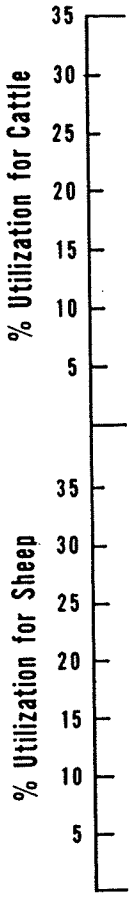

Figure 4.

grasses and lowest in browse in both aspen and sagebrush-grass types (table 14). Diets of sheep were lowest in browse with about equal amounts of grasses and forbs on aspen range, but were highest in grasses and lowest in browse on sagebrush-grass range.

Nutrient intake — Diets of sheep from sagebrush-grass range were higher in ether extract, lignin, and cellulose compared to aspen range, while diets of cattle from sagebrush-grass range were somewhat higher in protein, ash, and lignin than aspen range (table 15).

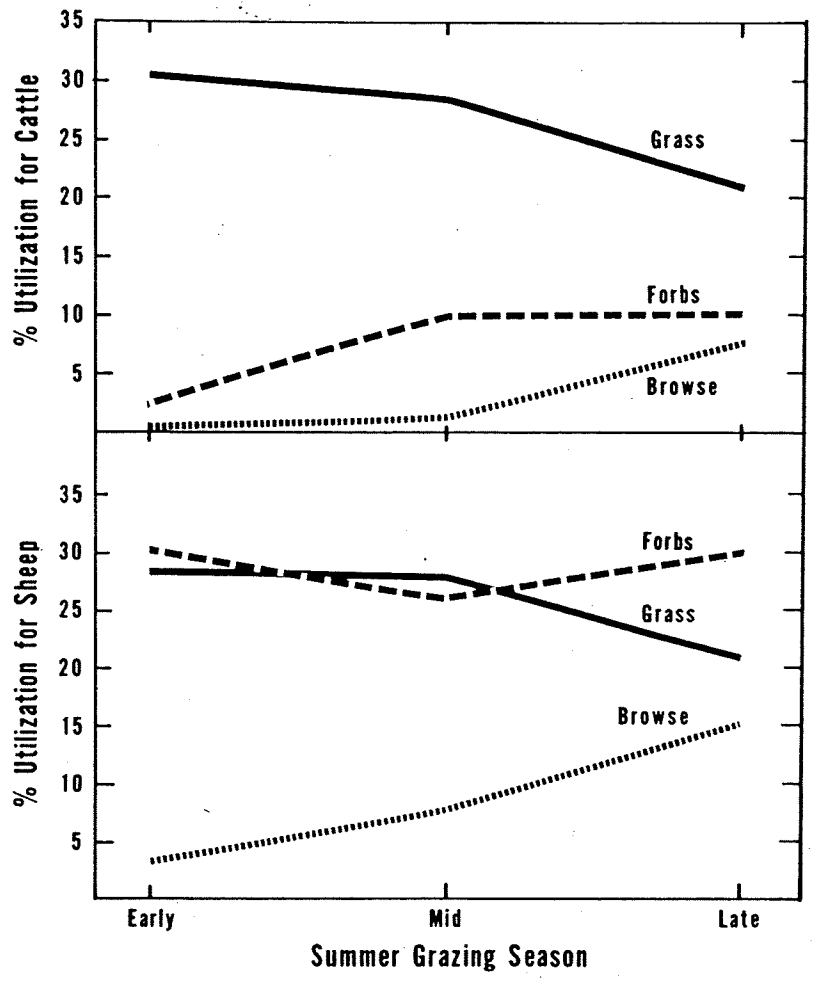

Figure 4. Preference of forage classes by cattle and sheep on typical mountain aspen and sagebrush-grass range during the summer from June 10 to September 10.

Table 14. Average utilization and diet by forage class for cattle and sheep on sagebrush-grass and aspen mountain range during early (June 8 to July 16) and late (August 6 to September 10) season in 1963 and 1964

Type	Season	Forage class	Cattle Utilization (%)	Cattle Diet (%)	Sheep Utilization (%)	Sheep Diet (%)
Sagebrush	Early	Grass	30.08	89.62	34.29	41.99
		Forbs	5.46	10.36	33.75	40.38
		Browse	0.00	00.00	2.44	17.63
	Late	Grass	23.07	62.16	24.67	42.32
		Forbs	9.07	10.32	32.62	19.24
		Browse	7.28	27.52	13.36	38.44
Aspen	Early	Grass	31.94	89.42	25.38	24.40
		Forbs	1.84	9.14	28.56	74.20
		Browse	5.68	1.44	17.86	1.40
	Late	Grass	20.02	73.49	19.52	44.91
		Forbs	9.96	19.44	28.18	36.87
		Browse	9.35	7.07	21.44	18.22
Average	Early	Grass	31.37	89.48	27.85	28.45
		Forbs	2.33	9.50	29.19	66.40
		Browse	0.29	1.02	2.98	5.15
	Late	Grass	21.37	67.62	21.75	43.60
		Forbs	9.61	14.72	29.58	27.94
		Browse	7.60	17.66	15.16	28.46

Diets for both sheep and cattle from aspen range contained higher levels of digestible energy and TDN than those from sagebrush-grass range. This resulted from diets in aspen areas being higher in cellulose for cattle and in other carbohydrates for both sheep and cattle, which, along with total protein, were more digestible on aspen range compared to sagebrush-grass range.

Digestibility of total protein and the other carbohydrate fraction in the diets on sagebrush-grass range was higher for sheep, but digestibility of these constituents in the diets on aspen range was higher for cattle. Cellulose in the diets of cattle on aspen range was more effectively digested than cellulose in the diets of cattle on sagebrush-grass range (table 16).

Table 15. Average chemical content of ingested forage for cattle and sheep grazing sagebrush-grass and aspen types on mountain ranges during early (June 8 to July 16) and late (August 6 to September 10) season in 1963 and 1964

Animal	Season	Ether extract (%)	Total protein (%)	Ash (%)	Lignin (%)	Cellulose (%)	Other carbohydrates (%)	Gross energy (kcal/lb)	Phosphorus (%)

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season in 1963 and

Sheep Utili-zation (%)	Diet (%)
34.29	41.99
33.75	40.38
2.44	17.63
24.67	42.32
32.62	19.24
13.36	38.44
25.38	24.40
28.56	74.20
17.86	1.40
19.52	44.91
28.18	36.87
21.44	18.22
27.85	28.45
29.19	66.40
2.98	5.15
21.75	43.60
29.58	27.94
15.16	28.46

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Table 15. Average chemical content of ingested forage for cattle and sheep grazing sagebrush-grass and aspen types on mountain ranges during early (June 8 to July 16) and late (August 6 to September 10) season in 1963 and 1964

Animal	Season	Ether extract (%)	Total protein (%)	Ash (%)	Lignin (%)	Cellu-lose (%)	Other carbo-hydrates (%)	Gross energy (kcal/lb)	Phos-phorus (%)
Sheep									
Sagebrush-grass	early	2.4	19.5	11.0	11.2	20.6	35.3	1980	0.42
	late	4.6	10.4	8.4	13.3	23.5	39.8	2017	0.34
	average	3.5	14.9	9.7	12.2	22.0	37.6	1999	0.38
Aspen	early	4.1	18.1	16.1	6.9	20.2	34.6	1917	0.44
	late	5.0	11.0	9.9	11.2	24.5	38.4	2016	0.40
	average	4.6	14.6	13.0	9.0	22.4	36.5	1966	0.42
Cattle									
Sagebrush-grass	early	2.5	14.6	14.8	9.7	25.4	33.0	1849	0.34
	late	3.7	8.9	10.2	12.1	32.2	32.9	1968	0.25
	average	3.1	11.8	12.5	10.9	28.8	32.9	1908	0.29
Aspen	early	2.3	13.2	13.3	6.3	29.8	35.1	1976	0.35
	late	3.9	11.4	9.4	8.2	30.7	36.4	1946	0.30
	average	3.1	12.3	11.4	7.2	30.2	35.8	1961	0.32

Table 16. Average digestibility of chemical constituents in forage consumed by sheep and cattle grazing sagebrush-grass and aspen types on mountain ranges during early (June 8 to July 16) and late (August 6 to September 10) season in 1963 and 1964

Animal	Season	Digestion Coefficients (percent)				Gross energy	Digest. protein (%)	TDN (%)	Digest. energy (kcal/lb)
		Ether extract	Total protein	Cellu-lose	carbo-hydrates				
Sheep									
Sagebrush-grass	early	-63.2	35.2	45.4	52.8	34.3	6.9	34.8	679
	late	-53.1	20.3	31.6	51.5	22.4	2.1	30.1	452
	average	-58.2	27.8	38.5	52.2	28.4	4.5	32.4	568
Aspen	early	27.6	56.7	55.7	64.6	54.4	10.3	46.2	1251
	late	-10.3	37.0	23.7	51.9	34.4	4.1	29.8	694
	average	8.6	46.8	39.7	58.2	44.4	7.2	38.0	873
Cattle									
Sagebrush-grass	early	13.8	34.1	52.1	53.0	40.8	5.0	36.5	754
	late	- 4.9	25.1	49.1	49.3	32.1	2.2	34.2	632
	average	4.4	29.6	50.6	51.2	36.4	3.6	35.4	695
Aspen	early	15.9	49.6	61.3	65.8	52.5	6.5	48.7	1037
	late	- 2.4	38.6	58.2	56.9	42.0	4.4	43.0	817
	average	6.8	44.1	59.8	61.4	47.2	5.4	45.8	926

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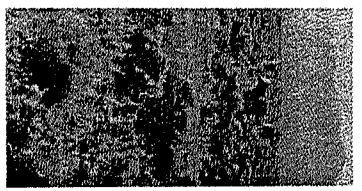

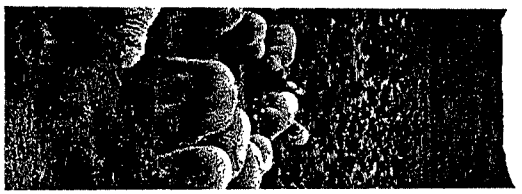

Figure 5. Catt
dese

Aspen	early	15.9	49.6	61.3	65.8	52.5	6.5	48.7	1037
	late	- 2.4	38.6	58.2	56.9	42.0	4.4	43.0	817
	average	6.8	44.1	59.8	61.4	47.2	5.4	45.8	926

Cattle diets contained a higher level of digestible energy (DE) and total digestible nutrients (TDN) primarily because their diets contained more cellulose, which was more efficiently digested (tables 15 and 16).

WINTER RANGE

The desert ranges of the Great Basin are composed primarily of browse species with various quantities of grasses. Generally, these ranges furnish forage for grazing animals for about 5 or 6 months during the winter (figure 5).

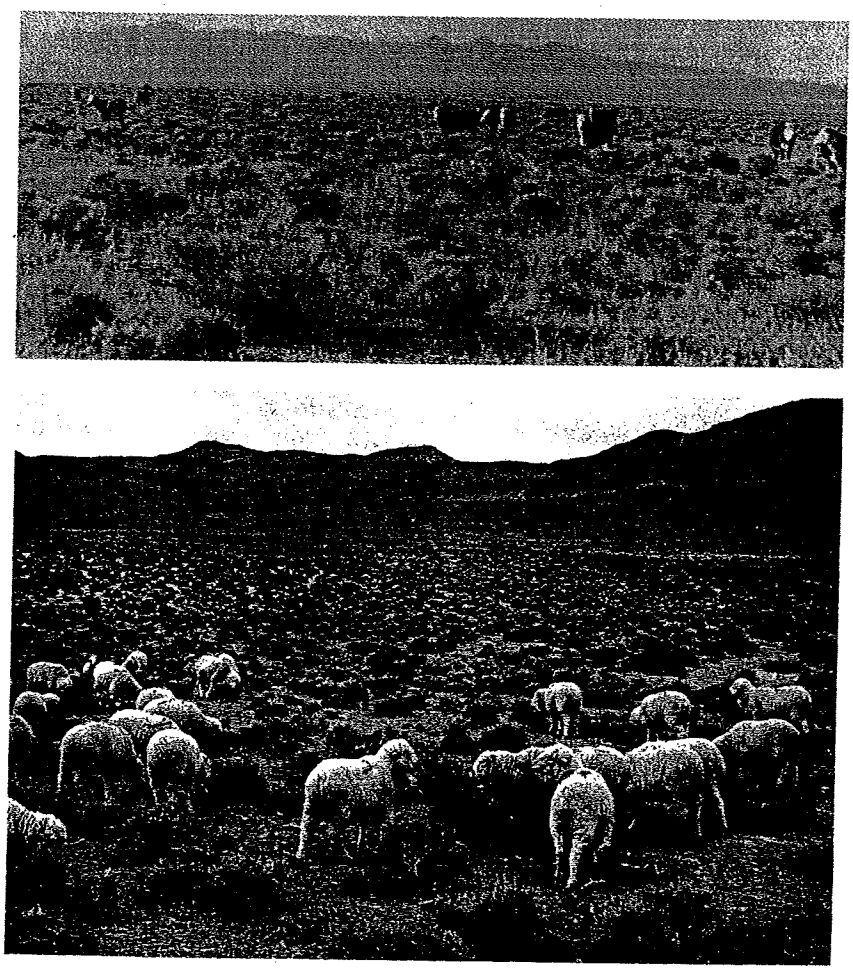

Figure 5. Cattle (above) and sheep (below) grazing typical salt-desert shrub ranges during the winter.

During this period livestock are in gestation and nutrient requirements are only slightly higher than for maintenance. If the animals are in good condition at the beginning of winter grazing, they can lose slightly without hindering normal production. The addition of supplements to produce increase in weight will generally increase production slightly but not always enough to offset the additional feed costs.

It is not a wise expenditure to supplement with energy when another nutrient such as phosphorus, protein, or vitamin A is limiting production. However, one of the first requirements to be met by range animals is energy because they frequently travel long distances to acquire feed and water. In addition, they must maintain body temperatures during the winter without the aid of shelter. When energy-supplying carbohydrates and fats are inadequate, the animal will use protein for energy. This will further aggravate any protein deficiency already present in the basal diet.

Recent research (Cook and Harris, 1967) has shown that protein feeds such as cottonseed meal and soybean meal are perhaps better supplements for winter ranges than energy supplements such as corn and barley even when energy is substantially low in the grazing animal's diet. Supplements such as corn and barley have a tendency to reduce the digestibility of cellulose and other carbohydrates (energy furnishing constituents) of the range forage and therefore, do not increase substantially the overall energy intake. The protein supplements (SBM and CSM) actually increase the digestibility of most nutritional constituents in the range forage and thereby enhance the nutritive value of the range feed.

Feeding supplements on the range at high levels may detract substantially from the quantity of range forage consumed. Feeding sheep at the rate of 0.25 to 0.33 pound per day and cattle at the rate of 1.00 to 2.00 pounds per day appear to be satisfactory.

Nutrient Deficiencies

To predict nutrient deficiencies on winter ranges and make practical recommendations for supplementing, it is necessary to establish minimum levels for nutrients critical to optimum production and greatest economic return. This can be done only when cost-return relations have been determined by actual feeding trials.

Such a study was carried on in conjunction with the plant investigation work on western Utah desert ranges (Harris *et al.*, 1956). The nutritive content of the range forage consumed by sheep and cattle indicated deficiencies of phosphorus, protein, and energy-supplying constituents. In view of these deficiencies, it was desirable to determine if pro-

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Lamb birth weight
Ewes lambing
Lamb crop at docking
Lamb weaning weight

Table 18. Average we
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Heifers, weight gain
Cows, weight gain (lb
Pounds of calf weaned

duction of range livestock could be increased by feeding supplements to furnish these nutrients. Feeding tests with sheep for a 3-year period were started in the fall of 1947. These trials were begun soon after the animals arrived on the winter range in November and were continued until they left in April. Similar trials with cattle were conducted from 1953 to 1956.

Results confirmed that animals do benefit from supplements (tables 17 and 18). Supplements of phosphorus and protein in combination increased wool yield and lamb crop for sheep and increased calf weights. The general condition of the breeding herd for both cattle and sheep also was improved (Harris *et al.* 1956; Harris *et al.*, 1957).

Table 17. Comparison of ewes fed a supplement consisting of about equal parts barley and soybean meal, solvent extract, plus 5 grams phosphorus at the rate of 0.3 pound per day, with ewes not fed supplements from November to April on salt desert ranges

Comparison	Average for fed	Average for controls
Gain from November to April 1	0.3 lb	-4.5 lb
Grease weight of fleece	9.5 lb	8.9 lb
Clean weight of fleece	3.70 lb	3.57 lb
Staple length of fleece	2.23 cm	2.12 cm
Lamb birth weight	10.1 lb	10.3 lb
Ewes lambing	92 %	82 %
Lamb crop at docking	110 %	100 %
Lamb weaning weight	75.3 lb	74.9 lb

Table 18. Average weight gain or loss from cattle during the winter grazing season on desert ranges from October to March 15 when fed 1.6 pound of supplement consisting of soybean meal, solvent extract, and phosphorus to balance the diet compared to no supplement

	Supplemented	Non-supplemented
Heifers, weight gain (lb)	35	15
Cows, weight gain (lb)	20	-38
Pounds of calf weaned per cow	310	287

Ewes receiving supplements produce 0.13 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 (table 17). During the last 2 years of the feeding tests, the supplements consisted of three levels of high energy feed (barley), three levels of high protein feed (soybean meal), and three levels of phosphorus (monosodium phosphate). These were fed separately and in all possible combinations. Intermediate supplement levels of the various nutrients gave the most economic return per unit of cost.

Replacement heifers, when supplemented on the winter range with cottonseed meal gained 20 pounds more during the winter than the controls (Harris *et al.*, 1957). Cows that were supplemented during the winter gained 20 pounds and weaned 310 pounds of calf while the unsupplemented cows lost 38 pounds during the winter and weaned only 287 pounds of calf per cow (table 18).

Utilization and diets

Diets of sheep and cattle on desert ranges during the winter grazing season are shown in tables 19 and 20. As might be expected, the diet of sheep contained more browse and the diet of cattle contained more grass.

The nutrient intake from range forage and the nutritional value of the feed supplement for sheep and cattle grazing desert ranges are shown in tables 21 and 22, respectively.

In general, desert browse plants meet the protein requirements for livestock during gestation and are exceptionally high in carotene (table 23). However, they may be slightly deficient in phosphorus and decidedly low in energy-furnishing constituents. As shown by Cook *et al.* (1950 and 1954) grasses, during the winter, are markedly deficient in protein, phosphorus, and carotene but are good energy sources (table 23). Therefore, herding practices or broad range areas that provide a mixture of browse and grass more nearly balances the diet than areas producing largely one forage class alone. Forbs are generally sparse on desert ranges and are unimportant in the diet during winter grazing.

If the diet is largely grass, phosphorus and digestible protein may be markedly deficient but if the diet is largely browse, energy may be decidedly deficient (table 26).

With present methods it is impossible to rehabilitate desert ranges

of the Great Basin area artificially (by seeding). Therefore, nutritional problems during winter grazing become largely a matter of supplementing the animal's diet and managing the range to provide adequate quantities of high quality forage.

A variety of vegetation and conservative grazing generally reduce the need for supplements on winter ranges compared to diets composed largely of one species or where heavy grazing is practiced.

Intensity of grazing

Animals on many winter ranges may require a particular supplement to meet the requirements when properly grazed but with increased

Table 19. Average botanical composition, degree of utilization and diet from average salt-desert ranges under average conditions calculated from all study areas where a mixed flora was present for sheep over a 5-year period from November 1 to April 1

Species	Plant composition (%)	Utilization (%)	Diet (%)
Black sage	10	50	17
Bud sage	5	40	7
Big sage	11	15	5
Shadscale	13	20	9
Nuttall saltbush	8	35	9
Yellowbrush	5	10	2
Winterfat	12	40	16
Desert molly	10	15	5
Browse total	74	28	70
Western wheatgrass	3	30	3
Beardless wheatgrass	3	40	4
Giant wildrye grass	1	10	0
Galleta or curlygrass	2	25	2
Indian ricegrass	6	45	9
Squirreltail grass	3	50	5
Alkali sacaton grass	1	10	0
Sand dropseed grass	2	10	1
Needle-and-thread grass	4	40	5
Grass total	25	29	29
Russian-thistle	1	20	1

grazing intensity the quantity and even the type of supplement needed may change. Overgrazing may result in a need for a greater quantity or even a more expensive supplement over a longer period of time.

Digestion trials using light, moderate, and heavy grazing on typical desert ranges from October to April show that with increased intensity of grazing the percentage of protein, phosphorus, and gross energy in the

Table 20. Species composition, utilization, and diet of cattle on desert range areas in western Utah during the winter grazing period from October 1 to March 15

Species	Plant composition (%)	Utilization (%)	Diet (%)
Big sage	1.3	5	0.2
Black sage	1.3	20	0.8
Brigham tea	2.0	10	0.6
Bud sage	0.6	20	0.3
Desert molly	2.0	10	0.6
Four-wing saltbush	3.6	60	6.6
Grease wood	0.8	5	0.1
Hop sage	4.7	30	4.4
Shadscale	13.6	20	8.4
Winterfat	8.2	60	14.6
Yellowbrush	16.3	20	10.0
Browse total	54.4	15	40.6
Miscellaneous weeds	1.9	5	0.3
Russian thistle	7.7	10	2.4
Forbs total	9.6	9	2.7
Alkali sacaton	0.4	10	0.1
Blue grama	3.6	40	4.4
Bunch wheatgrass	4.1	70	8.8
Cheatgrass	1.1	20	0.7
Galleta grass	14.0	50	21.5
Giant wildrye grass	0.1	40	0.2
Indian ricegrass	7.6	75	17.5
Needle-and-thread grass	1.6	50	2.5
Sand dropseed grass	2.2	10	0.7
Three-awn grass	1.2	5	0.2
Western wheatgrass	0.1	50	0.1
Grass total	36.0	18	56.7

Table 21

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ilization (%)	Diet (%)
5	0.2
20	0.8
10	0.6
20	0.3
10	0.6
60	6.6
5	0.1
30	4.4
20	8.4
60	14.6
20	10.0
15	40.6
5	0.3
10	2.4
9	2.7
10	0.1
40	4.4
70	8.8
20	0.7
50	21.5
40	0.2
75	17.5
50	2.5
10	0.7
5	0.2
50	0.1
18	56.7

Table 21. Intake of digestible protein, metabolizable energy, and phosphorus by a 130 pound ewe for most efficient production during winter on a salt desert range of the Great Basin area

	Intake of dry matter (lb)	Digestible protein (%)	Metabolizable energy (kcal/lb)	Phosphorus (%)
Range forage	3.30	2.6	640	0.09
Supplement	0.29	24.9	949	1.08
Requirement	3.59	4.4	665	0.17

Table 22. Chemical content of supplement fed to cattle on a salt desert range of the Great Basin area

	Intake (lb/day)	Protein (%)	Metabolizable energy (kcal/lb)	Phosphorus (%)
Range forage	20.00	2.64	671	0.08
Supplement	1.62	26.13	939	1.28
Requirement	21.62	4.40	665	0.17

Table 23. Average nutrient content of grass and browse[1] used for winter grazing on desert ranges of the Intermountain area compared to alfalfa hay

	Digestible protein (%)	Metabolizable energy (kcal/lb)	Phosphorus (%)	Carotene (mg/lb)
Grass	0.7	797	0.07	0.23
Browse	5.4	643	0.14	7.70
Alfalfa	10.5	899	0.21	7.90

1 Averages include 9 grass species and 10 browse species over a period of 6 years. All are common on desert ranges of the Intermountain area

Table 24. Average chemical constituents in the major desert plants during the winter grazing season

Species	Ether extract (%)	Total protein (%)	Ash (%)	Lignin (%)	Cellu-lose (%)	Other carbo-hydrates (%)	Gross energy (kcal/lb)	Phos-phorus (%)	Carotene (mg/lb)
Big sagebrush	10.1	9.4	6.1	16.1	21.3	37.1	2314	0.18	7.3
Black sage	9.4	8.5	6.2	15.8	21.6	38.7	2296	0.16	8.0
Bud sage	4.9	17.3	21.4	8.6	18.1	29.9	1923	0.33	10.8
Brigham tea	13.1	6.1	4.8	15.7	35.9	24.4	1890	0.10	7.6
Desert molly	4.1	9.0	24.8	7.6	12.8	43.1	1627	0.12	8.2
Four-wing saltbush	2.3	10.1	13.4	11.7	23.2	39.3	1817	0.10	8.1
Nuttall saltbush	2.2	7.2	21.5	9.9	19.2	40.0	1676	0.12	8.6
Shadscale	2.4	7.7	23.4	13.0	17.6	35.7	1648	0.09	8.9
Yellow brush	12.2	6.6	8.4	13.3	21.8	37.8	2223	0.10	2.1
Winterfat	3.4	9.1	13.3	11.7	27.7	34.8	1808	0.12	7.6
Browse average	6.4	9.1	14.3	12.3	21.9	36.1	1922	0.14	7.7
Alkali sacaton	2.2	3.4	12.6	9.6	32.8	39.4	1903	0.08	0.3
Beardless wheatgrass	4.1	3.1	10.6	7.8	38.4	36.0	1905	0.06	0.5
Galleta grass	2.0	5.5	16.6	7.7	27.9	41.2	1751	0.07	0.2
Giant wildrye grass	3.2	3.2	11.6	8.0	39.4	35.0	1857	0.06	0.0
Indian ricegrass	2.7	3.5	7.4	9.5	37.6	39.3	1942	0.06	0.2
Needle-and-thread	4.9	4.0	17.8	7.7	32.8	32.9	1776	0.07	0.2
Sand dropseed	1.4	5.0	6.3	8.4	46.1	32.7	1895	0.06	0.2
Squirreltail grass	2.6	4.5	17.1	8.7	37.5	29.6	1730	0.07	0.5
Western wheatgrass	8.3	2.4	10.0	6.6	36.3	36.5	1973	0.06	0.1
Grass average	3.5	3.8	12.2	8.2	36.5	35.8	1859	0.07	0.02

Table 25. Average digestibility of the chemical constituents, digestible protein and metabolizable energy in the major desert plants during the winter grazing season

Species	Digestion Coefficient (percent)					Dry matter (%)	Digest. protein (%)	Metab-olizable energy (kcal/lb)
	Ether extract (%)	Total protein (%)	Cellu-lose (%)	Other carbo-hydrates (%)	Gross energy (%)			
Big sagebrush	74.6	54.7	33.7	55.9	44.7	37.6	5.4	575

Galleta grass	2.0	3.3	10.0	7.7	2.1	1.2			
Giant wildrye grass	3.2	3.2	11.6	8.0	39.4	35.0	1857	0.06	0.0
Indian ricegrass	2.7	3.5	7.4	9.5	37.6	39.3	1942	0.06	0.2
Needle-and-thread	4.9	4.0	17.8	7.7	32.8	32.9	1776	0.07	0.2
Sand dropseed	1.4	5.0	6.3	8.4	46.1	32.7	1895	0.06	0.2
Squirreltail grass	2.6	4.5	17.1	8.7	37.5	29.6	1730	0.07	0.5
Western wheatgrass	8.3	2.4	10.0	6.6	36.3	36.5	1973	0.06	0.1
Grass average	3.5	3.8	12.2	8.2	36.5	35.8	1859	0.07	0.02

Table 25. Average digestibility of the chemical constituents, digestible protein and metabolizable energy in the major desert plants during the winter grazing season

	Digestion Coefficient (percent)							
Species	Ether extract (%)	Total protein (%)	Cellu-lose (%)	Other carbo-hydrates (%)	Gross energy (%)	Dry matter (%)	Digest. protein (%)	Metab-olizable energy (kcal/lb)
Big sagebrush	74.6	54.7	33.7	55.9	44.7	37.6	5.4	575
Black sage	62.3	52.5	31.0	58.7	41.0	38.6	4.4	510
Bud sage	72.3	79.1	58.1	61.7	60.3	55.3	13.7	911
Brigham tea	65.4	50.2	34.1	54.0	40.3	39.8	3.1	532
Desert molly	72.4	69.0	47.6	74.6	60.3	61.9	5.5	863
Four-wing saltbush	43.2	54.4	48.2	46.4	42.0	38.6	5.8	647
Nuttall saltbush	- 7.5	46.6	45.9	57.1	40.3	38.4	3.4	599
Shadscale	32.7	55.4	26.1	55.1	34.5	42.6	4.3	399
Yellow brush	74.6	46.9	33.1	49.4	45.8	38.3	3.1	760
Winterfat	33.7	53.3	41.0	49.5	38.8	31.2	4.8	635
Browse average	52.4	56.2	39.9	56.2	44.8	42.2	5.4	643
Alkali sacaton	12.7	0.0	45.5	50.8	46.8	42.6	0.0	750
Beardless wheatgrass	56.9	0.0	76.4	60.0	56.9	46.2	0.0	903
Galleta grass	- 1.8	26.6	55.8	50.6	43.1	38.9	1.4	595
Giant wildrye grass	- 1.6	0.0	58.5	55.9	44.4	44.2	0.0	658
Indian ricegrass	22.4	6.4	69.5	53.4	45.9	42.4	0.3	733
Needle-and-thread	24.6	27.6	69.7	60.8	50.7	49.9	1.2	747
Sand dropseed	31.0	25.2	76.6	64.1	58.3	56.2	1.9	939
Squirreltail grass	45.9	17.4	72.4	51.3	50.2	44.8	1.1	732
Western wheatgrass	65.8	6.4	81.7	70.1	64.3	59.8	0.2	1120
Grass average	25.6	12.2	67.3	57.4	51.2	46.8	0.7	797

Table 26. Average vegetation composition of the grazing animal's diet and content of the critical nutrients used in appraising nutrient value of desert ranges for winter grazing in the Great Basin for three major types

Forage class	Predominately grass range				Predominately saltbush range				Predominately sagebrush range			
	Vegetation composition of diet (%)	Dig. protein (%)	Phos-phorus (%)	Met. energy (kcal/lb)	Vegetation composition of diet (%)	Dig. protein (%)	Phos-phorus (%)	Met. energy (kcal/lb)	Vegetation composition of diet (%)	Dig. protein (%)	Phos-phorus (%)	Met. energy (kcal/lb)
Browse	24	4.9	0.12	616	61	4.6	0.12	619	70	4.8	0.12	575
Grass	76	0.8	0.06	821	39	0.9	0.07	757	30	0.7	0.06	803
Average	100	2.1	0.08	737	100	3.1	0.10	628	100	3.7	0.12	619

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Table 27. I

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Grasses
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Aristida lor
Bouteloua gr
Bromus carir
Bromus tectc
Elymus cine
Elymus glauc
Elymus junce
Festuca idat
Hilaria jame
Oryzopsis hy
Poa pratensi
Sitanion hys
Sporobolus a
Sporobolus c
Stipa comata
Stipa letter
Forbs
Bassia hysso
Salsola tenu
Browse
Artemisia no
Artemisia sp
Artemisia tr
Atriplex can
Atriplex con
Atriplex nut
Chrysothamnu
Chrysothamnu
Ephedra neva
Eurotia lana
Grayia spino
Gutierrezia
Kochia vesti
Populus trem
Sarcobatus v
Tetradymis s

diet decreased (Piper *et al.*, 1959; Cook *et al.*, 1962). In most cases the digestibility of the nutrients in the diet was seriously reduced by heavy grazing. Daily intake of forage was markedly reduced by heavy grazing during all trials.

As grazing intensity increases, animals show preference change among plants. Some plants are eaten closely before others are consumed even lightly. Thus, increased intensity of grazing on plant mixtures

Table 27. A list of scientific and common names of important range plants used in the presentation

Scientific name	Common name
Grasses	
Agropyron cristatum	Crested wheatgrass
Agropyron elongatum	Tall wheatgrass
Agropyron inerme	Beardless wheatgrass
Agropyron intermedium	Intermediate wheatgrass
Agropyron smithii	Western wheatgrass
Agropyron spicatum	Bunch wheatgrass
Agropyron trachycaulum	Slender wheatgrass
Agropyron trichophorum	Pubescent wheatgrass
Aristida longiseta	Three-awn grass
Bouteloua gracilis	Blue grama grass
Bromus carinatus	Mountain brome
Bromus tectorum	Downy bromegrass or Cheatgrass
Elymus cinereus	Giant wildrye
Elymus glaucus	Blue wildrye
Elymus junceus	Russian wildrye
Festuca idahoensis	Idaho fescue
Hilaria jamesii	Galleta grass
Oryzopsis hymenoides	Indian ricegrass
Poa pratensis	Kentucky bluegrass
Sitanion hystrix	Squirreltail grass
Sporobolus airoides	Alkali sacaton
Sporobolus cryptandrus	Sand dropseed
Stipa comata	Needle-and-thread grass
Stipa lettermanii	Green Needle and thread grass
Forbs	
Bassia hyssopifolia	Smother weed
Salsola tenuifolia	Russian thistle
Browse	
Artemisia nova	Black sage
Artemisia spinescens	Bud sage
Artemisia tridentata	Big sagebrush
Atriplex canescens	Four-wing saltbush
Atriplex confertifolia	Shadscale or saltbush
Atriplex nuttallii	Nuttall saltbush
Chrysothamnus stenophyllus	Yellow brush
Chrysothamnus viscidiflorus	Little rabbitbrush
Ephedra nevadensis	Jointfir or Brigham tea
Eurotia lanata	Winterfat or white sage
Grayia spinosa	Hop sage
Gutierrezia sarothrae	Snake weed
Kochia vestita	Desert molly
Populus tremuloides	Aspen
Sarcobatus virmiculatus	Grease wood
Tetradymis spinosa	Horsebrush

involves grazing certain species closer and a change in preference from one species to another. When animals graze a plant specie more intensively they are forced to consume the more harsh material which results in lowered palatability and lowered nutritive value.

Range condition

The nutrient content of range animal diets on good and poor condition winter ranges depends upon the plant species present and the intensity of utilization. When browse is high in the diet, the nutrient intake is generally high in protein, ash, lignin, and ether extract. When grass is high in the diet, however, the nutrient intake is generally high in cellulose, other carbohydrates, and metabolizable energy.

Studies show that digestibility of nutrients in diets from both poor and good ranges is about the same. Increased utilization decreases forage digestibility unless the diets change substantially in percentages of grass or browse (Cook *et al.,* 1962).

Daily intake is less on poor ranges than on good ranges. This is perhaps a result of animals spending more time traveling from plant to plant and less in actual grazing. In addition, animals are forced to consume less palatable material because of the heavier use on fewer desirable plants and secondary use on plants that have invaded the area. The desirable nutrients in less palatable plants on poor ranges, commonly referred to as undesirable plants, are as high and the nutrients are as easily digested as nutrients in herbage of highly palatable or desirable plants on good ranges. However, light grazing on relatively unpalatable species may be associated with extremely heavy use on the more palatable plants.

CONCLUSIONS AND RECOMMENDATIONS

Studies presented herein suggest that it would be better to graze the introduced species separately from native species and from each other for best management of spring ranges. Both sheep and cattle make best gains on introduced foothill seedings when grazing crested wheatgrass early in the spring, and intermediate wheatgrass and Russian wildrye during late spring. Native foothill ranges are best used during mid-spring from about May 1 to June 8.

If a particular spring forage becomes deficient in nutrients because of advanced growth stages, another forage species or range type which is later maturing should be developed or provided. This is believed a

more economical approach than supplementing to correct deficiencies while on spring range.

Animals on winter ranges should receive a nutrient level to meet gestation requirements. While on spring ranges animals are in early lactation and require from 25 to 30 percent higher nutrient level than animals in gestation. Animals during latter stages of lactation require less than during early lactation, hence on summer range the nutrient level should be at least 10 percent higher than gestation requirements.

It is impossible to rehabilitate salt-desert ranges of the Great Basin area artificially with present methods. Therefore, nutritional deficiencies of the winter range frequently must be corrected by supplements. Generally a protein and phosphorus supplement is recommended since many desert ranges are deficient in phosphorus, protein and energy. Protein supplements can be used as a source of both energy and protein and it increases the digestibility of range forage.

Range animals should be fed supplements to prevent large weight losses during the inclement weather from December to April.

In range livestock production it is not economical to feed the entire herd at a level to receive maximum production from the higher producing animals. Under these conditions, the average animal in the herd will not yield increased production proportionate to the increased feed.

There is significant variation in animal response to feeding during different years. Because of changing weather conditions, the livestock operator must exercise judgment and skill in feeding supplements to obtain maximum economic returns. A phosphorus supplement probably should always be fed on winter range since it can be supplied at nominal cost. The feeding of protein should be determined by the condition of the animals, the kind and amount of forage available, and climatic conditions.

Observations show that certain animals, particularly the middle-aged ones, stay in good flesh and produce well with little supplemental feed. Supplementing all animals regardless of age and condition may not be the most practical for a rancher. It may be cheaper to separate the yearlings, old animals, and those in poor condition and manage them separately.

Increased browse over grass in the diet increases the protein and phosphorus intake but reduces the energy value of the consumed material. Conversely, increased consumption of grass reduces the protein and phosphorus, but increases the high energy constituents. This indicates that a diversified plant cover on all seasonal ranges is more desirable than a single forage class.

SUMMARY

The nutritional value of forage is considerably higher on spring and summer ranges than on winter and fall ranges. Browse species on all ranges are higher in protein, calcium, phosphorus, and lignin while grasses are higher in crude fiber, cellulose, and energy-yielding constituents. Forbs are generally not important on fall and winter ranges but may be abundant on native summer and spring ranges. Generally forbs are intermediate to browse and grass in nutritive content on spring and summer ranges. Thus, animal preference for certain classes of forage is an important factor affecting the nutrient content of the diet.

Forage plants on spring ranges show a steady decrease in digestible protein, phosphorus, total digestible nutrients and digestible energy as the season advances, whereas ether extract, ash, lignin, and cellulose show a general increase. Most grasses at low elevation meet the energy requirements for lactating animals during the entire spring grazing period, but only a few grass species furnish adequate protein and phosphorus during the latter part of the spring season.

The reduced nutrient content of the diet because of plant maturity was believed responsible for reduction in livestock gains as the spring grazing season advanced. Likewise, the higher nutrient content of intermediate wheatgrass and Russian wildrye produced better livestock gains in late spring compared to crested wheatgrass or native foothill grasses.

The average nutrient intake of livestock on summer ranges indicated a satisfactory nutrient level with the possible exception of late summer. The nutritional composition of the diet and amount of forage consumed are dependent upon many factors. Those of major concern on summer ranges are stage of growth and species composition of the forage available. Cool weather species mature early and are low in nutrients late in the season, but warm weather species mature late and furnish adequate nutrients for grazing animals late in the summer. Likewise, shrubs retain their nutrient content at a higher level during the summer; whereas, grasses in most cases decrease rather markedly. On mountain ranges the forage on aspen areas remains green late into the summer and therefore is more suitable for late summer grazing than the drier sagebrush-grass areas.

Usually, both sheep and cattle change their dietary preference as the season progresses. Preference for grasses by both sheep and cattle decreased while preference for browse increased. Cattle preference for forbs increased during early season and remained intermediate to grass and browse the remainder of the season. Sheep preference for forbs was relatively high during the entire season.

In general, diets of sheep were higher in protein, phosphorus, and lignin and cattle diets were higher in cellulose. Sheep digested protein better than cattle but cattle digested cellulose better than sheep. Therefore, sheep diets were higher in digestible protein and cattle diets were higher in digestible energy.

Livestock gains on summer ranges during most years were considered satisfactory even though the nutrient levels declined rather rapidly during the late summer grazing period. Lactating animals gained during the entire summer and both lambs and calves made substantial body gains but at a decreasing rate as the season advanced.

On winter ranges nutritional deficiencies are common because of the limited variety of forage species and inclement weather conditions that reduce grazing time and forage intake. In addition, browse plants on winter range meet the recommended standards for protein in most cases, and are exceptionally high in carotene. They are, however, slightly deficient in phosphorus and decidely low in energy furnishing constituents. Grasses during winter are markedly deficient in protein, phosphorus, and carotene but are good sources of energy. A mixture of browse and grass in the diet more nearly meets the nutritional requirements of animals in gestation than either forage class alone.

Range animals during each year may go through cycles of inadequate and adequate nutrition. During spring and summer breeding animals gain slightly, and in the fall and early part of the winter they usually maintain their weight or lose slightly. During winter there is a critical period sometime between December and April when inclement weather and sometimes poor range conditions cause animals to lose weight excessively. Studies show that animals in good condition can lose some weight during the winter grazing season and still produce effectively.

The results from supplementary feeding trials on winter ranges confirm that livestock do benefit from supplements to correct nutritional deficiencies. Supplements of phosphorus and protein in combination increased the wool yield and lamb and calf weaning weights per breeding animal. Supplements composed primarily of energy-producing constituents gave less favorable results in most cases. All supplements maintained animal weights better throughout the winter compared to no supplements.

The nutrient intake of animals grazing winter ranges varies from area to area and is influenced by many factors of which intensity of use is most important. As degree of utilization increases, the content of desirable nutrients in the diet decreases and digestibility of the nutrients likewise decreases because animals are forced to eat the less nutritious

portions of the plants. In addition, animals consume less forage daily with increased degree of range utilization.

The chemical content of forage plants on winter ranges changed little during the grazing season; whereas, on spring and summer ranges, seasonal changes in chemical content were substantial. Seasonal changes were affected by both the changes in the stem-leaf ratio and actual changes in the chemical composition within each plant part. Protein and phosphorus generally decreased in all forage classes; whereas, crude fiber, lignin, and cellulose increased. Browse showed the least seasonal fluctuation and grass the greatest.

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