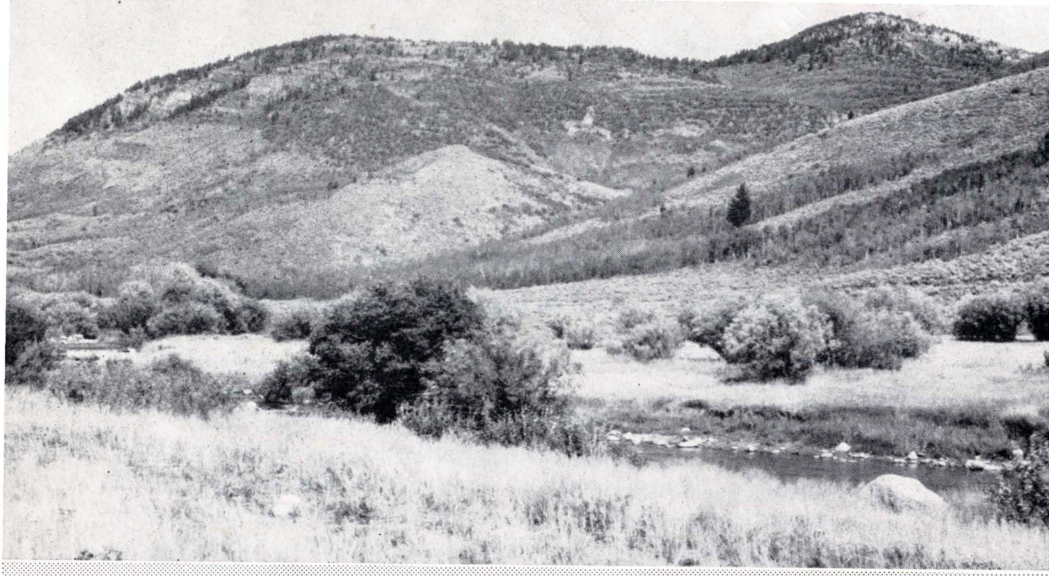
12-1942

Bulletin No. 305 - The Composition of Sumer Range Plants in Utah

L. A. Stoddart

J. E. Greaves



The Composition of Summer Range Plants in Utah

By L. A. Stoddart
J. E. Greaves

Bulletin 305
Utah Agricultural Experiment Station

Foreword

THIS bulletin is a report of research findings obtained under one phase of project 162 of the Utah Agricultural Experiment Station. This project, entitled "The Phosphorus content of summer range forage and its relationship to range cattle maintenance," was cooperative between the Departments of Range Management, Bacteriology and Chemistry, and Animal Husbandry. The project was active between the years of 1934 and 1938, during which period data were collected at monthly intervals on animal weights, blood analysis, and forage species believed to be of primary importance to grazing animals on mountainous summer ranges. This bulletin reports only the findings on the range plants. These plants were analyzed chemically in an attempt to assist in determining the adequacy of native plants to supply nutritional needs of domestic stock.

Range livestock production is one of the foremost industries of the West, and during the present emergency period it is on the front lines in national production and, hence, in national defense. Since the industry is dependent upon the comparatively inexpensive stock feed produced on the great open range lands of the West, studies of this kind are important for they throw light upon how best to make use of this great natural resource. Now as never before is there need to increase the efficiency of the range in producing meat, and an understanding of the nutritional problems involved is essential to this efficiency.

Cover picture: High mountain range upon which experimental work was conducted. The steep and densely vegetated hills in the background are typical of thousands of acres of the western range.

December 1942 Logan, Utah

The Composition of Summer Range Plants in Utah[1]

L. A. Stoddart and J. E. Greaves[2]

Introduction

In Utah, a vast industry of livestock grazing, which is the backbone of the state's agriculture, has arisen during the past 75 years. Range land furnishes between 6 and 7 million animal unit months of forage to some 2½ million sheep and 275 thousand range cattle. Income from meat, wool, and range livestock sales in Utah is about $15,801,500 annually, of which $11,700,000 is calculated to be obtained from range lands exclusive of cultivated pastures[3].

These range lands can be used economically in no other way than by grazing livestock and, because of heavy winter snows and protracted dry periods, most of these lands are distinctly seasonal in character. Livestock, then, must be supported for long periods upon farm lands or upon other range lands. The animals must be driven or shipped over distances sometimes well in excess of 100 miles from one range to another. The specific seasonal nature of these lands makes important the study of seasonal variations in forage value. That animals can make the most efficient use of the range lands, it is important to understand the forage value, the balance of various chemical constituents, and the importance of deficiencies in the diet of animals existing wholly upon these native plants.

Range Conditions

In 1934, the Utah Agricultural Experiment Station realizing the importance of knowing more about range vegetation and its role in supplying food for grazing animals began a study of the forage on mountainous summer ranges. Investigations were conducted on an experimental pasture located about 20 miles east of Logan in the sagebrush and aspen types typical of high elevation ranges through much of the West (see cover picture). The topography is steep and the soil is heterogeneous, derived mostly from residual sandstone and limestone. A substratum of dolomite is close to the surface of most of the area. Although the soils in this region

---

[1]Contribution from the Departments of Range Management and Bacteriology and Biochemistry.

[2]Research professor of range management, and research professor of bacteriology and biochemistry, respectively.

[3]These calculations are based upon figures of the U. S. Bureau of Census *16th census of the United States, 1940,* and upon the U. S. Department of Agriculture *Agricultural Statistics, 1940,* the data for which were mostly gathered in 1939.

have never been officially named or described, they are generally mature and are underlaid by a heavy red clay, whereas the surface soils are generally dark brown to black loam, being high in organic matter. All soils are neutral or slightly alkaline in reaction and limestone is abundant.

The climate in the experimenal area is typcial of many Rocky Mountain and Intermountain ranges, having heavy winter snows and relatively dry summers with an annual precipitation estimated at 20 inches. The winters are cold and summer temperatures are mild, resulting in good growing conditions despite frequent dry periods. The weather during the period involved in the present study was abnormally hot and very dry (figure 1). As a result, growing conditions, especially in 1934, were unusually poor and plants made notably less growth than usual.

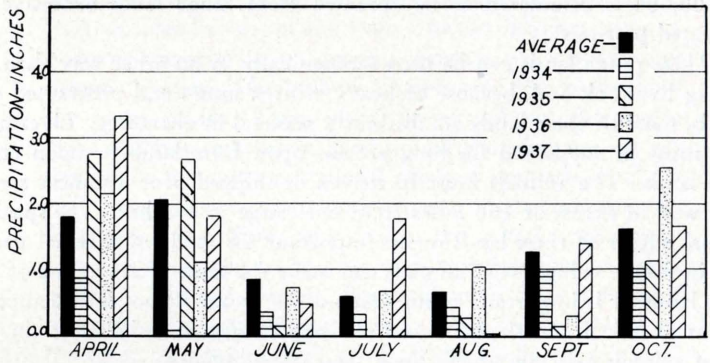


Figure 1. Monthly precipitation in inches at Logan, Utah, for the growing seasons of 1934 to 1937 compared to the long-time normal. These records are fairly indicative of the seasonal variation found in the experimental pastures, but the total on the pastures was likely somewhat greater

The pasture vegetation is highly complex, 123 flowering plant species occurring in appreciable quantity in the flora. Because of this complexity, it was impossible to analyze and study each plant, hence 24 species were selected because of abundance and importance. Together, these species constitute 67.6 percent of the entire vegetation density and were estimated to form a 15.02 percent ground cover. The 24 species and the percent each contributes to the floral composition follow:

		percent
Roundleaf snowberry	*Symphoricarpos rotundifolius*	15.62
Western chokecherry	*Prunus melanocarpa*	8.66
Serviceberry	*Amelanchier alnifolia*	7.54
Aspen	*Populus tremuloides*	5.20
American vetch	*Vicia americana*	5.01
Peavine	*Lathyrus leucanthus*	4.04

		percent
Rose	*Rosa spauldingii*	3.91
Bearded wheatgrass	*Agropyron subsecundum*	1.74
Sawtooth butterweed	*Senecio serra*	1.71
Yellow willow	*Salix lutea*	1.67
Fremont geranium	*Geranium fremontii*	1.46
Rabbitbrush	*Chrysothamnus nauseosus*	1.33
Yellowbrush	*Chrysothamnus viscidiflorus*	1.32
Yarrow	*Achillea lanulosa*	1.30
Bitterbrush	*Purshia tridentata*	1.27
Sedge	*Carex rostrata*	1.02
Mountain brome	*Bromus carinatus*	0.98
Horsemint	*Agastache urticifolia*	0.89
Niggerhead	*Rudbeckia occidentalis*	0.77
Beardless wheatgrass	*Agropyron inerme*	0.73
Kentucky bluegrass	*Poa pratensis*	0.71
Letterman needlegrass	*Stipa lettermani*	0.49
Twinberry	*Lonicera involucrata*	0.13
Giant wild-rye	*Elymus condensatus*	0.10
		67.60

Experimental Methods

FROM 1934 to 1937, inclusive, plant samples were collected for chemical analysis at monthly intervals throughout the grazing season which extends from July 1 to October 15. In late June, a collection was made of 24 species believed to be major contituents of the diet of grazing steers. In July and again in August collections were made of only 6 plants believed to be the most important. In late September a second collection was made of 24 species. Complete data were obtained, therefore, only at the beginning and toward the end of the grazing season; however, trends are obtainable from data on representative species during the grazing season.

Calendar dates rather than plant development determined the time of collection because animal diet at a specific period was desired to correspond with weight and blood analysis data. A single large sample was collected which was air dried in the laboratory, thoroughly mixed, and ground previous to analysis. The samples consisted only of that part of the plant consumed by grazing animals. Grasses and forbs generally were cut at an inch or two height above the ground surface except for certain rank forbs such as *Senecio serra* in which merely the leaves and tender stem tips were included. Browse samples included only leaves and tender current growth. In no instance was mature woody material harvested. Samples were composited from a large number of small areas which were

scattered over the pastures in a manner designed to make the material representative of the entire area. Some variation existed from time to time in the exact location from which plants were gathered since, especially in the fall collections, material often was difficult to obtain, thus necessitating the location of new collection stations.

Standard methods of chemical analysis were used to determine total ash, crude protein, crude fat, crude fiber, phosphorus, calcium, magnesium, and sulfur. In addition, nitrogen-free extract and calcium-phosphorus ratios were calculated.

Dietary Requirements of Grazing Animals

CHEMICAL analysis, alone, gives only a partial picture of the adequacy of a given plant as livestock feed in that it ignores the important fact that by no means all of the various constituents are available to the animal. The digestion coefficient or percent of each constituent actually digested by the animal would be a valuable addition to these data. However, as a general index to forage value, chemical analysis generally is accepted to be of great value.

The first requirement of a grazing animal is food to maintain its body processes and normal muscular activity without body weight loss, which is known as the *maintenance requirement*. To meet these demands it is necessary to have (a) protein for repairing and building body tissues, (b) fats and carbohydrates for producing heat and energy, and (c) mineral materials for building bone and continuing general body functions. Growth and fattening take place only after the requirements for maintenance are met.

Protein Requirement. Animals grazing on the range require different qualities of feed depending upon whether they are growing, fattening, reproducing, or merely maintaining themselves. Good quality roughage with about 7 to 8 percent protein is satisfactory for maintaining mature cattle but growing animals require a higher percentage of protein. For rapid growth, 10 to 12 percent protein in the ration appears adequate (*4*). Some experimental work indicates that protein contents in excess of 16 to 18 percent do not add greatly to the value of a forage (*6*). Adequate amounts of fat and carbohydrate probably reduce the protein requirement to a minimum.

In general, forage requirements for pregnant cows and ewes do not differ greatly from maintenance requirements. During the last 3 months of gestation, however, the protein and mineral requirements are increased materially. Throughout pregnancy, the protein requirement is about 17 percent higher and, in late pregnancy, may be 40 percent higher (*11*).

During lactation, the requirement of both phosphorus and calcium is well above the maintenance requirement.

Mineral Requirement. Of the minerals not supplied in normal range salting, phosphorus and calcium are clearly the most important to the range manager for they are most likely to be deficient. Both are essential for bone growth and numerous body functions. Inadequate amounts result in deficiency diseases known variously as sweeny, creeps, osteophagia, and others. In addition, cattle appear to make more economical use of forage when phosphorus is adequate. Only rarely is sulfur deficient in range forage.

The phosphorus and calcium requirements for maintenance of cattle are not well known. The minimum satisfactory calcium content of range forage is probably about 0.25 percent and the minimum for phosphorus 0.12 percent (*12*). The minimum phosphorus content required for growth in cattle varies between 0.10 and 0.26 percent of the diet (*7*), although about 0.20 is generally considered desirable (*4*). Mitchell and McClure (*7*) found the phosphorus and calcium requirement in the forage to vary with the size of steer. They estimated that a 300 pound growing steer required 0.35 percent phosphorus and 0.43 percent calcium, while a 1200 pound animal required only 0.17 percent phosphorus and 0.11 calcium.

Investigators in Texas found that sheep (assuming a daily dry matter intake of 3.0 pounds) required 0.25 percent phosphorus in the ration and 0.66 percent calcium (*1*); however, Mitchell and McClure (*7*) found that, under the best conditions of mineral utilization, rations containing 0.15 percent phosphorus and 0.13 percent calcium were adequate for normal growth.

In pregnant cows, phosphorus requirement rises to about 0.25 percent of the feed in the 8th month of pregnancy and to about 0.35 percent during the last month. Similarly, calcium requirement rises from 0.19 percent to 0.42 percent (*7*). Studies made in California show that lactating cows require only 0.20 percent of phosphorus in the feed (*4*).

Pregnant ewes require a ration containing about 0.18 percent of phosphorus and about 0.18 percent of calcium, whereas milking ewes should have about 0.19 percent phosphorus and 0.23 percent calcium (*7*).

A group of 48 good pastures in England was found to contain an average of 0.790 percent calcium and 0.334 percent phosphorus in the forage (*10*).

As well as total content of calcium and phosphorus, the ratio of calcium to phosphorus may be important. The ideal ratio is from 1:1 to 2:1 (*8*, *11*); however, if ample vitamin D is present, much wider ratios have been found satisfactory. In the presence of adequate vitamin D, a ratio of 5:5 to 1 has proved adequate (*7*), and a ratio of 6.5:1 was found

adequate for growing calves (*8*). There seems to be little doubt that increasing the absolute amount of phosphorus tends to offset difficulties arising from an excessively high calcium-phosphorus ratio (*7*). Ratios of as high as 10:1 have, under certain conditions, proved satisfactory.

The relationship existing between calcium, phosphorus, and vitamin D is not well understood, hence an absolute expression of the calcium-phosphorus ratio limitation is impossible. It is known that vitamin D is absent in growing pasture plants (5) but, since it is readily obtained by animals through radiation by ultraviolet light in sunshine, it is doubtful if there is normally a deficiency among grazing animals.

Magnesium is probably in all cases adequate for animals grazing on natural vegetation (*10*). Sulfur also is unlikely to be lacking in pasture. Although actual requirements of these minerals are little known, a group of adequate diets reported by Orr contained 0.24 to 0.51 percent magnesium and a group of high producing pastures in Scotland contained an average of 0.428 percent sulfur, varying from 0.262 to 0.551 percent (*10*). Magnesium contents as low as 0.1 percent have proved adequate (5).

Since total ash may be composed of such a diverse number of elements of such variable availability to the animal, the total ash content of a diet has little or no significance without further elaboration.

Fat Requirements. Animals appear to be able to exist with but little fat in the diet provided adequate carbohydrates, proteins, and vitamins are present. Carbohydrates are readily changed into fats and, hence, are a source of most of the fats which are essential constituents of animal tissue (5). It is doubtful if grazing animals ever suffer from lack of fat in the diet (5, *8*), hence the fat content is of interest only in that fat is a concentrated source of heat and energy.

Nitrogen-free Extract and Fiber Relationships. The carbohydrates of the plant are broken down in analysis to nitrogen-free extract and fiber. In general, the nitrogen-free extract contains the sugars, starches, and hemicellulose, whereas the fiber consists of cellulose and other polysaccharides. This represents roughly the digestible and the non-digestible fractions although it is known that large parts of the nitrogen-free extract may be unused by the animal and large parts of the fiber may be digested (*9*). Despite these limitations, this breakdown is a useful measure of the nutritive value of the carbohydrates (5).

Experimental Results

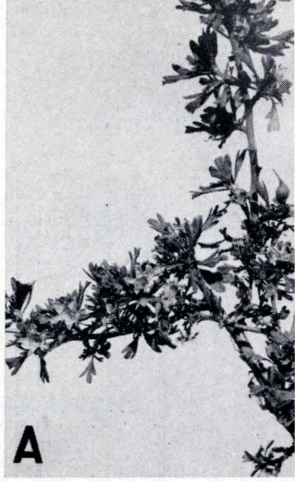
Ash. In general, forbs were higher in ash than any other class of vegetation at all seasons (table 1). Grasses in the spring were higher in

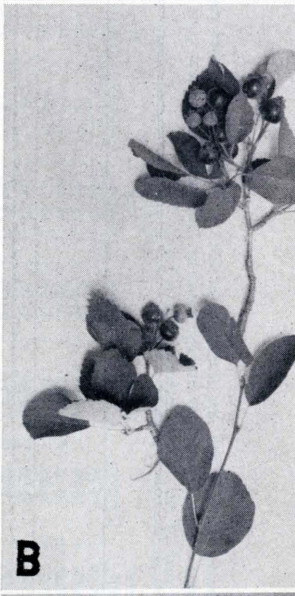
ash than were browse plants although by fall the browse was higher than the grass, presumably because of greater leaching in grasses. Grasses tended to decrease in total ash as the season progressed although many species increased in ash from August to September. Browse plants, conversely, tended to increase rapidly in ash content as they matured. These results agree with analyses in California (2), in which it was found that deciduous-leaved shrubs increased in ash content as they matured whereas herbs decreased.

In the spring, consistently high ash contents were exhibited by stoneseed (*Lithospermum ruderale*), butterweed, niggerhead, and yarrow (table 2) and in the fall by niggerhead, butterweed, and twinberry (table 3). Low ash content was found regularly in bitterbrush (figure 2A) and yellow willow in the spring, and in bitterbrush, mountain brome, needlegrass, and the wheatgrasses in the fall.

Protein. Protein showed the most definite seasonal trend of all chemical constituents. All species and all classes of vegetation exhibited marked decreases in protein as they matured. Much the most rapid drop in all classes occurred during June and July (figure 3), the decrease thereafter being less rapid. The forbs although high in protein, as a class decreased more rapidly than any other class of vegetation. Browse plants maintained their protein level better than any other class of vegetation.

Grasses were at all seasons lower than any other class of vegetation in protein content (table 1) and the forbs weer somewhat higher than were the browse plants, especially in the spring. Experiments in California found deciduous-leaved shrubs to exceed all





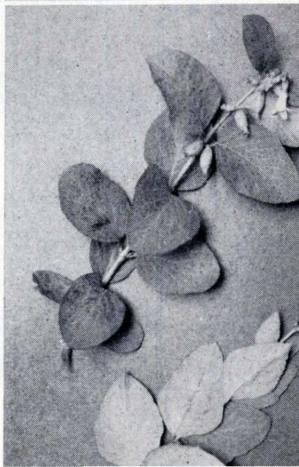


Figure 2A. Bitterbrush (*Purshia tridentata*) a low-growing dark green shrub producing inconspicuous yellow flowers with five petals. The leaves are three-toothed and grey colored on the under surface

Figure 2B. Serviceberry (*Amelanchier alnifolia*), a tall-growing shrub producing white flowers with five petals early in the spring. These are followed by a small apple-like edible fruit, dark purple to black in color when ripe

Figure 2C. Snowberry (*Symphoricarpos rotundifolius*) is a low-growing shrub forming dense mats and is abundant in western mountains. The flowers are trumpet shaped and white or light pink in color. The fruits are white and juicy yet bitter in taste but are relished by grazing animals

Table 1. *Average percentage of each constituent in early and late season collections of forage plants from northern Utah mountainous summer ranges by class of forage. The grass data represent the average value of the 7 most important grass forages, the browse of the 10 most important browse forages, and the forb of the 7 most important forb forages**

Vegetation class	Season	Year	Total ash	Protein	Crude fat	Fiber	Nitrogen-free extract	Calcium	Magnesium	Phosphorus	Sulfur	Calcium-phosphorus ratio
GRASS	Spring	1934	8.59	9.43	3.21	29.80	48.96	0.62	.167	.148	.166	4.39
		1935	8.34	13.94	1.83	26.00	49.89	0.57	.135	.342	.250	1.65
		1936	8.38	19.14	2.01	26.71	43.76	0.72	.161	.365	.253	1.98
		1937	7.34	13.25	2.80	31.11	45.67	0.45	.204	.278	.197	1.51
		Avg.	8.16	13.94	2.46	28.40	47.07	0.59	.167	.283	.216	2.38
	Fall	1934	7.54	7.60	3.31	31.76	49.78	0.67	.132	.139	.145	5.22
		1935	7.26	6.07	2.89	36.34	47.45	0.42	.188	.229	.142	1.88
		1936	7.57	.....	3.44	36.27	.....	0.37	.128	.227	.152	2.72
		1937	6.49	5.07	2.22	38.09	47.03	0.68	.094	.144	.144	2.95
		Avg.	7.21	6.25	2.96	35.61	48.09	0.53	.135	.185	.146	3.19
	Grass avg.		7.68	10.09	2.71	32.00	47.58	0.56	.151	.234	.181	2.78
BROWSE	Spring	1934	7.07	11.69	4.21	14.41	62.64	1.96	.377	.272	.200	7.85
		1935	7.49	21.39	2.50	13.36	55.26	1.21	.322	.494	.275	2.47
		1936	6.95	20.01	3.20	12.55	57.28	1.18	.341	.467	.271	2.72
		1937	6.68	18.01	4.25	13.34	57.72	1.28	.375	.414	.251	3.72
		Avg.	7.05	17.77	3.54	13.41	58.22	1.41	.354	.412	.249	4.19
	Fall	1934	10.06	9.81	4.85	15.97	59.31	2.41	.458	.234	.223	10.81
		1935	9.15	10.66	5.30	14.82	60.07	2.26	.484	.558	.232	4.88
		1936	8.05	11.63	4.42	16.52	58.13	2.39	.522	.717	.234	3.75
		1937	7.40	.....	5.67	17.15	.....	2.09	.446	.321	.217	6.60
		Avg.	8.66	10.70	5.06	16.11	59.17	2.29	.477	.457	.226	6.51
	Browse avg.		7.85	14.23	4.30	14.76	58.69	1.85	.415	.434	.237	5.35
FORB	Spring	1934	10.95	13.87	3.72	19.06	52.40	2.06	.357	.258	.230	7.83
		1935	11.34	26.23	2.25	15.25	44.92	1.33	.309	.516	.304	4.31
		1936	11.07	31.96	3.18	13.90	42.14	1.09	.281	.603	.359	3.98
		1937	9.39	23.78	3.78	18.66	44.45	1.05	.353	.528	.311	3.74
		Avg.	10.69	23.96	3.23	16.72	45.98	1.38	.325	.476	.301	4.95
	Fall	1934	12.42	9.90	4.32	23.32	50.03	2.37	.327	.227	.224	11.03
		1935	10.87	10.21	6.03	19.29	53.59	2.22	.477	.442	.228	5.31
		1936	9.83	14.50	4.20	21.65	48.01	2.62	.382	.545	.294	4.75
		1937	8.69	.....	3.72	31.73	.....	1.71	.387	.280	.223	6.73
		Avg.	10.45	11.54	4.57	24.00	50.54	2.23	.393	.373	.242	6.95
	Forb avg.		10.57	17.75	3.90	20.36	48.26	1.80	.359	.424	.272	5.95
AVERAGE			8.70	14.02	3.64	22.37	51.51	1.40	.308	.364	.230	4.69

*The grasses used were *Agropyron inerme, Agropyron subsecundum, Bromus carinatus, Carex rostrata, Elymus condensatus, Poa pratensis,* and *Stipa lettermani.*
The shrubs used were *Amelanchier alnifolia, Chrysothamnus nauseosus, Chrysothamnus viscidiflorus, Lonicera involucrata, Populus tremuloides, Prunus melanocarpa, Purshia tridentata, Rosa spauldingii, Salix lutea,* and *Symphoricarpos rotundifolius.*
The forbs used were *Achillea lanulosa, Agastache urticifolia, Geranium fremontii, Lathyrus leucanthus, Rudbeckia occidentalis, Senecio serra,* and *Vicia americana.*

Table 2. *Four-year average composition of major grass, forb, and browse plants collected in June from northern Utah mountainous summer ranges, together with their class rating as a source of each constituent, A denoting a highly reliable source, B a generally good source, C a variable or average source, D a generally poor source, and E a universally poor source**

Constituent	Total ash		Crude protein		Crude fat		Crude fiber		Nitrogen-free extract		Phosphorus		Calcium		Magnesium		Sulfur		Calcium-phosphorus ratio	
Species	%	Class	%	Class	%	Class	%	Class	%	Class	%	Class	%	Class	%	Class	%	Class	Ratio	Class
Agropyron inerme	7.08	C	14.10	E	2.85	C	27.02	B	48.90	C	.270	E	0.73	D	.127	E	.202	D	3.47	C
Agropyron subsecundum	6.93	D	14.09	D	2.19	D	26.57	B	50.18	C	.336	D	0.57	D	.139	E	.189	E	1.31	D
Bromus carinatus	9.74	C	13.03	E	2.04	D	29.03	A	46.15	D	.426	C	0.54	E	.191	D	.236	D	1.71	E
Carex rostrata	7.40	C	13.32	E	1.99	D	28.72	A	50.14	C	.293	E	0.56	E	.183	D	.245	C	2.31	C
Elymus condensatus	7.71	C	14.87	D	2.04	C	30.99	A	44.38	E	.235	E	0.43	E	.111	E	.194	E	2.60	D
Poa pratensis	10.15	B	15.86	D	2.31	C	28.17	A	43.49	D	.332	D	0.50	E	.251	D	.271	C	1.41	E
Stipa lettermani	7.64	C	15.53	C	2.54	C	28.04	A	46.24	C	.256	E	0.73	D	.146	E	.186	E	3.09	C
Amelanchier alnifolia	6.67	D	18.03	C	3.92	A	13.41	D	57.96	B	.485	B	1.60	B	.430	A	.254	C	4.54	C
Chrysothamnus nauseosus	8.85	C	20.68	C	2.40	C	19.66	C	48.45	C	.451	B	0.95	C	.287	C	.296	B	3.66	C
Chrysothamnus viscidiflorus	9.75	C	22.61	B	3.85	B	13.84	D	49.90	C	.465	B	0.99	C	.263	C	.356	A	2.12	C
Lonicera involucrata	6.84	D	18.25	C	2.37	C	10.52	E	62.01	A	.421	C	1.05	C	.327	C	.258	C	2.47	C
Populus tremuloides	6.24	D	19.29	C	4.67	A	13.48	D	56.29	B	.508	B	1.35	C	.355	B	.289	C	2.88	C
Prunus melanocarpa	7.06	D	15.90	C	3.15	C	10.84	E	63.05	A	.409	B	1.80	A	.416	A	.163	E	4.63	B
Purshia tridentata	4.79	E	15.36	C	4.37	A	16.18	C	59.32	B	.226	E	1.38	C	.238	D	.143	E	6.48	A
Rosa spauldingii	7.60	C	18.59	C	3.66	B	11.73	E	58.40	B	.530	A	1.50	B	.452	B	.263	B	2.99	C
Salix lutea	5.81	E	17.72	C	3.09	C	13.68	D	59.69	A	.295	E	1.68	A	.343	B	.273	C	5.73	A
Symphoricarpos rotundifolius	6.91	D	15.95	C	3.89	B	11.73	E	61.49	A	.381	C	1.22	C	.344	C	.244	C	3.64	C
Achillea lanulosa	11.38	A	16.46	C	3.05	C	17.60	C	51.39	C	.396	C	1.19	C	.381	B	.209	D	3.32	C
Agastache urticifolia	11.93	B	22.85	B	3.05	C	15.83	C	46.33	D	.422	C	1.49	B	.427	B	.299	B	4.02	C
Geranium fremontii	7.16	D	18.82	C	3.31	C	8.39	E	62.31	A	.484	A	1.25	C	.243	D	.245	C	3.12	C
Lathyrus leucanthus	9.67	C	22.27	A	3.04	C	27.29	A	37.72	E	.422	B	1.33	C	.239	D	.234	C	4.02	C
Lithospermum ruderale	15.32	A	17.21	C	3.04	C	15.79	C	48.64	C	.358	C	2.52	A	.281	C	.288	B	7.87	B
Rudbeckia occidentalis	11.52	A	28.41	A	4.07	B	11.19	E	44.79	D	.623	A	1.57	C	.325	C	.387	A	3.49	C
Senecio serra	14.69	A	25.24	A	3.78	B	12.52	D	43.86	D	.596	A	1.56	C	.373	B	.528	A	8.63	A
Vicia americana	8.47	C	27.28	A	2.31	D	24.19	B	37.76	E	.393	C	1.30	C	.283	C	.204	D	8.08	A

*These classifications of good and poor sources are strictly comparative and do not indicate a superabundance or deficiency so far as livestock is concerned.

Table 3. *Four-year average composition of major grass, forb, and browse plants collected in September from northern Utah mountainous summer ranges, together with their class rating as a source of each constituent, A denoting highly reliable source, B a generally good source, C a variable or average source, D a generally poor source, and E a universally poor source**

Constituent	Total ash		Crude protein		Crude fat		Crude fiber		Nitrogen-free extract		Phosphorus		Calcium		Magnesium		Sulfur		Calcium-phosphorus ratio	
Species	%	Class	%	Class	%	Class	%	Class	%	Class	%	Class	%	Class	%	Class	%	Class	Ratio	Class
Agropyron inerme	6.07	E	6.05	E	4.25	C	34.10	A	50.09	C	.178	E	0.51	D	.121	E	.131	C	3.65	C
Agropyron pauciflorum	6.76	E	4.72	E	3.07	D	39.41	A	45.95	E	.130	E	0.36	E	.356	C	.122	E	3.10	D
Agropyron subsecundum	5.22	E	4.29	E	2.25	E	42.49	A	45.73	E	.105	E	0.32	E	.064	E	.090	E	2.97	C
Bromus carinatus	5.78	E	3.04	E	1.84	E	44.24	A	44.69	E	.247	E	0.40	D	.144	E	.105	E	1.70	E
Carex rostrata	9.31	C	11.25	C	2.26	E	29.93	B	48.24	D	.333	C	0.58	D	.212	C	.237	C	1.71	D
Elymus condensatus	7.50	D	4.26	E	2.97	D	39.08	A	45.96	E	.130	E	0.37	E	.123	E	.112	D	3.92	C
Poa pratensis	9.53	C	8.77	C	2.46	D	30.42	B	49.95	C	.184	C	0.36	E	.153	D	.213	C	3.79	D
Stipa lettermani	6.57	E	6.25	E	3.88	C	34.51	B	49.32	C	.161	E	0.96	D	.121	E	.124	D	2.79	D
Amelanchier alnifolia	8.51	C	10.90	B	6.23	B	14.78	C	59.45	B	.623	A	2.32	C	.466	C	.138	D	4.83	C
Chrysothamnus nauseosus	8.83	C	12.85	B	3.17	D	22.62	C	52.21	C	.384	C	1.38	C	.395	C	.286	A	2.74	C
Chrysothamnus viscidiflorus	7.97	C	12.10	B	4.68	C	25.81	C	51.43	C	.352	C	1.46	C	.446	C	.267	A	5.31	C
Lonicera involucrata	11.04	A	9.64	C	5.28	C	11.56	E	62.42	A	.620	B	2.73	A	.615	A	.415	A	7.35	B
Populus tremuloides	8.54	B	9.50	C	6.24	C	14.98	C	62.52	A	.305	C	3.02	A	.579	B	.261	B	7.12	B
Prunus melanocarpa	10.25	B	8.12	C	6.50	A	11.49	E	62.46	A	.667	A	3.03	A	.543	A	.093	E	5.79	C
Purshia tridentata	4.86	E	10.27	B	5.65	A	21.16	C	58.70	B	.165	E	1.48	C	.206	D	.120	E	9.55	A
Rosa spauldingii	8.26	C	11.65	B	6.25	B	11.44	E	61.84	A	.647	A	2.34	B	.570	A	.238	C	4.61	C
Salix lutea	7.67	D	11.09	B	2.60	E	14.28	C	63.32	A	.242	C	2.51	B	.379	B	.185	C	11.73	A
Symphoricarpos rotundifolius	9.73	C	8.68	C	4.58	C	13.61	E	63.21	A	.518	A	2.58	B	.598	A	.323	C	6.60	C
Achillea lanulosa	10.94	B	11.73	B	4.94	C	23.44	C	50.45	C	.357	C	1.68	C	.421	C	.156	C	5.97	C
Agastache urticifolia	9.29	C	8.31	C	5.16	B	24.97	C	55.55	B	.312	C	1.98	C	.468	C	.174	C	7.06	B
Geranium fremontii	9.16	C	7.55	D	5.47	B	14.09	D	65.88	A	.494	A	2.25	B	.355	C	.174	C	5.18	C
Lathyrus leucanthus	7.88	C	13.30	B	2.35	E	36.30	B	42.00	E	.299	C	1.42	C	.237	C	.151	C	5.61	C
Rudbeckia occidentalis	15.13	A	14.90	A	7.85	A	11.64	E	51.47	C	.435	A	2.93	A	.546	C	.319	B	7.23	B
Senecio serra	13.94	A	8.70	D	4.62	C	21.22	C	53.11	C	.474	B	3.32	A	.455	C	.593	A	7.98	A
Vicia americana	8.07	C	12.03	B	2.51	E	33.48	B	44.97	E	.217	E	2.10	C	.310	C	.133	D	10.27	A

*These classifications of good and poor sources are strictly comparative and do not indicate a superabundance or deficiency so far as livestock is concerned.

other plant classes in protein content whereas grasses were consistently low (2).

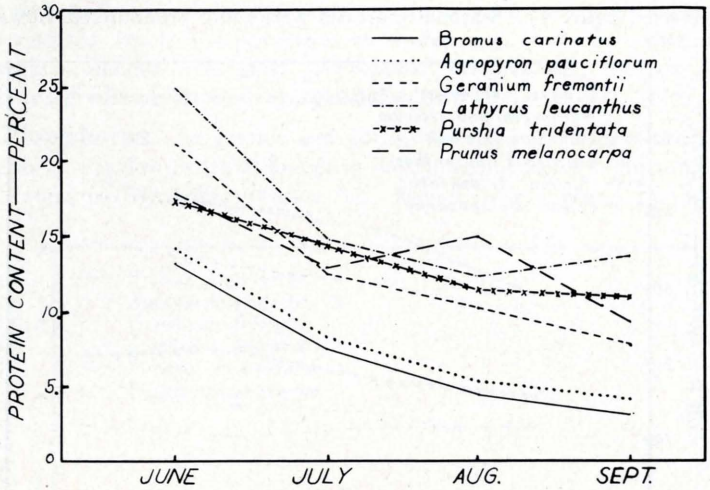


Figure 3. Seasonal variation in protein content of six major forage species on mountain ranges of Utah, 1935-1937

Of the grasses, Kentucky bluegrass and needlegrass were consistently highest in protein content (table 4). Niggerhead was consistently higher in protein than any other plant, although in the spring butterweed, vetch and peavine also were always high. Niggerhead, in one instance, contained in excess of 35 percent protein and even at the close of the grazing season it was found to average almost 15 percent (tables 2 and 3). All grasses ranked low in protein content although the grass-like *Carex rostrata* maintained an excellent protein content in the fall. Contents as low as 3 to 5 percent were common in the grasses in late summer. This low protein content of grasses is common everywhere (*2, 12*) and emphasizes the importance of other classes of forage, especially upon fall ranges.

Crude Fat. Fat content was found to be highly variable through the season although the general trend was upward. Grasses were found to be low in fat content, averaging as a class only 2.71 percent as compared to 3.90 for forbs and 4.30 for browse (table 1). Consistently high fat contents were found in aspen, bitterbrush, and serviceberry (figure 2B) in the spring, whereas, by September, bitterbrush, niggerhead, and chokecherry were outstanding.

Crude Fiber. Fiber content was found at all times to be highest in grasses, intermediate in forbs, and lowest in browse. This agrees with

California range plant studies which showed deciduous shrubs to be lower than forbs in fiber and grasses to be higher, regardless of season (2). In all classes there was a pronounced increase in fiber content as the season progressed (figure 4). Seasonal increases were more pronounced, however,

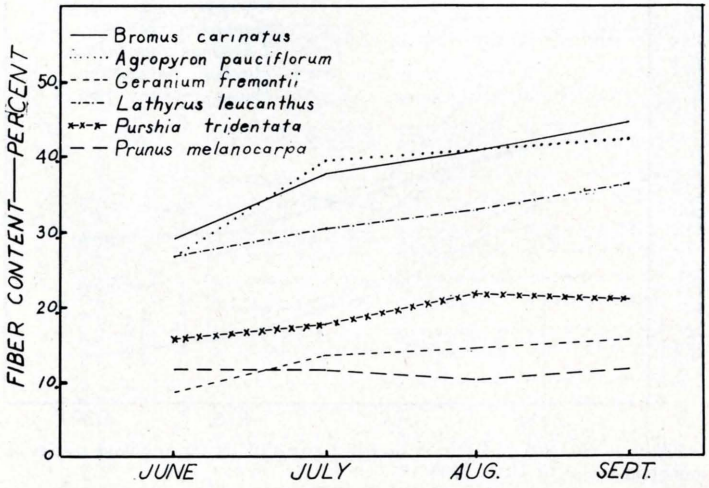


Figure 4. Seasonal variation in fiber content of six major forage species on mountain ranges of Utah, 1935-1937

in grasses and forbs than in browse, the browse plants as a class increasing only from 13.41 percent to 16.11 percent from June to September (table 1). In almost all species there was a progressive increase each month, however, some grasses failed to show increases from August to September.

Many exceptionally high fiber contents were found, especially in the grasses. As a class, the grasses averaged a fiber content of over 35 percent in September, and mountain brome averaged over 44 percent. Individual fiber contents in excess of 40 percent were not at all uncommon in the grasses and, as a group, they consistently outranked all other forage plants. Notably high fiber contents, however, were found in vetch and peavine at all seasons, these averaging 33.48 and 36.30 percent, respectively, in September. At all seasons geranium, niggerhead, twinberry, chokecherry, rose and snowberry (figure 2C) were notably low in fiber.

Nitrogen-Free Extract. Nitrogen-free extract was found to be highly variable, seasonally. In general, there was a tendency for it to increase as the plants matured but many exceptions were apparent both between species and between years. As a class, the browse plants were consistently higher in nitorgen-free extract than any other class. Over the grazing season, the browse averaged over 58 percent whereas grasses and forbs averaged 47.58 and 48.26 percent, respectively.

Consistently higher ratings were obtained for twinberry, chokecherry, yellow willow, snowberry, and geranium (figure 6A) in the spring, whereas, in the fall, aspen and rose, in addition to the above group, contained large amounts of nitrogen-free extract. Low values were obtained for giant ryegrass, vetch, and peavine at all seasons and, in the fall, mountain bromegrass, slender wheatgrass (*Agropyron pauciflorum*) (figure 6B), and bearded wheatgrass were exceptionally low.

Phosphorus. In grasses and forbs, the general seasonal trend in phosphorus was downward although in individual instances slight increases were found in September (figure 5). Browse plants began the season

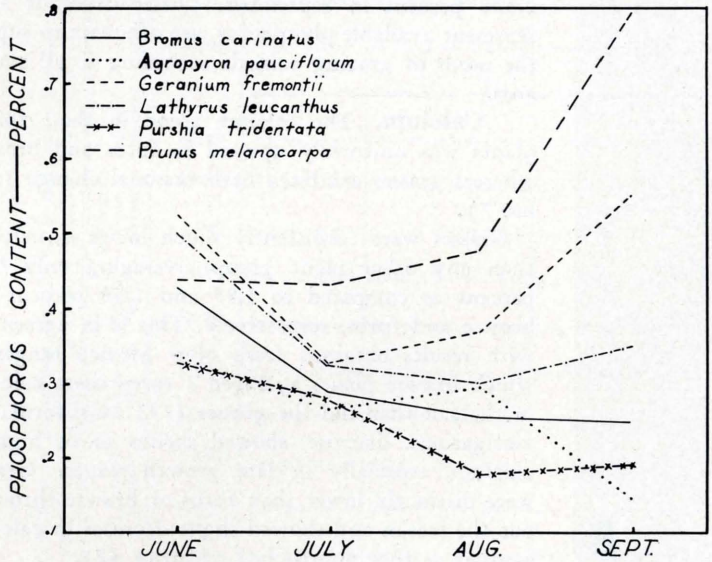
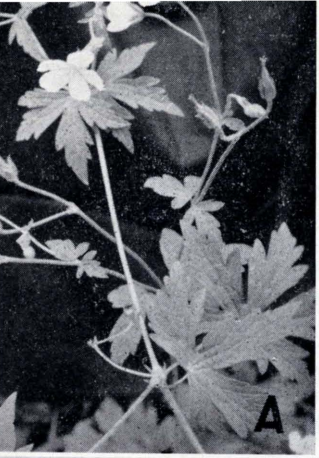
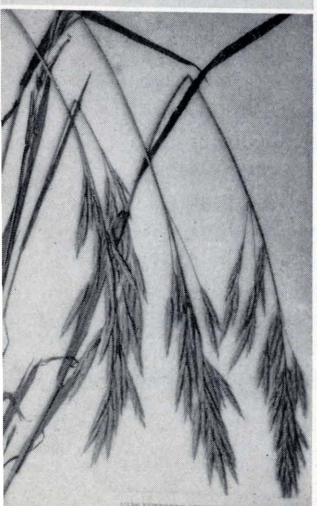


Figure 5. Seasonal variation in phosphorus content of six major forage species on mountain ranges of Utah, 1935-1937

at a lower level than did forbs, but, since the shrubs increased in phosphorus whereas other classes decreased, they ended the season at a higher level than any other class of plants. Grasses were uniformly lower than any other class of vegetation in phosphorus content. In New Mexico, browse plants were found to be 61 percent higher in phosphorus than were the grasses in the fall (*12*). California studies showed a downward trend in the phosphorus content of range plants throughout the season. In early growth stages, shrubs were highest in phosphorus and grasses lowest, however, in late stages, little difference existed between shrubs, grasses, and forbs (*2*).

Plants having consistently high phosphorus contents in the spring were





niggerhead, rose, butterweed, and geranium. Bitterbrush, yellow willow, and all grasses excepting bromegrass were unusually low in phosphorus (table 2). In the fall, high phosphorus values were found consistently in serviceberry, chokecherry, rose, snowberry, geranium, and niggerhead. Vetch, bitterbrush, needlegrass, giant ryegrass, mountain bromegrass (figure 6C), and all wheatgrasses were consistently low in phosphorus in the fall. Mountain bromegrass was, however, outstandingly high among the grasses (table 4).

The phosphorus levels on all vegetation were surprisingly high, averaging 0.39 percent in June and 0.338 percent in September. These values, if they represent available phosphorus, are adequate to supply the needs of grazing animals according to all standards.

Calcium. The calcium trend in these forage plants was uniformly upward in forbs and browse, whereas grasses exhibited little seasonal change (figure 7).

Grasses were consistently much lower in calcium than any other plant group, averaging only 0.56 percent as compared to 1.85 and 1.80 percent for browse and forbs, respectively. This is in agreement with results obtained from New Mexico ranges in which browse plants averaged 3 times more calcium in the fall than did the grasses (*13*). California investigations, likewise, showed shrubs to be high in calcium, especially in late growth stages. Grasses were distinctly lower than forbs or browse throughout the season and showed slight decreaes in calcium content as they approached maturity (*2*).

Figure 6A. Wild geranium (*Geranium fremontii*) is a common forb in western mountains. Its five-petaled flowers, white to pink in color, are followed by dry seed-like fruits bearing a long beak, an inch or more in length

Figure 6B. Slender wheatgrass (*Agropyron pauciflorum*) is one of the most common mountain grasses and is widely used as a dry-pasture plant. It grows in bunches or small tufts and differs from many of the wheatgrasses in having no awns or bristles

Figure 6C. Mountain bromegrass (*Bromus carinatus*) is a common mountain grass. It grows, about three feet tall and produces large, heavy seed heads in midsummer

Table 4. *Four-year average intra-forage-class comparisons for various constituents in early and late season collections from northern Utah mountainous summer ranges, – denoting consistently low and * denoting consistently high content*

Constituent	Total ash		Crude protein		Crude fat		Crude fiber		Nitrogen-free extract		Phosphorus		Calcium		Magnesium		Sulfur		Calcium-phosphorus ratio	
Season	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late
Agropyron inerme	–	0	0	0	0	*	0	0	0	0	0	0	*	*	–	0	0	0	*	0
Agropyron pauciflorum	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0
Agropyron subsecundum	0	–	0	0	0	0	0	*	0	0	0	0	0	0	0	–	0	–	0	0
Bromus carinatus	0	0	0	0	0	–	0	*	0	–	*	*	0	0	0	0	0	0	–	–
Elymus condensatus	0	0	0	0	0	0	*	0	0	0	–	–	0	0	–	0	0	–	0	0
Poa pratensis	*	*	*	*	0	0	0	–	0	*	*	0	0	0	*	0	*	*	0	0
Stipa lettermani	0	0	*	*	0	*	0	0	0	0	0	0	*	*	0	0	0	0	0	0
Amelanchier alnifolia	0	0	0	0	*	*	0	0	0	0	0	*	0	0	*	0	0	–	0	0
Chrysothamnus nauseosus	0	0	0	0	–	0	*	*	–	–	0	0	–	–	0	0	*	*	0	–
Chrysothamnus viscidiflorus	*	0	*	*	*	0	0	*	–	–	0	0	–	–	–	0	*	0	–	0
Lonicera involucrata	0	*	0	–	0	0	–	–	*	0	0	0	0	*	0	*	0	*	0	*
Populus tremuloides	0	*	0	0	*	0	0	0	0	0	0	–	0	*	0	0	0	0	0	*
Prunus melanocarpa	0	0	–	0	0	*	–	–	*	0	*	*	*	0	0	0	–	–	0	*
Purshia tridentata	–	–	0	0	0	*	*	*	0	0	0	–	0	–	–	–	–	–	*	*
Rosa spauldingii	0	0	*	0	0	0	–	–	0	0	*	*	0	0	*	*	0	0	–	*
Salix lutea	–	–	*	0	0	–	0	0	0	0	–	–	*	0	0	0	0	0	*	*
Symphoricarpos rotundifolius	0	0	–	–	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0
Achillea lanulosa	0	0	0	0	0	0	0	0	0	0	0	0	0	–	*	0	0	–	0	0
Agastache urticifolia	0	0	–	–	0	0	0	0	0	0	0	–	0	0	*	*	0	0	0	0
Geranium fremontii	–	–	–	–	0	0	–	–	*	*	0	*	0	0	–	0	0	0	0	0
Lathyrus leucanthus	–	–	0	*	0	–	*	*	–	–	0	0	0	–	–	–	0	–	0	0
Lithospermum ruderale	*	*	–	0	0	0	0	0	0	0	–	0	0	0	0	0	0	0	0	0
Rudbeckia occidentalis	*	*	*	*	*	*	–	–	0	0	*	*	0	*	0	0	*	*	0	0
Senecio serra	*	*	*	–	*	0	–	–	0	0	*	*	0	*	0	0	*	*	*	*
Vicia americana	–	–	*	0	–	–	*	*	–	–	0	–	0	0	0	0	–	–	*	*

In June, stoneseed with a calcium content of 2.52 percent was outstandingly high, though yellow willow and chokecherry were also consistently high. In September, niggerhead, butterweed, chokecherry, aspen, and twinberry were high in calcium whereas the grasses as a group all tended to be low. Among the browse plants both species of *Chrysothamnus* were consistently low in calcium at all seasons (table 4).

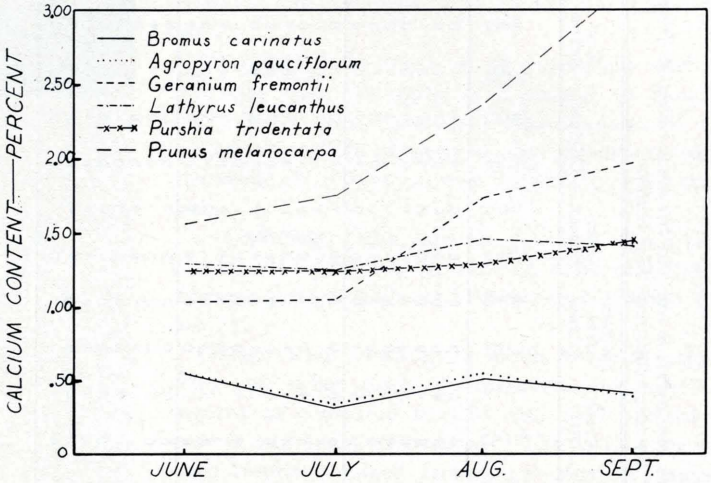


Figure 7. Seasonal variation in calcium content on six major forage species on mountain ranges of Utah, 1935-1937

Magnesium. No seasonal trend was evident in magnesium content although increases were common from August to September. As a group, browse appeared to contain more magnesium than forbs, whereas the grasses were materially lower than any other group.

In the spring, serviceberry and chokecherry were consistently high in magnesium whereas, in the fall twinberry, chokecherry, rose, and snowberry were outstanding. All grasses, excepting slender wheatgrass in the fall were low in magnesium at all seasons.

Sulfur. Seasonal trends in sulfur content were definitely downward, although increases from August to September were common. Heavy declines were universal from June to July. These trends are opposite to analyses reported by Orr (*10*) in which sulfur increased throughout the season.

As a group, the grasses were found to be notably below any other in sulfur content, the forbs being intermediate, and the browse high.

Outstanding as a source of sulfur was butterweed in both early and late collections. In addition, yellowbrush and niggerhead were consistently

high in the spring and rabbitbrush (figure 8A), yellowbrush (figure 8B), and twinberry in the fall.

Calcium-phosphorus ratio. The ratio obtained by dividing the calcium content of a plant by the phosphorus content is known as the calcium-phosphorus ratio and is considered by many nutritionists to be of great importance, since the phosphorus is likely of lessened value to the animals when it occurs in the presence of large amounts of calcium.

Great change is effected in the composition of forage with advancing maturity by leaching of the soluable constituents and by redistribution within the plant. It is likely that phosphorus is distinctly lowered but calcium is not greatly affected, hence the calcium-phosphorus ratio can be expected to widen with maturity of the plant (2). In all instances, such increases in the ratio were found as the season advanced, but rises were especially rapid in the browse and forb groups.

Grasses had materially lower ratios than did shrubs and forbs, averaging 2.78 as compared to 5.35 and 5.95, respectively, for shrubs and forbs. All of these ratios are excessively high, ratios of between 1 and 2 being desirable. California studies (2) showed the ratio in grasses to be from 0.7 to 1.8 and to remain constant throughout the life of the plant. Forbs and shrubs, conversely, increased the ratio greatly as they matured, reaching levels of 50 or more to 1 in extreme instances.

Consistently high calcium-phosphorus ratios for all seasons were found in vetch, butterweed, yellow willow and bitterbrush, whereas consistently low ratios were found in Kentucky bluegrass and mountain bromegrass in the spring and in mountain bromegrass in the fall.

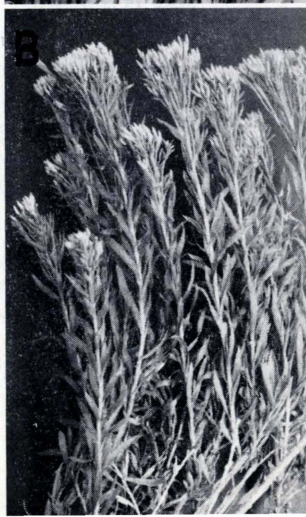


Figure 8A. Rabbitbrush (*Chrysothamnus nauseosus*) is usually taller than yellowbrush, often three to four feet high, and its leaves are not so green in color nor do they twist. This plant is common in the West, especially in dry bottomlands. It, likewise, produces large and beautiful bright yellow flower heads in late summer

Figure 8B. Yellowbrush (*Chrysothamnus viscidiflorus*) is a bright green shrub, usually only about a foot in height, producing bright yellow flowers in midsummer. A slight twist in the leaves is common in this species

Animal Diet

SINCE the 24 forage plants included in this study were present on the range in different quantities, a common mathematical average of the plant compositions gives an incomplete picture of the forage actually before the animals. For this reason, a weighted average composition was computed based upon floral composition and using both spring and fall analyses. This average is shown in table 5.

Table 5. *Weighted average composition of mountain range forage in percent based upon chemical analyses of the 24 major plant species in June and again in September, weighted according to floral composition*

	Total ash	Crude protein	Crude fat	Crude fiber	Nitrogen-free extract	Phosphorus	Calcium	Magnesium	Sulfur	Calcium-phosphorus ratio
Spring average ..	7.59	18.89	3.45	15.59	55.05	.421	1.34	.339	.243	3.18
Fall average	8.98	9.75	4.80	19.38	57.88	.439	2.25	.456	.281	5.13
Seasonal average.	8.28	14.32	4.12	17.48	56.46	.430	1.79	.397	.262	4.15

These plants actually composed only two-thirds of the entire range flora but, these being the major forage species, it is believed that the weighted averages are fairly indicative of what is actually consumed by grazing animals.

These figures may be compared to an average of 146 alfalfa samples reported by Morrison (*8*) as follows:

Ash	Protein	Fat	Fiber	Nitrogen-free extract
percent	*percent*	*percent*	*percent*	*percent*
9.45	18.11	3.94	27.56	40.94

This diet contains adequate protein in the spring for any kind or class of grazing animal, however, by fall, the protein content falls to 9.75 percent which, though quite adequate for maintaining mature stock, probably is somewhat deficient for rapidly growing animals. This deficiency, however, is not considered serious.

The fiber contents of 15.59 percent in the spring and 19.38 percent in the fall are remarkably low and indicate excellent forage conditions. These contents are both below that of a selected group of good pastures in England which were found to average 23.2 percent fiber (*10*).

The total ash content averaging 8.28 percent compares favorably with Orr's figure of 9.72 percent obtained by averaging the ash content of forage from 48 good pastures in England (*10*).

The phosphorus contents of 0.422 in the spring and 0.439 in the fall are well above the requirement of any kind or class of livestock.

The calcium content is in all seasons excessively high, being 3 to 5 times greater than required by grazing animals. This high calcium con-

tent brings about a calcium-phosphorus ratio of 3.18 in the spring and 5.13 in the fall, a ratio well above the usual standard of about 2.00. This may be compared with a ratio of about 1.88 which exits between these two constituents in the body of the animal (*7*). While definite information is not available upon the seriousness of this ratio in light of a comparatively high phosphorus content, it is considered the most serious condition brought to light by these studies and merits further investigation. Such investigation would preferably involve feeding phosphorus supplement sufficient to bring the ratio to a normal one to determine the effect upon grazing animals.

Summary

UTAH'S range lands support an industry calculated to bring to the state almost 16 million dollars annually. Since these lands can be used economically in no way other than by grazing livestock, it is important that information be obtained on forage value and seasonal variation which will lead to the most efficient and economical use of the range.

Between 1934 and 1937, forage plants were collected at monthly intervals from mountainous summer ranges near Logan, and analyzed for total ash, crude protein, crude fat, crude fiber, nitrogen-free extract, phosphorus, calcium, magnesium, and sulfur. Only those parts of the plant actually being consumed by grazing animals were collected for analysis.

The levels and seasonal trends in each constituent were studied for 24 major forage species throughout the grazing season, major differences in species and forage class being found.

In all plants general decreases were found in protein and sulfur as the season progressed, whereas fiber, nitrogen-free extract, fat, and, except in the case of grasses, calcium increased.

Grasses were always low in protein, fat, calcium, phosphorus, magnesium, sulfur, and calcium-phosphorus ratio compared to other forage groups, and were at all seasons highest in fiber. The low level of all minerals was emphasized in the fall, for without exception, grasses appeared to decrease in mineral content, showing great seasonal fluctuation.

Browse plants were high in fat and nitrogen-free extract and low in fiber compared to other groups. Browse appears to be less subject to leaching and, hence, does not display such great seasonal fluctuation as do other plants.

Forbs were outstandingly high in protein and ash and, in general, displayed seasonal fluctuation intermediate between the grasses and shrubs.

The weighted average composition of the flora available to grazing animals was found to indicate a satisfactory feed, especially in the early season, with the possible exception of the calcium-phosphorus ratio. This ratio, averaging 4.15:1, is considerably above usual standards and under certain conditions may interfere with normal nutrition, especially in the fall season. These studies do not indicate the advisability of supplementing this type of range.

References Cited

1. Fraps, G. S. Mineral requirements of sheep. Texas Agr. Exp. Sta. Bul. 627. 1939.
2. Gordon, A., and Sampson, A. S. Composition of common California foothill range plants as a factor in range management. Calif. Agr. Exp. Sta. Bul. 627. 1939.
3. Guilbert, H. R., Mead, S. W., and Jackson, A. C. The effect of leaching on the nutritive value of forage plants. Hilgardia 6(1): 1-12. 1931.
4. Guilbert, H. R., and Rachford, L. H. Beef production in California. Calif. Agr. Col. Ext. Cir. 115. 1940.
5. Maynard, L. A. Animal nutrition. New York, McGraw-Hill Co., 1937.
6. Maynard, L. A. Interpretation of variations in plant composition in relation to feeding value. Amer. Soc. Agron. Jour. 29:504-511. 1937.
7. Mitchell, H. H. and McClure, F. J. Mineral nutrition of farm animals. Natl. Res. Council Bul. 99. 1937.
8. Morrison, F. B. Feeds and feeding. 20th ed. Ithaca, N. Y., The Morrison Publishing Co., 1936.
9. Norman, A. G. Biological approach to the grass problems. Amer. Soc. Agron. Jour. 31:751-760. 1939.
10. Orr, J. B. Minerals in pastures and their relation to animal nutrition. London, H. K. Lewis and Co. Ltd., 1929.
11. U. S. Department of Agriculture. Food and life. Yearbook of Agriculture 1939. Washington, D. C., U. S. Govt. Printing Office, 1939.
12. Watkins, W. E. The calcium and phosphorus content of important New Mexico range forages. New Mexico Agr. Exp. Sta. Tech. bul. 246. 1937.
13. Watkins, W. E. and Ellis, G. F. Feeding value of New Mexico range grasses in the fall of 1941. New Mex. Agr. Exp. Sta. Press bul. 935. 1942.

College series no. 646