PHENOLOGY AS RELATED TO CHEMICAL COMPOSITION OF PLANTS AND TO CATTLE GAINS ON SUMMER RANGES IN NEVADA

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Johnson, L. E., et al. Cows, calves and grass. S. D. Agric. Expt. Sta. Bull. 412. 1951.

Kennedy, P. B. and S. C. Dinsmore. Digestion experiments on the range. Nev. Agr. Exp. Sta. Bull. 71. 1909.

Kipple, G. E. Weight gains made by range cattle while grazing summer ranges. Rocky Mtn. For. & Range Expt. Sta. Research Note 12 (Mimeo U.S.D.A.) 1953.

Koenig, R. A. and C. R. Johnson. Colormetric determination of phosphorus in biological materials. Ind. and Eng. Chem. 14:155–6. 1942.

Morrison, F. B. Feeds and feeding. The Morrison Publishing Co. 1950.

Pammel, L. H. Manual of Poisonous Plants. The Torch Press. p. 517. 1911.

Sampson, A. W. Native American Forage Plants. John Wiley and Sons. 1924.

Shipley, M. A. Range studies in northeastern Nevada. The Grazing Bulletin, Grazing Service, U. S. D. I. 1941.

Snapp, R. R. Beef cattle. John Wiley and Sons. 1950.

Stanley, E. B. and C. W. Hodgson. Seasonal changes in the chemical composition of some Arizona range grasses. Ariz. Agr. Expt. Sta. Tech. Bull. 73. 1938.

Stoddart, L. A. Gains made by cattle on summer range in northern Utah. Utah Agr. Expt. Sta. Bull. 314. 1944.

Watkins, W. W. Compositions of range grasses and browse at varying stages of maturity. New Mex. Agr. Expt. Sta. Bull. (Tech.) 311. 1943.

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SUMMARY AND CONCLUSIONS

Forty forage plants of northeastern Nevada were clipped at successive stages of growth for chemical analysis. Grasses, weeds and shrubs were sampled during four years. Most of the samples were from summer ranges. Those from winter ranges are included for comparison. Crude protein, crude fiber, nitrogen-free extract and ether extract were determined for all samples. Calcium and phosphorus were determined for a smaller number. Chemical composition was related to stage of plant development in all instances. Over half of the species analyzed were deficient in phosphorus for normal growth of young beef cattle. The deficiency occurred in grasses, weeds and shrubs.

Ten groups of young beef cattle were weighed at 28-day intervals during eight grazing seasons. Their rates of gain were studied in relation to plant maturity and to abundance of forage. Although declining forage quality accompanied advancing maturity of key grasses, rates of livestock gain showed no consistent corresponding decline. Mid-summer gain slackened in certain years, apparently at the time of lowest moisture content of the grasses and immediately preceding the inclusion of browse in the diet. Much the best gains, over two pounds daily, were made during the boot and heading stages of bluebunch wheatgrass. Average daily gains per head were less than one pound in only the first and last of the six months on summer range.

Actual losses in weight of cattle in the fall occurred only when the range was fully utilized and the herbaceous plants were over-mature.

LITERATURE CITED

Beeson, R. W., F. P. Cronemiller, R. L. Deering, A. Fausett, E. P. Meinecke, P. O. Pitchlynn, S. B. Show, Handbook for range managers, Region 5, U. S. Forest Service, U.S.D.A. 1940.

Bennett, H. H. Northeast Nevada cooperative land use study. Soil Conservation Service, U.S.D.A. 1939.

Blaisdell, J. P., A. C. Wiese, and C. W. Hodgson. Variations in chemical composition of bluebunch wheatgrass, arrowleaf balsamroot, and associated range plants. Jour. Range Mngt., 5:346–353, 1952.

Bohman, V. R. Unpublished data. Nevada Agricultural Experiment Station, 1958.

Brennen, C. A. and C. E. Fleming. More beef from the same number of cattle on Nevada ranches. Nev. Agric. Expt. Sta. Bull. 162. 1942.

Brierly, Thos. District Forest Ranger, Lamoille, Nevada. Personal communication. 1956.

Clawson, A. B. Normal growth of range cattle. U.S.D.A. Bull. 1394. 1926.

Clements, F. E. Plant indicators: the relation of plant communities to process and practice. Carnegie Inst. Wash. Pub. 290, 1920.

Cook, C. W. and L. E. Harris. The nutritive value of range forage as affected by vegetation type, site, and stage of maturity. Utah State Agric. Tech. Bull. 344. 1950.

....., L. A. Stoddart and Lorin E. Harris. Measuring consumption and digestibility of winter range plants by sheep. Jour. Range Mngt. 4:335–346. 1951.

Costello, David F. and Raymond Price. Weather and plant development data as determinants of grazing periods on mountain range. U.S.D.A. Tech. Bull. No. 686. 1939.

Forbes, R. M. Protein as an indicator of pasture forage digestibility. Jour. Animal Sci. 9:231–237. 1950.

Guilbert, H. R., Paul Gerlaugh, and L. L. Madsen. National Research Council. IV. Recommended nutrient allowances for beef cattle. A report of the committee on animal nutrition. National Research Council. Washington, D. C. 1950.

Halliday, Blaine O. Official correspondence. U. S. Soil Conservation Service. 1956.

Hart, G. H., H. R. Guilbert, and H. Goss. Seasonal changes in the chemical composition of range forage and their relation to nutrition of animals. Calif. Agr. Exp. Sta. Bull. 543. 1932.

Heinrichs, P. H. and R. B. Carson. Chemical composition of nine grasses at six stages of development. Canadian Jour. of Agric. Sc. 36:95–106. 1956.

Horton, Gerald F. Official correspondence. U. S. Forest Service. 1956.

Jackman, E. R. Experiences with Nomad alfalfa in Oregon and other states. The Grazier 41:6. 1956.

Appendix Table 3. Plant species mentioned.

GRASSES

Botanical name	Common name
Agropyron spicatum	bluebunch wheatgrass
Agropyron trachycaulum	slender wheatgrass
Bromus marginatus	mountain brome
Bromus rigidus	ripgut brome
Bromus tectorum	cheatgrass brome
Elymus cinereus	Greatbasin wildrye
Festuca idahoensis	Idaho fescue
Oryzopsis hymenoides	Indian ricegrass
Poa ampla	big bluegrass
Poa longiligula	longtongue bluegrass
Poa nevadensis	Nevada bluegrass
Poa secunda	Sandberg bluegrass
Sitanion hystrix	bottlebrush squirreltail
Stipa comata	needle-and-thread

WEEDS (forbs)

Achillea lanulosa	yarrow
Agastache urticifolia	nettleleaf gianthyssop
Artemisia gnaphalodes	cudweed sagebrush
Balsamorhiza sagittata	arrowleaf balsamroot
Delphinium stachydeum	tall larkspur
Geranium richardsoni	Richardson geranium
Halogeton glomeratus	halogeton
Helianthella uniflora	one-flowered sunflower
Leptotaenia multifida	carrotleaf leptotaenia
Lupinus caudatus	tailcup lupine
Osmorhiza occidentalis	sweet anise
Salsola kali	Russian thistle
Senecio serra	butterweed groundsel
Sphaeralcea grossulariaefolia	gooseberryleaf globemallow
Wyethia amplexicaulis	mulesears

BROWSE (shrubs)

Amelanchier utahensis	serviceberry
Artemisia arbusula (A. nova)	low sagebrush
Artemisia tridentata	big sagebrush
Atriplex confertifolia	shadscale
Atriplex nuttallii	sweetsage
Cercocarpus ledifolius	mountain mahogany
Chrysothamnus nauseosus	rubber rabbitbrush
Chrysothamnus puberulus	downy rabbitbrush
Chrysothamnus viscidiflorus	Douglas rabbitbrush
Eriogonum heraclioides	Wyeth eriogonum
Eurotia lanata	whitesage
Grayia spinosa	spiny hopsage
Juniperus utahensis	Utah juniper
Kochia vestita	gray molly
Populus tremuloides	aspen
Prunus virginiana melanocarpa	black chokecherry
Purshia tridentata	bitterbrush
Quercus gambelii	Gambel oak
Salix spp.	willow
Symphonicarpos rotundifolius	snowberry
Tetradymia canescens	gray horsebrush

PHENOLOGY AS RELATED TO CHEMICAL COMPOSITION OF PLANTS AND TO CATTLE GAINS ON SUMMER RANGES IN NEVADA

JOS. H. ROBERTSON AND CLARK TORELL[1]

INTRODUCTION

THE PROBLEM

The problem which this study sought to solve may be stated most clearly by asking a series of related and dependent questions: Do beef cattle on fall ranges of northern Nevada commonly lose weight before they are gathered? If so, is the decline in nutritional value of the forage responsible? Are other factors such as abundance of forage or water involved? If low nutritive value of the forage is the primary cause, can it be gauged by observed stage of plant maturity? Will stage of maturity of key forages then serve as a convenient and reliable indicator of an approaching date at which beef animals should be gathered if weight losses are to be avoided?

The presumption was that management practices might result that would be economically and ecologically sound if beef production could be increased while forage could be conserved.

There is abundant support for this train of thought in the work of other range management students and in practice among cattle ranchers.

BACKGROUND

In the first place, the occurrence of weight losses by beef cattle on fall ranges is recognized, or at least strongly suspected. Johnson in South Dakota (1951) measured slight losses in weight by nursing cows as early as August. Their calves, at the same time, made excellent gains. Net losses by cows and calves did not appear until October. Kipple (1953) reported a net gain of 1.5 lb. per day by cows and calves in September on the Colorado plains. In October, the cows lost more than their calves gained. In the Utah mountains, Stoddard (1944) reported October gains of .6 to .9 lb. per day by heifers, steers, and calves, while the mother cows lost .2 lb.

[1]Range ecologist, Department of Agronomy and Range Management, and assistant animal husbandman, Department of Animal Husbandry, respectively; Agricultural Experiment Station, Max C. Fleischmann College of Agriculture, University of Nevada.

Jackman wrote of Oregon conditions as follows: "On most of our ranges the cattle do not gain much weight after July 1 and they are likely to lose weight in the late summer" (1956).

"Stockmen are aware of the fact that cattle start to lose weight when range grasses reach maturity and begin to dry," to quote directly from Brennen and Fleming (1942). Cattle ranchers of northern Nevada are so convinced of this situation that most of them have adjusted their operations in accord with it. Many ranches of northern Nevada no longer turn their steers on the summer ranges. Rather, they keep growing animals, soon to be sold, on irrigated pasture, either owned or rented. A few sell in July directly off crested wheatgrass. Many who formerly sold steers now sell calves. Among the permittees on the Ruby District of the Humboldt National Forest, only one runs steers on the summer range (Brierly, 1956).

Many who do turn yearlings and two-year-old cattle on the range remove the steers early and turn them on meadow aftermath for about two months before selling. This appears to be a more common and widespread practice now than when the present study was begun in 1939. It is a practice encouraged by the U. S. Forest Service. "Closing, like opening dates, depend primarily on stages of the vegetation. The more the animal husbandry scientists study the relation of livestock condition to fall growth stages of plants, the more clear it is that the practice of leaving livestock on the range far into the fall, is poor economics" (Beeson *et al.,* 1940).

While published data from other states show consistently lower rates of gain with approaching forage maturity, actual losses are seldom shown in October except for nursing cows.

Other investigations have shown through chemical and bio-assay methods, that range forage decreases in valuable nutrients as it increases in maturity.

Kennedy and Dinsmore (1909) in describing digestion trials in which range plants were fed to sheep, did not mention relationships between digestibility and plant maturity. Phenology was given for most of the species fed but with respect to the plant parts eaten rather than to chemical composition or digestibility. Sampson (1924) in describing conditions which influence the outcome of feeding trials, mentioned among others, "the stage of development of the plant." Remarkable changes in nutritive values of annual forage plants at various stages of growth were found by Hart *et al.,* (1932).

Chemical analyses throughout the growing season revealed clear trends in nutrients in three perennial range grasses (Stanley and Hodgson, 1938). A seasonal decline in phosphorus and crude protein accompanied an increase in nitrogen-free extract and lignin. A sharp rise in percent

Appendix Table 2—Continued

Species		Early leaf	Pre-bloom	Bloom	Dough	Mature	Seed casting	Seed cast	Weathered
Weeds (forbs)									
Nettle-leaved gianthyssop	Ca	----	----	1.13	----	.92	----	----	----
	P	----	----	.36	----	.24	----	----	----
Cudweed sagebrush	Ca	----	.69	----	----	----	----	----	----
	P	----	.24	----	----	----	----	----	----
Balsamroot	Ca	1.57	----	1.64	----	----	----	2.54	----
	P	.44	----	.45	----	----	----	.27	----
Tall larkspur	Ca	.77	----	----	----	----	----	----	----
	P	.27	----	----	----	----	----	----	----
Richardson geranium	Ca	.68	----	----	----	----	----	----	----
	P	.52	----	----	----	----	----	----	----
One-flowered sunflower	Ca	1.80	----	----	----	----	----	----	----
	P	.29	----	----	----	----	----	----	----
Carrotleaf	Ca	1.29	----	----	----	----	----	----	----
	P	.45	----	----	----	----	----	----	----
Lupine leaves	Ca	.92	----	.84	1.13	----	1.44	1.11	----
	P	.37	----	.22	.17	----	.11	.09	----
Lupine flower stalks	Ca	----	----	.58	.65	----	.75	----	----
	P	----	----	.30	.21	----	.13	----	----
Russian thistle	Ca	----	----	----	----	----	----	----	1.97
	P	----	----	----	----	----	----	----	.14
Mulesears	Ca	.84	----	.90	----	1.08	----	----	----
	P	.49	----	.38	----	.07	----	----	----
Browse (shrubs)									
Low sagebrush	Ca	----	.42	----	----	.48	----	----	----
	P	----	.16	----	----	.10	----	----	----
Big sagebrush	Ca	----	----	----	----	.41	----	.44	----
	P	----	----	----	----	.10	----	.09	----
Shadscale	Ca	----	----	----	----	1.84	----	----	----
	P	----	----	----	----	.08	----	----	----
Sweetsage	Ca	----	----	----	----	1.86	----	----	----
	P	----	----	----	----	.11	----	----	----
Yellowbrush	Ca	1.70	----	----	----	1.03	----	----	1.66
	P	.45	----	----	----	.16	----	----	.07
Whitesage	Ca	----	----	----	----	1.71	----	----	----
	P	----	----	----	----	.06	----	----	----
Spiny hopsage	Ca	----	.77	----	----	----	----	.74	----
	P	----	.09	----	----	----	----	.08	----
Gray molly	Ca	----	----	----	----	2.16	----	----	----
	P	----	----	----	----	.04	----	----	----
Chokecherry	Ca	.56	----	1.10	----	1.61	----	----	----
	P	.47	----	.44	----	.14	----	----	----
Bitterbrush	Ca	----	----	----	.94	.81	----	1.11	----
	P	----	----	----	.20	.15	----	.14	----
Snowberry	Ca	.67	----	.78	1.04	1.15	----	----	----
	P	.42	----	.29	.31	.20	----	.24	----
Gray horsebrush	Ca	----	----	----	----	1.21	----	----	----
	P	----	----	----	----	.06	----	----	----

Percentages underscored are below the recommended nutrient content of rations for normal growth of 600-pound heifers and steers according to Guilbert, et al., 1950.

The 71 pairs of values among 31 species are based upon 192 laboratory analyses

Appendix Table 1—Nutrient analyses of miscellaneous range plants at progressive stages of maturity.

Grasses	No. of analyses	Protein	NFE	Fat	Fiber
Slender wheatgrass—					
Dough	1	5.3	44.7	2.2	37.7
Ripgut brome—					
Early leaf	2	14.2	43.4	3.2	22.6
Mature	2	8.6	58.5	1.2	20.9
Indian ricegrass—					
Cast	19	3.5	42.4	1.6	38.4
Big bluegrass—					
Dough	1	8.1	41.4	2.2	36.4
Mature	1	5.5	44.5	2.3	37.6
Longtongue bluegrass—					
Mature	2	5.3	49.5	2.3	31.3
Needle-and-thread—					
Mature	1	7.5	48.5	2.2	29.2
Weathered	2	3.8	43.0	1.8	34.9
Weeds (forbs)					
Cudweed sagebrush—					
Pre-bloom	1	12.1	37.2	4.1	31.5
Bloom	1	10.0	39.6	7.2	27.6
Tall larkspur—					
Early leaf	1	17.8	40.0	3.0	18.3
Carrotleaf—					
Bloom	1	17.4	43.9	6.1	13.5
Sweet anise—					
Mature	1	10.0	42.2	2.4	25.9
Russian thistle—					
Weathered	1	7.1	40.3	3.6	36.2
Butterweed groundsel—					
Pre-bloom	1	13.8	42.1	2.7	23.4
Browse (shrubs)					
Wyeth eriogonum	1	9.6	57.9	1.5	18.5
Willow—Bloom	1	14.0	56.8	3.0	13.1

Appendix Table 2—Percentage calcium (Ca) and phosphorus (P) in range forage plants at progressive stages of development in northeastern Nevada.

		Phenological Stage							
Species Grasses		Early leaf	Pre-bloom	Bloom	Dough	Mature	Seed casting	Seed cast	Weath-ered
Bluebunch wheatgrass	Ca	.56	.38	----	----	.36	.47	.51	----
	P	.30	.27	----	----	.29	.21	.14	----
Cheatgrass brome	Ca	.41	----	----	.51	.39	.60	----	.51
	P	.30	----	----	.22	.27	.22	----	.15
Greatbasin wildrye	Ca	.27	----	----	----	.31	----	.20	----
	P	.35	----	----	----	.09	----	.07	----
Idaho fescue	Ca	.44	----	.35	----	----	.50	.36	----
	P	.34	----	.20	----	----	.11	.09	----
Indian ricegrass	Ca	----	----	----	----	----	----	.54	----
	P	----	----	----	----	----	----	.04	----
Nevada bluegrass	Ca	----	----	.26	----	----	----	.19	----
	P	----	----	.07	----	----	----	.07	----
Sandberg bluegrass	Ca	----	----	----	.53	.26	----	.17	.14
	P	----	----	----	.22	.11	----	.13	.04
Needle-and-thread	Ca	----	----	----	----	.29	----	----	.53
	P	----	----	----	----	.17	----	----	.02

crude protein during the spring was measured in New Mexico by Watkins (1943) in a group of three perennial grasses. An equally sharp decline followed in late season.

Chemical composition of snowberry, yarrow, and mountain brome were shown by Cook and Harris (1950) to vary at four periods of the growing season, independently of vegetation type or soil. In snowberry leaves, for example, highly significant differences among stages of growth were found for protein, ash, phosphorus, calcium, cellulose and cellulose-lignin ratios. These workers point out that chemical analysis of forage gives an incomplete picture of its nutritive value.

Another reason for care in interpretation of such analyses is brought out by Heinrichs and Carson (1956). Among nine grasses, none of which were included in the present study, they found significant differences in nutritive content at the same stage of maturity in two consecutive years. The differences existed in protein, nitrogen-free extract and fiber. They were attributed to differences in proportion of leaves to culms in the two years.

Stage of maturity as an indicator of chemical composition of bluebunch wheatgrass, balsamroot, and other key species on the upper Snake River plains was questioned recently. Phosphorus and crude protein content appeared to be correlated with the length of interval since inception of growth more closely than with reproductive stage of the plant (Blaisdell, *et al.*, 1952).

It is generally known (Snapp, 1950; Morrison, 1950) that rate of gain of growing animals is dependent upon many factors, including quality and abundance of forage. The extent to which an increase in either nutritive value or abundance of range forage can compensate for a decrease in the other is not clear. Whether cattle will lose weight if forage is both mature and abundant, is less clear.

Trends in gain by cattle on mixed range types have been followed seasonally with some attention to plant phenology. Cattle were weighed at two-week intervals from mid-June to mid-September on good range in northeastern California. The types were mainly cutover ponderosa pine, sagebrush-grass, and dry meadow. Cattle that weighed 800–900 pounds when turned on the range continued gaining until September 15. The group turned on at 600 pounds gained in weight until September 25. Losses in weight were observed at the time aspen leaves started changing color. It is probably significant that September gains exceeded August gains of one year, without supplementation.

In another example, cows maintained their weight and heifers gained until August 15 on browse range during three summers in the west central Sierra Nevadas. Thereafter both lost weight (Beeson, *et al.*, 1940).

The normal, seasonal growth of range cattle of various ages was studied

by the Bureau of Animal Industry from 1916–1924 (Clawson, 1926). Individual animals were weighed weekly during nine summers. Usually the grazing season extended from early June to late September on well-watered range located at 7000–8500 feet in the Wasatch Mountains of south central Utah. Predominant types were aspen, oak brush and meadows. Under moderate use during the period of study the condition of this browse-weed-grass range improved. It may be assumed that forage was ample each year. One hundred eight cattle were used over the nine years, the yearly number varying from 3 to 22. Weekly average gains of all animals in all years were 2.8 percent of initial weights. September gains were the slowest, 1.5 percent of initial weight. The general averages were equivalent to 1.1 pounds per day on animals weighing 500 pounds when turned on the range. Examination of the seasonal animal growth curves of this study reveals an apparent lag in rate of gain in July or August in six of the nine years. In only two years did Clawson find the cattle to be losing weight at the close of the summer grazing season. The first of these years was drier than normal, while the second was one of nearly double the average stocking rate.

The indirect evidence indicates that cattle make satisfactory gains later in the grazing season at higher elevations and latitudes than at lower, possibly as a reflection of delayed plant maturity. Chemical transformations, food storage in the roots, shattering of foliage and seed, accumulation of minerals and weathering or leaching all play a part in changing quality of range forage.

Numerous outward, conspicuous changes in the appearance of plants signal advancing maturity, and so, indirectly, perhaps, their stage of decline in forage quality.

The use of plant indicators is well established. The basic principles and their application to range management were set forth by Clements in 1920.

The values to a range in conservation of plants and soil through shortening the season of grazing are recognized by the U. S. Forest Service (Beeson, *et al.*, 1940).

"The break from summer to fall reduces both plant palatability and nutritive qualities and seems to result in drawing cattle successively to certain types.

"As a result on many ranges by the middle of October there will be excessive concentration and utilization of wet spots. Regardless of the stocking of the range as a whole this means overstocking of the concentration points from then on. Since meadows and stringers are, of all types, most susceptible to damage by trampling in late fall, such use is apt to develop permanent injury. On ranges of more uniform type the use will be concentrated on the remaining nutritious or succulent species, leading

Only nursing cows were unable to make steady gains on ranges having abundant dry grass. This statement is supported by the average performance of 278 head of Hereford cattle weighed as 9 groups during 8 summers on the Knoll Creek range. These were all yearlings excepting 42 two-year-old heifers in 2 groups. The fifth weigh period of Figure 16 is an average of eight groups in seven years, the sixth is of groups in 1950, 1955 and 1957 only.

Accordingly, the cattleman who uses his summer range moderately need not fear weight losses by young growing cattle, barring storms, as long as plenty of water and forage are available.

The authors wish to express appreciation to M. A. Shipley and R. K. Miller for collecting herbage samples; to M. R. Miller and W. B. Dye for the chemical analyses; to Thomas Cook, Henry Johnson, Kirk Day and H. M. Kilpatrick for weighing cattle; to Fred Stewart and Robert Strathearn for use of their cattle; and to F. E. Kinsinger for assistance in preparing the figures.

As a group, grasses decline faster and further in crude protein than do shrubs.

By selecting more browse, and avoiding the more mature herbs in late season, stock can uphold their average daily protein and phosporus intakes. Stock may also gain these benefits in late season by seeking forage in moister sites such as meadows, swales, and north-facing slopes.

For these, and perhaps other reasons, the groups of cattle grazed on

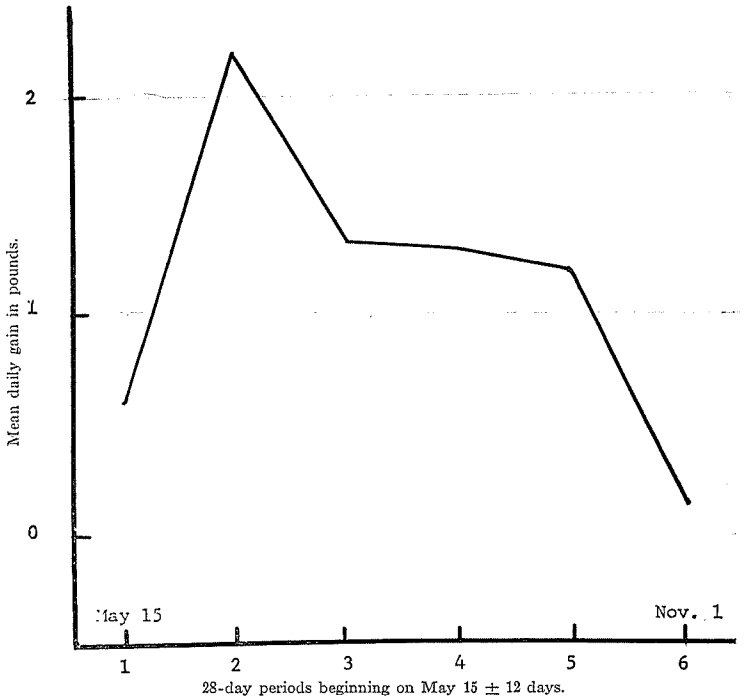

Figure 16. Trend in average daily gain made by 10 groups of young Hereford cattle during eight summers on Knoll Creek Field Station range, 1950–1957.

three widely separated and unlike ranges, gained in excess of one pound per day as long as dry forage was abundant.

Losses occurred when over-maturity and over-utilization coincided in the fall. The report (Morrison, 1950) that young cattle may lose weight on the range after maturity of the forage as the result of a scanty feed supply is confirmed by these results.

Gains were poor in the spring before the grasses began to head.

to overuse of these. In the ranges with a combination of types, management becomes progressively more difficult and finally impossible without excessive fencing. At this time watering places become fewer in number, increasing the problems of management and localized overuse. Of course, when fall rains have softened the soil to an extent that trampling occurs, it is obvious that grazing should be terminated. This becomes a major factor in the belts or seasons of high rainfall."

The same considerations might well serve as guides on privately controlled fall ranges.

THE AREAS OF STUDY

The areas selected for sampling in 1939 were large fenced cattle ranges in northeastern Elko County, Nevada. They are locally known as Golliher and Loomis pastures. The former of some 24,000 acres, at 6500 to 7500 feet elevation, centers at about 41° 52′ N, 114° 50′ E. Loomis pasture is 38 miles southwest of Golliher pasture.

In addition, limited sampling was done on winter range in Antelope Valley, one hundred miles south of the Golliher pasture. Golliher pasture was probably grassland, originally, an outlier of the Palouse prairie. If so, its aspect changed to sagebrush between 1870 and 1915 when it was a part of the open range. Enclosed by fence from 1915 to the present, and grazed in summer, it has become a good condition brush-bunchgrass range (Shipley, 1941). Loomis pasture was fenced more recently and has only remnants of the original bunchgrass scattered through dominant sagebrush.

The two fenced areas thus provided a variety of mountain slopes, canyons and ridges with corresponding variations in composition of the cover and in phenology.

The physical conditions and forage resources of these ranges in 1937–1939 were recorded in the northeastern Nevada cooperative land use study (Bennett, 1939). The study group found Golliher pasture to be very good range for cattle. The soil was described as shallow, brownish, of medium texture, moderately to highly productive. Slopes were mostly of 30 to 100 percent. Gully erosion was negligible, sheet erosion slight.

The various aspects were characterized by such dominants as snowberry, aspen, big sagebrush, serviceberry, bluebunch wheatgrass, and Idaho fescue. Subdominant grasses were important in all types.

Loomis pasture was similar to Golliher with respect to soil and erosion. It had less rugged topography and more xeric vegetation types. Low sagebrush, big sagebrush, bitterbrush and mountain mahogany were dominants, usually mixed with grass and weeds.

Antelope Valley, by the same survey, was found to consist of brown, loose, productive outwash material on slopes of less than 3 percent.

The principal types were dominated by shadscale, little rabbitbrush, sweetsage, whitesage, greasewood and spiny hopsage. Its principal use was as winter sheep range.

Another sampling area became available when the Northeast Nevada Range Field Station was moved to a new location.

The station was established, with the help of the Bureau of Land Management, on Knoll Creek twelve miles southwest of Golliher pasture. Nearly four sections of summer range were leased from the Salmon River Cattle Association and fenced in 1948.

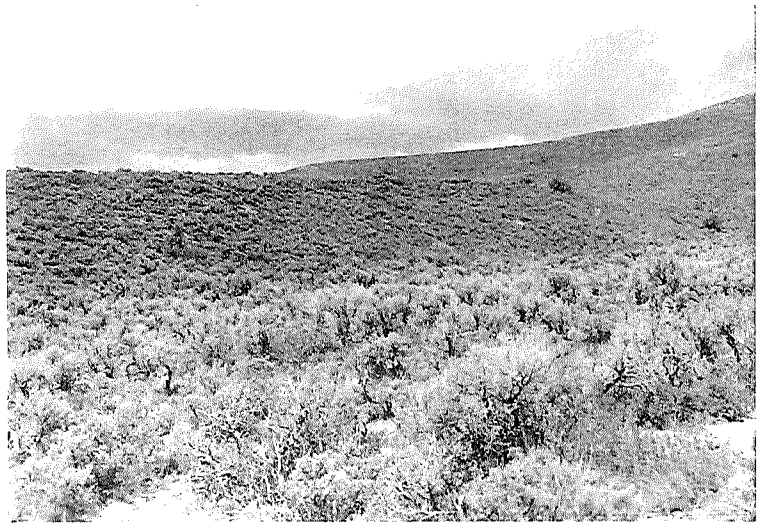

Figure 1. Plant sampling area on east-facing slope on Knoll Creek summer range, 1952–1957.

A survey of this range was made by the Soil Conservation Service before experimental grazing was begun. Range condition was judged to vary from very poor to good with the bulk of the acreage falling in the class "poor." An allowable stocking rate of 4.2 acres per animal unit month was calculated. Conservative grazing during the next three years was reflected in improved vigor of the primary forage plants. In soil, topography, and elevation, but not in condition, this range was similar to Golliher pasture. The pasture was examined in 1952 for a key sampling location that could be considered typical or average as to site, accessibility, and condition. The most satisfactory location was an east-facing slope of about 30 percent at 7000 feet elevation and .6 mile

Moisture content on an oven dry basis was determined for three herbaceous species, a forb and two grasses at intervals through the summer of 1955. Trends in moisture content are given in Figure 15.

Balsamroot was most succulent in early bloom on June 22. Thereafter it dried steadily until the last sampling date, August 28.

Bluebunch wheatgrass, in pre-bloom stage, reached its peak moisture content also about June 22. It dried gradually until reaching 63 percent moisture in the late bloom on July 15. By July 28, the awns had begun to diverge and moisture content dropped below 40 percent. A gradual increase in moisture followed to 53 percent at seed-cast stage. The moisture trend in Idaho fescue was similar except that it was not as succulent in the spring nor did it dry as early or as much as bluebunch wheatgrass in late summer. Scarcely any culms were produced by Idaho fescue in 1955.

The two-year-old cattle began to eat browse during early August 1955 when the moisure percentage of the key grasses was the lowest. They did not show a mid-summer growth slump as the yearlings did in both 1952 and 1954. The flattening of the growth curve was later in 1953 than in 1954 and corresponded with later ripening of bluebunch wheatgrass (Fig. 14). There may be a causative relationship between moisture content of grasses in mid-summer, relative palatability of browse, quantity of forage eaten, nutrient balance, and rate of gain.

Daily gains of 1.2 pounds on the Susie Creek range and 1.6 pounds on the Santa Rosa range in the fall of 1956 again indicated that overmaturity of the grasses and weeds did not inhibit growth of young cattle. Palatable browse was too spare to form a major portion of the diet. However, both ranges had an abundance of dry grass and weeds remaining at the end of the grazing period. A reconnaisance survey of the Susie Creek range of some 6000 acres under fence indicated that the heifers had traveled widely in search of occasional browse plants, e. g. whitesage and *Wyeth eriogonum*. Their continued growth was sufficient evidence that the heifers were able to rustle a satisfactory diet for two months after the steers had been shipped.

CONCLUSIONS

This study indicates that the forage quality of a few of the most utilized species is not the primary determinant of rate of gain of young beef cattle on summer ranges of mixed plant composition. Although a decline in quality accompanies advancing maturity, the rate and extent of decline differ among life-form groups, and among species within groups. Species arrive at the same growth stages on different dates.

October 15 to November 4. A group of twenty 600-pound heifers were returned from the open range to Knoll Creek range on October 15. The more palatable browse and the dry grasses on this range were fully utilized by that time. They lost 5 pounds in 20 days, which they failed to regain in 22 days on hay.

Periodic ocular checks each season revealed that first and second rank in intensity of utilization must be accorded to blue-bunch wheatgrass or Idaho fescue until mid-August. While needle-and-thread, the third most abundant perennial grass, was grazed well early, its later value

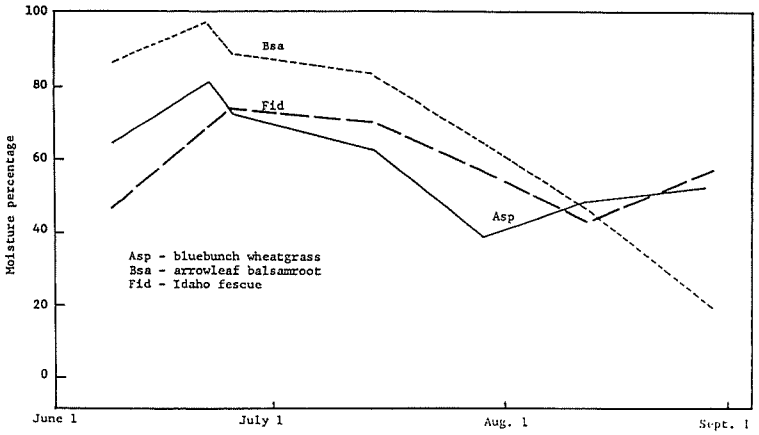

Figure 15. Seasonal trend in moisture content of key forage plants on Knoll Creek summer range.

appeared small. The period of maximum utilization of bluebunch wheatgrass extended from about the first of June to mid-August, or from boot to seeds-ripe stages. Animal preference for Idaho fescue appeared about the last week in May, extending through June, or from leaves four-six inches to seeds-ripe stage. Fescue failed to head in 1955 so was grazed closer than normal. A very similar time of preference was shown for balsamroot, from the bud to seeds-casting stages. After a sharp freeze blasted the opening buds of balsamroot on May 10, 1955, it was not utilized. Bitterbrush was browsed from seed cast in mid-August until the end of the season. Bitterbrush and two primary grasses dropped their seeds at about the same time.

Periods of poor gain were not consistently associated with particular stages of plant development. Those in summer occurred toward maturity of the perennial grasses, after maturity of cheatgrass brome, and prior to any utilization of bitterbrush, the primary browse species.

from water. The type was sagebrush-grass in fair condition (Fig. 1). Various species of shrubs and forbs (weeds) were present.

Climatic data for the years 1952–1957 are given because of the possible influence of climate on the physiological well-being of the animals, and the certainty that plant phenology is strongly under the influence of both temperature and available moisture (Tables 1 and 2). Inception of growth of grasses was found to vary as much as 6 weeks over a period of 10 years at an elevation equal to that of the Knoll Creek range (Costello and Price, 1939).

Table 1—Mean daily Fahrenheit temperatures by month at Contact, Nevada, during six grazing seasons on the Knoll Creek range (nearest station with continuous record, eight miles northwest of experimental range).

	April	May	June	July	Aug.	Sept.	Oct.
1952	46.8	53.9	61.0	68.7	68.5	60.9	52.1
1953	42.3	45.4	57.7	71.1	66.2	60.8	49.2
1954	47.1	56.6	58.3	71.6	64.5	58.2	45.9
1955	40.7	51.8	61.1	67.5	70.2	57.7	49.2
1956	44.1	53.9	61.5	68.2	63.8	58.9	45.6
1957	41.2	51.3	60.5	67.3	66.4	58.4	45.7
1952–1957 Avg.	43.7	52.2	60.0	69.1	66.6	59.2	48.0

Table 2—Monthly precipitation in inches at Contact, Nevada, elevation 5365 feet.

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
1952	.72	.61	1.65	.68	.93	.73	.52	.36	.00	.01	.46	.39	7.06
1953	.50	.40	.61	.69	1.69	.79	.81	.85	.35	.51	.32	.65	8.37
1954	.37	.30	.69	.90	.02	1.89	.57	T	.14	.12	.06	.31	5.37
1955	.33	.35	.34	.58	2.29	1.52	.90	.66	2.13	.17	.72	1.85	11.84
1956	1.72	.25	.11	.58	1.79	.55	.29	.03	.68	1.74	.09	1.68	9.51
1957	.51	.55	1.11	.75	.55	1.95	.30	.42	.19	.80	.94	.59	8.66
1952–57 Avg.	.69	.41	.75	.70	1.21	1.24	.56	.39	.58	.56	.43	.91	8.47

METHODS OF STUDY

The procedures followed in this study included collection and chemical analysis of range forage plants, recording plant phenology, degrees of utilization, and weighing different classes of Hereford cattle at monthly intervals.

From the beginning of spring growth until late fall maturity, the current growth of over 30 forage species of grasses, forbs and browse was collected at Golliher and Loomis pastures. Samples were taken from ungrazed plants to represent full utilization. Sampling was done throughout the ranges of phenology, elevation (5500′–7000′) and topography available. Most of these samples were taken during 1940 and 1941, a few in 1943 and 1944.

Ash, crude protein, ether extract, nitrogen-free extract (NFE), and crude fiber were determined on a moisture-free basis. Moisture was removed by drying to constant weight of 105° C. Methods of the Association of Official Agricultural Chemists were followed in determining ether extract, crude fiber and calcium. Crude protein was determined as nitrogen by the Kjeldahl method, phosphorus by a modification of the method published by Koenig and Johnson (1942). Nitrogen-free extract was determined by difference. Additional samples from the Knoll Creek range were analyzed in 1952. Only two species of each life-form were sampled. Grasses were bluebunch wheatgrass and Idaho fescue; weeds were tailcup lupine and balsamroot; shrubs were bitterbrush and snowberry. Grazing intensity has been such that lupine and snowberry have scarcely been utilized. Their chemical composition could, therefore, have had no influence upon cattle gains. Their phenology, however, might have value as an indicator of seasonal advance and general trend of forage maturity.

A stock scale for weighing individual animals was installed on the Knoll Creek range in 1950. Weights of cattle on the Knoll Creek range were obtained at 28-day intervals throughout the grazing season. Concurrently, herbage samples and phenological data were taken at 14-day intervals.

Chemical analysis was discontinued after 1952 but records of plant phenology, cattle gains and forage utilization were continued through 1957. The moisture content of herbage of three key species was determined periodically during the summer of 1955.

A 50–50 ratio: salt-bonemeal mixture was provided while the stock were on the range. The animals were sprayed throughout the summer to control flies.

in the springs of 1952 and 1957, when the turnout dates were earlier than average. Two were by different groups, steers and heifers, in the fall of 1957. The 24 yearlings in 1952 lost at the rate of 0.7 pounds per day for the first 21 days on the range. The 36 steers turned out May 2, 1957 lost weight at the average rate of 0.3 pounds per day for

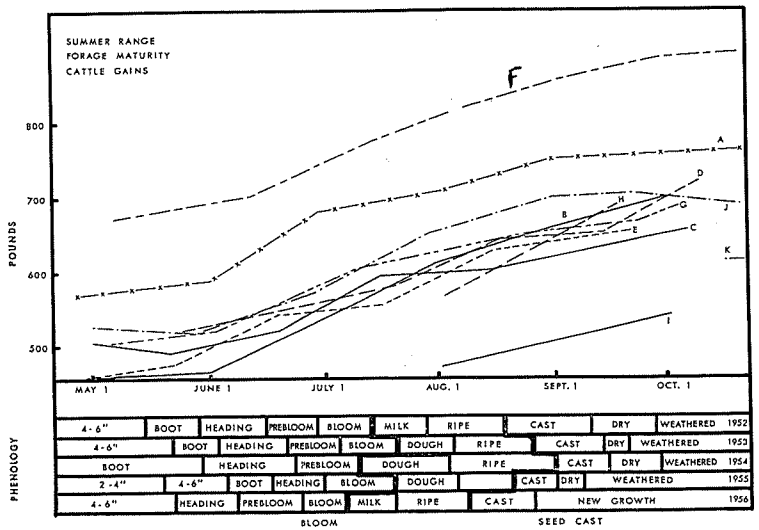

Figure 14. Trends in weight of 11 groups of young Hereford cattle weighed on summer ranges of northern Nevada, 1950 to 1957. All but H & I were on the Knoll Creek Field Station range. (A) 1950, 31 purebred heifers, (B) 1951, 31 grade heifers, (C) 1952, 24 purebred heifers, (D) 1953, 16 grade yearlings, (E) 1954, 26 grade yearlings, (F) 1955, 19 2-year-old heifers, (G) 1956, 35 yearlings, (H) 1956, 8 steers, Santa Rosa District, Humboldt National Forest, (I) 1956, 8 heifers, Strathearn's range, (J) 1957, 36 steers, (K) 20 heifers.

27 days. Possibly this merely reflected an adjustment in the content of the digestive tract (Bonham, 1955).

In the fall of 1953, the 16 yearlings made excellent gains on the range until October 10. During the following month on meadow aftermath they lost at the rate of one pound per day. The 36 steers weighed in 1957 lost weight at an accelerated rate after Septemebr 23. The average daily loss rates were .36 pound by October 3, .51 pound by October 15 and .86 pound by November 4. Snow and low temperature on November 2–4 doubtless contributed to the daily loss of 1.24 pounds from

Calcium

The calcium content of most species analyzed satisfied the recommendation of the committee on nutrition, NRC, for growth of 600-pound beef steers and heifers at most stages of plant maturity (Guilbert et al., 1950; Table 2). Reference to Appendix Table 2 will show that a few grasses after maturity contained less than the .25 percent calcium believed necessary. Greatbasin wildrye, Nevada bluegrass and Sandberg bluegrass were deficient in calcium from maturity onward. No calcium deficiency was found in weeds or browse at any stage. They varied from two to seven times the minimum level.

Phosphorus

The phosphorus situation was found to be much less favorable. Phosphorus contents of less than the recommended .21 percent appeared in all stages of maturity, nor was this deficiency restricted to any species or life-form. Although Nevada bluegrass was low in phosphorus content at bloom stage, the other perennial grasses held up until seed maturity or later. Cheatgrass brome remained just above the recommended level until dry and weathered in late August. This stage occurred about two months later in the perennial bunchgrasses.

Seasonal trends in phosphorus content of weeds were similar to those in grasses. Most of the shrubs were very low in phosphorus by the time of seed maturity. Three shrubs of winter range, gray molly, gray horsebrush and whitesage, contained one-fourth to one-fifth the recommended percentage.

BEEF CATTLE

Hereford cattle of various age classes, both grade and purebred, grazed the Knoll Creek range from two waters. One was a creek at a corner of the 2358-acre field, the other a spring centrally located by the scale.

Trend in weight of groups of young, growing animals and of phenology of the bluebunch wheatgrass in each of six years is shown in Fig. 14. The development of wheatgrass is shown rather than of Idaho fescue because it passed through all stages each season, furnished a large portion of the forage and occurred generally in the pasture.

The best rates of gain appeared to be during the period from the boot to dough stages of the wheatgrass. It is noted, however, that in 1952 and 1954 relatively weak gains were shown for one mid-season period. This is similar to the performance reported in Utah by Clawson (1926). The curves for 1955, 1956, and 1957 show no such flattening.

Actual weight losses appeared at 4 of 42 weigh periods of the 9 groups weighed at Knoll Creek. Two of these loss periods were

Continued late-season cattle gains on the Knoll Creek range were thought to be due partially to an abundance of browse, especially bitterbrush. In an effort to determine whether this was true, cooperative cattle weighings were made on two other ranges.

Eight yearling heifers were weighed individually on the Susie Creek range nine miles north of Carlin, Nevada, on July 31, 1956. This range is 90 miles southwest of the Knoll Creek Station. Steers were being shipped and were not available. These eight heifers were reweighed after two more months on the range.

The plant cover of the Susie Creek range consisted of cheatgrass, brome, big sagebrush, Sandberg bluegrass, Utah juniper, and bottlebrush squirrel-tail in order of decreasing abundance. Secondary or minor components included yellowbrush, needle-and-thread, Greatbasin wildrye, gooseberryleaf globemallow, halogeton and whitesage. No meadows were present on the range available to these heifers. The terrain is characterized by slopes of 10-30 percent, resulting from dissection of lake deposits on benches about 5000 feet elevation. The soil is highly erodible, whitish, and unproductive (Bennett, 1939).

A range condition survey by the U. S. Soil Conservation Service in 1954 rated this range at 30 percent of climax and desirable species. Residues were rated inadequate, erosion moderately active, trend down and proper stocking at 12 a./a.u.m. Big sagebrush was the only browse listed on the range condition write-up sheet (Halliday, 1956).

Phenology was far advanced on the first weigh date, the vegetation was dry and inflammable. The seeds were ripe on gooseberryleaf globemallow and Greatbasin wildrye. Other grasses had cast their seeds, only Greatbasin wildrye and needle-and-thread retaining any green color in the lower leaves. No effective precipitation occurred between weigh dates.

On September 28, when the heifers were reweighed, they had made full utilization of globemallow, whitesage and needle-and-thread. Desirable browse was almost nonexistent on this range but dry grass was abundant, as precipitation for the first half of 1956 was 2.5 inches above normal.

Arrangements were made with the Stock Land and Livestock Co. to weigh 16 steers on summer range. This range was a 90,000-acre allotment on the Santa Rosa district of the Humboldt National Forest at 5500–6500 feet in elevation, T 44 N, R 39 E (41° 40′ N, 117° 27′ W). The range types were sagebrush-grass with interspersed small meadows. Grasses and weeds formed a rich mixture of abundant volume following above-normal precipitation. However, they were mostly mature by August 3 when the steers were first weighed. Very little palatable browse was present. From a survey by the U. S. Forest Service it is known that 1850 acres of this allotment are in good condition. Much

of this best-condition range surrounds the corral where the steers were weighed. The bulk of the range was in fair condition. Forage production varied from 175 to 310 pounds per acre. The key species, Idaho fescue, was utilized 41 percent at the end of the grazing season (Horton, 1956).

Eight of the steers were removed after 44 days, drifted slowly to the home ranch about 20 miles, and given an overnight shrink before weighing by the owner.

RESULTS

FORAGE PLANTS

The average nutrient composition of six grasses, eight forbs and 14 shrubs, at progressive stages of maturity, is presented separately for crude protein, nitrogen-free extract, ether extract, and fiber. Data for several winter range shrubs are included for ease of comparison with shrubs of summer range, although no cattle weights from winter range are reported here. Miscellaneous nutrient analyses are placed in Appendix Table 1.

PROTEIN

Crude protein content of six grasses at different stages of maturity is shown in Fig. 2. The four samples of Greatbasin wildrye (Elymus) contained an average of over 16 percent protein on the oven-dry basis in the early leaf stage. The same species in the fall, when the leaves were dry and the seed cast, contained only 3 to 4 percent protein, less than any other grass analyzed.

After the seed casting stage the digestible protein content of all grasses fell below the minimum requirements recommended by the committee on nutrition of the National Research Council (NRC) for two-year-old beef cattle gaining 1.2 pounds daily. This requirement is approximated by the continuous white line vertical to all bars of Fig. 2. With the advent of cool weather in the fall, a marked increase in protein occurred in the two grasses analyzed. The comparatively satisfactory protein level of the annual cheatgrass brome (Bromus) is noteworthy, in view of its abundance on intermountain ranges.

An estimate of digestibility of protein in the grasses was obtained by the formula: $Y = 35.31\ (X^{.2717})$ as an expression of the relationship between protein digestibility and protein content. Digestion trials with steers that were fed grasses ranging from 5 percent to 33 percent protein showed agreement in protein digestibility by the above method to be about the same as by the lignin method (Forbes, 1950).

Apparently no satisfactory formula has been developed for calculating the digestibility of protein in forbs or shrubs. Belonging, as they do, to many distinct families of plants, their chemical composition is more diverse than that of the grass family

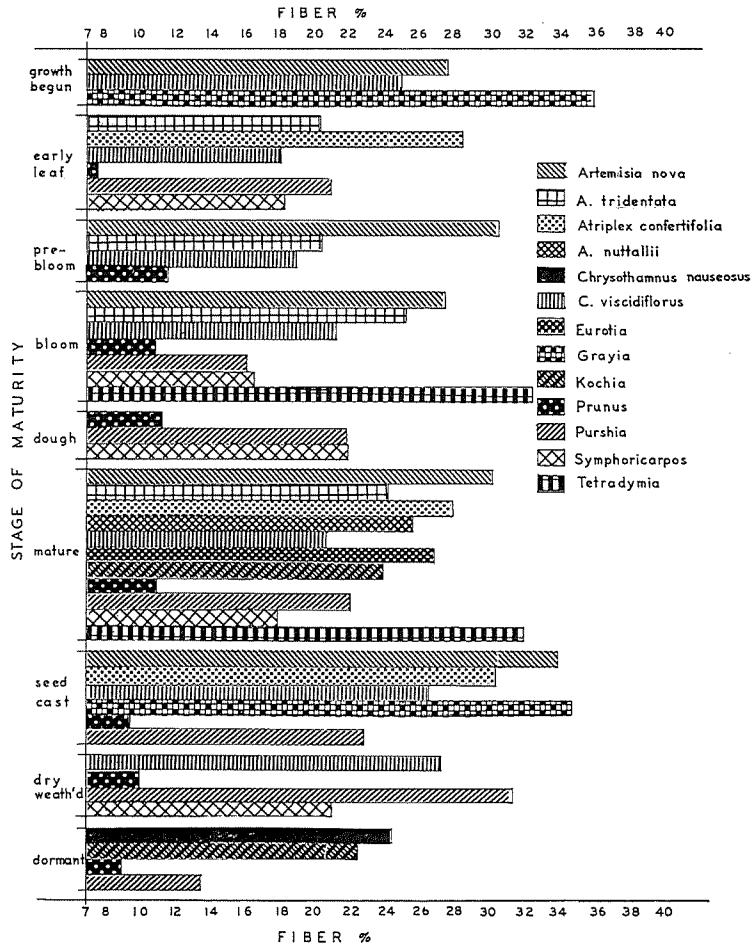

Figure 13. Crude fiber content of 14 shrubs of both summer and winter ranges at progressive stages of maturity.

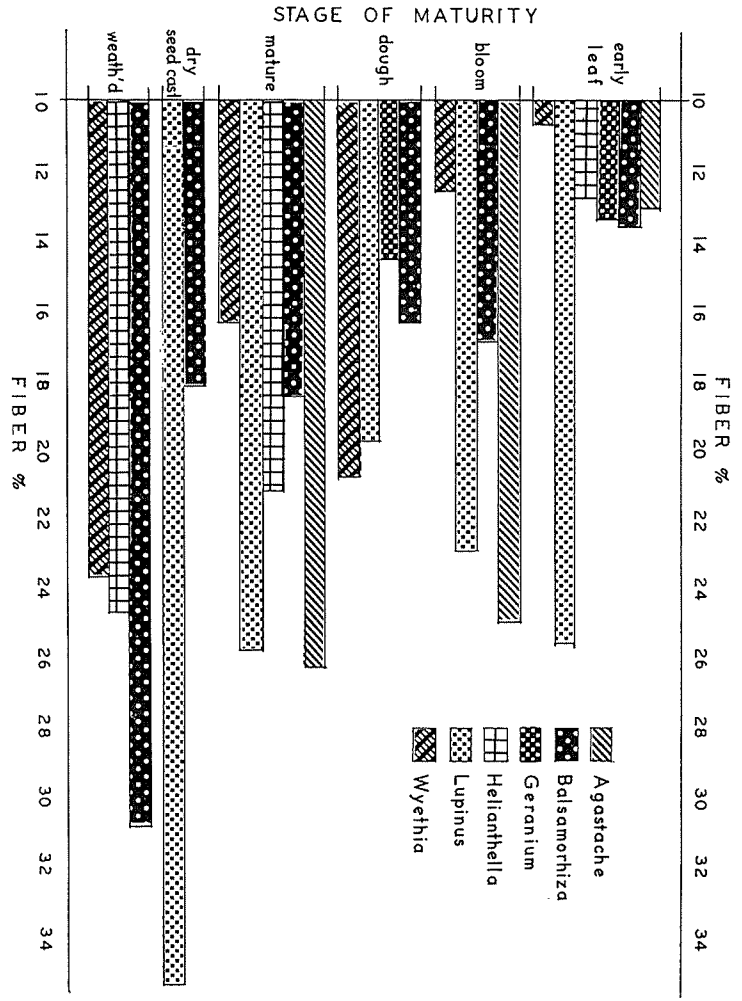

Figure 12. Crude fiber content of six selected forbs of summer range at progressive stages of maturity.

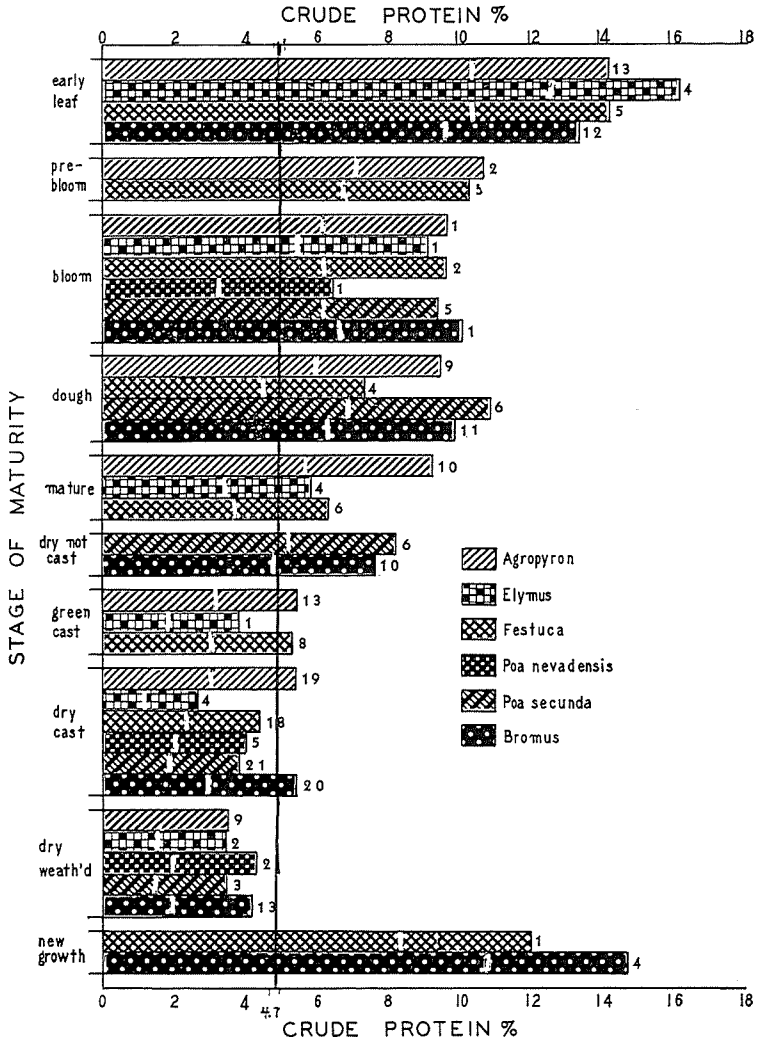

Figure 2. Crude protein of six selected grasses of summer range at progressive stages of maturity. Portion of each bar at the left of the break represents calculated digestible protein. Continuous vertical line represents recommended minimum requirement of digestible protein for normal growth of 800-pound steers and heifers. The numbers of samples used in the averages are shown at the ends of the bars.

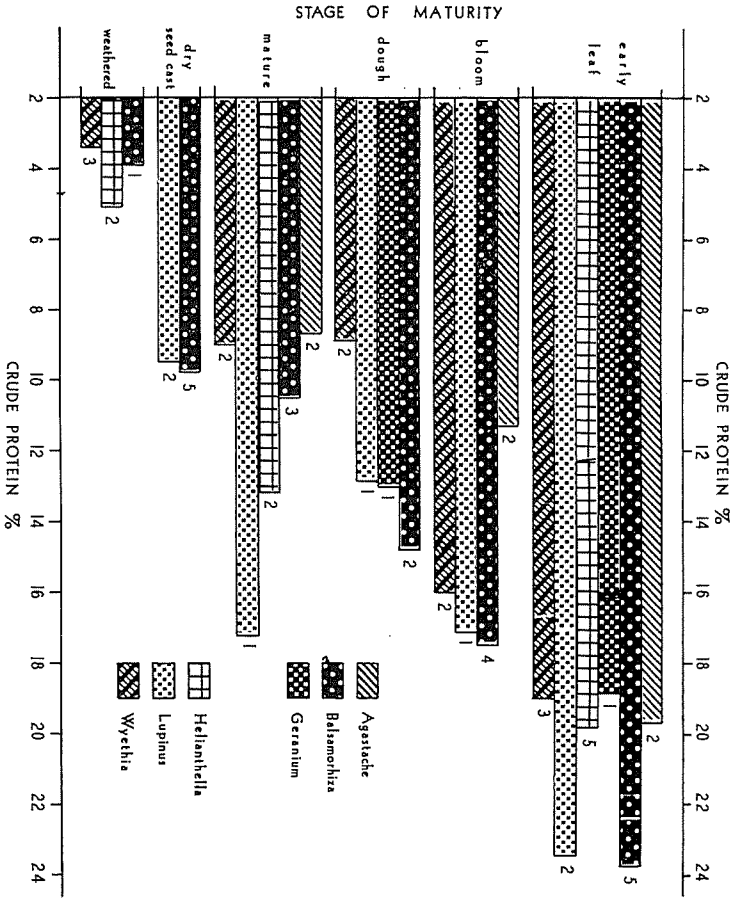

Figure 3. Crude protein content of six selected forbs of summer range at progressive stages of maturity. The numbers of samples used in the averages are shown at the ends of the bars.

Forbs (weeds) begin the season with a very high protein content which diminishes by fall to about the same level as that found in grasses (Fig. 3).

Balsamroot was seldom utilized in the early leaf stage when the protein content was nearly 24 percent because of the higher palatability of the grasses. It was utilized considerably from bloom to maturity, but very little thereafter. Lupine, it may be noted, lost about half of its protein on dropping its seed.

Fiber

Fiber content of grasses varied widely at most stages of maturity. Wildrye was generally highest and cheatgrass brome lowest (Fig. 11). The perennial weeds, with the exception of lupine, contained less fiber early in the spring than the perennial grasses. Balsamroot remained

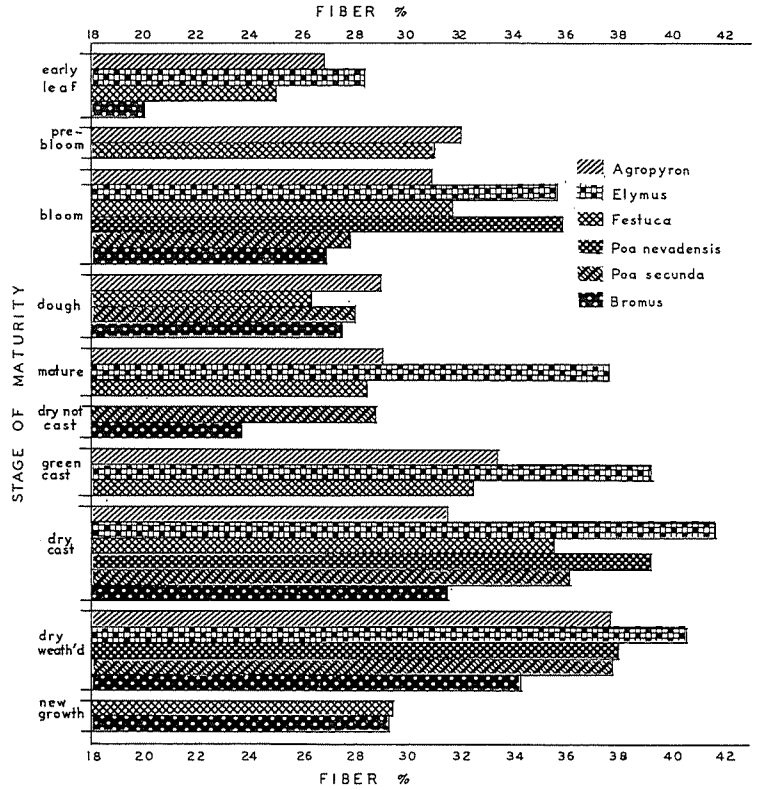

Figure 11. Crude fiber content of six selected grasses of summer range at progressive stages of maturity.

relatively low, below 20 percent, in fiber until its seeds dropped. In the weathered condition it reached 31 percent fiber content (Fig. 12). Shrubs of winter range tended to contain more fiber than those of summer range. In general, shrubs tended to be uniform in fiber content from stage to stage of maturity (Fig. 13). As a group, they were more fibrous than the weeds but less so than the grasses.

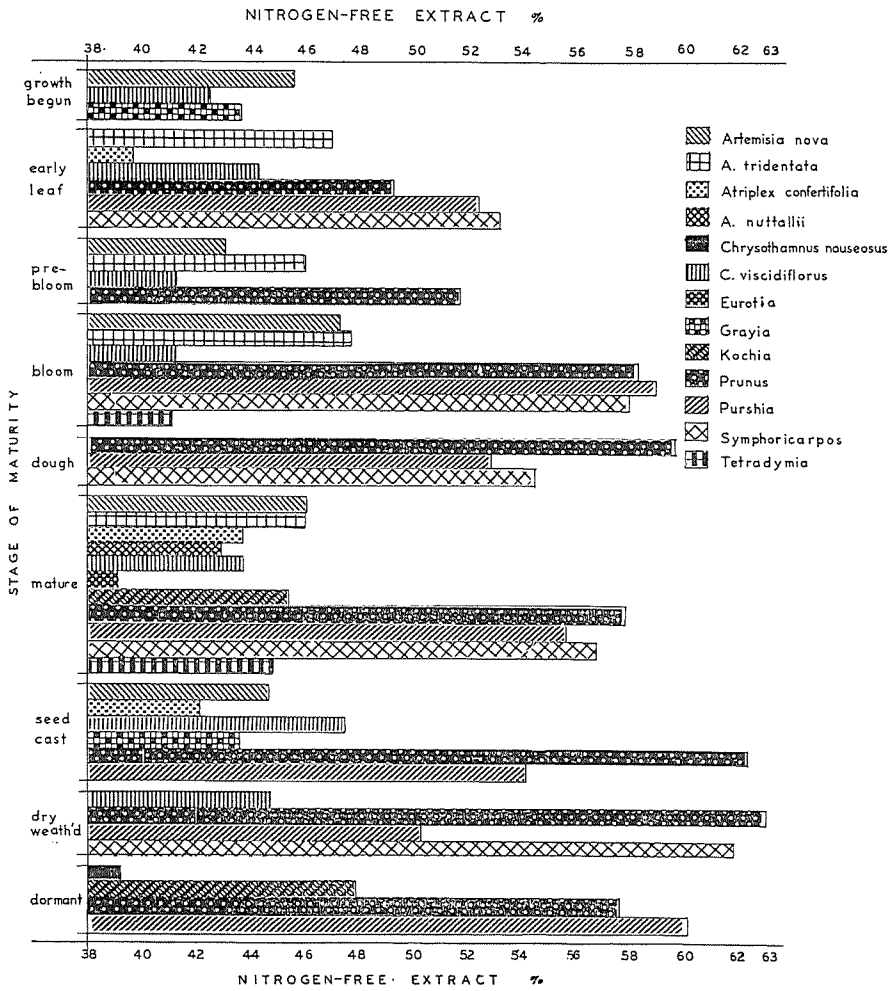

Figure 10. Nitrogen-free extract content of 14 selected shrubs of both summer and winter range at progressive stages of maturity.

The 14 shrubs for which protein content is represented in figure 4 belong to four plant families. The two members of the rose family, chokecherry (Prunus) and bitterbrush (Purshia) stand out above others in protein content. The apparent high protein content of young leaves of chokecherry cannot be due to their amygdalin content, because of the low proportion of amygdalin in the leaves (Pammel, 1911). Amygdalin is 3 percent nitrogen and leaves contain only 3 to 4 percent amygdalin. In the method of analysis used, nitrogen is determined and multiplied by the factor 6.25 to estimate protein. The number of samples upon which the average values of all nutrients in figures 2 to 11 are based are the same as shown at the ends of the corresponding bars for crude protein in figures 2 to 4.

The greater seasonal variation in some shrubs than in others appears to be due in part to leaf-fall in the deciduous species. Low sagebrush, an evergreen shrub, was only 1 percent lower in crude protein when spring growth began than at the bloom stage in late summer.

While adequate protein in range forage is regarded as of foremost importance in the growth of young animals, it is also a source of metabolizable energy. But the energy requirements of the grazing animal are met in larger part by the nutrient fractions referred to as ether extract, which included fats, and NFE which includes starches and some other carbohydrates. Digestibility of these constituents usually ranges between 30 and 70 percent, depending upon the amount of lignification of the plant tissue. Since lignification ordinarily proceeds along with maturation, digestibility declines from spring till fall. Ether extract and nitrogen-free extract contents of *grasses,* weeds and shrubs are given in the six following figures, 5 to 10.

Ether Extract

Bluebunch wheatgrass and Idaho fescue, except in early and late season, contained more ether extract than other grasses analyzed. The new growth of cheatgrass brome compared favorably in early and late season (Fig. 5).

Among the forbs balsamroot was high in ether extract, exceeded only by mulesear's. The ether extract content of balsamroot, during the flowering and fruiting stages when it is eaten most, was around 5 percent, or slightly higher than in the major grasses during that period (Fig. 6).

In general, the grasses were lower than the weeds and much lower than the shrubs in the high-energy constituent, ether extract. Browse species known to be high in content of essential oils appear highest in ether extract. These oils, as pointed out by Cook et al. (1951) are non-metabolites. The high apparent fat contents of sagebrushes and perhaps

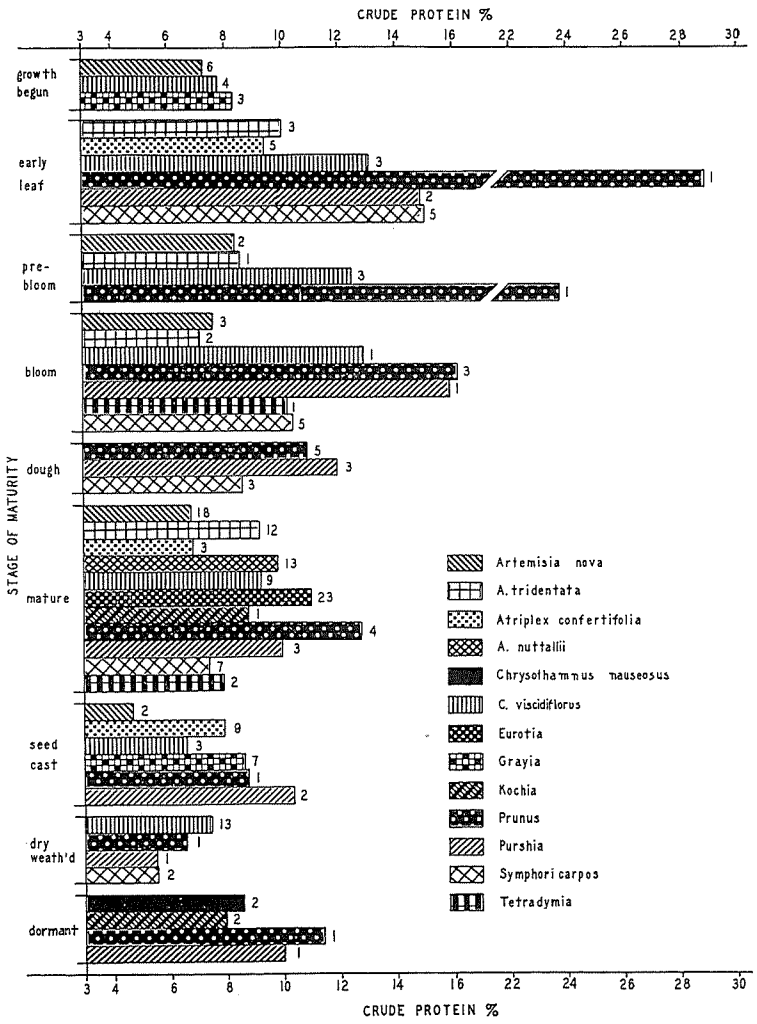

Figure 4. Crude protein in 14 selected shrubs of summer and winter ranges. The numbers of samples used in the averages are shown at the ends of the bars.

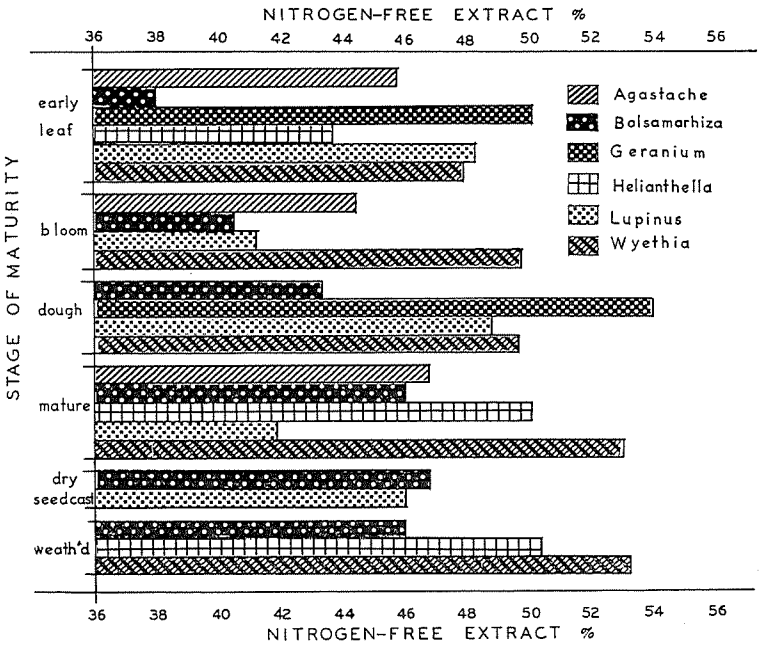

Figure 9. Nitrogen-free extract content of six selected forbs of summer range at progressive stages of maturity.

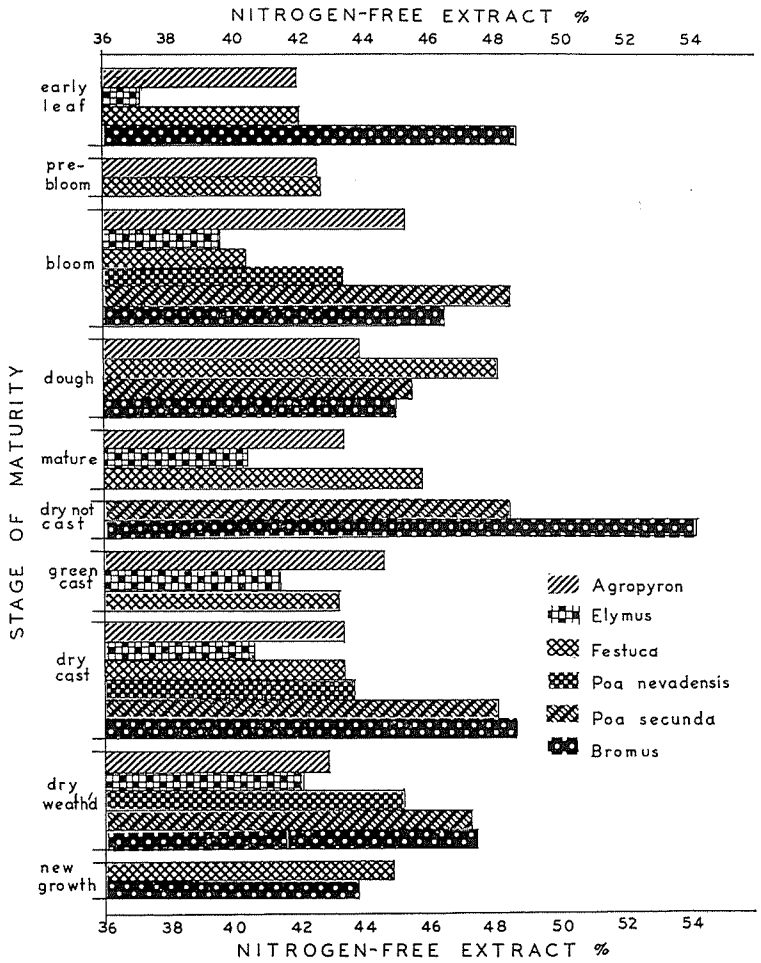

Figure 8. Nitrogen-free extract content of six selected grasses of summer range at progressive stages of maturity.

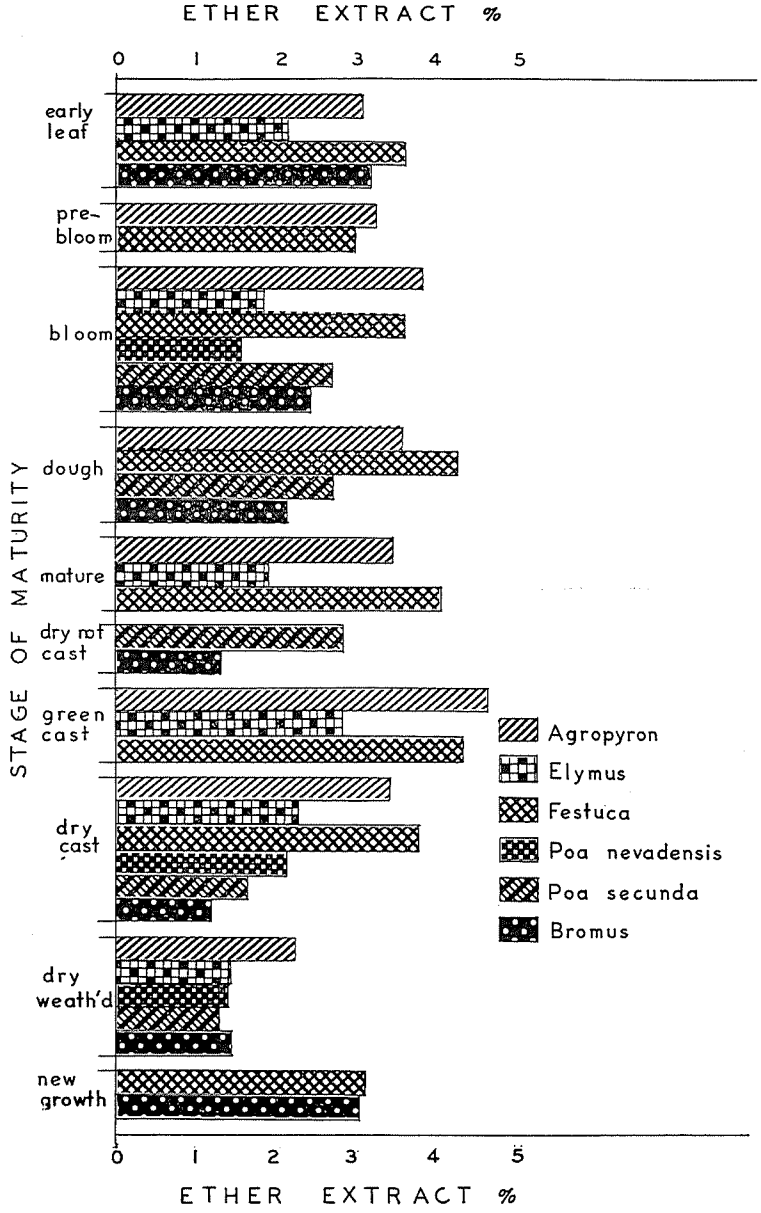

Figure 5. Ether extract content of six selected grasses of summer range at progressive stages of maturity.

yellowbrushes must, therefore, be regarded as exaggerations of their nutritive value (Fig. 7).

Nitrogen-free Extract

Fescue and wheatgrass, all season, were very similar to NFE content, standing above wildrye and below Nevada bluegrass and cheatgrass brome. Wildrye remained relatively low while cheatgrass brome was

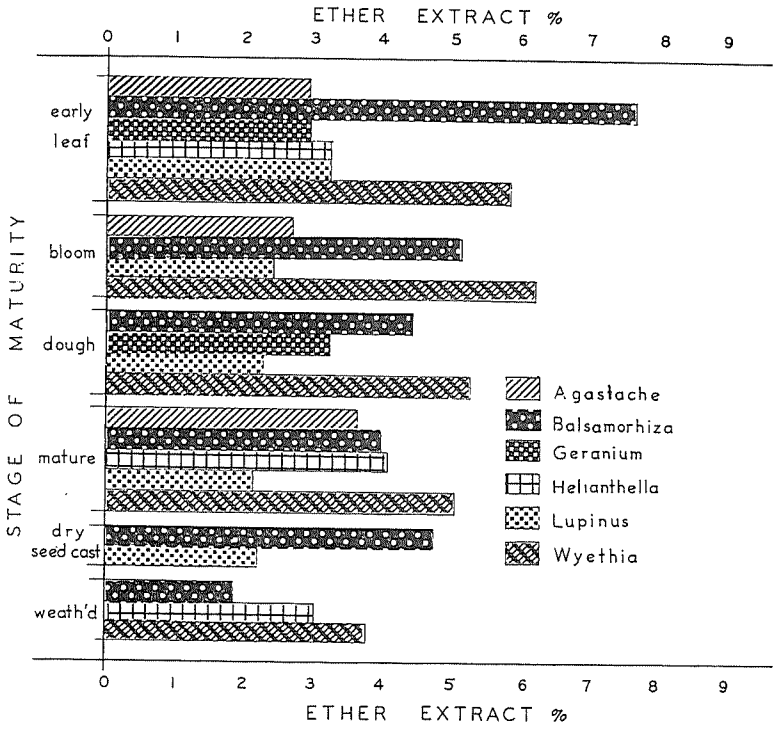

Figure 6. Ether extract content of six selected forbs of summer range at progressive stages of maturity.

generally high in NFE. The highest analysis was obtained from cheatgrass brome before it shed its seed, 54 percent as an average of 10 samples (Fig. 8). This, unfortunately is its stage of lowest palatability.

NFE content of the six weeds varied widely between species at the same stage of maturity as well as between stages. Balsamroot in early leaf, with 38 percent NFE, was exceeded by the other five weeds. Geranium was especially high in NFE at early stages, as mulesear's was at late stages (Fig. 9). Among the shrubs, highest levels of NFE were

found in deciduous species of the summer range. Bitterbrush, snowberry and chokeberry are examples. The desert-shrubs of winter range, e. g. saltbushes, whitesage, and hopsage, were relatively low and quite similar to the grasses and weeds (Fig. 10).

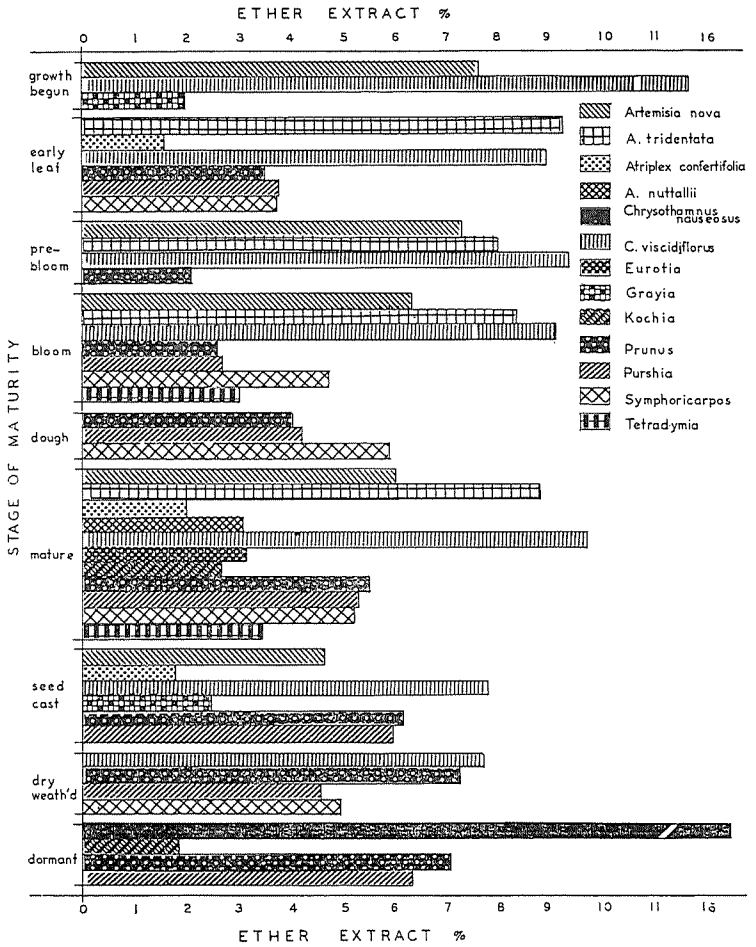

Figure 7. Ether extract content of 14 selected shrubs of both summer and winter range at progressive stages of maturity.