Shade Effects on Chemical Composition of Herbage in the Black Hills

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Highlight

Kentucky bluegrass and some associated species contained more nitrogen-free extract and less crude fiber, calcium, and phosphorus when growing on open meadow sites than when growing on pine-shaded sites. During early development, plants growing on soils derived from limestone had a higher crude protein content than plants growing on soils developed from metamorphic parent materials.

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Forested ranges in the Black Hills of South Dakota and Wyoming produce large amounts of potentially valuable livestock and game forage. Although herbage in adjacent meadows is heavily utilized, grasses and other plant species growing under forest shade are often underutilized. To determine if the reason for this difference in preference was related to chemical composition, studies were initiated to investigate the effect of shade on the chemical composition of herbage grown on two major parent soil materials during seasonal progression.

Study Area

The Black Hills of South Dakota and Wyoming are characterized by stands of ponderosa pine *(Pinus ponderosa)* interspersed with meadows, parks, and other openings. These openings cover one-fourth to one-third of the total area. Average annual precipitation varies from about 16 inches in the foothills and the southern part of the Black Hills to about 26 inches in the northern part; the greatest amounts fall in spring and early summer (Orr, 1959). Average January temperatures are in the low 20's and average July temperatures are in the low 70's, with maximums and minimums more moderate than those of the surrounding plains. Average growing seasons at official weather stations vary from 97 and 154 days, depending largely on elevation. Elevations range from about 3,500 feet in the foothills to 7,200 feet at the highest point in the Black Hills. Two of the major geological formations are (1) a high limestone plateau completely encircling (2) a central area of igneous and metamorphic mountains.

Four primary site types were sampled in the study. These con-

sisted of meadow and forested sites on both the limestone plateau and the metamorphic area.

Kentucky bluegrass *(Poa pratensis)* provided about 60 percent of the total weight of herbage on the meadows sampled. Timothy *(Phleum pratense)* and other grasses and sedges produced about 14 percent, forbs 25 percent, and shrubs less than 1 percent of the total herbage weight. Common forbs were yarrow *(Achillea lanulosa)*, fleabanes *(Erigeron* spp.), cinquefoils *(Potentilla* spp.), and white clover *(Trifolium repens)*. On the forested sites, Kentucky bluegrass produced about 10 percent of the total herbage weight, while associated grasses and sedges made up about 50 percent. Silvertop sedge *(Carex foenea)*, fuzzyspike wildrye *(Elymus innovatus)*, and roughleaf ricegrass *(Oryzopsis asperifolia)* were the most common forage plants. A wide variety of forbs produced about 20 percent of the herbage weight. Shrubs, mainly bearberry *(Arctostaphylos uva-ursi)*, produced the remainder, or about 20 percent of the total herbage weight.

Methods and Procedures

Herbage samples were collected at six paired meadow and forested range locations. Three pairs were located on the limestone plateau and three in the metamorphic region. The meadow areas are typified by narrow Kentucky bluegrass bottoms referred to as "stringer bottoms." Forested collecting areas were located near the edges of moderately open ponderosa pine stands.

Herbage samples were collected at 2- to 3-week intervals from early June to mid-August, and at 4-week intervals thereafter through mid-October in 1957, 1958, and 1959. The phenological stage of plant development was recorded at time of collection. Plants were clipped about 0.25 inch above ground level. Only the current year's growth of ungrazed plants was taken. About 75 grams fresh weight per species were collected each sampling date at each site. All herbage samples were air-dried in the laboratory. The samples were analyzed for percent moisture, crude protein, ether extract (crude fat), nitrogen-free extract, ash, calcium, and phosphorus. The biochemistry department of the South Dakota State College, Brookings, performed the analyses in accordance with the Official Methods of Analysis of the Association of Official Agricultural Chemists (A.O.A.C., 1950).

A standard rain gage was maintained at each pair of sites during the collecting periods in 1958 and 1959. Soil samples were collected for gravimetric soil moisture determinations (Olson and Hoover, 1954) in conjunction with herbage samples in 1958 and 1959.

Results

Crude Protein.—Mean crude protein content of Kentucky bluegrass for the periods collected was significantly higher in plants growing on forested limestone sites than on the other three site types (Table 1). Roughleaf ricegrass and silvertop sedge from the forested limestone sites also were higher in crude protein than when growing on forested metamorphic sites, the only other type on which those species occurred. Although crude protein levels varied within site from year to year, plants from the forested limestone sites were highest in protein each year.

Table 2 indicates that protein content of bluegrass was related to the stage of plant development at the time of collection. Following the usual pattern of crude protein content in grasses, it was highest in the early vegetative stage and decreased as the plants matured. This may account for the apparent difference in protein content of forage on the forested limestone site. The plants from forested sites on the limestone soils were at an earlier stage of development than plants of the same species collected on the other sites during the same chronological period. Kentucky bluegrass samples collected from meadow limestone sites were almost as high in protein as samples from forested limestone sites during the vegetative growth stage (first collection period), but declined more rapidly in later growth stages (Table 2). There was a difference in protein content of bluegrass forage between years of collection. This was especially noticeable while plants were in the vegetative stage (Table 2).

Timothy, fuzzyspike wildrye, silvertop sedge, and other sedge species declined to a lower average crude protein content than Kentucky bluegrass in September and October (Fig. 1). Roughleaf ricegrass had a lower range in crude protein content in early June, 11 to 14 percent, and a higher range in October, 7 to 10 percent, than any of the other species sampled.

Crude protein content was related to herbage moisture levels in all species. In Kentucky bluegrass, crude protein declined rapidly as herbage moisture declined from 75 to 80 percent to 55 to 60 percent, but the protein decrease was small at the lower moisture percentages (Fig. 2). In the other four species sampled a similar curve was obtained, except that crude protein decreases were greater as moisture declined below 55 to 60 percent. The index of correlation was

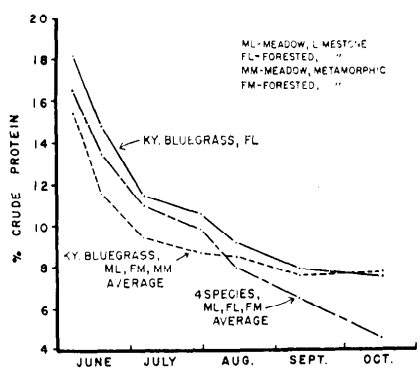

FIGURE 1. Crude protein as a function of maturity in Kentucky bluegrass and some associated species (timothy, ML; *Carex* spp., ML; fuzzyspike wildrye, FL; and *Carex foenea* FM, FL). Lines represent 3-year averages.

Table 1. Proximate analyses of Kentucky bluegrass collected from four site types in the Black Hills (dry weight basis), 1957-59.

Site	Year	Collection date: June 2-6	June 16-19	June 30-July 9	July 15-30	August 11-20	September 9-23	October 14-17	Average	Difference comparisons between averages: Difference of--	Significant at-- (Percent)
		(Percent chemical composition)									
CRUDE PROTEIN											
Meadow, limestone:	1957	16.4	13.3	8.6	8.2	8.3	8.4	9.2	10.3	1.4	5
	1958	16.2	9.4	8.1	8.0	6.9	6.7	5.5	8.7	1.4	5
	1959	18.3	14.7	10.5	9.3	7.7	6.8	6.0	10.5	1.4	5
Forested, limestone:	1957	15.6	15.6	11.8	10.7	10.0	8.2	9.4	11.6	1.4	5
	1958	17.0	12.6	10.3	8.7	8.6	7.9	5.9	10.1	1.4	5
	1959	22.1	16.2	12.8	10.7	8.7	7.7	7.2	12.2	1.4	5
Meadow, metamorphic:	1957	14.0	11.7	8.7	8.4	9.5	9.9	9.1	10.2	1.4	5
	1958	13.6	9.2	7.5	6.6	7.9	6.7	7.5	8.4	1.4	5
	1959	14.0	12.8	11.9	10.1	9.6	8.2	8.7	10.8	1.4	5
Forested, metamorphic:	1957	14.9	11.9	9.1	8.4	9.7	8.3	7.6	10.0	1.4	5
	1958	12.2	9.4	8.9	7.6	8.2	6.3	7.0	8.5	1.4	5
	1959	17.9	13.3	11.1	9.6	9.2	8.1	9.7	11.3	1.4	5
NITROGEN-FREE EXTRACT											
Meadow, limestone:	1957	42.8	48.9	49.1	50.8	46.7	49.4	47.9	47.9	4.5	1
	1958	45.2	51.7	52.3	50.9	51.7	50.0	50.4	50.3	4.4	5
	1959	44.9	44.5	47.1	47.6	48.8	51.3	50.8	47.9	3.9	1
Forested, limestone:	1957	40.6	43.1	45.7	44.6	42.2	45.2	42.7	43.4	4.5	1
	1958	39.8	42.4	40.4	42.6	42.9	44.3	48.5	43.0	4.4	5
	1959	38.0	37.7	42.2	43.7	46.6	49.6	50.1	44.0	3.9	1
Meadow, metamorphic:	1957	44.9	48.1	51.9	50.4	47.6	47.8	47.4	48.3	4.5	1
	1958	52.4	47.0	51.1	49.0	46.2	46.7	47.8	48.6	4.4	5
	1959	49.4	45.1	47.6	49.0	50.4	48.5	47.9	48.3	3.9	1
Forested, metamorphic:	1957	40.0	44.4	46.6	45.4	41.6	40.7	44.2	43.3	4.5	1
	1958	40.6	43.8	45.2	44.1	42.4	46.7	46.6	44.2	4.4	5
	1959	41.5	40.3	41.6	43.7	45.2	46.1	46.2	43.5	3.9	1
CRUDE FIBER											
Meadow, limestone:	1957	25.5	24.7	29.3	27.3	29.8	27.9	28.0	27.5	1.8	1
	1958	26.0	27.0	26.9	27.6	27.6	30.1	29.8	27.9	3.8	1
	1959	21.0	26.2	28.1	28.1	29.6	28.1	29.5	27.2	1.4	5
Forested, limestone:	1957	27.6	25.9	28.9	29.7	31.4	31.3	31.2	29.4	1.8	1
	1958	28.9	31.3	34.5	33.3	32.4	33.5	32.0	32.3	3.8	1
	1959	23.0	29.6	30.2	29.8	30.0	28.9	28.9	28.6	1.4	5
Meadow, metamorphic:	1957	25.2	24.4	25.1	27.6	27.8	24.9	26.4	25.9	1.8	1
	1958	19.5	28.9	27.5	30.2	30.3	32.4	30.2	28.4	3.8	1
	1959	21.8	26.8	24.6	25.3	24.9	28.3	29.0	25.8	1.4	5
Forested, metamorphic:	1957	27.5	27.2	28.0	29.8	30.2	31.9	30.6	29.3	1.8	1
	1958	32.3	33.5	28.7	31.8	32.1	32.5	31.6	31.8	3.8	1
	1959	24.4	30.2	30.1	30.1	29.9	29.9	28.1	29.0	1.4	5
ETHER EXTRACT											
Meadow, limestone:	1957	2.7	2.8	1.9	2.2	2.7	2.5	3.4	2.6	0.3	5
	1958	2.5	2.1	2.1	2.2	2.2	2.6	2.5	2.3	0.3	5
	1959	2.6	2.6	2.4	3.0	2.3	2.7	2.3	2.6	0.3	5
Forested, limestone:	1957	2.2	2.3	2.1	2.2	2.3	2.5	2.3	2.3	0.3	5
	1958	2.6	2.1	2.4	2.1	2.4	2.4	2.5	2.4	0.3	5
	1959	2.4	2.5	2.0	2.3	2.3	2.6	2.1	2.3	0.3	5
Meadow, metamorphic:	1957	2.3	2.4	2.3	2.2	2.5	2.9	2.8	2.5	0.3	5
	1958	2.3	2.1	1.9	1.9	2.4	2.1	2.2	2.1	0.3	5
	1959	2.6	2.7	2.6	2.7	2.5	2.2	2.6	2.6	0.3	5
Forested, metamorphic:	1957	2.4	2.1	2.3	2.4	2.5	2.3	2.5	2.4	0.3	5
	1958	2.1	2.2	2.2	2.4	2.3	2.1	2.2	2.2	0.3	5
	1959	2.2	2.1	2.8	2.4	2.7	2.5	2.6	2.5	0.3	5
ASH											
Meadow, limestone:	1957	10.0	7.6	7.4	7.7	8.3	7.7	7.5	8.0	1.6	1
	1958	6.4	6.5	6.9	7.7	7.9	7.5	8.8	7.4	1.0	5
	1959	8.5	7.2	6.6	6.7	6.5	5.5	6.0	6.7	0.7	5
Forested, limestone:	1957	9.6	8.8	7.5	8.8	9.6	8.1	9.5	8.8	1.6	1
	1958	7.5	7.5	8.6	9.7	9.2	9.0	7.7	8.5	1.0	5
	1959	10.6	9.7	8.4	8.7	8.0	6.3	7.2	8.4	0.7	5
Meadow, metamorphic:	1957	9.4	9.1	7.5	7.6	8.7	9.8	9.2	8.8	1.6	1
	1958	8.3	8.9	8.1	8.3	9.2	8.3	8.8	8.6	1.0	5
	1959	7.6	8.1	8.6	8.4	8.1	8.2	7.0	8.0	0.7	5
Forested, metamorphic:	1957	10.7	10.5	10.0	9.5	10.8	11.6	9.8	10.4	1.6	1
	1958	9.1	8.1	11.0	10.1	11.0	8.3	8.9	9.5	1.0	5
	1959	9.7	9.4	9.7	9.2	8.4	8.7	8.5	9.1	0.7	5

Table 2. Crude protein percentage (ovendry basis) and phenological stage of Kentucky bluegrass collected in the Black Hills in relation to site, chronological period, and year of collection.

Site	Year	Collection date: June 2-6	June 16-19	June 30-July 9	July 15-30	August 11-20	September 9-23	October 14-17
		(Percent protein and phenological stage[1])						
Forested, limestone:	1957	15.6 V	15.6 V	11.8 H	10.7 F	10.0 F	8.2 S	9.4 S
	1958	17.0 V	12.6 H	10.3 H	8.7 F	8.6 F	7.9 FS	5.9 D
	1959	22.1 V	16.2 V	12.8 HF	10.7 F	8.7 FD	7.7 FD	7.2 FD
	Mean	18.2 V	14.8 VH	11.6 H	10.0 F	9.1 F	7.9 FS	7.5 SD
Meadow, limestone:	1957	16.4 V	13.3 VH	8.6 H	8.2 F	8.3 F	8.4 D	9.2 D
	1958	16.2 VH	9.4 H	8.1 HF	8.0 F	6.9 F	6.7 FS	5.5 D
	1959	18.3 V	14.7 H	10.5 F	9.3 F	7.7 FD	6.8 FD	6.0 FD
	Mean	17.0 V	12.5 H	9.1 HF	8.5 F	7.6 F	7.3 FD	6.9 D
Forested, metamorphic:	1957	14.9 V	11.9 VH	9.1 HF	8.4 F	9.7 F	8.3 SD	7.6 SD
	1958	12.2 VH	9.4 H	8.9 HF	7.6 F	8.2 F	6.3 FS	7.0 D
	1959	17.9 VH	13.3 HF	11.1 F	9.6 F	9.2 FD	8.1 FD	9.7 FD
	Mean	15.0 VH	11.5 H	9.7 HF	8.5 F	9.0 F	7.6 FD	8.1 SD
Meadow, metamorphic:	1957	14.0 VH	11.7 H	8.7 HF	8.4 FS	9.5 S	9.9 SD	9.1 D
	1958	13.6 H	9.2 HF	7.5 F	6.6 F	7.9 F	6.7 FS	7.5 D
	1959	14.0 H	12.8 F	11.9 F	10.1 FD	9.6 FD	8.2 FD	8.7 D
	Mean	13.9 H	11.2 HF	9.4 F	8.4 FS	9.0 FS	8.3 FD	8.4 D

[1] V = vegetative; H = seed heads showing; F = flowering to seed maturity; S = seeds disseminated; D = plants drying.

0.78 for the Kentucky bluegrass curve and 0.87 for the curve for the mean of the other species, which were combined for analysis. The relationships were curvilinear and indices of correlation were obtained by the method of Ezekiel (1956) presented on pages 152-156. Crude protein percentages were linearly related (r = 0.76) to herbage moisture percentages in roughleaf ricegrass.

Crude Fiber and Nitrogen-Free Extract.—There were significant differences in the crude fiber and nitrogen-free extract content between forages grown in open meadows and those from shaded areas (Table 1). Crude fiber is the relatively nondigestible portion of the plant carbohydrates, while nitrogen-free extract is the more digestible portion containing sugars, starches, and other soluble carbohydrates. Kentucky bluegrass growing on forested sites on both parent soil materials averaged 30.1 percent crude fiber over three grazing seasons, while Kentucky bluegrass growing in open meadows in full sunlight averaged 27.1 percent crude fiber. Nitrogen-free extract content of the shaded Kentucky bluegrass averaged 43.6 percent, while open-grown plants averaged 48.6 percent. The differences in nitrogen-free extract and crude fiber content between shaded and open-grown Kentucky bluegrass were consistent through the grazing season (Fig. 3) and were highly significant. The three other plants collected showed similar differences. Those from shaded sites averaged 29.7 percent crude fiber compared with 26.8 percent in the plants collected from the meadows. Nitrogen-free extract in the plants other than Kentucky bluegrass averaged 44.9 percent in the shaded plants and 51.4 percent in the open-grown.

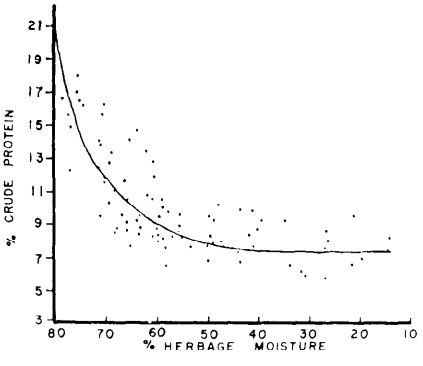

FIGURE 2. Percentage crude protein in relation to percentage herbage moisture (percent of dry weight) in Kentucky bluegrass collected periodically from four site types in the Black Hills (r = 0.78).

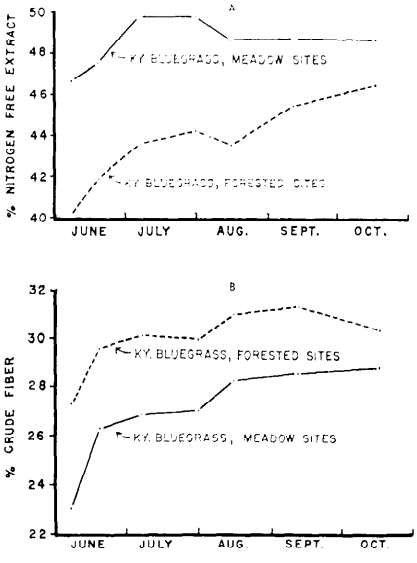

FIGURE 3. *A*, Nitrogen-free extract, and *B*, Crude fiber as a function of maturity in Kentucky bluegrass on different site types in the Black Hills. Lines represent 3-year averages.

Calcium, Phosphorus, and Ash.—Calcium in Kentucky bluegrass averaged significantly higher in plants growing on shaded metamorphic sites (Fig. 4). The plants decreased in calcium after the vegetative stage, but then increased again through the later phenological stages. Not all the plants other than Kentucky bluegrass were analyzed for calcium. In the samples analyzed, calcium increased as the season progressed.

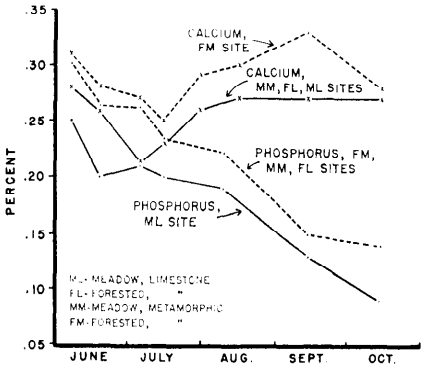

FIGURE 4. Calcium and phosphorus in Kentucky bluegrass on different site types in the Black Hills. Lines represent 3-year averages.

Phosphorus content declined throughout the season in Kentucky bluegrass (Fig. 4). The highest values were obtained from plants in the vegetative stage, and the lowest while the plants were drying. Kentucky bluegrass plants growing on open limestone soils contained significantly less phosphorus than bluegrass from the other three site types. Phosphorus was not determined for all samples of the other plants collected. Seasonal trends were similar to trends in Kentucky bluegrass in those samples that were analyzed.

Total ash content was generally higher in plants growing on soil derived from metamorphic rock compared with those on soil derived from limestone (Table 1). Within the two soils, shaded plants averaged higher in ash than comparable open-grown plants. Kentucky bluegrass growing in the shade on metamorphic soils averaged the highest in ash, 9.7 percent; open-grown plants on limestone soils averaged the lowest, Kentucky bluegrass, 7.4 percent, and timothy and sedges, 6.4 percent. No regular seasonal trends in total ash content of the plants were apparent.

Ether Extract.—Ether extract (crude fat) in Kentucky bluegrass showed no regular seasonal trends or consistent differences between sites from year to year (Table 1). Apparently, stage of plant development or amount of shading had little effect on crude fat content. Differences did exist between species of plants collected. Fuzzyspike wildrye averaged the highest, 3.4 percent, and silvertop sedge averaged the lowest, 1.8 percent.

Discussion

Livestock utilize forested sites in the Black Hills markedly less than adjacent meadow sites, both on limestone and metamorphically derived soils. Livestock on the forested sites utilized an average of only 7.8 percent of the forage, compared to 42.3 percent (herbage weight removal basis) on nearby meadows. The low use of forage on the forested range may be due to lower palatability. Shading of grasses decreases sugars and the easily hydrolyzable carbohydrates (Welton and Morris, 1928; Watkins, 1940). High sugar content is usually associated with high palatability of forage to livestock. Sugars were not separated within the nitrogen-free extract analyzed in this study, hence it can only be inferred from the significantly lower nitrogen-free extract content of the shaded grasses that their sugar content, and consequently their palatability, was also lower. The significantly higher crude fiber content of the shaded grasses could also have contributed to reduced palatability, since crude fiber imparts mechancial toughness and contains the less digestible carbohydrate fractions and indigestible lignin. Certain animal behavior traits may have caused the animals to partially avoid the confinements of forested sites. Although the herbage on the forested sites contained less nitrogen-free extract and more crude fiber, its protein and mineral content indicated a potentially valuable feed source.

Decline of crude protein with advancing maturity of grasses and sedges has been reported by Cook and Harris (1950). In the present study, roughleaf ricegrass was the only species that did not follow this pattern. Roughleaf ricegrass differed from the other plants studied by having earlier seed maturity and dispersal, and by retaining green leaves through the winter period. Crude protein in both the final fall and first spring samples of the old leaves of this species averaged 8.4 percent, which was higher than the crude protein content of the herbage of the other species tested at those periods.

Herbage moisture was correlated with crude protein in the forage plants tested. Herbage moisture was highest in plants from forested sites on both soils, although both forested sites were lower in soil moisture than the meadow sites. Herbage moisture content on forested sites may have been influenced by stage of plant maturity. Plants on the forested sites were generally 1 to 2 weeks later in their phenological development than plants growing in the meadows. At both forested and meadow sites, plants on limestone soils had a higher herbage moisture content than plants on metamorphic soils. This cannot be attributed solely to soil differences, because most of the limestone sites were located at higher elevations and had a higher annual

precipitation than the metamorphic sites. Differences in stage of plant maturity also influenced herbage moisture values.

All classes of cattle on range forage require a minimum of 8 percent crude protein in their diet (National Research Council, 1949). Growing and lactating animals need correspondingly higher amounts of protein to satisfy physiological demands. Crude protein content of the herbage analyzed generally dropped below the recommended level in September and October. Even though average protein falls below recommended levels, it is questionable if animals on ranges in good condition actually experience a protein deficiency. Selective utilization of plant parts and of late-developing species containing sufficient protein would allow livestock to maintain an adequate protein intake (Robertson and Torell, 1958). On ranges in poor condition, however, late-developing species and high-protein plant parts of other species may be depleted to the point where protein supplements might be required for proper animal nutrition.

Calcium levels were probably adequate to meet nutritional requirements for cattle and sheep throughout the year, since calcium content never fell below 0.20 percent and was usually higher in the samples tested. The recommended daily allowances of calcium for winter maintenance of beef cows and ewes are 0.24 and 0.30 percent, respectively (National Research Council, 1949).

Phosphorus content of the herbage tested fell below recommended levels in September and October. Recommended daily allowances of phosphorus for winter maintenance of beef cows and ewes are 0.18 and 0.22 percent, respectively. As with protein intake, however, if the animals are on good range with the opportunity for forage selection, they probably can maintain an adequate phosphorus intake. On poor or heavily utilized range, a phosphorus supplement might be needed near the end of the grazing season.

Summary

Livestock in the Black Hills of South Dakota have shown a decided preference for forage species grown on open meadows over those grown beneath ponderosa pine stands.

To determine whether shading influenced chemical composition of forage species, plant samples were collected at 2- to 3-week intervals throughout the grazing season—June through October—during 1957, 1958, and 1959. Herbage samples were clipped from Kentucky bluegrass, roughleaf ricegrass, fuzzyspike wildrye, timothy, silvertop sedge, and other sedge species on limestone and metamorphic sites both on open meadows and under pine stands. The plant samples were analyzed for moisture, crude protein, crude fat, crude fiber, nitrogen-free extract, ash, calcium, and phosphorus.

The plants on the forested sites were 1 to 2 weeks behind those on open meadows in stage of plant development, which may account for some of the differences in nutritive content.

Kentucky bluegrass and other grass and sedge species growing on the forested areas were generally higher in protein, crude fiber, calcium, and phosphorus, and lower in nitrogen-free extract than similar plants from open meadows on the same soils.

Only during the vegetative growth stage were Kentucky bluegrass and other plants growing on soils derived from limestone generally higher in protein than similar plants growing on metamorphic soils. Soils appear to have little effect on nitrogen-free extract, crude fiber, crude fat, calcium, and phosphorus content of the plants, but plants growing on soil derived from metamorphic rock were generally higher in ash content.

Calcium content was highest in plants growing on forested, metamorphic sites. Phosphorus was lowest in plants growing on meadow, limestone sites. The two other site combinations produced plants nearly equal in calcium and phosphorus content.

Herbage moisture content of Kentucky bluegrass and other forage plants was closely correlated with crude protein content.

In general, the important Black Hills forage plants tested contained sufficient amounts of all major nutrients with the exception of crude protein and phosphorus. These were deficient during the late fall when the plants had completed seed dissemination and were drying.

The heavier grazing use of the meadow vegetation in preference to the available forage on the forested sites was attributed in part to lower palatability of the shaded forage. This lower palatability was indicated by lower nitrogen-free extract percentages, a measure of sugar content, and by higher crude fiber percentages. The quality of the shaded plants in terms of protein, fat, and mineral content appeared nutritionally adequate for livestock production. Improved range management practices are needed to increase use of these forested ranges.

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