Effect of Site and Fertilization on Protein Content of Native Grasses

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Highlight: *Protein content of selected native range grass and sedge species was followed during the course of the growing season over a 6-year period on four major range sites in western North Dakota. The study included three rates of nitrogen fertilizer plus some added treatments of phosphorus alone and in combination with nitrogen during the study. Protein content varied appreciably between the same species on different sites, different species on the same site, and between the same species on the same site due to fertilization. Certain species were inherently high in protein content (*Agropyron smithii*), while others were intermediate (*Stipa comata *and* Stipa viridula*), and still another was comparatively low (*Bouteloua gracilis*). The presence of nitrogen fertilizer generally increased protein content of all species regardless of level of treatment or site; the magnitude of increase, however, varied greatly between sites and species. Decline in protein content is progressive in all species with the advance in maturity regardless of fertilizer treatment level or site. However, the rate of protein loss is accelerated with fertilization and becomes more rapid with a decline in summer moisture. Cool-season species show a more rapid protein loss than was observed from warm-season* Bouteloua gracilis. *The length of the grazing period when forage values remain near the minimum protein requirement is appreciably extended on some sites with certain species, especially* Bouteloua gracilis. *Proper range management must take into consideration the potential of each major range site and the inherent species capabilities to produce and maintain a high level of protein for an extended period of grazing.*

Production of native grasslands is generally measured in terms of actual pounds of forage produced at a given time during the course of the growing season. It is well recognized that appreciable differences in forage quality exist between species, levels of treatment, and season of year which must be considered when production statistics are to be correlated with animal performance (Cook and Harris, 1950). A common measure of forage quality is the determination of the protein content during the growing season by laboratory analysis, when grazing animals are not available for experimentation. This allows the possibility of determining differences in quality by individual species, season, and range sites employing the same or different species of plants.

Considerable emphasis has been placed on the determination of protein content of seeded grasses, mainly crested wheatgrass (*Agropyron desertorum*) and Russian wildrye (*Elymus junceus*) at the Dickinson Agricultural Experiment Station at Dickinson, North Dakota (Whitman and Goetz, 1958–1973) and at the Northern Plains Research Station, Mandan, North Dakota (Rogler and Lorenz, 1969 and personal communications). These studies and others have been concerned with only the two species mentioned or other seeded species and generally on a single range site. Different nitrogen fertilizer treatments and harvesting techniques were, however, applied in the studies.

A study without fertilization was carried out by Whitman et al. (1951) in the Dickinson vicinity, employing several native and tame grass species on a single site. Adequate amounts of carotene, phosphorus, and protein to meet animal requirements were found in all species in the early spring and summer period. By fall protein and phosphorus were generally at or below deficiency levels. Generally similar results were reported in a study of mineral and protein contents of blue grama and western wheatgrass (*Agropyron smithii*) in Wyoming (Rauzi et al., 1969). Differences in seasonal trends in herbage and nutrient production of important range grasses without fertilization on two sandy range sites were reported in a study by Sims et al. (1971) in eastern Colorado employing some of the same species utilized in this study. Seasonal trends of percentages of crude protein followed a pattern similar to that reported by previously mentioned authors but showed distinct percentage differences due to site influences.

In general, the results from the above-mentioned studies indicated a continuous decline in protein and other nutrients with advances in maturity of the species. The objectives of this study were to determine the levels of protein content of selected native range grass and sedge species under different levels of nitrogen fertilization and range sites throughout the growing season. Another closely associated objective of the study was to determine the relationship between effect of site upon the apparent rate of decline and ultimate protein content of the major forage species and the probable extension of the grazing season due to fertilization.

Study Area and Experimental Procedure

Range Site Description

The protein study was carried out in conjunction with other investigations over a 6-year period (1964–1969) on four major range sites in western North Dakota. The experimental sites were located within the broad vegetation zone designated as mixed grass prairie. Range sites selected encompass extreme site conditions found in the area but also represent a major portion of the grazing land of this region. The sites were located within a 35-mile radius of the Dickinson Experiment Station. Long-term precipitation averages 15.42 inches at Dickinson with approximately 75% received during the active growing season. Individual site precipitation measurements

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were taken during the course of the study period and were found to be reasonably similar to the amounts and distribution reported from the Dickinson Experiment Station. The range sites are designated by their soil series names and include the Vebar fine sandy loam (sandy site), Havre silt loam (loamy site), Rhoades silt loam (panspots), and Manning silt loam (shallow site).

The Vebar sandy loam is a soil developed from weathered weakly-cemented tertiary sandstone and is associated mainly with gently undulating to moderately steep topography. The site is situated on a gentle, southwest-facing slope and is heavily grazed in late fall of each year. The species of major importance on the site are western wheatgrass, needleandthread (*Stipa comata*), plains reedgrass (*Calamagrostis montanensis*), blue grama (*Bouteloua gracilis*), threadleaf sedge (*Carex filifolia*), and white sagebrush (*Artemisia ludoviciana*).

The Havre silt loam soil series comprises a deep, light colored alluvial soil occupying creek bottom floodplains. This range site is found extensively only in the Badlands, where it is used for both summer and winter grazing. The study site is being summer grazed and is in excellent range condition. The most important dominants of this site are western wheatgrass, plains reedgrass, green needlegrass (*Stipa viridula*) and dwarf sagebrush (*Artemisia cana*).

The Rhoades soil series is classed as a silty loam and designated as a Solonetz, high in sodium, with a near-impervious layer of dispersed clay particles in the profile varying in depth from the soil surface to approximately 20 inches. The grazing capacity of this site is considerably reduced by claypans and barren panspots which support little or no vegetation. The major dominant species of this site are western wheatgrass, blue grama, Sandberg bluegrass (*Poa secunda*), and brittle prickly pear (*Opuntia fragilis*).

The Manning silt loam is a soil type developed on a high river terrace underlain by a gravel layer at about 18–24 inches below the surface. The site is generally heavily grazed during the early summer months and is in low good condition. Dominant grasses, sedges, and forbs of major importance on this site are western wheatgrass, needleandthread, blue grama, threadleaf sedge, and fringed sagebrush (*Artemisia frigida*).

Experimental Design and Sampling Procedure

The experiment was designed as a random block of three different nitrogen treatments and a check plot (no nitrogen) replicated four times on all sites studied. Individual plots measured 30 × 100 feet with 6-foot alleyways between replications. Treatments consisted of check plots, 33, 67, and 100 lb/acre elemental nitrogen. Additional plots with treatments of 50 lb phosphorus alone and in combination with 33 lb/acre nitrogen were added to the Vebar, Havre, and Rhoades sites during the course of the study. Years when these additional treatments were initiated are indicated by appropriate footnotes in the data tables included in the body of the text.

The sampling procedure was carried out in two steps varying with the time when cattle were allowed to graze the experimental area. Early in the season, or if no animals grazed the area during the normal grazing season, samples were taken by a systematic pacing system at approximate bi-weekly intervals from all sites. Imaginary lines were drawn in each plot and 10 samples were collected from each plot at 3-pace intervals. A sample consisted of either a single plant in the case of single-stalked species (western wheatgrass), or several plants when clipping a clump or sod-forming species (needleandthread or blue grama). The sample of each species nearest to the tip of the boot was selected as the sample to be collected. Species selected and sampled from each site were needleandthread, blue grama, threadleaf sedge on the Vebar site; western wheatgrass, needleandthread and blue grama on the Manning site. Following the initiation of grazing, sampling was restricted to inside the caged areas. Samples were oven-dried at 105°F, composited by treatment and date, and analyzed, employing standard protein determinations, by the

Table 1. Seasonal levels (%) of protein on the Vebar site fertilized at three different rates (lb/acre) of nitrogen, nitrogen in combination with phosphorus, and phosphorus alone (1964–1969 averages).

Species	Treatment (lb/acre)	Protein content May 15	June 1	June 15	July 1	July 15	Aug. 1	Aug. 15	Sept. 1	Treatment means[1]
Needleandthread	0 N	14.8	14.2	13.8	7.9	8.1	6.7	6.4	5.9	9.7 b
	33 N	16.7	14.8	12.4	9.5	8.1	6.8	6.8	6.4	10.2 ab
	67 N	16.7	17.1	14.2	10.1	9.3	7.3	7.2	7.8	11.2 ab
	100 N	17.9	18.2	15.4	10.3	10.1	9.5	8.7	7.9	12.3 a
	50 P[2]	12.3	11.9	11.0	9.0	8.4	8.4	7.4	9.6	9.8 ab
	33 N + 50 P[3]	16.6	14.0	13.1	9.7	8.8	7.8	6.3	6.2	10.3 ab
	Means[1]	15.8 a	15.0 a	13.3 b	9.4 c	8.8 cd	7.8 cde	7.1 de	7.3 e	
Blue grama	0 N	–[4]	11.5	11.2	10.0	9.2	8.2	7.6	7.2	9.3 b
	33 N	–	12.8	12.7	9.5	9.3	8.8	7.7	8.4	9.9 ab
	67 N	–	15.0	14.8	12.1	10.7	10.2	8.7	7.5	11.3 a
	100 N	–	15.4	16.0	13.4	10.4	10.8	9.2	8.5	12.0 a
	50 P[2]	–	9.7	11.3	10.5	9.7	10.1	9.7	11.1	10.2 ab
	33 N + 50 P[3]	–	16.4	14.0	11.3	9.9	10.1	9.1	9.4	11.5 a
	Means[1]	–	13.5 a	13.3 a	11.1 b	9.9 bc	9.7 c	8.5 cd	8.7 d	
Threadleaf sedge	0 N	12.8	12.4	11.2	8.8	8.5	7.4	6.4	7.0	9.3 c
	33 N	16.3	13.6	12.6	9.4	9.0	6.9	6.9	8.0	10.3 bc
	67 N	16.0	15.3	14.1	11.8	10.6	9.2	8.6	10.6	12.0 ab
	100 N	16.3	15.7	14.8	12.4	11.0	10.1	8.8	11.3	12.6 a
	50 P	12.0	10.4	11.7	9.7	10.4	8.9	9.8	8.8	10.2 abc
	33 N + 50 P[3]	15.7	12.3	12.9	9.2	10.3	7.3	7.3	10.3	10.7 abc
	Means[1]	14.9 a	13.3 ab	12.9 b	10.2 c	10.0 cd	8.3 de	8.0 de	9.3 e	

[1] Means associated with the same letter are not significantly different at the 0.05% level.
[2] 1968 and 1969 averages only.
[3] 1967–1969 averages.
[4] Insufficient plant development for sampling.

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Results and Discussions

The major grasses and sedges began growth in April and completed the growth cycle by about July 15. Blue grama was the only exception, beginning its growth later and reaching maturity later in the growing season than was the case for the other species. Most species generally attained maximum protein content by mid-May. This was apparent on all sites, at all rates of nitrogen fertilization, and for all seasons of study.

Fertilization with nitrogen increased the protein content of all species studied regardless of site or level of treatment. However, the greatest variability existed due to the level of nitrogen applied in early season for the same species on the different range sites. The presence of phosphorus, even though the experiment was of short duration, did not generally indicate a definite advantage for species to develop a higher level of protein beyond that observed from check plots. In some instances, phosphorus alone appeared to inhibit protein production in some species to levels below that observed from check plots receiving no nitrogen treatment.

Western wheatgrass, present on three of the four sites studied, generally showed the highest values in protein content on all sites when compared to the other major species observed. The exception was on the Rhoades site, where Sandberg's bluegrass showed early spring values comparable to western wheatgrass. Greatest amounts of protein in early season were found on the Havre site, followed by the Manning and Rhoades sites, respectively. When comparing the percentage differences between the check plots and 67 lb N/acre treatment in early spring, the values were approximately 34, 13, and 9% between the Manning, Havre, and Rhoades sites, respectively (Tables 2, 3, and 4). All sites showed only slightly greater percentage gains at the 100 lb N/acre treatment.

The decrease in protein content is progressive until late fall regardless of species, treatment, or site. By mid-July approximately 40% of the protein content is lost in the cool-season species without or at light rates of fertilization and approximately 50% at the moderate and heavy rates. Differences between treatments and check plots are small by early August. Site differences become apparent, however, with values of 30% lower total protein content observed in this species (western wheatgrass) at the Manning site at all levels of treatment by September 1. The restricted water holding capacity of the soil on this site may inhibit continued late summer growth when protein production is still continuing, or losses are slowed by this species on the Rhoades and Havre sites. Fertilized plots generally maintained a slightly higher protein level than check plots throughout the growing season until early to mid-August.

Phosphorus alone (50 lb/acre) and in combination with 33 lb N/acre was added to the Havre, Vebar, and Rhoades sites. Western wheatgrass protein values were generally lower with phosphorus fertilization than with any of the nitrogen treatments alone, and below check plot values. With the addition of 33 lb N/acre only slightly higher values were observed, which were not generally above check plot values on both sites (Tables 3 and 4). Forage value of western wheatgrass, as indicated by the protein percentage, remains relatively high (between 8 and 9% on the Havre and Rhoades sites by early September) while being considerably lower at approximately 6% on the Manning site by the same date. Statistically significant differences in protein content between dates became evident by mid-June or early July. No significant difference was found between treatment means.

Needleandthread was considered a major species only on the Vebar and Manning sites (Tables 2 and 3). The protein content of the species showed a lower value when compared with western wheatgrass regardless of site or level of treatment, approaching about a 20% difference on the Manning site where both species were present. The decline in percent protein was not as rapid with advance in season as was observed in western wheatgrass although total amounts remained lower for any given date (Table 2). Values were generally higher for this species on the Vebar site regardless of the level of nitrogen treatment. Differences in protein content due to fertilization in early season were between 8 and 11% between the check and 67 lb N/acre plots on the Manning and Vebar sites, respectively, with higher values (15–25%) reached in mid-summer. The 100 lb N/acre rate of fertilization maintains the species at a higher protein content throughout

Table 2. Seasonal levels (%) in protein on the Manning Site fertilized with nitrogen at three different rates (lb/acre) (1964–1969 averages).

Species	Treatment (lb/acre)	Protein content May 15	June 1	June 15	July 1	July 15	Aug. 1	Aug. 15	Sept. 1	Treatment means[1]
Western wheatgrass	0 N	17.0	15.2	11.7	12.3	9.7	8.3	6.5	6.3	10.9 a
	33 N	20.3	16.2	13.2	11.0	10.6	8.6	6.5	6.2	11.6 a
	67 N	22.8	18.1	15.5	12.6	10.8	8.9	7.0	6.2	12.7 a
	100 N	24.5	20.0	16.3	13.2	11.9	9.4	7.4	7.2	13.7 a
	Means[1]	21.2 a	17.4 a	14.2 b	12.3 b	10.8 c	8.8 cd	6.9 de	6.5 de	
Needleandthread	0 N	14.6	12.3	9.9	7.7	7.9	6.9	6.7	6.1	9.0 a
	33 N	15.5	12.5	10.2	8.6	7.8	6.6	6.3	6.1	9.2 a
	67 N	15.8	15.3	13.9	9.0	8.4	6.6	6.8	6.7	10.3 a
	100 N	18.4	16.5	12.6	10.0	8.6	7.5	6.9	7.3	11.0 a
	Means[1]	16.1 a	14.2 ab	11.7 b	8.8 c	8.2 cd	6.9 d	6.7 d	6.6 d	
Blue grama	0 N	–[2]	12.0	10.9	8.8	8.9	9.2	6.7	7.1	9.1 c
	33 N	–	11.0	11.6	12.8	10.7	8.6	7.1	7.3	9.9 c
	67 N	–	13.6	13.4	13.9	10.3	10.0	8.2	7.9	10.9 ab
	100 N	–	15.6	15.0	11.5	12.0	9.7	10.1	8.8	11.8 a
	Means[1]		13.1 a	12.7 ab	11.8 bc	10.5 cd	9.4 de	8.0 ef	7.8 ef	

[1] Means associated with the same letters not significantly different at the 0.05% level.
[2] Insufficient plant development for sampling.

Table 3. Seasonal levels (%) of protein on the Havre site fertilized at three different rates (lb/acre) of nitrogen, nitrogen in combination with phosphorus and phosphorus alone (1964–1969 averages).

Species	Treatment (lb/acre)	Protein content May 15	June 1	June 15	July 1	July 15	Aug. 1	Aug. 15	Sept. 1	Treatment means[1]
Western wheatgrass	0 N	19.5	17.1	15.7	12.2	11.7	10.1	9.0	8.8	13.0 a
	33 N	19.9	17.6	14.9	11.7	11.4	9.8	7.8	8.9	12.8 a
	67 N	22.2	19.3	16.2	11.7	12.6	9.0	8.4	8.8	13.5 a
	100 N	22.5	19.7	17.7	13.7	14.1	8.2	8.5	9.9	14.3 a
	50 P[2]	16.2	14.5	13.7	11.0	9.1	7.3	7.6	6.5	10.7 a
	33 N + 50 P[2]	17.6	15.6	14.2	10.9	9.7	9.7	5.7	5.4	11.1 a
	Means[1]	19.7 a	17.3 a	15.4 a	11.9 b	11.4 b	9.0 c	7.8 c	8.1 c	
Green needlegrass	0 N	16.3	14.9	12.5	9.7	9.1	6.8	7.1	7.3	10.5 a
	33 N	17.2	15.6	12.5	8.9	9.1	6.8	6.4	7.6	10.5 a
	67 N	19.9	15.7	14.6	10.2	9.8	7.7	7.5	7.6	11.6 a
	100 N	21.1	19.3	15.6	11.4	11.0	8.2	8.0	8.2	12.9 a
	50 P[2]	15.5	12.7	11.9	9.3	7.0	6.9	6.6	5.5	9.4 a
	33 N + 50 P	17.9	14.1	14.5	8.5	6.8	6.9	6.2	6.2	10.1 a
	Means1	18.0 a	15.4 b	13.6 c	9.7 d	8.8 d	7.2 e	7.0 e	7.1 e	

[1] Means associated with the same letters not significantly different at the 0.05% level.
[2] 1967–1969 averages only.

the summer.

Phosphorus treatments for needleandthread were added only on the Vebar site (Table 1). The data indicate a lower protein value on plots fertilized with phosphorus alone than was observed from check plots early in the season. However, by July 1 values increased and surpassed the nitrogen fertilized plots by September 1. The plots fertilized with 33 lb N+50 lb P/acre responded similarly to the 67 lb N/acre treatment except for a more rapid loss in protein towards the end of the season (Table 1). Treatment means were significant in needleandthread only between check and the 100 lb N/acre treatment on the Vebar site.

Green needlegrass was found only on the Havre site (Table 3). Protein content of this species appeared to be generally intermediate between western wheatgrass and needleandthread although present on only this site. A pattern of protein loss similar to that observed in the other species was also present in this species. Differences in percent protein between check and 67 lb N/acre plots were approximately 22 and 29% at the 100-pound-nitrogen treatment. All plots maintained protein levels of nearly 9–10% through July 15 with the 100 lb N/acre treatment maintaining about 8% by September 1. Phosphorus alone depressed protein content below that observed from check plots while with the addition of 33 pounds of nitrogen

Table 4. Seasonal levels (%) of protein on the Rhoades Site fertilized at three different rates (lb/acre) of nitrogen, nitrogen in combination with phosphorus, and phosphorus alone (1964–1969 averages).

Species	Treatment (lb/acre)	Protein content May 15	June 1	June 15	July 1	July 15	Aug. 1	Aug. 15	Sept. 1	Treatment means[1]
Western wheatgrass[2]	0 N	17.7	16.2	13.3	14.6	12.9	8.0	8.6	8.7	12.5 a
	33 N	16.8	17.1	15.3	12.4	14.9	9.5	10.2	8.0	13.0 a
	67 N	19.3	19.0	15.8	13.9	14.7	9.8	10.1	8.6	13.9 a
	100 N	21.1	21.0	15.0	14.6	14.9	11.5	6.6	9.9	14.3 a
	50 P[3]	20.3	15.7	14.3	13.9	11.4	9.9	5.4	7.0	12.2 a
	33 N + 50 P[3]	19.5	15.5	10.3	12.7	10.6	11.7	8.8	8.7	12.2 a
	Means[1]	19.1 a	17.4 a	14.0 b	13.7 b	13.2 b	10.1 c	8.3 c	8.5 c	
Sandberg bluegrass[2]	0 N	15.7	11.5	9.4	7.3	–	–[4]	–[4]	4.9	9.8 a
	33 N	20.1	15.2	12.7	7.3	5.7	–	–	5.6	11.1 a
	67 N	17.1	17.5	14.8	8.8	8.8	–	–	5.7	12.1 a
	100 N	22.1	18.0	16.0	8.5	14.2	–	–	5.7	14.1 a
	Means[1]	18.8 a	15.6 ab	13.2 bc	8.0 cd	9.6 cd	–	–	5.5 d	
Blue grama[2]	0 N	13.6	11.7	14.1	11.6	11.1	10.0	10.3	9.2	11.5 a
	33 N	14.1	14.1	13.9	10.4	13.5	12.4	10.0	9.1	12.2 a
	67 N	15.4	15.2	15.7	14.5	12.8	13.5	9.9	10.4	13.4 a
	100 N	17.7	15.9	16.2	17.4	14.2	16.6	9.8	11.0	14.9 a
	50 P[3]	–[5]	11.3	18.1	10.9	12.7	9.8	7.5	9.0	11.3 a
	33 N + 50 P[3]	–	11.3	12.2	11.1	12.5	16.9	8.0	9.0	11.6 a
	Means[1]	20.3	13.3 a	15.0 a	12.7 a	12.8 a	13.2 a	9.3 b		

[1] Means associated with the same letters not significantly different at the 0.05% level.
[2] 1967 data not included in average.
[3] Data for 1968 and 1969 only.
[4] Missing data indicates plant material too dry for continual regular sampling.
[5] Inadequate growth for proper sampling.

the inhibition was only slightly less (Table 3). In both species, needleandthread and green needlegrass, the lowest values for protein were apparently reached by August 1 with only slight additional losses beyond this date. Significant differences in protein were found in early June and mid June and between mid June and early July. No significant differences were found between treatment means.

Blue grama, the only warm-season grass of this study, was a major dominant on the Vebar, Rhoades, and Manning sites. Although growth is initiated early in the spring in this species, substantial leaf development is slow and generally inadequate for sampling until late May or early June. This species showed the lowest protein values in early spring of the three major species studied.

Initial protein content values by June 1 were found to be approximately 30 and 13% between check plots and the 67 lb N/acre treatment on the Vebar, Rhoades, and Manning sites, respectively. A reverse situation was apparent when comparing the check plots and the 100 lb N/acre treatment where 30% differences were observed from the Rhoades and Manning sites and only a slight increase above the 67 lb N/acre values from the Vebar site for the same sampling date. Growth was slightly earlier on the Rhoades site, perhaps due to the imposition of heavy fall grazing and lack of any significant amount of plant litter.

The 67 and 100 lb N/acre rates of fertilization maintained the protein level of blue grama at or near the 10% level to September. The exception was the Vebar site where values below 10% were observed by August 15. In general, however, the application of the higher rates of nitrogen added an additional 15 days of high value forage for each increase in increment of fertilizer. On the Manning site, the 100 lb N/acre treatment showed an increase of 1.5 months of forage above 10% protein when compared to the check plots.

The response of blue grama to phosphorus alone on the Vebar site indicated early spring values lower than those of check plots. Later response showed values similar to those from higher fertilized plots with considerably higher values than from any fertilized plots by the end of the growing season. The 50 P + 33 lb N/acre treatment plots showed high initial values but showed values comparable to phosphorus alone by September. No special advantage appeared to be gained by this species by adding the same treatments to the Rhoades site. Significant differences in treatment means were observed from the Vebar and Rhoades sites. Differences in dates were significant between June 1 and June 15 on the Vebar and Manning sites and at various times later in the season. No significant differences in dates were observed on the Rhoades site.

Threadleaf sedge, an important early-growing, cool-season associated species on the Vebar and Manning sites, compared favorably in protein content with blue grama. Protein analysis was carried out only on the Vebar site with this species. With fertilization the protein content remained near 10% throughout the summer period despite severe leaf drying by late summer. The high loss of 'leaf material' due to the drying, however, greatly reduces the value of the species for late summer grazing. Another early-growing, cool-season species, Sandberg bluegrass, occurred in substantial amounts only on the Rhoades site. Early spring response to nitrogen fertilizer was high showing an approximate 30% increase in protein over check plots at the high level of fertilization. The extremely short life span of the leaf material results in near complete deterioration by early summer and renders the species of only limited utilization as a grazing resource.

Conclusions and Summary

The range site characteristics and the species of plant are of major importance when considering forage quality with or without fertilization. It is apparent from this study that appreciable differences exist between the same species and different range sites regardless of the level of fertilization. Statistically significant differences were observed between the same species and treatments on different sites, especially early in the growing season. The variation, however, was highly inconsistent throughout the growing season all years of the study. The addition of nitrogen fertilizer generally increases the percent protein of a species although the magnitude of the effect is largely determined by the site under consideration. The cool-season species respond more quickly and to a more substantial degree than was observed from the warm-season grasses. Decline in protein content, however, was a common phenomena in all species regardless of level of fertilization, time of season, or range site.

The ability of the cool-season species, especially western wheatgrass, to maintain a fairly high level of protein content throughout the summer period on the major range sites particularly under fertilization, allows early and mid summer grazing of high quality forage when the warm-season grasses have not yet reached maximum production and are not yet ready for intensive grazing. Needleandthread, commonly a major co-dominant in the sites studied, also showed a similar protein content pattern, although the amounts remained slightly lower, but losses were less for a longer period into late summer or early fall than was observed from western wheatgrass. The combined presence of these two species will allow a grazing program to more fully exploit the higher protein content of western wheatgrass in early spring with a similarly high protein grass, needleandthread, available later in the grazing period.

Blue grama showed a lower protein content than any of the other species on all sites. The lower values, however, are still within the requirements necessary for adequate nutrition of grazing livestock. The response to nitrogen fertilizer was slightly less at all treatments than was observed from the western wheatgrass and the needlegrasses. However, the extension of the higher protein content of blue grama into late summer and early fall with fertilization on all sites is an important attribute of this species. The rate of protein loss also is considerably less than that observed in the cool-season species regardless of site or fertilizer treatment. The deferment of grazing on ranges where this species is dominant, while earlier cool-season native species are being utilized, can substantially extend a normal grazing season without serious loss in forage quality. The delay in significant leaf drying due to fertilization on most major range sites coupled with the higher maintenance of forage quality, is of prime importance in the management of rangelands with significant amounts of blue grama (Goetz, 1970).

Native range fertilization in the Northern Great Plains generally results in improved species composition, increased forage production, and protein values. Protein content of most major range grass species is adequate to meet minimum nutritional requirements for livestock early in the growing season but reaches levels below this requirement in early summer. The addition of nitrogen, and perhaps phosphorus on some sites, results in a generally substantially higher protein content above that realized from unfertilized forage with the maintenance of a generally longer period of sufficient protein content. The increase in forage production associated with nitrogen fertilization, plus the higher protein content and lengthened grazing season, allows a considerably greater benefit by way of animal products on a per acre basis than would be possible in the absence of fertilization. Management of native rangelands to include the individual species performance with respect to protein production dictates a knowledge of range site characteristics as well as inherent capability of individual species to convert nitrogen and possibly other fertilizers to plant protein.

Literature Cited

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

Goetz, H. 1970. Growth and development of Northern Great Plains species in relation to nitrogen fertilization. J. Range Manage. 23:112-117.

Rauzi, F., L. I. Painter, and A. K. Dobrenz. 1969. Mineral and protein contents of blue grama and western wheatgrass. J. Range Manage. 22:47-49.

Rogler, George A., and Russell J. Lorenz. 1969. Pasture productivity of crested wheatgrass as influenced by nitrogen fertilization and alfalfa. U.S. Dep. Agr. Tech. Bull. 1402.

Sims, P. L., G. R. Lovell, and D. F. Hervey. 1971. Seasonal trends in herbage and nutrient production of important Sandhill grasses. J. Range Manage. 24:55-59.

Whitman, W. C., D. W. Bolin, E. W. Klosterman, H. J. Klosterman, D. W. Ford, L. Moomaw, D. G. Hoag, and M. L. Buchanan. 1951. Carotene, protein, and phosphorus in range and tame grasses of Western North Dakota. North Dakota Agr. Exp. Sta. Bull. No. 370. 55 p.

Whitman, W. C., and H. Goetz. 1958-1973. Grass and legume production and performance under dryland conditions. Agr. Exp. Sta. Annual Rep., Dickinson, D. Dak.