Effects of Grazing on the Soils and Forage of Mixed Prairie in Southwestern Saskatchewan

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OF AN estimated 20 million acres of native grasslands in Saskatchewan, over 8 million acres consist of mixed grass prairie. Characteristics of mixed grass prairie that have been studied include yield, chemical composition, seasons of growth and reaction to grazing.

Research was initiated in 1950 to determine if heavy grazing causes chemical or structural changes in the soil, and consequent changes in the chemical composition of the vegetation of mixed grass prairie with primary emphasis on phosphorus. This report summarizes the observations made with respect to differences in stands, yields and chemical contents of ungrazed and overgrazed mixed grass prairie in southwestern Saskatchewan.

Literature Review

Clarke and Tisdale (1945) have shown the seasonal trends in chemical composition of five grasses of the short-grass prairie. They report that phosphorus contents range from 0.252 percent in plants collected in the leaf stage to 0.062 percent in the cured plants after winter exposure. They indicate that phosphorus content is deficient in the cured forage.

Stoddart (1941) found that changes in phosphorus content of browse plants resulted from changes in soil type.

Musser (1948) and Webb *et al.* (1948) found that changes in floristic composition of pastures occur with changes in the amount of available phosphorus. Cook and Harris (1950) found the availability of soil moisture to be more important than the available phosphorus in the soil in influencing the phosphorus content of plants. Godden (1926) and Daniel and Harper (1934) showed that with over 10 parts per million of soluble phosphorus in the soil there was a slight positive correlation between the total phosphorus in the grass and the soluble phosphorus in the soil; with less than ten parts per million of available phosphorus in the soil, there was a slight negative correlation.

Daubenmire and Colwell (1942), in studies of the Agropyron-Poa prairie of Eastern Washington, found a decrease in the amount of available phosphorus in the soil below one decimeter as a result of grazing. The amount of organic matter in the upper decimeter of soil increased.

In contrast, Tebbe *et al.* (1947), in studies conducted on shortgrass prairie grazed at three different rates, found small but consistent reductions in amount of organic matter in the surface soil under grazing.

Description of the Area

The mixed grass prairie area of Saskatchewan, the northern portion of the Northern Great Plains Region, lies west of the Missouri Coteau, which runs diagonally across the province from the southeast to approximately the center of the west boundary. It is characterized by an undulating to rolling topography interspersed with extensive flat, dry glacial lake beds.

Generally, the soils are derived from glacial material and range from sand to heavy clays. They have a shallow surface horizon that varies from grey-brown to dark brown in color. A calcium carbonate layer occurs at a depth of from 10 to 18 inches below the surface.

The climate is semi-arid. Average annual precipitation ranges from 13 to 16 inches with slightly over half occurring in the period from April to July inclusive. May–September evaporation is approximately 30 inches.

The vegetation of mixed grass prairie is dominated by blue grama grass (*Bouteloua gracilis*) and needle-and-thread (*Stipa comata*). Other grasses of importance are June grass (*Koeleria cristata*), western wheatgrass (*Agropyron smithii*), short-awned porcupine grass (*Stipa spartea* var. *curtiseta*) and northern wheatgrass (*Agropyron dasystachyum*).

Common broad-leaved plants include pasture sage (*Artemisia frigida*), puberulent androsace (*Androsace puberulenta*), moss phlox (*Phlox hoodii*) and broomweed (*Gutierrezia diversifolia*). Little clubmoss (*Selaginella densa*) is abundant.

Methods

During the summer of 1950, four mixed grass prairie sites were selected, each crossed with a fence line which separated grazed from ungrazed areas. Sites were located on similar soils, loams and silt loams. Site 2 was located on a level upland, Sites 1 and 3 on level parts of generally sloping areas; Site 4 was located on a low-lying area. At each site, exclosures one by two rods were erected on each side of the fence. Throughout this report these exclosures are referred to as the grazed and ungrazed treatments. The grazing histories of the grazed portions of the various sites indicate that Site 3 was the most heavily used, but has not, of late, been used in the spring. Informa-

tion for Site 2 is limited. Site 1 was grazed for a long season at relatively light rates. Site 4 was grazed only slightly heavier than the accepted rate, but from early spring to late fall. The composition and percent basal area of species on each treatment were obtained by the point method of sampling as described and used by Clarke *et al.* (1942). Data obtained showed the ungrazed treatments to be representative of the vegetation of the mixed grass prairie in the region.

In late June, 1951, four plots (one-half by two yards) in each treatment were clipped. At this time needle-and-thread was in the late leaf stage. The forage harvested from each plot was divided into three groups consisting of needlegrasses, wheatgrasses and other forage, each bagged separately. Composite samples of the forage from adjacent plots in each treatment were analyzed by the Division of Chemistry, Science Service, Ottawa for protein, crude fiber, ether extract, nitrogen-free extract, total ash, calcium and phosphorus.

Soil samples consisted of a core sample of the surface 0 to 4 inches, and bulk samples from 6- to 12-inch and 12- to 24-inch depths. The 4- to 6-inch depth containing both A and B horizons was deleted. Soil analyses included volume weight, soil moisture, nitrogen, pH and organic matter. Carbonic-acid soluble phosphorus was determined by the method of McGeorge as used by Ensminger and Larson (1944).

Results

Vegetation

Grazing produced changes in the composition of the vegetation at all sites. However, few species reacted similarly on all sites. The dominants usually decreased with grazing, but needle-and-thread on Site 1 and blue grama on Site 3 showed increases in basal area. The wheatgrasses decreased on all but Site 4. Total grasses and sedges decreased with grazing on all sites except Site 3, at which the decrease was overshadowed by the large increase in blue grama grass. With the exception of Site 1, total broad-leaved species were more abundant on the grazed area. Of the principal broad-leaved species, pasture sage showed the most uniform trend, increasing in abundance on the grazed portion of three sites. Puberulent androsace usually decreased with grazing, while moss phlox varied in its response.

Forage yields by sites are presented in Table 1. Yields were lower for the grazed than the ungrazed treatments at all sites. The difference was particularly striking in needlegrasses in which the bulk of the reduction occurred. The reduction of yield in needlegrasses corresponds to changes which occurred in the cover.

Results of the protein and phosphorus analyses are summarized in Table 2. Higher percentage contents of protein and phosphorus were noted on grazed than on ungrazed treatments, although the differences in phosphorus content were not significant. It is of particular interest to note that protein contents of the wheatgrasses show smaller differences between grazed and ungrazed sites than needlegrasses and other forage. Chemical analyses of other nutrient constituents suggested that NFE and calcium were higher in grazed than in ungrazed treatments, while the reverse condition held for ether extract, crude fiber and total ash. Significant differences were not established between treatments for the other nutrient analyses.

Table 3 shows the average yield of protein and phosphorus in

Table 1. Average forage yields of four sites in mixed grass prairie, June, 1951

Class of Forage	Site 1		Site 2		Site 3		Site 4	
	Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed
	Lbs. per acre		*Lbs. per acre*		*Lbs. per acre*		*Lbs. per acre*	
Needlegrasses	211.3	377.7*	40.6	85.4*	210.2	491.9**	161.1	666.8**
Wheatgrasses	125.9	128.0	102.4	230.5**	6.4	24.5	168.6	82.2*
Other forage	146.2	170.8	167.5	149.4	407.6	510.0	106.7	211.3**
Total	483.4	676.5*	310.5	465.3**	624.2	1026.4*	436.4	960.3**

* Significant difference between grazed and ungrazed treatments at 5 percent level.

** Significant difference between grazed and ungrazed treatments at 1 percent level.

Table 2. Protein and phosphorus(P) content of forage from four sites in mixed grass prairie, June, 1951

Class of Forage	Condition	Site 1		Site 2		Site 3		Site 4	
		Protein	P	Protein	P	Protein	P	Protein	P
		%	%	%	%	%	%	%	%
Needlegrasses	Grazed	10.46*	0.15	13.06*	—	8.54	0.14	9.76	0.16
	Ungrazed	9.47	0.15	9.44	0.17	8.66	0.11	7.86	0.13
Wheatgrasses	Grazed	8.72	0.13	11.72	0.19	7.03	0.16	10.02*	0.16
	Ungrazed	7.68	0.11	8.88	0.16	8.01	0.15	8.22	0.15
Other forage	Grazed	11.24**	0.12	13.42**	0.17	9.90**	0.14	11.42**	0.16
	Ungrazed	9.90	0.14	9.52	0.16	8.84	0.14	8.88	0.11

* Significant difference between grazed and ungrazed treatments at 5 percent level.

** Significant difference between grazed and ungrazed treatments at 1 percent level.

Table 3. Average weight of protein and phosphorus in the forage of four sites in mixed grass prairie, June, 1951

Site	Protein		Phosphorus	
	Grazed	Ungrazed	Grazed	Ungrazed
	Lbs. per acre			
1	49.3	63.1	0.64	0.96
2	39.8	37.9	0.59	0.77
3	59.1	90.0	0.95	1.56
4	47.7	78.1	0.70	1.28

pounds per acre. Forage from grazed areas showed significantly lower amounts of phosphorus than that from ungrazed areas. Differences between sites were especially marked in the amounts of this element found in the wheatgrasses and in the other forage class. Differences between treatments were greatest in needlegrasses. In wheatgrasses and 'other forage', the grazed sites occasionally produced more phosphorus per acre in the forage than the ungrazed areas. The variations in gross amounts of crude protein produced per unit area are an expression of the varying yield of forage and the differences in percent of this constituent in the forage. It could be expected that, if the percent protein is increased in the grazed forage, the increase would be reflected in the gross production. The validity of this assumption is emphasized by the data obtained on Site 2. On this site, 465.3 pounds of ungrazed forage produced 37.9 pounds of protein, and 310.5 pounds of grazed forage produced 39.8 pounds of protein. Qualitative increases in protein in the forage are reflected in the gross protein produced.

Soils

Pertinent soil analyses are reported in Table 4. These indicate similarity in pH, moisture equivalent, and organic matter at Sites 1, 2 and 3. Soil textures at all sites were loams and silt loams. With the exception of the ungrazed treatment of Site 4, all treatments contained similar amounts of total nitrogen (0.23 to 0.26 percent). Site 4 had a slightly acid soil, but resembled the other sites in the remaining soil characteristics studied. Statistical analyses of the factors evaluated indicates that differences in pH, moisture equivalent and organic matter cannot be considered significant between sites or treatments. Differences in volume weight, available phosphorus and moisture content were significant between treatments. These results indicate that grazing tends to cause soil compaction and reduces soil moisture-holding capacity. The availability of phosphorus is less clearly established, but there is an indication that phosphorus is more available on grazed than on ungrazed sites within the 0- to 4-inch horizon. There was some association between availability of phosphorus and moisture content of the soils but the trend was not consistent.

Table 4. Soil characteristics from four sites, in mixed grass prairie, June, 1951

Treatment	pH	Moisture Equiv.	Organic Matter	Avail. P.	Volume Weight	Field Moisture
		Percent	*Percent*	*p.p.m.*		*Percent*
Site 1						
Grazed						
0–4″	6.5	17.2	3.7	24**	1.20	13.5
6–12″	7.7		2.1	3		14.2**
12–24″	8.1		1.1	3		10.9*
Ungrazed						
0–4″	6.8	17.5	3.6	16	1.19	15.6
6–12″	7.6		2.2	4		15.4
12–24″	8.1		0.9	4		12.2
Site 2						
Grazed						
0–4″	7.5	16.0	5.4	10**	1.17**	4.7*
6–12″	7.8		4.5	4		4.0**
12–24″	7.9		2.5	6		4.8*
Ungrazed						
0–4″	7.2	18.6	4.8	7	1.04	6.0
6–12″	7.8		3.0	7		6.4
12–24″	8.0		1.6	4		6.4
Site 3						
Grazed						
0–4″	6.9	21.5	4.9	22	1.18	17.1
6–12″	7.9		2.5	3		19.7
12–24″	7.8		0.9	2		16.3
Ungrazed						
0–4″	6.7	21.2	6.0	18	1.20	18.0
6–12″	7.9		2.7	2		17.7
12–24″	7.7		1.0	3		14.0
Site 4						
Grazed						
0–4″	6.2	20.6	4.6	14**	1.21**	15.2**
6–12″	6.5		1.9	4		14.6
12–24″	6.1		1.7	1**		16.9*
Ungrazed						
0–4″	5.7	19.5	7.9	27	1.02	27.8
6–12″	6.1		2.9	4		16.6
12–24″	6.4		1.9	3		14.4

* Significant difference between grazed and ungrazed treatments at 5 percent level.

** Significant difference between grazed and ungrazed treatments at 1 percent level.

Discussion and Conclusions

The four sites illustrate the variability in the reaction of mixed grass prairie to grazing. Specific reactions to grazing have been attributed to individual species of the mixed grass prairie. The reaction of individual species to grazing is a complex interaction, modified by differences in topography, exposure, moisture supply, surface and sub-surface drainage and soils. Site 4 differed considerably from the other three sites in the reaction of species to grazing.

Forage yields were lower on all sites under grazing. Yields from needlegrasses were reduced with grazing on all sites. On Sites 2 and 3, wheatgrasses were reduced with grazing, while on Site 1, grazing produced little change in the forage yields of these species. Evidently the less intense rate of grazing, to which Site 1 had been subjected, influenced the forage production of the dominant needle-and-thread, but had less effect on the production by wheatgrasses than the heavier rates at which Sites 2 and 3 were grazed. On Site 4, wheatgrass forage production was increased with grazing. Grazing markedly reduced the production from other forage species on Site 4.

Mixed grass prairie varied with site in its ability to produce forage when grazed. Reductions in total forage production occurred on all sites with grazing, but the reaction of the various species was not consistent.

Changes in chemical composition of the forage in the late leaf stage of the four sites showed general trends. Ether extract, crude fiber and ash were usually lower for all classes of forage on the grazed treatment, while protein, nitrogen-free extract, calcium and phosphorus tended to be higher.

The differences in protein between grazed and ungrazed treatments were most significant. The decrease in gross protein in the grazed forage was of a smaller order, percentagewise, than the decrease in total forage yield. This differential reduction in forage and in gross protein (Table 5) might be expected in the 'other forage' class due to variations in species composition on grazed and ungrazed treatments. If this were true in only the 'other forage' class, the increase in protein could be attributed to an increase in less palatable species. However, in both the needlegrasses and wheatgrasses, the percentage reduction in gross protein is less than that in forage production.

This finding is of significance in that it suggests that the protein content of ungrazed forage may not be the true measure of the protein value of that forage when grazed. In the past, measurements of ungrazed vegetation have been used to determine the ability of mixed prairie to support grazing animals. Although it is realized that protein is not the only nutritional factor, these data indicate that the use of nutritive content of ungrazed forage may lead to errors.

Examination of the soil conditions on the grazed and ungrazed treatments was primarily concerned with the influence of grazing on the available phosphorus.

Moisture characteristics of the site may influence the relation of availability of soil phosphorus to grazing as shown by the data from Site 4. In this site, with more favorable moisture conditions, phosphorus content of the soil was reduced under grazing. These data, although not conclusive, indicate that changes in available phosphorus of the soil apparently occur due to grazing, but may be modified by the moisture conditions of the site. Further study on this problem in the mixed prairie would entail a detailed appraisal of edaphic and vegetational types.

Table 5. Percentage differences in forage production and gross protein content of forage due to grazing on four sites in mixed grass prairie, June, 1951

Site	Forage Production	Gross Protein
1	−28.0	−22.0
2	−33.0	+5.4
3	−39.2	−34.2
4	−54.6	−38.9

Summary

The effects of heavy grazing on chemical and structural conditions in the soil and on the phosphorus and protein content of forage were evaluated in a study in the mixed prairie in southwestern Saskatchewan.

Forage analyses in the late leaf stage and soil analyses were conducted on grazed and ungrazed treatments on four sites. Forage constituents were separated into needlegrasses, wheatgrasses and other forage for chemical analyses. Soils were analysed for texture, volume weight, percent moisture, pH, moisture equivalent, organic matter content, total nitrogen and available phosphorus.

Forage analyses showed that ether extract, crude fiber and ash were higher and protein, nitrogen-free-extract, calcium and phosphorus were lower on the ungrazed treatments as compared to the grazed areas in all classes of forage. Differences in protein between grazed and ungrazed treatments were most significant.

Changes in the availability of phosphorus in the soils studied apparently occurred due to grazing but were influenced by soil moisture conditions. On sites of low moisture content, available phosphorus tended to increase under grazing. The single site with more favorable moisture conditions showed diminished available phosphorus under grazing.

The reactions to grazing of the vegetation of mixed grass prairie were modified by differences in site characteristics.

Acknowledgment

The author is indebted to Mr. J. B. Campbell, Officer-in-Charge, Pasture Division, Experimental Station, Swift Current, Saskatchewan, and Dr. E. W. Tisdale, Head, Range Management, School of Forestry, University of Idaho, for direction and guidance during the study and pertinent discussion of the manuscript.

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