Response of Western North Dakota Mixed Prairie to Intensive Clipping and Five Stages of Development

CHARLES A. HOLDERMAN AND HAROLD GOETZ

Abstract

The effects of clipping to a 2.54 cm (1 inch) height at 5 stages of development of western North Dakota mixed prairie were investigated. Soil moisture content at the beginning of the growing season had a greater effect on yields than did the clipping treatments. Observations from this two-year study indicate that soil moisture removal was not affected by the clipping treatments. Clipping significantly affected peak yields by needle-and-threadgrass (*Stipa comata*) and the *Carex* species during 1977; and the miscellaneous grasses (*Agropyron smithii* and *Agropyron subsecundum*) during 1978, at the sandy loam site. No significant differences in yields were observed for the other species and groups at the sandy loam site, or, the species and groups at the loam site for the two-year period.

Late season livestock gains in western North Dakota may be improved if the amount of blue grama (*Bouteloua gracilis*), the dominant palatable warm-season shortgrass, could be increased without decreasing the overall productivity of the range. Whitman (1953) reported that normal grazing usage results in a cover which is probably of greater grazing value than the completely protected cover. Employing a deferred and rotation system, Sarvis (1923) reported greater total gains on fewer acres when compared to a continuous grazing system. Under the deferred and rotation system, the vegetation was allowed to mature periodically before being subjected to grazing again. A new system of ranching, referred to as the Short Duration Grazing or SDG system, was developed in Rhodesia in 1964 (Goodloe 1969). This system consists of a high intensity-low frequency harvesting of the forage, even with intensive harvesting range conditions improved under the semiarid climate where the SDG system was developed. The present study was designed to determine the effect of intensive harvesting on the developmental stages of Northern Great Plains mixed prairie.

Clipping results in more severe injury to grass stands than does defoliation from normal grazing use (Whitman et al. 1961). Although clipping does not directly duplicate the effects of grazing, considerable information may be gained by the reactions of species to foliage removal (Sarvis 1923).

The effects of clipping on the Northern Great Plains have been reported by different authors. In South Dakota, Black et al. (1937) reported that frequency of clipping buffalo grass (*Buchloe dactyloides*) and blue grama appeared to have little effect on yield. Total production of buffalo grass, blue grama, western wheatgrass (*Agropyron smithii*), plains bluegrass (*Poa arida*), and six weeks fescue (*Festuca octoflora*) was greatest when clipped at 40-day intervals. Total production by all plants was also greatest when clipped at 40-day intervals. Two vegetation types in western North

Dakota, a western wheatgrass-blue grama type, and a needle-and-threadgrass (*Stipa comata*)-blue grama-sedge (*Carex* spp.) type were studied by Whitman and Helgeson (1946). Average yields for blue grama decreased in both vegetation types when clipped twice during a season to a height of 1.27 cm (1/2 in). Needle-and-threadgrass decreased under all clipping treatments in height, yield, and basal area. Average yields for western wheatgrass were maintained under single clipping to a height of 3.81 cm (1 1/2 in) and 7.62 cm (3 in), but decreased under double clipping. Sarvis (1923) reported blue grama was benefited by frequent clipping while needle-and-threadgrass decreased in relation to clipping frequency. Heinrichs and Clark (1961) in Saskatchewan, and Whitman et al. (1961) at Dickinson, North Dakota, reported that yields of green needlegrass (*Stipa viridula*) increased when clipped 2 or 3 times a year compared to annual clipping.

These studies applied periodic and/or annual clipping treatments. The present paper reports the response of Northern Great Plains mixed prairie to intensive clipping at five stages of development, with respect to peak yields and basal cover of selected species and groups, and the seasonal removal of soil moisture in the profile.

Description of Study Locations

This study was carried out on two major range sites in western North Dakota. Vegetation of the region is mixed grass prairie as described by Weaver and Clements (1938). Study site 1 is located approximately 9.6 km (6 miles) northwest of the city of Dickinson on a sandy loam of the Vebar-Parshall-Arnegard toposequence (Larson et al. 1968). Dominant perennial grasses are needle-and-threadgrass, green needlegrass, blue grama, prairie Junegrass (*Koeleria cristata*), and Sandberg bluegrass (*Poa secunda*). The miscellaneous grasses are dominated by western wheatgrass and bearded wheatgrass (*Agropyron subsecundum*). Major *Carex* species are *C. filifolia*, *C. eleocharis*, and *C. heliophila*. Study site 2 is located approximately 14.4 km (9 miles) southeast of the town of Medora on a loam soil similar to the Shambo series (U.S. Dep. Agr. Forest Serv. 1971; and personal communication with Ken Thompson, Soil Conserv. Serv., Dickinson, N.D.). Dominant perennial grasses are western wheatgrass, blue grama, prairie Junegrass, and needle-and-threadgrass. The miscellaneous grasses are dominated by green needlegrass (*Stipa viridula*) and Sandberg bluegrass (*Poa secunda*). Major *Carex* species are *C. filifolia*, *C. eleocharis*, and *C. heliophila*. Scientific and common names follow Stevens (1963). Abbreviated scientific names follow the Range Analysis Handbook U.S.F.S. (1977).

The climate of the region is semiarid with an annual precipitation between 40.13 cm (15.80 inches) and 42.06 cm (16.56 in), 75% of which falls during the growing season April through September.

Experimental Procedures

The experimental plots were randomly located with three repli-

At the time of the research, authors were graduate student and chairman, Botany Department, North Dakota State University, Fargo, 58105. Holderman's present address is Ozark Francis National Forests, P.O. Box 1008, Russellville, Arkansas 72801.

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cates of eight treatments on each of two study sites. Plot size was 10.1 m by 11.9 m (33 ft by 39 ft) with four rows of six plots. Plots were subdivided into six 3.96 m by 5.03 m (13 ft by 16.5 ft) subplots, half of which were randomly selected to be sampled for above ground biomass in alternating years. Six-foot alley ways were left between plots to facilitate movement. Five of the treatments were clipping trials, two were herbicide trials, and one the control which received no treatment. This paper reports only the results of the clipping trials.

Three plots (replications) on each of the two study sites were mowed to a 2.54 cm (1 in) height on each of the treatment dates. Clipping (mowing) dates for 1977 were: May 24 and 25; June 9 and 10; June 22 and 23; July 6 and 7; and July 19 and 20, for sites 1 and 2, respectively. Clipping dates for 1978 were: May 20 and 21; June 7 and 8; June 22 and 21; July 7 and 6; and July 21 and 19, for sites 1 and 2, respectively. Plots received only one clipping treatment per year. Plots clipped in 1977 were clipped at approximately the same time period in 1978. The clipped herbage was removed following the treatment. Prior to each treatment three subplots from each replication were randomly sampled for above ground biomass using one 1/8-m² (25 cm by 50 cm) quadrat for a total of nine 1/8-m² quadrats per treatment. Control plots were sampled for biomass at approximate biweekly intervals from mid May through mid July and a terminal harvest in mid October 1977 and early September 1978. The May clip, first June clip, and the second June clip were sampled for regrowth at approximate monthly intervals until mid to late July and during mid October of 1977 and early September of 1978. Nine 1/8-m² quadrats were randomly located for the regrowth sampling. Species composition by weight was estimated using the double sampling technique. The double sampling technique consisted of estimating the percent by weight of species composition, and then clipping by species the first and last quadrats of the 9 quadrats clipped for the biomass samples. The percent by weight of species composition was estimated for quadrats 2 through 8 and the clipped herbage combined for the quadrat sample. Clipped herbage was then dried at 66° C for 72 hours and weighed to the nearest 0.1 gram. Correction percentages from quadrats 1 and 9 were applied to quadrats 2 through 8. Peak yields for the clipping treatments were determined from adding the biomass samples taken prior to the clipping treatment with each of the samples taken for regrowth. Peak yield reported is the maximum cumulative average yield per treatment for the selected species and groups. Peak yields on control plots were the biomass peaks for the selected species and groups.

Soil moisture content was determined utilizing the gravimetric method in 1977 and the neutron-scattering method in 1978. Sampling depths for 1977 were: 1–15 cm, 15–30 cm, 30–45 cm, 45–60 cm, 60–75 cm, 75–90 cm, and 90–120 cm. Sampling depths for 1978 were: 0–15 cm, 15–30 cm, 30–45 cm, 45–60 cm, 60–75 cm, and 75–105 cm. (A 15-cm error in lowering the probe's source resulted in the change of sampling depths in 1978). The gravimetric method was utilized for the 0–15 cm depth in 1978. Gravimetric samples were dried at 105° C for 72 hours and weighed to the nearest 0.1 gram. The soil moisture content was sampled at biweekly intervals from approximately May 15 through August 15. The amount of soil water removed was determined utilizing a method described by Neff and Wight (1977). They reported: "The available soil water is the difference between the soil water measurement and the minimum soil water measured at anytime during the period of record. This definition assumed that the minimum soil water measured during the period of record approximated the soil water holding capacity at wilting point". Their definition of available soil water was interpreted to be the amount of soil water removed through evapotranspiration. Soil moisture removed for 1977 is reported for the period of June 7 through August 11; and for 1978 the period of May 15 through August 24.

Basal cover was determined in August of 1977 and 1978 using the point contact method. A hit was recorded when the point came into contact with the base of a living (green) plant. Percent basal cover was determined from 3,600 points per treatment. According to

Whitman and Siggeirsson (1954) 3,600 basal contact points would provide sampling errors of 10% or less for the three major components—needle-and-threadgrass, blue grama, and the sedges; and sampling errors between 10 and 20% for all other species and groups, except for plains reedgrass (*Calamagrostis montanensis*).

Data were analyzed using standard analysis of variance techniques. The Duncan's multiple range test was used to separate mean differences when significant ($P < 0.10$ or $P < 0.05$) values were found. Acceptance levels for significant differences reported are at the $P < 0.05$ level unless otherwise stated to be at the $P < 0.10$ level.

Results and Discussion

Above-ground Biomass

Clipping to a 2.54 cm (1 in) height on May 24 and June 10 reduced ($P < 0.10$) yields of needle-and-threadgrass compared to yields observed for the 2.54-cm (1 in) clipping in July 19 and control plots during 1977 at site 1 (Fig. 1). Needle-and-threadgrass yields were not significantly different between the control plots, June 22, July 7, and July 19 clipping treatments; or between the May 24, June 10, June 22, and July 7 clipping treatments. Yields by *Carex* species increased ($P < 0.10$) when clipped to a 2.54 cm (1 in) height on June 10 compared to yields on control plots, May 24, and July 19 2.54 cm (1 in) clipping treatments. When clipped to a 2.54 cm (1 in) height on July 7, yields by *Carex* species increased ($P < 0.10$) above yields observed for the control plots and the July 19 2.54-cm (1 in) clipping treatment. No significant differences in yield of *Carex* species were observed for: the May 24, June 22, and July 7 2.54 cm (1 in) clipping treatments. Clipping did not significantly affect yields by green needlegrass, prairie Junegrass, blue grama, Sandberg bluegrass, miscellaneous grasses, or the forbs for 1977. The June 22 clipping treatments increased ($P < 0.10$) the peak yield compared to the May 24 clipping treatment and control plots (Fig. 2). Clipping did not significantly affect peak yields between: the June 10, June 22, July 7, and July 19 2.54 cm (1 in) clips; or the control plots, May 24, and July 19 2.54 cm (1 in) clipping treatments. Peak yields were increased ($P < 0.10$) by the June 10, June 22, and July 7 2.54 cm (1 in) clipping treatments above those observed on May 24 clipping treatment and control plots for 1977. Observation indicated an increase ($P < 0.10$) in yield by the miscellaneous grasses when clipped to a 2.54 cm (1 in) height on July 21 as compared to all other 2.54-cm (1 in) clipping treatments and control plots for the 1978 growing season (Fig. 1). Clipping did not significantly reduce yields by needle-and-threadgrass and prairie Junegrass in 1978. No significant differences in yield were observed for the other species and groups, or the peak yields at site 1 for the 1978 growing season (Fig. 1 and Fig. 2, respectively). Clipping did not affect yields during the 1977 or 1978 growing seasons at site 2 (Fig. 1 and Fig. 2).

The relationship between soil moisture and forage yields was observed at both sites during this two-year study period (Fig. 1 and Fig. 2). These observations agree with studies reported by Rogler and Haas (1947) working near Mandan, North Dakota. They reported that when soil moisture was above or below average, forage yields showed a positive relationship of being above or below average. The dry conditions observed at the beginning of the 1977 growing season, when compared to 1978, appeared to have a greater effect on yields than the clipping treatments. However, early season clipping appeared to have compounded the effects of dry conditions on needle-and-threadgrass by reducing yields at site 1 during 1977 (Fig. 1). Precipitation for the period of January through May of 1977 was 12% below normal at Dickinson and Medora (Table 1). For the same time period in 1978, precipitation was 18.7% of 51.2% above normal at Dickinson and Medora, respectively. The growing season precipitation, April through September, was above normal at both stations during 1977 and 1978. Even with above-average growing season precipitation during both years, forage yields were higher in 1978 as a result of higher soil moisture levels at the beginning of the growing season when

Fig. 1. The effect of clipping date on the peak dry matter yields of selected species and groups at two western North Dakota mixed prairie study sites during 1977 and 1978.

compared to 1977.

Basal Cover

The basal cover of Sandberg bluegrass was reduced ($P < 0.10$) by the June 22, July 6, and July 19 2.54 cm (1 in) clipping treatments during 1977 and reduced by all 2.54 cm (1 in) clipping treatments in 1978 at site 1 (Table 2). The July 19 2.54-cm (1 in) clip increased basal cover of the sedges compared to the control plots, and the May 24, June 10, and June 22 2.54-cm (1 in) clipping treatments for 1977. The basal cover of the sedges increased when clipped to a 2.54 cm (1 in) height on July 6 above that observed for the May 24 and June 22 2.54-cm (1 in) clipping treatments during 1977. Total basal cover, when excluding small clubmoss (*Selaginella densa*), increased under the June 10 2.54-cm (1 in) clipping compared to the May 24, June 22, July clipping treatments, and control plots in 1977. Total basal cover, when excluding small clubmoss, decreased in 1978 under the June 22, July 7, and July 21 clipping treatments

Fig. 2. The effect of clipping date on the peak yields at two western North Dakota mixed prairie study sites during 1977 and 1978.

Table 1. Precipitation (cm) at Medora, North Dakota, and the Dickinson Experiment Station during the period 1977–1978 compared with the 29-year (1941–1970) average at each station.

Location	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Site 1													
Dickinson ND Experiment Station 1977	1.11	0.91	3.33	0.33	6.60	13.67	2.74	3.86	14.68	5.49	2.77	3.25	58.67
Dickinson ND Experiment Station 1978	0.64	0.99	0.23	4.60	10.13	5.33	6.12	5.11	6.50	0.74	3.40	0.99	44.78
1941–1970 average	1.04	1.04	1.68	3.84	6.38	10.19	5.82	4.72	3.48	1.83	1.30	0.76	42.06
Site 2													
Medora ND 1977	1.37	0.48	2.06	0.20	6.65	9.17	2.31	5.26	13.87	2.87	2.49	1.96	48.69
Medora ND 1978	0.33	1.73	0.58	3.15	12.73	7.34	7.70	3.84	4.34	0.61	3.00	0.89	46.23
1941–1970 average*	0.99	0.89	1.30	3.63	5.44	10.24	5.77	4.60	3.45	1.80	1.30	0.74	40.13

*Medora ND is located approximately in the center of a triangle formed when the three closest recording weather stations were averaged for the 1941–1970 period. The three weather stations are Amidon, N.D., Sentinel Butte, N.D., and Fairfield, N.D.

Table 2. Average percent basal cover of selected species and groups in August of 1977 and 1978, for each of the 5 clipping treatments and control plots at site 1.

Species	1977						1978					
	May 24	June 10	June 22	July 6	July 19	Control	May 20	June 7	June 22	July 7	July 21	Control
<i>Stipa viridula</i> (Green needlegrass)	3.50	1.06	0.66	0.97	0.93	0.23	0.63	1.37	0.17	0.70	0.70	
<i>Stipa comata</i> (Needle-and-thread-grass)	0.73	0.90	1.37	0.93	1.50	1.83	1.43	0.97	1.17	0.73	1.13	2.17
<i>Koeleria cristata</i> (Prairie Junegrass)	1.17	1.17	1.67	0.63	0.47	0.93	1.83	1.73	1.70	0.90	1.70	2.43
<i>Bouteloua gracilis</i> (Blue grama)	2.37	3.00	2.60	2.07	2.17	2.33	4.33a ¹	3.77ab	3.70abc	2.53bc	2.27c	2.37bc
<i>Poa secunda</i> (Sandberg bluegrass)	0.37ab ²	0.70a	0.16b	0.07b	0.06b	0.67a	0.15b ¹	0.57b	0.16b	0.20b	0.15b	1.17a
Misc. grasses	0.37	0.23	0.27	0.12	0.09	0.13	0.77	0.57	0.33	0.50	0.40	0.29
<i>Carex</i> spp. (Sedges)	1.18c ¹	2.57cb	1.57c	3.13ab	3.73a	2.50cb	1.70	2.40	1.30	2.47	1.83	2.03
Forbs	0.40	0.37	0.40	0.19	0.16	0.05	0.05	0.16	0.12	0.37	0.13	0.19
<i>Selaginella densa</i> (Small clubmoss)	2.10	0.90	3.80	1.10	0.80	4.80	4.30	2.10	5.60	1.80	1.20	4.70
Total*	7.90b ¹	9.90a	8.33b	8.03b	9.10ab	8.40b	10.87a ¹	11.43a	8.77b	7.87b	8.20b	11.27a

*Total basal cover values excluding *Selaginella densa*.

¹Means in the same row followed by similar letters are not significantly different at the 0.05 level of probability.

²Means in the same row followed by similar letters are not significantly different at the 0.10 level of probability.

compared to the control plots, the May 20, and June 7 clipping treatments. The May 20 clipping treatment increased the basal cover of blue grama during 1978 above that observed for the control plots, July 7, and July 21 clipping treatments. Even though the basal cover of Sandberg bluegrass decreased on the clipping treatments and a general increase in basal cover of blue grama was observed for the May 20, June 7, and June 22 clipping treatments during 1978, clipping did not significantly affect yields by either species (Fig. 1).

Prairie Junegrass decreased ($P<0.10$) in basal cover when clipped to a 2.54 cm (1 in) height on July 20 compared to the control plots, the May 25, and June 9 clipping treatments at site 2 for 1977 (Table 3). The June 23 clipping treatment reduced ($P<0.10$) the basal cover of prairie Junegrass compared to the May 24 clipping treatment and control plots. Prairie Junegrass made very little regrowth following the June 23, July 7, and July 20 clipping treatments during 1977. It was difficult to distinguish between living (green) plants and dead plants when the point contact method was used in August, resulting in the lower number

of hits observed. The difficulty in distinguishing between living and dead plants, rather than the clipping treatments, may have accounted for the decrease in basal cover in 1977. Clipping did not affect the basal cover for prairie Junegrass in 1978. The clipping treatments did not affect the basal cover of the other species and groups, or the total basal cover, when excluding small clubmoss, on site 2 for the two-year period.

Soil Moisture

The soil moisture content at the beginning of the growing season greatly influenced forage production. Dickinson received 9.40 cm of precipitation from October 1976 through April 1977, 18.1% below normal. Precipitation for the same time period in 1977 and 1978 was 56.4% above normal (Table 1). During mid May 1977, the average percent soil moisture on the control plots at site 1 was 4.4% and 19.7% at mid May 1978. Medora, a measuring station within 14.4 km of site 2, received 6.76 cm of precipitation from October 1976 through April 1977, or 36.5% below normal. Precipitation for the same time period in 1977 and 1978 was 23.2% above normal

Table 3. Average percent basal cover of selected species and groups in August of 1977 and 1978, for each of the 5 clipping treatments and control plots at site 2.

Species	1977						1978					
	May 25	June 9	June 23	July 7	July 20	Control	May 21	June 8	June 21	July 6	July 19	Control
<i>Agropyron smithii</i> (Western wheatgrass)	1.50	1.40	1.60	1.07	0.80	1.07	0.87	1.40	1.17	1.17	1.00	0.63
<i>Stipa comata</i> (Needle-and-thread-grass)	0.10	0.26	0.26	0.40	0.50	0.40	0.27	0.20	0.13	0.13	0.23	0.33
<i>Koeleria cristata</i>	1.07a ¹	0.87ab	0.30bc	0.43abc	0.13c	1.00a	1.50	1.30	0.73	0.87	1.13	1.47
<i>Bouteloua gracilis</i> (Blue grama)	3.53	3.97	4.47	4.90	5.47	5.20	5.97	5.43	4.87	4.73	5.10	5.40
Misc. grasses	0.0	0.0	0.02	0.0	0.0	0.0	0.23	0.03	0.05	0.09	0.0	0.17
<i>Carex</i> spp. (Sedges)	1.80	1.47	1.37	1.60	2.73	2.13	1.13	1.29	1.07	0.90	1.60	1.47
Forbs	0.53	0.67	0.67	0.27	0.17	0.36	0.30	0.23	0.70	0.08	0.20	0.19
<i>Selaginella densa</i> (Small clubmoss)	12.0	16.80	13.80	17.30	21.50	24.70	7.70	14.20	10.50	12.30	12.60	21.40
Total*	8.40	8.57	8.57	8.70	9.73	10.30	10.3	9.23	8.87	7.93	9.20	9.70

*Total basal cover values excluding *Selaginella densa*.

¹Means in the same row followed by similar letters are not significantly different at the 0.10 level of probability.

Table 4. A comparison of the amount (cm) of soil moisture removed for the 5 clipping treatments and control plots at site 1 for the 1977 and 1978 sampling periods.

Clipping treatment date	0-15	15-30	30-45	45-60	60-75	75-90	90-120
1977							
May 24	3.05	2.32	1.29	0.78	1.19	0.93	1.20
June 10	3.52	2.55	2.24	1.07	0.77	1.06	1.06
June 22	2.84	2.35	2.07	1.36	1.85	0.75	1.07
July 6	3.40	2.60	2.09	1.41	1.74	1.69	1.83
July 19	3.04	1.94	1.74	0.96	1.25	1.11	2.13
Control	2.94	2.08	1.75	1.28	1.14	0.75	0.30
	0-15	15-30	30-45	45-60	60-75	75-105	
1978							
May 20	2.81	3.10	2.79	2.89	2.86	4.31	
June 7	2.83	3.51	3.13	3.12	3.05	4.31	
June 22	3.34	3.10	2.79	2.59	2.59	3.78	
July 7	2.76	3.48	2.95	2.91	2.68	3.37	
July 21	2.79	3.22	3.03	2.91	2.95	4.06	
Control	2.15	2.76	2.71	2.60	2.59	5.05	

(Table 1). During mid May 1977 the average percent soil moisture on the control plots at site 2 was 7.0% and 25.1% at mid May 1978. The higher soil moisture levels at the beginning of the growing season in 1978 resulted in higher forage yields when compared to 1977 (Fig. 1 and 2).

Clipping did not significantly affect soil moisture removal at site 1 during 1977 and 1978 (Table 4). Significant ($P<0.10$) differences in soil moisture removal were observed at the 30-45 cm (12 to 18 in) depth and ($P<0.05$) at the 75-90 cm (30 to 36 in) depth during the 1977 sampling period at site 2 (Table 5). The gravimetric method was used for the 1977 sampling period. Spotty natric horizons (claypans) were encountered on some of the treatment replications at site 2. The differences in soil moisture may be the result of a combination of the "claypan" layers and below normal precipitation at the beginning of the 1977 growing season. A slight recharge in soil moisture was observed in the 75-105 cm (30 to 42 in) depth on the control plots and the July 19 2.54-cm (1 in) clipping treatment for the 1978 sampling period at site 2. Lateral movement of

Table 5. A comparison of the amount (cm) of soil moisture removed for the 5 clipping treatments and control plots at site 2 for the 1977 and 1978 sampling periods.

Clipping treatment date	0-15	15-30	30-45	45-60	60-75	75-90	90-120
1977							
May 25	1.92	1.82	1.19ab ¹	1.33	1.24	1.44a ²	2.98
June 9	1.24	1.35	0.52b	0.97	0.97	1.31a	2.24
June 23	2.30	1.36	1.16ab	1.08	1.30	1.95a	1.88
July 7	1.52	1.37	0.97ab	1.28	1.39	1.41a	1.50
July 20	2.28	1.58	1.62a	1.34	1.54	0.14b	2.10
Control	1.78	2.10	1.50a	1.39	1.57	1.49a	2.32
	0-15	15-30	30-45	45-60	60-75	75-105	
1978							
May 21	3.23	3.67	3.74	2.65	2.70	1.68	
June 8	4.31	3.71	3.73	3.12	1.97	0.64	
June 21	4.70	4.11	4.07	3.20	2.05	0.08	
July 6	3.86	3.29	3.36	2.81	0.95	1.20	
July 19	4.20	2.49	2.40	2.13	1.31	-.32	
Control	4.70	4.33	3.81	3.51	2.45	-.30	

¹ Means in the same column with different letters are significantly different at the 0.10 level of probability.

² Means in the same column with different letters are significantly different at the 0.05 level of probability.

Table 6. A comparison (average of all clipping treatments and control plots) of the amount (cm) of soil moisture removed between the 0-45 cm depth and the 45-105 cm depth from two western North Dakota mixed prairie study sites for the 1977 and 1978 sampling periods.

Year	Site 1		Site 2	
	0-45	45-105	0-45	45-105
1977	7.30a ¹	4.15b	4.60	4.94
1978	8.88a	9.77b	11.29a ¹	5.31b

¹ Means in the same row followed by different letters are significantly different at the 0.05 level of probability.

water may have accounted for the recharge. Observations from this 2-year study indicate that soil moisture removal was not affected by the clipping treatments.

Precipitation and soil texture influenced the removal of soil moisture. More moisture was removed in the 0-45 cm depth compared to the 45-105 cm depth on the sandy loam soil of site 1 during 1977 (Table 6). During 1978 more moisture was removed from the 45-105 cm depth when compared to the 0-45 cm depth. The increase in soil moisture removal at the 0-45 cm depth during 1977 may have resulted from the lack of moisture infiltration to the 45-105 cm depth following the above average growing season precipitation (Table 1). No significant differences in soil moisture removal were observed between the 0-45 cm depth and the 45-105 cm depth on the loam soil of site 2 during 1977 (Table 6). During 1978, more moisture was removed from the 0-45 cm depth when compared to the 45-105 cm depth. Even with the above average growing season precipitation during 1977, water infiltration may have been reduced on the finer textured loam soil at site 2 as compared to the more coarse textured sandy loam soil at site 1.

Conclusions

The soil moisture content at the beginning of the growing season greatly influenced forage production. Even with above average growing season precipitation during both years, forage yields were higher in 1978 as a result of higher soil moisture levels at the beginning of the growing season when compared to 1977. Early season soil moisture appeared to have a greater affect on yields than the clipping treatments. However, early season clipping appeared to have compounded the effects of dry conditions on needle-and-threadgrass by reducing yields on the sandy loam site during 1977. Observations from this 2-year study indicate the removal of soil moisture was not affected by the clipping treatments. Precipitation and soil texture had a greater influence on the removal of soil moisture than did the clipping treatments.

The basal cover of Sandberg bluegrass was reduced by all 2.54-cm (1 in) clipping treatments on the sandy loam site during 1978. Early season clipping increased the basal cover of blue grama on the sandy loam site during 1978. However, clipping did not significantly affect yields by either species.

Hurt (1951), working near Miles City, Montana, reported the average drought frequency in the Northern Great Plains at once in 5 years. Drought conditions play a major role in proper range and livestock management. Long-term projections can not be made from two years of study. Further research is needed to determine long-term effects of intensive harvesting on the development of western North Dakota mixed prairie.

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