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PRIMARY PRODUCTIVITY AND ABIOTIC STUDIES AT THE DICKINSON SITE, 1970 SEASON

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TABLE OF CONTENTS

ABSTRACT

This report describes the methods used in the study of primary productivity and abiotic influences on grazed and ungrazed treatments at the Dickinson Site in the 1970 season and gives a summary of the data obtained in the field during the study period. The general abiotic data provided include precipitation, soil moisture, soil and air temperatures, net radiation, soil heat flux, wind movement, and relative humidity on both treatments. The primary productivity data include data from vegetation clippings made at essentially two-week intervals throughout the growing season from May 25 through August 18, supplemented with clippings on September 17 and October 17. Underground biomass data were obtained from core samples taken to a depth of 1 m at the same time that clippings were made. Results obtained show the grazed site to have warmer soil and air temperatures, greater wind movement, slightly less favorable soil moisture conditions, less energy utilization, and nearly equal atmospheric moisture conditions as compared to the ungrazed site. The maximum standing crop on the ungrazed area was over 50% larger than on the grazed area. Standing dead material on the grazed area was only 13% of that on the ungrazed area, while litter on the grazed area was less than one-third that on the ungrazed area. Belowground biomass was greater under the grazed treatment than under the ungrazed, averaging 53% greater dry weight for the season.

GENERAL SAMPLING PROCEDURES

Vegetation and soil at the Dickinson Site have been described in detail in the Site Description and this descriptive material will not be repeated here. The vegetation on the site is a reasonably representative example of the mixed grass prairie of the region, as found on sandy soils, with *Stipa comata*, *Agropyron smithii*, *Bouteloua gracilis*, *Carex eleocharis*, and *Koeleria cristata* as the principal grass and sedge species. In addition, on the grazed portion of the site *Calamagrostis montanensis* assumes considerable importance, while on the ungrazed portion *Calamovilfa longifolia* makes up an appreciable portion of the total yield of the type.

The ungrazed portion of the area consists of an exclosure of approximately four acres in size, which was fenced in the summer of 1961 and has not been grazed since. The grazed portion of the site, approximately 30 acres in extent, has been grazed heavily in late fall, beginning about October 15, since 1957. Utilization of the grazed portion is ordinarily heavy, and the use treatment has consequently been designated as four. At the end of the grazing period, the average height of the stubble varies from about 3 to 7 cm. The treatments available on the site are thus (1) ungrazed, and (4) heavily grazed. The sample areas for the two treatments were situated about 250 ft from each other.

Two replications on each treatment area were studied during the 1970 season. Aboveground biomass determinations were made approximately every two weeks during the season, with the initial sampling beginning on May 24. The sampling period ended on October 19, when the

last standing crop clippings were made. Initially (May 25 and June 8) five 0.25 cm^2 plots were clipped in each replication. The number of clipped plots on each replication was raised to six, beginning on June 22, and was continued at this level throughout the rest of the season. At the first clipping (May 25) only the plots in the first replication of each treatment were clipped. A general summary of sampling procedures is given in the "Interim Report of Research Conducted in the 1970 Season - Dickinson Site." At the same time that the plots were clipped, fifty 0.25 m^2 plots were ranked in each replication in compliance with the outlined sampling procedures. Data from the ranking procedure have not been included in this report. The two replications in each of the treatments were located subjectively, but the quadrats to be clipped and ranked at each date of sampling were selected randomly by means of a random numbers table.

Species separations were made in the field at the time of clipping. Previous years standing dead was separated from the rest of the material, but no attempt was made to separate this material by species. Current season's standing dead was evaluated by estimate beginning about mid-season. All clipping was at ground surface level, with the exception that on the ungrazed treatment, removal of the litter usually showed some stem bases still above ground level. These were clipped, and since the stem base material appeared to be about 90% or more dead, this material was placed in the standing dead category.

Litter was gathered from each clipped plot. This was initially accomplished by scraping the material up with the fingers after the clipping was completed. Later, a small portable vacuum cleaner was purchased and the litter collected by this means. The vacuum cleaner worked very

well for this purpose, but appreciably more soil material was incorporated into the sample than was the case with hand collection. Percent ash was determined by ashing in a muffle furnace at 500°F for all litter samples, and litter weights are reported in the data on an ash-free basis.

Samples for belowground biomass determinations were taken on each of the clipped quadrats in each replication shortly after the clipping was completed at each date. Five soil cores, each approximately 1 inch in diameter, were taken on each clipped plot to a depth of 100 cm. The cores for each depth segment were composited to give one sample per clipped quadrat per depth segment. The sampling segments were 0-5 and 5-10 cm, and thence by 10 cm units to the depth of 1 m. From each replication, six complete profile samples were taken, with a total of 12 samples for each depth segment for each grazing treatment being obtained.

Soil material was washed from the roots under water pressure and the roots collected on a 32-mesh (500 m) screen. Root material was oven-dried at 65°C and weighed to the nearest 0.01 g. The root samples were then ashed at 500°F and reweighed to obtain the ash-free weight.

All aboveground and belowground biomass data were recorded on the specified field data sheets. The original field data sheets were forwarded to the Natural Resource Ecology Laboratory at Colorado State University, Fort Collins, Colorado. Xerox copies of all field data sheets have been retained on file in the Botany Department, North Dakota State University, Fargo, North Dakota. Since all detailed data have been supplied to the biome director's office at Fort Collins, they have not been added to this report. Instead, the primary productivity

date have been consolidated and summarized on the m^2 basis for each time of clipping, and are presented on a summary basis in this report.

Abiotic data collected on the ungrazed and heavily grazed treatments included weekly gravimetric soil moisture determinations to a depth of 120 cm, precipitation measured in standard USWB gauges, net radiation at canopy height plus 1 m (145 cm on the ungrazed and 130 cm on the grazed treatment), air temperatures and soil temperatures at various heights above and depths below the soil surface, wind movement at various heights above the soil surface and the plant canopy, and relative humidity values at two heights above the soil surface. All measurements specified in the comprehensive network manual were taken except the thermocouple-psychrometer measurements of soil moisture tension. Apparatus for these measurements was secured too late in the season to be effectively used. Soil heat flux measurements were made using Thornthwaite heat flux disks at a depth of 2.5 cm in the soil on both grazing treatments.

Since the detailed abiotic data had not been supplied to the project previously, they are given in detail in this report. Details of sensor placement and data gathering procedures are also given in detail.

Some general information on vegetation and soil moisture sampling is given in Table 1.

ABIOTIC FACTORS

Precipitation

Precipitation as measured on the site is given in Table 2 for the period May 23 to October 14. Precipitation was measured in each of three standard Weather Bureau gauges at 8:00 a.m. on each day following

Table 1. General information on vegetation and soil moisture sampling on the grazed and ungrazed treatments at the Dickinson Site during the 1970 season.

Type of Determination	No. of replications [a/]	No. of samples per replication	Times of Sampling								
			1st clip.	2nd clip.	3rd clip.	4th clip.	5th clip.	6th clip.	7th clip.	8th clip.	9th clip.
Standing crop	2	6	5/24-26	6/8-11	6/22-25	7/6-9	7/22-27	8/3-6	8/17-19	9/15-18	10/15-19
Litter	2	6	5/24-26	6/8-11	6/22-25	7/6-9	7/22-27	8/3-6	8/17-19	9/15-18	10/15-19
Belowground biomass	2	6	5/26-27	6/15	6/26	7/9	7/30	8/10	8/20	9/19	10/20
Soil moisture [b/]	2	2	5/27	6/15	6/22, 6/29	7/6, 7/13	7/20, 7/28	8/4, 8/11	8/18, 8/24	8/31, 9/8, 9/14	9/21, 9/28, 10/5, 10/12, 10/19

[a/] For each treatment.

[b/] Soil moisture sampled weekly after 6/15.

Table 2. Precipitation (mm) at the Dickinson Site - 1970 Summer Season

Date	Precipitation (mm)	Cumulative Total (mm)	Date	Precipitation (mm)	Cumulative Total (mm)
May 23	12.95	12.95	July 19	1.02	123.68
May 24	2.79	15.74	July 23	18.54	142.22
May 25	0.51	16.25	July 24	16.51	158.73
June 2	26.16	42.41	July 28	0.51	159.24
June 9	0.25	42.66	July 29	46.48	205.72
June 10	0.76	43.42	July 31	3.81	209.53
June 11	9.40	52.82	Aug. 4	0.25	209.78
June 12	6.10	58.92	Aug. 7	2.03	211.81
June 13	19.81	78.73	Aug. 9	3.81	215.62
June 15	7.11	85.84	Aug. 21	3.81	219.43
June 16	0.76	86.60	Sept. 8	1.52	220.95
June 17	0.25	86.85	Sept. 9	11.43	232.38
June 18	2.79	89.64	Sept. 10	2.54	234.92
June 19	3.81	93.45	Sept. 14	0.76	235.68
June 20	0.25	93.70	Sept. 15	3.56	239.24
June 25	2.29	95.99	Sept. 21	2.79	242.03
June 29	0.25	96.24	Sept. 22	0.25	242.28
July 12	1.78	98.02	Sept. 24	17.78	260.06
July 13	1.27	99.29	Oct. 13	2.29	262.35
July 14	22.86	122.15	Oct. 14	4.06	266.41
July 15	0.51	122.66			

any occurrence of rainfall. The data presented represent the average of the three gauges, which were located in the ungrazed exclosure, approximately 50 yards apart. In general differences in readings between gauges were small. The readings were taken in hundredths of an inch and have been converted to millimeters.

Precipitation was not particularly heavy during the period of measurement on the site, with the total amount for the entire period May 23 to October 14 being 266.41 mm (10.49 inches). However, the number of days on which there was a measurable amount of precipitation was unusually high, totaling 41 days. In addition, traces of precipitation were recorded on six other days.

Precipitation amounts measured in 1970 at the Dickinson Station, but not on the immediate study site for the period preceding the period of record on the site, were as follows: January - 17.02 mm (0.67 inches); February - 0.01 mm (0.04 inches); March - 13.97 mm (0.55 inches); April - 89.66 mm (3.53 inches); May 1-21 - 125.73 mm (4.95 inches). The precipitation picture for the season as a whole was one of rather heavy precipitation early in the season, followed by light precipitation during the middle and latter parts of the season. One rather heavy rainfall occurred on July 29 with a total of 46.48 mm being received. This precipitation did result in some renewal of growth, particularly in blue grama, and postponed the drying trend which had become apparent in nearly all grasses.

Soil Moisture

Percent soil moisture on the ungrazed and grazed treatments to a depth of 120 cm are given in Tables 3 and 4. Two samples were taken

Table 3. Percent soil moisture on ungrazed treatment at the Dickinson site - 1970 season.

Date	Depth	Rep 1			Rep 2			Avg. both Reps.
		S-1	S-2	Avg.	S-1	S-2	Avg.	
5/27	0-10	22.68	24.01	23.35	16.58	25.60	21.09	22.22
	10-20	15.04	14.55	14.80	24.80	15.78	20.29	17.55
	20-30	14.52	14.64	14.58	27.61	13.90	20.76	17.67
	30-40	12.93	13.25	13.09	21.02	13.69	17.36	15.23
	40-50	12.50	12.16	12.33	13.01	12.66	12.83	12.58
	50-60	12.50	12.16	12.33	13.01	12.66	12.84	12.59
	60-70	13.55	13.52	13.54	12.28	11.93	12.10	12.82
	70-80	13.55	13.52	13.53	12.28	11.93	12.11	12.82
	80-90	15.91	16.63	16.27	9.99	13.60	11.79	14.03
	90-100	15.91	16.63	16.27	9.99	13.60	11.80	14.03
	100-120	18.49	13.51	16.00	9.59	9.17	9.38	12.69
6/15	0-10	25.62	23.64	24.63	25.84	27.67	26.76	25.70
	10-20	18.12	16.15	17.14	17.48	16.99	17.24	17.19
	20-30	14.23	15.22	14.73	15.26	15.57	15.42	15.08
	30-40	12.55	13.89	13.22	13.50	15.91	14.71	13.97
	40-50	11.48	12.73	12.11	11.74	12.33	12.04	12.08
	50-60	11.71	11.15	11.43	11.89	11.90	11.90	11.67
	60-70	12.26	12.97	12.62	11.90	12.33	12.12	12.37
	70-80	10.30	12.21	11.26	12.85	11.09	11.97	11.62
	80-90	10.48	16.06	13.27	15.20	11.25	13.23	13.25
	90-100	10.87	15.47	13.17	17.54	12.41	14.88	14.03
	100-120	7.46	15.55	11.51	15.54	12.66	14.10	12.81
6/22	0-10	16.59	13.18	14.89	15.14	-	15.14	15.02
	10-20	9.72	36.61	23.17	11.69	-	11.69	17.43
	20-30	9.26	9.44	9.35	11.59	-	11.59	10.47
	30-40	10.00	9.26	9.63	9.38	-	9.38	9.51
	40-50	10.49	7.80	9.15	9.06	-	9.06	9.11
	50-60	9.35	8.27	8.81	30.63	-	30.63	14.72
	60-70	9.70	5.02	7.36	30.91	-	30.91	19.14
	70-80	8.98	4.01	6.50	26.93	-	26.93	16.72
	80-90	6.10	5.35	5.73	31.13	-	31.13	18.43
	90-100	2.87	8.81	5.84	15.49	-	15.49	10.67
	100-120	10.63	10.22	10.43	13.60	-	13.60	12.02
6/29	0-10	9.14	5.51	7.33	12.96	18.37	15.67	11.50
	10-20	9.64	5.82	7.73	8.29	13.42	10.86	9.30
	20-30	9.05	8.80	8.93	9.50	13.63	11.57	10.25
	30-40	8.53	10.77	9.65	12.30	14.06	13.18	11.42
	40-50	8.74	9.90	9.32	9.82	15.51	12.67	11.00
	50-60	10.17	9.06	9.62	18.49	15.53	17.01	13.32
	60-70	2.92	8.82	5.87	13.91	13.57	13.74	9.81
	70-80	2.94	13.44	8.69	14.43	12.32	13.38	11.04
	80-90	3.41	14.45	8.93	17.06	13.29	15.18	12.06
	90-100	9.13	15.90	12.52	18.54	15.65	17.20	14.86
	100-120	13.89	15.99	14.94	16.12	16.04	16.08	15.51

Table 3. (continued)

Date	Depth	Rep 1			Rep 2			Avg. both Reps.
		S-1	S-2	Avg.	S-1	S-2	Avg.	
7/6	0-10	7.47	3.59	5.53	6.15	6.39	6.27	5.90
	10-20	6.53	5.18	5.86	4.67	5.82	5.25	5.56
	20-30	5.12	5.73	5.43	6.55	4.85	5.70	5.57
	30-40	7.82	5.90	6.86	6.99	5.52	6.26	6.56
	40-50	9.32	6.84	8.08	7.21	5.34	6.28	7.18
	50-60	10.29	6.58	8.44	6.93	10.07	8.50	8.47
	60-70	14.96	5.99	10.48	7.23	-	7.23	8.86
	70-80	20.04	4.95	12.50	8.40	17.89	13.15	12.83
	80-90	21.65	6.76	14.21	9.11	17.39	13.25	13.73
	90-100	22.87	21.29	22.08	10.36	12.38	11.37	16.73
	100-120	22.17	16.41	19.29	11.08	9.66	10.37	14.83
7/13	0-10	5.69	4.80	5:25	6.26	7.58	6.92	6.09
	10-20	4.63	4.61	4.62	4.26	7.79	6.03	5.33
	20-30	4.78	4.32	4.55	4.79	6.29	5.54	5.05
	30-40	4.32	4.64	4.48	4.77	6.04	5.41	4.95
	40-50	5.79	5.14	5.47	5.90	7.56	6.73	6.10
	50-60	6.11	5.30	5.71	7.58	8.57	8.08	6.90
	60-70	5.96	5.30	5.63	8.14	9.49	8.82	7.23
	70-80	6.42	5.82	6.12	8.60	10.51	9.51	7.82
	80-90	7.54	5.46	6.50	9.00	12.02	10.51	8.51
	90-100	7.16	7.79	7.48	9.04	12.03	10.54	9.01
	100-120	7.05	8.83	7.94	8.43	11.56	10.00	8.97
7/20	0-10	5.77	7.02	6.40	9.57	6.83	8.20	7.30
	10-20	4.17	4.32	4.25	6.72	6.55	6.64	5.45
	20-30	3.94	3.58	3.76	13.19	4.54	8.87	6.32
	30-40	3.62	4.30	3.96	4.30	3.82	4.06	4.01
	40-50	3.79	5.48	4.64	4.91	4.21	4.56	4.60
	50-60	5.17	4.85	5.01	5.04	4.58	4.81	4.91
	60-70	5.55	5.49	5.52	5.19	5.43	5.31	5.42
	70-80	4.40	5.69	5.05	5.46	6.24	5.85	5.45
	80-90	4.73	7.80	6.27	6.23	9.14	7.69	6.98
	90-100	6.11	8.92	7.52	8.21	11.19	9.70	8.61
	100-120	5.80	9.60	7.70	9.88	10.84	10.36	9.03
7/28	0-10	14.17	12.78	13.48	18.03	18.44	18.24	15.86
	10-20	-	9.16	9.16	11.88	13.12	12.50	10.83
	20-30	4.67	5.96	5.32	4.11	9.31	6.71	6.02
	30-40	4.04	4.00	4.02	4.60	5.10	4.85	4.44
	40-50	3.04	4.21	3.63	5.06	5.35	5.21	4.42
	50-60	4.61	4.95	4.78	6.26	5.65	5.96	5.37
	60-70	4.06	5.55	4.81	5.23	6.21	5.72	5.27
	70-80	4.37	3.99	4.18	6.98	7.69	7.34	5.76
	80-90	3.34	7.66	5.50	6.95	9.35	8.15	6.83
	90-100	5.47	9.25	7.36	7.10	9.65	8.38	7.87
	100-120	5.16	8.02	6.59	8.83	10.04	9.44	8.02

Table 3. (continued)

Date	Depth	Rep 1			Rep 2			Avg. both Reps.
		S-1	S-2	Avg.	S-1	S-2	Avg.	
8/4	0-10	15.22	17.57	16.40	19.91	22.20	21.06	18.73
	10-20	12.63	11.09	16.86	12.15	13.60	12.88	14.67
	20-30	10.63	10.10	10.37	11.34	13.12	12.23	11.30
	30-40	8.68	11.07	9.85	12.19	11.86	12.03	10.94
	40-50	4.12	9.78	6.95	12.01	11.56	11.79	9.37
	50-60	4.87	6.41	5.64	7.68	11.35	9.52	7.58
	60-70	6.34	4.50	5.42	5.36	9.25	7.31	6.37
	70-80	4.99	4.57	4.78	5.65	9.17	7.41	6.20
	80-90	4.67	5.57	5.12	7.40	10.55	8.88	7.00
	90-100	5.70	8.43	7.07	9.18	12.73	10.96	9.02
	100-120	5.92	.89	3.41	9.95	9.00	9.48	6.45
8/11	0-10	11.11	11.18	11.15	10.95	9.34	10.15	10.65
	10-20	10.78	9.77	10.38	8.27	9.91	9.09	9.74
	20-30	9.58	10.07	9.83	8.21	10.52	9.37	9.60
	30-40	9.54	9.20	9.37	17.71	9.58	13.65	11.51
	40-50	9.15	9.89	9.52	7.00	8.61	7.81	8.67
	50-60	8.44	9.32	8.88	12.66	6.13	9.40	9.14
	60-70	6.05	8.48	7.24	5.18	5.82	5.50	6.37
	70-80	6.41	7.88	7.15	4.57	6.88	5.73	6.44
	80-90	7.17	8.08	7.63	5.12	7.67	6.40	7.02
	90-100	8.09	9.91	9.00	5.78	8.49	7.14	8.07
	100-120	10.26	9.71	9.99	8.23	10.04	9.14	9.57
8/18	0-10	3.93	4.31	4.12	5.91	7.03	6.47	5.30
	10-20	4.18	4.10	4.14	6.98	5.87	6.43	5.29
	20-30	3.79	3.93	3.86	6.81	7.59	7.20	5.53
	30-40	3.65	3.94	3.80	5.67	7.23	6.45	5.13
	40-50	3.66	5.47	4.57	4.87	6.96	5.92	5.25
	50-60	4.40	4.75	4.58	5.49	5.29	5.39	4.99
	60-70	2.57	3.94	3.26	5.36	3.88	4.62	3.94
	70-80	3.58	3.64	3.61	4.42	4.63	4.53	4.07
	80-90	3.76	4.36	4.06	5.92	6.36	6.14	5.10
	90-100	4.13	6.08	5.11	7.63	7.46	7.55	6.33
	100-120	4.75	7.16	5.96	8.74	7.81	8.38	7.17
8/24	0-10	2.91	6.17	4.54	Scale off			4.54
	10-20	3.60	5.46	4.53				4.53
	20-30	3.88	5.70	4.79				4.79
	30-40	4.28	5.90	5.09				5.09
	40-50	3.92	7.00	5.46				5.46
	50-60	4.69	6.90	5.80				5.80
	60-70	4.85	6.07	5.46				5.46
	70-80	4.99	6.72	5.86				5.86
	80-90	4.86	10.14	7.50				7.50
	90-100	6.73	10.98	8.86				8.86
	100-120	8.15	8.60	8.38				8.38

Table 3. (continued)

Date	Depth	Rep 1			Rep 2			Avg. both Reps.
		S-1	S-2	Avg.	S-1	S-2	Avg.	
8/31	0-10	5.04	3.17	4.11	4.57	5.50	5.04	4.58
	10-20	4.80	2.88	3.84	3.97	4.60	4.39	4.12
	20-30	3.94	3.98	3.96	3.70	3.80	3.75	3.86
	30-40	3.80	4.61	4.21	3.00	2.77	2.89	3.55
	40-50	3.91	4.01	3.96	3.34	3.57	3.46	3.71
	50-60	4.53	4.42	4.48	4.78	5.59	5.19	4.84
	60-70	3.85	4.24	4.05	4.42	3.76	4.09	4.07
	70-80	3.31	4.49	3.90	3.72	3.76	3.74	3.82
	80-90	4.34	4.58	4.46	4.05	3.58	3.82	4.14
	90-100	5.26	6.87	6.07	3.56	4.22	3.89	4.98
	100-120	6.74	7.53	7.19	4.90	6.00	5.45	6.32
9/8	0-10	5.31	3.97	4.64	4.29	8.31	6.30	5.47
	10-20	4.66	3.63	4.15	3.66	3.63	3.65	3.90
	20-30	4.34	3.54	3.94	4.10	3.70	3.90	3.92
	30-40	3.70	3.91	3.81	3.87	3.82	3.85	3.83
	40-50	4.07	3.99	4.03	4.10	3.89	4.00	4.02
	50-60	3.98	5.27	4.63	4.58	3.82	4.20	4.42
	60-70	4.31	6.65	5.98	4.43	4.23	4.33	5.16
	70-80	4.32	6.75	5.54	4.78	3.91	4.35	4.95
	80-90	4.19	5.82	5.01	4.96	5.49	5.23	5.12
	90-100	3.87	5.83	4.85	5.85	5.90	5.88	5.37
	100-120	6.08	7.27	6.68	6.15	6.18	6.17	6.43
9/14	0-10	10.90	8.51	9.71	12.17	9.69	10.93	10.32
	10-20	4.36	3.69	4.03	4.56	4.53	4.55	4.29
	20-30	4.53	3.88	4.21	3.75	3.67	3.71	3.96
	30-40	4.50	3.03	3.77	3.80	3.52	3.66	3.72
	40-50	4.36	3.75	4.06	3.70	2.96	3.33	3.70
	50-60	4.29	3.74	4.02	4.18	3.63	3.91	3.97
	60-70	4.70	4.26	4.48	3.89	3.84	3.87	4.18
	70-80	3.89	4.92	4.41	4.02	3.58	3.80	4.11
	80-90	3.06	5.24	4.15	3.58	3.98	3.78	3.97
	90-100	3.49	7.01	5.25	5.55	4.54	5.05	5.15
	100-120	3.68	7.22	5.45	5.43	5.77	5.60	5.53
9/21	0-10	10.92	9.81	10.37	8.68	12.07	10.38	10.38
	10-20	4.56	4.12	4.34	4.01	5.50	8.76	6.55
	20-30	3.44	3.63	3.54	5.88	4.24	5.06	4.30
	30-40	3.97	3.57	3.77	3.63	3.95	3.79	3.78
	40-50	3.45	3.54	3.50	3.76	3.34	3.55	3.53
	50-60	3.89	3.71	3.80	3.86	3.18	3.52	3.66
	60-70	3.97	4.43	4.20	4.29	3.31	3.80	4.00
	70-80	4.24	4.30	4.27	4.01	3.70	6.86	5.57
	80-90	3.19	5.09	4.14	4.00	4.36	4.18	4.16
	90-100	4.15	5.30	4.73	3.85	4.69	4.28	4.51
	100-120	4.35	6.67	5.51	4.89	5.01	4.95	5.23

Table 3. (continued)

Date	Depth	Rep 1			Rep 2			Avg. both Reps.
		S-1	S-2	Avg.	S-1	S-2	Avg.	
9/28	0-10	16.97	13.70	15.34	15.49	18.76	17.13	16.24
	10-20	10.56	6.73	8.65	6.92	11.60	9.36	9.01
	20-30	4.67	4.30	4.49	4.44	4.74	4.59	4.54
	30-40	4.52	4.18	4.35	4.35	3.90	4.13	4.24
	40-50	4.03	4.11	4.07	4.84	4.38	4.61	4.34
	50-60	3.88	4.31	4.20	5.01	4.50	4.76	4.48
	60-70	5.15	4.96	5.06	5.12	4.62	4.87	4.97
	70-80	4.12	4.71	4.41	5.15	4.71	4.93	4.67
	80-90	3.40	4.86	4.13	6.17	4.76	5.47	4.80
	90-100	4.53	6.93	5.73	6.04	5.69	5.87	5.80
	100-120	4.15	8.27	6.21	5.72	5.80	5.76	5.99
10/5	0-10	7.03	10.32	8.68	9.77	12.97	11.37	10.03
	10-20	3.87	7.50	5.69	6.79	7.77	7.28	6.49
	20-30	5.22	4.09	4.66	3.87	4.54	4.21	4.44
	30-40	3.33	3.52	3.43	3.92	4.32	4.12	3.78
	40-50	3.66	4.27	3.97	4.26	3.98	4.12	4.05
	50-60	3.58	3.98	3.78	4.49	3.81	4.15	3.97
	60-70	4.14	4.42	4.28	4.09	4.08	4.09	4.19
	70-80	3.23	4.33	3.28	4.20	4.14	4.17	3.73
	80-90	3.01	5.27	4.14	4.51	4.90	4.71	4.43
	90-100	4.08	8.30	6.19	5.09	5.57	5.33	5.76
	100-120	3.71	7.94	5.83	5.67	6.28	5.98	5.91
10/12	0-10	7.75	10.02	8.89	9.35	9.69	9.52	9.21
	10-20	7.75	6.59	7.17	7.13	7.74	7.44	7.31
	20-30	5.49	6.00	5.75	2.32	5.84	4.08	4.92
	30-40	5.43	5.82	5.63	3.80	3.95	3.88	4.76
	40-50	3.65	5.22	4.44	4.37	3.82	4.20	4.32
	50-60	4.74	6.33	5.54	4.55	3.93	4.24	4.89
	60-70	5.12	4.51	4.82	4.59	3.98	4.39	4.61
	70-80	4.11	4.64	4.38	3.02	3.91	3.47	3.93
	80-90	2.72	5.36	4.04	3.84	4.36	4.10	4.07
	90-100	3.31	3.65	3.48	4.56	6.95	5.76	4.62
	100-120	3.75	7.20	5.48	4.52	5.12	4.82	5.15
10/19	0-10	12.14	10.82	11.48	12.95	8.05	10.50	10.99
	10-20	5.39	6.16	5.78	7.90	5.63	6.77	6.28
	20-30	3.64	4.42	4.03	5.94	4.23	5.09	4.56
	30-40	3.59	3.26	3.43	6.95	3.02	4.99	4.21
	40-50	3.24	-	3.24	6.40	5.36	5.88	4.56
	50-60	3.96	3.30	3.63	6.96	4.03	5.50	4.57
	60-70	4.69	3.56	4.13	6.82	3.65	5.24	4.69
	70-80	4.14	4.33	4.24	8.16	3.54	5.85	5.05
	80-90	1.73	3.89	2.81	7.63	3.87	5.45	4.13
	90-100	2.19	4.99	3.59	7.61	4.04	5.83	4.71
	100-120	3.67	7.04	5.36	7.38	6.06	6.72	6.04

Table 4. Percent soil moisture on grazed treatment at the Dickinson site - 1970 season.

Date	Depth	Rep 1			Rep 2			Avg. both Reps.
		S-1	S-2	Avg.	S-1	S-2	Avg.	
5/27	0-10	13.56	18.20	15.88	16.50	19.58	18.04	16.96
	10-20	16.10	12.74	14.42	13.15	15.02	14.09	14.26
	20-30	16.47	13.53	15.00	11.95	14.25	13.35	14.18
	30-40	14.15	12.61	13.38	13.02	12.37	12.70	13.04
	40-50	13.72	14.07	13.90	11.47	11.44	11.46	12.68
	50-60	13.72	14.07	13.90	11.47	11.44	11.45	12.68
	60-70	11.80	15.13	13.47	10.61	10.08	10.34	11.91
	70-80	11.80	15.13	13.46	10.61	10.08	10.35	11.90
	80-90	11.35	11.08	11.22	8.51	7.90	8.20	9.71
	90-100	11.35	11.08	11.21	8.51	7.90	8.21	9.71
	100-120	10.40	10.56	10.48	11.98	9.33	10.66	10.57
6/15	0-10	24.16	27.65	25.91	19.84	28.30	24.07	24.99
	10-20	15.53	14.49	15.01	16.23	12.82	14.53	14.77
	20-30	10.53	9.14	9.84	11.17	8.87	10.02	9.93
	30-40	10.16	10.29	10.23	14.22	10.09	12.16	11.20
	40-50	10.11	9.62	9.87	12.33	9.81	11.07	10.47
	50-60	10.27	8.73	9.50	9.87	9.72	9.80	9.65
	60-70	11.43	11.71	11.57	8.70	9.78	9.24	10.41
	70-80	14.71	13.26	13.99	8.39	11.82	10.16	12.08
	80-90	13.44	12.74	13.09	18.50	21.54	20.02	16.56
	90-100	14.47	17.78	16.13	12.11	19.63	15.87	16.00
	100-120	13.87	12.26	13.07	10.76	11.76	11.36	12.22
6/22	0-10	60.84	14.38	37.61	11.92	14.80	13.36	25.89
	10-20	57.04	9.61	33.33	10.27	10.18	10.23	21.78
	20-30	48.20	11.01	29.61	8.47	8.42	8.45	19.03
	30-40	55.81	9.51	37.66	8.53	8.48	8.51	23.09
	40-50	53.06	7.74	30.40	8.39	7.73	8.06	19.23
	50-60	7.42	14.96	11.19	8.28	7.77	8.03	9.61
	60-70	7.38	9.92	8.65	4.13	7.39	5.76	7.21
	70-80	8.44	10.97	9.71	8.09	8.58	8.34	9.03
	80-90	8.95	13.43	11.19	9.58	7.91	8.75	9.97
	90-100	11.79	4.67	8.23	9.43	5.76	7.60	7.92
	100-120	11.43	6.83	9.13	10.36	7.03	8.69	8.91
6/29	0-10	13.87	26.43	20.15	16.29	105.00	60.65	40.40
	10-20	15.84	13.45	14.65	15.82	-	15.82	15.24
	20-30	13.50	14.02	13.76	18.28	33.04	25.66	19.71
	30-40	16.42	17.86	17.14	20.63	23.89	22.26	19.70
	40-50	16.11	17.17	22.72	19.78	-	19.78	21.25
	50-60	14.98	10.30	13.64	21.30	20.50	20.90	17.27
	60-70	17.96	21.54	19.75	21.37	19.11	20.24	20.00
	70-80	18.34	22.50	20.42	23.27	37.17	30.22	25.32
	80-90	18.90	28.29	23.60	22.08	34.84	28.46	26.03
	90-100	17.26	23.26	21.26	23.33	18.76	21.05	21.16
	100-120	12.38	19.16	15.77	23.20	16.96	20.08	17.93

Table 4. (continued)

Date	Depth	Rep 1			Rep 2			Avg. both Reps.
		S-1	S-2	Avg.	S-1	S-2	Avg.	
7/6	0-10	4.79	3.41	4.10	6.70	3.76	5.23	4.67
	10-20	5.08	4.71	4.90	5.43	10.49	7.96	6.43
	20-30	6.26	4.50	5.38	5.20	5.24	5.22	5.30
	30-40	7.96	4.44	6.20	5.65	4.70	5.18	5.69
	40-50	7.82	10.40	9.11	6.40	5.11	5.76	7.44
	50-60	7.55	8.90	8.23	5.30	5.64	5.47	6.85
	60-70	9.06	9.75	9.41	4.89	3.87	4.38	6.90
	70-80	9.23	9.14	9.19	8.49	4.63	6.56	7.88
	80-90	12.66	7.97	10.32	9.92	7.29	8.61	9.47
	90-100	9.14	11.92	10.53	7.52	4.57	6.05	8.29
	100-120	10.60	12.12	11.36	8.95	4.79	6.87	9.12
7/13	0-10	3.78	3.68	3.73	4.14	4.12	4.13	3.93
	10-20	5.28	4.76	5.02	4.12	4.06	4.09	4.56
	20-30	6.46	5.67	6.07	5.42	3.95	4.69	5.38
	30-40	5.38	5.39	5.39	4.78	4.99	4.89	5.14
	40-50	5.10	4.20	4.65	4.88	3.81	4.35	4.50
	50-60	5.53	5.32	5.43	5.41	4.62	5.02	5.23
	60-70	5.87	6.71	6.29	7.12	5.86	6.49	6.39
	70-80	7.06	10.12	8.59	7.58	5.42	6.50	7.55
	80-90	9.67	14.18	11.93	6.07	5.54	5.81	8.87
	90-100	-	10.68	10.68	5.13	5.15	5.14	7.91
	100-120	9.98	10.45	10.22	8.23	5.80	7.02	8.62
7/20	0-10	6.08	6.46	6.27	4.63	6.48	5.56	5.92
	10-20	4.84	3.67	4.26	3.56	4.93	4.25	4.36
	20-30	5.66	4.65	5.16	4.45	3.98	4.22	4.69
	30-40	4.63	4.28	4.46	3.79	4.02	3.91	4.19
	40-50	3.24	3.56	3.40	5.19	3.09	4.14	3.77
	50-60	3.34	5.21	4.28	4.70	3.54	4.12	4.20
	60-70	5.75	6.61	6.18	4.44	3.02	3.73	4.96
	70-80	7.97	7.77	7.87	4.77	2.76	3.77	5.82
	80-90	2.72	11.97	7.35	6.64	3.33	4.99	6.17
	90-100	3.08	13.12	8.10	5.99	3.33	4.66	6.38
	100-120	10.32	9.47	9.90	6.44	3.60	5.02	7.46
7/28	0-10	16.12	14.17	15.15	15.04	17.11	15.58	15.37
	10-20	11.44	9.35	10.40	9.63	11.14	10.39	10.40
	20-30	6.50	5.52	6.01	5.02	3.90	4.46	5.24
	30-40	5.08	2.95	4.02	5.06	3.58	4.32	4.17
	40-50	6.39	3.70	5.05	4.60	3.56	4.08	4.57
	50-60	5.25	3.04	4.15	5.21	3.32	4.27	4.21
	60-70	4.49	4.50	4.50	4.30	3.41	3.86	4.18
	70-80	5.77	6.85	6.31	4.82	2.72	3.77	5.04
	80-90	7.04	8.61	7.83	5.95	3.28	4.62	6.23
	90-100	9.71	11.95	10.83	7.35	3.33	5.34	8.09
	100-120	11.03	1.03	6.03	6.13	3.45	4.79	5.41

Table 4. (continued)

Date	Depth	Rep 1			Rep 2			Avg. both Reps.
		S-1	S-2	Avg.	S-1	S-2	Avg.	
8/4	0-10	17.57	16.11	12.84	14.57	20.75	17.66	15.25
	10-20	11.23	11.35	11.29	11.99	12.97	12.48	11.89
	20-30	11.75	11.39	11.57	10.19	12.85	11.52	11.55
	30-40	4.69	10.05	7.37	4.08	11.31	7.70	7.54
	40-50	4.19	7.55	5.87	5.50	8.74	7.12	6.50
	50-60	4.36	6.64	5.50	4.34	5.58	4.96	5.23
	60-70	5.18	10.15	7.67	2.37	6.94	4.66	6.17
	70-80	5.60	11.04	8.32	3.52	4.20	3.86	6.09
	80-90	7.64	10.96	9.30	4.85	4.07	4.46	6.88
	90-100	9.10	9.40	9.25	5.47	5.16	5.32	7.29
	100-120	10.28	9.86	10.07	6.56	6.31	6.44	3.76
8/11	0-10	6.36	7.72	7.04	8.29	10.90	4.69	5.87
	10-20	7.14	8.07	7.11	8.97	8.36	8.67	7.89
	20-30	8.79	9.39	9.09	8.83	8.80	8.82	8.96
	30-40	8.33	8.46	8.40	9.13	9.45	9.39	8.90
	40-50	6.45	5.79	6.12	6.48	7.25	6.87	6.50
	50-60	7.47	4.56	6.02	5.68	7.80	6.74	6.38
	60-70	6.34	6.78	6.56	5.52	5.65	5.59	6.08
	70-80	7.74	8.11	7.93	4.82	4.36	4.59	6.26
	80-90	6.38	8.94	7.66	6.44	3.72	5.08	6.37
	90-100	5.93	10.02	7.98	6.91	3.53	5.22	6.60
	100-120	7.42	10.56	8.99	7.38	4.44	5.91	7.45
8/18	0-10	4.84	4.31	4.58	4.41	6.11	5.26	4.92
	10-20	5.02	4.84	4.93	6.74	5.54	6.14	5.54
	20-30	5.64	5.89	5.77	5.73	4.53	5.13	5.45
	30-40	4.63	5.66	5.15	5.12	5.01	5.07	5.11
	40-50	4.68	5.01	4.85	5.84	9.14	7.49	6.17
	50-60	4.34	5.26	4.80	5.19	4.42	4.81	4.81
	60-70	5.41	6.02	5.72	3.03	4.04	3.53	4.63
	70-80	3.38	6.27	8.83	3.99	4.13	4.06	6.45
	80-90	7.33	9.36	8.35	4.75	4.02	4.39	6.37
	90-100	7.45	10.71	9.08	4.82	3.37	4.20	6.64
	100-120	9.70	9.21	9.46	6.31	5.41	5.86	7.66
8/24	0-10		Scale off		9.63	9.38	9.51	9.51
	10-20				10.00	8.44	9.22	9.22
	20-30				11.11	7.53	9.32	9.32
	30-40				11.08	8.37	9.73	9.73
	40-50				10.36	5.94	8.15	8.15
	50-60				6.66	5.39	6.03	6.03
	60-70				7.71	4.61	6.16	6.16
	70-80				8.67	4.07	6.37	6.37
	80-90				8.00	4.71	6.36	6.36
	90-100				8.73	3.70	6.72	6.72
	100-120				8.61	3.36	5.99	5.99

Table 4. (continued)

Date	Depth	Rep 1			Rep 2			Avg. both Reps.
		S-1	S-2	Avg.	S-1	S-2	Avg.	
8/31	0-10	2.65	3.31	2.98	2.67	3.05	2.86	2.92
	10-20	4.62	3.64	4.13	2.45	3.93	3.19	3.66
	20-30	4.96	3.72	4.39	2.51	4.07	3.29	3.84
	30-40	5.05	3.97	4.51	2.75	3.92	3.34	3.93
	40-50	5.26	4.13	4.20	2.90	4.68	3.79	4.00
	50-60	5.36	3.67	4.52	3.46	3.23	3.35	3.94
	60-70	5.15	4.85	5.00	3.85	3.60	3.73	4.37
	70-80	5.27	6.05	5.66	4.40	3.37	3.89	4.78
	80-90	4.65	5.63	5.14	4.71	3.32	4.02	4.58
	90-100	5.87	4.99	5.43	5.38	2.81	4.20	4.82
	100-120	6.35	8.78	7.57	5.18	2.84	4.01	5.79
9/8	0-10	4.84	3.89	4.37	5.29	5.01	5.15	4.76
	10-20	4.70	3.63	4.17	4.25	4.63	4.44	4.31
	20-30	4.07	3.64	3.86	5.44	3.80	4.62	4.24
	30-40	4.89	3.63	4.26	4.38	4.49	4.44	4.35
	40-50	4.17	3.94	4.06	5.54	4.09	4.82	4.44
	50-60	4.90	3.33	4.12	5.34	5.11	5.23	4.47
	60-70	5.57	6.10	5.84	5.40	3.44	4.42	5.13
	70-80	6.00	6.17	6.09	4.95	3.27	4.11	5.10
	80-90	6.67	5.92	6.30	5.52	2.76	4.14	5.22
	90-100	6.38	4.72	5.55	5.51	2.29	3.90	4.73
	100-120	7.21	5.17	6.69	3.96	2.97	3.47	5.08
9/14	0-10	9.11	8.95	9.03	8.37	5.56	6.97	8.00
	10-20	4.35	4.62	4.49	4.06	4.00	4.03	4.26
	20-30	5.12	4.32	4.72	4.19	4.05	4.12	4.42
	30-40	4.23	4.14	4.19	3.82	4.63	4.23	4.21
	40-50	3.80	3.08	3.44	3.44	5.20	4.32	3.88
	50-60	4.51	4.34	4.43	4.02	5.07	4.55	4.49
	60-70	4.79	4.66	4.73	3.37	4.29	3.83	4.28
	70-80	5.25	6.68	5.97	3.68	4.01	3.85	4.91
	80-90	5.56	7.92	7.74	4.00	3.05	3.53	5.64
	90-100	4.88	8.23	6.56	4.29	3.39	3.84	5.20
	100-120	7.21	6.56	6.89	5.20	3.14	4.17	5.53
9/21	0-10	10.96	7.38	9.17	9.90	9.80	9.85	9.51
	10-20	4.00	4.57	4.29	4.71	5.07	4.89	4.59
	20-30	5.02	4.99	5.01	4.32	4.55	4.44	4.73
	30-40	4.62	4.73	4.68	4.87	3.90	4.39	4.54
	40-50	4.01	4.04	4.03	4.71	3.30	4.01	4.02
	50-60	3.27	3.78	3.53	4.00	3.95	3.98	3.72
	60-70	4.27	4.41	4.34	3.23	3.64	3.44	3.89
	70-80	6.12	7.40	6.76	3.99	3.70	3.85	5.31
	80-90	5.29	6.73	6.01	4.55	3.41	3.98	5.00
	90-100	5.08	5.88	5.48	5.42	3.07	4.25	4.87
	100-120	7.23	7.80	7.52	5.40	3.20	4.30	5.91

Table 4. (continued)

Date	Depth	Rep 1			Rep 2			Avg. both Reps.
		S-1	S-2	Avg.	S-1	S-2	Avg.	
9/28	0-10	14.26	13.95	14.11	15.07	15.81	15.44	14.78
	10-20	7.27	6.02	6.65	7.50	6.32	6.91	6.78
	20-30	6.04	5.34	5.69	5.26	4.31	4.78	5.24
	30-40	5.82	4.78	5.30	5.22	4.47	4.85	5.08
	40-50	5.86	4.68	5.27	5.41	4.33	4.87	5.07
	50-60	4.55	4.25	4.40	5.28	3.92	4.60	4.50
	60-70	5.12	6.48	5.80	3.99	4.69	4.34	5.07
	70-80	6.42	7.01	6.72	3.99	4.19	4.09	5.41
	80-90	6.17	6.55	6.36	5.02	5.50	5.26	5.81
	90-100	6.22	6.27	6.25	5.41	2.86	4.14	5.20
	100-120	7.41	6.29	6.85	5.22	2.87	4.05	5.45
10/5	0-10	7.46	7.45	7.46	8.09	10.36	9.23	8.35
	10-20	6.70	5.66	6.18	6.23	6.61	6.42	6.30
	20-30	5.19	3.93	4.56	4.11	3.88	4.00	4.38
	30-40	5.31	3.59	4.45	4.39	4.29	4.34	4.40
	40-50	4.84	3.29	4.07	4.96	3.39	4.18	4.13
	50-60	4.32	3.95	4.14	4.20	3.63	3.92	4.03
	60-70	4.06	5.87	4.97	4.58	3.66	4.12	4.55
	70-80	5.31	7.54	6.43	4.03	3.91	3.97	5.20
	80-90	5.25	7.18	6.22	4.74	6.83	5.79	6.01
	90-100	4.10	7.08	5.59	4.87	3.66	4.27	4.93
	100-120	6.96	8.72	7.84	4.78	2.77	3,78	5.81
10/19	0-10	10.06	10.98	10.52	9.26	11.95	10.61	10.57
	10-20	4.49	3.60	4.05	6.55	5.76	6.16	5.11
	20-30	4.62	4.26	4.44	3.15	3.65	3.40	3.92
	30-40	4.78	4.11	4.45	4.14	4.07	4.11	4.28
	40-50	4.44	2.84	3.64	5.96	4.12	5.04	4.34
	50-60	4.48	4.87	4.27	3.82	3.58	3.70	4.49
	60-70	3.97	5.05	4.51	3.69	3.61	3.65	4.08
	70-80	4.84	5.05	4.95	4.06	3.75	3.91	4.43
	80-90	7.02	5.67	6.35	4.79	2.70	3.75	5.05
	90-100	4.82	4.93	2.47	5.27	3.25	4.36	3.42
	100-120	3.87	7.63	5.75	5.47	3.09	4.28	5.02

in each of the two replications on each treatment at each sampling date. The first samples were taken on May 27, the second set on June 15, and thereafter, the samples were taken at weekly intervals through October 19. Samples were taken manually in the field using the one-inch soil tube with the 15-lb. hammer. The samples were placed in moisture cans with snug-fitting covers as they were taken. The covered cans with the samples were weighed in the laboratory to the nearest 0.01 g, uncovered, and the samples dried at 105°C for 48 hours. Soil moisture was calculated by expressing the moisture lost as percent of the dry weight of the soil.

Percent soil moisture values on the ungrazed and grazed sites were converted to cm of water in the soil using the bulk density values shown in Table 5. The bulk density values were derived from 5 volume samples taken with the 1-inch tube for each 10 cm segment to a depth of 120 cm. The individual samples showed considerable variation, but the average values correspond closely to those taken in the 1969 season using a relatively large core (2 5/8 inch). The formula used for converting percent soil moisture to cm of water in the soil was:

$$\text{cm water in soil} = \frac{\text{\% water in soil} \times \text{Thickness of soil layer-cm} \times \text{Bulk density}}{100}$$

Table 6 gives the cm of water in the 0-50 and 50-120 cm soil layers on the grazed and ungrazed sites at each date of sampling. In general, there seems to be slightly more total soil water on the ungrazed than on the grazed treatment until about the middle of August, after which amounts of water in the soil appear to be very similar under both treatments. Allowing for differences in soil moisture values which might result from

Table 5. Average soil bulk density values on the ungrazed and grazed treatments at the Dickinson site - 1970 season.

Depth	Thickness of layer-cm	Bulk density - g/cc	
		Ungrazed	Grazed
0-10	10	1.03	1.16
10-20	10	1.27	1.35
20-30	10	1.40	1.40
30-40	10	1.40	1.40
40-50	10	1.40	1.35
50-60	10	1.50	1.35
60-70	10	1.50	1.45
70-80	10	1.50	1.45
80-90	10	1.50	1.45
90-100	10	1.50	1.40
100-120	20	1.59	1.40

Table 6. Total cm of water in the 0-50 and 50-120 cm soil layers on the grazed and ungrazed sites at sampling dates from May-October, 1970.

Date	Grazed			Ungrazed		
	0-50	50-120	Total	0-50	50-120	Total
5/27	9.43	10.78	20.21	10.88	13.97	24.85
6/15	9.30	12.52	21.82	10.59	13.51	24.10
6/22	6.63	8.65	15.28	7.84	15.77	23.61
6/29	11.51	20.19	31.70	6.94	14.10	21.04
7/6	3.95	8.07	12.02	4.03	13.81	17.84
7/13	3.16	7.47	10,63	3.56	8.77	12.33
7/20	3.04	5.95	8.99	3.52	7.58	11.10
7/28	5.11	5.40	10.51	5.09	7.21	12.30
8/4	6.94	5.49	12.43	8.21	7.48	15.69
8/11	5.13	6.52	11.65	6.50	8.60	15.10
8/18	3.63	6.21	9.84	3.45	5.95	9.40
8/24	6.10	6.10	12.20	3.19	7.69	10.88
8/31	2.46	4.76	7.22	2.55	5.29	7.84
9/8	2.93	4.87	7.80	2.71	5.79	8.50
9/14	3.24	5.00	8.24	3.19	4.98	8.17
9/21	3.56	4.86	8.42	3.52	4.95	8.47
9/28	4.75	5.17	9.92	4.65	5.61	10.26
10/5	3.61	5.12	8.73	3.57	5.19	8.76

surface irregularities affecting water intake, from minor variations in soil texture, and from sampling error, there would appear to be little difference in soil moisture status under the grazed and ungrazed treatments. Calculations of available water for all segments of the soil profile under both treatments, based on percent water retained at 15 atmospheres, are now being made and will be submitted as soon as they are completed.

Air Temperatures

Air temperatures were recorded hourly on the ungrazed and grazed treatment areas at heights above the ground surface of 2.5, 7.5, 15, 25, 55, 75, and 120 cm, with an additional measurement being taken on both treatments at mature canopy height plus 1 m. On the ungrazed area this latter height was considered to be 145 cm and on the grazed area 130 cm. These temperatures were measured by means of shielded thermocouples with the values at the time of measurement being recorded in degrees F on a strip chart Brown Electronik recording potentiometer. Hourly readings were taken from the strip charts and summarized on the basis of weekly averages.

The weekly average air temperatures at the different heights above ground on the ungrazed and grazed areas are given in Tables 7 and 8. In general the air temperatures over the grazed area averaged appreciably warmer throughout the season than the temperatures over the ungrazed area. For the season as a whole and with all heights of measurement included, the air temperatures averaged 2.7°F warmer over the grazed area than over the ungrazed area.

To illustrate the nature of the air temperature gradients that exist over the ungrazed and grazed areas at different times during the

Table 7. Weekly average air temperatures on the ungrazed treatment at the Dickinson Site - 1970 season.

Week	Height (cm)							
	2.5	7.5	15.0	25.0	55.0	75.0	120.0	145.0
5/17-23	54	55	56	56	55	55	56	56
5/24-30	57	57	56	56	56	56	56	56
5/31-6/6	66	67	66	65	65	66	66	67
6/7-13	66	66	66	66	66	66	67	67
6/14-20	64	64	62	62	61	62	62	63
6/21-27	73	72	71	71	71	71	71	72
6/28-7/4	73	70	68	68	68	68	69	69
7/5-11	80	80	77	76	76	76	76	76
7/12-18	74	74	72	72	72	72	73	73
7/19-25	72	72	70	70	69	70	70	70
7/26-8/1	72	72	70	70	70	70	70	70
8/2-8	73	72	71	70	69	70	70	70
8/9-15	72	71	70	70	70	71	71	71
8/16-22	72	70	69	69	69	70	70	71
8/23-29	74	73	72	72	72	72	72	73
8/30-9/5	73	71	69	70	69	70	70	70
9/6-12	59	56	55	55	54	54	55	55
9/13-19	52	51	50	51	51	51	52	52
9/20-26	51	49	48	49	49	49	50	50
9/27-10/3	55	56	56	58	58	59	59	59

Table 8. Weekly average air temperatures on the grazed treatment at the Dickinson Site - 1970 season.

Week	Height (cm)							
	2.5	7.5	15.0	25.0	55.0	75.0	120.0	130.0
5/17-23	58	57	59	58	57	59	59	58
5/24-30	59	57	59	59	57	59	59	58
5/31-6/6	69	67	69	69	68	70	69	69
6/7-13	70	68	70	69	68	70	70	69
6/14-20	65	63	65	65	63	66	65	64
6/21-27	76	72	74	74	73	75	74	74
6/28-7/4	73	70	72	72	70	72	72	71
7/5-11	84	80	81	80	79	80	80	79
7/12-18	76	73	75	75	74	76	75	75
7/19-25	75	72	74	73	72	74	73	72
7/26-8/1	74	71	73	73	72	73	73	72
8/2-8	74	71	74	73	72	74	73	72
8/9-15	73	71	73	73	72	74	73	73
8/16-22	73	71	73	72	71	73	72	72
8/23-29	76	74	76	75	74	76	75	75
8/30-9/5	74	72	74	73	72	74	73	73
9/6-12	58	56	58	57	56	58	57	57
9/13-19	54	52	54	55	53	55	55	54
9/20-26	52	51	53	52	51	53	53	52
9/27-10/3	58	58	60	61	60	63	62	52

24-hour daily period, the average air temperatures at each height above the ground surface for each hour in the daily period are given for selected weeks. Tables 9, 10, and 11 give the average air temperatures at each hour for the different heights of measurement on the ungrazed area for the weeks of June 14-20, July 12-18, and August 16-22. Tables 12, 13, and 14 give the same data for the grazed area for the same weeks.

Over both grazed and ungrazed areas, the general night-time trend of the temperature profile is warmer upward, while during the daylight period, the trend is warmer downward. Lowest daily temperatures were usually reached about 4:00 a.m. on both areas, with highest daily temperatures being reached about 2:00 p.m. (14:00 hours). Gradients were about equally strong over both grazed and ungrazed vegetation, with a range of about 8-10°F from the temperature at maximum height (145 or 130 cm) to highest temperature in the profile at that same hour, usually found at the 2.5 or 7.5 cm height above the ground surface. When the temperatures for the whole profile at any specific hour are averaged together, it is apparent that this average temperature is greater above the grazed vegetation than above the ungrazed vegetation.

Soil Temperatures

Soil temperatures were measured by means of thermocouples situated at 1.2, 2.5, 7.5, 15, 25, 55, 75, and 120 cm below the soil surface on both the ungrazed and grazed areas. The values were recorded hourly on the strip chart recorder, as in the case of the air temperatures. Average weekly soil temperatures at the different depths in the soil are given in Tables 15 and 16. It is apparent from these data that substantial

Table 9. Average air temperatures on the ungrazed site at each hour of the day at different heights above the surface for the week June 14-20, 1970.

Time of Day	Temperatures (°F) at heights above surface (cm)							
	2.5	7.5	15.0	25.0	55.0	75.0	120.0	145.0
1:00 a.m.	53	48	49	51	51	51	52	53
2:00	52	48	48	50	50	51	51	52
3:00	51	48	48	49	50	50	51	51
4:00	52	48	48	49	50	50	51	51
5:00	52	48	48	50	50	50	51	51
6:00	52	50	50	51	51	51	53	53
7:00	56	57	55	56	55	55	56	55
8:00	59	62	61	60	59	59	59	59
9:00	64	68	66	64	63	62	62	63
10:00	69	74	72	67	66	65	65	66
11:00	74	80	76	69	67	68	67	68
12:00	76	81	74	70	69	69	68	70
13:00 p.m.	79	86	76	71	69	69	69	70
14:00	75	77	73	72	70	69	69	70
15:00	73	75	72	71	70	71	71	71
16:00	72	75	73	71	69	70	70	70
17:00	68	71	71	69	69	67	69	69
18:00	65	65	65	65	65	65	66	66
19:00	62	62	62	62	62	62	64	65
20:00	59	57	57	59	60	60	61	61
21:00	57	53	53	55	56	56	57	58
22:00	54	50	50	52	53	54	55	55
23:00	54	50	50	51	52	53	54	54
24:00	53	49	49	51	51	52	53	54

Temperatures have been corrected (-2 subtracted) WCW.

Table 10. Average air temperatures on the ungrazed site at each hour of the day at different heights above the surface for the week July 12-18, 1970.

Time of Day	Temperatures (°F) at heights above surface (cm)							
	2.5	7.5	15.0	25.0	55.0	75.0	120.0	145.0
1:00 a.m.	59	54	54	57	59	60	61	62
2:00	58	54	54	56	58	59	60	60
3:00	58	53	53	55	57	58	59	60
4:00	58	52	52	55	57	57	58	59
5:00	58	53	53	56	57	58	59	59
6:00	59	56	55	59	58	59	61	60
7:00	62	64	63	63	64	63	64	64
8:00	67	72	69	69	68	64	68	68
9:00	74	81	76	69	73	73	73	74
10:00	82	89	84	79	78	78	78	79
11:00	90	94	87	81	79	79	79	79
12:00	97	103	92	89	82	82	82	82
13:00 p.m.	98	101	92	85	83	83	83	82
14:00	94	97	90	85	83	83	82	86
15:00	91	97	92	87	85	85	86	87
16:00	86	92	89	86	83	82	83	83
17:00	84	88	88	85	82	82	82	82
18:00	78	80	81	80	79	80	80	80
19:00	71	70	71	73	72	72	73	73
20:00	66	62	61	66	69	69	71	72
21:00	66	58	58	63	66	67	68	68
22:00	62	57	58	62	64	64	66	67
23:00	60	56	56	59	61	62	63	64
24:00	60	54	55	57	59	60	61	62

Table 11. Average air temperatures on the ungrazed site at each hour of the day at different heights above the surface for the week August 16-22, 1970.

Time of Day	Temperatures (°F) at heights above surface (cm)							
	2.5	7.5	15.0	25.0	55.0	75.0	120.0	145.0
1:00 a.m.	55	50	51	54	57	57	58	59
2:00	53	48	49	52	54	55	56	57
3:00	52	47	48	50	51	52	53	54
4:00	51	45	45	48	50	51	52	52
5:00	49	42	42	46	48	50	51	53
6:00	50	44	44	47	49	50	51	52
7:00	54	53	52	56	55	55	56	56
8:00	61	65	65	66	62	63	63	63
9:00	72	78	76	72	69	69	69	70
10:00	84	87	83	76	74	74	74	74
11:00	94	94	88	80	78	78	77	78
12:00	98	97	88	82	80	80	80	80
13:00 p.m.	101	99	89	84	82	83	82	82
14:00	98	96	91	87	84	83	82	83
15:00	93	94	90	87	84	84	83	83
16:00	88	91	89	87	84	84	84	84
17:00	82	85	85	84	82	83	83	82
18:00	75	76	77	78	79	80	80	80
19:00	70	68	70	73	74	74	75	76
20:00	63	58	59	64	67	67	69	70
21:00	60	55	56	61	63	64	65	66
22:00	58	54	55	60	62	63	64	64
23:00	57	54	55	59	61	62	63	64
24:00	56	52	53	58	59	60	61	62

Table 12. Average air temperatures on the grazed site at each hour of the day at different heights above the surface for the week June 14-20, 1970.

Time of Day	Temperatures (°F) at heights above surface (cm)							
	2.5	7.5	15.0	25.0	55.0	75.0	120.0	130.0
1:00 a.m.	54	52	54	54	53	55	55	54
2:00	54	51	53	53	52	55	54	54
3:00	53	51	53	53	52	54	54	54
4:00	53	50	52	52	52	54	55	53
5:00	53	51	53	54	53	55	55	54
6:00	55	54	56	56	55	57	56	56
7:00	58	58	60	60	58	61	60	57
8:00	63	63	64	64	62	64	63	63
9:00	67	66	67	67	65	66	66	65
10:00	71	69	70	70	67	68	68	68
11:00	75	72	72	71	70	72	70	71
12:00	75	74	74	73	70	71	70	71
13:00 p.m.	76	73	74	74	71	74	72	71
14:00	79	75	75	76	72	75	73	72
15:00	75	72	73	73	72	73	72	70
16:00	73	71	72	72	69	71	70	70
17:00	71	70	71	70	69	70	70	69
18:00	68	67	68	68	66	68	68	67
19:00	64	62	65	67	64	66	66	65
20:00	61	59	61	61	61	62	62	61
21:00	58	55	57	58	57	59	59	59
22:00	56	53	55	56	56	58	58	57
23:00	55	52	54	56	55	57	56	56
24:00	53	51	53	54	53	56	55	54

Temperatures have been corrected (-2 subtracted) WCW.

Table 13. Average air temperatures on the grazed site at each hour of the day at different heights above the surface for the week July 12-18, 1970.

Time of Day	Temperatures (°F) at heights above surface (cm)							
	2.5	7.5	15.0	25.0	55.0	75.0	120.0	130.0
1:00 a.m.	61	58	61	61	61	64	64	63
2:00	61	58	60	61	61	64	63	63
3:00	59	55	58	60	59	62	62	61
4:00	59	57	59	60	60	62	62	61
5:00	59	57	59	60	59	61	61	61
6:00	62	61	64	61	62	65	63	64
7:00	67	68	69	69	66	69	67	68
8:00	72	73	75	74	71	73	71	73
9:00	80	78	79	78	76	78	76	77
10:00	87	83	83	82	80	82	79	80
11:00	89	85	86	83	82	83	82	82
12:00	92	86	87	85	84	85	84	83
13:00 p.m.	90	87	89	86	84	85	85	83
14:00	96	89	90	88	87	88	86	87
15:00	92	88	88	86	85	86	85	87
16:00	91	88	86	85	84	85	84	83
17:00	89	86	86	85	84	85	84	83
18:00	79	78	83	82	78	81	79	78
19:00	73	70	76	75	75	78	77	76
20:00	67	66	69	70	71	74	73	73
21:00	65	63	66	67	67	69	69	69
22:00	63	62	64	65	67	68	68	67
23:00	62	59	62	64	64	67	66	65
24:00	61	58	60	63	65	65	65	64

Table 14. Average air temperatures on the grazed site at each hour of the day at different heights above the surface for the week August 16-22, 1970.

Time of Day	Temperatures (°F) at heights above surface (cm)							
	2.5	7.5	15.0	25.0	55.0	75.0	120.0	130.0
1:00 a.m.	56	54	55	58	58	60	60	59
2:00	55	53	54	55	56	59	59	58
3:00	53	50	53	54	54	56	56	55
4:00	52	48	51	53	53	57	55	55
5:00	50	46	49	51	51	54	54	53
6:00	52	48	51	54	53	56	54	56
7:00	58	59	62	61	58	61	59	60
8:00	68	69	71	69	66	69	64	67
9:00	77	75	76	75	72	74	71	73
10:00	84	81	81	78	76	78	75	76
11:00	91	85	85	83	80	81	79	80
12:00	95	88	88	84	83	85	82	82
13:00 p.m.	90	86	88	86	84	85	84	84
14:00	94	90	90	88	85	86	83	84
15:00	94	88	90	88	86	87	86	85
16:00	93	90	90	87	85	86	85	84
17:00	87	86	87	86	84	87	84	83
18:00	81	81	83	82	80	82	82	80
19:00	72	71	74	75	75	77	77	76
20:00	65	64	67	68	68	71	72	70
21:00	62	62	64	66	66	68	69	67
22:00	61	60	63	64	64	67	67	66
23:00	60	59	61	63	63	64	64	65
24:00	59	58	60	62	62	64	64	63

Table 15. Weekly average soil temperatures on the ungrazed treatment at the Dickinson Site - 1970 season.

Week	Depth (cm)							
	1.2	2.5	7.5	15.0	25.0	55.0	75.0	120.0
5/17-23	55	54	53	52	50	47	45	42
5/24-30	58	57	56	55	53	50	47	45
5/31-6/6	65	64	62	60	57	53	50	47
6/7-13	66	66	65	63	61	57	54	50
6/14-20	67	66	65	64	62	58	55	52
6/21-27	72	71	69	68	65	60	57	54
6/28-7/4	73	72	70	69	66	62	59	56
7/5-11	78	76	73	71	68	63	60	56
7/12-18	75	75	73	72	69	65	62	58
7/19-25	73	72	71	70	68	65	62	59
7/26-8/1	74	74	73	72	69	66	63	60
8/2-8	73	73	72	71	70	66	64	60
8/9-15	73	73	72	71	70	67	64	61
8/16-22	72	72	70	69	68	66	64	61
8/23-29	73	72	71	70	68	66	64	61
8/30-9/5	72	71	70	69	68	65	64	61
9/6-12	64	64	64	64	65	64	63	61
9/13-19	55	55	55	55	56	58	59	59
9/20-26	54	54	55	55	56	57	57	57
9/27-10/3	56	56	55	55	55	55	56	56

Table 16. Weekly average soil temperatures on the grazed treatment at the Dickinson Site - 1970 season.

Week	Depth (cm)							
	1.2	2.5	7.5	15.0	25.0	55.0	75.0	120.0
5/17-23	60	57	57	58	55	53	51	46
5/24-30	61	58	61	61	58	56	54	48
5/31-6/6	71	68	68	67	64	59	57	51
6/7-13	71	69	71	71	68	65	63	55
6/14-20	67	63	70	69	67	64	63	57
6/21-27	76	73	76	75	71	67	66	59
6/28-7/4	74	70	78	78	74	71	69	62
7/5-11	82	79	83	81	78	73	71	64
7/12-18	79	75	80	79	76	74	72	66
7/19-25	77	72	78	78	75	73	72	66
7/26-8/1	77	72	78	78	75	73	72	67
8/2-8	79	72	77	77	74	73	72	67
8/9-15	79	72	79	79	76	74	73	68
8/16-22	78	72	77	77	75	74	73	68
8/23-29	80	74	78	78	75	73	72	68
8/30-9/5	78	72	76	76	74	73	72	68
9/6-12	66	56	67	69	68	71	70	68
9/13-19	58	53	58	59	58	62	64	64
9/20-26	57	52	58	59	58	61	62	62
9/27-10/3	60	61	58	59	57	59	60	59

gradients in soil temperatures exist at nearly all times during the season under both ungrazed and grazed treatments. The general tendency is for these gradients to be cooler downward in May, June, July, and August (soil is absorbing heat) and cooler upwards in September (soil is losing heat), with near equilibrium in temperatures reached by the first part of October.

Maximum soil temperatures were reached in the upper 15 cm of the soil on both the ungrazed and grazed areas during the period July 5-18. Maximum temperatures below this level, however, were not reached until about mid-August. By mid-September the soils on both the ungrazed and grazed areas had cooled significantly throughout the depth of the measured profile.

The most interesting feature of the soil temperatures is the contrast between the average temperatures at the different depths on the grazed and the ungrazed sites. Throughout the season, temperatures measured at all depths were substantially higher on the grazed area than on the ungrazed area. In general, the average values on the grazed area range from 4°to 7°F higher than on the ungrazed area, except at the end of the season, when the average values are about 3°to 4°F apart. In addition to the occurrence of higher average soil temperature values on the ungrazed treatment, the diurnal range at a depth of 15 cm was found to be much greater on this treatment than on the ungrazed treatment. In many cases, the range on the grazed area at this depth was twice that occurring on the ungrazed area. Hourly and daily temperature values have not been supplied in this report, but they are on file in the Botany Department at NDSU and will be provided on request.

Net Radiation

Net radiation was measured with a Beckman-Whitley net radiometer on both the ungrazed and grazed area. The radiometers were placed so that the absorbing plate was at a height of 145 cm over the ungrazed vegetation and at 130 cm over the grazed vegetation. These heights were considered to represent mature canopy height plus one meter on the ungrazed and grazed vegetation, respectively. Net radiation values on each treatment were recorded 15 times each hour, and the average of these values was taken as the hourly average. The hourly averages were added and subtracted as required to give the average calories per cm^2 for each 24 hour period. The 24-hour totals were summed algebraically to give the total calories for the seasonal measured period.

The net radiation on the ungrazed and grazed areas was measured from May 16 to October 3, a period of 141 days. The daylight accumulations, the night-time losses, the net for each 24-hour period, and the cumulative total calories per cm^2 are given for the ungrazed area in Table 17 and for the grazed area in Table 18. Examination of these data shows that the total net radiation on the ungrazed area during the entire measured period was 48,511.7 cal/cm^2, while on the grazed area the cumulative seasonal total R_n was 44,105.6 cal/cm^2.

A breakdown of the data in Tables 17 and 18 shows that the average energy retention during the daylight portion of each 24-hour period was 391.5 cal/cm^2 on the ungrazed treatment and 368.4 cal/cm^2 on the grazed treatment. The daylight energy absorption on the ungrazed area thus averaged 23.1 cal/cm^2/day more than on the grazed area. The net loss of energy during the night-time portion of each 24-hour period, however, was higher on the grazed than on the ungrazed area, averaging 56.6 cal/cm^2

Table 17. Daily net radiation on ungrazed native grass site - 1970 season.

Date	Daylight cal/cm^2	Night cal/cm^2	Net for 24 hours cal/cm^2	Cumulative total cal/cm^2
5/16	59.3	-25.5	33.8	33.8
5/17	486.0	-57.8	428.2	462.0
5/18	348.0	-38.3	309.7	771.7
5/19	279.0	-57.0	222.0	993.7
5/20	114.8	-14.3	100.5	1,094.2
5/21	156.8	-12.8	144.0	1,238.2
5/22	249.8	-24.8	225.0	1,463.2
5/23	134.3	-32.3	102.0	1,565.2
5/24	394.5	-45.8	348.7	1,913.9
5/25	531.0	-39.8	491.2	2,405.1
5/26	453.8	-18.0	435.8	2,840.9
5/27	477.0	-78.0	399.0	3,239.9
5/28	244.5	-19.5	225.0	3,464.9
5/29	315.8	-30.8	285.0	3,749.9
5/30	179.3	-64.5	114.8	3,864.7
5/31	493.5	-44.3	449.2	4,313.9
6/1	547.5	-36.8	510.7	4,824.6
6/2	511.5	-42.8	468.7	5,293.3
6/3	556.5	-32.3	524.2	5,817.5
6/4	568.5	-28.5	540.0	6,357.5
6/5	551.3	-18.0	533.3	6,890.8
6/6	552.8	-33.8	519.0	7,409.8
6/7	568.5	-16.5	552.0	7,961.8
6/8	525.8	-12.0	513.8	8,475.6
6/9	573.8	-52.5	521.3	8,996.9
6/10	81.8	-22.5	59.3	9,056.2
6/11	485.3	-41.3	444.0	9,500.2
6/12	87.0	-76.5	10.5	9,510.7
6/13	337.5	-32.3	305.2	9,815.9
6/14	162.8	-24.8	138.0	9,953.9
6/15	510.0	-42.0	468.0	10,421.9
6/16	522.0	-40.5	481.5	10,903.4
6/17	355.5	-58.5	297.0	11,200.4
6/18	613.5	-82.5	531.0	11,731.4
6/19	399.0	-32.3	366.7	12,098.1
6/20	535.5	-26.3	509.2	12,607.3
6/21	587.3	-36.8	550.5	13,157.8
6/22	587.3	-39.8	547.5	13,705.3
6/23	578.3	-38.3	540.0	14,245.3
6/24	507.0	-38.3	468.7	14,714.0
6/25	585.8	-18.8	567.0	15,281.0
6/26	566.3	-39.0	527.3	15,808.3
6/27	563.3	-36.8	526.5	16,334.8
6/28	534.0	-30.0	504.0	16,838.8
6/29	494.3	-27.8	466.5	17,305.3
6/30	525.8	-51.8	474.0	17,779.3
7/1	518.3	-36.0	482.3	18,261.6

Table 17. (continued)

Date	Daylight cal/cm^2	Night cal/cm^2	Net for 24 hours cal/cm^2	Cumulative total cal/cm^2
7/2	458.3	-45.0	413.3	18,674.9
7/3	470.3	-33.8	436.5	19,111.4
7/4	561.8	-33.8	528.0	19,639.4
7/5	505.5	-29.3	476.2	20,115.6
7/6	459.0	-36.8	422.2	20,537.8
7/7	584.3	-33.0	551.3	21,089.1
7/8	537.8	-32.3	505.5	21,594.6
7/9	535.5	-39.0	496.5	22,091.1
7/10	459.8	-23.3	436.5	22,527.6
7/11	408.8	-43.5	365.3	22,892.9
7/12	543.8	-49.5	494.3	23,387.2
7/13	458.3	-29.1	429.2	23,816.4
7/14	409.5	-40.5	369.0	24,185.4
7/15	554.3	-42.8	511.5	24,696.9
7/16	570.8	-21.8	549.0	25,245.9
7/17	424.5	-24.0	400.5	25,646.4
7/18	553.5	-53.3	500.2	26,146.6
7/19	294.8	-27.0	267.8	26,414.4
7/20	521.3	-57.8	463.5	26,877.9
7/21	511.5	-22.5	489.0	27,366.9
7/22	544.5	-61.5	483.0	27,849.9
7/23	-41.3	-63.8	-105.1	27,744.8
7/24	551.3	-48.8	502.5	28,247.3
7/25	543.0	-17.3	525.7	28,773.0
7/26	464.3	-33.0	431.3	29,204.3
7/27	552.8	-91.5	461.3	29,665.6
7/28	324.8	-25.5	299.3	29,964.9
7/29	534.0	-39.8	494.2	30,459.1
7/30	113.3	-41.3	72.0	30,531.1
7/31	546.0	-44.3	501.7	31,032.8
8/1	542.3	-42.0	500.3	31,533.1
8/2	456.8	-56.3	400.5	31,933.6
8/3	297.0	-45.8	251.2	32,184.8
8/4	575.3	-45.8	529.5	32,714.3
8/5	490.5	-31.5	459.0	33,173.3
8/6	417.0	-30.8	386.2	33,559.5
8/7	543.0	-41.3	501.7	34,061.2
8/8	491.3	-60.8	430.5	34,491.7
8/9	530.3	-55.5	474.8	34,966.5
8/10	510.0	-54.0	456.0	35,422.5
8/11	513.0	-36.0	477.0	35,899.5
8/12	527.3	-49.5	477.8	36,377.3
8/13	267.8	-63.8	204.0	36,581.3
8/14	355.5	-66.8	288.7	36,870.0
8/15	458.3	-50.3	408.0	37,278.0
8/16	460.5	-66.8	393.7	37,671.7
8/17	429.0	-66.8	362.2	38,033.9
8/18	446.3	-75.8	370.5	38,404.4

Table 17. (continued)

Date	Daylight cal/cm^2	Night cal/cm^2	Net for 24 hours cal/cm^2	Cumulative total cal/cm^2
8/19	425.3	-45.8	379.5	38,783.9
8/20	429.8	-69.8	360.0	39,143.9
8/21	424.5	-63.8	360.7	39,504.6
8/22	447.8	-39.0	408.8	39,913.4
8/23	427.5	-73.5	354.0	40,267.4
8/24	397.5	-53.3	344.2	40,611.6
8/25	394.5	-84.8	309.7	40,921.3
8/26	276.8	-80.3	196.5	41,117.8
8/27	355.5	-50.3	305.2	41,423.0
8/28	368.3	-57.8	310.5	41,733.5
8/29	315.0	-57.8	257.2	41,990.7
8/30	357.0	-70.5	286.5	42,277.2
8/31	349.5	-56.3	293.2	42,570.4
9/1	147.8	-48.8	99.0	42,669.4
9/2	348.8	-27.0	321.8	42,991.2
9/3	337.5	-53.3	284.2	43,275.4
9/4	344.3	-55.5	288.8	43,564.2
9/5	328.5	-33.8	294.7	43,858.9
9/6	251.3	-68.3	183.0	44,041.9
9/7	311.3	-90.0	221.3	44,263.2
9/8	355.5	-51.8	303.7	44,566.9
9/9	138.0	-69.0	69.0	44,635.9
9/10	365.3	-90.0	275.3	44,911.2
9/11	292.5	-29.3	263.2	45,174.4
9/12	176.3	-67.5	108.8	45,283.2
9/13	78.0	-38.3	39.7	45,322.9
9/14	-9.8	-62.3	-72.1	45,250.8
9/15	319.5	-59.3	260.2	45,511.0
9/16	298.5	-69.8	228.7	45,739.7
9/17	240.0	-48.0	192.0	45,931.7
9/18	297.8	-57.0	240.8	46,172.5
9/19	320.3	-50.3	270.0	46,442.5
9/20	57.8	-45.0	12.8	46,455.3
9/21	220.5	-84.0	136.5	46,591.8
9/22	291.0	-56.3	234.7	46,826.5
9/23	147.8	-63.8	84.0	46,910.5
9/24	99.8	-66.8	33.0	46,943.5
9/25	228.0	-67.5	160.5	47,104.0
9/26	186.8	-62.3	124.5	47,228.5
9/27	285.8	-60.2	225.6	47,454.1
9/28	259.5	-70.5	189.0	47,643.1
9/29	291.8	-52.5	239.3	47,882.4
9/30	249.0	-90.0	159.0	48,041.4
10/1	233.3	-73.5	159.8	48,201.2
10/2	225.8	-71.3	154.5	48,355.7
10/3	231.0	-75.0	156.0	48,551.7

Table 18. Daily net radiation on grazed native grass site - 1970 season.

Date	Daylight cal/cm^2	Night cal/cm^2	Net for 24 hours cal/cm^2	Cumulative total cal/cm^2
5/16	75.9	-46.6	29.3	29.3
5/17	513.7	-65.4	448.3	477.6
5/18	320.9	-39.0	281.9	759.5
5/19	289.5	-52.2	237.3	996.8
5/20	137.1	-20.2	116.9	1,113.7
5/21	193.5	-13.2	180.3	1,294.0
5/22	245.7	-24.4	221.3	1,515.3
5/23	140.6	-36.9	103.7	1,619.0
5/24	383.5	-56.4	327.1	1,946.1
5/25	497.6	-49.4	448.2	2,394.3
5/26	459.4	-24.4	435.0	2,829.3
5/27	476.8	-84.2	392.6	3,221.9
5/28	234.6	-43.2	191.4	3,413.3
5/29	299.3	-32.0	267.3	3,680.6
5/30	169.8	-76.6	93.2	3,773.8
5/31	464.2	-53.6	410.6	4,184.4
6/1	495.6	-50.1	445.5	4,629.9
6/2	513.6	-50.8	462.8	5,092.7
6/3	547.1	-55.7	491.4	5,584.1
6/4	549.8	-46.6	503.2	6,087.3
6/5	538.7	-38.3	500.4	6,587.7
6/6	522.0	-47.3	474.7	7,062.4
6/7	510.2	-35.5	474.7	7,537.6
6/8	485.1	-46.6	438.5	7,975.6
6/9	547.8	-59.9	487.9	8,463.5
6/10	93.3	-39.0	54.3	8,517.8
6/11	470.5	-43.2	427.3	8,945.1
6/12	99.5	-73.8	25.7	8,970.8
6/13	347.3	-34.1	313.2	9,284.0
6/14	162.2	-43.4	118.8	9,402.8
6/15	496.9	-48.0	448.9	9,851.7
6/16	519.9	-41.1	478.8	10,330.5
6/17	330.6	-82.1	248.5	10,579.0
6/18	607.6	-88.4	519.2	11,098.2
6/19	386.3	-48.7	337.6	11,435.8
6/20	493.5	-44.5	449.0	11,884.8
6/21	572.1	-52.2	519.9	12,404.7
6/22	560.3	-44.5	515.8	12,920.5
6/23	524.8	-44.5	480.3	13,400.8
6/24	469.8	-52.9	416.9	13,817.7
6/25	525.5	-34.1	491.4	14,309.1
6/26	530.4	-46.6	483.8	14,792.9
6/27	524.8	-46.6	478.2	15,271.1
6/28	513.6	-38.3	475.3	15,746.4
6/29	509.5	-37.6	471.9	16,218.3
6/30	488.6	-69.6	419.0	16,637.3

Table 18. (continued)

Date	Daylight cal/cm^2	Night cal/cm^2	Net for 24 hours cal/cm^2	Cumulative total cal/cm^2
7/1	485.1	-51.5	433.6	17,070.9
7/2	419.7	-60.6	359.1	17,430.0
7/3	469.1	-40.4	428.7	17,858.7
7/4	545.0	-47.3	497.7	18,356.4
7/5	471.9	-39.7	432.2	18,788.6
7/6	487.2	-43.8	443.4*	19,232.0
7/7	520.6	-66.1	454.5	19,686.5
7/8	508.8	-46.6	462.2	20,148.7
7/9	493.5	-58.5	435.0	20,583.7
7/10	405.1	-29.2	375.9	20,959.6
7/11	373.8	-47.3	326.5	21,286.1
7/12	492.8	-56.4	436.4	21,722.5
7/13	416.2	-44.5	371.7	22,094.2
7/14	400.2	-49.4	350.8	22,445.0
7/15	523.4	-62.6	460.8	22,905.8
7/16	544.3	-43.2	501.1	23,406.9
7/17	403.7	-41.1	362.6	23,769.5
7/18	517.8	-59.2	458.6	24,228.1
7/19	279.1	-41.8	237.3	24,465.4
7/20	499.6	-75.2	424.4	24,889.8
7/21	457.3	-34.1	423.2	25,313.0
7/22	509.5	-57.8	451.7	25,764.7
7/23	-12.5	-57.8	-70.3	25,694.4
7/24	531.7	-70.3	461.4	26,155.8
7/25	531.0	-30.6	500.4	26,656.2
7/26	434.3	-45.9	388.4	27,044.6
7/27	516.4	-92.6	423.8	27,468.4
7/28	318.8	-31.3	287.5	27,755.9
7/29	515.7	-41.8	473.9	28,229.8
7/30	87.0	-57.8	29.2	28,259.0
7/31	502.5	-61.9	440.6	28,699.6
8/1	524.1	-48.0	476.1	29,175.7
8/2	451.7	-64.0	387.7	29,563.4
8/3	272.8	-48.0	224.8	29,788.2
8/4	545.7	-49.4	496.3	30,284.5
8/5	471.9	-39.7	432.2	30,716.7
8/6	375.1	-35.5	339.6	31,056.3
8/7	515.7	-49.4	466.3	31,522.6
8/8	467.7	-72.4	395.3	31,917.9
8/9	484.4	-66.8	417.6	32,335.5
8/10	474.7	-67.5	407.2	32,742.7
8/11	498.3	-45.9	452.4	33,195.1
8/12	498.3	-43.2	455.1	33,650.2
8/13	269.4	-62.6	206.8	33,857.0
8/14	317.4	-74.5	242.9	34,099.9
8/15	431.5	-59.2	372.3	34,472.2

*This value is the average of the figures for 7/5 and 7/7.

Table 18. (continued)

Date	Daylight cal/cm^2	Night cal/cm^2	Net for 24 hours cal/cm^2	Cumulative total cal/cm^2
8/16	430.1	-78.6	351.5	34,823.7
8/17	417.6	-67.5	350.1	35,173.8
8/18	414.8	-83.5	331.3	35,505.1
8/19	401.6	-68.9	332.7	35,837.8
8/20	374.4	-89.1	285.3	36,123.1
8/21	432.9	-75.9	357.0	36,480.1
8/22	417.6	-57.8	359.8	36,839.9
8/23	397.4	-80.0	317.4	37,157.3
8/24	361.2	-71.0	290.2	37,447.5
8/25	385.6	-91.9	293.7	37,741.2
8/26	266.6	-82.8	183.8	37,925.0
8/27	338.9	-43.8	295.1	38,220.1
8/28	350.1	-66.8	283.3	38,503.4
8/29	348.7	-59.9	288.8	38,792.2
8/30	332.7	-87.0	245.7	39,037.9
8/31	329.2	-70.3	258.9	39,296.8
9/1	142.7	-49.4	93.3	39,390.1
9/2	324.3	-51.5	272.8	39,662.9
9/3	303.5	-80.7	222.8	39,885.7
9/4	305.5	-80.0	225.5	40,111.2
9/5	300.0	-59.2	240.8	40,352.0
9/6	218.5	-84.2	134.3	40,486.3
9/7	285.4	-120.4	165.0	40,651.3
9/8	355.7	-58.5	297.2	40,948.5
9/9	140.6	-75.2	65.4	41,013.9
9/10	336.2	-96.0	240.2	41,254.1
9/11	252.6	-20.2	232.4	41,486.5
9/12	167.0	-78.6	88.4	41,574.9
9/13	66.1	-41.1	25.0	41,599.9
9/14	-40.4	-82.1	-122.5	41,477.4
9/15	300.7	-80.0	220.7	41,698.1
9/16	281.2	-80.7	200.5	41,898.6
9/17	229.0	-66.1	162.9	42,061.5
9/18	277.0	-78.0	199.0	42,260.5
9/19	282.6	-55.0	227.6	42,488.1
9/20	59.9	-43.2	16.7	42,504.8
9/21	185.8	-83.5	102.3	42,607.1
9/22	268.0	-64.0	204.0	42,811.1
9/23	140.6	-78.6	62.0	42,873.1
9/24	88.4	-71.0	17.4	42,890.5
9/25	227.6	-67.5	160.1	43,050.6
9/26	178.9	-72.4	106.5	43,157.1
9/27	254.0	-75.2	178.8	43,335.9
9/28	256.1	-70.3	185.8	43,521.7
9/29	258.9	-80.0	178.9	43,700.6
9/30	222.7	-84.2	138.5	43,839.1
10/1	213.7	-73.1	140.6	43,979.7
10/2	220.6	-94.7	125.9	44,105.6
10/3	27.1			

on the grazed and 50.7 cal/cm^2 on the ungrazed area. The 5.9 cal greater loss on the grazed site was, of course, insufficient to offset the greater daylight energy absorption on the ungrazed site.

Soil Heat Flux

Thornthwaite soil heat flux disks were installed at a depth of 2.5 cm on the ungrazed and grazed areas. Only one disk was used in each area. Readings from the disks were recorded 15 times each hour, as in the case of the net radiation values. The average of the 15 recorded values was taken as the average soil heat flux in cal/cm^2/hr. The positive hourly averages and the negative hourly averages, which were recorded mainly during the night-time portion of each 24-hour period, were summed algebraically to give net calories for each 24-hour period. The soil heat flux data for the ungrazed and grazed areas are given in Tables 19 and 20.

The soil heat flux disk in the grazed area was found to be giving erroneous readings on the morning of June 19, the day after the disks were installed. Another disk was installed in the grazed area and was found to be working satisfactorily by the afternoon of June 19. Thus, there was approximately one day less of recorded soil heat flux values on the grazed area than on the ungrazed area.

The data of Tables 19 and 20 show that there were considerable differences in soil heat flux between the ungrazed and grazed areas. On October 15 at the end of the soil heat flux recording period, the cumulative total cal/cm^2 on the ungrazed area was 818.75 and on the grazed site, only 247.50. The cumulative total cal/cm^2 on the ungrazed site was at its maximum on September 7, with a value of 1205.90.

Table 19. Daily soil heat flux on ungrazed native grass site - 1970 season.

Date	Daylight cal/cm^2	Night cal/cm^2	Net for 24 hrs. cal/cm^2	Cumulative total cal/cm^2
6/18	9.03	-15.68	- 6.65	
6/19	32.14	-23.19	8.95	2.30
6/20	46.10	-22.49	23.61	25.91
6/21	49.54	-18.13	31.41	57.32
6/22	45.70	-13.02	32.68	90.00
6/23	43.52	-16.63	26.89	116.89
6/24	39.27	-12.17	27.10	143.99
6/25	41.68	-19.14	22.54	166.53
6/26	45.50	-10.37	35.13	201.66
6/27	49.00	- 8.52	40.48	242.14
6/28	33.73	-20.65	13.08	255.22
6/29	37.10	- 5.03	32.07	287.29
6/30	28.18	-27.10	1.08	288.37
7/1	36.52	-22.89	13.63	302.00
7/2	33.45	-15.85	17.60	319.60
7/3	33.03	-17.15	15.88	335.48
7/4	40.15	-12.95	27.20	362.68
7/5	41.47	-10.47	30.99	393.67
7/6	37.24	-10.99	26.25	419.92
7/7	42.61	-16.34	26.27	446.19
7/8	43.78	-10.07	33.71	479.90
7/9	41.72	-11.87	29.85	509.75
7/10	34.48	- 9.05	25.43	535.18
7/11	29.23	-16.05	13.18	548.36
7/12	32.59	-19.48	13.11	561.47
7/13	31.32	-20.03	11.29	572.76
7/14	16.48	-23.00	- 6.52	566.24
7/15	41.33	-22.46	18.87	585.11
7/16	46.24	-21.87	24.37	609.48
7/17	33.24	-15.05	18.19	627.67
7/18	39.68	-16.34	23.34	651.01
7/19	7.09	-17.58	-10.49	640.52
7/20	33.70	-15.65	18.05	658.57
7/21	37.76	- 5.21	32.55	691.12
7/22	36.02	-12.17	23.85	714.97
7/23	- 4.97	-16.39	-21.36	693.61
7/24	43.07	-16.63	26.44	720.05
7/25	40.47	-12.72	27.75	747.80
7/26	28.47	-17.77	10.70	758.50
7/27	38.27	-13.06	25.21	783.71
7/28	17.37	-12.02	5.35	789.06
7/29	44.78	-16.18	28.60	817.66
7/30	8.56	-22.82	-14.26	803.40
7/31	34.93	-26.18	8.75	812.15

Table 19. (continued)

Date	Daylight cal/cm^2	Night cal/cm^2	Net for 24 hrs. cal/cm^2	Cumulative total cal/cm^2
8/1	36.68	-23.49	13.19	825.34
8/2	23.90	-29.48	- 5.58	819.76
8/3	9.45	-23.11	-13.66	806.10
8/4	40.42	-17.83	22.59	828.69
8/5	39.85	- 8.92	30.93	859.62
8/6	32.95	- 9.06	23.89	883.51
8/7	38.39	-14.60	23.79	907.30
8/8	33.24	-20.55	12.69	919.99
8/9	24.94	-28.46	- 3.52	916.47
8/10	33.00	-14.83	18.17	934.64
8/11	34.56	-15.28	19.28	953.92
8/12	34.93	-14.27	20.66	974.58
8/13	18.94	-12.49	6.45	981.03
8/14	17.58	-22.52	- 4.94	976.09
8/15	26.33	-20.02	6.31	982.40
8/16	33.23	-11.51	21.72	1004.12
8/17	34.37	-14.80	19.57	1023.69
8/18	28.61	-23.48	5.13	1028.82
8/19	26.48	-24.01	2.47	1031.29
8/20	31.62	-13.44	18.18	1049.47
8/21	16.80	-26.63	- 9.83	1039.64
8/22	28.47	-19.60	8.87	1048.51
8/23	29.92	-12.73	17.19	1065.70
8/24	29.99	-15.15	14.84	1080.54
8/25	27.34	-30.32	- 2.98	1077.56
8/26	19.39	-15.44	3.95	1081.51
8/27	21.79	-13.25	8.54	1090.05
8/28	25.78	-10.60	15.18	1105.23
8/29	26.14	-16.18	9.96	1115.19
8/30	17.83	-15.64	2.19	1117.38
8/31	26.94	-11.24	15.70	1133.08
9/1	11.23	-10.31	.92	1134.00
9/2	28.66	-14.98	13.68	1147.68
9/3	28.80	-14.78	14.02	1161.70
9/4	31.73	-15.88	15.85	1177.55
9/5	35.66	-13.99	21.67	1199.22
9/6	17.27	-13.36	3.91	1203.13
9/7	15.88	-13.11	2.77	1205.90
9/8	14.27	-18.51	- 4.24	1201.66
9/9	- 7.67	-24.65	-32.32	1169.34
9/10	18.80	-28.88	-10.08	1159.26
9/11	8.11	-20.76	-12.65	1146.61
9/12	- 1.79	-29.65	-31.44	1115.17
9/13	- 4.63	-15.17	-19.80	1095.37
9/14	- 4.90	-13.84	-18.74	1076.63
9/15	15.66	-23.92	- 8.26	1068.37

Table 19. (continued)

Date	Daylight cal/cm^2	Night cal/cm^2	Net for 24 hrs. cal/cm^2	Cumulative total cal/cm^2
9/16	20.92	-17.84	3.08	1071.45
9/17	15.27	-22.16	- 6.89	1064.56
9/18	24.38	-17.92	6.46	1071.02
9/19	23.65	-14.41	9.24	1080.26
9/20	- 1.14	-15.82	-16.96	1063.30
9/21	4.42	-20.36	-15.94	1047.36
9/22	16.68	-14.97	1.71	1049.07
9/23	12.32	-12.79	- .47	1048.60
9/24	2.14	-22.78	-20.64	1027.96
9/25	8.51	-23.78	-15.27	1012.69
9/26	8.46	-21.61	-13.15	999.54
9/27	21.96	-17.99	3.97	1003.51
9/28	23.78	-19.13	4.65	1008.16
9/29	24.01	-22.82	1.19	1009.35
9/30	21.50	-17.07	4.43	1013.78
10/1	14.12	-15.03	- .91	1012.87
10/2	11.96	-27.91	-15.95	996.92
10/3	14.93	-16.56	- 1.63	995.29
10/4	20.25	-17.14	3.11	998.40
10/5	19.58	-11.88	7.70	1006.10
10/6	- 6.93	-18.98	-25.91	980.19
10/7	-10.99	-21.01	-32.00	948.19
10/8	- 5.28	-15.46	-20.74	927.45
10/9	- .37	-24.39	-24.76	902.69
10/10	7.70	-18.90	-11.20	891.49
10/11	11.78	-12.10	- .32	891.17
10/12	- 1.58	-15.31	-16.89	874.28
10/13	- 5.66	-17.54	-23.20	851.08
10/14	2.05	-19.82	-17.77	833.31
10/15	6.61	-21.17	-14.56	818.75

Table 20. Daily soil heat flux on grazed native grass site - 1970 season.

Date	Daylight cal/cm^2	Night cal/cm^2	Net for 24 hrs. cal/cm^2	Cumulative total cal/cm^2
6/19	17.33	-23.87	- 6.54	
6/20	25.82	-22.35	3.47	- 3.07
6/21	48.34	-20.23	28.11	25.04
6/22	49.01	-14.50	34.51	59.55
6/23	31.61	-18.92	12.69	72.24
6/24	35.99	-15.14	20.85	93.09
6/25	29.42	-21.96	7.46	100.55
6/26	43.28	-13.42	29.86	130.41
6/27	49.36	- 8.77	40.59	171.00
6/28	31.03	-20.51	10.52	181.52
6/29	41.34	- 6.63	34.71	216.23
6/30	28.62	-27.42	1.20	217.43
7/1	37.59	-22.34	15.25	232.68
7/2	32.47	-18.72	13.75	246.43
7/3	30.08	-20.49	9.59	256.02
7/4	49.19	-15.26	33.93	289.95
7/5	46.97	-12.29	34.68	324.63
7/6	37.52	-13.36	24.16	348.79
7/7	43.12	-20.04	23.08	371.87
7/8	50.12	-13.29	36.83	408.70
7/9	50.71	-13.40	37.31	446.01
7/10	36.20	-10.21	25.99	472.00
7/11	33.40	-19.48	13.92	485.92
7/12	30.92	-22.48	8.44	494.36
7/13	24.11	-25.04	- .93	493.43
7/14	6.92	-26.48	-19.56	473.87
7/15	40.09	-26.95	13.14	487.01
7/16	35.99	-25.94	10.05	497.06
7/17	36.55	-22.01	14.54	511.60
7/18	31.69	-24.61	7.08	518.68
7/19	11.08	-21.97	-10.89	507.79
7/20	32.76	-22.66	10.10	517.89
7/21	37.46	- 5.38	32.08	549.97
7/22	44.59	-18.13	26.46	576.43
7/23	- 5.26	-17.59	-22.85	553.58
7/24	43.83	-18.83	25.00	578.58
7/25	35.38	-16.48	18.90	597.48
7/26	26.44	-21.88	4.56	602.04
7/27	34.67	-18.20	16.47	618.51
7/28	15.42	-14.23	1.19	619.70
7/29	38.72	-20.44	18.28	637.98
7/30	6.79	-24.22	-17.43	620.55
7/31	27.38	-28.17	- .79	619.76

Table 20. (continued)

Date	Daylight cal/cm^2	Night cal/cm^2	Net for 24 hrs. cal/cm^2	Cumulative total cal/cm^2
8/1	31.33	-23.23	8.10	627.86
8/2	23.59	-31.03	- 7.44	620.42
8/3	9.37	-24.62	-15.25	605.17
8/4	37.68	-21.53	16.15	621.32
8/5	40.09	-12.86	27.23	648.55
8/6	29.20	-10.55	18.65	667.20
8/7	37.01	-18.11	18.90	686.10
8/8	32.27	-26.38	5.89	691.99
8/9	17.56	-29.51	-11.95	680.04
8/10	30.66	-19.27	11.39	691.43
8/11	33.89	-18.93	14.96	706.39
8/12	34.34	-16.90	17.44	723.83
8/13	22.71	-14.81	7.90	731.73
8/14	18.18	-25.00	- 6.82	724.91
8/15	23.51	-23.65	- .14	724.77
8/16	37.11	-13.48	23.63	748.40
8/17	38.21	-17.17	21.04	769.44
8/18	27.33	-26.81	.52	769.96
8/19	22.31	-26.36	- 4.05	765.91
8/20	34.32	-17.45	16.87	782.78
8/21	8.74	-29.12	-20.38	762.40
8/22	22.27	-25.12	- 2.85	759.55
8/23	28.22	-17.55	10.67	770.22
8/24	29.72	-18.48	11.24	781.46
8/25	26.30	-14.93	11.37	792.83
8/26	18.04	-18.63	- .59	792.24
8/27	21.34	-15.46	5.88	798.12
8/28	26.08	-13.72	12.36	810.48
8/29	21.03	-19.47	1.56	812.04
8/30	18.00	-19.30	- 1.30	810.74
8/31	28.46	-13.18	15.28	826.02
9/1	11.06	-11.43	- .37	825.65
9/2	23.63	-15.99	7.64	833.29
9/3	27.28	-17.35	9.93	843.22
9/4	30.19	-18.09	12.10	855.32
9/5	24.93	-14.89	10.04	865.36
9/6	15.67	-14.42	1.25	866.61
9/7	10.34	-14.67	- 4.33	862.28
9/8	10.48	-23.23	-12.75	849.53
9/9	-12.85	-27.12	-39.97	809.56
9/10	9.61	-30.57	-20.96	788.60
9/11	- 2.92	-26.94	-29.86	758.74
9/12	-36.91	-31.91	-68.82	689.92
9/13	- 2.05	-15.17	-17.22	672.70
9/14	- 3.11	-13.03	-16.14	656.56
9/15	10.60	-25.19	-14.59	641.97

Table 20. (continued)

Date	Daylight cal/cm^2	Night cal/cm^2	Net for 24 hrs. cal/cm^2	Cumulative total cal/cm^2
9/16	18.93	-20.20	- 1.27	640.70
9/17	13.73	-23.77	-10.04	630.66
9/18	20.76	-21.05	- .29	630.37
9/19	17.47	-16.01	1.46	631.83
9/20	- 2.51	-19.18	-21.69	610.14
9/21	.02	-22.96	-22.94	587.20
9/22	16.68	-17.34	- .66	586.54
9/23	12.53	-16.37	- 3.84	582.70
9/24	1.06	-24.44	-23.38	559.32
9/25	4.69	-23.65	-18.96	540.36
9/26	5.84	-21.64	-15.80	524.56
9/27	15.53	-17.92	- 2.39	522.17
9/28	18.10	-21.08	- 2.98	519.19
9/29	18.61	-25.70	- 7.09	512.10
9/30	15.05	-21.82	- 6.77	505.33
10/1	6.13	-17.86	-11.73	493.60
10/2	2.06	-30.62	-28.56	465.04
10/3	10.61	-18.46	- 7.85	457.19
10/4	17.84	-18.23	- .39	456.80
10/5	15.31	-13.83	1.48	458.28
10/6	-10.54	-23.81	-34.35	423.93
10/7	-13.48	-21.65	-35.13	388.80
10/8	- 4.96	-16.46	-21.42	367.38
10/9	.57	-24.85	-24.28	343.10
10/10	3.71	-19.47	-15.76	327.34
10/11	8.58	-11.57	- 2.99	324.35
10/12	- 1.39	-15.62	-17.01	307.34
10/13	- 4.66	-15.44	-20.10	287.24
10/14	- 1.20	-19.59	-20.79	266.45
10/15	2.39	-21.34	-18.95	247.50

On the grazed site, the cumulative total was at its maximum on September 6 with a value of 866.61 cal/cm^2. The total calories lost on the ungrazed area from the maximum value on September 7 to the end of the recording period on October 15 was 387.15 per cm^2. Loss from the grazed site for the same period (September 6 - October 15) totaled 619.11 cal/cm^2. It is apparent that the late season loss of heat from the soil occurred much more rapidly on the grazed site than on the ungrazed site.

A closer analysis of the data shows that at nearly all times during the season the soil heat flux values for the daylight portion of each 24-hour period were greater on the ungrazed area than on the grazed area, while the night-time losses were greater on the grazed area than on the ungrazed. The interpretation of the significance of these differences will not be apparent until the energy budgets on the sites have been developed and can be evaluated on a comparative basis.

Wind Movement

Anemometers were activated on the ungrazed and grazed areas on June 4, and the first readings were taken on June 6 to cover the period from 8:00 a.m. on June 5 to 8:00 a.m. on June 6. Wind unit recordings were terminated on October 4. Small rotating-cup anemometers were supported at heights of 15, 30, 90, and 145 cm (mature canopy plus 1 m) above the ground surface on the ungrazed area, and at the same heights on the grazed area except that the uppermost unit was at a height of 130 cm (mature canopy height plus 1 m).

The anemometers used in this study are not truly micrometeorological instruments, although they are small in size. The diameter of the rotors is 12 1/8 inches, and the diameter of an individual cup is 2 7/8 inches.

The rotors require a breeze of about 2 mph to start turning and then have an appreciable coast period after the breeze has died down. Obviously breezes of less than 2 mph have not been adequately evaluated with these instruments. Revolutions of the rotors were counted electrically, with the ordinary industrial counters being read once each day. Each count represented 1/60 mile of wind. On those periods when several days elapsed between readings of the counters, the total miles of wind for the period was divided by the number of days in the period to give an average daily value for miles of wind.

The daily miles of wind measured at the various heights above the ground on the ungrazed area are given in Table 21, and the same data for the grazed area are given in Table 22. Total weekly miles of wind for the different heights above ground on the ungrazed and grazed areas are given in Tables 23 and 24. Interpretation of the differences in wind movement on the two areas is made easier by reference to these latter two tables.

It is apparent from the data of Tables 23 and 24 that wind movement at all measured heights was appreciably greater over the grazed area than over the ungrazed area. The average weekly miles of wind on the ungrazed area at a height of 15 cm was 65.6, representing an average velocity of 0.39 mph. On the grazed area the average weekly value for miles of wind at the 15 cm height was 228.8, an average velocity of approximately 1.36 mph. Wind velocity increased rapidly on both areas as height above ground increased. At 30 cm average velocity was 1.57 mph on the ungrazed area and 2.46 mph on the grazed area. At 90 cm the average velocities were 4.40 mph and 4.97 mph on the ungrazed and grazed areas, respectively. At 145 cm on the ungrazed

Table 21. Daily miles of wind at different heights above the ground surface on the ungrazed site - 1970 season.

Date	Instrument height - cm			
	15	30	90	145
6/6	13.4	38.2	89.7	105.5
6/7	13.4	38.2	89.7	105.5
6/8	13.4	38.2	89.7	105.5
6/9	3.8	23.9	65.9	75.7
6/10	23.5	74.8	143.5	163.3
6/11	21.6	63.5	123.5	150.6
6/12	68.8	144.6	238.0	278.9
6/13	28.1	86.9	178.2	201.1
6/14	8.9	45.3	112.5	126.9
6/15	8.9	45.3	112.5	126.9
6/16	7.1	35.9	98.2	116.1
6/17	48.0	136.2	244.2	284.9
6/18	19.9	64.9	141.8	172.3
6/19	1.9	22.1	76.1	89.0
6/20	13.3	58.8	136.5	164.5
6/21	2.7	22.0	79.8	96.5
6/22	2.7	22.0	79.8	96.5
6/23	12.5	49.0	125.0	154.6
6/24	9.8	50.8	134.6	167.9
6/25	11.6	76.0	161.2	186.0
6/26	9.8	41.7	110.3	132.1
6/27	18.3	67.9	152.7	181.4
6/28	18.3	67.9	152.7	181.4
6/29	18.3	67.9	152.7	181.4
6/30	10.9	83.0	203.4	238.2
7/1	29.4	91.5	190.2	230.3
7/2	28.1	84.3	181.3	217.8
7/3	8.8	40.0	111.5	137.5
7/4	8.8	40.0	111.5	137.5
7/5	8.9	40.0	111.5	137.5
7/6	8.9	40.0	111.5	137.5
7/7	3.3	33.6	112.5	136.6
7/8	2.6	19.1	79.0	95.8
7/9	1.5	22.4	93.5	114.3
7/10	1.9	28.5	111.0	133.3
7/11	2.3	21.7	101.5	122.2
7/12	2.3	21.8	101.5	122.2
7/13	1.5	4.9	53.4	64.1
7/14	12.0	7.2	136.0	166.3
7/15	15.4	53.2	146.2	183.3
7/16	1.2	20.6	69.9	88.7
7/17	0.5	8.0	51.1	66.1
7/18	3.7	20.7	104.9	130.1
7/19	3.7	20.7	104.9	130.2
7/20	3.7	20.7	104.9	130.2

Table 21. (continued)

Date	Instrument height - cm			
	15	30	90	145
7/21	15.2	60.0	155.3	186.3
7/22	5.2	44.2	121.4	151.1
7/23	2.1	18.5	85.6	105.1
7/24	7.1	59.2	146.1	175.7
7/25	0.9	10.3	77.2	92.7
7/26	7.0	28.9	91.7	114.2
7/27	0.2	2.4	37.8	46.7
7/28	6.3	37.8	119.5	138.5
7/29	2.3	15.9	74.8	87.1
7/30	0.9	8.1	67.6	75.8
7/31	1.2	6.5	66.5	75.9
8/1	1.7	11.1	64.4	72.8
8/2	1.7	11.1	64.4	72.8
8/3	1.7	11.1	64.4	72.8
8/4	4.3	32.1	87.2	94.0
8/5	0.0	4.4	49.1	50.1
8/6	1.5	20.9	94.8	96.1
8/7	9.0	26.5	107.7	113.1
8/8	8.7	22.2	83.3	85.9
8/9	8.8	22.2	83.3	85.9
8/10	0.3	5.4	43.5	40.9
8/11	3.6	22.0	92.3	100.0
8/12	0.6	7.6	39.3	37.7
8/13	0.1	0.5	38.0	38.2
8/14	4.0	21.8	80.0	91.2
8/15	6.2	36.6	98.2	112.0
8/16	6.2	36.6	98.2	112.0
8/17	6.2	36.6	98.2	112.0
8/18	3.5	29.0	80.5	91.4
8/19	5.2	30.3	90.0	106.8
8/20	4.0	21.6	73.3	85.4
8/21	6.3	38.0	107.8	122.1
8/22	8.6	27.6	85.1	101.3
8/23	8.6	27.6	85.2	101.3
8/24	8.6	27.6	85.2	101.3
8/25	2.7	16.4	62.6	70.3
8/26	5.5	41.5	123.4	137.4
8/27	9.9	40.3	109.9	125.2
8/28	1.1	5.6	71.7	77.9
8/29	12.0	51.5	128.5	147.2
8/30	12.0	51.5	128.5	147.2
8/31	12.0	51.5	128.5	147.2
9/1	14.6	44.2	101.9	119.5
9/2	2.1	23.0	77.1	87.8
9/3	5.2	23.6	76.6	89.5

Table 21. (continued)

Date	Instrument height - cm			
	15	30	90	145
9/4	3.8	16.1	72.0	82.3
9/5	9.7	34.3	93.5	155.7
9/6	9.7	34.3	93.5	155.7
9/7	9.7	34.3	93.5	155.7
9/8	9.7	34.3	93.5	155.7
9/9	11.8	44.1	138.9	152.1
9/10	17.8	51.3	135.2	169.3
9/11	7.9	33.6	105.8	126.3
9/12	7.9	33.6	105.8	126.3
9/13	7.9	33.6	105.8	126.3
9/14	7.9	33.6	105.8	126.3
9/15	1.8	17.1	79.8	91.6
9/16	10.9	37.6	98.5	124.6
9/17	14.4	32.5	107.8	132.6
9/18	11.9	37.7	106.0	132.4
9/19	10.4	33.4	98.5	113.4
9/20	10.4	33.3	98.5	113.4
9/21	20.1	74.2	149.0	175.5
9/22	34.3	106.1	205.5	243.1
9/23	17.3	51.2	122.0	148.3
9/24	13.1	67.7	113.5	157.3
9/25	3.1	30.7	92.9	113.7
9/26	9.1	36.3	97.6	116.7
9/27	9.1	36.3	97.6	116.7
9/28	9.1	36.3	97.6	116.7
9/29	4.0	23.1	79.7	98.4
9/30	0.2	4.3	20.4	22.5
10/1	14.8	54.9	117.6	139.4
10/2	37.9	77.0	156.1	187.2
10/3	10.7	63.4	137.2	170.4
10/4	18.1	52.6	126.5	153.1

Table 22. Daily miles of wind at different heights above the ground surface on the grazed site - 1970 season.

Date	Instrument height - cm			
	15	30	90	130 a/
6/6	20.6	33.2	98.0	107.7
6/7	20.7	33.3	98.2	107.8
6/8	20.7	33.2	98.2	107.8
6/9	16.6	21.9	67.1	74.0
6/10	59.3	84.6	151.8	165.7
6/11	59.1	85.9	151.4	162.1
6/12	109.3	163.9	253.7	294.3
6/13	48.7	78.5	158.1	179.0
6/14	30.1	48.1	102.9	117.5
6/15	30.1	48.1	102.7	117.3
6/16	12.5	45.6	98.8	112.2
6/17	12.5	167.4	259.3	290.1
6/18	61.9	100.1	178.4	185.7
6/19	12.8	33.5	82.7	92.7
6/20	53.2	89.5	162.3	177.3
6/21	19.8	35.4	87.5	97.3
6/22	19.8	35.5	87.7	97.5
6/23	40.2	66.9	138.0	152.7
6/24	46.6	78.2	157.9	168.1
6/25	52.1	88.2	161.0	181.7
6/26	34.2	67.7	127.4	149.6
6/27	51.1	87.6	162.2	181.0
6/28	51.0	87.7	162.2	181.0
6/29	51.2	87.5	162.2	181.0
6/30	62.1	105.5	187.3	219.1
7/1	71.8	123.3	214.6	241.9
7/2	65.7	109.9	197.4	223.7
7/3	33.3	64.2	130.0	135.3
7/4	33.3	64.2	130.0	135.3
7/5	33.2	64.2	130.0	135.0
7/6	33.4	64.2	130.0	135.6
7/7	26.1	54.5	118.2	136.3
7/8	23.5	43.4	92.6	107.2
7/9	23.7	39.8	101.3	110.3
7/10	29.2	50.8	109.7	124.2
7/11	23.4	45.9	105.7	118.6
7/12	23.4	45.9	105.8	118.6
7/13	13.1	29.3	65.8	76.6
7/14	41.2	78.9	146.6	168.1
7/15	54.5	96.9	180.7	197.2
7/16	14.8	32.7	82.6	91.8
7/17	13.8	32.2	66.7	73.9
7/18	23.3	50.4	110.0	124.9

Table 22. (continued)

Date	Instrument height - cm			
	15	30	90	130[a/]
7/19	23.3	50.3	110.0	124.9
7/20	23.3	50.4	110.0	124.9
7/21	52.9	88.6	166.1	180.9
7/22	41.0	69.5	140.0	149.6
7/23	21.0	45.5	99.6	110.5
7/24	56.5	97.2	167.4	185.8
7/25	14.6	34.2	83.8	93.4
7/26	27.0	50.4	110.0	123.3
7/27	2.5	11.6	47.2	52.6
7/28	35.3	58.4	117.8	135.5
7/29	15.4	31.0	74.3	89.5
7/30	14.2	34.4	81.3	91.4
7/31	9.9	27.3	75.9	87.0
8/1	14.1	33.0	77.6	54.8
8/2	14.1	33.0	77.6	54.8
8/3	14.1	33.0	77.6	54.8
8/4	21.9	37.1	87.5	101.7
8/5	2.0	11.8	52.7	59.1
8/6	16.8	37.3	90.3	105.2
8/7	30.1	53.0	111.9	125.4
8/8	25.3	45.3	98.8	106.5
8/9	25.3	45.3	98.8	106.5
8/10	8.9	20.9	55.5	63.5
8/11	21.6	43.9	101.5	110.9
8/12	6.0	15.8	47.6	51.2
8/13	1.8	9.5	44.1	49.8
8/14	20.7	40.5	91.1	104.3
8/15	33.2	57.2	117.2	128.3
8/16	33.2	57.2	117.2	128.3
8/17	33.2	57.2	117.2	128.3
8/18	21.7	46.5	95.4	109.1
8/19	30.8	56.2	116.2	124.8
8/20	26.7	43.9	97.1	102.8
8/21	35.1	57.7	116.7	129.7
8/22	28.4	48.5	104.6	113.3
8/23	28.4	48.6	104.6	113.3
8/24	28.4	48.5	104.6	113.2
8/25	13.8	27.6	78.8	86.2
8/26	35.0	57.5	118.3	137.0
8/27	37.0	67.1	131.7	146.1
8/28	12.5	23.7	71.0	80.2
8/29	46.2	72.7	139.7	153.4
8/30	46.2	72.7	139.7	153.4
8/31	46.2	72.7	139.7	153.4

Table 22. (continued)

Date	Instrument height - cm			
	15	30	90	130 a/
9/1	31.9	55.8	113.4	123.0
9/2	16.5	32.2	85.6	95.1
9/3	27.0	47.8	98.3	107.0
9/4	15.7	32.7	84.8	93.6
9/5	31.1	53.0	109.0	119.1
9/6	31.1	53.0	109.0	119.1
9/7	31.1	53.0	109.0	119.1
9/8	31.1	53.0	109.0	119.1
9/9	44.1	75.8	144.3	162.2
9/10	50.0	91.4	167.3	182.9
9/11	39.2	64.4	125.1	135.0
9/12	39.2	64.4	125.1	135.0
9/13	39.2	64.4	125.1	135.0
9/14	39.2	64.4	125.1	135.0
9/15	18.2	33.8	84.9	93.9
9/16	35.9	58.9	119.5	134.5
9/17	36.4	62.7	125.0	132.6
9/18	37.2	62.0	129.6	143.8
9/19	27.4	54.9	116.2	131.7
9/20	27.4	54.9	116.2	131.7
9/21	67.9	106.8	176.3	193.1
9/22	96.5	148.0	240.3	261.2
9/23	41.0	74.6	138.1	154.7
9/24	50.6	91.6	157.6	178.2
9/25	29.5	60.7	118.6	129.6
9/26	35.3	60.8	120.3	127.6
9/27	35.3	60.8	120.3	127.6
9/28	35.3	60.8	120.3	127.6
9/29	15.8	38.7	95.7	106.3
9/30	1.8	7.9	35.0	41.6
10/1	40.9	69.0	135.6	147.2
10/2	72.6	110.6	196.3	200.7
10/3	66.7	104.3	183.1	196.6
10/4	45.9	75.5	143.3	153.7

a/ 1 m plus average mature canopy height.

Table 23. Total weekly miles of wind at different heights above the ground surface on the ungrazed site - 1970 season.

Week	Instrument height - cm			
	15	30	90	145[a/]
6/7 -13	162.6	470.1	928.5	1080.6
6/14-20	108.0	408.5	921.8	1080.6
6/21-27	67.4	329.4	843.4	1015.0
6/28-7/4	122.6	474.6	1103.3	1324.1
7/5 -11	29.4	205.3	720.5	877.2
7/12-18	36.6	136.4	663.0	820.8
7/19-25	37.9	233.6	795.4	971.3
7/26-8/1	19.6	110.7	522.3	611.0
8/2 -8	26.9	128.3	550.9	584.8
8/9 -15	23.6	116.1	474.6	505.9
8/16-22	40.0	219.7	633.1	731.0
8/23-29	48.4	210.5	666.5	760.6
8/30-9/5	59.4	244.2	678.1	829.2
9/6 -12	74.5	265.5	766.2	1041.1
9/13-19	65.2	225.5	702.2	847.2
9/20-26	107.4	399.5	879.0	1068.0
9/27-10/3	85.8	295.3	706.2	851.3
Average	65.6	263.1	738.5	882.3

[a/] 1 m plus mature canopy height.

Table 24. Total weekly miles of wind at different heights above the ground surface on the grazed site - 1970 season.

Week	Instrument height - cm			
	15	30	90	130 [a/]
6/7 -13	334.4	501.3	978.5	1090.7
6/14-20	213.1	532.3	987.7	1092.8
6/21-27	263.8	459.5	921.7	1027.9
6/28-7/4	368.4	642.3	1183.7	1317.3
7/5 -11	192.5	362.8	787.5	867.6
7/12-18	184.1	366.3	758.2	851.1
7/19-25	232.6	435.7	876.9	970.0
7/26-8/1	118.4	246.1	584.1	634.1
8/2 -8	124.3	250.5	596.4	607.5
8/9-15	117.5	233.1	555.8	614.5
8/16-22	209.1	367.2	764.4	836.3
8/23-29	201.3	345.7	748.7	829.4
8/30-9/5	214.6	366.9	770.5	844.6
9/6 -12	265.8	455.0	888.8	972.4
9/13-19	233.5	401.1	825.4	906.5
9/20-26	348.2	597.4	1067.4	1176.1
9/27-10/3	268.4	452.1	886.3	947.6
Average	228.8	412.7	834.2	916.8

[a/] 1 m plus mature canopy height.

area the average velocity was 5.25 mph, while an average velocity of 5.46 mph was found for the 130 cm height above the grazed vegetation. While these latter two heights are considered to represent mature canopy height plus 1 m on each of the two treatments, it would seem that the taller canopy on the ungrazed site was still influencing wind movement to some extent at the 145 cm height.

The detailed analysis of the wind data has not yet been accomplished. The seasonal changes have not yet been evaluated, although it would appear that wind movement remained relatively high in the early part of the season, decreased during midseason, and then increased again toward the end of the season. The influence of the developing vegetation on wind movement has not yet been evaluated, but without doubt, the growth patterns of the vegetation on the two treatments significantly influenced wind movement, particularly close to the ground.

Relative Humidity

Relative humidity was recorded hourly at heights of 15 cm and 145 cm above the ground surface on the ungrazed area and at 15 cm and 130 cm on the grazed area. The humidity sensor elements used were Hygrodynamics, Inc. wide-range humidity sensing elements. These units operate on the Dunmore principle (resistance of lithium chloride as affected by moisture content of the air), and the values obtained at the hourly readings were recorded on a Brown Electronik strip-chart recorder. Relative humidity recording was started on June 3. However, a lightning strike on July 12 at one of the instrument sites burned out the chart drive motor on the recording unit. The unit was

out of action from that date until August 18, at which time the rebuilt motor was returned from the Minneapolis repair shop where it had been sent. Thus, there was a period of over a month during which relative humidity data was not obtained from either treatment.

The relative humidity data obtained are in the process of being reduced and summarized, and cannot be included in this report. A later supplemental report will be provided to cover the relative humidity data. Vapor pressure deficit values are being calculated from the data obtained and will be included with the report on relative humidity.

A preliminary check of the data obtained from the relative humidity recordings indicates that at the 15 cm height relative humidity values on the grazed area were higher than on the ungrazed area in June, about the same on both areas in July, and then in August, the average values were slightly higher on the ungrazed than on the grazed area. At canopy plus 1 m heights (130 cm - grazed and 145 cm - ungrazed) the average relative humidity values were slightly higher over the grazed treatment than over the ungrazed treatment throughout the season. When some of the data were converted to vapor pressure deficit values, the average vapor pressure deficits at the 15 cm height were found to be higher at all times on the grazed area than on the ungrazed. The differences in relative humidity and vapor pressure deficit values between the treatments were relatively small.

HERBAGE DYNAMICS

Plant Identification

In general, the flora of the area was so well known that very little specific identification work was needed. In a few cases very small forb individuals had to be recorded as unknown forbs, but usually subsequent growth of similar individuals made it possible to identify those species which had originally been recorded as unknown. All species found in the clipped plots on the Dickinson site, together with their four-letter designations, are given in Table 25. Many other species do occur on the site as a whole, but those listed are the only ones found in the clipped plots during the course of the season.

The nomenclature used followed O. A. Stevens (1963), *Handbook of North Dakota Plants*, which is the principal local flora for the area. In the few instances where any checking beyond this handbook was necessary, reference was made to the herbarium sheets at North Dakota State University.

Phenology

In describing the phenological status of the species at the time of clipping, the designations given on the field data sheets were used and recorded on those sheets. Since this material has been submitted to the Natural Resource Ecology Laboratory, it will not be considered in detail here. However, some data were taken which were not incorporated into the previously submitted material. In each plot at the time it was clipped, a measurement was made of average leaf and average stalk height of all grasses and sedges and average stalk

Table 25. Species list for clipped quadrats of the Dickinson Site - 1970 season.

Agsm - *Agropyron smithii*

Agtr - *Agropyron trachycaulum*

Alny - *Allionia nyctaginea*

Alte - *Allium textile*

Arca - *Artemisia caudata*

Arfr - *Artemisia frigida*

Arhi - *Arabis hirsuta*

Arho - *Arabis holboellii*

Arlu - *Artemisia ludoviciana*

Aser - *Aster ericoides*

Asst - *Astragalus striatus*

Bogr - *Bouteloua gracilis*

Bran - *Brauneria angustifolia*

Brar - *Brassica arvensis*

Cael - *Carex eleocharis*

Cafi - *Carex filifolia*

Calo - *Calamovilfa longifolia*

Camo - *Calamagrostis montanensis*

Cape - *Carex pennsylvanica*

Chal - *Chenopodium album*

Chle - *Chenopodium leptophyllum*

Chvi - *Chrysopsis villosa*

Ciun - *Cirsium undulatum*

Coli - *Collomia linearis*

Eaan - Early annual forbs

Eaan(4) - Early annual forbs

Eafo(4) - Early annual forbs

Eafo(6) - Early perennial forbs

Ecan - *Echinacea angustifolia*

Eras - *Erisymum asperum*

Erca - *Erigeron canadensis*

Eugl - *Euphorbia glytosperma*

Feoc - *Festuca octoflora* (listed once as Feid)

Gaco - *Gaura coccinea*

Hehi(1) - *Hedeoma hispida*

Hehi(2) - *Heuchera hispida*

Heri - *Helianthus rigidus*

Kocr - *Koeleria cristata*

Lafo(4) - Late forbs, annual

Lafo(6) - Late forbs, perennial

Laoc - *Lappula occidentalis*

Lapu - *Lactuca pulchella*

Lase - *Lactuca serriola*

Lipu - *Liatris punctata*

Loam - *Lotus americana*

Lofo - *Lomatium foeniculaceum*

Table 25 (continued)

Lydr - *Lychnis drummondii*

Lyju - *Lygodesmia juncea*

Mavi - *Mamillaria vivipara*

Mela - *Mertensia lanceolata*

Oeal - *Oenothera albicaulis*

Opfr - *Opuntia fragilis*

Orfa - *Orobanche fasiculata*

Orlu - *Orthocarpus luteus*

Oxla - *Ocytropis lambertii*

Peal - *Penstemon albidus*

Pegr - *Penstemon gracilis*

Pepu - *Petalostemum purpureum*

Phhe - *Physalis heterophylla*

Phho - *Phlox hoodii*

Phle - *Phacelia leucophylla*

Plpu - *Plantago purshii*

Poco - *Polygonum convolvulus*

Pose - *Poa secunda*

Psar - *Psoralea argophylla*

Raco - *Ratibida columnifera*

Roar - *Rosa arkansana*

Saka - *Salsola kali*

Sede - *Selaginella densa*

Somi - *Solidago missouriensis*

Somo - *Solidago mollis*

Sone - *Solidago nemoralis*

Sori - *Solidago rigida*

Spco - *Sphaeralcea coccinea*

Spcr - *Sporobolus cryptandrus*

Stde - Standing dead

Stde( ) - Standing dead - current season

Stco - *Stipa comata*

Stvi - *Stipa viridula*

Taof - *Taraxacum officinale*

Thrh - *Thermopsis rhombifolia*

Trdu - *Tragopogon dubius*

UK - Unknown forb

Vinu - *Viola nuttallii*

Visp - *Vicia sparsifolia*

heights of all forbs. These data are in the field data books for the Dickinson Site.

The data in Table 26 represent a summary of the average leaf heights at approximately monthly intervals of the principal grasses and sedges on the site under the grazed and ungrazed treatments. The individual values were derived by taking the average of all the measurements of each species on each quadrat just before clipping. In addition to the average leaf heights, a figure representing approximate canopy height is also given for each of the monthly intervals. This figure is somewhat subjective, since it represents an occular estimate of the combined effects of leaf heights and flowering-stalk heights on each plot in relation to the overall aspect of canopy height.

The data of Table 26 show an increase in leaf height under both treatments of most of the major species up to about July 22, after which little or no additional height growth occurred in the leaves of most grass or sedge species. *Calamovilfa longifolia*, which occurred in appreciable amounts only on the ungrazed site, continued to show leaf growth beyond the middle of August. It is apparent from the data that the average leaf heights of the species on the grazed treatment were appreciably less than the leaf heights of the same species on the ungrazed treatment. As a general observation, it could be said that the leaf heights of the same species averaged 20 to 40% greater on the ungrazed treatment than on the grazed treatment. When the overall canopy height is considered, the average canopy height on the ungrazed area was from 25 to 35% greater than on the grazed area.

Table 26. Average leaf heights of major species and average canopy heights of grazed and ungrazed vegetation at approximate monthly intervals during the 1970 growing season.

Species	Leaf heights - cm at different dates							
	Grazed				Ungrazed			
	5/24	6/22	7/22	8/18	5/24	6/22	7/22	8/18
Stipa comata	6	12	14	21	11	25	33	35
Agropyron smithii	9	25	25	27	16	32	34	35
Bouteloua gracilis	2	7	9	9	4	13	16	16
Carex eleocharis	6	9	9	10	8	15	17	16
Calamagrostis mont.	10	13	18	17	--	--	--	--
Calamovilfa long.	--	--	--	--	--	30	42	47
AVERAGE	7	13	15	17	10	23	28	30
Approx. canopy ht. [a/]	9	25	32	35	12	32	47	53

[a/] Combined leaf and stalk heights of all standing vegetation - estimated.

It should be mentioned that, in the initial placement of the micrometerological instruments relative to mature canopy height, an estimated mature canopy height of 30 cm was selected for the grazed vegetation and a mature height of 45 cm for the ungrazed vegetation. The later estimates of canopy height, as shown in Table 26, placed the mature canopy on the grazed area at 35 cm and on the ungrazed area at 53 cm. Thus, the apparent mature canopy heights on both treatments were only slightly greater than the original estimates.

Aboveground Biomass

Summarized aboveground biomass data for the ungrazed treatment are given in Table 27 and for the grazed treatment in Table 28. The individual quadrat data from which the data in the tables have been derived were supplied to the Natural Resource Ecology Laboratory on the original field sheets and have not been included in this report. The data reported are simple means of dry weight for the individual species and species groups as indicated in the tables. The clipped quadrat size was 0.25 m^2, and in the summary tables the weight values have been converted to g/m^2. Clipped samples were collected in paper bags in the field, were oven-dried at 60-65°C for approximately 72 hours, and were then weighed to the nearest 0.01 g.

Plant material in the plots was clipped at ground level, and the species and species groups were separated in the field at the time of clipping. In each plot, all individual species that were judged to make up at least 5% of the yield were clipped and bagged separately. Frequently, in the case of the annual and perennial forbs, no one species would average 5% or more of the yield. Under these conditions,

Table 27. Herbage dynamics on the ungrazed treatment (1) at the Dickinson Site - 1970 season.

Species	gm/m^2 at clipping times								
	May 25	June 10	June 24	July 8	July 22	Aug. 4	Aug. 18	Sept. 17	Oct. 17
Stipa comata	26.2	33.8	49.6	77.4	100.8	118.3	105.1	105.5	103.7
Agropyron smithii	4.0	7.4	26.5	23.9	29.0	27.2	33.8	34.6	12.9
Calamovilfa longifolia	---	3.3	7.8	8.8	9.9	---	16.6	30.0	20.0
Bouteloua gracilis	1.2	4.8	10.4	19.4	25.9	20.4	28.9	29.8	25.0
Carex eleocharis	1.7	7.5	7.5	11.3	8.4	12.2	10.3	9.1	16.4
Miscellaneous grasses	---	---	5.8	3.1	0.3	0.4	3.3	4.4	5.2
Artemisia ludoviciana	2.6	11.9	18.7	19.9	37.7	36.3	42.6	83.0	52.9
Other perennial forbs	1.0	3.3	14.9	22.3	5.5	21.4	6.3	21.2	2.0
Biennial forbs	0.5	1.1	12.8	8.0	5.2	8.2	4.3	1.0	3.5
Annual forbs	---	0.1	0.9	4.8	0.2	0.5	0.7	1.3	0.9
TOTAL standing crop	37.2	73.2	154.9	198.9	222.9	244.9	251.9	319.9	242.5
Standing dead (previous year's)	331.3	383.2	345.5	276.1	333.8	331.0	271.8	352.5	286.0
Litter	796.7	604.2	538.3	523.4	626.8	624.9	661.5	607.0	648.8
TOTAL biomass	1165.2	1060.6	1038.7	998.4	1183.5	1200.8	1185.2	1279.4	1177.3
Selaginella densa	3.0	---	1.1	1.4	---	0.8	0.2	0.2	---
TOTAL with *Selaginella*	1168.2	1060.6	1039.8	999.8	1183.5	1201.6	1185.4	1279.6	1177.3

Table 28. Herbage dynamics on the grazed treatment (4) at the Dickinson Site - 1970 season.

Species	gm/m^2 at clipping times								
	May 25	June 10	June 24	July 8	July 22	Aug. 4	Aug. 18	Sept. 17	Oct. 17
Stipa comata	8.3	24.0	30.1	35.0	42.1	56.1	45.0	47.9	46.9
Agropyron smithii	---	5.5	6.2	10.6	11.7	7.9	19.8	16.3	11.1
Calamagrostis montanensis	21.5	19.1	23.4	26.6	27.1	19.9	15.3	20.6	22.3
Koeleria cristata	5.5	12.3	6.4	18.0	13.3	18.5	16.8	10.3	15.9
Bouteloua gracilis	4.2	18.3	42.0	37.8	50.6	46.1	59.9	56.0	59.9
Carex eleocharis	4.6	6.8	16.9	13.7	13.8	11.0	11.5	8.1	7.5
Miscellaneous grasses	---	1.5	0.9	0.1	1.1	0.2	0.4	---	---
Artemisia ludoviciana	---	---	---	3.0	1.6	3.4	4.2	5.2	---
Other perennial forbs	4.3	11.1	16.9	21.6	24.0	21.8	18.3	33.2	20.8
Biennial forbs	---	---	---	---	---	0.1	0.2	---	0.2
Annual forbs	---	1.4	5.9	5.0	4.1	3.4	5.0	12.3	2.1
TOTAL standing crop	48.4	100.0	148.7	171.4	189.4	188.4	196.4	209.9	186.7
Standing dead (previous year's)	17.4	18.7	26.3	29.3	58.2	49.8	35.6	24.9	17.8
Litter	94.8	87.2	91.1	100.2	169.4	202.4	209.3	198.7	205.7
TOTAL biomass	160.6	205.9	266.1	300.9	417.0	440.6	441.3	433.5	410.2
Selaginella densa	43.6	30.6	54.3	42.4	35.6	45.1	25.9	47.6	70.8
TOTAL with *Selaginella*	204.2	236.5	320.4	343.3	452.6	485.7	467.2	481.1	481.0

the forbs were lumped according to the groups - early annual forbs, late annual forbs, early perennial forbs, late perennial forbs, and occasionally, biennial forbs, the principal biennial forb being *Tragopogon dubius*. *Selaginella densa* was clipped separately on all plots where it occurred. It was abundant only on the grazed area, but it did occur to a very limited extent in the ungrazed vegetation.

The clippings made on September 17 and October 17 (approximate dates) were not separated in the field, but were clipped and estimated in the laboratory as to percent composition by species and groups. This estimation procedure had to be resorted to because only limited help was available for the clipping work at this time of the season. After the data for these two clippings were summarized, it was realized that plant material that would have appeared as standing dead or litter under the clipping treatment had been included in the category of current production. Accordingly, the clippings were re-examined and the initial estimates adjusted. The data for the initial and adjusted estimates for the eighth and ninth clippings on the ungrazed area are given in Tables 29 and 30 and the same information for the clippings on the grazed area is given in Tables 31 and 32. The data in Tables 27 and 28 include only the adjusted estimates for the 8th and 9th clippings.

The data of Table 27 show the greatest standing crop yield on the ungrazed area to have been estimated from the clippings on September 17, 319.9 g/m^2, while the initial clipping on May 25 showed a standing crop yield (current season's production) of only 37.2 g/m^2. The fact that the standing crop yield reached its peak so late in the season, actually after most grasses had ceased to grow, was due to

the late growth of *Calamovilfa longifolia* and the perennial forb, *Artemisia ludoviciana*. These two species made a substantial portion of their growth after the middle of August.

The peak standing crop of *Stipa comata* was reached on August 4. *Agropyron smithii* showed essentially equal peak standing crop yields on August 18 and September 17. The same was true for *Bouteloua gracilis*, with essentially the same yields on August 18 and September 17. *Carex eleocharis* showed a peak yield on August 4. Miscellaneous perennial forbs showed a peak on July 8, although subsequent yields on August 4 and September 2 were nearly equal to the July 8 peak. Biennial forbs showed a peak yield on June 24, while annual forbs showed a peak on July 8.

Based on the condition of the vegetation as observed in the field in relation to the information obtained from the clippings, the following dates would seem to represent the actual peak production dates for the different species: *Stipa comata* - August 4; *Agropyron smithii* - August 18; *Calamovilfa longifolia* - September 17; *Bouteloua gracilis* - August 18; *Carex eleocharis* - July 8; *Artemisia ludoviciana* - September 17; other perennial forbs - July 8; biennial forbs - June 24; and annual forbs - July 8. The principal grass species which were included as miscellaneous grasses were *Koeleria cristata* and *Agropyron trachycaulum*. June 28 seems to be the logical date to consider these species as being at peak production. The values for total standing crop show a fairly regular progression from the early low value in the spring to the maximum value in September. This probably reflects the fact that total standing crop was the only value adequately sampled by the clipping procedure.

Standing dead material (previous year's) showed a fluctuation around a mean of 323.5 g/m^2 throughout the season. There seems to be no discernible trend in these fluctuations, and the somewhat different values at each date of clipping apparently reflect the sampling error. This conclusion would be substantiated by the field observations. The standing dead material actually went down very little until near the end of the season.

Litter decreased rapidly in amount to July 8, when it reached a seasonal low and then increased to a nearly level value for the remainder of the season. Field observation would substantiate the apparent behavior of the litter fraction, with the principal seasonal contribution being made after the middle of July which was probably related to the breakup of the seedheads and upper portions of the fruiting stalks of *Stipa comata*.

Total aboveground biomass decreased from 1165.2 g/m^2 to a low value of 998.4 g/m^2 on July 8, as losses in litter occurred which were only partially offset by increases in the current season's standing crop. After mid-July, total aboveground biomass apparently stabilized at a value very near to that found at the beginning of the clipping period. *Selaginella densa* was relatively unimportant in the cover on the ungrazed site and contributed very little to the total aboveground biomass.

The greatest standing crop yield on the grazed area was recorded on September 17 (Table 28), as was the case on the ungrazed area. The initial yield on the grazed area from the May 25 clipping was 48.4 g/m^2, slightly more than was present on the ungrazed area. The standing crop on the grazed area on June 10, 100 g/m^2, was also greater than

on the ungrazed area at that clipping date. It was not until the clipping of June 24 that the standing crop on the ungrazed area exceeded that produced on the grazed area.

Peak standing crop on the grazed area for *Stipa comata* was recorded on August 4, the same date as peak standing crop for that species on the ungrazed area. The actual dry weight of this species present on the grazed area on that date was 56.1 g/m^2, about 50% of the weight for this species on the ungrazed area. *Agropyron smithii* reached its peak standing crop on August 18 on the grazed area. *Calamagrostis montanensis*, however, reached its peak on July 22. Actually, there was very little difference between the yields for this species on July 8 and July 22. The peak yield for *Koeleria cristata* was recorded on August 4, but there was no real difference between this yield and the yield on July 8. *Bouteloua gracilis* shows a peak standing crop on August 18. *Carex eleocharis* reached its peak yield on the grazed site on June 24.

There was not as much *Artemisia ludoviciana* on the grazed area as on the ungrazed area. In fact, it was definitely a minor species on the grazed area. Peak yield for this species occurred on September 17. The category of "other perennial forbs", principally composed of late forbs, also showed a peak standing crop on September 17. Biennial forbs were scarce on the grazed area. The annual forbs showed a peak yield on September 17, but actually there was no growth of annuals after mid-summer.

From the relation of field observations to the clipped plot yields, the following dates seem indicated for peak standing crop of the different species and groups on the grazed area: *Stipa comata* - August 4;

Agropyron smithii - August 18; *Calamagrostis montanensis* - July 8; *Koeleria cristata* - July 8; *Bouteloua gracilis* - August 18; *Carex eleocharis* - June 24; *Artemisia ludoviciana* - September 17; perennial forbs - September 17; annual forbs - June 24.

Total standing crop (exclusive of *Selaginella*) on the grazed area shows a progressive increase to the July 22 clipping date. For the period July 22 to August 4, there would appear to have been little or no production. Apparently, there then followed a modest increase in production, with the peak yield showing in the September 17 clipping. The field observations show nothing to contradict this general picture.

Data for the previous year's standing dead show considerable variation with a peak value of 58.2 g/m^2 recorded on July 22. This value is over three times the value recorded at the beginning and at the end of the season. The mean for the season was 30.9 g/m^2. The field observations indicate that very little of the previous season's standing dead went down during the course of the 1970 summer period. It consisted mostly of about a two-inch stubble of the more resistant material such as *Calamagrostis*, *Agropyron*, and *Stipa*, with a few tough perennial forb stalks. The amount of standing dead material from the previous season did vary appreciably over the area. As part of the dynamic picture, however, it seems unlikely that there was much change in standing dead from the previous season on the grazed area as a whole.

The amount of litter on the grazed area showed a nearly stable level from May 25 through June 24, after which it increased to a maximum value of 209.3 g/m^2 on August 18, which was more than twice the amount present at the beginning of the season. The field observations do not contradict the litter picture, although the drying and breaking

up of *Selaginella* as the season advanced, without a doubt, contributed to the increased amount of material appearing in the litter fraction. Only a relatively small amount of the increase in litter came from the current season's production.

Total aboveground biomass (exclusive of *Selaginella*) increased up to August 4, after which it remained fairly constant, or possibly showed a slight declining trend. The field observations are in general agreement with the data obtained from the clipped plots for total aboveground biomass (exclusive of *Selaginella*). While there were some transfers from the standing crop to current standing dead to litter after the middle of the season, the actual amount of transfer to litter seemed relatively small. Once produced, much of the standing crop remained standing for most of the rest of the observed season on both the grazed and ungrazed areas.

Selaginella was of considerable importance on the grazed area. The maximum standing crop of this species was recorded on October 17 at 70.8 g/m^2. The mean standing crop for the season was 44.0 g/m^2, and the quadrat yields seemed to vary fairly closely around this mean, except for the October 17 yield. In general, the species seemed to have growth spurts when moisture and temperature conditions were favorable, and the material produced passed through all three categories from standing live to standing dead to litter. Total peak biomass for the grazed area, with *Selaginella* included, was recorded at 485.7 g/m^2 on August 4.

Direct comparison of the recorded peak values for the components of the aboveground biomass on the ungrazed and grazed areas serve to emphasize the differences between the vegetation on the two areas.

Peak standing crop on the ungrazed area was 319.9 g/m^2, while it was 209.9 g/m^2 on the grazed area. Peak recorded value for previous year's standing dead was 383.2 g/m^2 on the ungrazed treatment and 58.2 g/m^2 on the grazed treatment. The maximum value for litter recorded on the ungrazed area was 796.7 g/m^2, and on the grazed area 209.3 g. Total peak biomass on the ungrazed treatment was 1279.4 g/m^2 and for the grazed area 485.7 g/m^2.

Current season's standing dead material was not separated from the current season's total standing crop. However, estimates of the amount of current season's standing dead by species were made beginning about mid-July. Values of current season's standing dead, based on these estimates, have been supplied to the Natural Resource Ecology Laboratory. Data on current season's standing dead have not been treated in this report, pending a closer examination of the data. However, the approximate overall standing dead estimates average about 30% on July 22, 35% on August 4, 35% on August 18, 40% on September 17, and about 90% on October 17.

The adjustments made in composition estimates for the eighth and ninth clippings on the ungrazed area given in Tables 29 and 30 show that the principal adjustment made in the eighth clipping was to transfer part of the *Stipa* and *Agropyron* biomass to the litter fraction, while the principal adjustment in the ninth clipping was the transfer of part of the *Stipa* and *Bouteloua* biomass to the standing dead and litter components. On the grazed area (Tables 31 and 32) portions of the *Calamagrostis* and *Bouteloua* biomass estimates were transferred to the litter component for the eighth clipping, and on the ninth clipping, part of the *Stipa* biomass was assigned to the litter category.

Table 29. Initial estimates and adjusted estimates for herbage yields on the ungrazed treatment - eighth clipping, September 17, 1970.

Species	Initial estimate - g/m^2			Adjusted estimate - g/m^2		
	Rep 1	Rep 2	Avg.	Rep 1	Rep 2	Avg.
Stipa comata	135.8	115.5	125.6	115.7*	95.6*	105.5*
Agropyron smithii	39.9	79.3	59.6	14.9*	54.3*	34.6*
Calamovilfa longifolia	---	59.9	30.0	---	59.9	30.0
Bouteloua gracilis	19.1	40.4	29.8	19.1	40.4	29.8
Carex eleocharis	7.0	11.2	9.1	7.0	11.2	9.1
Miscellaneous grasses	---	8.7	4.4	---	8.7	4.4
Artemisia ludoviciana	44.3	121.8	83.0	44.3	121.8	83.0
Other perennial forbs	7.2	35.2	21.2	7.2	35.2	21.2
Biennial forbs	0.8	1.1	1.0	0.8	1.1	1.0
Annual forbs	0.8	1.8	1.3	0.8	1.8	1.3
TOTAL standing crop	254.9	474.9	364.9	209.8	430.0	319.9
Standing dead (previous year's)	400.4	304.6	352.5	400.4	304.6	352.5
Litter	573.9	550.1	562.0	618.9*	595.1*	607.0*
TOTAL biomass	1229.2	1329.6	1279.4	1229.1	1329.7	1279.4
Selaginella densa	0.4	---	0.2	0.4	---	0.2
TOTAL with *Selaginella*	1229.6	1329.6	1279.6	1229.5	1329.7	1279.6

* Values derived from adjusted estimates.

Table 30. Initial estimates and adjusted estimates for herbage yields on the ungrazed treatment - ninth clipping, October 17, 1970.

Species	Initial estimate - g/m^2			Adjusted estimate - g/m^2		
	Rep 1	Rep 2	Avg.	Rep 1	Rep 2	Avg.
Stipa comata	195.6	161.9	178.7	120.6*	86.9*	103.7*
Agropyron smithii	21.0	4.8	12.9	21.0	4.8	12.9
Calamovilfa longifolia	21.0	18.9	20.0	21.0	18.9	20.0
Bouteloua gracilis	55.3	34.8	45.0	35.3*	14.8*	25.0*
Carex eleocharis	9.9	22.8	16.4	9.9	22.8	16.4
Miscellaneous grasses	---	10.4	5.2	---	10.4	5.2
Artemisia ludoviciana	60.5	45.3	52.9	60.5	45.3	52.9
Other perennial forbs	0.8	3.2	2.0	0.8	3.2	2.0
Biennial forbs	4.2	2.7	3.5	4.2	2.7	3.5
Annual forbs	1.0	0.8	0.9	1.0	0.8	0.9
TOTAL standing crop	369.3	305.6	337.5	274.3*	210.6*	242.5*
Standing dead (previous year's)	223.6	198.4	211.0	298.6*	273.4*	286.0*
Litter	571.8	685.8	628.8	591.8*	705.8*	648.8*
TOTAL biomass	1164.7	1189.8	1177.3	1164.7	1189.8	1177.3
Selaginella densa	---	---	---	---	---	---
TOTAL with *Selaginella*	1164.7	1189.8	1177.3	1164.7	1189.8	1177.3

* Values changed as the result of adjusted estimates.

Table 31. Initial estimates and adjusted estimates for herbage yields on the grazed treatment - eighth clipping, September 17, 1970.

Species	Initial estimate - g/m^2			Adjusted estimate - g/m^2		
	Rep 1	Rep 2	Avg.	Rep 1	Rep 2	Avg.
Stipa comata	26.5	69.3	47.9	26.5	69.3	47.9
Agropyron smithii	4.2	28.4	16.3	4.2	28.4	16.3
Calamagrostis montanensis	37.0	24.2	30.6	27.0*	14.2*	20.6*
Koeleria cristata	16.1	4.4	10.3	16.1	4.4	10.3
Bouteloua gracilis	134.2	77.9	106.0	84.2*	27.9*	56.0*
Carex eleocharis	8.0	8.2	8.1	8.0	8.2	8.1
Miscellaneous grasses	---	---	---	---	---	---
Artemisia ludoviciana	10.4	---	5.2	10.4	---	5.2
Other perennial forbs	43.3	23.1	33.2	43.3	23.1	33.2
Biennial forbs	---	---	---	---	---	---
Annual forbs	23.0	1.5	12.3	23.0	1.5	12.3
TOTAL standing crop	302.7	237.0	269.9	242.7*	177.0*	209.9*
Standing dead (previous year's)	38.3	11.6	24.9	38.3	11.6	24.9
Litter	125.0	152.4	138.7	185.0*	212.4*	198.7*
TOTAL biomass	466.0	401.0	433.5	466.0	401.0	433.5
Selaginella densa	67.0	28.1	47.6	67.0	28.1	47.6
TOTAL with *Selaginella*	533.0	429.1	481.1	533.0	429.1	481.1

* Values changed as the result of adjusted estimates.

Table 32. Initial estimates and adjusted estimates for herbage yields on the grazed treatment - ninth clipping, October 17, 1970.

Species	Initial estimate - g/m^2			Adjusted estimate - g/m^2		
	Rep 1	Rep 2	Avg.	Rep 1	Rep 2	Avg.
Stipa comata	43.7	80.1	61.9	28.7*	65.1*	46.9*
Agropyron smithii	----	22.1	11.1	----	22.1	11.1
Calamagrostis montanensis	33.5	11.1	22.3	33.5	11.1	22.3
Koeleria cristata	29.1	2.6	15.9	29.1	2.6	15.9
Bouteloua gracilis	39.9	80.0	59.9	39.9	80.0	59.9
Carex eleocharis	6.1	9.0	7.5	6.1	9.0	7.5
Miscellaneous grasses	----	----	----	----	----	----
Artemisia ludoviciana	----	----	----	----	----	----
Other perennial forbs	15.7	25.9	20.8	15.7	25.9	20.8
Biennial forbs	----	0.4	0.2	----	0.4	0.2
Annual forbs	2.0	2.1	2.1	2.0	2.1	2.1
TOTAL standing crop	170.0	233.3	201.7	155.0*	218.3*	186.7*
Standing dead (previous year's)	12.4	23.2	17.8	12.4	23.2	17.8
Litter	177.7	203.8	190.8	192.7*	218.8*	205.7*
TOTAL biomass	360.1	460.3	410.2	360.1	460.3	410.2
Selaginella densa	70.8	48.6	59.8	70.8	48.6	70.8
TOTAL with *Selaginella*	430.9	508.9	470.0	430.9	508.9	470.0

* Values changed as the result of adjusted estimates.

Belowground Biomass

As previously mentioned, belowground biomass, essentially the root material, was sampled from each clipped plot at each date of clipping, with five cores taken to a depth of 100 cm by 10 cm increments and with the first 10 cm increment divided into 0-5 and 5-10 cm sections. The diameter of the sampling tube was actually 2.25 cm, with the total area of the five cores thus equal to 19.88 cm^2. In the actual sampling procedure, about half or less of the total core length was taken at one time, depending on soil conditions. The soil column was then pushed from the tube onto a 45° angled cutting board and sectioned at the proper intervals with a sharp paring knife. The remainder of the column was then taken and sectioned in a similar manner.

The five samples for each depth increment from each clipped plot were composited into a single sample in a paper bag, and from then on, the composite samples were treated as one sample. The procedure used thus yielded six samples per replication for each of the 11 depth increments. With the two replications per treatment, a total 12 samples for each of the 11 depth increments was obtained from each treatment at each time of clipping. Where exceptions to this procedure occurred, they have been noted on the data tables.

Belowground biomass data for the ungrazed area expressed on a g/m^2 basis are given in Table 33, and the same data for the grazed area are given in Table 34. The individual sample data for each date of sampling have been provided to the Natural Resource Ecology Laboratory and are not repeated in this report.

Probably the most interesting point about the underground biomass is that the values were higher at every sampling date on the grazed

Table 33. Belowground biomass (g/m^2) on the ungrazed treatment (1) at the Dickinson Site - 1970 season.

Depth (cm)	Date of sampling						
	May 26	June 15	June 25	July 9	July 30	Aug. 10	Aug. 19
0-5	855.1	812.4	1084.0	769.6	714.3	747.0	731.9
5-10	155.9	176.1	206.2	163.5	211.3	196.2	206.2
10-20	135.8	135.8	233.9	198.7	120.7	125.8	168.5
20-30	85.5	83.0	140.8	135.8	105.6	96.1	118.2
30-40	45.3	75.4	100.6	100.6	80.5	80.5	98.1
40-50	35.2	35.2	80.5	72.9	60.4	45.3	78.0
50-60	30.2	37.7	95.6	65.4	40.2	65.4	78.0
60-70	25.2	37.7	62.9	60.4	35.2	75.5	60.4
70-80	25.2	35.2	52.8	50.3	40.2	25.2	47.8
80-90	30.2	27.7	62.9	37.7	35.2	40.2	47.8
90-100	30.2	32.7	47.8	32.7	30.2	35.2	57.9
TOTALS	1453.8	1488.9	2168.0	1687.6	1473.8	1532.4	1692.8

Table 34. Belowground biomass (g/m^2) on the grazed treatment (4) at the Dickinson Site - 1970 season.

Depth (cm)	Dates of sampling						
	May 26	June 15	June 25	July 9	July 30	Aug. 10	Aug. 19
0-5	1584.5	1177.0	1629.8	1423.5	1222.3	1109.1	1169.5
5-10	231.4	249.0	241.5	261.6	201.2	254.0	274.1
10-20	216.3	281.7	228.9	231.4	226.4	266.6	218.8
20-30	181.1	108.2	181.1	186.1	166.0	173.5	155.9
30-40	155.9	110.7	150.9	161.0	125.8	128.3	135.8
40-50	110.7	78.0	118.2	93.1	115.7	135.8	108.?
50-60	90.5	105.6	110.7	45.3	85.7	78.0	80.5
60-70	60.4	57.9	90.5	50.3	115.7	40.2	62.9
70-80	50.3	40.2	55.3	65.4	55.3	78.0	57.9
80-90	40.2	60.4	50.3	37.8	30.2	50.3	42.8
90-100	50.3	32.7	50.3	25.2	25.2	47.8	35.2
TOTALS	2771.6	2301.4	2907.5	2580.7	2369.5	2361.6	2341.6

area than on the ungrazed area. The average for the season on the ungrazed area to a depth of 100 cm was 1613.9 g/m^2, while on the grazed area, the seasonal average underground biomass was 2519.1 g/m^2, 905.2 g, or 56% more than on the ungrazed area. On both the ungrazed and grazed areas, about 72% of the total underground biomass was found in the top 20 cm of the soil.

Another interesting point was that the peak underground biomass on both the ungrazed and grazed areas was found on the June 25-26 sampling date. On this date, the underground biomass on the ungrazed area was found to be 2168.0 g/m^2, up 679.1 g/m^2 from the June 15 sampling date. The underground biomass on the grazed area on June 26 was found to be 2907.5 g/m^2, up 606.1 g/m^2 from the value on the June 15 sampling date. Following the attainment of peak underground biomass values on the June 25-26 sampling date, underground biomass on both treatments declined by the end of July to the same approximate levels that were found on the June 15 sampling date. Underground biomass on the grazed area continued on a slight decline to the August 19 sampling date, the last sampling period for which data are given in the tables. Underground biomass on the ungrazed site showed a slight increase from the end of July to August 10 sampling date and then a somewhat greater increase to the August 19 sampling date.

A final underground biomass sampling was made on both the ungrazed and grazed areas on October 19. The samples from this period have not yet been washed out and will not be until about the end of April. The data from this sampling are needed to round out the picture of seasonal underground biomass dynamics on the ungrazed and grazed treatments. Previous samplings on the area have indicated the

possibility of a late season increase in underground biomass, at least on the ungrazed treatment. Present indications are that a relatively low point in underground biomass occurs early in June, followed by an increase in production which reaches a peak about the end of June. This is followed by a decline in biomass to about the early June level.

STATUS OF DICKINSON SITE
DATA SUMMARY

There are a number of tasks remaining to be done before the summation of the Dickinson data can be said to be completed. The first of these is the statistical evaluation of the significance of the above and belowground biomass data. Printout sheets from the Natural Resource Ecology Laboratory have supplied standard deviations on most data sets. But other than these, no statistical estimates of error have been made. The more sophisticated analyses of relations between productivity and microenvironmental conditions are still in the planning stage.

The actual analysis of productivity patterns on the ungrazed and grazed areas remains to be done. Productivity by species must be compared on the basis of the three proposed approaches: community peak biomass, species peak biomass, and summation of the positive growth increments. Approaches to the problem of belowground productivity must be considered and compared as to results obtained with the data available.

The last set of root samples taken on October 19, 1970 must be washed out, dried, weighed, and ashed. It is hoped to get this task

completed by the end of April. In addition, it is intended to take a final set of root samples on both the ungrazed and grazed areas before the end of April, so that the status of underground biomass under both treatments following the winter period can be evaluated.

The relative humidity data summary, which has not been completed, will be completed in the next few weeks. The work of converting these values to vapor pressure deficits has begun and also should be completed in the next few weeks.

Considerably more work must be done in relation to the analysis of soil water status during the season. Pressure-plate data at 15 atmospheres were obtained some years ago from the soils on the site, but additional samples have been obtained, and these will be checked for water retention at 15 atmospheres. Calculations of available soil water based on the previous 15 atmosphere values have not been satisfactory.

Work has begun on the energy budgets for the 1970 season on the ungrazed and grazed areas. Most of the work of calculating the energy budgets has been done, but the caloric values of the above and below-ground plant materials must still be determined.

On the basis of the projected work remaining to be done, the work-load for the coming months, and the availability of student help, it would appear that a realistic time for the completion of data analysis on the project would be about the end of the 1971 summer period.

LITERATURE CITED

Stevens, D. A. 1963. Handbook of North Dakota plants. North Dakota Inst. for Regional Studies, Fargo. 324 p.

APPENDIX I

Field Data

Aboveground Biomass Data

Aboveground biomass data collected in 1970 at the Dickinson Site is Grassland Biome Data Set A2U0005. Data were collected on Form NREL-01. A copy of the data form and an example of the data follow.

IBP

GRASSLAND BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

FIELD DATA SHEET - ABOVEGROUND BIOMASS

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	QUADRAT	CLIP-RANK	GROWTH FM.	GENUS	SPECIES	SUBSPECIES	PHENOLOGY	RANK	SACK NO.	DRY WT.	SPECIAL	DRY WT. SP.
			Day	Mo	Yr															
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21-23	25	27	29-30	31-32	34	36-37	39-40	42-45	47-52	54-57	59-64

DATA TYPE

01 Aboveground Biomass
02 Litter
03 Belowground Biomass
10 Vertebrate - Live Trapping
11 Vertebrate - Snap Trapping
12 Vertebrate - Collection
20 Avian Flush Census
21 Avian Road Count
22 Avian Road Count Summary
23 Avian Collection - Internal
24 Avian Collection - External
25 Avian Collection - Plumage
30 Invertebrate
40 Microbiology - Decomposition
41 Microbiology - Nitrogen
42 Microbiology - Biomass
43 Microbiology - Root Decomposition
44 Microbiology - Respiration

SITE

01 Ale
02 Bison
03 Bridger
04 Cottonwood
05 Dickinson
06 Hays
07 Hopland
08 Jornada
09 Osage
10 Pantex
11 Pawnee

TREATMENT

1 Ungrazed
2 Lightly grazed
3 Moderately grazed
4 Heavily grazed
5 Grazed 1969, ungrazed 1970
6
7
8
9

PHENOLOGY

01 Germinated or sprouted
02 Early vegetation
03 Prebud
04 Bud stage
05 Early bloom
06 Mid-bloom
07 Full bloom
08 Late bloom
09 Milk stage
10 Dough stage
11 Ripe seed
12 Past ripe
13 Stem cured
14 Vegetative regrowth
15 Regrowth flowering
16 Regrowth ripe seed
17 Standing dead
18 Winter dormant

CLIP RANK

1 Harvested
2 Harvested and ranked
3 Ranked

GROWTH FORM

1 Perennial grass
2 Annual grass
3 Sedge, rush, etc.
4 Annual forb
5 Biennial forb
6 Perennial forb
7 Half-shrub
8 Shrub
9 Tree
0 Miscellaneous

*** EXAMPLE OF DATA ***

```
        1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

0105IRC150970110.50
                    4 2    STDEAD 17  1       163.93
                    4 2 1  AGSM   13  2        15.48
                    4 2 1  AGSM   19  4        10.32
                    4 2 1  STCO   13  3        14.93
                    4 2 1  STCO   19  5        12.21
                    4 2 1  BOGB   13  6         5.72
                    4 2 1  BOGB   19  8         3.08
                    4 2 4  LOAM   19 11         0.06
                    4 2 5  LTPU   11  7         2.13
                    4 2 5  SOMT   11  9         1.64
                    4 2 0  SEDF      10         0.60
                   35 2    STDEAD 17  2       103.12
                   35 2 1  AGSM   13  5         5.64
                   35 2 1  AGSM   19  8         2.42
                   35 2 1  STCO   13  3        11.99
                   35 2 1  STCO   19  4         9.81
                   35 2 1  BOGB   13  9         1.74
                   35 2 1  BOGB   19 10         0.75
                   35 2 3  CAFI   13  6         1.08
                   35 2 3  CAFI   19  7         1.08
                   35 2 5  TRDU   19 11         0.31
                   35 2 6  APLU   08  1        34.81
                   76 2    STDEAD 17  1       109.74
                   76 2 1  STCO   13  2        19.01
                   76 2 1  STCO   19  4        15.56
                   76 2 1  BOGB   13  6         3.05
                   76 2 1  BOGB   19 11         2.04
                   76 2 1  AGSM   13  3         3.26
                   76 2 1  AGSM   19  7         4.90
                   76 2 3  CAFI   13  5         4.35
                   76 2 3  CAFI   19  9         1.87
                   76 2 6  APLU   08 12         0.25
                   76 2 6  SPCO   19  8         0.42
                   76 2 6  CACO   19 10         0.64
                  108 2    STDEAD 17  3        43.69
                  108 2 1  STCO   13  1        25.58
                  108 2 1  STCO   19  4        13.78
                  108 2 1  BOGB   13  7         1.02
                  108 2 1  BOGB   19 10         0.83
                  108 2 1  AGSM   13  5         1.16
                  108 2 1  AGSM   19  8         0.50
                  108 2 3  CAFI   13  6         0.20
```

108	2	3	CAFL	19	11	0.08
108	2	4	LOAM	19	12	0.28
108	2	6	ARLU	08	2	31.40
108	2	6	ASER	08	5	4.30
160	2		STDEAD	17	1	94.79
160	2	1	BOGR	13	6	3.74
160	2	1	BOGR	19	10	2.50
160	2	1	AGSM	13	4	3.45
160	2	1	AGSM	19	7	2.82
160	2	1	STCO	13	2	20.46
160	2	1	STCO	19	3	18.14
160	2	3	CAFL	13	8	0.57
160	2	3	CAFL	19	11	0.19
160	2	4	LASE	19	12	0.21
160	2	4	LOAM	19	13	0.18
160	2	5	TRDU	19	5	3.80
160	2	6	SPCO	10	9	0.98
173	2		STDEAD	17	2	75.33
173	2	1	STCO	13	1	27.38
173	2	1	STCO	19	3	14.75
173	2	1	AGSM	13	4	6.92
173	2	1	AGSM	19	6	2.96
173	2	1	BOGR	13	5	1.87
173	2	1	BOGR	19	9	2.29
173	2	3	CAFL	13	8	0.64
173	2	3	CAFL	19	10	0.43
173	2	4	LASE	19	13	0.13
173	2	5	TRDU	19	12	0.83
173	2	6	SPCO	11	7	0.83
173	2	6	OENU	19	11	0.63
141	3	1	STCO	13	1	
141	3	1	STCO	19	3	
141	3	1	BOGR	13	5	
141	3	1	BOGR	19	7	
141	3	1	AGSM	13	4	
141	3	1	AGSM	19	6	
141	3	3	CAFL	13	8	
141	3	3	CAFL	19	11	
141	3	5	TRDU	19	9	
141	3	6	SPCO	11	10	
141	3	4	CHAL	13	12	
141	3		STDEAD	17	2	
145	3	1	STCO	13	3	
145	3	1	STCO	19	6	
145	3	1	CALO	13	1	
145	3	1	CALO	19	5	
145	3	1	BOGR	13	7	
145	3	1	BOGR	19	10	
145	3	1	AGSM	13	4	
145	3	1	AGSM	19	8	
145	3	3	CAFL	13	9	

145	3	3	CAFL	19	12
145	3	6	GACO	19	14
145	3	4	CHAL	13	13
145	3	5	TRDU	19	11
145	3		STDEAD	17	2
20	3	1	STCO	13	3
20	3	1	STCO	19	6
20	3	1	AGSM	13	4
20	3	1	AGSM	19	7
20	3	1	ROGR	13	5
20	3	1	ROGR	19	9
20	3	3	CAFL	13	8
20	3	3	CAFL	19	11
20	3	6	ARLI	06	2
20	3	6	LIRU	11	10
20	3		STDEAD	17	1
28	3	1	STCO	13	3
28	3	1	STCO	19	6
28	3	1	AGSM	13	4
28	3	1	AGSM	19	8
28	3	1	ROGR	13	5
28	3	1	ROGR	19	9
28	3	3	CAFL	13	7
28	3	3	CAFL	19	10
28	3	6	ARLI	06	1
28	3		STDEAD	17	2
31	3	1	STCO	13	3
31	3	1	STCO	19	5
31	3	1	AGSM	13	6
31	3	1	AGSM	19	7
31	3	1	ROGR	13	4
31	3	1	ROGR	19	8
31	3	6	ARLI	06	1
31	3		STDEAD	17	2

Litter Data

Litter data collected in 1970 at the Dickinson Site is Grassland Biome Data Set A2U0015. Data were collected on form NREL-02. A copy of the data form and an example of the data follow.

IBP

GRASSLAND BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

FIELD DATA SHEET - LITTER

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	QUADRAT	TYPE	SACK NO.	DRY WT.	SACK WT.	ASH WT.	PREVIOUS DATE		
			Day	Mo	Yr										Day	Mo	Yr
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16	17-18	19	20-27	28-32	33-37	38-42	43-44	45-46	47-48

DATA TYPE

01 Aboveground Biomass
02 Litter
03 Belowground Biomass
10 Vertebrate - Live Trapping
11 Vertebrate - Snap Trapping
12 Vertebrate - Collection
20 Avian Flush Census
21 Avian Road Count
22 Avian Road Count Summary
23 Avian Collection - Internal
24 Avian Collection - External
25 Avian Collection - Plumage
30 Invertebrate
40 Microbiology - Decomposition
41 Microbiology - Nitrogen
42 Microbiology - Biomass
43 Microbiology - Root Decomposition
44 Microbiology - Respiration

SITE

01 Ale
02 Bison
03 Bridger
04 Cottonwood
05 Dickinson
06 Hays
07 Hopland
08 Jornada
09 Osage
10 Pantex
11 Pawnee

TREATMENT

1 Ungrazed
2 Lightly grazed
3 Moderately grazed
4 Heavily grazed
5 Grazed 1969, ungrazed 1970
6
7
8
9

TYPE

1 Quadrat, total
2 Quadrat, part
3 Cleared plot
4 Litter bag

*** FIELD DATA ***

1	2	3	4	5	6	7	8
12345678901234567890123456789012345678901234567890123456789012345678901234567890							
0205WCW24057/0110.50	10 1	410.80	242.37				
	80 1	441.70	196.11				
	127 1	293.00	155.29				
	191 1	629.20	400.99				
	165 1	530.80	316.67				
0205WCW25057/0410.50	19 1	56.56	19.17				
	58 1	58.65	31.80				
	87 1	30.43	10.41				
	105 1	24.95	8.53				
	165 1	26.69	8.86				
0205WCW08067/0110.50	29 1	205.76	86.91				
	54 1	268.48	123.61				
	95 1	156.82	61.82				
	138 1	304.66	165.61				
	171 1	151.19	58.51				
0205WCW10067/0120.50	18 1	462.42	138.35				
	80 1	389.25	211.09				
	98 1	390.64	267.47				
	112 1	329.25	161.93				
	173 1	381.86	254.59				
0205WCW09067/0410.50	29 1	9.25	2.03				
	54 1	18.94	5.73				
	95 1	48.78	15.74				
	138 1	49.38	19.17				
	171 1	26.98	9.52				
0205WCW11067/0420.50	18 1	46.85	24.63				
	80 1	47.67	21.60				
	98 1	34.35	16.39				
	112 1	51.93	21.34				
	174 1	38.02	18.01				
0205WKL22067/0110.50	41 1	401.56	238.69				
	62 1	217.95	101.02				
	106 1	251.70	114.33				
	123 1	332.92	205.25				
	157 1	264.68	163.55				
0205WKL24067/0120.50	42 1	461.89	313.81				
	36 1	196.25	97.60				
	61 1	289.09	135.93				
	116 1	294.16	148.05				
	191 1	267.59	113.91				
0205WKL22067/0410.50	41 1	43.72	25.99				
	62 1	30.90	11.48				
	106 1	14.32	3.26				
	123 1	47.24	20.74				

	157	1	58.14	24.27
0205WKL2406/0420.50	36	1	14.54	5.67
	42	1	33.58	15.19
	116	1	53.98	26.57
	61	1	80.14	39.51
	191	1	36.60	12.77
0205WKL060/70110.50	21	1	300.75	207.04
	56	1	478.05	328.09
	99	1	338.07	261.91
	116	1	334.55	235.69
	152	1	277.67	127.03
	175	1	226.31	131.01
0205WKL070/70120.50	40	1	230.71	131.09
	55	1	247.98	111.71
	89	1	337.99	166.49
	114	1	253.89	96.68
	132	1	278.82	113.87
	195	1	413.47	237.41
0205WKL060/70410.50	21	1	45.70	18.72
	56	1	91.00	41.87
	99	1	33.11	10.19
	116	1	52.59	20.23
	152	1	51.00	18.20
	175	1	26.90	10.32
0205WKL080/70420.50	40	1	23.36	9.08
	55	1	23.64	7.77
	89	1	32.16	11.30
	114	1	49.08	20.09
	133	1	24.66	9.48
	195	1	36.39	11.87
0205JRC220/70110.50	15	1	594.56	437.72
	39	1	490.45	308.44
	82	1	323.07	178.40
	132	1	366.69	237.65
	162	1	555.76	383.59
	188	1	350.51	206.28
0205JRC220/70120.50	10	1	898.20	644.28
	29	1	459.80	312.71
	66	1	513.28	377.62
	107	1	444.39	263.39
	126	1	518.40	407.83
	164	1	469.89	346.64
0205JRC220/70410.50	15	1	65.37	33.40
	39	1	57.38	27.85
	82	1	77.66	32.80
	132	1	48.39	21.18
	162	1	90.09	48.56
	187	1	233.91	156.51
0205JRC220/70420.50	10	1	134.80	90.72
	29	1	207.04	156.75
	66	1	132.35	90.21
	107	1	108.65	60.33

	126	1	79.65	42.27
	162	1	112.24	78.75
0205JRC0308/0110.50	26	1	431.00	324.38
	52	1	454.56	274.78
	91	1	406.31	270.16
	118	1	371.38	216.51
	140	1	439.23	237.80
	177	1	420.49	329.66
0205JRC0308/0120.50	15	1	516.33	194.91
	25	1	475.58	353.02
	63	1	325.78	206.02
	110	1	309.97	186.45
	154	1	418.20	242.68
	166	1	383.32	241.03
0205JRC0308/0410.50	26	1	162.84	99.89
	52	1	163.56	106.00
	91	1	135.03	65.83
	118	1	178.05	120.74
	140	1	106.29	64.20
	177	1	127.50	75.66
0205JRC0308/0420.50	15	1	112.96	69.72
	25	1	118.42	90.11
	63	1	100.22	62.71
	110	1	127.24	73.96
	154	1	216.45	159.46
	166	1	139.60	92.60

Belowground Biomass Data

Belowground biomass data collected in 1970 at the Dickinson Site is Grassland Biome Data Set A2U0025. Data were collected on form NREL-03. A copy of the form and an example of the data follow.

IBP

GRASSLAND BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

FIELD DATA SHEET - BELOWGROUND BIOMASS

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	QUADRAT	CORE DIAM.	HORIZON	TOP DEPTH	BOTTOM DEP.	LENGTH	WASH WT.	DRY WT.	ASH WT.	CROW DRY WT
			Day	Mo	Yr													
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21-23	25-27	29	31-33	35-37	39-41	43-47	49-54	56-61	63-6

DATA TYPE

01 Aboveground Biomass
02 Litter
03 Belowground Biomass
10 Vertebrate - Live Trapping
11 Vertebrate - Snap Trapping
12 Vertebrate - Collection
20 Avian Flush Census
21 Avian Road Count
22 Avian Road Count Summary
23 Avian Collection - Internal
24 Avian Collection - External
25 Avian Collection - Plumage
30 Invertebrate
40 Microbiology - Decomposition
41 Microbiology - Nitrogen
42 Microbiology - Biomass
43 Microbiology - Root Decomposition
44 Microbiology - Respiration

SITE

01 Ale
02 Bison
03 Bridger
04 Cottonwood
05 Dickinson
06 Hays
07 Hopland
08 Jornada
09 Osage
10 Pantex
11 Pawnee

TREATMENT

1 Ungrazed
2 Lightly grazed
3 Moderately grazed
4 Heavily grazed
5 Grazed 1969, ungrazed 1970
6
7
8
9

HORIZON

1 AO
2 A
3 B
4 C

*** EXAMPLE OF DATA ***

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         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

0305WCW260570110.50 1655.03 2    0    5    5          2.68    1.01
                    1655.03 2    5   10    5           .64    0.30
                    1655.03 3   10   20   10           .69    0.31
                    1655.03 3   20   30   10           .22    0.10
                    1655.03 4   30   40   10           .15    0.07
                    1655.03 4   40   50   10           .12    0.08
                    1655.03 4   50   60   10           .13    0.07
                    1655.03 4   60   70   10           .11    0.06
                    1655.03 4   70   80   10           .17    0.11
                    1655.03 4   80   90   10           .16    0.12
                    1655.03 4   90  100   10           .18    0.12
                    0805.03 2    0    5    5          1.74    0.66
                    0805.03 2    5   10    5           .40    0.19
                    0805.03 3   10   20   10           .51    0.23
                    0805.03 3   20   30   10           .28    0.13
                    0805.03 4   30   40   10           .22    0.10
                    0805.03 4   40   50   10           .31    0.20
                    0805.03 4   50   60   10           .06    0.03
                    0805.03 4   60   70   10           .12    0.07
                    0805.03 4   70   80   10           .12    0.08
                    0805.03 4   80   90   10           .32    0.24
                    0805.03 4   90  100   10           .12    0.08
                    1275.03 2    0    5    5          2.20    0.83
                    1275.03 2    5   10    5           .26    0.12
                    1275.03 3   10   20   10           .32    0.14
                    1275.03 3   20   30   10           .19    0.09
                    1275.03 4   30   40   10           .14    0.06
                    1275.03 4   40   50   10           .20    0.13
                    1275.03 4   50   60   10           .13    0.07
                    1275.03 4   60   70   10           .08    0.05
                    1275.03 4   70   80   10           .29    0.19
                    1275.03 4   80   90   10           .46    0.35
                    1275.03 4   90  100   10           .37    0.25
                    1915.03 2    0    5    5          4.84    1.83
                    1915.03 2    5   10    5          1.16    0.54
                    1915.03 3   10   20   10           .58    0.26
                    1915.03 3   20   30   10           .36    0.16
                    1915.03 4   30   40   10           .21    0.10
                    1915.03 4   40   50   10           .08    0.05
                    1915.03 4   50   60   10           .14    0.08
                    1915.03 4   60   70   10           .16    0.09
                    1915.03 4   70   80   10           .09    0.06
                    1915.03 4   80   90   10           .24    0.18
```

	1915.03	4	90	100	10	.12	0.08
	0105.03	2	0	5	5	2.22	0.84
	0105.03	2	5	10	5	.42	0.19
	0105.03	3	10	20	10	.32	0.14
	0105.03	3	20	30	10	.54	0.24
	0105.03	4	30	40	10	.15	0.07
	0105.03	4	40	50	10	.26	0.17
	0105.03	4	50	60	10	.19	0.10
	0105.03	4	60	70	10	.12	0.07
	0105.03	4	70	80	10	.03	0.02
	0105.03	4	80	90	10	.12	0.09
	0105.03	4	90	100	10	.08	0.05
0305WCW260570410.50	0195.03	2	0	5	5	3.80	1.31
	0195.03	2	5	10	5	1.22	0.62
	0195.03	3	10	20	10	1.15	0.73
	0195.03	3	20	30	10	1.01	0.69
	0195.03	4	30	40	10	1.37	0.85
	0195.03	4	40	50	10	.92	0.58
	0195.03	4	50	60	10	.70	0.46
	0195.03	4	60	70	10	.36	0.25
	0195.03	4	70	80	10	.26	0.18
	0195.03	4	80	90	10	.24	0.16
	0195.03	4	90	100	10	.12	0.08
	0585.03	2	0	5	5	4.00	0.14
	0585.03	2	5	10	5	.70	0.36
	0585.03	3	10	20	10	.57	0.36
	0585.03	3	20	30	10	.75	0.51
	0585.03	4	30	40	10	.60	0.37
	0585.03	4	40	50	10	.25	0.16
	0585.03	4	50	60	10	.34	0.22
	0585.03	4	60	70	10	.20	0.14
	0585.03	4	70	80	10	.20	0.14
	0585.03	4	80	90	10	.21	0.14
	0585.03	4	90	100	10	.23	0.14
	1655.03	2	0	5	5	4.30	1.48
	1655.03	2	5	10	5	.81	0.41
	1655.03	3	10	20	10	1.02	0.65
	1655.03	3	20	30	10	.84	0.58
	1655.03	4	30	40	10	.51	0.32
	1655.03	4	40	50	10	.90	0.57
	1655.03	4	50	60	10	.62	0.41
	1655.03	4	60	70	10	.49	0.34
	1655.03	4	70	80	10	.35	0.24
	1655.03	4	80	90	10	.15	0.10
	1655.03	4	90	100	10	.18	0.11
	1055.03	2	0	5	5	5.91	2.04
	1055.03	2	5	10	5	1.16	0.59
	1055.03	3	10	20	10	1.52	0.96
	1055.03	3	20	30	10	2.28	1.56
	1055.03	4	30	40	10	.78	0.48
	1055.03	4	40	50	10	.36	0.23

1055.03	4	50	60	10	.38	0.25
1055.03	4	60	70	10	.39	0.27
1055.03	4	70	80	10	.48	0.33
1055.03	4	80	90	10	.43	0.28
1055.03	4	90	100	10	.38	0.24
0875.03	2	0	5	5	4.16	1.43
0875.03	2	5	10	5	.83	0.42
0875.03	3	10	20	10	1.58	1.00
0875.03	3	20	30	10	.84	0.58
0875.03	4	30	40	10	.82	0.51
0875.03	4	40	50	10	.53	0.33
0875.03	4	50	60	10	.62	0.41
0875.03	4	60	70	10	.48	0.33
0875.03	4	70	80	10	.24	0.16
0875.03	4	80	90	10	.13	0.08
0875.03	4	90	100	10	.38	0.24