

Technical Report No. 239

ABUNDANCE AND BIOMASS OF SOIL MACROINVERTEBRATES
OF THE PAWNEE SITE COLLECTED FROM PASTURES
SUBJECTED TO DIFFERENT GRAZING PRESSURES,
IRRIGATION AND/OR NITROGEN FERTILIZATION, 1970-1971

John E. Lloyd, Rabinder Kumar, Russell R. Grow, John W. Leetham, and Vicki Keith

Plant Science Division
University of Wyoming
Laramie, Wyoming 82070

Plant Science Division
University of Wyoming
Laramie, Wyoming 82070

Plant Science Division
University of Wyoming
Laramie, Wyoming 82070

Natural Resource Ecology Laboratory
Colorado State University
Fort Collins, Colorado 80521

and

Natural Resource Ecology Laboratory
Colorado State University
Fort Collins, Colorado 80521

Grassland Biome
U.S. International Biological Program

November 1973

TABLE OF CONTENTS

	Page
Title Page	i
Table of Contents	ii
Abstract	iii
Introduction	1
Materials and Methods	1
Pasture Treatments	1
Sampling and Extraction Methods	7
Sampling Frequency	7
Identification and Recording of Data	8
Results and Discussion	8
Identification of Soil Macroinvertebrates	8
Soil Macroarthropod Numbers and Biomass	8
Conclusions	45
Literature Cited	47
Appendix I. Pawnee Site Study Plots 1970-71	48
Appendix II. Field Data Sheets	59
Appendix III. Soil Invertebrate Species	61
Appendix IV. Soil Macroarthropod Orders Collected From	
Four Differentially Grazed Pastures, Pawnee Site, 1970	71
Appendix V. Soil Macroarthropod Orders Collected From	
Four Differentially Grazed Pastures, Pawnee Site, 1971	87
Appendix VI. Soil Macroarthropod Orders Collected From	
Ungrazed Exclosures and a Recently Heavily Grazed Pasture,	
Pawnee Site, 1971	92
Appendix VII. Soil Macroarthropod Families Collected From	
Four Differentially Grazed Pastures, Pawnee Site, 1970	105
Appendix VIII. Soil Macroarthropod Families Collected From	
Four Differentially Grazed Pastures, Pawnee Site, 1971	133
Appendix IX. Soil Macroarthropod Families Collected From	
Ungrazed Exclosures and a Recently Heavily Grazed Pasture,	
Pawnee Site, 1971	142
Appendix X. Field Data	155

ABSTRACT

A survey of soil macroarthropods of the Pawnee Site of the IBP Grassland Biome program was conducted in 1970 and 1971. This study revealed large numbers of organisms, e.g., 407, 619, 304, and 228 soil macroarthropods per square meter from ungrazed and lightly, moderately, and heavily grazed pastures in 1970. Most of the organisms collected were Hymenoptera, Coleoptera and Homoptera. The Hymenoptera were mainly Formicidae, and the Homoptera were the Scarabaeidae. The Tenebrionidae were not nearly as abundant as Scarabaeidae, but were a dominant group due to their relatively large size and thus greater biomass.

More soil macroarthropods and greater biomass were consistently collected from the ungrazed treatment than from light, moderate, and heavy grazing treatments. Fewer soil macroarthropods and less biomass were consistently collected from the heavily grazed situation. The differences were due in large part to differences in numbers of Scarabaeidae, many of which were probably decomposer organisms.

An increase in numbers and biomass of soil macroarthropods occurred when the shortgrass prairie was subjected to irrigation and irrigation plus fertilization. These increases were primarily due to rises in numbers of Scarabaeidae and Margarodidae.

INTRODUCTION

The objective of this study was to conduct an inventory of soil macroarthropods of the Pawnee Site. To achieve this, soil macroarthropods (arthropods that would not wash through a 1 mm sieve) were extracted from soil cores that were collected at regular intervals from pastures subjected to various treatments. All macroarthropods were identified as closely to species as possible.

This report presents the results obtained in the first 2 years of the study. In 1970 the objective was to conduct a bimonthly inventory of soil macroarthropod abundance and biomass from ungrazed exclosures and lightly, moderately, and heavily grazed pastures. In 1971 a bimonthly soil macroarthropod inventory was determined from ungrazed exclosures and new exclosures established on pastures grazed heavily since 1939. Also in 1971, a study was begun to determine the response of soil macroarthropod numbers and biomass to treatments of irrigation, nitrogen fertilization, and irrigation plus nitrogen fertilization.

The purpose of this report is to present a summary of data collected in 1970 and 1971 to point out what appears to be trends in insect abundance and biomass collected from the various grazing exclosures and pastures.

MATERIALS AND METHODS

Pasture Treatments

Differential grazing. The study area, the Pawnee National Grassland Intensive Study Site of the Central Plain Experimental Range, Agricultural Research Service, U.S.D.A., was described by Jameson and Bement (1969). Better known as the "Pawnee Site," it is located approximately 12 miles northeast of Nunn, Colorado, and 25 miles south of Cheyenne, Wyoming.

The Central Plains Experimental Range was established in 1939 to evaluate cattle grazing practices (Klippel and Costello 1960). Half-section pastures (320 acres) were established for long-term cattle grazing experiments. These included three summer-use pastures (May to October inclusive) with light, moderate, and heavy grazing treatments. These three grazing treatments are based on the percent weight utilization of the current herbage growth of the major forage species, as determined at the end of the six-month grazing season. For heavy use, approximately 60% of the forage is utilized. For moderate and light use, the figures are 40% and 20%, respectively. Conversely, the amount of forage remaining at the end of the grazing season was 200, 300, and 400 lb. per acre for heavy, moderate, and light use, respectively. A fourth no-grazing treatment was provided by 2.5 acre exclosures fenced in 1939.

Eight microwatersheds were established, two each in Sections 23 West (light summer grazing), 23 East (heavy summer grazing), and 15 East (moderate summer grazing), and one each in "permanently" ungrazed exclosures in Sections 23 East and 15 West. These microwatersheds were designed to study the behavior of water in grasslands (Smith and Striffler 1969). A study plot was established adjacent to each of these microwatersheds before 1970, and one each in two grazing exclosures was established immediately prior to the 1971 grazing season. The study plots were marked with permanent sample points to guide plant and insect collections. The location of the Pawnee Site, the differentially grazed pastures, and the study plots utilized in 1970 and 1971 are presented in Fig. 1. A closer look at the pastures involved in the study of differential grazing pressure is presented in Fig. 2. Fig. 2 also presents the number assigned to each study plot and,

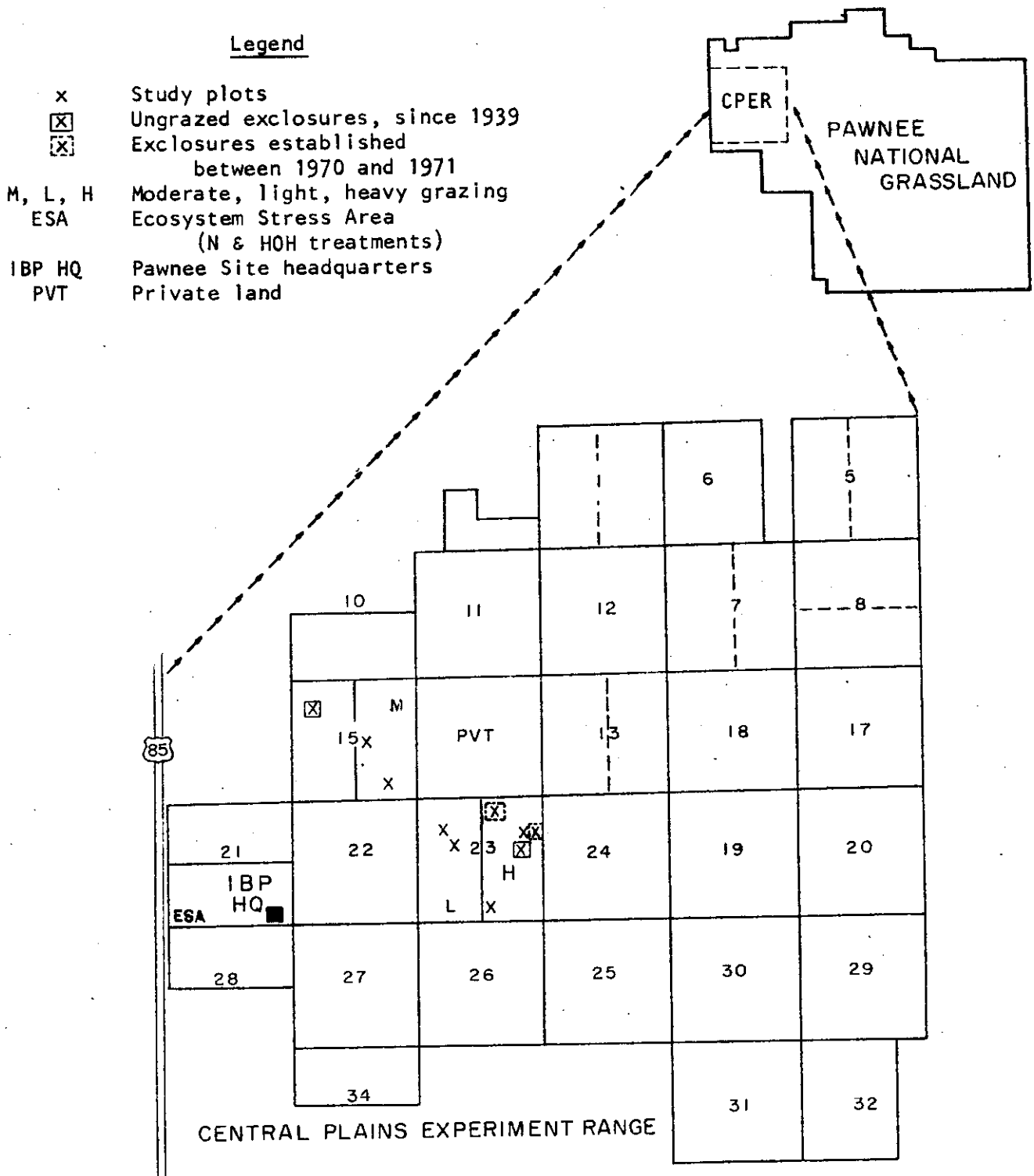


Fig. 1. Location of the Central Plains Experiment Range, Pawnee Site, the differentially grazed pastures, the ESA area, and study plots, 1970 - 1971.

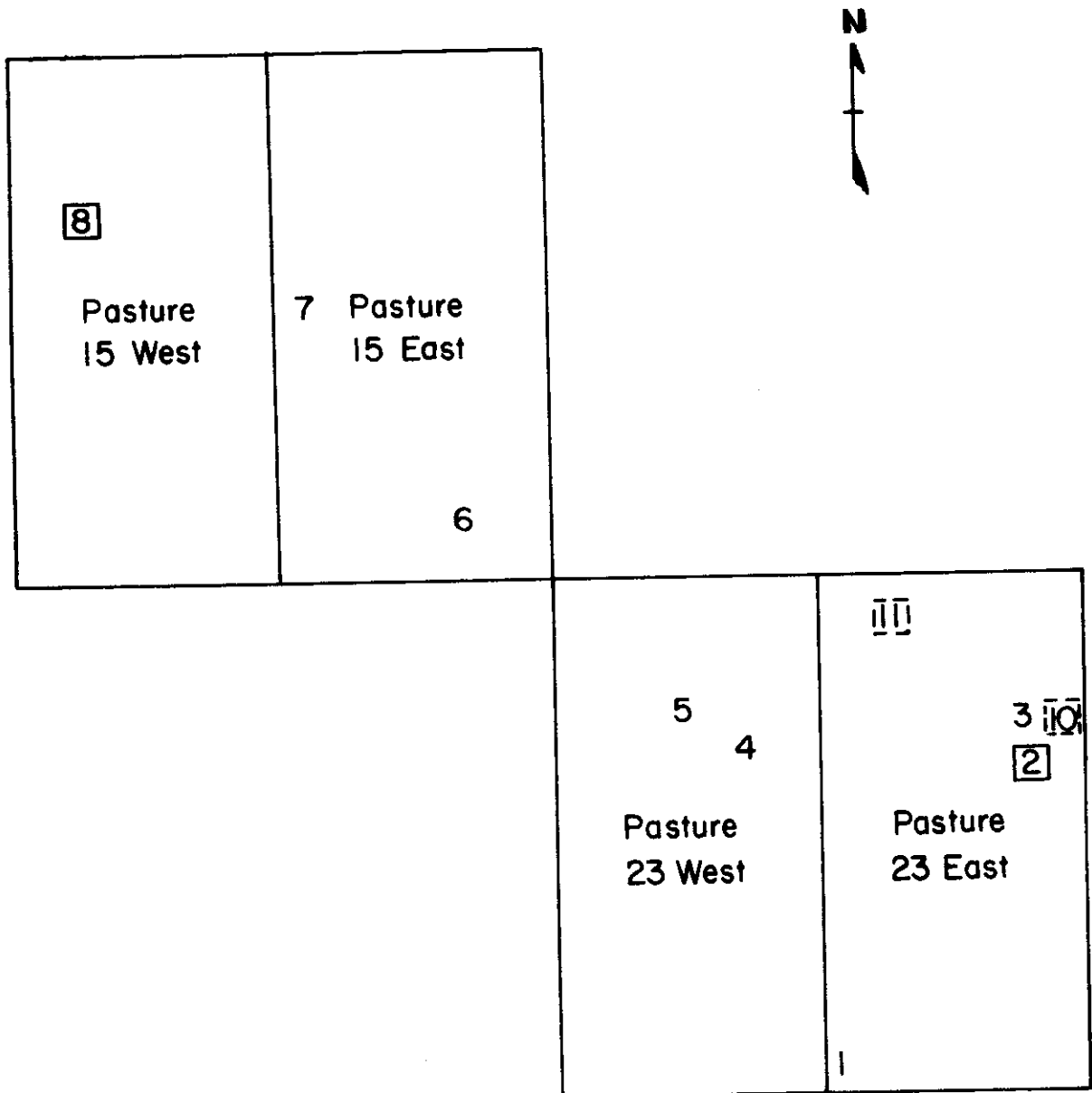
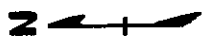


Fig. 2. Location of the soil macroarthropods study plots in sections 15 and 23 of the Pawnee Site, 1970-71.

where established, each microwatershed. The details of the study plots utilized in 1970 and 1971 are presented in Appendix I.

A comparison of the effects of four differential grazing pressures on soil macroarthropod numbers and biomass was conducted in 1970. To conduct this study samples were collected regularly from study plots 2 and 8 (ungrazed), 4 and 5 (lightly grazed), 6 and 7 (moderately grazed), and 1 and 3 (heavily grazed). A comparison of the effect of ungrazed vs. recently heavily grazed pastures was begun on the Pawnee Site in 1971. Study plots 2 and 8, the ungrazed exclosures in Sections 23 East and 15 West, were utilized as ungrazed treatments for the study. New grazing exclosures, study plots 10 and 11, were established prior to the 1971 grazing season in half-section 23 East, the heavily grazed pasture (Fig. 1 and 2, Appendix I).

Irrigation and/or nitrogen fertilization. Treatments of nitrogen fertilization, irrigation, nitrogen plus irrigation, and no treatment were established in Section 21 (Fig. 1) in 1969. Each treatment was applied to two 1-ha plots in the area called the Ecosystem Stress Area (ESA) (Fig. 3). The site description and some details of the treatments are presented in Technical Report No. 99 (Sims et al. 1971). Some 150 kg/ha of actual N were applied to "F" treatments (nitrogen fertilization alone) and to "G" treatments (nitrogen plus water) on 1 June 1970. The plan was to maintain a difference of approximately 50 kg/ha between fertilized and unfertilized treatments. The irrigation treatment was designed to maintain a water level in the soil between zero and -0.8 bars.



Treatment : D Control (No treatment)
 E Irrigation
 F Nitrogen fertilization
 G Irrigation and nitrogen fertilization

Plot no. 9/1 Unused	Plot no. 9/2 Treatment E Replicate 1	Plot no. 9/3 Treatment D Replicate 1	Plot no. 9/4 Treatment G Replicate 2	Plot no. 9/5 Treatment D Replicate 2
Plot no. 9/6 Unused	Plot no. 9/7 Treatment F Replicate 1	Plot no. 9/8 Treatment G Replicate 1	Plot no. 9/9 Treatment E Replicate 2	Plot no. 9/10 Treatment F Replicate 2

Fig. 3. Ecosystem Stress Area in Section 21, Pawnee Site, 1971.

Sampling and Extraction Methods

Sampling, extraction, and sorting techniques were those described in Technical Report No. 104 (Lloyd and Grow 1971). Soil cores, 12.5 cm in diameter and 15.25 cm deep, were removed from the earth at the time of sampling of above- and belowground plants, soil microarthropods, and aboveground macroarthropods. Soil macroarthropods were then extracted using a modification of the flotation method of Salt and Hollick (1944). A total of five soil cores were collected per replicate on each date. Since there were two replicates of each treatment, a total of 10 samples per treatment were collected.

Sampling Frequency

To determine the effect of differential grazing stress on soil macroarthropod abundance and biomass, each of the first eight study plots was sampled in 1970 on 17 April, 30 April, 15 May, 29 May, 13 June, 25 June, 11 July, 22 July, 4 August, 18 August, 2 September, 14 September, 1 October, and 29 October; in 1971 on 31 January, 25 March, 3 May, 5 July, 31 August, and 6 October.

In order to compare the effect of ungrazed vs. recently heavily grazed pasture treatments on soil macroarthropod abundance and biomass, samples were collected from study plots 2, 8, 10, and 11 in 1971 on 22 April, 12 May, 24 May, 4 June, 15 June, 5 July, 15 July, 29 July, 11 August, 31 August, 27 September, and 6 October. When sampling dates of the four different grazing intensities coincided with those of the recently grazed and ungrazed treatments in 1971, collections from samples from the ungrazed exclosures (study plots 2 and 8) were utilized in both experiments.

Soil cores were collected from the irrigation, nitrogen fertilization, irrigation plus nitrogen fertilization treatments, and no treatments on 20 March, 8 May, 9 July, 1 September, and 13 October 1971.

Identification and Recording of Data

Soil macroarthropods were identified as far as possible, then sent to specialists for further identification. Data sheets utilized in 1971 were slightly different from those of 1970 (Appendix II). Basically the same information was gathered both years, and an explanation of all entries can be found in Technical Report No. 104 (Lloyd and Grow 1971).

RESULTS AND DISCUSSION

Identification of Soil Macroinvertebrates

Some 117 soil macroarthropod and oligochaete species were collected in 1970, and 89 were collected in 1971. Lists of the species collected in 1970 and 1971 are presented in Appendix III. Code names of species yet unidentified are presented in the lists. Possibly some of the unidentified specimens are but different life stages of other unknown or known arthropod species. Additional information on these and other Arthropoda and Annelida collected at the Pawnee Site is available in Technical Report No. 172, "Insects of the Pawnee Site" (Kumar et al. 1972).

Soil Macroarthropod Numbers and Biomass

Soil macroarthropod collections included those organisms which inhabited the litter and crown areas of the plants included in the soil core. Therefore the term "soil macroinvertebrates" as used in this report includes some organisms that spend no part of their lives as true soil inhabitants.

Groups such as the Formicidae and Isoptera, which are obviously very strongly clumped in distribution, exert considerable influence on the

total number of arthropods when a colony is struck by the coring tool. To eliminate this effect the data of total soil macroarthropods are frequently presented excluding Formicidae or Formicidae and Isoptera.

Differentially grazed pastures (total soil macroarthropods). Numbers and biomass of soil macroarthropods collected from the four differentially grazed pastures in 1970 are presented in Table 1. The effect of ants and termites was removed from the 1970 data in Table 2. Table 2 shows that the least biomass was produced in the heavily grazed pasture in 1970. The data also show the greatest number of soil macroarthropods in the ungrazed enclosure and the lowest numbers in the heavily grazed pasture.

The 1970 data presented graphically in Fig. 4 show two peaks of soil macroarthropod numbers occurring in the ungrazed, lightly grazed, and moderately grazed pastures. The early peak, occurring on 15 May 1970, appeared to be due to several groups of soil macroarthropods including Annelida, Coleoptera, and Homoptera. The second peak in numbers and biomass occurred in August and September and was largely due to increases in Coleoptera in all of the grazing treatments, and a large catch of Isoptera in the moderately grazed pasture on 18 August. The peaks of Fig. 4 are not as obvious in collections from the heavily grazed pasture which yielded the fewest arthropods on 11 of 15 sample dates. Arthropod biomass plotted on a seasonal basis (Fig. 5) also reveals two distinct peaks of abundance in all but the heavily grazed pasture.

In 1971, as in 1970, the greatest number of soil macroarthropods were collected from the ungrazed treatments and the fewest were collected from the heavily grazed treatment (Tables 3 and 4). The greatest quantity of biomass was collected from the moderately grazed treatment in 1971. This

Table 1. Numbers and biomass of soil macroarthropods collected from four differentially grazed pastures, Pawnee Site, 1970.

Date	Grazing Treatment					
	Ungrazed		Lightly grazed		Moderately grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
17 April 1970	26	466	26	2512	31	470
30 April 1970	77	663	36	896	27	988
15 May 1970	55	2265	62	2683	64	3035
29 May 1970	46	985	28	574	18	261
13 June 1970	17	488	20	947	26	648
25 June 1970	23	927	7	121	22	257
11 July 1970	31	231	61	888	14	92
22 July 1970	240	2465	741	8724	56	461
4 August 1970	44	312	58	859	57	1030
18 August 1970	48	1633	26	602	126	3338
2 September 1970	40	516	25	434	14	681
14 September 1970	48	1169	19	555	61	1812
1 October 1970	15	907	31	1630	33	666
29 October 1970	18	1044	25	1223	13	876
31 January 1971	47	860	13	885	17	218
Total number	775		1178		578	
Avg. biomass		995.4		1568.8		988.8
					435	647.7

Table 2. Numbers and biomass of soil macroarthropods, excluding Formicidae and Isoptera, collected from four differentially grazed pastures, Pawnee Site, 1970.

Date	Grazing Treatment					
	Ungrazed		Lightly grazed		Moderately grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
17 April 1970	21	444	10	2468	23	442
30 April 1970	31	401	34	890	25	978
15 May 1970	39	2203	56	2649	38	2954
29 May 1970	43	945	27	572	17	256
13 June 1970	16	483	19	942	24	637
25 June 1970	22	922	6	107	21	252
11 July 1970	21	88	14	400	9	64
22 July 1970	19	830	25	568	26	250
4 August 1970	36	271	33	731	37	953
18 August 1970	46	1625	26	602	36	2926
2 September 1970	37	498	25	434	14	681
14 September 1970	41	1140	17	537	57	1769
1 October 1970	13	896	29	1612	24	615
29 October 1970	18	1044	23	1216	13	876
1 January 1971	46	849	13	885	16	213
Total number	449		357		380	
Avg. biomass		842.6		974.2		924.4
					206	436.7

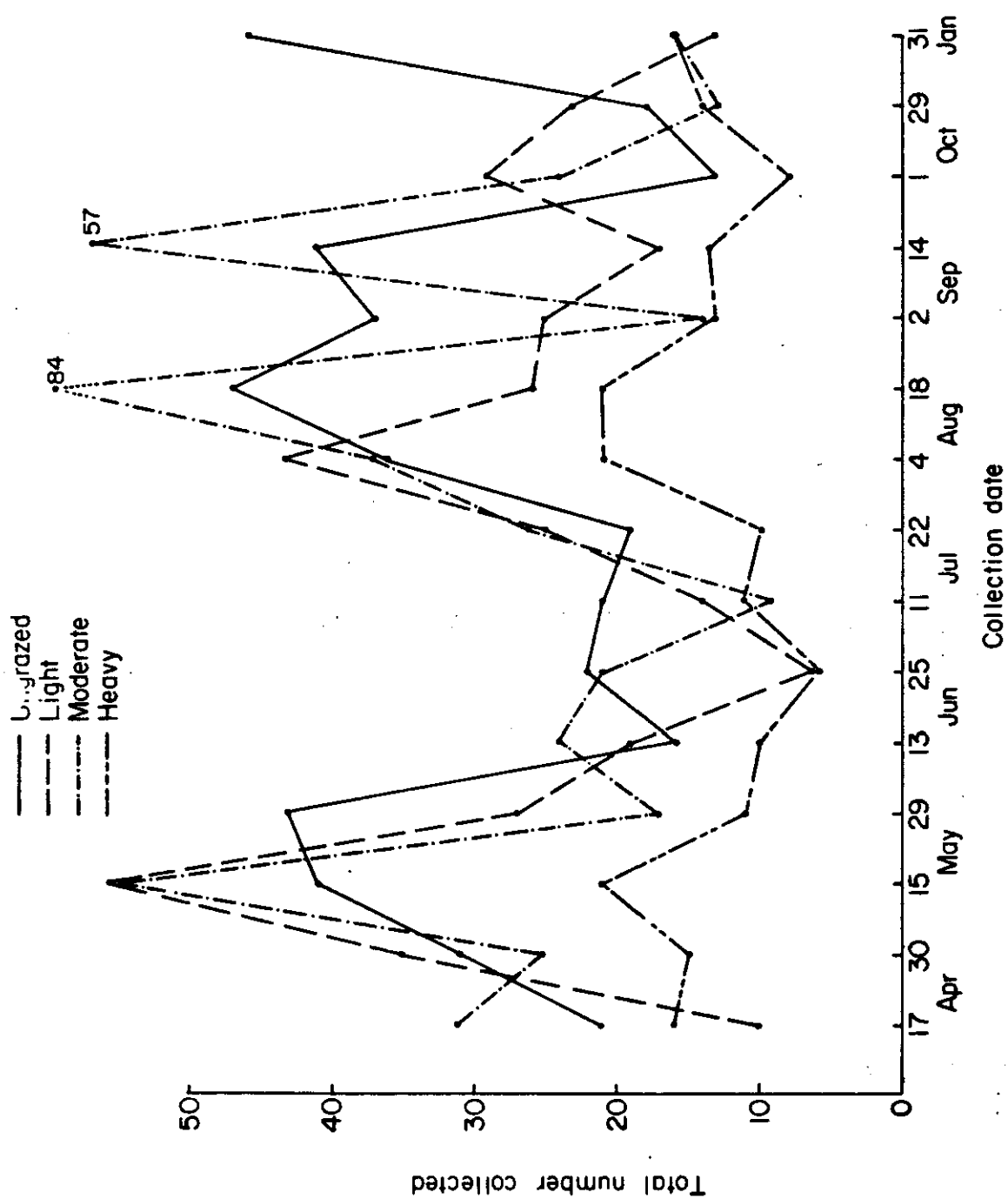


Fig. 4. Seasonal abundance of soil macroarthropods, excluding Formicidae, collected from four differentially grazed pastures, Pawnee Site, 1970.

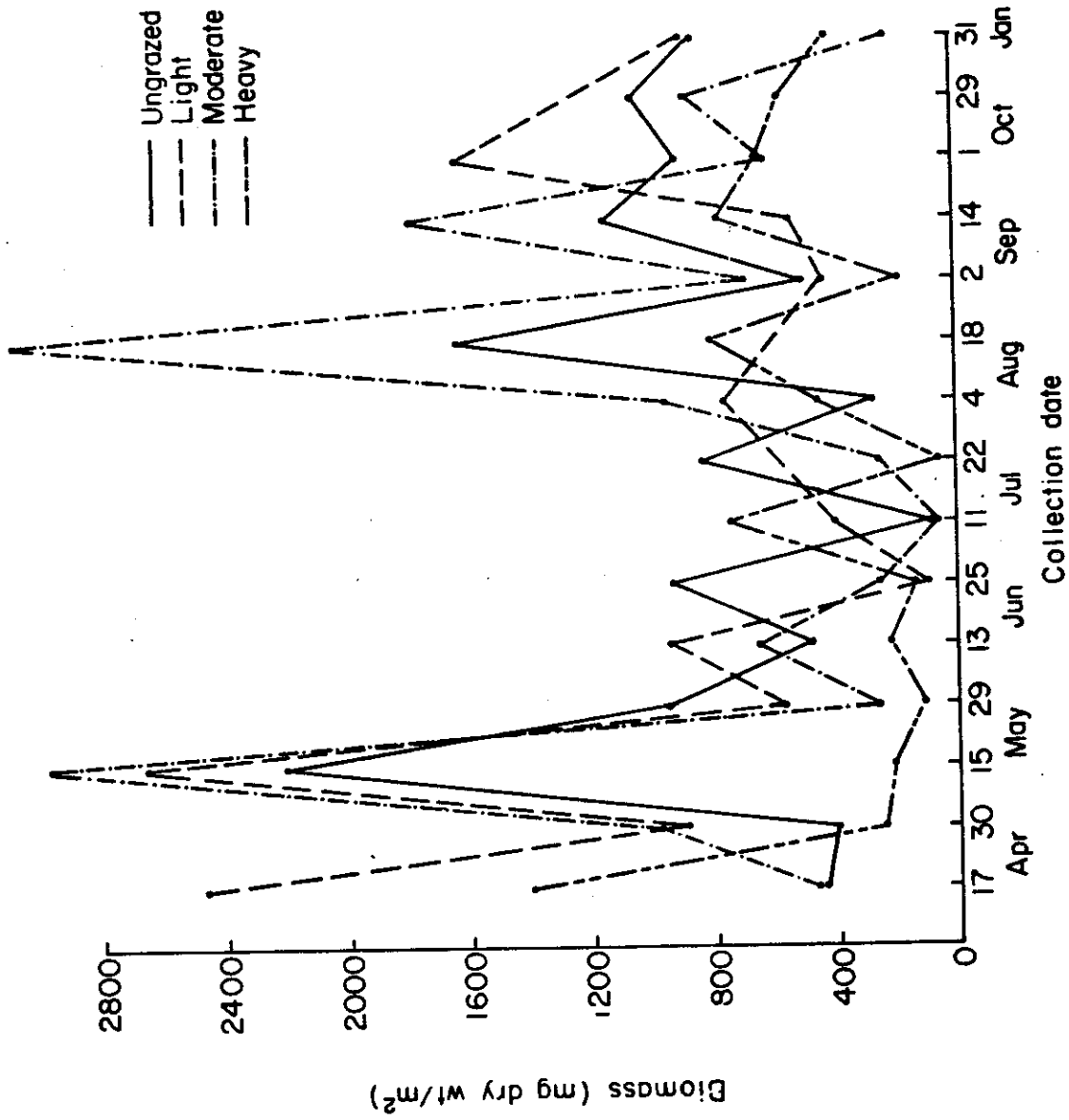


Fig. 5. Biomass of soil macroarthropods, excluding Formicidae, collected from four differentially grazed pastures, Pawnee Site, 1970.

Table 3. Numbers and biomass of soil macroarthropods collected from four differentially grazed pastures, Pawnee Site, 1971.

Date	Grazing Treatment							
	Ungrazed		Lightly grazed		Moderately grazed		Heavily grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
25 March 1971	36		27		29		23	
3 May 1971	24	228	22	329	21	629	10	268
5 July 1971	14	329	5	161	4	24	4	90
31 August 1971	5	124	9	274	8	361	8	379
6 October 1971	12	179	3	346	5	637	9	90
Total number	91		66		67		54	
Avg. biomass		215.0		277.5		412.7		206.7

Table 4. Numbers and biomass of soil macroarthropods, excluding Formicidae, collected from four differentially grazed pastures, Pawnee Site, 1971.

Date	Grazing Treatment							
	Ungazed		Lightly grazed		Moderately grazed		Heavily grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
25 March 1971	33		27		27		22	
3 May 1971	23	223	20	320	20	624	10	268
5 July 1971	13	311	4	147	4	24	4	90
31 August 1971	5	124	9	274	8	361	8	379
6 October 1971	11	167	3	346	5	637	8	78
Total number	85		63		64		52	
Avg. biomass		206.2		271.7		411.5		203.7

greater biomass occurred on 3 May primarily due to a few large carabids and scarabaeids and on 6 October due to large tenebrionids. Biomass figures for 25 March 1971 must be recalculated and will be added to Tables 3 and 4 at a later date.

The ungrazed and recently grazed treatments of the Pawnee Site (Tables 5 and 6) indicate greater soil macroarthropod numbers and biomass in the ungrazed than in the recently grazed pastures. A plot of numbers collected through the season in 1971 (Fig. 6) shows a rather steady decline in numbers starting in the spring. The heavily grazed situation produced fewer arthropods on 10 of 12 sample dates. A rather large peak on 11 August 1971 is evident in Fig. 7 when biomass of the ungrazed enclosure is plotted against time in 1971. This peak in biomass is due to a collection of large tenebrionids.

Differentially grazed pastures (soil macroarthropod orders). A summary of soil macroarthropod orders collected from the four differentially grazed pastures in 1970 is presented in Table 7. A presentation of the abundance and biomass of the orders on each collection date are presented in Appendix IV.

The Coleoptera and Hymenoptera were obviously the dominant orders with respect to both numbers and biomass. When ranked according to abundance as in Table 8, the Coleoptera and Hymenoptera are consistently either first or second. The Homoptera is a group that also ranks high especially in the ungrazed situation.

Ranking the orders according to biomass (Table 9) changes the dominance somewhat. The Coleoptera, with one exception, becomes the dominant order when ranked according to biomass. The oligochaetes contribute considerably to the soil macroarthropod biomass, but are actually relatively

Table 5. Numbers and biomass of soil macroarthropods collected from ungrazed and recently heavily grazed pastures, Pawnee Site, 1971.

Date	Grazing Treatment			
	Ungrazed		Recently heavily grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
22 April 1971	24	228	32	273
12 May 1971	48	1111	25	389
24 May 1971	42	543	26	531
4 June 1971	65	510	28	177
15 June 1971	30	215	29	310
5 July 1971	14	329	4	128
15 July 1971	45	791	27	216
29 July 1971	16	299	8	287
11 August 1971	13	2332	12	110
31 August 1971	3	86	0	0
27 September 1971	11	135	4	19
6 October 1971	12	179	5	102
Total number	323		200	
Avg. Biomass		563.1		211.8

Table 6. Numbers and biomass of soil macroinvertebrates, excluding Formicidae, collected from ungrazed and recently heavily grazed pastures, Pawnee Site, 1971.

Date	Grazing Treatment			
	Ungrazed		Recently heavily grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
22 April 1971	23	247	32	273
12 May 1971	47	1099	25	389
24 May 1971	39	533	26	531
4 June 1971	28	284	24	157
15 June 1971	25	188	29	310
5 July 1971	13	311	4	128
15 July 1971	24	528	22	191
29 July 1971	15	287	8	287
11 August 1971	13	2332	12	110
31 August 1971	3	86	0	0
27 September 1971	11	135	3	14
6 October 1971	11	167	4	90
Total number	252		189	
Avg. biomass		560.4		206.6

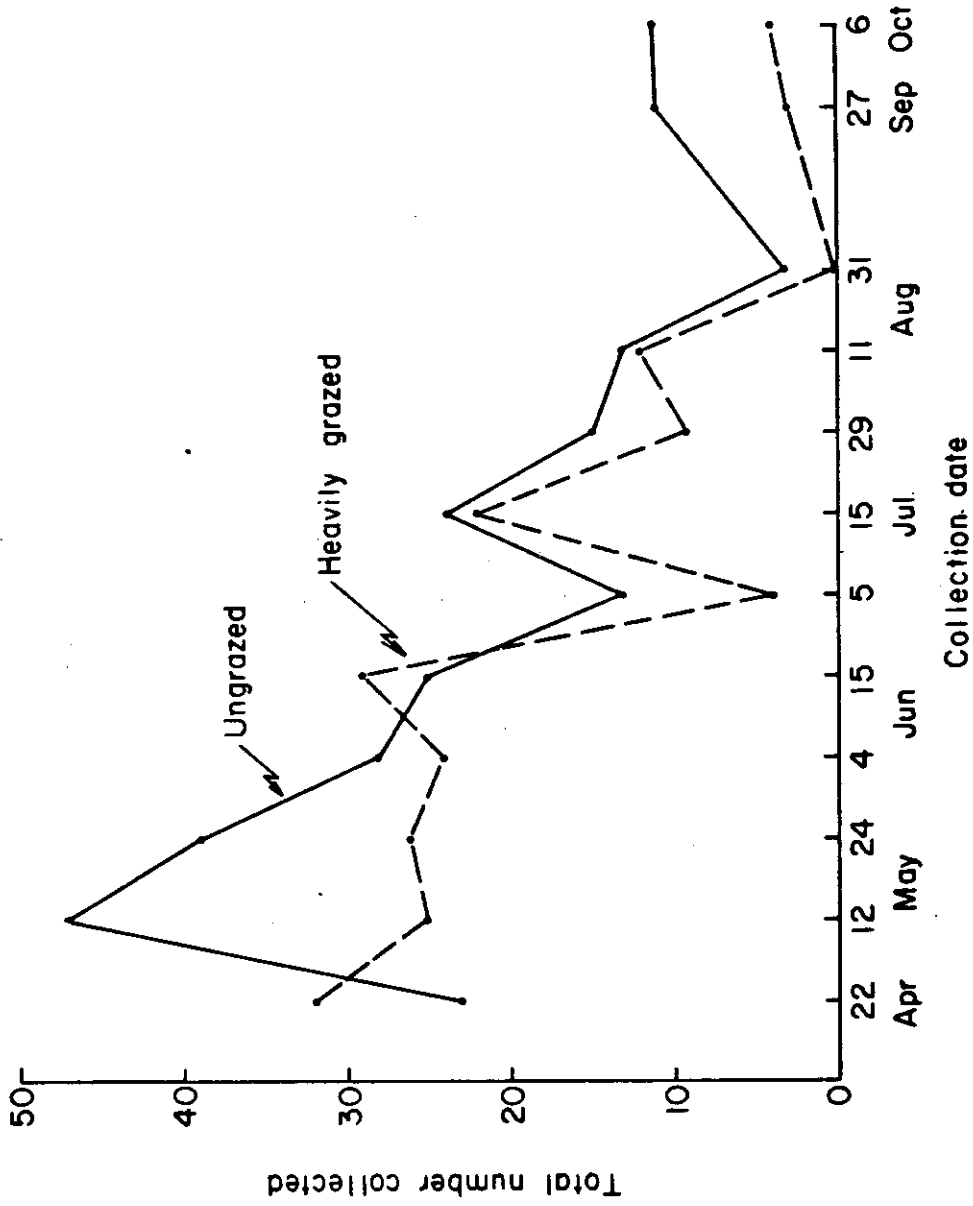


Fig. 6. Seasonal abundance of soil macroarthropods, excluding Formicidae, collected from ungrazed and recently heavily grazed pastures, Pawnee Site, 1971.

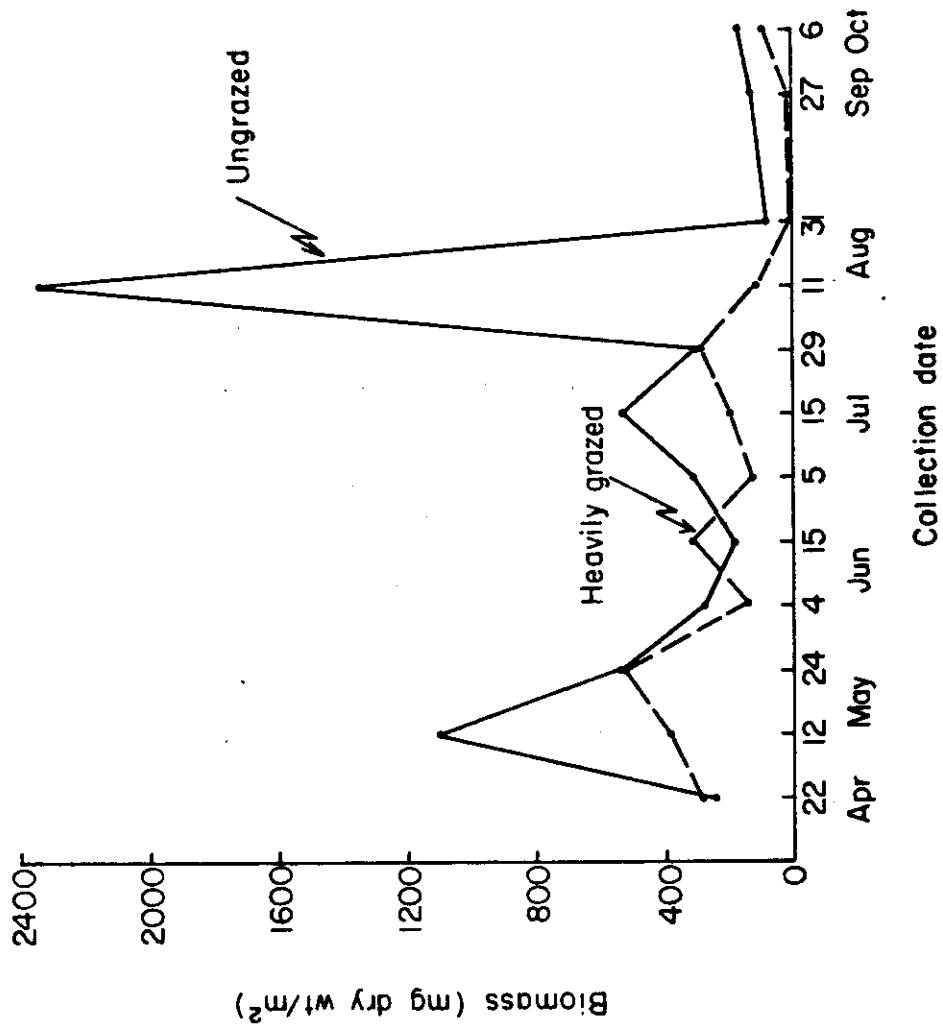


Fig. 7. Biomass of soil macroarthropods, excluding Formicidae, collected from ungrazed and recently heavily grazed pastures, Pawnee Site, 1971.

Table 7. Soil macroarthropod orders collected from four differentially grazed pastures, Pawnee Site, 1970.

Order	Grazing Treatment							
	Ungrazed		Lightly grazed		Moderately grazed		Heavily grazed	
	Number	Biomass ₂ (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass ₂ (mg/m ²)
Acarina	1	0.1	5	0.4	2	0.1	4	0.4
Araneida	1	0.4	17	0.3	5	1.3	1	0.1
Coleoptera	338	598.7	227	566.2	275	766.6	131	399.7
Diptera	10	34.1	10	20.0	19	58.5	9	28.0
Hemiptera	5	7.3	14	8.2	13	1.0	1	0.1
Homoptera	77	35.2	20	13.0	30	16.6	56	34.0
Hymenoptera	338	144.3	803	593.7	127	50.3	229	181.0
Isoptera	4	0.6	11	2.5	93	16.7	0	0
Lepidoptera	1	0.3	17	29.4	15	9.2	2	0.5
Oligochaeta	9	149.4	39	315.8	3	45.2	1	0
Orthoptera	0	0	0	0	14	4.4	0	0

Table 8. Relative abundance of soil macroarthropod orders collected from four differentially grazed pastures, Pawnee Site, 1970.

Order	Grazing Treatment			
	Ranking*			
	Ungrazed	Light	Moderate	Heavy
Acarina	7	9	11	5
Araneida	7	5	9	7
Coleoptera	1	2	1	2
Diptera	3	8	5	4
Hemiptera	5	6	8	7
Homoptera	2	4	4	3
Hymenoptera	1	1	2	1
Isoptera	6	7	3	8
Lepidoptera	7	5	6	6
Oligochaeta	4	3	10	7
Orthoptera	8	10	7	8

*1 = most abundant.

Table 9. Relative abundance of biomass of soil macroarthropod orders collected from four differentially grazed pastures, Pawnee Site 1970.

Order	Grazing Treatment			
	Ranking*			
	Ungrazed	Light	Moderate	Heavy
Acarina	10	9	11	6
Araneida	8	10	9	7
Coleoptera	1	2	1	1
Diptera	5	5	2	4
Hemiptera	6	7	10	8
Homoptera	4	6	6	3
Hymenoptera	3	1	3	2
Isoptera	7	8	5	10
Lepidoptera	9	4	7	5
Oligochaeta	2	3	4	9
Orthoptera	11	11	8	10

*1 = most abundant.

rare organisms. Larger, less abundant orders such as the Diptera become much more dominant when the orders are ranked according to biomass.

The abundance of insect orders collected from the four differentially grazed pastures in 1971 is presented in Table 10. These data are presented by sample date in Appendix V. Sampling on only five occasions is the reason for the low numbers collected from these treatments in 1971. Very few Hymenoptera were collected in 1971; obviously, then, the dominant orders were Coleoptera and Homoptera. Although all biomass data are not available at present, it appears certain that total biomass of the Coleoptera would far exceed that of the Homoptera.

The orders present in greatest numbers and biomass from the ungrazed and recently grazed treatments were also Coleoptera and Homoptera (Table 11). Approximately equal numbers of Homoptera were collected from the two treatments; however, almost twice as many Coleoptera were collected from the ungrazed pasture as from the recently heavily grazed. Soil macroarthropod orders by collection date from these two treatments are presented in Appendix VI.

Differentially grazed pastures (soil macroarthropod families). A presentation of the abundance and biomass of soil macroarthropod families collected in 1970 from four differentially grazed pastures is in Table 12. Frequently identification of a specimen to family will give a clue to the feeding habit. Unfortunately, however, many soil macroarthropod families contain phytophages, decomposers, and predators.

The most abundant Coleoptera family in 1970 was by far the Scarabaeidae. Most of the Scarabaeidae collected in this study were plant feeders, feeding on either live or dead plant material. The greatest number of Scarabaeidae

Table 10. Soil macroarthropod orders collected from four differentially grazed pastures, Pawnee Site, 1971.

Order	Grazing Treatment			
	Number of Macroarthropods			
	Ungrazed	Light	Moderate	Heavy
Acarina	0	0	0	1
Coleoptera	34	35	46	27
Collembola	0	0	1	0
Diptera	1	3	2	1
Hemiptera	0	1	0	0
Homoptera	49	22	18	21
Hymenoptera	6	3	3	2
Isoptera	1	0	0	0
Lepidoptera	0	1	0	0
Orthoptera	0	0	0	2

Table 11. Soil macroarthropod orders collected from ungrazed and recently heavily grazed pastures, Pawnee Site, 1971.

Order	Grazing Treatment			
	Ungrazed		Recently Heavily Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	0	0	1	0.1
Coleoptera	113	402.4	61	92.6
Diptera	20	19.5	5	14.2
Hemiptera	3	0.3	2	5.9
Homoptera	115	94.6	109	90.1
Hymenoptera	71	48.7	11	5.2
Lepidoptera	1	3.1	0	0
Neuroptera	1	0.5	0	0
Orthoptera	0	0	11	1.5

Table 12. Soil macroarthropod families collected from four differentially grazed pastures, Pawnee Site, 1970.

Family	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina								
Erythraeidae	0	0	1	0.1	1	0	4	0.5
Trombididae	1	0.1	3	0.3	1	0.1	1	0.1
Araneida								
Lycosidae	0	0	2	0.3	0	0	1	0.1
Coleoptera								
Anthicidae	1	0	0	0	1	0.1	1	0.1
Carabidae	12	36.7	29	79.8	12	36.2	17	72.4
Cerambycidae	1	5.1	1	5.1	1	5.1	2	5.5
Chrysomelidae	1	0.4	2	0.7	3	2.1	3	1.1
Cicindelidae	0	0	1	3.0	0	0	0	0
Curculionidae	22	33.6	21	26.3	11	24.2	10	17.3
Elateridae	20	25.4	1	0.8	10	26.3	8	14.2

Table 12. (continued).

Family	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass ₂ (mg/m ²)	Number	Biomass ₂ (mg/m ²)	Number	Biomass ₂ (mg/m ²)	Number	Biomass ₂ (mg/m ²)
Coleoptera (continued)								
Endomyidae	0	0	0	0	2	0.4	0	0
Heteroceridae	0	0	1	0.7	0	0	0	0
Hydrophilidae	0	0	1	0.6	0	0	0	0
Meloidae	1	2.6	1	5.2	1	2.7	1	2.6
Mycetophagidae	0	0	0	0	1	0.7	0	0
Phalacridae	0	0	0	0	1	0.1	0	0
Scarabaeidae	236	6.7	137	233.4	177	126.8	56	67.0
Staphylinidae	24	275.7	20	4.7	31	14.2	22	8.0
Tenebrionidae	18	5623.5	19	214.3	20	530.6	11	211.6
Diptera								
Asilidae	7	34.3	6	29.3	13	56.3	6	26.9
Hemiptera								
Coreidae	1	3.2	1	4.7	0	0	0	0
Corixidae	1	4.0	0	0	0	0	0	0
Cynidae	0	0	1	2.1	0	0	0	0
Lygaeidae	3	0.2	12	1.4	13	1.2	1	0.1

Table 12. (continued).

Family	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass ₂ (mg/m ²)	Number	Biomass ₂ (mg/m ²)	Number	Biomass ₂ (mg/m ²)	Number	Biomass ₂ (mg/m ²)
Homoptera								
Aphididae	2	0.1	0	0	3	0.1	2	0.1
Margarodidae	73	49.4	19	12.9	24	16.1	50	33.5
Pseudococcidae	4	1.1	1	0.2	4	1.1	3	0.6
Psyllidae	0	0	0	0	0	0	1	0
Hymenoptera								
Formicidae	323	144.7	802	592.5	127	50.7	229	184.3
Halictidae	1	0	0	0	0	0	0	0
Isoptera								
Rhinotermitidae	3	0.7	11	2.6	66	16.8	0	0
Lepidoptera								
Arctiidae	1	0.3	14	3.9	9	2.3	0	0
Geometridae	0	0	1	0.1	0	0	0	0
Hesperiidae	0	0	1	24.8	0	0	0	0
Oligochaeta								
Megascolicidae	0	0	11	182.6	3	45.3	0	0
Orthoptera								
Acrididae	0	0	0	0	4	1.3	0	0

occurred in the ungrazed exclosures; the least occurred in the heavily grazed pasture.

The Curculionidae, which were plant feeders, were more abundant in the ungrazed and lightly grazed situations than in the moderately or heavily grazed pastures. The Elateridae, which were all larvae and could well be phytophagous, were most abundant in the ungrazed exclosures.

The Tenebrionidae, as indicated in Table 12, are massive organisms and both adults and larvae were collected in these studies. Most tenebrionids feed primarily on plant materials. In 1970 tenebrionids were equally abundant in the ungrazed exclosure and the lightly and moderately grazed pastures, but were only half as abundant in the heavily grazed pasture.

The Staphylinidae, which are primarily predaceous, were most numerous in the moderately grazed pasture. They might be expected to be most abundant in areas where there is cow dung since they frequent this sort of habitat in search of prey. Staphylinids are extremely mobile, however, and would be expected to readily wander into the ungrazed exclosures.

The Carabidae, another predominately predaceous family, was most abundant in the lightly grazed pastures and abundant equally in the others.

The most abundant group other than the Coleoptera and Hymenoptera is the Homoptera. From Table 12 the most abundant Homopterans are the Margarodidae or "ground pearls." These are undoubtedly phytophagous, feeding on plant fluids, and are probably host specific (Morrison 1928). The greatest number of margarodids occurred in the ungrazed exclosures in 1970. Many more occurred in the heavily grazed pasture than in the lightly or moderately grazed pastures.

Appendix VII presents the soil macroarthropod families collected on each sample date in 1970. A look at soil macroarthropod families collected from the four differentially grazed pastures in 1971 (Table 13) again shows that the Scarabaeidae is the most abundant family of Coleoptera present in all grazing treatments. Once again there were almost half as many present in the heavily grazed pasture as in the other pasture treatments. So few samples were taken from the four differentially grazed pastures in 1971, resulting in low numbers of organisms collected, that it is difficult to comment on the less abundant remaining Coleoptera.

In 1971, as in 1970, many more Margarodidae were collected from the ungrazed pasture than from the other treatments. There appeared to be no difference among the remaining three treatments. Seasonal abundance in 1971 of the soil macroarthropod families collected from the four differentially grazed pastures is presented in Appendix VIII.

Bimonthly sampling of the ungrazed exclosure and the exclosure established in the heavily grazed pasture between the grazing seasons of 1970 and 1971 revealed almost twice as many Scarabaeidae in the ungrazed exclosure (Table 14). These findings are consistent with those of 1970. Many more Tenebrionidae were captured in the ungrazed exclosure, which also agrees with the findings of 1970.

Both the ungrazed and recently grazed treatments yielded approximately the same number of Margarodidae in 1971. The difference in the number of margarodids collected from ungrazed and heavily grazed treatments was not great in the previous year.

It is tempting to note the differences between numbers in Coleoptera families collected from the ungrazed exclosures and recently heavily grazed pastures in 1971. The total number of organisms is extremely small,

Table 13. Abundance and biomass of soil macroarthropod families collected from four differentially grazed pastures, Pawnee Site, 1971.

Family	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera						
Carabidae	4	19.3	3	48.0	4	84.3*
Curculionidae	3	4.7	6	52.0*	3	16.0*
Elateridae	1	0.8	1	--*	1	--*
Histeridae	1	6.3	0	0	0	0
Scarabaeidae	23	83.7*	20	37.3*	24	107.9*
Staphylinidae	1	--*	1	0.6	3	1.1*
Tenebrionidae	1	6.0	2	66.8*	8	192.1*
Collembola						
Entomobryidae	0	0	0	0	1	--*
Diptera						
Asilidae	0	0	1	14.6	2	--*
Therevidae	0	0	1	3.3	0	0
Hemiptera						
Cydnidae	0	0	1	6.2	0	0
Homoptera						
Margarodidae	48	75.2*	22	22.6*	17	10.0*
Pseudococcidae	1	2.9	0	0	1	0.1
Hymenoptera						
Formicidae	6	0.7*	3	4.7	3	1.4*
Isoptera						
Rhinotermitidae	1	--*	0	0	0	0
Orthoptera						
Acrididae	0	0	0	0	0	0
					2	1.9

* Does not include biomass of soil macroarthropods collected on 25 March 1971.

Table 14. Soil macroarthropod families collected from ungrazed and recently heavily grazed pastures, Pawnee Site, 1971.

Family	Grazing Treatment			
	Ungrazed		Recently Heavily Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera				
Carabidae	9	5.0		
Cerambycidae	0	0	4	37.5
Curculionidae	8	20.8	1	6.4
Elateridae	9	9.4	4	18.3
Scarabaeidae	61	61.6	1	0.7
Staphylinidae	3	1.8	39	18.1
Tenebrionidae	21	253.7	7	3.0
			3	8.1
Diptera				
Asilidae	3	15.3	2	12.2
Hemiptera				
Cydnidae	0	0	1	5.9
Lygaeidae	3	0.3	1	0.1
Homoptera				
Margarodidae	113	94.4	109	90.4
Pseudococcidae	2	0.5	0	0
Hymenoptera				
Formicidae	71	49.2	11	5.4
Neuroptera				
Myrmeleontidae	1	0.5	0	0
Orthoptera				
Acrididae	0	0	11	1.5

but there were more Carabidae, Curculionidae, Elateridae, Scarabaeidae, and Tenebrionidae, and fewer Staphylinidae collected from the ungrazed exclosures.

Seasonal appearance of soil macroarthropod families collected from the ungrazed and recently heavily grazed pasture treatments in 1971 is presented in Appendix IX.

Ecosystem stress treatments. Soil macroarthropod numbers and biomass from plots in the Ecosystem Stress Area, which were treated with water, nitrogen, water plus nitrogen, and no treatment, are presented in Table 15 (including ants) and Table 16 (excluding ants). Sample numbers were few in 1971; however, those taken appear to reflect a response of soil macroarthropods to the treatments. When ants were excluded from the data (Table 16), water alone appeared to increase abundance and biomass over nitrogen alone or no treatment. Water plus nitrogen increased abundance and biomass over those of the water only treatment.

Increases in numbers and biomass of Coleoptera and Homoptera with the water and water plus nitrogen treatments can be seen in Table 17. Except for Hymenoptera, the Coleoptera and Homoptera were the dominant insect orders in this study.

Families of soil macroarthropods collected in this study are presented in Table 18. A close look at the Coleoptera responsible for the increase in numbers due to water and nitrogen plus water shows that the Scarabaeidae were primarily responsible. The Margarodidae of the Homoptera increased considerably due to the stress treatments of water and water plus nitrogen.

Table 15. Numbers and biomass of soil macroarthropods collected from four stressed pastures, Pawnee Site, 1971.

Date	Stress Treatment					
	No Treatment		Water		Nitrogen	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
20 March 1971	22	274	26	618	11	218
8 May 1971	125	1133	15	146	24	491
9 July 1971	8	289	7	401	10	179
1 September 1971	3	112	5	387	3	230
13 October 1971	10	206	24	772	8	369
Total number	168		77		56	
Avg. Biomass		402.8		464.8		297.4
					133	510.8

Table 16. Total numbers and biomass of soil macroarthropods, excluding ants, collected from four stressed pastures, Pawnee Site, 1971.

Date	Stress Treatment					
	No Treatment		Water		Nitrogen	
	Number	Biomass	Number	Biomass	Number	Biomass
20 March 1971	20	263	26	618	11	218
8 May 1971	15	731	15	146	19	474
9 July 1971	8	289	7	401	8	151
1 September 1971	3	112	5	387	3	230
13 October 1971	10	206	23	760	5	332
Total number	56		76		46	
Avg. Biomass		320.2		462.4		281.0
						493.8

Table 17. Soil macroarthropod orders collected from pastures receiving no treatment, irrigation, nitrogen fertilization, or irrigation plus nitrogen, Pawnee Site, 1971.

Order	Sample Date											
	20 March		8 May		9 July		1 September		13 October		Total	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
<i>No Treatment</i>												
Araneida												
Coleoptera	9	173	11	701	7	254	3	112	7	93	37	266.6
Diptera	4	19	1	8					3	112	8	5.4
Hemiptera			1	1	1	35					2	7.2
Homoptera	7	70	2	20							9	18
Hymenoptera	2	11	110	402							112	82.6
Lepidoptera												
Total	22	273	125	1132	8	289	3	112	10	205		
<i>Irrigated</i>												
Araneida												
Coleoptera	11	476	1	6	7	401	3	310	1	9	1	1.8
Diptera							2	77	21	749	43	388.4
Hemiptera	1	1									2	15.4
Homoptera	14	140	14	140					1	1	2	0.4
Hymenoptera											28	56.0
Lepidoptera									1	12	1	2.4
Total	26	617	15	146	7	401	5	387	24	771		

Table 17. (continued).

Order	Sample Date										Total	
	20 March		8 May		9 July		1 September		13 October			
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
<i>Fertilized</i>												
Araneida	1	1										
Coleoptera	7	187	9	373	5	36	3	230	5	332	1	0.2
Diptera					1	73					29	231.6
Hemiptera											1	14.6
Homoptera	3	30	10	100	1	2						
Hymenoptera			5	17	2	28					14	26.4
Lepidoptera					1	38			3	37	10	16.4
Total	11	218	24	490	10	177	3	230	8	369	1	7.6
<i>Fertilized and Irrigated</i>												
Araneida												
Coleoptera	4	134	13	133	9	509	6	223	18	694	50	338.6
Diptera	2	146			1	73					3	43.8
Hemiptera			2	2							2	0.4
Homoptera	8	80	37	370	6	60	1	10	3	30	55	110.0
Hymenoptera	1	2	19	67			3	16			23	17.0
Lepidoptera												
Total	15	362	71	572	16	642	10	249	21	724		

Table 18. Soil macroarthropod families collected from pastures receiving no treatment, irrigation, nitrogen fertilization, or irrigation plus nitrogen, Pawnee Site, 1971.

Family	Sample Date					
	20 March	8 May	9 July	1 September	13 October	
	Number	Number	Number	Number	Number	Biomass (mg/m ²)
Coleoptera						
Scarabaeidae	5	5	1		3	77.0
Curculionidae	1	349.3	4	4.7		9.4
Tenebrionidae	1	14.9		24.6		
Carabidae	1	337.2	2	224.8	3	112.4
Staphylinidae	1	112.4				
Chrysomelidae	1	13.1				
Elateridae						
Histeridae					1	7.2
Anthicidae						
Homoptera						
Margarodidae	7	70.1				
Pseudococcidae		2		20.0		
Hymenoptera						
Formicidae	2	11.5	110	402.4		
Diptera						
Asilidae						
Therevidae		1		8.5	3	112.9
Hemiptera						
Lygaeidae		1	1	35.3		
Total	18	254.7	125	1133.4	3	112.4
			8	289.4	10	206.5

Table 18. (continued).

Family	Sample Date									
	20 March		8 May		9 July		1 September		13 October	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
<i>Irrigated</i>										
Coleoptera										
Scarabaeidae	3	209.5			2	139.7	3	310.0	14	392.8
Curculionidae	2	12.3	1	6.1	2	12.3				
Tenebrionidae					1	122.0				
Carabidae	1	150.9			2	127.6			5	350.8
Staphylinidae									2	5.8
Chrysomelidae										
Elateridae										
Histeridae										
Anthicidae										
Homoptera										
Margarodidae	14	140.3	14	140.3						
Pseudococcidae										
Hymenoptera										
Formicidae									1	12.4
Diptera										
Asilidae							1	73.2		
Hemiptera										
Lygaeidae	1	1.1							1	1.1
Total	21	514.1	15	146.4	7	401.6	4	383.2	23	762.9

Table 18. (continued).

Family	Sample Date									
	20 March		8 May		9 July		1 September		13 October	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
<i>Fertilized</i>										
Coleoptera										
Scarabaeidae	1	4.7					1	5.6	1	69.8
Curculionidae			5	28.7	4	20.9			1	7.2
Tenebrionidae	6	182.3							1	30.3
Carabidae			3	337.7	1	15.2	2	224.8	2	224.8
Staphylinidae										
Chrysomelidae										
Elateridae										
Histeridae										
Anthicidae										
Homoptera										
Margarodidae	3	30.0	10	100.2						
Pseudococcidae					1	2.9				
Hymenoptera										
Formicidae			5	17.7	2	28.4			3	37.4
Diptera										
Asilidae					1	73.2				
Therevidae										
Hemiptera										
Lygaeidae										
Total	10	217.0	23	484.3	9	140.6	3	230.4	8	369.5

Table 18. (continued).

Family	Sample Date					
	20 March		8 May		9 July	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
					1 September	13 October
					Number	Biomass (mg/m ²)
<i>Irrigation and Fertilization</i>						
Coleoptera						
Scarabaeidae	2	11.3	10	119.1	2	69.8
Curculionidae	1	11.1	1	6.1	1	5.6
Tenebrionidae					1	30.3
Carabidae	1	112.4			1	112.4
Staphylinidae			2	8.5		
Chrysomelidae					1	5.6
Elateridae						
Histeridae						
Anthicidae						
Homoptera						
Margarodidae	8	80.2	37	370.9	1	10.0
Pseudococcidae					3	30.0
Hymenoptera						
Formicidae	1	2.8	19	67.4	3	16.5
Diptera						
Asilidae	2	146.5			1	73.2
Therevidae						
Hemiptera						
Lygaeidae			2	2.3		
Total	15	364.3	71	574.3	10	250.2
					21	724.6

CONCLUSIONS

The grazing and stress treatments had a definite effect on soil macroarthropod abundance and biomass. Heavy grazing by large herbivores is accompanied by a reduction in soil macroarthropods. Absence of grazing, i.e., in the permanently ungrazed exclosures, appears to result in an increased soil macroarthropod abundance and biomass, especially those macroarthropods likely to be decomposers.

The feeding habits of most of the soil macroarthropods is unknown. For this reason the "trophic" designation "0" (= unknown) is the most commonly used. A presentation of soil macroarthropod abundance and biomass by trophic position would be meaningless because of the overwhelming numbers in the unknown category.

At the beginning of the research it was hoped that food habits of at least the dominant organisms might be determined experimentally. At present there appears to be little interest in determining this. Therefore, current plans are to assign a trophic position to each organism based on the food habits of taxonomically related organisms.

Soil macroarthropods appear to be relatively abundant at the Pawnee Site. The collections made in 1970 and 1971 have been reported here as number collected per sample. If the data are presented on a number per square meter basis the numbers become enormous. For example, the average number of soil macroarthropods collected per square meter in 1970 were 407, 619, 304, and 228 from the ungrazed, and lightly, moderately, and heavily grazed treatments, respectively. In 1971 collections from the same four grazing treatments were 143, 104, 105, and 85 soil macroarthropods/m². The 1971 collections were not made at the time of appearance of maximum numbers. The permanently ungrazed and recently heavily grazed pastures in

1971 yielded 212 and 131 soil macroarthropods/m². The plots established in 1971 and subjected to no treatment, irrigation, nitrogen fertilization, or irrigation plus nitrogen, yielded 265, 121, 88, and 209 soil macroarthropods/m².

Although the purpose of this report is not to provide a synthesis of soil macroarthropod and other studies conducted at the Pawnee Site, it seems appropriate to mention a few of the comparisons that might be made.

A correlation of true soil forms with soil water at various depths might provide a clue to the seasonal fluctuation seen in soil core samples.

The amount of food available in the various pasture treatments may influence populations of soil macroarthropods. Excess detritus in ungrazed exclosures may cause a buildup of decomposers. The amount of root material available may influence populations of root grazers.

The quality of food may influence populations of primary consumers. The ecosystem stress studies involving irrigation and fertilization may well provide food of varying quality.

Other than competing for food, the presence of large herbivores may affect populations of soil macroarthropods. Cow dung, for example, is known to be extremely important in the development of some of the organisms.

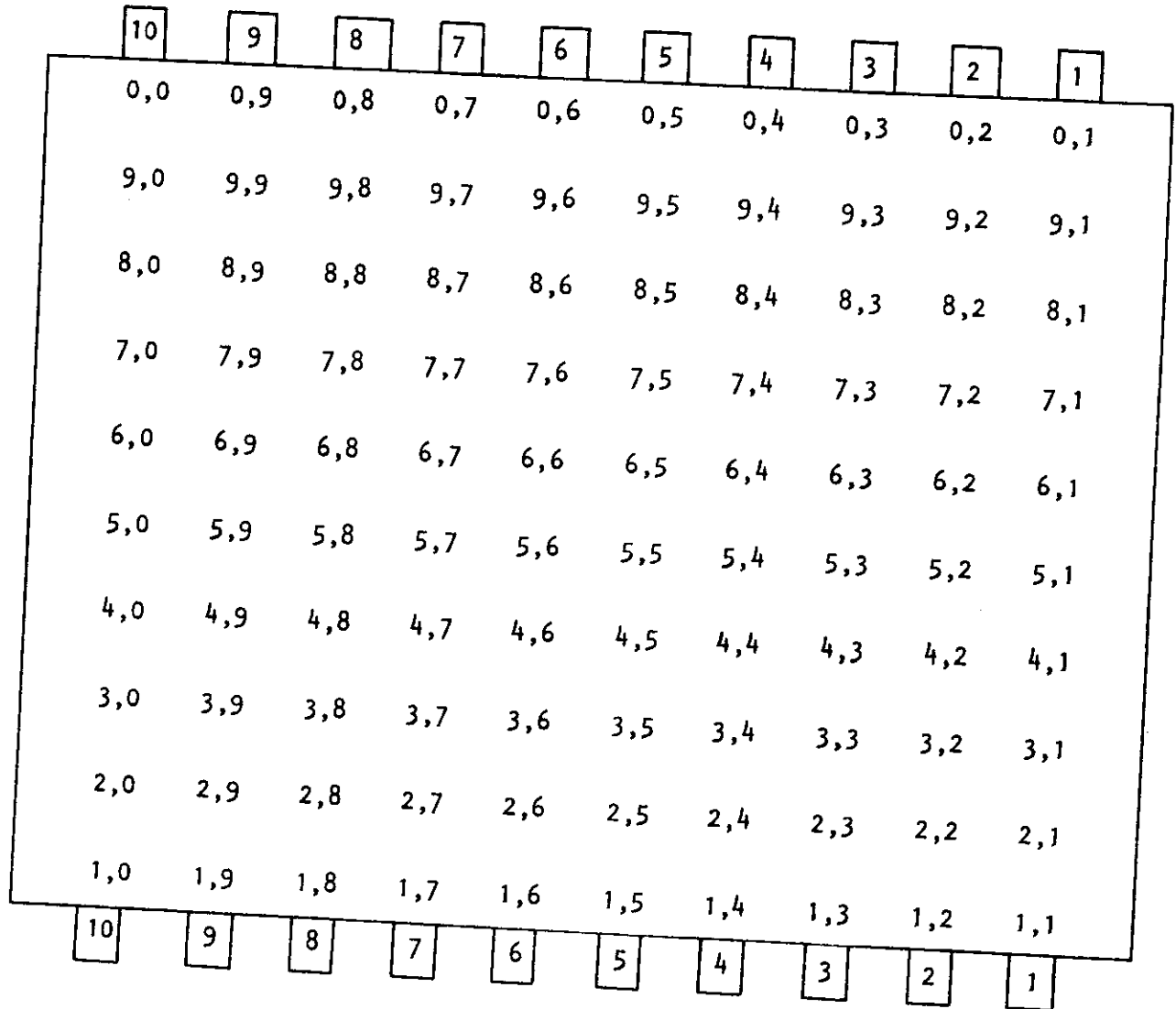
No attempt has yet been made to determine the effect of the various stress treatments on species diversity. It may be that sampling methods are not yet refined to the accuracy required for a study of species diversity.

LITERATURE CITED

- Jameson, D. A., and R. E. Bement. 1969. General description of the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 1. Colorado State Univ., Fort Collins. 32 p.
- Klipple, G. E., and D. F. Costello. 1960. Vegetation and cattle responses to different intensities of grazing on short-grass ranges on the central Great Plains. USDA Tech. Bull. No. 1216. 82 p.
- Kumar, R., R. J. Lavigne, J. E. Lloyd, R. E. Pfadt, J. Chu, R. R. Grow, and L. E. Rogers. 1972. Insects of the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 192. Colorado State Univ., Fort Collins. 62 p.
- Lloyd, J. E., and R. R. Grow. 1971. Soil macroarthropods of the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 104. Colorado State Univ., Fort Collins. 18 p.
- Morrison, H. 1928. A classification of the higher groups and genera of the coccid family Margarodidae. USDA Tech. Bull. No. 52. 48 p.
- Salt, G., and F. S. J. Hollick. 1944. Studies of wireworm populations. I. A census of wireworms in pasture. Ann. Appl. Biol. 31:53-63.
- Sims, P. L., D. W. Uresk, D. L. Bartos, and W. K. Lauenroth. 1971. Herbage dynamics on the Pawnee Site: Aboveground and belowground herbage dynamics on the four grazing intensity treatments; and preliminary sampling on the ecosystem stress site. U.S. IBP Grassland Biome Tech. Rep. No. 99. Colorado State Univ., Fort Collins. 95 p.
- Smith, F. M., and W. D. Streffler. 1969. Pawnee Site microwatersheds: Selection, description and instrumentation. U.S. IBP Grassland Biome Tech. Rep. No. 5. Colorado State Univ., Fort Collins. 29 p.

APPENDIX I
PAWNEE SITE STUDY PLOTS 1970-71

Study Plot No. 1



Lowest Edge of Plot

Pasture - 23 East

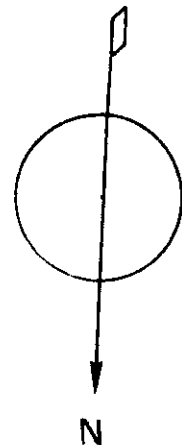
Treatment - heavily grazed

Replicate - one

Area - one acre

Number of sample points - 100

Exposure - northern



Study Plot No. 2

4	3	2	1
0,4	0,3	0,2	0,1
9,4	9,3	9,2	9,1
8,4	8,3	8,2	8,1
7,4	7,3	7,2	7,1
6,4	6,3	6,2	6,1
5,4	5,3	5,2	5,1
4,4	4,3	4,2	4,1
3,4	3,3	3,2	3,1
2,4	2,3	2,2	2,1
1,4	1,3	1,2	1,1
4	3	2	1

Lowest Edge of Plot

Pasture - 23 East

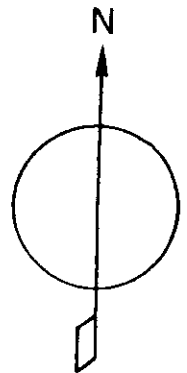
Treatment - ungrazed

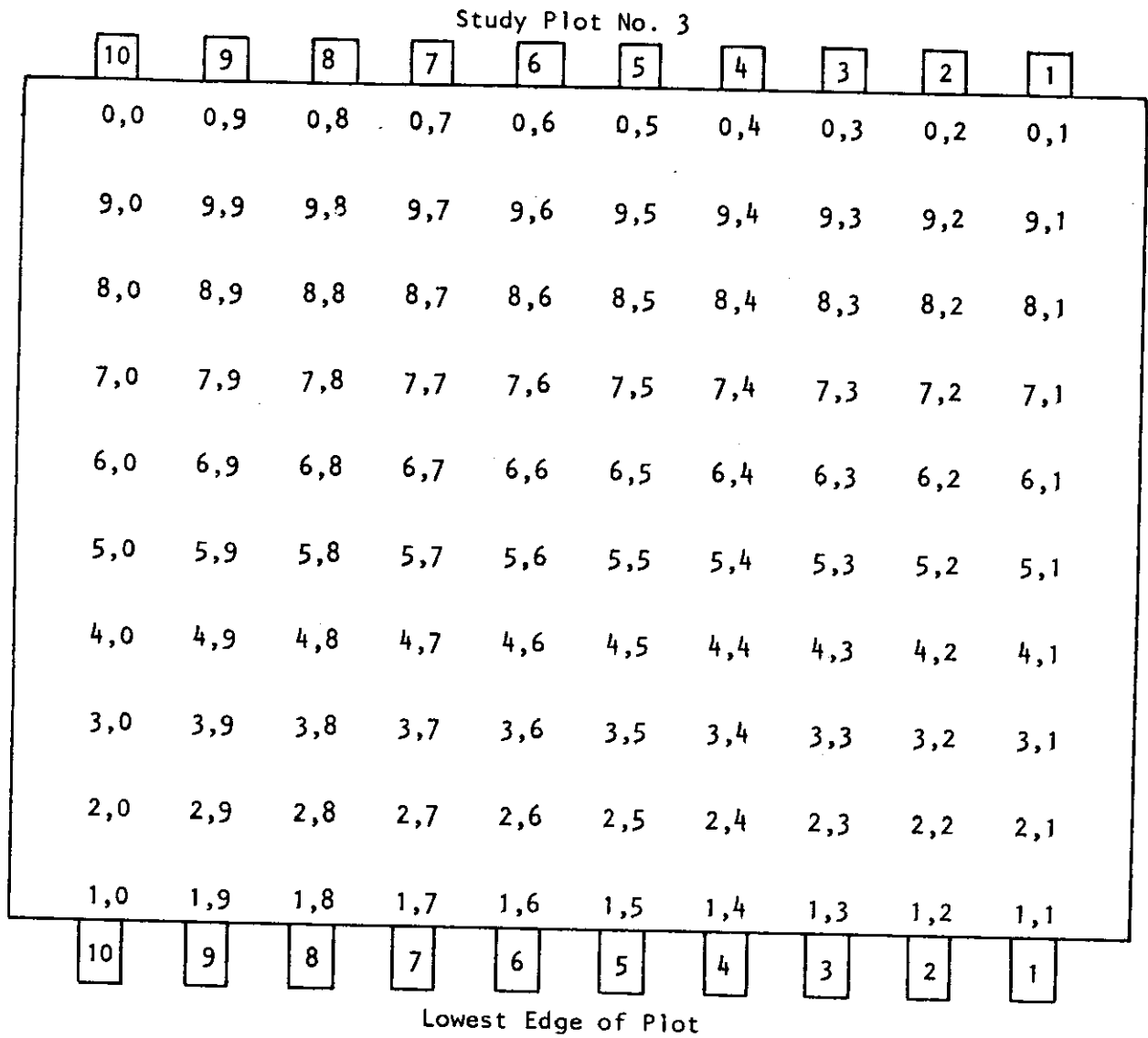
Replicate - one

Area - 0.4 acre

Number of sample points - 40

Exposure - southern





Pasture - 23 East

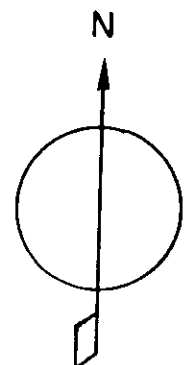
Treatment - heavily grazed

Replicate - two

Area - one acre

Number of sample points - 100

Exposure - southern



Study Plot No. 4

10	9	8	7	6	5	4	3	2	1
0,0	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1
9,0	9,9	9,8	9,7	9,6	9,5	9,4	9,3	9,2	9,1
8,0	8,9	8,8	8,7	8,6	8,5	8,4	8,3	8,2	8,1
7,0	7,9	7,8	7,7	7,6	7,5	7,4	7,3	7,2	7,1
6,0	6,9	6,8	6,7	6,6	6,5	6,4	6,3	6,2	6,1
5,0	5,9	5,8	5,7	5,6	5,5	5,4	5,3	5,2	5,1
4,0	4,9	4,8	4,7	4,6	4,5	4,4	4,3	4,2	4,1
3,0	3,9	3,8	3,7	3,6	3,5	3,4	3,3	3,2	3,1
2,0	2,9	2,8	2,7	2,6	2,5	2,4	2,3	2,2	2,1
1,0	1,9	1,8	1,7	1,6	1,5	1,4	1,3	1,2	1,1
10	9	8	7	6	5	4	3	2	1

Lowest Edge of Plot

Pasture - 23 West

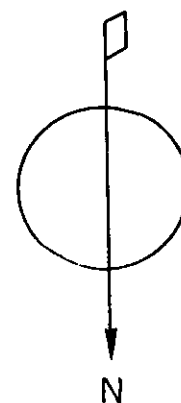
Treatment - lightly grazed

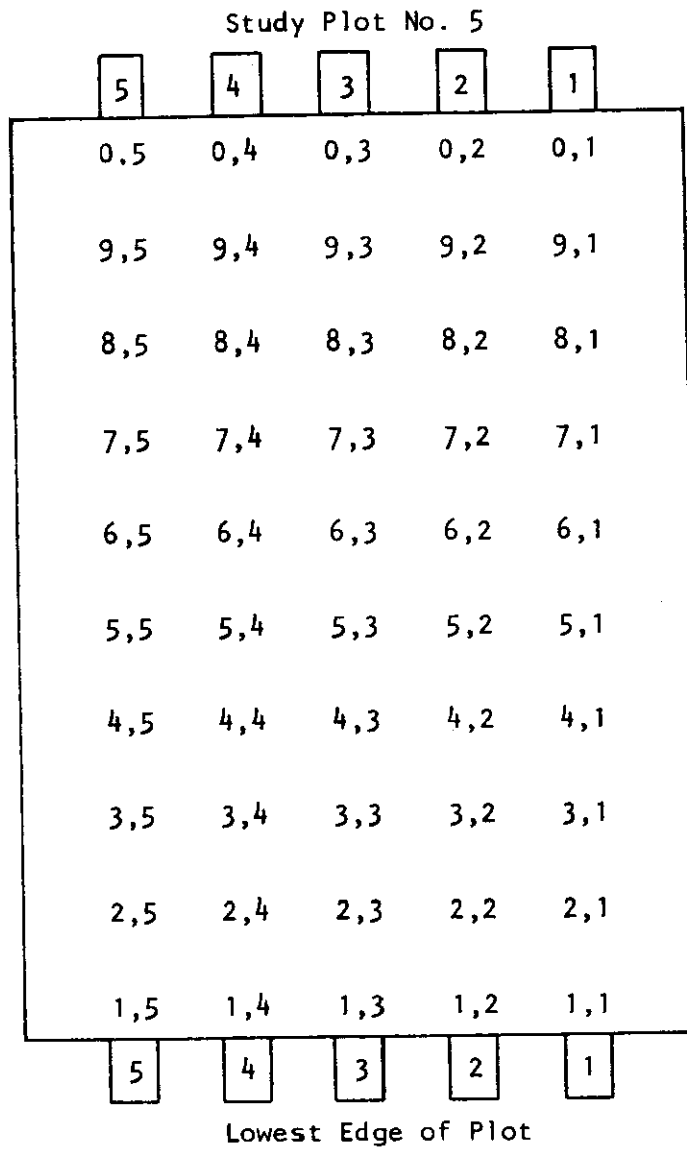
Replicate - one

Area - one acre

Number of sample points - 100

Exposure - northern





Pasture - 23 West

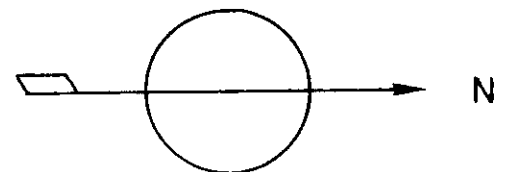
Treatment - lightly grazed

Replicate - two

Area - 0.5 acre

Number of sample points - 50

Exposure - eastern



Study Plot No. 6

10	9	8	7	6	5	4	3	2	1
0,0	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1
9,0	9,9	9,8	9,7	9,6	9,5	9,4	9,3	9,2	9,1
8,0	8,9	8,8	8,7	8,6	8,5	8,4	8,3	8,2	8,1
7,0	7,9	7,8	7,7	7,6	7,5	7,4	7,3	7,2	7,1
6,0	6,9	6,8	6,7	6,6	6,5	6,4	6,3	6,2	6,1
5,0	5,9	5,8	5,7	5,6	5,5	5,4	5,3	5,2	5,1
4,0	4,9	4,8	4,7	4,6	4,5	4,4	4,3	4,2	4,1
3,0	3,9	3,8	3,7	3,6	3,5	3,4	3,3	3,2	3,1
2,0	2,9	2,8	2,7	2,6	2,5	2,4	2,3	2,2	2,1
1,0	1,9	1,8	1,7	1,6	1,5	1,4	1,3	1,2	1,1
10	9	8	7	6	5	4	3	2	1

Lowest Edge of Plot

Pasture - 15 East

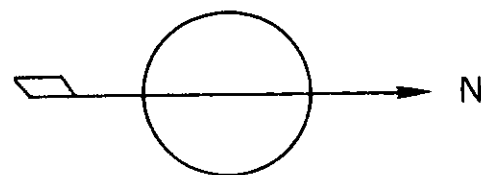
Treatment - moderately grazed

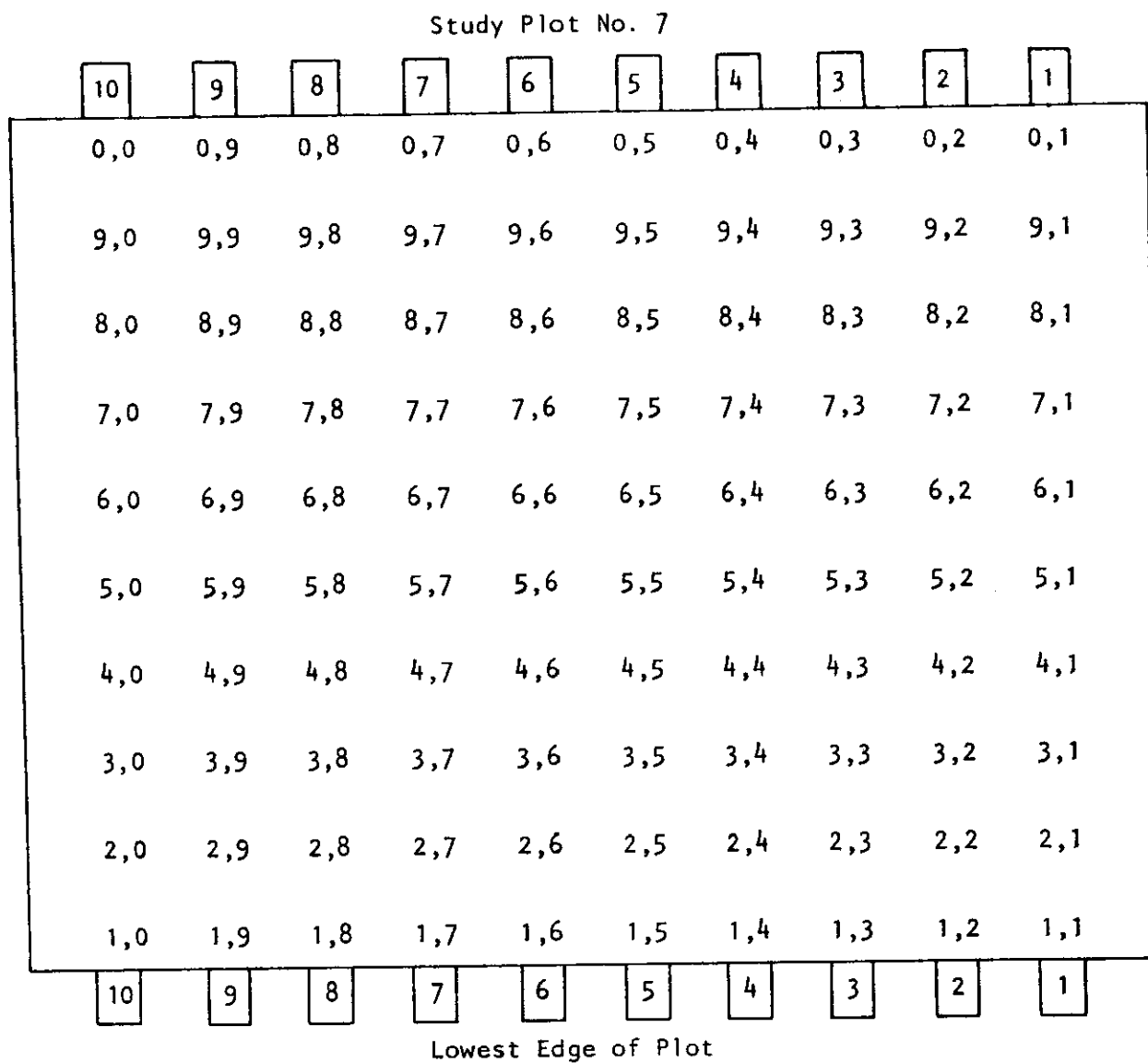
Replicate - one

Area - one acre

Number of sample points - 100

Exposure - eastern





Pasture - 15 East

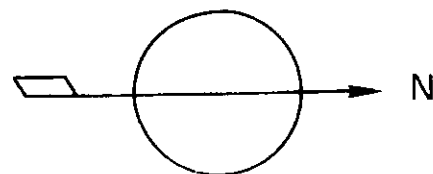
Treatment - moderately grazed

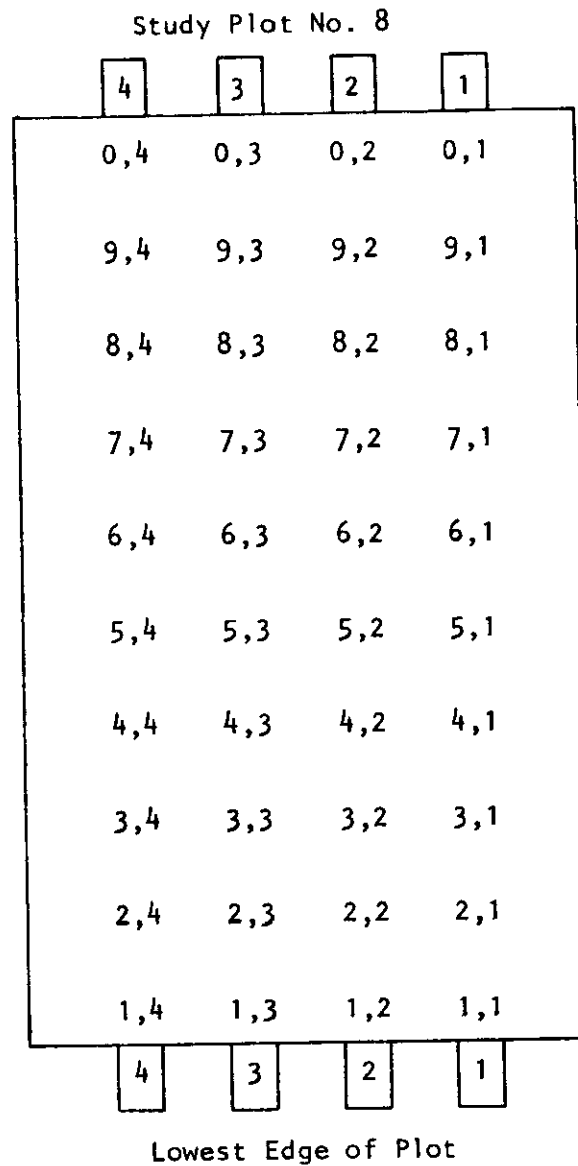
Replicate - two

Area - one acre

Number of sample points - 100

Exposure - eastern





Pasture - 15 West

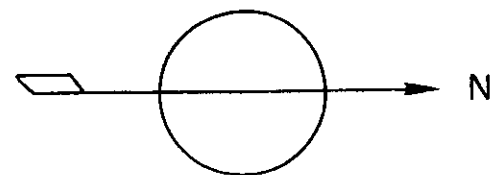
Treatment - ungrazed

Replicate - two

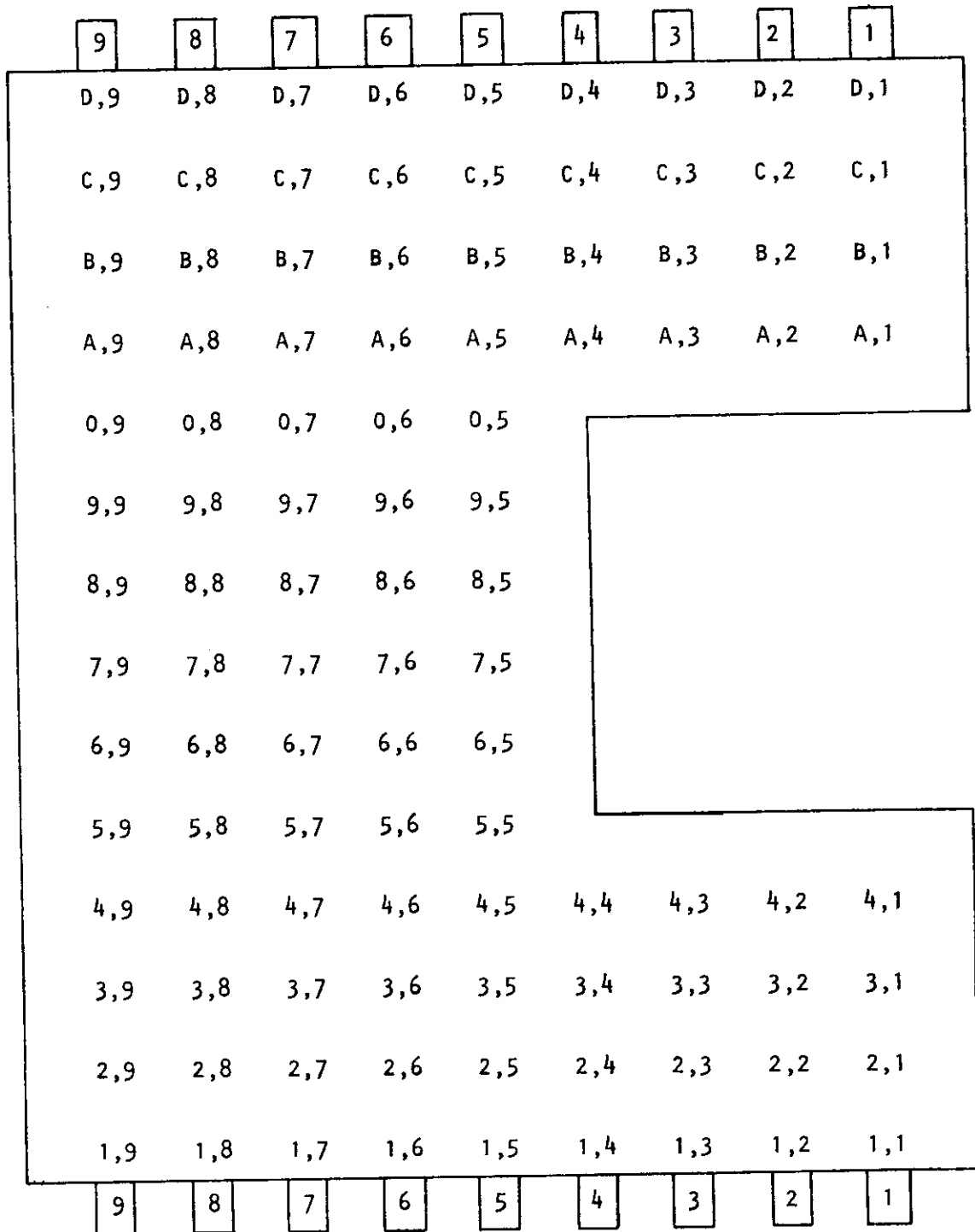
Area - 0.4 acre

Number of sample points - 40

Exposure - eastern



Study Plot No. 10



Lowest Edge of Plot

Pasture - 23 East

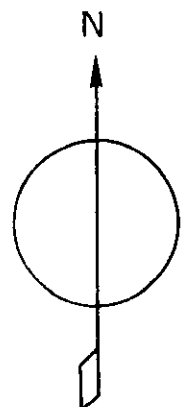
Treatment - grazed 1970, ungrazed 1971

Replicate - one

Area - 0.34 acre (0.14 ha)

Number of sample points - 102

Exposure - southern



Study Plot No. 11

10	9	8	7	6	5	4	3	2	1
0,0	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1
9,0	9,9	9,8	9,7	9,6	9,5	9,4	9,3	9,2	9,1
8,0	8,9	8,8	8,7	8,6	8,5	8,4	8,3	8,2	8,1
7,0	7,9	7,8	7,7	7,6	7,5	7,4	7,3	7,2	7,1
6,0	6,9	6,8	6,7	6,6	6,5	6,4	6,3	6,2	6,1
5,0	5,9	5,8	5,7	5,6	5,5	5,4	5,3	5,2	5,1
4,0	4,9	4,8	4,7	4,6	4,5	4,4	4,3	4,2	4,1
3,0	3,9	3,8	3,7	3,6	3,5	3,4	3,3	3,2	3,1
2,0	2,9	2,8	2,7	2,6	2,5	2,4	2,3	2,2	2,1
1,0	1,9	1,8	1,7	1,6	1,5	1,4	1,3	1,2	1,1
10	9	8	7	6	5	4	3	2	1

Lowest Edge of Plot

Pasture - 23 East

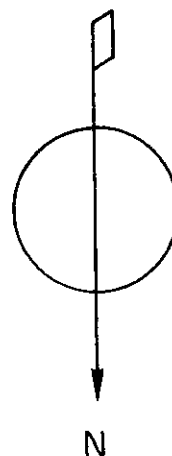
Treatment - grazed 1970, ungrazed 1971

Replicate - two

Area - 0.33 acre (0.13 ha)

Number of sample points - 100

Exposure - northern



APPENDIX II
FIELD DATA SHEETS

Soil macroarthropod data of the Pawnee Site were recorded on form NREL-33 in 1970. A copy is attached.



GRASSLAND BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

FIELD DATA SHEET--SOIL MACROARTHROPODS

Data Type	Initials	Date			Time	Penicillate	Treatent	Plot no.	Quadrat	Trophic	Host	Condition	Level	Class	Order	Family	Genus	Species	Life stage	Total no.	Dry weight (mg)	Estimated weight	No. weighed	(cm)	
		Day	Month	Year																					
1-2	3-4	5-7	8-9	10-11	12-13	14-15	16	17	18	19-20	21	22-27	28	29	31-34	36-39	41-44	46-49	51-53	55-56	58-60	62-67	68	69-71	72
33	11	JEL																							

<u>Data Type</u>	<u>Host</u>
33 Soil macroarthropods	00 Unknown
	01 AGSM
	02 ARFR
	03 ARLO
<u>Site</u>	04 BOGR
11 Pawnee	05 BUDA
	06 CAFI
	07 CAHE
<u>Time (hour)</u>	08 CHNA
00 Unknown	09 EREF
	10 MUTO
	11 OPPO
<u>Treatment</u>	12 PSTE
1. Ungrazed	13 SPCO
2. Lightly grazed	14 STCOL
3. Moderately grazed	15 BAOP
4. Heavily grazed	16 ASMI
5. Grazed 1969, Ungrazed 1970	
	<u>Level</u>
D ESA-0	1. 0"-6"
E ESA-W	2. 6"-12"
F ESA-N	3. 0"-12"
G ESA-LRI	
<u>Life Stage</u>	<u>Condition</u>
Undetermined	1. Alive
Adult	2. Dead
1. Adult male	3. Unknown
12 Adult female	
20 Pupa	
30 Egg	
31 Egg case	
32 Egg case, with eggs	
33 Egg case, with nymphs	
40 Nymph or larva	
41 Nymph or larva early	
42 Nymph or larva middle	
43 Nymph or larva late	
50 Instar	
51 Instar 1st	
52 Instar 2nd	
53 Instar 3rd	
54 Instar 4th	
55 Instar 5th	
56 Instar 6th	
57 Instar 7th	
<u>Trophic</u>	
0. Unknown	
1. Plant feeding (tissue)	
2. Plant feeding (sap)	
3. Plant feeding (pollen & nectar)	
4. Plant feeding (seed)	
5. Predator	
6. Parasite or parasitoid	
7. Omnivore	
8. Scavenger	
9. Non-feeding stage	
A Root feeding (tissue)	
Root feeding (sap)	
<u>Estimate</u>	
e. Weight estimate	

Soil macroarthropod data of the Pawnee Site were recorded on a modified form NREL-33 in 1971. A copy is attached.



GRASSLAND BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

FIELD DATA SHEET--SOIL MACROARTHROPODS

Type	Size	Initials	Date			Time	Treatment	Soil no.	Trophic	Host	Level	Class	Order	Family	Genus	Species	Life stage	Total no.	Dry weight (mg)	Est. weight (mg)	No. weighed	
			Day	Month	Year																	
1-2	3-4	5-7	8-9	10-11	12-13	14-15	16	17	18	19-20	21	22-27	28	29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69
33																						

Data Type

33 Soil macroarthropods

Site

11 Pawnee

Time (hour)

00 Unknown

Treatment

1. Ungrazed
2. Lightly grazed
3. Moderately grazed
4. Heavily grazed
5. Grazed 1969,
Ungrazed 1970

Life Stage

00 Undetermined
1 Adult
11 Adult male
12 Adult female
20 Pupa
30 Egg
31 Egg case
32 Egg case, with eggs
33 Egg case, with nymphs
40 Nymph or larva
41 Nymph or larva early
42 Nymph or larva middle
43 Nymph or larva late
50 Instar
51 Instar 1st
52 Instar 2nd
53 Instar 3rd
54 Instar 4th
55 Instar 5th
56 Instar 6th
57 Instar 7th

Trophic

0. Unknown
1. Plant feeding (tissue)
2. Plant feeding (sap)
3. Plant feeding (pollen & nectar)
4. Plant feeding (seed)
5. Predator
6. Parasite or parasitoid
7. Omnivore
8. Scavenger
9. Non-feeding stage

Estimate

e. Weight estimate

Host

00 Unknown
01 AGSM
02 ARFR
03 ARLO
04 BOGR
05 BUDA
06 CAFI
07 CAHE
08 CHNA
09 EREF
10 MUTO
11 OPPO
12 PSTC
13 SPCO
14 STCOL
15 BAOP
16 ASMI

Level

1. 0"-6"
2. 6"-12"
3. 0"-12"

Condition

1. Alive
2. Dead
3. Unknown

APPENDIX III
SOIL INVERTEBRATE SPECIES

Pawnee Site, 1970

<u>Phylum</u>	<u>Order</u>	<u>Family</u>	<u>Species</u>
Annelida	Oligochaeta	Megascolicidae	<i>Diplocardia</i> sp. MEGA 03
Arthropoda	Acarina	Erythraeidae	ERYT 02 ERYT 07
		Trombidiidae	TROM 01 TROM 03
		Araneida	Lycosidae LYCO 03
		Thomisidae	<i>Xysticus</i> sp. 1 <i>Xysticus</i> sp. 2
	Araneida		ARAN 49 ARAN 50 ARAN 51 ARAN 52 ARAN 53
		Coleoptera	Anthicidae <i>Anthicus lutulentus</i> Casey <i>Anthicus</i> sp.
			Carabidae <i>Amara farcta</i> LeConte <i>Bembidion obscurellum</i> Mots. <i>Harpalus desertus</i> LeConte <i>Stenolophus conjunctus</i> Say CARA 33
		Chrysomelidae	<i>Altica</i> sp. <i>Brachycoryna</i> sp. <i>Chaetocnema</i> sp. CHRY 09

Coleoptera	Cicindelidae	CICI 02
	Curculionidae	<i>Apion</i> sp.
		<i>Calyptrillus cryptops</i> Horn
		<i>Calandrinus insignis</i> Casey
		<i>Epicaerus</i> sp.
		<i>Gerstaeckeria basalis</i> LeConte
		<i>Mesagroicus</i> sp.
	Elateridae	<i>Ctenicera</i> sp.
	Endrinidae	ENDR 01
	Heteroceridae	<i>Heterocerus</i> sp.
	Histeridae	<i>Abraeus</i> sp.
	Hydrophilidae	<i>Berosus styliferus</i> Horn
	Meloidae	MELO 04
		MELO 05
		MELO 06
	Mordellidae	<i>Pentaria trifasciata</i> Mels.
	Scarabaeidae	<i>Aphodius vittatus</i> Say
		<i>Canthon pilularius</i> (L).
		<i>Diplotaxis haydeni</i> LeConte
		<i>Ochodaeus kansanus</i> Fall
		<i>Phyllophaga</i> sp. 1
		<i>Rhyssemus</i> n.sp.
	Phalacridae	<i>Phalacrus</i> sp.
	Staphylinidae	<i>Aleochara bipustulata</i> L.
		<i>Bledius strenuus</i> Casey
		STAP 09

Coleoptera	Tenebrionidae	<i>Athous</i> sp.
		<i>Blapstinus</i> sp.
		<i>Edrotes</i> sp.
		<i>Eleodes extricata</i> Say
		<i>Eleodes</i> sp. 1
		<i>Eleodes</i> sp. 4
		<i>Eleodes</i> sp. 6
		<i>Eleodes</i> sp. 7
		<i>Trimytis pruinosa</i> LeConte
		TENE 32
Diptera	Asilidae	ASIL 01
		ASIL 02
	Ceratopogonidae	<i>Culicoides crepuscularis</i> Malloch
		<i>Forcipomyia brevipennis</i> Macq.
	Mycetophilidae	<i>Rymosia</i> sp.
	Sphaeroceridae	<i>Leptocera</i> sp.
		DIPT 03
		DIPT 04
		DIPT 08
		DIPT 37
		DIPT 45
		DIPT 75
		DIPT 76
		DIPT 77
		DIPT 78
		DIPT 79

Hemiptera	Coreidae	<i>Coriomeris humilis</i> Uhler
		CORE 01
	Cydnidae	<i>Pangeaus congruus</i> Uhler
	Lygaeidae	<i>Blissus leucopterus</i> Say
		<i>Crophius disconotus</i> Say
		LYGA 02
Homoptera	Aphididae	<i>Epameibaphis frigidae</i> Oestlund
		<i>Iziphya</i> sp.
		<i>Pleotrichophorus pseudoglandulosus</i> Palmer
	Margarodidae	<i>Stomacoccus</i> sp.
	Pseudococcidae	<i>Anisococcus oregonensis</i> ? Ferris
		<i>Cryptoripersia arizonensis</i> Ehrhorn
		<i>Symmococcus pecoensis</i> Ferris
Hymenoptera	Formicidae	<i>Formica neogagates</i> Emery
		<i>Formica obtusapilosa</i> Emery
		<i>Formica</i> sp.
		<i>Formica wheeleri</i> Creighton
		<i>Lasius alienus americanus</i> Emery
		<i>Lasius</i> (A.) <i>latipes</i> Walsh
		<i>Leptothorax tricarinatus</i> Emery
		<i>Monomorium minimum</i> Buckley
		<i>Myrmica sabuleti americana</i> Weber
		<i>Myrmica</i> sp.
		<i>Pheidole pilifera coloradensis</i> Emery
		<i>Solenopsis molesta validiuscula</i> Emery
		<i>Tapinoma sessile</i> Say

Hymenoptera	Halictidae	<i>Dialictus pruinosiforme</i> Crawford
Hymenoptera		HYME 32
		HYME 33
Isoptera	Rhinotermitidae	<i>Reticulitermes</i> sp.
Lepidoptera	Arctiidae	<i>Apantesis blakei</i> Grote
	Geometridae	GEOM 02
	Hesperiidae	HESP 01
Lepidoptera		LEPI 13
		LEPI 70
		LEPI 71
		LEPI 72
		LEPI 74
		LEPI 75
Orthoptera	Acrididae	ACRI 01

Pawnee Site, 1971

<u>Phylum</u>	<u>Order</u>	<u>Family</u>	<u>Species</u>
Arthropoda	Acarina	Trombidiidae	<i>Allothrombium</i> sp.
			TROM 03
	Araneida		ARAN 01
			ARAN 68
	Coleoptera	Anthicidae	<i>Anthicus hastatus</i> Casey
		Carabidae	<i>Amara farceta</i> LeConte
			<i>Anisotarsus</i> sp.
			<i>Bembidion obscurellum</i> Mots.
			<i>Harpalus desertus</i> LeConte
			<i>Piosoma setosa</i> LeConte
			<i>Selenophorus planipennis</i> LeConte
		Chrysomelidae	<i>Altica</i> sp.
			<i>Chaetocnema</i> sp.
		Coccinellidae	<i>Delphastus</i> sp.
		Curculionidae	<i>Anthonomus ochreopilosus</i> Dietz
			<i>Anthonomus sphaeralciae</i> Fall
			<i>Apion</i> sp.
			<i>Calandrinus insignis</i> Casey
			<i>Epicaerus</i> sp.
			<i>Gerstaeckeria basalis</i> LeConte
			<i>Hyperodes grypidioides</i> Dietz
			<i>Macrorhoptus hispidus</i> Dietz
			<i>Mesagroicus</i> sp.
			<i>Ophryastes tuberosus</i> LeConte

Coleoptera	Elateridae	<i>Ctenicera</i> sp.
	Histeridae	<i>Hister abbreviatus</i> F. <i>Spilodiscus ulkei</i> Horn <i>Xerosaprinus</i> (X.) <i>fimbriatus</i> LeConte
Coleoptera	Scarabaeidae	<i>Aphodius fimetarius</i> (L.) <i>Aphodius haemorrhoidalis</i> (L.) <i>Aphodius vittatus</i> Say <i>Cremastocheilus retractus incisus</i> Casey <i>Phyllophaga</i> sp. 1 <i>Phyllophaga</i> sp. 2 <i>Rhyssemus</i> n.sp.
		Staphylinidae
		<i>Aleochara bipustulata</i> L. <i>Anotylus</i> sp. <i>Bledius strenuus</i> Casey
		Tenebrionidae
		<i>Athous</i> sp. <i>Blapstinus</i> sp. <i>Edrotes rotundus</i> Say <i>Eleodes obsoleta</i> Say <i>Eleodes</i> sp. 2 <i>Eleodes</i> sp. 4 <i>Eleodes</i> sp. 7 <i>Trimytis pruinosa</i> LeConte
		COLE 09
		COLE 25
		COLE 26
Collembola	Entomobryidae	<i>Entomobrya multifasciata</i> Tullberg

Diptera	Asilidae	ASIL 01
		ASIL 02
		ASIL 05
Diptera	Cecidomyiidae	<i>Edestochilus</i> sp.
	Ceratopogonidae	<i>Forcipomyia brevipennis</i> Macq.
	Therevidae	THER 02
Diptera		DIPT 05
		DIPT 06
		DIPT 07
		DIPT 08
		DIPT 15
		DIPT 32
		DIPT 33
		DIPT 37
		DIPT 45
Hemiptera		DIPT 82
	Cydnidae	<i>Pangeaus congruus</i> Uhler
	Lygaeidae	<i>Blissus leucopterus</i> Say
		<i>Neacoryphus bicrucis</i> Say
Homoptera	Margarodidae	<i>Stomacoccus</i> sp.
	Pseudococcidae	<i>Cryptoripersia arizonensis</i> (Ehrhorn)
		PSEU 04
Hymenoptera	Formicidae	<i>Dorymyrmex pyramicus</i> Roger
		<i>Formica neogagates</i> Emery
		<i>Formica obtusapilosa</i> Emery
		<i>Formica</i> sp.
		<i>Lasius alienus americanus</i> Emery

		<i>Lasius (Acanthomyops) latipes</i> Walsh
		<i>Leptothorax tricarinatus</i> Emery
		<i>Monomorium minimum</i> Buckley
Hymenoptera	Formicidae	<i>Myrmica sabuleti americana</i> Weber
		<i>Solenopsis molesta validiuscula</i> Emery
		<i>Tapinoma sessile</i> Say
Isoptera	Rhinotermitidae	<i>Reticulitermes tibialis</i> Banks
Lepidoptera		LEPI 02
		LEPI 13
Neuroptera	Myrmeleontidae	MYRM 01
Orthoptera	Acrididae	ACRI 01

APPENDIX IV

SOIL MACROARTHROPOD ORDERS COLLECTED FROM FOUR
DIFFERENTIALLY GRAZED PASTURES, PAWNEE SITE, 1970

Appendix Table 1. Soil macroarthropod orders collected 17 April 1970, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass ₂ (mg/m ²)	Number	Biomass ₂ (mg/m ²)	Number	Biomass ₂ (mg/m ²)	Number	Biomass ₂ (mg/m ²)
Acarina	--	--	--	--	--	--	--	--
Araneida	--	--	--	--	2	5	--	--
Coleoptera	16	127	9	451	19	353	12	1306
Diptera	--	--	--	--	1	73	1	73
Hemiptera	1	47	--	--	--	--	--	--
Homoptera	--	--	--	--	1	10	2	20
Hymenoptera	16	22	9	68	--	--	--	--
Isoptera	--	--	--	--	8	28	--	--
Lepidoptera	--	--	--	--	--	--	--	--
Oligochaeta	1	249	8	1992	--	--	--	--
Orthoptera	--	--	--	--	--	--	--	--

Appendix Table 2. Soil macroarthropod orders collected 30 April 1970, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	1	1	--	--	--	--	3	5
Araneida	--	--	--	--	--	--	--	--
Coleoptera	23	301	13	106	20	1071	--	--
Diptera	1	73	1	16	1	1	2	146
Hemiptera	--	--	2	4	2	2	--	--
Homoptera	6	60	1	10	1	11	10	100
Hymenoptera	46	226	1	3	2	10	--	--
Isoptera	--	--	1	3	--	--	--	--
Lepidoptera	--	--	--	--	1	2	--	--
Oligochaeta	--	--	17	751	--	--	--	--
Orthoptera	--	--	--	--	--	--	--	--

Appendix Table 3. Soil macroarthropod orders collected 15 May 1970, Pawnee Site.

Order	Grazing Treatment							
	Ungazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	--	--	--	--	--	--	--	--
Araneida	--	--	15	1	--	--	--	--
Coleoptera	21	136	10	1086	30	1939	9	119
Diptera	--	--	1	1	1	14	--	--
Hemiptera	2	2	1	7	1	3	--	--
Homoptera	8	70	5	50	2	3	11	91
Hymenoptera	14	55	6	34	10	67	22	106
Isoptera	2	7	--	--	17	53	--	--
Lepidoptera	--	--	--	--	--	--	--	--
Oligochaeta	8	1992	12	1496	3	679	1	0.3
Orthoptera	--	--	--	--	--	--	--	--

Appendix Table 4. Soil macroarthropod orders collected 29 May 1970, Pawnee Site.

Order	Grazing treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	--	--	--	--	--	--	--	--
Araneida	--	--	--	--	--	--	--	--
Coleoptera	42	939	18	334	12	221	7	95
Diptera	--	--	3	11	--	--	--	--
Hemiptera	--	--	4	4	1	1	1	1
Homoptera	1	5	2	13	4	33	3	23
Hymenoptera	3	40	1	2	1	5	3	17
Isoptera	--	--	--	--	--	--	--	--
Lepidoptera	--	--	--	--	--	--	--	--
Oligochaeta	--	--	--	--	--	--	--	--
Orthoptera	--	--	--	--	--	--	--	--

Appendix Table 5. Soil macroarthropod orders collected 17 June 1970, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	--	--	--	--	1	1	1	1
Araneida	--	--	--	--	--	--	--	--
Coleoptera	4	332	15	269	18	521	7	199
Diptera	1	81	1	73	1	73	1	8
Hemiptera	--	--	1	1	--	--	--	--
Homoptera	11	122	--	--	4	40	1	10
Hymenoptera	1	6	1	5	2	11	151	2186
Isoptera	--	--	--	--	--	--	--	--
Lepidoptera	--	--	--	--	--	--	--	--
Oligochaeta	--	--	2	498	--	--	--	--
Orthoptera	--	--	--	--	--	--	--	--

Appendix Table 6. Soil macroarthropod orders collected 25 June 1970, Pawnee Site.

Order	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass ₂ (mg/m ²)	Number	Biomass ₂ (mg/m ²)	Number	Biomass ₂ (mg/m ²)
Acarina	--	--	1	1	--	--
Araneida	--	--	--	--	--	--
Coleoptera	16	805	4	105	10	121
Diptera	--	--	--	--	3	119
Hemiptera	--	--	1	1	6	7
Homoptera	5	32	--	--	--	--
Hymenoptera	2	5	1	14	1	5
Isoptera	--	--	--	--	--	--
Lepidoptera	--	--	--	--	1	1
Oligochaeta	--	--	--	--	--	--
Orthoptera	--	--	--	--	--	--

Appendix Table 7. Soil macroarthropod orders collected 11 July 1970, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	--	--	--	--	--	--	--	--
Araneida	--	--	--	--	1	7	--	--
Coleoptera	19	168	11	376	7	55	10	695
Diptera	--	--	--	--	--	--	1	37
Hemiptera	--	--	--	--	--	--	--	--
Homoptera	1	5	2	20	1	1	--	--
Hymenoptera	11	57	47	488	5	28	--	--
Isoptera	--	--	--	--	--	--	--	--
Lepidoptera	--	--	1	4	--	--	--	--
Oligochaeta	--	--	--	--	--	--	--	--
Orthoptera	--	--	--	--	--	--	--	--

Appendix Table 8. Soil macroarthropod orders collected 22 July 1970, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	--	--	--	--	--	--	--	--
Araneida	--	--	--	--	--	--	--	--
Coleoptera	14	802	22	493	16	114	10	46
Diptera	--	--	--	--	2	84	--	--
Hemiptera	--	--	1	70	1	1	--	--
Homoptera	2	20	--	--	3	30	--	--
Hymenoptera	223	1639	716	8156	30	211	40	315
Isoptera	--	--	--	--	--	--	--	--
Lepidoptera	1	4	1	4	--	--	--	--
Oligochaeta	--	--	--	--	--	--	--	--
Orthoptera	--	--	--	--	4	19	--	--

Appendix Table 9. Soil macroarthropod orders collected 4 August 1970, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	--	--	1	1	--	--	--	--
Araneida	--	--	--	--	--	--	--	--
Coleoptera	32	148	24	666	25	867	11	231
Diptera	1	6	1	8	1	--	2	146
Hemiptera	--	--	--	--	--	--	--	--
Homoptera	3	27	2	20	3	21	7	70
Hymenoptera	8	41	15	93	20	77	3	17
Isoptera	--	--	10	35	--	--	--	--
Lepidoptera	--	--	4	16	7	62	1	2
Oligochaeta	--	--	--	--	--	--	--	--
Orthoptera	--	--	--	--	--	--	--	--

Appendix Table 10. Soil macroarthropod orders collected 18 August 1970, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	--	--	--	--	--	--	--	--
Araneida	1	6	--	--	--	--	--	--
Coleoptera	35	1454	18	606	30	2816	18	792
Diptera	1	73	--	--	1	73	--	--
Hemiptera	--	--	--	--	--	--	--	--
Homoptera	9	90	3	33	--	--	2	5
Hymenoptera	1	5	--	--	42	242	1	5
Isoptera	1	3	--	--	48	170	--	--
Lepidoptera	--	--	4	26	3	21	1	6
Oligochaeta	--	--	--	--	--	--	--	--
Orthoptera	--	--	--	--	1	4	--	--

Appendix Table 11. Soil macroarthropod orders collected 2 September 1970, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	--	--	1	1	--	--	--	--
Araneida	--	--	--	--	2	8	--	--
Coleoptera	27	339	14	289	8	638	9	147
Diptera	1	69	3	118	--	--	--	--
Hemiptera	--	--	1	1	--	--	--	--
Homoptera	9	90	--	--	2	20	4	40
Hymenoptera	3	18	--	--	--	--	1	12
Isoptera	--	--	--	--	--	--	--	--
Lepidoptera	--	--	6	21	2	14	--	--
Oligochaeta	--	--	--	--	--	--	--	--
Orthoptera	--	--	--	--	--	--	--	--

Appendix Table 12. Soil macroarthropod orders collected 14 September 1970, Pawnee Site.

Order	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	--	--	--	--	--	--
Araneida	--	--	1	2	--	2
Coleoptera	38	983	13	426	55	1694
Diptera	2	146	1	73	2	74
Hemiptera	--	--	2	34	--	--
Homoptera	1	10	--	--	--	40
Hymenoptera	7	29	2	18	4	43
Isoptera	--	--	--	--	--	--
Lepidoptera	--	--	--	--	--	--
Oligochaeta	--	--	--	--	--	--
Orthoptera	--	--	--	--	--	--

Appendix Table 13. Soil macroarthropod orders collected 1 October 1970, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	--	--	--	--	1	1	--	--
Araneida	--	--	--	--	--	--	--	--
Coleoptera	11	822	25	1219	12	429	7	636
Diptera	1	73	--	--	2	110	--	--
Hemiptera	--	--	1	1	1	1	--	--
Homoptera	1	1	2	20	8	71	1	10
Hymenoptera	2	11	2	18	9	51	4	23
Isoptera	--	--	--	--	--	--	--	--
Lepidoptera	--	--	1	371	--	--	--	--
Oligochaeta	--	--	--	--	--	--	--	--
Orthoptera	--	--	--	--	--	--	--	--

Appendix Table 14. Soil macroarthropod orders collected 29 October 1970, Pawnee Site.

Order	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	--	--	--	--	--	--
Araneida	--	--	1	2	--	--
Coleoptera	17	1034	22	1214	9	653
Diptera	--	--	--	--	3	184
Hemiptera	--	--	--	--	--	--
Homoptera	1	10	--	--	--	10
Hymenoptera	--	--	2	7	--	5
Isoptera	--	--	--	--	--	--
Lepidoptera	--	--	--	--	1	38
Oligochaeta	--	--	--	--	--	--
Orthoptera	--	--	--	--	--	--

Appendix Table 15. Soil macroarthropod orders collected 31 January 1971, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	--	--	1	1	--	--	--	--
Araneida	--	--	--	--	--	--	--	--
Coleoptera	23	591	9	853	4	84	8	325
Diptera	2	3	--	--	1	73	--	--
Hemiptera	2	61	--	--	1	1	--	--
Homoptera	19	193	3	30	1	10	8	81
Hymenoptera	1	11	--	--	1	5	--	--
Isoptera	--	--	--	--	--	--	--	--
Lepidoptera	--	--	--	--	--	--	--	--
Oligochaeta	--	--	--	--	--	--	--	--
Orthoptera	--	--	--	--	9	44	--	--

APPENDIX V

SOIL MACROARTHROPOD ORDERS COLLECTED FROM FOUR
DIFFERENTIALLY GRAZED PASTURES, PAWNEE SITE, 1971

Appendix Table 16. Soil macroarthropod orders collected from ungrazed exclosures, Pawnee Site, 1971.

Order	Collection Date									
	25 March		3 May		5 July		31 August		6 October	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	--	--	--	--	--	--	--	--	--	--
Coleoptera	13	*	2	12	11	297	5	124	3	87
Collembola	--	--	--	--	--	--	--	--	--	--
Diptera	1	--	--	--	--	--	--	--	--	--
Hemiptera	--	--	--	--	--	--	--	--	--	--
Homoptera	18	--	21	210	2	13	--	--	8	80
Hymenoptera	3	--	1	5	1	18	--	--	1	12
Isoptera	1	--	--	--	--	--	--	--	--	--
Lepidoptera	--	--	--	--	--	--	--	--	--	--
Orthoptera	--	--	--	--	--	--	--	--	--	--

*Not available at time of report.

Appendix Table 17. Soil macroarthropod orders from a lightly grazed pasture, Pawnee Site, 1971.

Order	Collection Date									
	25 March		3 May		5 July		31 August		6 October	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	--	--	--	--	--	--	--	--	--	--
Coleoptera	11	*	11	222	2	106	9	274	2	272
Collembola	--	--	--	--	--	--	--	--	--	--
Diptera	1	--	1	16	--	--	--	--	1	73
Hemiptera	--	--	--	--	1	30	--	--	--	--
Homoptera	13	--	8	80	1	10	--	--	--	--
Hymenoptera	--	--	2	9	1	14	--	--	--	--
Isoptera	--	--	--	--	--	--	--	--	--	--
Lepidoptera	1	--	--	--	--	--	--	--	--	--
Orthoptera	--	--	--	--	--	--	--	--	--	--

* Not available at time of report.

Appendix Table 18. Soil macroarthropod orders from a moderately grazed pasture, Pawnee Site, 1971.

Order	Collection Date									
	25 March		3 May		5 July		31 August		6 October	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	--	--	--	--	--	--	--	--	--	--
Coleoptera	14	*	17	602	3	14	8	361	4	627
Collembola	1	--	--	--	--	--	--	--	--	--
Diptera	2	--	--	--	--	--	--	--	--	--
Hemiptera	--	--	--	--	--	--	--	--	--	--
Homoptera	13	--	3	20	1	10	--	--	1	10
Hymenoptera	2	--	1	5	--	--	--	--	--	--
Isoptera	--	--	--	--	--	--	--	--	--	--
Lepidoptera	--	--	--	--	--	--	--	--	--	--
Orthoptera	--	--	--	--	--	--	--	--	--	--

* Not available at time of report.

Appendix Table 19. Soil macroarthropod orders from a heavily grazed pasture, Pawnee Site, 1971.

Order	Collection Date									
	25 March		3 May		5 July		31 August		6 October	
	Number	Biomass ₂ (mg/m ²)	Number	Biomass ₂ (mg/m ²)	Number	Biomass ₂ (mg/m ²)	Number	Biomass ₂ (mg/m ²)	Number	Biomass ₂ (mg/m ²)
Acarina	--	--	1	1	--	--	--	--	--	--
Coleoptera	5	*	8	285	3	80	8	379	3	38
Collembola	--	--	--	--	--	--	--	--	--	--
Diptera	1	--	--	--	--	--	--	--	--	--
Hemiptera	--	--	--	--	--	--	--	--	--	--
Homoptera	16	--	1	11	1	10	--	--	3	30
Hymenoptera	1	--	--	--	--	--	--	--	1	12
Isoptera	--	--	--	--	--	--	--	--	--	--
Lepidoptera	--	--	--	--	--	--	--	--	--	--
Orthoptera	--	--	--	--	--	--	--	--	2	9

* Not available at time of report.

APPENDIX VI

SOIL MACROARTHROPOD ORDERS COLLECTED FROM UNGRAZED ENCLOSURES
AND A RECENTLY HEAVILY GRAZED PASTURE, PAWNEE SITE, 1971

Appendix Table 20. Soil macroarthropod orders collected
22 April 1971.

Order	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	0	0	0	0
Coleoptera	2	12	12	68
Diptera	0	0	1	14
Hemiptera	0	0	0	0
Homoptera	21	210	19	190
Hymenoptera	1	5	0	0
Lepidoptera	0	0	0	0
Neuroptera	0	0	0	0

Appendix Table 21. Soil macroarthropod orders collected
12 May 1971, Pawnee Site.

Order	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	0	0	1	1
Coleoptera	19	878	7	217
Diptera	12	77	0	0
Hemiptera	0	0	0	0
Homoptera	16	160	17	170
Hymenoptera	1	12	0	0
Lepidoptera	0	0	0	0
Neuroptera	0	0	0	0
Orthoptera	0	0	0	0

Appendix Table 22. Soil macroarthropod orders collected
24 May 1971, Pawnee Site.

Order	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	0	0	0	0
Coleoptera	8	221	9	361
Diptera	0	0	0	0
Hemiptera	0	0	0	0
Homoptera	31	310	17	170
Hymenoptera	3	10	0	0
Lepidoptera	0	0	0	0
Neuroptera	0	0	0	0
Orthoptera	0	0	0	0

Appendix Table 23. Soil macroarthropod orders collected
4 June 1971, Pawnee Site.

Order	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	0	0	0	0
Coleoptera	9	48	4	39
Diptera	1	73	0	0
Hemiptera	2	2	0	0
Homoptera	16	160	9	82
Hymenoptera	37	226	4	21
Lepidoptera	0	0	0	0
Neuroptera	0	0	0	0
Orthoptera	0	0	11	18

Appendix Table 24. Soil macroarthropod orders collected
15 June 1971, Pawnee Site.

Order	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	0	0	0	0
Coleoptera	13	69	7	38
Diptera	2	25	0	0
Hemiptera	0	0	2	71
Homoptera	10	93	20	200
Hymenoptera	5	27	0	0
Lepidoptera	0	0	0	0
Neuroptera	0	0	0	0
Orthoptera	0	0	0	0

Appendix Table 25. Soil macroarthropod orders collected
5 July 1971, Pawnee Site.

Order	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	0	0	0	0
Coleoptera	11	297	2	108
Diptera	0	0	0	0
Hemiptera	0	0	0	0
Homoptera	2	13	2	20
Hymenoptera	1	18	0	0
Lepidoptera	0	0	0	0
Neuroptera	0	0	0	0
Orthoptera	0	0	0	0

Appendix Table 26. Soil macroarthropod orders collected
15 July 1971, Pawnee Site.

Order	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	0	0	0	0
Coleoptera	15	443	6	31
Diptera	2	14	1	8
Hemiptera	0	0	0	0
Homoptera	7	70	15	150
Hymenoptera	21	263	5	25
Lepidoptera	0	0	0	0
Neuroptera	0	0	0	0
Orthoptera	0	0	0	0

Appendix Table 27. Soil macroarthropod orders collected 29 July 1971, Pawnee Site.

Order	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	0	0	0	0
Coleoptera	10	221	5	194
Diptera	0	0	1	73
Hemiptera	1	1	0	0
Homoptera	2	20	2	20
Hymenoptera	1	12	0	0
Lepidoptera	1	38	0	0
Neuroptera	1	6	0	0
Orthoptera	0	0	0	0

Appendix Table 28. Soil macroarthropod orders collected 11 August 1971, Pawnee Site.

Order	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	0	0	0	0
Coleoptera	12	2322	4	30
Diptera	0	0	0	0
Hemiptera	0	0	0	0
Homoptera	1	10	8	80
Hymenoptera	0	0	0	0
Lepidoptera	0	0	0	0
Neuroptera	0	0	0	0
Orthoptera	0	0	0	0

Appendix Table 29. Soil macroarthropod orders collected 31 August 1971, Pawnee Site.

Order	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	0	0	0	0
Coleoptera	4	151	0	0
Diptera	0	0	0	0
Hemiptera	0	0	0	0
Homoptera	0	0	0	0
Hymenoptera	0	0	0	0
Lepidoptera	0	0	0	0
Neuroptera	0	0	0	0
Orthoptera	0	0	0	0

Appendix Table 30. Soil macroarthropod orders collected 27 September 1971, Pawnee Site.

Order	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	0	0	0	0
Coleoptera	7	80	2	9
Diptera	3	45	1	3
Hemiptera	0	0	0	0
Homoptera	1	10	0	0
Hymenoptera	0	0	1	5
Lepidoptera	0	0	0	0
Neuroptera	0	0	0	0
Orthoptera	0	0	0	0

Appendix Table 31. Soil macroarthropod orders collected 6 October 1971, Pawnee Site.

Order	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina	0	0	0	0
Coleoptera	3	87	3	17
Diptera	0	0	1	73
Hemiptera	0	0	0	0
Homoptera	8	80	0	0
Hymenoptera	1	12	1	12
Lepidoptera	0	0	0	0
Neuroptera	0	0	0	0
Orthoptera	0	0	0	0

APPENDIX VII

SOIL MACROARTHROPOD FAMILIES COLLECTED FROM FOUR
DIFFERENTIALLY GRAZED PASTURES, PAWNEE SITE, 1970

Appendix Table 32. Soil macroarthropod families collected 17 April 1970, Pawnee Site.

Family	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera						
Anthicidae	1	0.3	--	--	--	--
Carabidae	3	46.1	2	127.6	2	22.0
Chrysomellidae	--	--	--	--	1	23.3
Curculionidae	--	--	3	16.2	2	110.2
Elateridae	--	--	--	--	1	86.4
Scarabaeidae	7	38.8	2	11.0	7	38.8
Staphylinidae	4	11.6	2	17.2	4	11.6
Tenebrionidae	1	30.3	2	289.6	2	60.7
Diptera						
Asilidae	--	--	--	--	1	73.2
					1	73.2

Appendix Table 32. (continued).

Family	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Hemiptera						
Coreidae	1	47.8	--	--	--	--
Homoptera						
Margarodidae	2	20.0	--	--	1	10.0
Hymenoptera						20.0
Formicidae	5	22.1	8	44.2	--	--
Isoptera						
Rhinotermitidae	--	--	--	--	1	28.4
Oligochaeta						
Megascolicidae	1	249.0	8	1992.4	--	--

Appendix Table 33. Soil macroarthropod families collected 30 April 1970, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina								
Erythraeidae	--	--	--	--	--	--	3	5.9
Trombidiidae	1	1.8	--	--	--	--	--	--
Coleoptera								
Carabidae	2	22.0	2	30.4	--	--	--	--
Curculionidae	1	6.1	--	--	1	6.8	--	--
Scarabaeidae	13	64.4	8	39.7	16	88.4	--	--
Staphylinidae	7	208.8	2	5.8	1	3.2	--	--
Tenebrionidae	--	--	1	30.3	2	972.5	--	--
Diptera								
Asilidae	1	73.2	--	--	--	--	2	146.5
Hemiptera								
Lygaeidae	--	--	2	4.8	2	2.6	--	--

Appendix Table 33. (continued).

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Homoptera								
Margarodidae	6	60.1	1	10.0	1	10.0	10	100.2
Hymenoptera								
Formicidae	46	226.5	1	3.6	2	10.3	--	--
Isoptera								
Rhinotermitidae	--	--	1	3.5	--	--	--	--

Appendix Table 34. Soil macroarthropod families collected 15 May 1970, Pawnee Site.

Order	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera						
Carabidae	1	15.2	3	45.7	--	1 15.2
Cicindelidae	--	--	1	11.2	--	-- --
Curculionidae	2	8.6	2	12.3	--	2 10.4
Elatерidae	1	36.8	--	--	--	-- --
Meloidae	--	--	2	78.2	--	-- --
Scarabaeidae	13	61.5	10	48.3	19	132.5 6 93.5
Staphylinidae	4	14.3	1	2.9	7	140.9 -- --
Tenebrionidae	--	--	3	897.7	4	1665.6 -- --
Hemiptera						
Lygaeidae	2	2.3	1	3.6	1	3.3 -- --
Homoptera						
Aphididae	1	0.6	--	--	1	0.6 2 1.4
Margarodidae	7	70.1	5	50.1	--	9 90.2
Pseudococcidae	--	--	--	--	1	2.7 -- --

Appendix Table 34. (continued).

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Hymenoptera								
Formicidae	14	55.7	6	34.8	10	67.2	22	106.3
Isoptera								
Rhinotermitidae	2	7.1	--	--	17	53.0	--	--
Oligochaeta								
Megascolicidae	8	1992.4	1	249.0	3	679.2	--	--

Appendix Table 35. Soil macroarthropod families collected 29 May 1970, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera								
Curculionidae	--	--	4	10.1	--	--	--	--
Elateridae	2	46.7	--	--	3	173.9	--	--
Scarabaeidae	37	250.7	11	315.4	8	41.6	4	85.0
Staphylinidae	1	2.9	3	8.7	--	--	3	10.1
Tenebrionidae	2	638.5	--	--	--	--	--	--
Diptera								
Asilidae	--	--	3	219.7	--	--	--	--
Hemiptera								
Lygaeidae	--	--	4	4.7	1	1.1	1	1.1
Homoptera								
Margarodidae	--	--	1	10.0	3	30.0	2	20.0
Pseudococcidae	1	5.5	1	2.9	1	2.9	1	2.9
Hymenoptera								
Formicidae	3	40.8	1	2.8	1	5.7	3	17.2

Appendix Table 36. Soil macroarthropod families collected 13 June 1970, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina								
Trombididae	--	--	--	--	1	1.8	1	1.8
Coleoptera								
Carabidae	1	16.9	2	163.4	2	30.4	2	131.5
Cerambycidae	--	--	1	76.5	1	76.5	--	--
Elateridae	1	13.0	--	--	3	98.9	--	--
Scarabaeidae	1	5.2	8	40.1	11	312.6	2	9.4
Staphylinidae	--	--	2	5.8	1	2.9	2	5.8
Tenebrionidae	1	296.8	2	83.4	--	--	1	53.0
Diptera								
Asilidae	1	81.3	1	73.2	1	73.2	--	--
Hemiptera								
Lygaeidae	--	--	1	1.1	--	--	--	--

Appendix Table 36. (continued).

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Homoptera								
Margarodidae	11	122.5	--	--	4	40.1	1	10.0
Hymenoptera								
Formicidae	1	6.4	1	5.7	2	11.5	151	2186.5
Oligochaeta								
Megascolicidae	--	--	2	498.1	--	--	--	--

Appendix Table 37. Soil macroarthropod families collected 25 June 1970, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina								
Trombididae	--	--	1	0.9	--	--	--	--
Coleoptera								
Carabidae	--	--	2	30.4	1	15.2	--	--
Chrysomelidae	--	--	--	--	1	3.4	--	--
Curculionidae	3	194.3	--	--	--	--	2	110.2
Elateridae	1	10.6	--	--	--	--	--	--
Scarabaeidae	11	47.3	2	74.5	8	103.0	--	--
Staphylinidae	--	--	--	--	--	--	1	2.9
Tenebrionidae	1	552.8	--	--	--	--	--	--
Diptera								
Asilidae	--	--	--	--	2	110.9	--	--
Hemiptera								
Lygaeidae	--	--	1	1.1	6	7.1	--	--

Appendix Table 37. (continued).

Order	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Homoptera						
Margarodidae	3	27.3	--	--	--	10.0
Pseudococcidae	2	5.4	--	--	--	--
Hymenoptera						
Formicidae	1	5.2	1	14.2	1	12.4
Halictidae	1	0.2	--	--	--	--
Lepidoptera						
Arctiidae	--	--	--	--	1	1.7
					--	--

Appendix Table 38. Soil macroarthropod families collected 11 July 1970, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera								
Carabidae	--	--	4	203.9	--	--	1	112.4
Chrysomelidae	--	--	1	5.6	--	--	2	11.2
Curculionidae	2	10.2	1	104.0	1	6.1	--	--
Elateridae	1	11.6	--	--	2	23.5	1	11.7
Mycetophagidae	--	--	--	--	1	10.0	--	--
Scarabaeidae	15	143.7	2	10.4	3	16.1	4	19.9
Staphylinidae	1	2.9	1	2.9	--	--	1	2.9
Tenebrionidae	--	--	2	49.1	--	--	1	537.5
Diptera								
Asilidae	--	--	--	--	--	--	1	37.6

Appendix Table 38. (continued).

Order	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Homoptera						
Aphididae	--	--	--	--	1	0.7
Margarodidae	--	--	2	20.0	--	--
Pseudococcidae	1	5.5	--	--	--	--
Hymenoptera						
Formicidae	10	57.3	47	488.1	5	28.8
Lepidoptera						
Arctiidae	--	--	1	4.1	--	--

Appendix Table 39. Soil macroarthropod families collected 22 July 1970, Pawnee Site.

Order	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera						
Anthicidae	--	--	--	--	1	0.9
Carabidae	--	--	2	127.6	--	--
Cerambycidae	1	76.5	--	--	--	--
Curculionidae	--	--	--	--	1	6.1
Elateridae	1	11.7	1	11.7	1	--
Heteroceridae	--	--	1	10.4	--	--
Hydrophilidae	--	--	1	9.6	--	--
Meloidae	--	--	--	--	1	40.4
Scarabaeidae	9	45.4	16	331.0	9	46.4
Staphylinidae	--	--	1	2.9	3	8.7
Tenebrionidae	3	668.9	--	--	--	--
Diptera						
Asilidae	--	--	--	--	1	73.2

Appendix Table 39. (continued).

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Hemiptera								
Coreidae	--	--	1	70.4	--	--	--	--
Lygaeidae	--	--	--	--	1	1.1	--	--
Homoptera								
Margarodidae	2	20.2	--	--	3	30.0	--	--
Hymenoptera								
Formicidae	221	1635.9	716	8156.6	30	211.7	40	359.8
Lepidoptera								
Arctiidae	1	4.1	1	4.1	--	--	--	--
Orthoptera								
Acrididae	--	--	--	--	4	19.5	--	--

Appendix Table 40. Soil macroarthropod families collected 4 August 1970, Pawnee Site.

Order	Grazing Treatments							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina								
Trombididae	--	--	1	1.8	--	--	--	--
Coleoptera								
Carabidae	--	--	6	146.3	2	30.4	1	15.2
Curculionidae	2	11.1	2	110.2	--	--	2	12.3
Elateridae	1	10.6	--	--	--	--	--	--
Scarabaeidae	29	126.5	14	404.8	15	208.8	3	80.2
Staphylinidae	--	--	1	2.9	7	20.4	3	62.6
Tenebrionidae	--	--	--	--	1	608.1	2	60.7
Diptera								
Asilidae	1	66.5	--	--	--	--	2	146.5
Homoptera								
Margarodidae	3	27.3	2	20.0	1	10.0	7	70.1
Pseudococcidae	--	--	--	--	2	11.0	--	--

Appendix Table 40. (continued).

Order	Grazing Treatments					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Hymenoptera						
Formicidae	8	45.4	15	93.1	20	77.1
					3	17.0
Isoptera						
Rhinotermitidae	--	--	10	35.5	--	--
Lepidoptera						
Arctiidae	--	--	4	16.4	6	24.6
					--	--

Appendix Table 41. Soil macroarthropod families collected 18 August 1970, Pawnee Site.

Order	Grazing Treatments					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina						
Trombididae	--	--	1	2.0	--	--
Coleoptera						
Carabidae	--	--	2	128.5	1	112.4
Cerambycidae	--	--	--	--	--	6.1
Chrysomelidae	1	5.6	--	--	1	5.6
Curculionidae	6	36.9	3	16.4	--	--
Elaterridae	2	55.3	--	--	--	--
Endomyidae	--	--	--	--	2	6.3
Phalacridae	--	--	--	--	1	1.7
Scarabaeidae	23	109.8	12	428.1	18	221.1
Staphylinidae	--	--	--	--	2	5.8
Tenebrionidae	3	1246.7	1	33.7	5	2463.0
Diptera						
Asilidae	1	73.2	--	--	1	73.2

Appendix Table 41. (continued).

Order	Grazing Treatments					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Homoptera						
Margarodidae	9	90.2	3	33.4	1	10.0
Pseudococcidae	--	--	--	--	--	5.9
Hymenoptera						
Formicidae	1	5.7	--	--	42	242.0
Isoptera						
Rhinotermitidae	1	3.5	--	--	48	170.5
Lepidoptera						
Arctiidae	--	--	3	13.6	1	4.1

Appendix Table 42. Soil macroarthropod families collected 2 September 1970, Pawnee Site.

Order	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina						
Erythraeidae	--	--	1	1.9	--	--
Coleoptera						
Carabidae	1	112.4	1	112.4	--	2 30.4
Chrysomelidae	--	--	2	11.2	--	--
Curculionidae	1	104.0	1	6.1	1	2.5
Meloidae	--	--	--	--	--	1 39.0
Scarabaeidae	21	111.7	8	104.9	5	24.6
Staphylinidae	3	23.6	--	--	1	2.9
Tenebrionidae	--	--	1	53.0	1	608.1
Diptera						
Asilidae	--	--	1	73.2	--	--

Appendix Table 42. (continued).

Order	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Hemiptera						
Lygaeidae	--	--	1	1.7	--	--
Homoptera						
Margarodidae	9	90.2	--	--	2	20.0
Hymenoptera						
Formicidae	3	18.1	--	--	--	12.4
Lepidoptera						
Arctiidae	--	--	5	20.5	1	4.1
Geometridae	--	--	1	0.9	--	--

Appendix Table 43. Soil macroarthropod families collected 14 September 1970, Pawnee Site.

Order	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Araneida						
Lycosidae	--	--	1	2.0	--	2.0
Coleoptera						
Carabidae	--	--	1	15.2	3	240.0
Curculionidae	2	12.3	2	106.5	5	231.5
Elateridae	3	15.7	--	--	--	110.6
Scarabaeidae	29	292.2	3	17.0	40	282.0
Staphylinidae	2	5.8	3	8.7	2	4.9
Tenebrionidae	2	638.5	1	259.2	3	931.8
Diptera						
Asilidae	2	146.5	1	73.2	1	73.2
Hemiptera						
Cydnidae	--	--	1	30.8	--	--
Lygaeidae	--	--	1	3.6	--	--

Appendix Table 43. (continued).

Order	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Homoptera						
Margarodidae	1	10.0	--	--	--	40.1
Psyllidae	--	--	--	--	--	0.6
Hymenoptera						
Formicidae	7	29.2	2	18.6	4	43.1
					2	18.2

Appendix Table 44. Soil macroarthropod families collected 1 October 1970, Pawnee Site.

Order	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Acarina						
Erythraeidae	--	--	--	--	1	0.6
Coleoptera						
Carabidae	--	--	--	--	1	112.4
Curculionidae	1	104.0	--	--	--	--
Elateridae	1	43.5	--	--	--	--
Scarabaeidae	6	33.1	22	380.8	10	276.1
Staphylinidae	1	2.9	--	--	--	5.8
Tenebrionidae	2	638.5	3	838.1	1	41.3
Diptera						
Asilidae	1	73.2	--	--	2	110.9
Hemiptera						
Lygaeidae	--	--	1	1.1	1	1.1
Homoptera						
Aphididae	1	0.7	--	--	1	0.4
Margarodidae	--	--	2	20.0	7	71.2
					1	10.0

Appendix Table 44. (continued).

Order	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Hymenoptera						
Formicidae	2	11.5	2	18.2	9	51.8
					4	23.0
Lepidoptera						
Hesperiidae	--	--	1	371.9	--	--

Appendix Table 45. Soil macroarthropod families collected 29 October 1970, Pawnee Site.

Order	Grazing Treatment					
	Ungrazed		Light		Moderate	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Araneida						
Lycosidae	--	--	1	2.0	--	--
Coleoptera						
Carabidae	2	224.8	2	66.2	--	240.0
Cerambycidae	--	--	--	--	--	76.5
Curculionidae	1	6.1	3	13.1	--	110.2
Elateridae	5	122.4	--	--	--	43.5
Meloidae	1	39.3	--	--	--	--
Scarabaeidae	5	28.4	11	446.6	6	34.1
Staphylinidae	1	2.9	3	8.7	1	2.9
Tenebrionidae	1	608.1	3	679.9	1	608.1
Diptera						
Asilidae	--	--	--	--	3	184.1
Homoptera						
Margarodidae	1	10.1	--	--	--	10.1
Hymenoptera						
Formicidae	--	--	2	7.1	--	5.7

Appendix Table 46. Soil macroarthropod families collected 31 January 1971, Pawnee Site.

Order	Grazing Treatment							
	Ungrazed		Light		Moderate		Heavy	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera								
Carabidae	2	113.8	--	--	--	--	2	224.8
Curculionidae	1	11.1	--	--	--	--	1	11.1
Elatерidae	1	2.9	--	--	--	--	--	--
Scarabaeidae	17	158.9	8	849.1	2	75.5	4	85.0
Staphylinidae	--	--	1	4.2	2	8.5	1	4.2
Tenebrionidae	2	304.4	--	--	--	--	--	--
Diptera								
Asilidae	--	--	--	--	1	73.2	--	--
Hemiptera								
Corixidae	1	60.5	--	--	--	--	--	--
Lygaeidae	1	1.1	--	--	1	1.1	--	--
Homoptera								
Margarodidae	19	193.4	3	30.5	1	10.1	8	81.4
Hymenoptera								
Formicidae	1	11.2	--	--	1	5.7	--	--

APPENDIX VIII

SOIL MACROARTHROPOD FAMILIES COLLECTED FROM FOUR
DIFFERENTIALLY GRAZED PASTURES, PAWNEE SITE, 1971

Appendix Table 47. Soil macroarthropod families collected from ungrazed exclosures, Pawnee Site, 1971.

Family	Collection Date							
	25 March		3 May		5 July		31 August	
	Number	Biomass* (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera								
Scarabaeidae	12	--	--	--	7	248.1	3	81.2
Curculionidae	--	--	2	12.3	--	--	1	11.1
Staphylinidae	1	--	--	--	--	--	--	--
Carabidae	--	--	--	--	3	45.7	--	--
Tenebrionidae	--	--	--	--	--	--	--	--
Elatерidae	--	--	--	--	1	4.1	--	--
Histeridae	--	--	--	--	--	--	1	21.7
Homoptera								
Margarodidae	18	--	21	210.5	1	10.0	--	--
Pseudococcidae	--	--	--	--	1	2.9	--	--
Hymenoptera								
Formicidae	3	--	1	5.7	1	18.7	--	--
Diptera								
Asilidae	--	--	--	--	--	--	--	--
Therevidae	--	--	--	--	--	--	--	--

12.4

80.2

50.9

30.3

5.6

Appendix Table 47. (continued).

Family	Collection Date									
	25 March		3 May		5 July		31 August		6 October	
	Number	Biomass* (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Collembola										
Entomobryidae	--	--	--	--	--	--	--	--	--	--
Isoptera										
Rhinotermitidae	1	--	--	--	--	--	--	--	--	--
Hemiptera										
Cydnidae	--	--	--	--	--	--	--	--	--	--
Orthoptera										
Acrididae	--	--	--	--	--	--	--	--	--	--
Total	35	--	24	228.5	14	329.5	5	124.0	12	179.4

*Not available at present.

Appendix Table 48. Soil macroarthropod families collected from a lightly grazed pasture, Pawnee Site, 1971.

Family	Collection Date							
	25 March		3 May		5 July		31 August	
	Number	Biomass* (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera								
Scarabaeidae	5	--	8	109.6	--	--	6	34.1
Curculionidae	4	--	1	104.0	1	104.0	--	--
Staphylinidae	--	--	1	2.9	--	--	--	--
Carabidae	--	--	--	--	--	--	3	240.0
Tenebrionidae	1	--	--	--	--	--	--	267.1
Elaterridae	1	--	--	--	--	--	--	--
Histeridae	--	--	--	--	--	--	--	--
Homoptera								
Margarodidae	13	--	8	80.2	1	10.0	--	--
Pseudococcidae	--	--	--	--	--	--	--	--
Hymenoptera								
Formicidae	--	--	2	9.4	1	14.2	--	--
Diptera								
Asilidae	--	--	--	--	--	--	1	73.2
Therevidae	--	--	1	16.7	--	--	--	--

Appendix Table 48. (continued).

Family	Collection Date									
	25 March		3 May		5 July		31 August		6 October	
	Number	Biomass* (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Collembola										
Entomobryidae	--	--	--	--	--	--	--	--	--	--
Isoptera										
Rhinotermitidae	--	--	--	--	--	--	--	--	--	--
Hemiptera										
Cydnidae	--	--	--	--	1	30.8	--	--	--	--
Orthoptera										
Acrididae	--	--	--	--	--	--	--	--	--	--
Total	24	--	21	322.8	4	159.0	9	274.1	3	345.9

*Not available at present.

Appendix Table 49. (continued).

Appendix Table 43. (continued).

Family	Collection Date									
	25 March		3 May		5 July		31 August		6 October	
	Number	Biomass* (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Isoptera										
Rhinotermitidae	--	--	--	--	--	--	--	--	--	--
Hemiptera										
Cydnidae	--	--	--	--	--	--	--	--	--	--
Orthoptera										
Acrididae	--	--	--	--	--	--	--	--	--	--
Total	29	--	21	628.6	4	24.6	8	361.4	5	637.0

* Not available at present.

Appendix Table 50. Soil macroarthropod families collected from a heavily grazed pasture, Pawnee Site, 1971.

[illegible]

Appendix Table 50. (continued).

Appendix Table 50. (continued).

Family	Collection Date									
	25 March		3 May		5 July		31 August		6 October	
	Number	Biomass* (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Hemiptera	--	--	--	--	--	--	--	--	--	--
Cydnidae	--	--	--	--	--	--	--	--	--	--
Orthoptera	--	--	--	--	--	--	--	--	2	9.7
Acrididae	--	--	--	--	--	--	--	--	9	90.5
Total	23	--	9	296.9	4	90.2	8	378.9	9	90.5

* Not available at present.

APPENDIX IX

SOIL MACROARTHROPOD FAMILIES COLLECTED FROM UNGRAZED ENCLOSURES
AND A RECENTLY HEAVILY GRAZED PASTURE, PAWNEE SITE, 1971

Appendix Table 51. Soil macroarthropod families collected 22 April 1971, Pawnee Site.

Family	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera				
Scarabaeidae	--	--	10	54.9
Curculionidae	2	12.3	--	--
Tenebrionidae	--	--	1	5.6
Elateridae	--	--	1	8.0
Carabidae	--	--	--	--
Cerambycidae	--	--	--	--
Staphylinidae	--	--	--	--
Homoptera				
Margarodidae	21	210.5	19	190.4
Pseudococcidae	--	--	--	--
Hymenoptera				
Gormicidae	1	5.7	--	--
Diptera				
Asilidae	--	--	--	--
Hemiptera				
Lygaeidae	--	--	--	--
Cydnidae	--	--	--	--
Orthoptera				
Acrididae	--	--	--	--
Neuroptera				
Myrmeleontidae	--	--	--	--

Appendix Table 52. Soil macroarthropod families collected 12 May 1971, Pawnee Site.

Family	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera				
Scarabaeidae	16	153.2	4	19.8
Curculionidae	--	--	--	--
Tenebrionidae	1	608.1	--	--
Elateridae	1	112.4	--	--
Carabidae	--	--	1	112.4
Cerambycidae	--	--	1	77.3
Staphylinidae	1	4.2	--	--
Homoptera				
Margarodidae	16	160.4	17	170.4
Pseudococcidae	--	--	--	--
Hymenoptera				
Formicidae	1	12.4	--	--
Diptera				
Asilidae	1	73.2	--	--
Hemiptera				
Lygaeidae	--	--	--	--
Cydnidae	--	--	--	--
Orthoptera				
Acrididae	--	--	--	--
Neuroptera				
Myrmeleontidae	--	--	--	--

Appendix Table 53. Soil macroarthropod families collected 24 May 1971, Pawnee Site.

Family	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera				
Scarabaeidae	4	21.7	5	28.4
Curculionidae	1	6.1	1	104.0
Tenebrionidae	1	30.3	--	--
Elateridae	--	--	--	--
Carabidae	2	163.4	2	224.8
Cerambycidae	--	--	--	--
Staphylinidae	--	--	1	4.2
Homoptera				
Margarodidae	31	310.7	17	170.4
Pseudococcidae	--	--	--	--
Hymenoptera				
Formicidae	3	10.6	--	--
Diptera				
Asilidae	--	--	--	--
Hemiptera				
Lygaeidae	--	--	--	--
Cydnidae	--	--	--	--
Orthoptera				
Acrididae	--	--	--	--
Neuroptera				
Myrmeleontidae	--	--	--	--

Appendix Table 54. Soil macroarthropod families collected 4 June 1971, Pawnee Site.

Family	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera				
Scarabaeidae	7	37.8	1	4.3
Curculionidae	1	6.1	--	--
Tenebrionidae	--	--	1	27.6
Elateridae	--	--	--	--
Carabidae	--	--	--	--
Cerambycidae	--	--	--	--
Staphylinidae	1	4.2	2	7.7
Homoptera				
Margarodidae	16	160.4	9	82.0
Pseudococcidae	--	--	--	--
Hymenoptera				
Formicidae	37	226.6	4	21.8
Diptera				
Asilidae	1	73.2	--	--
Hemiptera				
Lygaeidae	2	2.3	--	--
Cydnidae	--	--	--	--
Orthoptera				
Acrididae	--	--	11	18.1
Neuroptera				
Myrmeleontidae	--	--	--	--

Appendix Table 55. Soil macroarthropod families collected 15 June 1971, Pawnee Site.

Family	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera				
Scarabaeidae	12	66.3	5	31.8
Curculionidae	--	--	--	--
Tenebrionidae	--	--	--	--
Elateridae	1	2.9	--	--
Carabidae	--	--	--	--
Cerambycidae	--	--	--	--
Staphylinidae	--	--	1	2.9
Homoptera				
Margarodidae	9	90.2	20	200.5
Pseudococcidae	1	2.9	--	--
Hymenoptera				
Formicidae	5	27.6	--	--
Diptera				
Asilidae	--	--	--	--
Hemiptera				
Lygaeidae	--	--	1	1.1
Cydnidae	--	--	1	70.4
Orthoptera				
Acrididae	--	--	--	--
Neuroptera				
Myrmeleontidae	--	--	--	--

Appendix Table 56. Soil macroarthropod families collected 5 July 1971, Pawnee Site.

Family	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera				
Scarabaeidae	7	248.1	--	--
Curculionidae	--	--	1	104.0
Tenebrionidae	--	--	--	--
Elateridae	1	4.1	--	--
Carabidae	3	45.7	--	--
Cerambycidae	--	--	--	--
Staphylinidae	--	--	1	4.2
Homoptera				
Margarodidae	1	10.0	2	20.0
Pseudococcidae	1	2.9	--	--
Hymenoptera				
Formicidae	1	18.7	--	--
Diptera				
Asilidae	--	--	--	--
Hemiptera				
Lygaeidae	--	--	--	--
Cydnidae	--	--	--	--
Orthoptera				
Acrididae	--	--	--	--
Neuroptera				
Myrmeleontidae	--	--	--	--

Appendix Table 57. Soil macroarthropod families collected 15 July 1971, Pawnee Site.

Family	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera				
Scarabaeidae	1	5.6	5	27.4
Curculionidae	1	6.1	1	4.3
Tenebrionidae	9	283.7	--	--
Elatерidae	3	35.2	--	--
Carabidae	1	112.4	--	--
Cerambycidae	--	--	--	--
Staphylinidae	--	--	--	--
Homoptera				
Margarodidae	7	70.1	15	150.3
Pseudococcidae	--	--	--	--
Hymenoptera				
Formicidae	21	263.6	5	25.1
Diptera				
Asilidae	--	--	--	--
Hemiptera				
Lygaeidae	--	--	--	--
Cydnidae	--	--	--	--
Orthoptera				
Acrididae	--	--	--	--
Neuroptera				
Myrmeleontidae	--	--	--	--

Appendix Table 58. Soil macroarthropod families collected 29 July 1971, Pawnee Site.

Family	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera				
Scarabaeidae	7	103.0	2	10.4
Curculionidae	--	--	1	7.2
Tenebrionidae	--	--	1	64.4
Elateridae	1	3.3	--	--
Carabidae	1	112.4	1	112.4
Cerambycidae	--	--	--	--
Staphylinidae	--	--	--	--
Homoptera				
Margarodidae	2	20.0	2	20.0
Pseudococcidae	--	--	--	--
Hymenoptera				
Formicidae	1	12.4	--	--
Diptera				
Asilidae	--	--	1	73.2
Hemiptera				
Lygaeidae	1	1.1	--	--
Cydnidae	--	--	--	--
Orthoptera				
Acrididae	--	--	--	--
Neuroptera				
Myrmeleontidae	1	6.4	--	--

Appendix Table 59. Soil macroarthropod families collected 11 August 1971, Pawnee Site.

Family	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera				
Scarabaeidae	1	5.6	3	17.0
Curculionidae	2	208.0	--	--
Tenebrionidae	7	2053.4	--	--
Elateridae	2	55.3	--	--
Carabidae	--	--	--	--
Cerambycidae	--	--	--	--
Staphylinidae	--	--	1	13.1
Homoptera				
Margarodidae	1	10.0	8	80.2
Pseudococcidae	--	--	--	--
Hymenoptera				
Formicidae	--	--	--	--
Diptera				
Asilidae	--	--	--	--
Hemiptera				
Lygaeidae	--	--	--	--
Cydnidae	--	--	--	--
Orthoptera				
Acrididae	--	--	--	--
Neuroptera				
Myrmeleontidae	--	--	--	--

Appendix Table 60. Soil macroarthropod families collected 31 August 1971, Pawnee Site.

Family	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera				
Scarabaeidae	2	75.5	--	--
Curculionidae	1	11.1	--	--
Tenebrionidae	--	--	--	--
Elateridae	--	--	--	--
Carabidae	--	--	--	--
Cerambycidae	--	--	--	--
Staphylinidae	--	--	--	--
Homoptera				
Margarodidae	--	--	--	--
Pseudococcidae	--	--	--	--
Hymenoptera				
Formicidae	--	--	--	--
Diptera				
Asilidae	--	--	--	--
Hemiptera				
Lygaeidae	--	--	--	--
Cydnidae	--	--	--	--
Orthoptera				
Acrididae	--	--	--	--
Neuroptera				
Myrmeleontidae	--	--	--	--

Appendix Table 61. Soil macroarthropod families collected
27 September 1971, Pawnee Site.

Family	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera				
Scarabaeidae	3	17.0	1	5.6
Curculionidae	--	--	--	--
Tenebrionidae	2	38.1	--	--
Elateridae	1	11.7	--	--
Carabidae	--	--	--	--
Cerambycidae	--	--	--	--
Staphylinidae	1	13.1	1	4.2
Homoptera				
Margarodidae	1	10.0	--	--
Pseudococcidae	--	--	--	--
Hymenoptera				
Formicidae	--	--	1	5.5
Diptera				
Asilidae	1	37.6	--	--
Hemiptera				
Lygaeidae	--	--	--	--
Cydnidae	--	--	--	--
Orthoptera				
Acrididae	--	--	--	--
Neuroptera				
Myrmeleontidae	--	--	--	--

Appendix Table 62. Soil macroarthropod families collected 6 October 1971, Pawnee Site.

Family	Grazing Treatment			
	Ungrazed		Grazed	
	Number	Biomass (mg/m ²)	Number	Biomass (mg/m ²)
Coleoptera				
Scarabaeidae	1	5.6	3	17.0
Curculionidae	--	--	--	--
Tenebrionidae	1	30.3	--	--
Elateridae	--	--	--	--
Carabidae	1	50.9	--	--
Cerambycidae	--	--	--	--
Staphylinidae	--	--	--	--
Homoptera				
Margarodidae	8	80.2	--	--
Pseudococcidae	--	--	--	--
Hymenoptera				
Formicidae	1	12.4	1	12.4
Diptera				
Asilidae	--	--	1	73.2
Hemiptera				
Lygaeidae	--	--	--	--
Cydnidae	--	--	--	--
Orthoptera				
Acrididae	--	--	--	--
Neuroptera				
Myrmeleontidae	--	--	--	--

APPENDIX X

FIELD DATA

Soil macroarthropod data collected at the Pawnee Site in 1971 is Grassland Biome Data Set A2U302B. Data were collected on a form specialized for use at the Pawnee Site. A copy of the form and an example of the data is attached.

1		2		3		4		5		6		7		8	
12345678901234567890123456789012345678901234567890123456789012345678901234567890															
3311JWL2503711411213R		0413	INSE	HOMO	MARG	STO		01	40	1	01.27	1			
3311JWL2503711411231R		040613	INSE	HOMO	MARG	STO		01	40	3	01.27	1			
3311JWL25037114112340		0413	INSE	COLE	SCAR	TRI		01	10	7	00.72	1			
3311JWL2503711411234R		0413	INSE	HOMO	MARG	STO		01	40	1	01.27	1			
3311JWL25037114112540		0413	INSE	COLE	SCAR	TRI		01	10	2	00.72	1			
3311JWL25037114112 8		0413	INSE	HOMO	MARG	STO		01	40	2	01.27	1			
3311JWL25037114112620		041113	INSE	COLE	SCAR	TRI		01	40	1	00.62	1			
3311JWL25037114112 8		041113	INSE	HOMO	MARG	STO		01	40	2	01.27	1			
3311JWL25037114112 8		041113	INSE	COLE	STAP			02	10	1	01.66	1			
3311JWL2503711412822R		0413	INSE	HOMO	MARG	STO		01	40	7	01.27	1			
3311JWL25037114128 0		0413	INSE	DIPT				05	20		00.72	1			
3311JWL25037114128340		0413	INSE	COLE	SCAR	TRI		01	10	1	00.72	1			
3311JWL2503711412844		0400									.	1			
3311JWL25037114128637		0412	INSE	HYME	FORM	LAS		02	10	1	00.73	1			
3311JWL25037114128 7		0412	INSE	HYME	FORM			03	10	1	00.72	1			
3311JWL25037114128 8		0413	INSE	HOMO	MARG	STO		01	40	2	01.27	1			
3311JWL25037114128710		0412	INSE	COLE	SCAR	TRI		01	10	1	00.72	1			
3311JWL25037114128 8		0412	INSE	ISOP	RHIN			02	10	1	00.40	1			
3311JWL25037114128 7		0412	INSE	HYME	FORM	MYR		04	10	1	01.58	1			
3311JWL25037117214160		0212	INSE	COLE				01	40	1	07.64	1			
3311JWL2503711721423R		0413	INSE	HOMO	MARG	STO		01	40	1	01.27	1			
3311JWL25037117214270		0212	INSE	COLE	SCAR	TRI		01	10	1	00.72	1			
3311JWL25037117214 8		0213	INSE	HOMO	MARG	STO		01	40	1	01.27	1			
3311JWL25037117214 0		0212	INSE	COLE	CURC			02	40	4	00.78	1			
3311JWL2503711721455R		0413	INSE	HOMO	MARG	STO		01	40	5	01.27	1			
3311JWL25037117214 0		0413	INSE	DIPT				06	20	1	02.02	1			
3311JWL25037117214890		021013	INSE	COLE	TENE			03	40	1	77.04	1			
3311JWL25037117214 8		021013	INSE	HOMO	MARG	STO		01	40	2	01.27	1			
3311JWL2503711622503		00									.				
3311JWL25037116225050		030412	INSE	LEPI				02	40	1	27.02	1			
3311JWL2503711622505R		030413	INSE	HOMO	MARG	STO		01	40	4	01.27	1			
3311JWL25037116225130		0412	INSE	COLE	SCAR	TRI		01	10	1	00.72	1			
3311JWL2503711622514		00									.				
3311JWL25037116225340		0212	INSE	COLE	SCAR	TRI		01	10	3	00.72	1			
3311JWL25037116225 0		0212	INSE	COLE	FLAT			02	40	1	01.49				
3311JWL25037112316485		0312	INSE	COLE	CURC	CAL		01	40	1	01.41	1			
3311JWL25037112316540		0413	INSE	COLE	CURC			03	20	1	00.72	1			
3311JWL25037112316 8		0412	INSE	COLE	STAP			02	10	1	01.66	1			
3311JWL25037112316590		0412	INSE	COLE	SCAR	TRI		01	10	1	00.72	1			
3311JWL25037112316708		0412	INSE	COLE	STAP			02	10	1	01.66	1			
3311JWL25037112316760		041112	INSE	COLE	SCAR	TRI		01	10	2	00.72	1			
3311JWL25037112316 5		041112	INSE	COLE	CARA	HAP		02	10	1	14.24	1			
3311JWL25037113327127		041112	INSE	HYME	FORM			03	10	1	00.72	1			

3311 JWL2503711332745R	0413 INSE HOMO MARG STO	01 40	12	01.27	1
3311 JWL25037113327 0	0413 INSE DIPT	07 20	1	00.36	1
3311 JWL25037113327 0	0412 INSE COLE SCAP TRI	01 10	1	00.72	1
3311 JWL2503711332762R	0413 INSE HOMO MARG STO	01 40	1	01.27	1
3311 JWL25037113327 0	0412 INSE COLL ENTO	01 10	1	00.02	1
3311 JWL25037113327647	1112 INSE HYME FORM LAS	02 10	1	00.73	1
3311 JWL25037113327 5	1112 INSE DIPT ASIL	01 40	1	09.28	1
3311 JWL25037113327 0	1112 INSE COLE TENE BLA	01 10	1	03.85	1
3311 JWL25037113327780	020312 INSE COLE FLAT	02 40	1	01.49	1
3311 JWL25037113327 5	020312 INSE DIPT ASIL	01 40	1	09.28	1
3311 JWL2503711341116R	0413 INSE HOMO MARG STO	01 40	1	01.27	1
3311 JWL2503711341122R	0413 INSE HOMO MARG STO	01 40	3	01.27	1
3311 JWL25037113411235	0412 INSE DIPT ASIL	01 40	1	09.28	1
3311 JWL2503711341132R	0413 INSE HOMO MARG STO	01 40	1	01.27	1
3311 JWL2503711341146R	0413 INSE HOMO MARG STO	01 40	5	01.27	1
3311 JWL2503711341166R	0413 INSE HOMO MARG STO	01 40	6	01.27	1
3311 JWL2503711542303	00				
3311 JWL25037115423120	0412 INSE COLE SCAP TRI	01 40	1	00.60	1 0.45
3311 JWL25037115423210	1112 INSE COLE TENE	03 40	1	77.04	1
3311 JWL25037115423 0	1112 INSE COLE SCAP TRI	01 10	1	00.72	1
3311 JWL25037115423307	0412 INSE HYME FORM	03 10	1	00.73	1
3311 JWL25037115423450	0412 INSE COLE FLAT	03 40	1	00.92	1
3311 JWL25037115423 0	0412 INSE COLE SCAP TRI	01 10	1	00.72	1