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1970-1971 SOIL MOVEMENT AT THE PAWNEE INTENSIVE SITE

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ABSTRACT

Results from field application of a strontium-90 beta particle attenuation method for measuring soil movement at the Pawnee Intensive Site are presented. Generally, it is concluded from 1970-1971 data that soil type and grazing treatment have not significantly influenced soil movement, although a trend of more soil-litter accumulation in the lightly grazed pasture as compared to the heavily grazed pasture was observed. Climatic factors associated with season are highly significant in their effect on soil movement with winter being a period of erosion and spring, fall, and summer generally showing accumulation. The yearly mean accumulation of 16 g/m^2/month (.24 mm/year) is not significantly different from zero, indicating that on a short-term basis there is little net soil movement in the area of our plots.

INTRODUCTION

Implicit in understanding ecosystem function is knowledge pertaining to the abiotic elements of the system functioning as driving forces behind productivity. One such abiotic component, the soil, and in particular its erosional behavior, has been the objective of this research.

To investigate erosional behavior of soils at the Pawnee Intensive Site, a shortgrass plains ecosystem, a method involving strontium-90 beta particle attenuation was developed and employed. In lightly, moderately, and heavily summer grazed pastures 265 plots were established, and to date 1 year of data have been collected and analyzed.

METHODS

A detailed description of the beta particle attenuation method for measuring soil movement is presented in Alldredge and Whicker (1971). Therefore, only a brief resumé will be given here.

The basic principle of this method involves measurement of beta particles which penetrate the soil above a buried radioactive source. As soil or litter measured in milligrams per square centimeter is deposited over the source, a decreased count rate is measured using a portable Gieger-Mueller (GM) survey instrument. Removal of material results in an increased count rate.

Field application of this method allows detection of small soil fluctuations over a period of a few weeks. For example, a 45% change in count rate corresponds to a 1-mm change in soil depth which represents approximately 80 mg/cm^2 for Pawnee Site soils. As previously reported (Alldredge and Whicker, 1971), approximately 12% of the variance observed in data could be attributed to variability in counting. When examining variance between plots from field data it was found that 2% of this variation was attributable to variance associated with the method. It should be emphasized that counting error can be reduced by increasing the duration of the count. When soil movement is minimal, error associated with methods becomes proportionately larger, and counting time may need to be increased.

Initially, a method involving fallout cesium-137 as a soil particle tag was proposed to investigate soil accumulation at the Pawnee Site. From data gathered from the literature and our own field and laboratory studies, it was concluded that cesium-137 was a good tag for Pawnee Site soil particles. Its downward movement in the soil profile is negligible, and the majority of the isotope is tightly bound to small soil particles. Its behavior is essentially that of the particle. Our initial intent was to determine soil accumulation by relating the depth at which the cesium occurred in the soil profile to the duration this isotope has been in the biosphere. Such an approach would give no measurement of erosion, but would indicate relative buildup rates in areas of soil accumulation. Problems such as obtaining a reliable depth sample in increments of 1 or 2 mm and of sufficient volume to enable detection of fallout cesium resulted when field application of this method was begun. To analyze the great number of samples necessary to describe soil accumulation on the Pawnee Site would require a prohibitive amount of counting time. The problems have not been resolved, and we have abandoned the cesium approach in favor of the beta particle attenuation method, which we feel will yield a more precise and reliable measure of soil movement for much less cost.

STUDY AREA

To obtain soil movement data for the Pawnee Site, the summer grazed pastures were selected as study areas. In the heavily grazed pasture (T10N, R66W, Sec. 23E) 100 plots were established. The lightly grazed pasture (Sec. 23W) was sampled with 45 plots, while the moderately grazed pasture (Sec. 15E), which contained twice as many soil types as the other pastures, contained 120 plots. The experimental design for this study, as well as the procedure used in locating transects and plots, has been reported previously (Alldredge and Whicker, 1970, 1971).

In order to properly compare soil movement data between pastures, it was necessary to determine relative surface area occupied by each soil type within the pastures. These proportions were used as weighting factors in data analysis. The results of this determination are presented in Table 1.

RESULTS AND DISCUSSION

Soil movement data summarized by season, grazing treatment, and soil type are presented in Tables 2 through 7. The data have been corrected for physical decay of the strontium-90 sources and thus differ slightly from data previously reported (Alldredge and Whicker, 1970). Data in Table 6 have been weighted according to relative surface area occupied by individual soil types. No correction has been applied for variable sample number between soil types and pastures. For a detailed discussion of the analysis performed on these data consult IBP Grassland Biome Statistical Services Rep. Proj. No. 40101 (Campion and Francis, 1971).

Table 1. Relative surface area of soils at the Pawnee Intensive Site.

Soil Series	Grazing Treatment (320-acre pastures)		
	Heavy	Moderate	Light
Ascalon	.3786	.5239	.4414
Vona	.0899	.0359	.2189
Undifferentiated	.0855	.0924	.1226
Shingle-Renohill	.4073	.0911	.2189
Renohill	*[a]	.1252	*
Manzanola	*	.0217	*
Gravelly-Cobbly	*	.0322	*
Shingle	*	.0766	*

[a] * = Soil does not occur in this grazing treatment.

Table 2. Fall soil movement data (g/m^2/month).[a/]

Soil Series	ΔM[b/]	$S\bar{x}$	N
Heavily grazed			
Ascalon	145	110	13
Vona	116	83	15
Undifferentiated	-138.02	134	14
Shingle-Renohill	2.92	114	14
Moderately grazed	No Data	No Data	No Data
Lightly grazed			
Ascalon	88	108	15
Vona	141	88	15
Undifferentiated	218	59	14
Shingle-Renohill	152	75	15

a/ Fall sampling period from September to November.

b/ ΔM is the mean soil movement for the sampling period.

Table 3. Winter soil movement data (g/m^2/month).[a/]

Soil Series	ΔM	$S\bar{x}$	N
Heavily grazed			
Ascalon	-103	46	13
Vona	-188	29	13
Undifferentiated	-88	36	9
Shingle-Renohill	-99	43	10
Moderately grazed[b/]			
Ascalon	-88	45	14
Vona	-130	42	14
Undifferentiated	-8	19	15
Shingle-Renohill	-121	34	15
Shingle	-38	56	12
Renohill	-63	38	15
Manzanola	-137	51	13
Gravelly-Cobbly	-60	52	15
Lightly grazed			
Ascalon	-202	40	14
Vona	-83	85	13
Undifferentiated	-152	37	10
Shingle-Renohill	-144	45	15

a/ Winter sampling period from November to March.

b/ Winter sampling period from September to March for this grazing treatment.

Table 4. Spring soil movement data (g/m^2/month).[a/]

Soil Series	ΔM	$S\bar{x}$	N
Heavily grazed			
Ascalon	79	74	10
Vona	70	58	11
Undifferentiated	-58	79	8
Shingle-Renohill	-33	109	7
Moderately grazed			
Ascalon	254	104	13
Vona	96	108	10
Undifferentiated	85	57	15
Shingle-Renohill	37	79	13
Shingle	155	65	10
Renohill	140	97	12
Manzanola	252	117	12
Gravelly-Cobbly	22	123	7
Lightly grazed			
Ascalon	252	79	12
Vona	6	111	9
Undifferentiated	41	66	8
Shingle-Renohill	56	92	14

a/ Spring sampling period from March to June.

Table 5. Summer soil movement data ($g/m^2/month$).[a/]

Soil Series	ΔM	$S\bar{x}$	N
Heavily grazed			
Ascalon	137	25	9
Vona	97	86	10
Undifferentiated	0.26	73	12
Shingle-Renohill	17	72	8
Moderately grazed			
Ascalon	-56	190	11
Vona	-374	198	9
Undifferentiated	-53	58	9
Shingle-Renohill	-36	38	14
Shingle	-114	179	10
Renohill	112	45	12
Manzanola	-146	44	11
Gravelly-Cobbly	112	102	7
Lightly grazed			
Ascalon	15	69	14
Vona	-4	50	10
Undifferentiated	-42	37	13
Shingle-Renohill	-4	56	13

[a/] Summer sampling period from June to September.

Table 6. Summarized Pawnee Site soil movement data (g/m^2/month).[a]

Grazing Treatment	Fall			Winter			Spring			Summer			Grazing Mean	
	$\bar{X}$	$S\bar{x}$	N	$\bar{X}$	$S\bar{x}$	N	$\bar{X}$	$S\bar{x}$	N	$\bar{X}$	$S\bar{x}$	N	$\bar{X}$	$S\bar{x}$
Heavy	55	61	56	-104	26	45	18	46	36	68	30	39	9	24
Moderate				-63	24	58	148	63	51	-50	99	43	12	37
Light	130	52	59	-158	33	51	130	58	43	0	37	50	26	23
Season Mean	93	41		-104	16		96	34		7	36			

Area Mean = 16

$S\bar{x}$ = 16

[a] Data in this table are the result of pooled data weighted according to soil type relative surface area as presented in Table 1.

Table 7. Soil movement on sinks, Lynn Lake, Ascalon slopes, and Shingle slopes (g/m^2/month).

	Fall	Winter	Spring	Summer
Sinks				
$\bar{X}$	193	-147	321	-22.9
$S\bar{x}$	104	71	200	103
N	8	6	5	7
Lynn Lake				
$\bar{X}$	-572	a/		-407
$S\bar{x}$	303			154
N	6			8
Ascalon Slopes				
Southwest exposure				
$\bar{X}$	532	-66	450	186
$S\bar{x}$	278	70	320	208
N	4	4	3	3
Northeast exposure				
$\bar{X}$	94	-182	448	-394
$S\bar{x}$	168	79	194	132
N	5	4	4	4
Shingle Slopes				
Northwest exposure				
$\bar{X}$	b/	11	35	82
$S\bar{x}$		74	60	132
N		5	5	6
Southeast exposure				
$\bar{X}$	b/	-73	275	-407
$S\bar{x}$		82	92	386
N		7	5	4

a/ No data were taken due to soil cracking with freezing and thawing and exposing radioactive sources.

b/ Data were not taken for this pasture during the fall sampling period. The winter sampling period extends from September through March for this grazing treatment.

Analysis of variance on data collected from September 1970 through August 1971 resulted in no significant differences ($P < .10$) in soil type erosional behavior as well as no effect of grazing treatments on soil movement. Significance ($P < .05$) was detected in the effect of climatic factors associated with season on soil movement with winter season illustrating a great loss for all soil types and pastures. Climatic data for the Pawnee Site and the work of Chepil, Siddoway, and Armbrust (1964) indicate that wind is the major agent of erosion on this study area.

The lack of significant differences in erosional behavior among soil types is not surprising as these soils are not highly different in composition (Franklin, 1969). The soils examined in this study belong to interpretive soil groups 1-4 used by Hyder et al. (1966) in a study which illustrated highly similar soil texture and subsoil permeability. Trends in the soil type analysis indicate that Ascalon soils generally accumulate more soil-litter material while the coarser Vona sandy loam shows a greater loss than do other soil types on a yearly basis. The Shingle-Renohill complex, which occupies the steeper slopes on the study area, shows considerable loss of material and has been previously speculated to be a readily erodable soil type (Franklin, 1969).

It might be suspected that grazing treatment would influence soil movement. Conclusions drawn by Hyder et al. (1966) state that vegetative composition is not significantly altered by grazing intensity on the study area, but that herbage yields were significantly different between heavy and light grazing treatments. As stated by Woodruff and Siddoway (1965), the type and amount of vegetation influences soil response to erosive winds.

Our data illustrate trends that indicate an influence of grazing treatments (Table 6) congruent with what one would intuitively suspect, but due to large variability in data from individual plots within soil types no significant differences ($P < .10$) were detectable. This variability is apparently real and not due to poor precision in methods as previously stated (Alldredge and Whicker, 1971).

From examination of preliminary weather data from the Pawnee Site, we conclude that a greater frequency of high velocity winds occur during the winter period. Such winds coupled with relatively low surface soil water indicated by low precipitation lead one to suspect that erosion would occur during the winter which, in fact, is indicated by our data. The current weather installations at the Pawnee Site should provide us with the data necessary to correlate soil movement with climatic factors such as wind.

Data presented in Table 7 indicate that aspect influences soil movement as has been observed with snow accumulation (Van Haveren and Galbraith, 1971). The difference in erosional behavior of the southwest and northeast exposures of the Ascalon soil type is highly significant ($P < .05$) with the northeast exposure illustrating more erosion and less accumulation than the southwest. A similar comparison of a Shingle soil series occurring on northwest and southeast exposures shows no significant differences in soil movement.

Data taken from plots in the ephemeral Lynn Lake and the topographic sinks (Table 7) indicate that while the erosion pavement-covered lake basin is losing soil, the topographic sinks covered with dense stands of buffalo grass (*Buchloe dactyloides*) are accumulating soil. Data from individual plots at the edge of Lynn Lake where the buffalo grass community is established indicate that the lake may actually be filling in from its margins. This filling-in process, we speculate, proceeds with the advance of the grass community which serves to trap and hold soil particles. Data concerning the lake basin are tenuous due to the cracking of the high clay soil with freezing and thawing, which subsequently exposes many of the radioactive sources.

Examination of the mean accumulation of 16 g/m^2/month (.24 mm/year) for Pawnee Site soil movement leads us to conclude that very little net movement is occurring in the area of our plots. This is possibly true for the entire Pawnee Site, but further consideration leads us to speculate that during the winter long-distance transport of soil-litter material may occur as a result of high velocity northwesterly winds. For the remainder of the year only local movement may occur. We have not adequately sampled the elevated terrain in the area as most of it lies outside the grazing treatment pastures. Local movement from ridgetops and high areas to lower lying regions, where the majority of our sampling is conducted, would result in the net accumulation we have measured. This speculation cannot, of course, be substantiated by data collected to date, but could be ascertained by other types of investigations such as sampling uplands and possibly using a soil particle tag such as iron-59 to trace soil movement patterns at specific sites.

In conjunction with our continued observation on plots, we have established 10 standard plots in different soil types at the Pawnee Site to examine the proposed problem of frost heaving of the strontium-90 source nails (Alldredge and Whicker, 1971). These plots are identical to the soil movement plots with the exception that the strontium-90 sources are located above ground. If no alterations other than physical decay of the sources is observed in these plots, then we can assume that frost heaving has not influenced the data from the other field plots.

CONCLUSIONS

From a year of data recorded to date we observe the need for continued investigation to describe soil erosional behavior at the Pawnee Site. Observations are needed to further validate the method employed as well as to verify or refute trends observed in the first year's data. Continued readings to determine trend behavior would help elucidate long-term soil movement patterns. Generally, it can be stated from the 1970-1971 data that similarity exists in erosional behavior of soil types and that grazing treatment, while showing trends toward less accumulation in the heavily grazed pasture, does not significantly influence soil movement. Climatic factors associated with season have a significant effect on soil movement with the winter season showing soil erosion and the other seasons generally illustrating accumulation.

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APPENDIX I

Soil Movement Data: Pasture-Soil-Season

Data presented in this appendix are grams per square meter of soil fluctuation on plots at the Pawnee Intensive Site. Field data taken in counts per minute were applied in a regression equation to obtain data listed here, which constitute Grassland Biome Data Set A2U70DB. Format for this listing is as follows.

Columns	
1	Pasture
2	Soil
3	Season
6-10	Weight factor (Table 1)
16-21	g/m^2/month soil fluctuation

Key:

Pasture	Season	Soil
1 = Heavy	1 = Fall	1 = Ascalon
2 = Moderate	2 = Winter	2 = Vona
3 = Light	3 = Spring	3 = Undifferentiated
	4 = Summer	4 = Shingle-Renohill
		5 = Lynn Lake (Heavy)
		5 = Shingle (Moderate)
		6 = Renohill
		7 = Manzanola
		8 = Gravelly-Cobbly

Data punched without decimal. Two decimal places in each entry.

11110.3786	-38365
11110.3786	19758
11110.3786	12959
11110.3786	82512
11110.3786	-23388
11110.3786	-25483
11110.3786	47800
11110.3786	31065
11110.3786	-30059
11110.3786	29512
11110.3786	54230
11110.3786	50065
11110.3786	-25077
12110.0899	4124
12110.0899	15794
12110.0899	-27377
12110.0899	23606
12110.0899	12224
12110.0899	28512
12110.0899	68583
12110.0899	17924
12110.0899	-11618
12110.0899	6465
12110.0899	-11871
12110.0899	12418
12110.0899	-21812
12110.0899	-28059
12110.0899	84701
13110.0855	-106701
13110.0855	-18971
13110.0855	-1700
13110.0855	-83848
13110.0855	24365
13110.0855	-106066
13110.0855	26106
13110.0855	-10341
13110.0855	-1835
13110.0855	-11618
13110.0855	13159
13110.0855	12606
13110.0855	11694
13110.0855	59918
14110.4073	300
14110.4073	107789
14110.4073	-45847
14110.4073	-9335
14110.4073	23612
14110.4073	6159
14110.4073	-17182
14110.4073	31030
14110.4073	-24294
14110.4073	-853
14110.4073	-73042
14110.4073	24106

14110.4073	14435
14110.4073	-32824
151 0.0379	-167313
151 0.0379	-83336
151 0.0379	-96483
151 0.0379	-37683
151 0.0379	38059
151 0.0379	3629
11210.3786	-26107
11210.3786	5225
11210.3786	-30080
11210.3786	-12247
11210.3786	979
11210.3786	-15832
11210.3786	-19667
11210.3786	-1256
11210.3786	-32231
11210.3786	-3904
11210.3786	-5689
11210.3786	-21256
11210.3786	27269
12210.0899	-41210
12210.0899	-32306
12210.0899	-18717
12210.0899	-18148
12210.0899	-8847
12210.0899	-22016
12210.0899	-12083
12210.0899	-26531
12210.0899	-20815
12210.0899	-21116
12210.0899	-2255
12210.0899	-8360
12210.0899	-12149
13210.0855	-24104
13210.0855	12644
13210.0855	-11432
13210.0855	-9122
13210.0855	-10063
13210.0855	-11250
13210.0855	-21496
13210.0855	-874
13210.0855	-3977
14210.4073	-12195
14210.4073	-24799
14210.4073	-10315
14210.4073	-14807
14210.4073	-10517
14210.4073	2675
14210.4073	-7755

14210.4073	-10737
14210.4073	-29427
14210.4073	19194
11310.3786	-14762
11310.3786	15393
11310.3786	27023
11310.3786	14033
11310.3786	-3102
11310.3786	-7769
11310.3786	29065
11310.3786	-39674
11310.3786	31429
11310.3786	27383
12310.0899	-11424
12310.0899	-7671
12310.0899	29219
12310.0899	3290
12310.0899	8837
12310.0899	-9361
12310.0899	22600
12310.0899	19507
12310.0899	21570
12310.0899	28927
12310.0899	-28305
13310.0855	20867
13310.0855	-14650
13310.0855	-8949
13310.0855	-17979
13310.0855	-41952
13310.0855	26027
13310.0855	-15796
13310.0855	5972
14310.4073	29262
14310.4073	-42102
14310.4073	-10991
14310.4073	-4290
14310.4073	35315
14310.4073	1922
14310.4073	-32076
11410.3786	6651
11410.3786	19541
11410.3786	18823
11410.3786	2010
11410.3786	18106
11410.3786	15663
11410.3786	11572
11410.3786	24932
11410.3786	6217
12410.0899	21588
12410.0899	-15325
12410.0899	3323

12410.0899	-29036
12410.0899	35420
12410.0899	62483
12410.0899	25975
12410.0899	-3207
12410.0899	7427
12410.0899	-11793
13410.0855	14649
13410.0855	20792
13410.0855	16880
13410.0855	50249
13410.0855	-5121
13410.0855	-37726
13410.0855	-26117
13410.0855	-21325
13410.0855	3715
13410.0855	15254
13410.0855	-20954
13410.0855	-9950
14410.4073	580
14410.4073	23444
14410.4073	-34928
14410.4073	5600
14410.4073	10433
14410.4073	-842
14410.4073	27147
14410.4073	-17873
154 0.0379	-26164
154 0.0379	-42525
154 0.0379	-14534
154 0.0379	-75247
154 0.0379	-132457
154 0.0379	-16424
154 0.0379	692
154 0.0379	-18842
212 0.5239	8325
212 0.5239	1506
212 0.5239	885
212 0.5239	-8682
212 0.5239	-13991
212 0.5239	-37024
212 0.5239	-39260
212 0.5239	9242
212 0.5239	3450
212 0.5239	-013
212 0.5239	-36697
212 0.5239	-1531
212 0.5239	-9668
212 0.5239	57
222 0.0359	-44908
222 0.0359	882
222 0.0359	-22478
222 0.0359	9258
222 0.0359	-164
222 0.0359	5057
222 0.0359	-6201
222 0.0359	-29063
222 0.0359	-23033

222	0.0359	-10574
222	0.0359	-22595
222	0.0359	-16191
222	0.0359	4143
222	0.0359	-26216
232	0.0924	-3709
232	0.0924	3487
232	0.0924	-2067
232	0.0924	-15442
232	0.0924	-6263
232	0.0924	-11015
232	0.0924	6802
232	0.0924	9439
232	0.0924	-651
232	0.0924	6456
232	0.0924	3606
232	0.0924	7518
232	0.0924	179
232	0.0924	-10903
232	0.0924	1025
242	0.0911	-9708
242	0.0911	-8727
242	0.0911	-12997
242	0.0911	-33447
242	0.0911	-12802
242	0.0911	-8482
242	0.0911	1673
242	0.0911	-4975
242	0.0911	-13810
242	0.0911	-185
242	0.0911	-43121
242	0.0911	-19217
242	0.0911	7296
242	0.0911	-20210
242	0.0911	-3240
252	0.0766	-24412
252	0.0766	5222
252	0.0766	21142
252	0.0766	-848
252	0.0766	4324
252	0.0766	10230
252	0.0766	-36870
252	0.0766	21187
252	0.0766	-31745
252	0.0766	1668
252	0.0766	927
252	0.0766	-16500
262	0.1252	-082
262	0.1252	-7462
262	0.1252	-6890
262	0.1252	-10473
262	0.1252	9980
262	0.1252	-11917
262	0.1252	-5873

262	0.1252	3278
262	0.1252	-43337
262	0.1252	-14040
262	0.1252	423
262	0.1252	3449
262	0.1252	4881
262	0.1252	13621
262	0.1252	-30167
272	0.0217	-36222
272	0.0217	9461
272	0.0217	-51780
272	0.0217	-36546
272	0.0217	-7315
272	0.0217	-204
272	0.0217	-7181
272	0.0217	-21453
272	0.0217	-7141
272	0.0217	-14442
272	0.0217	-10085
272	0.0217	-3449
282	0.0322	6733
282	0.0322	9001
282	0.0322	15020
282	0.0322	-591
282	0.0322	-4978
282	0.0322	-24754
282	0.0322	-3829
282	0.0322	25751
282	0.0322	-1964
282	0.0322	-2146
282	0.0322	-11643
282	0.0322	-1156
282	0.0322	-17211
282	0.0322	-61202
282	0.0322	-17181
213	0.5239	-9397
213	0.5239	17270
213	0.5239	3747
213	0.5239	58701
213	0.5239	3372
213	0.5239	32717
213	0.5239	7429
213	0.5239	117531
213	0.5239	78045
213	0.5239	13223
213	0.5239	-5177
213	0.5239	5509
213	0.5239	7350
223	0.0359	-10242
223	0.0359	-65337
223	0.0359	19895
223	0.0359	33952
223	0.0359	28837
223	0.0359	41833
223	0.0359	5364
223	0.0359	2751
223	0.0359	-13162
223	0.0359	52094
233	0.0924	-5144

233	0.0924	26858
233	0.0924	12476
233	0.0924	9361
233	0.0924	4805
233	0.0924	-12711
233	0.0924	34764
233	0.0924	-2094
233	0.0924	1487
233	0.0924	19259
233	0.0924	47439
233	0.0924	-43363
233	0.0924	5686
233	0.0924	-1740
233	0.0924	30115
243	0.0911	-8390
243	0.0911	42775
243	0.0911	-56489
243	0.0911	25913
243	0.0911	53081
243	0.0911	-13400
243	0.0911	11227
243	0.0911	9935
243	0.0911	9682
243	0.0911	12032
243	0.0911	-2354
243	0.0911	-9411
243	0.0911	-25967
253	0.0766	5437
253	0.0766	18913
253	0.0766	- 4798
253	0.0766	-14534
253	0.0766	12543
253	0.0766	19660
253	0.0766	3285
253	0.0766	18252
253	0.0766	41190
253	0.0766	55034
263	0.1252	3682
263	0.1252	11732
263	0.1252	-5386
263	0.1252	-19429
263	0.1252	27245
263	0.1252	-1653
263	0.1252	7397
263	0.1252	046
263	0.1252	85969
263	0.1252	-36764
263	0.1252	56020
263	0.1252	39129
273	0.0217	87420
273	0.0217	-35728
273	0.0217	69669
273	0.0217	75615
273	0.0217	23003

273	0.0217	1664
273	0.0217	25963
273	0.0217	-11180
273	0.0217	5567
273	0.0217	33858
273	0.0217	-27187
273	0.0217	53190
283	0.0322	13534
283	0.0322	-28681
283	0.0322	58742
283	0.0322	-18324
283	0.0322	-25104
283	0.0322	27848
283	0.0322	-12660
214	0.5239	-35011
214	0.5239	-15838
214	0.5239	23863
214	0.5239	17039
214	0.5239	-143453
214	0.5239	127146
214	0.5239	-16945
214	0.5239	1904
214	0.5239	-22404
214	0.5239	-7044
214	0.5239	8761
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224	0.0359	-10285
224	0.0359	-139982
224	0.0359	6669
224	0.0359	32323
224	0.0359	5412
224	0.0359	-34462
224	0.0359	-50099
224	0.0359	-19524
234	0.0924	2870
234	0.0924	-6904
234	0.0924	-17475
234	0.0924	30452
234	0.0924	2823
234	0.0924	4287
234	0.0924	-25687
234	0.0924	-20777
234	0.0924	-17667
244	0.0911	-4446
244	0.0911	1102
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244	0.0911	-26442
244	0.0911	-5909
244	0.0911	-25926
244	0.0911	2378

244	0.0911	4887
244	0.0911	1796
244	0.0911	-19229
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254	0.0766	-51243
254	0.0766	41703
254	0.0766	7246
254	0.0766	29388
254	0.0766	3016
254	0.0766	13935
254	0.0766	3161
254	0.0766	-153743
254	0.0766	-26353
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264	0.1252	22883
264	0.1252	-7044
264	0.1252	30973
264	0.1252	19299
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264	0.1252	202
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274	0.0217	-19585
274	0.0217	5107
274	0.0217	-20505
274	0.0217	-25401
274	0.0217	-32844
274	0.0217	-11899
274	0.0217	-26822
274	0.0217	1501
274	0.0217	-11922
284	0.0322	5567
284	0.0322	25500
284	0.0322	-1412
284	0.0322	62682
284	0.0322	1026
284	0.0322	-22920
284	0.0322	7781
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31120.4414		-4774
31120.4414		26925
31120.4414		-57977
31120.4414		-4031
31120.4414		38821

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31120.4414	-14999
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31120.4414	67507
31120.4414	22864
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32120.2189	19731
32120.2189	27662
32120.2189	5163
32120.2189	35329
32120.2189	-1911
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32120.2189	5750
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32120.2189	-5960
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32120.2189	16550
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33120.1226	33065
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33120.1226	-7212
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33120.1226	3822
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34120.2189	-3378
34120.2189	19701
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34120.2189	23157
34120.2189	18497
34120.2189	16982
34120.2189	30693
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34120.2189	6248
34120.2189	-20342
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34120.2189	-19420
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31220.4414	-14025

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31220.4414	-28410
31220.4414	-38011
31220.4414	-13657
31220.4414	-17176
31220.4414	-11579
31220.4414	-8982
31220.4414	8837
31220.4414	-22512
32220.2189	-9872
32220.2189	-8366
32220.2189	-37180
32220.2189	-18731
32220.2189	-16616
32220.2189	7025
32220.2189	-9567
32220.2189	-25278
32220.2189	-22252
32220.2189	85624
32220.2189	-12645
32220.2189	-32733
32220.2189	-7811
33220.1226	-24600
33220.1226	-6991
33220.1226	-20727
33220.1226	-18283
33220.1226	-6525
33220.1226	-18863
33220.1226	2180
33220.1226	-7889
33220.1226	-38792
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34220.2189	-2222
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34220.2189	-49948
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34220.2189	-20102
34220.2189	-13518
34220.2189	10136
34220.2189	-27503
34220.2189	-13306
34220.2189	-12692
34220.2189	-21712
31320.4414	-10331
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31320.4414	32179
31320.4414	-2156
31320.4414	23404
31320.4414	43313
31320.4414	14880
31320.4414	21026
31320.4414	32899
31320.4414	26254
31320.4414	86651
31320.4414	47025
32320.2189	-35177
32320.2189	39700
32320.2189	-64771
32320.2189	-4754
32320.2189	-7733
32320.2189	23060
32320.2189	28922
32320.2189	5129
32320.2189	21016
33320.1226	2740
33320.1226	25416
33320.1226	-34245
33320.1226	-330
33320.1226	24967
33320.1226	-4120
33320.1226	9999
33320.1226	8504
34320.2189	6870
34320.2189	-3566
34320.2189	-3454
34320.2189	-34613
34320.2189	38295
34320.2189	-38768
34320.2189	39566
34320.2189	-17423
34320.2189	53261
34320.2189	-14310
34320.2189	67590
34320.2189	23265
34320.2189	2730
34320.2189	-40290
31420.4414	8822
31420.4414	15255
31420.4414	4937
31420.4414	-6782
31420.4414	-3193
31420.4414	-3480
31420.4414	-2601
31420.4414	1366
31420.4414	-63319
31420.4414	670
31420.4414	-11114
31420.4414	-3776
31420.4414	25204

31420.4414	58673
32420.2189	12759
32420.2189	-8439
32420.2189	-4454
32420.2189	-30089
32420.2189	7943
32420.2189	-14407
32420.2189	1327
32420.2189	10958
32420.2189	-5894
32420.2189	26496
33420.1226	-31346
33420.1226	11310
33420.1226	8522
33420.1226	2610
33420.1226	-5520
33420.1226	1188
33420.1226	-24143
33420.1226	-17939
33420.1226	5772
33420.1226	-2419
33420.1226	8913
33420.1226	-4241
33420.1226	-8008
34420.2189	3793
34420.2189	14003
34420.2189	-5612
34420.2189	21045
34420.2189	9570
34420.2189	11658
34420.2189	3719
34420.2189	-38384
34420.2189	19053
34420.2189	10671
34420.2189	7443
34420.2189	-26761
34420.2189	-34804

APPENDIX II

Soil Movement Data: Slopes

These data represent grams per square meter of soil fluctuations of plots at the Pawnee Intensive Site. They constitute Grassland Biome Data Set A2U709B. Data have been transformed from counts per minute to listed form. Format for this listing is as follows.

Columns	
1	Soil Series
2	Slope
3	Season
16-21	g/m^2/month soil fluctuation

Key:

Soil Series	Slope
1 = Ascalon	1 = Southwest
2 = Shingle	2 = Northeast

Data punched without decimal. All data reported with two decimal places.

111	134332
111	10016
111	28439
111	39853
121	-33723
121	68341
121	-8276
121	7257
121	13203
112	-13985
112	-12306
112	-14205
112	14230
122	-26046
122	-10911
122	-306
122	-35722
113	106744
113	29065
113	-661
123	98091
123	10390
123	23132
123	47392
114	-14787
114	13213
114	57261
124	-39195
124	-11567
124	-31954
124	-74985
212	-24412
212	5222
212	21142
212	-848
212	4324
222	10230
222	-36870
222	21187
222	-31745
222	1668
222	927
222	-16500
213	5437
213	18913
213	-4798
213	-14534
213	12543
223	19660
223	3285
223	18252
223	41190
223	55034
214	19290

214	-51243
214	41703
214	7246
214	29388
214	3016
224	13935
224	3161
224	-153743
224	-26353