US Army Corps of Engineers
Construction Engineering Research Laboratory

USA-CERL

TECHNICAL REPORT N-86/03
December 1985
Guild Based Training Area Maintenance

Wildlife as an Indicator of Site Quality and Site Trafficability During Army Training Maneuvers

by
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Field studies were conducted on four prairies during May-June 1983 on the Piñon Canyon Maneuver Site and Fort Carson, CO, to characterize the relationship of soils and vegetation to bird and mammal species composition and abundance. Results strongly suggest that meadowlark numbers increase and horned larks decrease with increasing grass cover, and that kangaroo rats increase and pocket mice decrease with increasing soil sand. Estimating the numbers of each species on various sites on semiarid maneuver lands may be an effective management tool for installation land management. The data can be used to assess the erodibility (relative grass cover) and trafficability (soil texture) of various shortgrass prairie sites.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CERL TR N-86/03	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) WILDLIFE AS AN INDICATOR OF SITE QUALITY AND SITE TRAFFICABILITY DURING ARMY TRAINING MANEUVERS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Victor E. Diersing William D. Severinghaus		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Construction Engr Research Laboratory P.O. Box 4005 Champaign, IL 61820-1305		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 4A162720A896-A-030
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE December 1985 13. NUMBER OF PAGES 19
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

wildlife
Fort Carson, CO
Pinon Canyon Maneuver Site
land areas
training

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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used to assess the erodibility (relative grass cover) and trafficability (soil texture) of various shortgrass prairie sites.

FOREWORD

This investigation was performed for the Office of the Assistant Chief of Engineers (OACE) by the Environmental Division (EN) of the U.S. Army Construction Engineering Research Laboratory (USA-CERL). The work was performed under Project 4A162720-A896, "Environmental Quality Technology"; Task A, "Installation Environmental Management"; Work Unit 030, "Guild Based Training Area Maintenance." The OACE Technical Monitor was Mr. D. Bandel, DAEN-ZCF-B.

Assistance of the following people is gratefully acknowledged: Steven Emmons, Timothy Prior, and Thomas L. Warren of the Environmental, Energy, and Natural Resources Office, Directorate of Engineering and Housing, Fort Carson, CO, for their contributions to this study; the Colorado Division of Wildlife (James B. Ruch, Director, and John L. Bevard, License Program Administrator) for providing authority to collect small mammals; Joe Bourke, Tony Krzysik, and Larry Schmitt (USA-CERL) for their field assistance; Steven I. Apfelbaum, Karin A. Heiman, and John A. Prokes (Applied Ecological Services, Juda, WI) for collecting and analyzing vegetation data; and Peter Smith (Camp, Dresser, and McKee, Inc., Denver, CO) for providing soils information. Dr. Edward W. Novak is the Leader of the Environmental Resources Team.

Dr. R. K. Jain is Chief of USA-CERL-EN. COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

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1 INTRODUCTION

Background

Meeting defense needs is a primary national concern. The availability of enough training land is an important and necessary ingredient in properly training a standing army. Since land is a limited resource which is impacted by Army training, Army managers and administrators must have scientifically sound information on the quality of the lands for which they are responsible. These data will serve as the basis for evaluating various impacts on the system. The law also requires that "...consideration of environmental factors must be integrated into existing Army procedures..."[1]

This report is one of a series documenting basic ecological research conducted to establish cause-and-effect relationships between Army activities and their impacts on ecosystems.[2]

Objective

The objective of this report is to compare the mammals, birds, vegetation, and soils of four prairie sites on the Piñon Canyon Maneuver Site and Fort Carson, CO, in order to identify biotic and abiotic factors that are highly correlated with site quality and site trafficability. The data collected will also help verify tactical vehicle cause-effect relationships established in previous research.

Approach

Extensive field surveys were conducted on the Piñon Canyon Maneuver Site and Fort Carson in areas representative of the shortgrass prairie. The results were analyzed and used to determine the relationship of mammals, birds, vegetation, and soils to site quality and site trafficability.

Mode of Technology Transfer

It is recommended that the information obtained in this study be used to develop predictive algorithms and an information base and then incorporated into a computerized system for planning and maintenance of Army lands. Information on using this system will be transmitted to the field by a Technical Manual.

2 GENERAL DESCRIPTION OF SITES

The four study sites were all located in Colorado along the western edge of the Great Plains in the shortgrass prairie (Figure 1). All prairie sites bordered the pinyon-juniper woodland adjacent to the foothills of the Rocky Mountain Front Range.

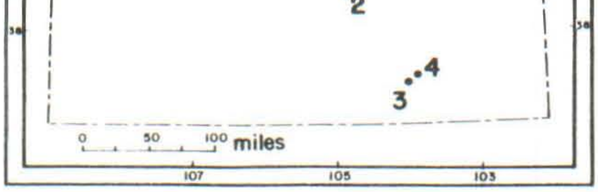

Figure 1. Location of the four prairie study sites in Colorado. (Site 1, Fort Carson, northern part of Sullivan Park, El Paso County; Site 2, Fort Carson, central part of Sullivan Park, El Paso-Pueblo County line; Sites 3 and 4, Piñon Canyon Maneuver Site, Las Animas County.)

[1] R. K. Jain, L. V. Urban, and G. S. Stacey, *Handbook for Environmental Impact Analysis*, Technical Report E-59/ADA006241 (U.S. Army Construction Engineering Research Laboratory [USA-CERL], 1974), p 13.

[2] W. D. Severinghaus, R. E. Riggins, and W. D. Goran, *Effects of Tracked Vehicle Activity on Terrestrial Mammals, Birds, and Vegetation at Fort Knox, KY*, Special Report N-77/ADA073782 (USA-CERL, 1979), pp 1-64; W. D. Severinghaus and W. D. Goran, *Effects of Tactical Vehicle Activity on the Mammals, Birds, and Vegetation at Fort Hood, TX*, Technical Report N-113/ADA109646 (USA-CERL, 1981), pp 1-22; W. D. Severinghaus and W. D. Goran, *Effects of Tactical Vehicle Activity on the Mammals, Birds, and Vegetation at Fort Lewis, Washington*, Technical Report N-116/ADA111201 (USA-CERL, 1981), pp 1-45; V. E. Diersing and W. D. Severinghaus, *Ecological Baseline–Piñon Canyon Maneuver Site, Colorado*, Technical Report N-85/02 (USA-CERL, 1984).

Fort Carson

Fort Carson is located along the interface of the Great Plains and Rocky Mountains in central Colorado. The installation is largely limited to El Paso County, with its southern and southwestern limits extending slightly into Pueblo and Fremont Counties, respectively. Fort Carson encompasses about 55,785 ha; its north-south length is nearly 39 km and its greatest width is almost 24 km. The eastern side of the installation is characterized by gently to moderately sloping grasslands with relatively low relief. The western portion of the installation is characterized by wooded foothills, steep and rocky slopes, and higher elevations. Topographical relief ranges between 1560 and 2121 m (east to west).

Intermittent streams on Fort Carson generally flow from northwest to southeast. Turkey Creek flows through the center of the installation and enters the Arkansas River south of the post. Rock Creek and Little Fountain Creek flow through the northern part of Fort Carson and enter the southflowing Fountain Creek just east of the installation.

Fort Carson has mild summers and cold winters. The average annual temperature is about 9°C with an average annual humidity of 54 percent. Prevailing winds are from the north. Mean annual precipitation is about 380 mm, with slightly higher averages to the west and north and slightly lower averages to the south and east. Slightly more than 80 percent of the total annual precipitation is received from April through September.

The sites chosen for quantitative sampling were picked based on the following criteria: similarity in soils, topography, and plant species composition. One of the sites was heavily used for tracked vehicle training, and the other was only moderately disturbed.

The relatively undisturbed site (site 1 of Figure 2) was located 1 km east of Camp Red Devil in Sullivan Park, about 600 m east of the landing strip at 088638 (Defense Mapping Coordinates). One hundred fifty-two (8 percent) of two thousand 1-m steps* intercepted tracked-vehicle tracks. Site 2 was located along each side of Route 8 at 097623. Six hundred forty-eight (32 percent) of two thousand 1-m steps intercepted tracked-vehicle tracks. In general, Fort Carson contains two basic vegetation types: shortgrass prairie and pinyon-juniper woodland.

*To assess the degree of site disturbance, two thousand 1-m steps were paced off, and the number of steps intercepting tracks from tracked vehicles counted.

Piñon Canyon

The Piñon Canyon Maneuver Site, located entirely within Las Animas County in southeastern Colorado, is in the Raton Section of the High Plains.[3] Piñon Canyon encompasses about 104,000 ha (Figure 3). Topographically, the parcel slopes gently to the southeast, culminating in the Purgatoire River (Arkansas River drainage), which serves as the parcel's eastern boundary. This slope is interrupted by mesas and deep canyons. Mean annual precipitation is about 33.5 cm, and the elevation varies from about 1311 to 1800 m. Historically, the parcel has been used for cattle grazing, but military training is expected to begin on it in 1985.[4] Piñon Canyon contains two basic vegetation types: (1) shortgrass prairie interspersed with varying densities of cholla and yucca species and (2) pinyon-juniper woodland.

The two sites chosen for quantitative analysis (Figure 3) were selected for their vegetative and topographic similarity. Site 4 was located at Township 29S, Range 59W, Section 2 (Figure 3). Site 3 was located at Township 30S, Range 59W, Section 1. Both sites are typical blue grama (*Bouteloua gracilis*) grassland. Topographically, the sites are gently sloping. Other than moderate cattle grazing, there were no obvious disturbances.

3 METHODS FOR OBTAINING DATA

Soils

Particle size sampling investigations were undertaken 21-22 May 1983 to provide data for comparing particle size distributions between prairie areas and to characterize the baseline conditions. Samples were collected from the surface horizon, labeled, and placed in plastic bags. The hydrometer method was used to determine the percent by weight of sand, silt, and clay.[5] Eight samples were collected from each prairie site.

[3] N. M. Fenneman, *Physiography of Western United States* (McGraw-Hill, 1931), pp 1-534.

[4] *Draft Environmental Impact Statement for Acquisition of Training Land for Fort Carson, Colorado in Huerfano, Las Animas and Pueblo Counties, Colorado* (Fort Carson, 1980), pp 1-220.

[5] E. J. Felt, "Physical and Mineralogical Properties, Including Statistics of Measurement and Sampling," *Methods of Soil Analysis,* Monograph 9 (American Society of Agronomy, 1965), pp 400-412.

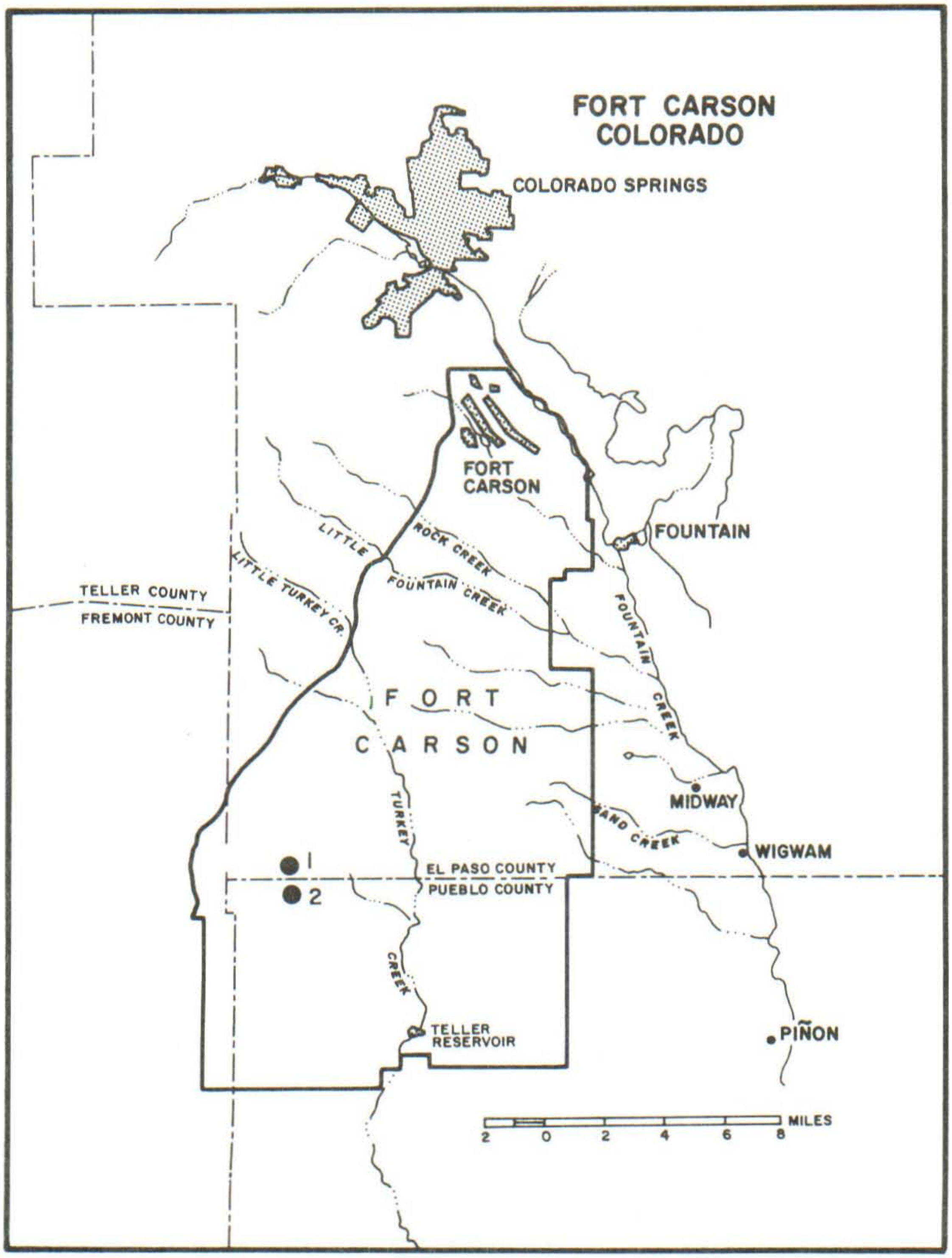

Figure 2. Fort Carson, CO (location of shortgrass prairie sites 1 and 2).

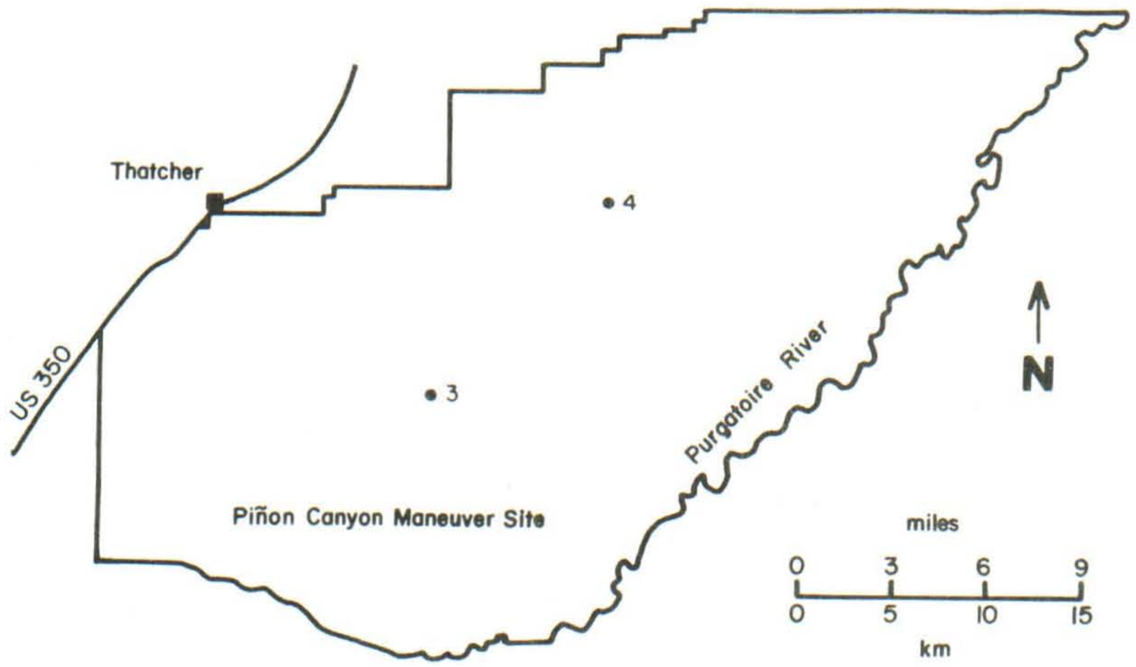

Figure 3. Piñon Canyon Maneuver Site, CO (location of shortgrass prairie sites 3 and 4).

Vegetation

Vegetation transects originated from the bird survey transects. Two 1000-m-long parallel bird transects, separated from each other by 250 m, were established at each site. Each vegetation transect originated from a designated point along the bird transects. On each prairie site, the vegetation transects, which were each 50 m long, originated at the points delineating 0, 200, 400, 600, 800 (or 1000) m on one bird transect and from the odd-numbered points on the other bird transect (100, 300, 500, 700, and 900 m). Thus, 10 vegetation transects were established at each site. Each one was measured from the bird transects along randomly generated compass bearings.

In each of the four study areas, intercepts of woody vegetation greater than 2 cm in diameter or 1 m tall were tallied, by species, along ten 2- × 50-m transects.[6] Species importance and tree and shrub density and frequency were then determined. Herbaceous vegetation (and all plants less than 1 m tall) was studied for plant cover in 1-m^2 quadrats which were placed systematically along the 50-m study transects at 5-m intervals. Ten quadrats were studied along each 50-m transect; 100 quadrats were sampled in each study site. Random number generation was used to determine which of the 10 quadrats in each transect were to be evaluated for biomass. One 1-m^2 sample quadrat was clipped to ground level, and only herbaceous (graminoid and nongraminoid) plants were separated from it. Biomass samples were air-dried for 1 week and weighed to the nearest gram on a spring scale.

Plant identifications follow Harrington.[7] Plant species lists were prepared for the early summer study period and thus include spring plants and perennial species that might bloom later in the year, especially woody perennials that bloom in fall. Voucher specimens were collected and maintained in the U.S. Army Construction Engineering Research Laboratory's (USA-CERL) Biological Inventory Collection.

The percent cover of study quadrats by bare ground, woody litter, and rock was measured to facilitate remote-sensing programs for monitoring vegetation cover dynamics and the types and success of revegetation and reclamation.

[6] D. Mueller-Dombois, *Aims and Methods of Vegetation Ecology* (John Wiley and Sons, 1974), pp 1–547.

[7] H. D. Harrington, *Manual of the Plants of Colorado* (The Swallow Press, 1964), pp 1–666.

Birds

Birds were surveyed using the combined transect methods of Emlen, Severinghaus, and Balph, Stoddart, and Balph.[8] Two parallel transects, 250 m apart, were established at each site. Each one was 1000 m long. Transects were established at each site. Each one was 1000 m long. Transects were established by compass bearing and identified by placing 91-cm-high flags at 50-m intervals. Transects were walked slowly, starting at sunrise for 10 days (23 May – 1 June at Fort Carson and 9 – 18 May at Piñon Canyon). As each transect was walked, the location of each bird detected on each side of the transect was recorded. The absolute density (birds per unit/area) of each species was estimated by calculating the distance from the transect to the point where detection of a species declines significantly. On each site, the observable distance along each side of a transect was calculated at 50 m, or a daily observable area of 2000 m × 100 m = 20 ha.

The bird fauna occupying the four study sites were compared by measuring species diversity and density. Significant differences were identified using Student's t-test of means.

Mammals

Small mammals were surveyed using 100 snap traps per night (92 Museum Specials and eight rat traps) at each site over a 10-day period (1000 trapnights/site). These surveys were conducted during the same 10-day period as the bird surveys. At each site, the 100 traps were set parallel or along the full length of the bird transects. The traps were placed at 10-pace (10-m) intervals. Each trap line was moved every 2 days in the following sequence: days 1-2, about 50 m outside one of the bird transects; days 3–4, about 50 m outside the other bird transect; days 5–6, midway between the two bird transects; days 7–8, along one bird transect; and days 9–10, along the other transect.

Each evening, traps were set and baited with a mixture of rolled oats and peanut butter, and captures were removed each morning immediately after the morning bird counts. All mammals collected were placed in a plastic bag labeled with the date and place of collection, then frozen, prepared as scientific study specimens (maintained in the USA-CERL Biological Inventory Collection), and identified according to species.

Data collection included species diversity, total number of species collected per site, and actual capture numbers for each species by site. Chi-square tests were used to identify significant differences in the number of individuals of each species collected among the sites.

4 RESULTS

Soils

The A-horizon was sampled in eight places on each prairie study site at Fort Carson. The soils on both sites were Neville[9] sandy loam, and were typically deep and slightly sloping. The average texture on site 1 was silty loam to loam, and on site 2, the average texture was silty loam. On the average, site 2 contained significantly more sand (72 percent versus 53 percent), much less silt (17 percent versus 32 percent), and less clay (11 percent versus 15 percent, not significant) than site 1. Table 1 and Figure 4 present the particle size distribution data of all sampling locations.

The A-horizon on the Piñon Canyon Maneuver Site was sampled nine times on site 3 and 10 times on site 4. The soil was relatively undisturbed in the sampled areas. The soils on site 3 were Fort Collins soils[10], the samples of which were either sandy loam or loam. Site 4 was composed of Manzanola soils[11], with samples ranging from silty clay, silty clay loam, clay loam, to silty loam. On the average, site 4 contained much less sand (15 percent versus 42 percent), significantly more silt (52 percent versus 37 percent), and much more clay (31 percent versus 21 percent) than site 3. Table 2 and Figure 5 give the particle size distribution data of all sampling locations.

Vegetation

All four prairie sites had no measurable shrub or tree cover and only an incidental amount of rock cover

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[8] J. T. Emlen, "Population Densities of Birds Derived from Transect Counts," *Auk*, Vol 88 (1971), pp 323-342; J. T. Emlen, "Estimating Breeding Bird Densities from Transect Counts," *Auk*, Vol 94 (1977), pp 455–468; W. D. Severinghaus, *Guidelines for Terrestrial Ecosystem Survey*, Technical Report N-89/ADA086526 (USA-CERL, 1980); M. H. Balph, L. C. Stoddart, and D. F. Balph, "A Simple Technique for Analyzing Bird Transect Counts," *Auk*, Vol 94 (1977), pp 606–607.

[9] *Soil Survey of El Paso County, Colorado* (Soil Conservation Service, 1981).

[10] *Soil Survey of Las Animas County, Colorado* (Soil Conservation Service, 1983).

[11] Soil Conservation Service, 1983.

Table 1

Particle Size Distribution in Surface Horizons of the Fort Carson Prairie Study Sites

	Sand	Silt	Clay	Texture*	Depth (cm)
			Site 1		
	72	18	10	SL	0–10
	65	25	10	SL	0–10
	56	31	13	SL	0–10
	65	25	10	SL	0–13
	40	40	20	L	0–10
	49	34	17	L	0–10
	41	39	20	L	0–13
	39	41	20	L	0–13
Mean	53.4	31.6	15.0		
			Site 2		
	79	11	10	SL	0–15
	75	14	11	SL	0–15
	74	20	6	SL	0–13
	76	18	6	SL	0–13
	62	23	15	SL	0–8
	60	25	15	SL	0–8
	74	13	13	SL	0–8
	73	14	13	SL	0–8
Mean	71.6	17.3	11.1		

*SL = silty loam, L = loam.

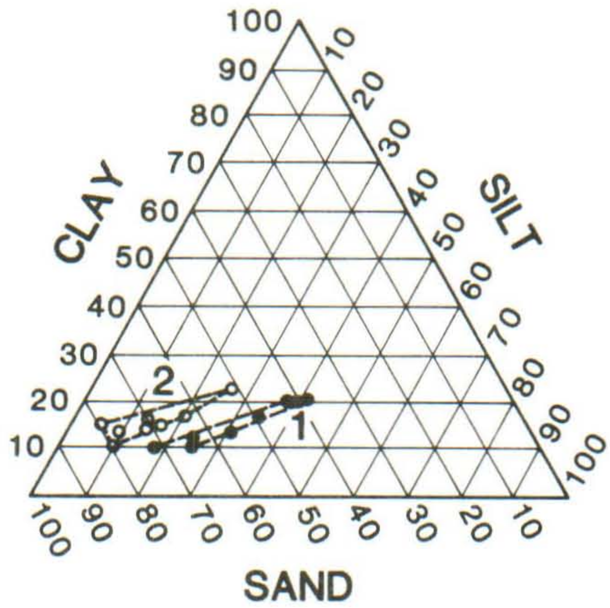

Figure 4. Soil particle size distribution of Fort Carson prairie sites 1 and 2. Each dot represents one soil sample. The dashed lines delimit the textural distribution of samples within a site.

on one site (Table 3). Live vegetative ground cover (basal cover) was very similar on all sites, averaging highest on site 3 (Piñon Canyon, 43.9 percent) and site 2 (Fort Carson, 43.6 percent) and lowest on site 4 (Piñon Canyon, 26.5 percent) and site 1 (Fort Carson, 36.4 percent). Of the total, grass cover averaged more than forb cover on all sites except site 3 at Piñon Canyon (30 percent forb and 14 percent grass). Site 4, also at Piñon Canyon, had about equal amounts of forb and grass cover (14 percent grass and 13 percent forb). The two Fort Carson sites each had much more grass cover than forb cover; site 1 had 31 percent grass and 5 percent forb, and site 2 had 26 percent grass and 18 percent forb. Percent bare soil differed little among the four sites, averaging 74 percent at site 4, 64 percent at site 1, and 56 percent at sites 2 and 3.

The dominant grass on all four sites was blue grama (*Bouteloua gracilis*). This species accounted for more of the total cover on Fort Carson (76 percent at site 1, 48 percent at site 2) than on Piñon Canyon (32 percent at site 4, 28 percent at site 3). Plant production (g/m^2) was similar on both installations, with production being the greatest at Piñon Canyon on site 4 (130 g/m^2), next highest on site 1 (126 g/m^2, Fort Carson), then site 3 (92 g/m^2, Piñon Canyon), and least on site 2 (77 g/m^2, Fort Carson). No significant difference in plant production was detected between the four sites (Table 3) due to the high variation within samples on a site. On each site, grass production accounted for almost all of the total herbaceous production with forbs contributing little to total production. However, forb production did average higher on Piñon Canyon (26 g at site 3 and 31 g at site 2).

Birds

The horned lark was the most common bird on all sites, ranging from 25 individuals per 100 ha on site 2 (Fort Carson) to 116 individuals per 100 ha on site 4 (Piñon Canyon). The western meadowlark was the second most common species on all sites (9 to 24 per 100 ha), except on site 4 at Piñon Canyon, which averaged 6 per 100 ha, two fewer than the number of Brewer's sparrows on this site (Table 4). These two species together (horned lark and meadowlark)

Table 2

Particle Size Distribution in Surface Horizons of the Piñon Canyon Prairie Study Sites

	Sand	Silt	Clay	Texture*	Depth (cm)
			Site 4		
	16	42	42	SIC	0–13
	8	63	29	SICL	0–10
	13	53	34	SICL	0–10
	16	45	39	SICL	0–10
	15	47	38	SICL	0–8
	19	57	24	SIL	0–10
	22	49	29	CL	0–10
	13	42	45	SIC	0–10
	18	59	23	SIL	0–10
	17	60	23	SIL	0–10
Mean	14.7	51.7	30.6		
			Site 3		
	37	38	25	L	0–20
	44	40	16	L	0–13
	59	23	18	SL	0–13
	59	22	19	SL	0–13
	43	34	23	L	0–13
	44	36	20	L	0–13
	34	45	21	L	0–13
	36	38	26	L	0–13
	34	45	21	L	0–13
Mean	42.1	36.9	21.0		

*SIC = silty clay, SICL = silty clay loam, SIL = silty loam, CL = clay loam, L = loam, SL = sandy loam.

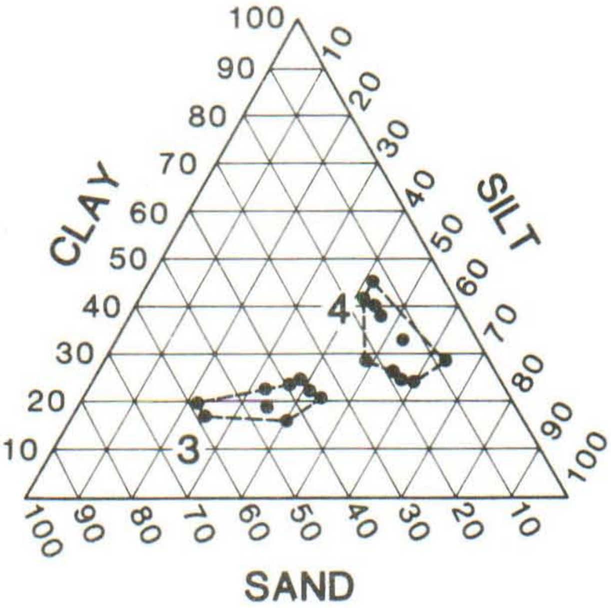

Figure 5. Soil particle size distribution of Piñon Canyon prairie sites 3 and 4. Each dot represents one soil sample. The dashed lines delimit the textural distribution of samples within a site.

Table 3

Summary of Ground Cover and Substrate Cover Types on All Prairie Study Sites

(Data presented [mean ± 1 standard deviation] is based on one hundred 1-m^2 quadrat samples in each study site.)

	Piñon Canyon		Fort Carson	
	Site 4	Site 3	Site 1	Site 2
Bare Soil %	73.5 ± 11.3	55.6 ± 20.1	63.6 ± 8.0	56.2 ± 15.1
Rock %	---	---	---	0.2 ± 0.5
Live Vegetative Ground Cover %	26.5	43.9	36.4	43.6
Forb Cover %	13	30	5	18
Grass Cover %	14	14	31	26
Shrub/Tree Cover	---	---	---	---
Dominant Grass	Blue Grama	Blue Grama	Blue Grama	Blue Grama
Herbaceous Production g/m^2	130 ± 95	92 ± 50.5	125.8 ± 46.1	77.0 ± 46.9

Table 4

Avian Species Densities on the Prairie Sites

Species List	Fort Carson*		Piñon Canyon*	
	Site 1	Site 2	Site 3	Site 4
Western kingbird	0a	0a	1a	1a
Horned lark	33a	25a	56b	116c
Western meadowlark	24a	20a	9b	6b
Lark bunting	0a	1ab	4b	4b
Lark sparrow	5ab	13a	3b	1b
Brewer's sparrow	0a	0a	1a	1a
Sparrow (unknown kind)	1a	0a	1a	1a
Mourning dove	1a	2a	1a	0a
Total Individuals/Site	64a	61a	75a	136b
Total Diversity	5a	5a	8a	7a

*Means followed by the same letter (for each species) are not significantly different at the 0.05 probability level.

accounted for 74 to 89 percent of the total individuals observed on each site. On the average, the lark sparrow was the third most common species on the four sites, ranging from 1 per 100 ha on site 4 (Piñon Canyon) to 13 per 100 ha on site 2 (Fort Carson). The lark bunting and Brewer's sparrow were, on the average, next most abundant, ranging from zero (site 1) to 4 (site 4) per 100 ha, and zero (sites 1 and 2) to 8 (site 4) per 100 ha, respectively. Although not common on any site, the mourning dove and western kingbird were most numerous on site 2 (2 per 100 ha) and sites 1, 3, and 4 (1 per 100 ha), respectively.

The presence and numbers of Brewer's sparrows and lark buntings on each site seemed to be closely related to the availability of "shrubby" plants for nest sites. The lark bunting occurred in areas with scattered cholla (*Opuntia arborescens*), and Brewer's sparrow occurred in scattered stands of greasewood (*Sarcobatus vermiculatus*). Lark sparrows were often seen perched on shrubby species, but all nests found were on the ground, typically under the canopy of large bunch grasses.

The total number of individuals per site ranged from 61 per 100 ha (site 2) to 136 per 100 ha (site 4). The total numbers observed on sites 1 through 3 (n = 61-75) did not differ significantly, but all were much less than the 136 per 100 ha observed on site 4. Total diversity on all sites ranged from five to eight, but was not significant among sites.

Mammals

Eight species of nocturnal small mammals were collected on the four sites (Table 5). Four of these species were common to all sites: kangaroo rat (*Dipodomys ordii*), pocket mouse (*Perognathus flavus*), grasshopper mouse (*Onychomys leucogaster*), and deer mouse (*Peromyscus maniculatus*). The other four species were collected on three of the four sites: plains harvest mouse (*Reithrodontomys montanus*), western harvest mouse (*Reithrodontomys megalotis*), white-footed mouse (*Peromyscus leucopus*), and pinyon mouse (*Peromyscus truei*). The kangaroo rat was the most common species on sites 1 through 3, averaging 27 to 49 individuals/1000 trapnights; however, this species was nearly absent on site 4 (n = 1). The most common species on site 4 was the pocket mouse, which averaged 14 per 1000 trapnights. This species was not as common on the other sites, averaging 3 to 10 per 1000 trapnights. The deer mouse, white-footed mouse, grasshopper mouse, and western harvest mouse were common on at least one of the four sites. The plains harvest mouse and the pinyon mouse were typically rare on all sites. The latter species usually inhabits pinyon-juniper woodlands.[12] There were stands of this woodland within 1 mile of the three sites where it was obtained.

[12] D. M. Armstrong, *Distribution of Mammals in Colorado*, Monograph No. 3 (Museum of Natural History, University of Kansas, 1972), pp 1-415.

Table 5

Mammal Capture Data*

Species (scientific name)	Fort Carson**		Piñon Canyon**	
	Site 1	Site 2	Site 3	Site 4
Dipodomys ordii	27a	49b	28a	1c
Perognathus flavus	10ab	3ab	9ab	14b
Reithrodontomys megalotis	18a	20a	4b	0b
Reithrodontomys montanus	1a	0a	8b	1a
Onychomys leucogaster	9a	18a	10a	1b
Peromyscus leucopus	9b	38b	3ac	0c
Peromyscus maniculatus	25a	34a	7b	5b
Peromyscus truei	1a	3a	0a	2a
Total Individuals/Site	100a	165b	69c	24d
Total Diversity	8a	7a	7a	6a

*Nocturnal species only.

**Means followed by the same letter (for each species) are not significantly different at the 0.05 probability level.

The total number of individuals per site ranged from 24 per 1000 trapnights (site 4) to 165 per 1000 trapnights (site 2). It is interesting to note that the total number of individuals collected on each site was significant relative to the number collected on all other sites. Total diversity on all sites ranged from six to eight, and did not differ significantly among sites.

5 ANALYSIS

Vegetation Compared With Birds

The role of rangeland avifaunas in the ecosystem is poorly understood; in particular, little is known of the factors that determine the presence, absence, or abundance of a species.[13] In this study, total grass, total forb, and total herbaceous ground cover were compared with the abundance of the two most common bird species (meadowlark and horned lark) on each of the four prairie sites. The assumption was that if a component of the vegetative cover correlated closely with the numbers of these two species on all four sites, then that component would strongly regulate their numbers.

Figure 6 compares meadowlark and horned lark numbers with total herbaceous cover in a double bivariate analysis. For each site, average herbaceous cover was determined by averaging one hundred 1-m^2 quadrats. As illustrated in Figure 6, there is no significant correlation between total herbaceous cover and meadowlark and horned lark numbers. Thus, there is no relationship between changes in meadowlark and

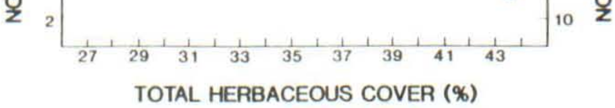

Figure 6. Meadowlark and horned lark numbers compared to total herbaceous cover. (Dots represent meadowlark numbers, and open circles represent horned lark numbers.)

[13] J. A. Wiens and M. I. Dyer, *Rangeland Avifaunas: Their Composition, Energetics, and Role in the Ecosystem*, General Technical Report WO-1 (U.S. Department of Agriculture, Forest Service, 1975), pp 146–182.

horned lark numbers and total herbaceous cover. Figure 7 compares meadowlark and horned lark numbers with total forb cover. Again, there is no significant correlation between either of these species and total forb cover.

Figure 8 compares meadowlark and horned lark numbers to total grass cover, and both species of birds are found to correlate significantly. For meadowlarks, R = 0.981, and for horned larks, R = 0.898. There is an inverse relationship between the two species: meadowlark numbers increase and horned lark numbers decrease with increasing grass cover.

The relationship of meadowlarks and horned larks to grass cover agrees with what is known about the natural history of these two species. The horned lark prefers the open plains, dirt roadsides, and shores, whereas the meadowlark prefers grassy meadows, fields, and well vegetated prairies. Estimating meadowlark or horned lark numbers may be an effective management tool for assessing the quality (relative grass cover) of various shortgrass prairie sites.

Soils Compared With Mammals

Much research has been conducted to try to understand the forces that regulate the abundance and presence of small rodent species. Most of these studies have documented that interspecific competition, vegetative structure, and availability of food resources are the primary parameters for determining the structure of small rodent communities.[14] However, in reaching these conclusions, few researchers have included in their data sets the effect of edaphic factors in influencing rodent community structure.

Figure 9 compares, in a double bivariate analysis, percent soil sand with mammal diversity and abundance. As shown, there is no significant correlation between mammal diversity and percent soil sand. However, mammal abundance is highly correlated (R = 0.972) with percent soil sand. As soil sand increases, mammal abundance also increases. Site 4 on Piñon Canyon contained only 14.7 percent sand, and only 24 mammals were collected (100 trapnights); in comparison, at site 2 on Fort Carson, which contained 71.6 percent soil sand, 165 mammals were collected (1000 trapnights). Apparently, an increase in soil sand facilitates burrowing, particularly for larger rodents like the kangaroo rat.

To further test this hypothesis, percent soil sand was compared with kangaroo rat and pocket mouse numbers in a double bivariate analysis (Figure 10). Kangaroo rat numbers increased and were significantly correlated (R = 0.963) with increasing soil sand, and

[14] M. V. Price, "The Role of Microhabitat in Structuring Desert Rodent Communities," *Ecology*, Vol 59, No. 5 (1978), pp 910-921.

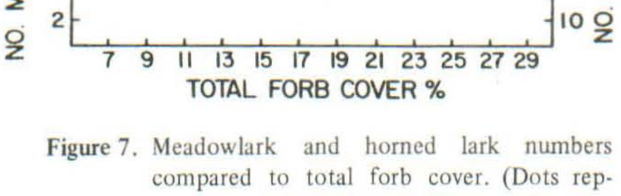

Figure 7. Meadowlark and horned lark numbers compared to total forb cover. (Dots represent meadowlark numbers, and open circles represent horned lark numbers.)

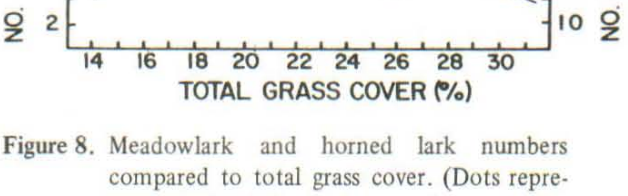

Figure 8. Meadowlark and horned lark numbers compared to total grass cover. (Dots represent meadowlark numbers, and open circles represent horned lark numbers.)

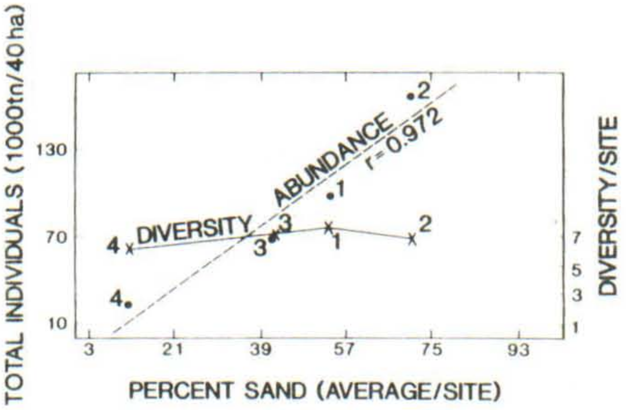

Figure 9. A double bivariate analysis comparing percent soil sand with mammal diversity and total individuals. (Numbers in the figure designate the four prairie sites.)

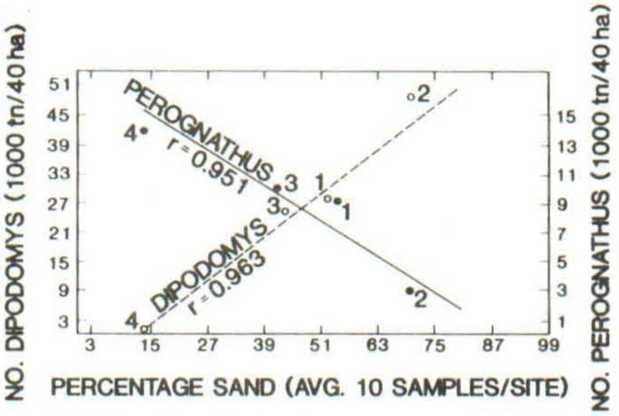

Figure 10. A double bivariate analysis comparing percent soil sand with kangaroo rat (*Dipodomys*) and pocket mouse (*Perognathus*) numbers. (Numbers in the figure designate the four prairie sites; dots represent pocket mouse numbers, and open circles represent kangaroo rat numbers.)

pocket mice numbers decreased and were significantly correlated (R = 0.951) with soil sand. As soil sand increases, kangaroo rat numbers increase, and pocket mice numbers decrease. Kangaroo rats are competitors of pocket mice.[15] Since kangaroo rats are large-bodied, it is hard for them to burrow in "tight" soils like the clay soils of site 4. In their absence, the smaller pocket mouse becomes relatively abundant. On sandy soils, which are easy to burrow in (site 2), the kangaroo rat excludes many pocket mice. Estimating the numbers of kangaroo rats and pocket mice on a site may be an effective management tool for assessing the trafficability (sandiness) of shortgrass prairie sites.

Management Implications

Every land manager must inventory and monitor the changing condition of the land as it is used. The data reported here indicate that wildlife (birds and mammals) can be used to determine the condition of a site. This condition can be expressed in terms of the site's trafficability and potential erosiveness.

In Figure 11, total grass cover and percent soil sand are used in a bivariate analysis to determine the relative erodibility and trafficability of the four study sites. Site 4 has low grass cover and a low percentage of soil sand; therefore, it is an erodible site (little grass cover) and unacceptable for traffic (low sand). In comparison, sites 1 and 2 have a high grass cover and are less erodible; they also have a higher percentage of sand and can better support tracked vehicles. Site 3 is intermediate in erodibility and trafficability.

In Figure 12, the most common birds and small mammals occurring on these four sites are used to provide a similar assessment of site erodibility and trafficability. As shown, the meadowlark/horned lark ratio (many horned larks and few meadowlarks) is low for site 4, and the kangaroo rat/pocket mouse ratio is also low (low kangaroo rats and high pocket mice). This translates into high erodibility (horned larks prefer bare ground) and generally unacceptable trafficability (low sand and high silt and clay) for the site. This is the same result shown in Figure 11. In comparison, sites 1 and 2 have a high meadowlark/horned lark ratio and a high kangaroo rat/pocket mouse ratio. Thus, these sites have low erodibility and are acceptable for tracked vehicles. Site 3 is intermediate for both wildlife ratios and is also intermediate in erodibility and trafficability (Figure 11).

[15] C. Lemen and P. W. Freeman, "Quantification of Competition Among Coexisting Heteromyids in the Southwest," *The Southwestern Naturalist*, Vol 28 (1983), pp 41–46.

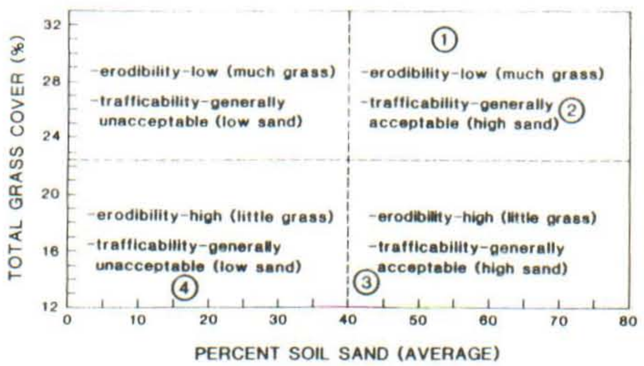

Figure 11. Calculating site erodibility and trafficability based on vegetation and soils measurements.

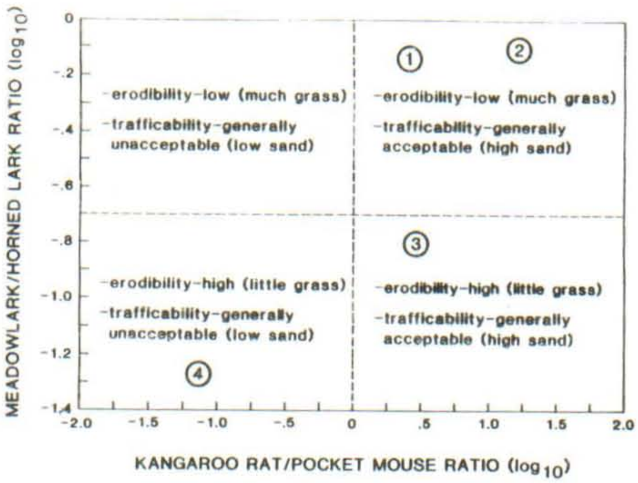

Figure 12. Predicting site erodibility and trafficability based on wildlife observations.

6 CONCLUSIONS

This report has compared the mammals, birds, vegetation, and soils of four shortgrass prairie sites on the Piñon Canyon Maneuver Site and Fort Carson, CO, and has identified biotic and abiotic factors that are highly correlated with site quality and site trafficability. The following relationships were noted:

Assessing bird (meadowlarks and horned larks) and small mammal (kangaroo rats or pocket mice) numbers on the shortgrass prairie will allow a land manager to compare the ability of various sites to withstand use (erodibility and trafficability).

As total grass cover on a site increases, meadowlark numbers increase, and horned lark numbers decrease. Therefore, estimating meadowlark or horned lark numbers may be an effective means of assessing a site's erodibility (percent grass cover) since the higher the amount of grass, the less erodible a site will be. On sites with sandy soils, the number of rodents was high, with kangaroo rats being particularly abundant and pocket mice being unusually uncommon. On sites with silty soils, rodent abundance was low, with kangaroo rats being largely absent and pocket mice found relatively frequently. Thus, estimating kangaroo rat and pocket mice numbers may be a good way to assess a site's trafficability, since a low kangaroo rat/pocket mouse ratio indicates a higher potential for erosion.

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