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Impact of Grazing Systems on Rodent and Cottontail Rabbit Populations in South Texas

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IMPACT OF GRAZING SYSTEMS ON RODENT AND COTTONTAIL RABBIT POPULATIONS IN SOUTH TEXAS

BY

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IMPACT OF GRAZING SYSTEMS ON RODENT AND COTTONTAIL RABBIT POPULATIONS IN SOUTH TEXAS

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor	Date
Head, Dept. of Wildlife and Fisheries Sciences	Date

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To my parents I dedicate this thesis. Their love, understanding, encouragement and support are a monumental step in the realization of my dreams.

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ABSTRACT

Study sites were established at Rob and Bessie Welder Refuge and Encino Division of the King Ranch in south Texas to monitor the impact of Short-duration cell grazing (SDG) and Continuous grazing on small mammal and cottontail rabbit populations. Small mammals were live trapped (with occasional snap trapping) and cottontails were spotlighted. Vertical and horizontal components of vegetative structure were measured in terms of percent cover.

There was a paucity of rodents on the Welder Refuge - 8 captures for 9705 trap nights. In 1984 127 cottontails were seen along 432 km of road transects (.29 cottontails/km) and in 1985-1986 64 cottontails were seen along 436.8 km of road transects (.14 cottontails/km). Small mammal and cottontail numbers were small to measure the impact of grazing treatments on small mammals and cottontails.

At the Encino study site a total of 9,600 trap nights yielded 1211 unique captures of small mammals in 1985-1986. Nine species of small mammals were captured. There was a significant difference ($p<.05$) between grazing treatments and most of the small mammal species were captured in greater numbers in SDG treatment.

There was no observed deleterious impact due to Short-duration grazing on small mammals, cottontails and vegetative cover on the Welder Refuge, and the Short-duration grazing treatment appeared to positively impact rodents and vegetation at the Encino study site.

Key words: rodents, rabbits, Short-duration grazing, Continuous grazing, south Texas.

GENERAL INTRODUCTION

Grazing management has developed rapidly over the last two decades (Bryant 1982), particularly in Texas where researchers have promoted the use of deferred-rotation grazing systems for beef production (Merrill 1957). Although many beef ranchers in south Texas, including the Coastal Bend and Rio Grande Plains, have tried deferred-rotation systems and more recently, short-duration grazing (Savory) systems, experimental data for evaluating such systems are limited (Drawe and Cox 1979). There is a paucity of information, from an ecological standpoint, on wildlife responses to grazing systems. Attention has been focused on white-tailed deer (*Odocoileus virginianus*), northern bobwhite (*Colinus virginianus*), wild turkey (*Meleagris gallapavo*), and waterfowl. Impacts of cattle grazing systems on rodent and cottontail rabbit (*Sylvilagus floridanus*) populations in south Texas are particularly unclear.

Rodents and rabbits are an integral part of the ecosystem. These mammals are important prey species for mammalian, avian and reptilian predators. Small mammals may play a important role as buffer species by their abundance. Their presence or absence might influence the amount of predation on ground nesting birds and deer fawns. Furthermore, some rodent species may compete with man for forage, food or fiber in a direct or indirect manner. A grazing system could be implemented to achieve a certain goal, but it could be irreversibly damaging to the ecosystem if the goal had no sound, ecological theory underlying it.

Johnson (1982) suggested that small mammal populations respond quite rapidly to ecological change because of their high reproductive potential. Such ecological changes could result from the effects of different grazing systems.

To understand the impact of short-duration grazing (SDG) on small mammal ecology, it is essential to understand vegetation responses to grazing and livestock behavior in SDG systems. According to Drawe and Cox (1979) vegetation analyses of pastures within the High-Intensity Low-Frequency (HILF) system indicated that range condition of pastures at the Welder Refuge was on an upward trend with the pastures on sandy range sites showing the most improvement. They also found that cattle grazing in the HILF system did not alter plant composition, but it did alter vegetative structure by removing tall, rough grasses and opening the canopy. Taylor et al. (1980) suggested that competition between different species of livestock may be reduced by changing to SDG on ranges that are common to several different livestock species.

Periodic deferment improves range conditions (Merrill 1957, Stoddart et al. 1975). On good to excellent condition range, the less intensive rotation systems and even moderate continuous grazing allow maximum livestock returns while maintaining range condition (Stoddart et al. 1975).

The high intensity grazing period in SDG is important for seedbed preparation while the rest period is important for seedling establishment and the rebuilding of root reserves in existing plants (Savory 1978). Savory (1983) in his holistic resource management approach stated that the 'Savory Grazing Method' provided the technology to halt the desertification process, yet it never required stock reduction even on the most 'overstocked' and deteriorating ranges. It leads to better livestock performance and management. Less range deterioration during drought, better growth of perennial plants and greater seed production have been attributed to SDG (Steger 1981). According to Merrill (1982), most wildlife respond favorably to SDG.

Many range scientists dispute Savory's claim as it is not supported by scientific data or ecological theory at the present time. Notwithstanding, ranchers indiscreetly implement the Savory grazing system, taking it on Savory's word, as a panacea to all grazing systems' problems (Teer, J. G., personal communication). This study was undertaken primarily to determine the impact of a highly popularized, but relatively new and ecologically unclear, cattle grazing system - a short-duration cell grazing (SDG) system, on rodent and rabbit populations.

The study was conducted at the Rob and Bessie Welder Wildlife Foundation Refuge, San Patricio County, Texas, in 1984 and 1985-1986, and the Encino Division of the King Ranch, Brooks County, Texas, in 1985-1986 (Fig. 1).

This manuscript, except for the 'Introduction', is divided into Chapters I and II covering studies at Welder and Encino study sites, respectively. The lack of rodents on the grazing system sites at Welder in 1984, made it necessary to present the information in chapter format to avoid reader confusion. The Encino study site was included in 1985.

Specific objectives at the Welder study site (Chapter I) were to determine the impact of 3 cattle grazing systems (treatments), SDG and 2 units of continuous grazing at different stocking rates, on: (1) relative abundance of rodents, and (2) relative abundance of eastern cottontail rabbits.

The objective at the Encino study site (Chapter II) was to determine the impact of a SDG and a continuous grazing (CG) system on the relative abundance of rodents.

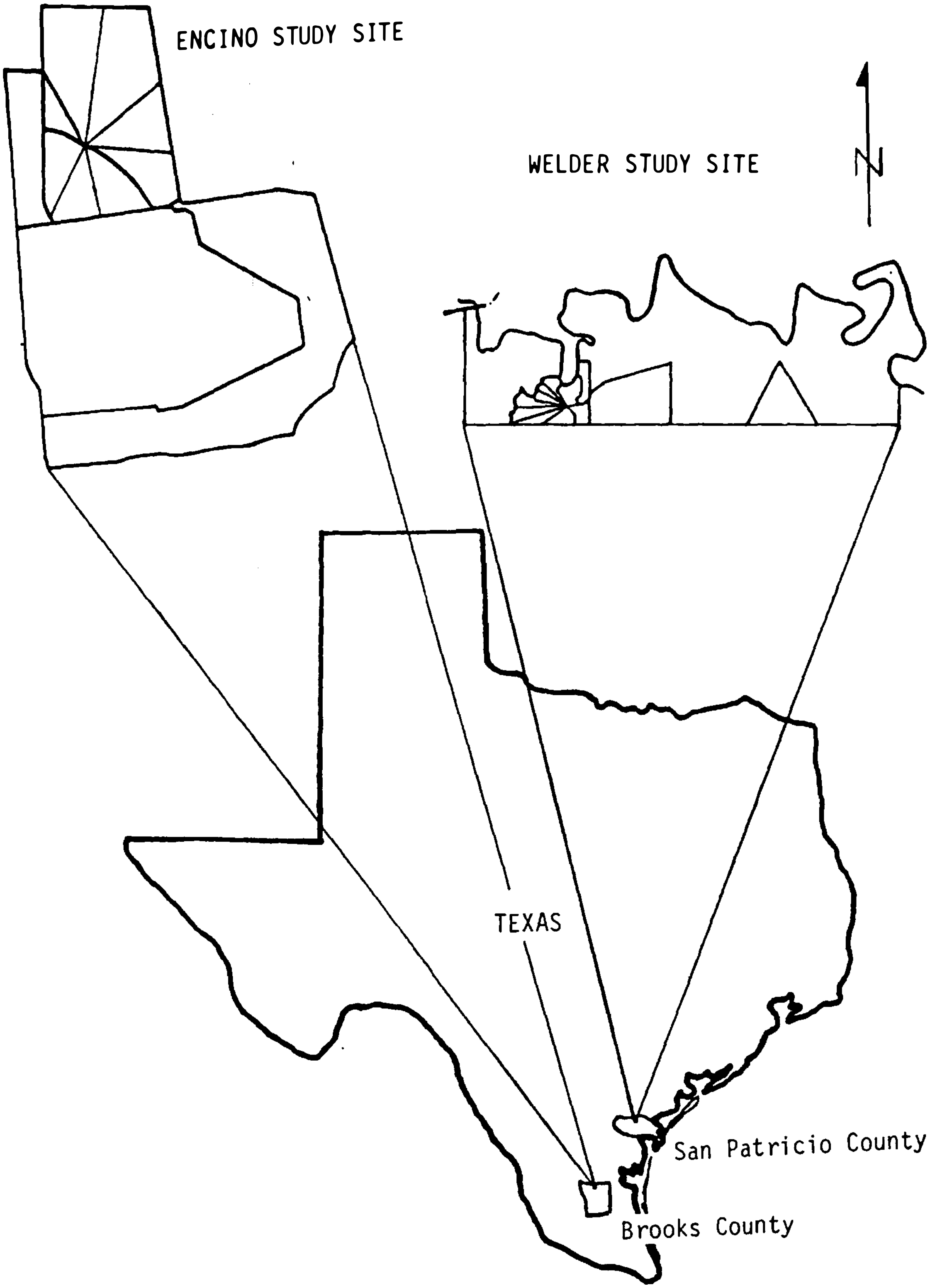


Fig. 1. Location of study sites in south Texas.

CHAPTER ONE

SMALL MAMMAL AND LAGOMORPH RESPONSE TO THREE CATTLE GRAZING SYSTEMS AT THE ROB AND BESSIE WELDER WILDLIFE FOUNDATION REFUGE

STUDY AREA

The Rob and Bessie Welder Wildlife Foundation Refuge (henceforth referred to as Welder Refuge), San Patricio County, Texas, consists of 3,157 ha of native rangeland (Drawe and Cox 1979) (Fig. 2). It is located in a transitional zone between the Gulf Prairies and Marshes and the South Texas Plains (Thomas 1975). Soils have developed from Beaumont and Lissie Pleistocene formations (Dean et al. 1960). The flora is mostly of tropical or sub-tropical origin (Box and Gould 1958, Gould 1975). The vegetation is currently classed as high-fair to low-good range condition (Drawe et al. 1978).

Welder Refuge annual precipitation averages approximately 88.9 cm, but extreme fluctuations make annual averages meaningless. The extremes and not the average rainfall control the permanent vegetation (Drawe et al. 1978). Rainfall occurs during all seasons with late summer and fall maxima (Table 1). Areas comprised of heavier soils are sometimes innundated for 3 to 6 weeks after heavy rainfall. The general climate is humid and sub-tropical with cool winters and hot summers.

WELDER STUDY SITE

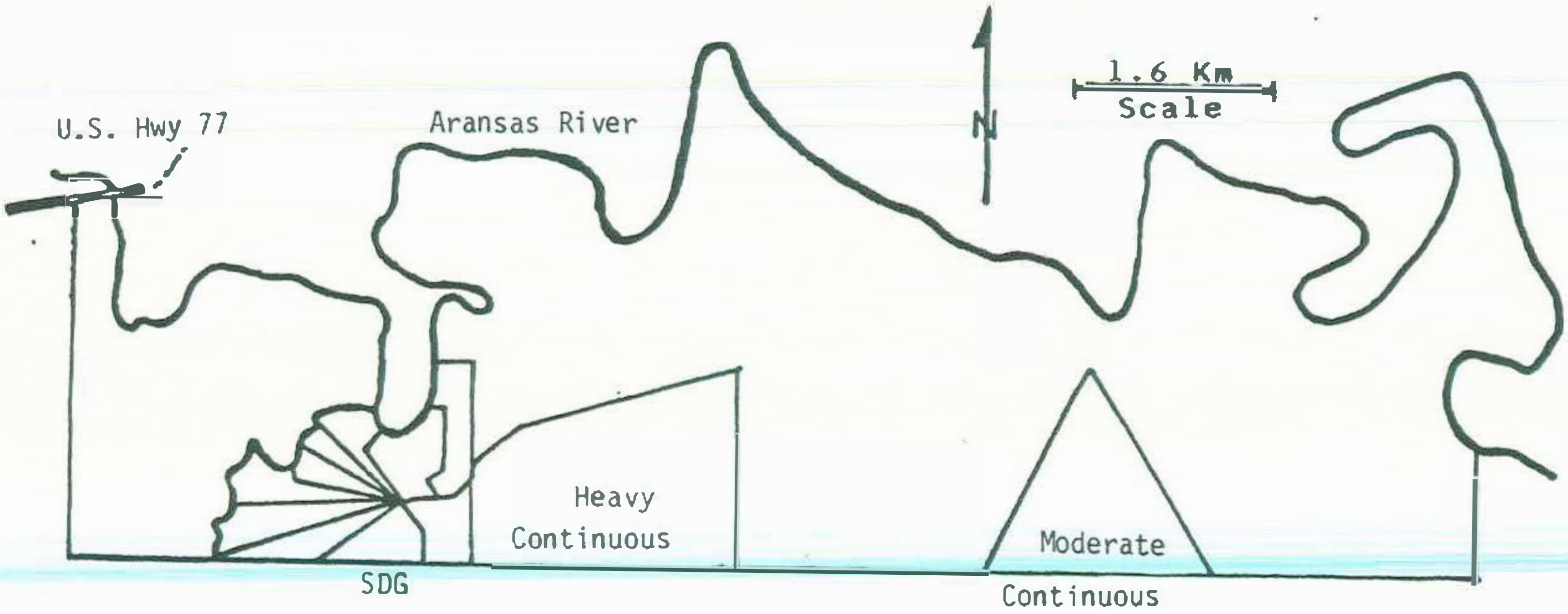


Fig. 2. WELDER STUDY SITE showing Short-Duration Grazing Cell Grazing (SDG), Heavy-Continuous Grazing, and Moderate-Continuous Grazing.

Table 1: Rainfall averages for Welder Wildlife Refuge during field seasons in 1984 and 1985-1986.

MONTHS	AVERAGE (cm)	
	1984	1985
May	3.6	15.1
June	2.7	7.3
July	1.9	2.9
August	1.6	2.8
September	6.9	24.4
October	23.6	5.6
November	2.7	13.0
December	11.4	5.6
	1986	
January	3.2	
February	3.6	
March	2.2	
April	2.9	
May	10.3	

METHODS

This study was primarily concerned with 3 different cattle grazing treatments. These treatments were within the poorly drained Victoria clay soil type, 0-1% slope, and mesquite (Prosopis glandulosa)-mixed grass vegetation community. The 3 treatments were, (1) a short-duration cell grazing (SDG) pasture, (2) a continuous grazing pasture with moderate stocking rate (MC), and (3) a continuous grazing pasture with heavy stocking rate (HC). The 10-paddock, 214.4 ha, SDG pasture was established in 1982, and had a stocking rate of about 4 ha/AU (.25 AU/ha). Cattle were rotated at a rate of 3-5 days per paddock. The HC pasture was 250 ha with a stocking rate of 2.8 ha/AU (.36 AU/ha), and the MC pasture was 144 ha with a stocking rate of 5.8 ha/AU (.17 AU/ha).

SMALL MAMMAL TRAPPING

Nine live trapping grids were established, with 3 grids per grazing treatment. Each grid was 7x7 (49 trap stations). Distance between adjacent trap stations was established at 15 m. Grid sites within each grazing treatment were established at random, and were permanently marked. In late August, 1984, more live traps were purchased and subsequently grid size was increased to 10x10 (100 trap stations/grid).

Live trapping was conducted in 1984 and 1985 for 15 consecutive nights every month. Of the 9 grids only 3, 1 from each treatment, were operational at any time for a period of 5 successive nights. Traps were moved on the sixth day to the next set of 3 grids. By the sixteenth day all 9 grids had been sampled. The order of grid location for trapping within each treatment was random.

Tomahawk #101 live traps (Tomahawk Live Trap Co., Tomahawk, WI) were used for live trapping small mammals. Traps were baited with "hen scratch", a mixture of grain sorghum and cracked corn. Captured rodents were identified to species, weighed, aged, sexed, checked for breeding condition, toe clipped (Baumgartner 1940, Melchior and Iwen 1965) and released. Live trapping was conducted during June, 1986, for 5 successive days (1500 trap nights; 100 traps/grid/treatment) and was subsequently abandoned on the 3 grazing treatments.

SURVEY OF COTTONTAIL RABBITS

A roadside spotlighting technique (Flinders and Hansen 1973) was used to survey rabbits along roadside transects. A 100,000 candle power, hand-held spotlight (Q-BEAM) was used to illuminate approximately a 75 m strip on either side along each transect. Paved and caliche roads were used as transects. Transects within each of the 3 treatments, SDG, HG and MG, were 1.6 km long. Transects were traversed by a 2-wheel drive automobile at a speed of 16 km/hr. Rabbit surveys along transects were conducted on 5 successive nights each month from August-December 1984 and from

July 1985 to May 1986. Surveys were conducted 1 hour before sunrise and 1 hour after sunset, because of the crepuscular activity of rabbits (Trippensee 1938). Rabbits were counted both on the outward and return traverses on each transect . Under the circumstances, an individual rabbit may have been counted twice during each run. This observer bias was consistent across all 3 grazing treatments.

VEGETATION 1984

Percent ground cover and vertical structure of the vegetation were measured. A 20x50 cm Daubenmire frame (quadrat) (Daubenmire 1959) was used to estimate ground cover. Ground cover was estimated by species in cover classes I-VII (I = 0%, II = 1-5%, III = 6-25%, IV = 26-50%, V = 51-75%, VI = 76-95%, VII = 96-100%). Forty-five Daubenmire quadrats were placed at random on the small mammal grids in each treatment, and species composition was estimated within these same quadrat sites seasonally.

A visual obstruction profile pole (Guthery et al. 1981), 1 m high and 6.5 cm in diameter, was used to measure vertical vegetation structure. The pole was divided into ten 1 dm blocks. Percent visual obstruction by stratum of the profile pole caused by vegetation screening was estimated from a distance of 4 m (distance yielding maximum variation of vegetative obstruction as established in a study initiated prior to the current one, on the

Welder Refuge), in a kneeling position, along a N-S direction. Forty-nine profile pole stations were established at random in each treatment on the small mammal grids, and measurements were obtained from these same stations seasonally.

VEGETATION 1985-1986

Modifications in the 1985-1986 field season included an increase in sample size per treatment for both percent ground cover and vertical vegetative structure. Forty-five Daubenmire quadrat (ground cover) samples per treatment per season were increased to 60 samples/treatment/season. Similarly, 49 profile pole samples per treatment per season were increased to 60 samples/treatment/season. Sampling followed a completely randomized design. Furthermore, the unequal cover classes were dispensed with and actual percentages of cover were estimated. Species composition was replaced by the following life form categories: grasses, grass-like plants, forbs, woody plants, litter and bare ground.

Methods were modified for the following reasons: (1) sample size was increased for statistical reasons; (2) actual percentages of cover were estimated as these data were more conducive to statistical analysis than the unequal class intervals of the Daubenmire cover classes; (3) general plant categories replaced species composition as the latter was very time consuming to measure; and (4) by being consistent with the techniques between the 2 study sites in 1985-1986 there was a better possibility of comparison of data from these sites if required.

DATA ANALYSIS

Chi-square tests of significance (SAS 1985a) were run on all data with sufficient sample size. The probability level for acceptance of significant differences was established at 0.05 and 0.01. Whenever sample size was <5, data were regrouped for statistical purposes.

Both rodent capture data and rabbit survey data yielded too little data to be quantified statistically. They have been reported as raw data.

Chi-square tests were run on the Daubenmire class intervals to detect differences of species between treatments by season for ground cover data from 1984. Ground cover data from 1985-1986 were grouped in percent classes ranging between 0% and 100%, and the frequency of these groups were subjected to chi-square tests by individual seasons. Categories analyzed were grasses, forbs, litter and bare ground. Woody plants, grass-like plants and plant phenology data were not sufficiently large to be tested statistically.

Chi-square tests of significance were run on visual obstruction data by stratum between treatments, specifically on frequency of grouped percent classes, ranging between 0% and 100%

of each stratum. These results were obtained for individual seasons (1984 and 1985-1986).

RESULTS

SMALL MAMMALS

A total of 8,205 live trap nights on the 3 grazing treatments in 1984 yielded 8 rodent captures that included 4 species (Table 2). The 4 species were northern pygmy mouse (Baiomys taylori), white-footed mouse (Peromyscus leucopus), fulvous harvest mouse (Reithrodontomys fulvescens) and hispid cotton rat (Sigmodon hispidus). In June 1985 a total of 1500 live trap nights on the 3 grazing treatments resulted in zero captures.

RABBIT SURVEY

In 1984 a total of 127 cottontails were seen along 432 km of road transects, and the number of rabbits per kilometer of transect, .29 rabbits/km, was small (Table 3). Similarly, in 1985-1986, a total of 64 cottontails were seen along 436.8 km of road transects, and again the number of rabbits per kilometer, .14 rabbits/km, was very small (Table 4). Rabbit numbers in both sample years were greater on transects in SDG (.58 and .19) than on transects in MC (.17 and .09) or HC (.14 and .16) grazing systems.

VEGETATION

1984

Forty-three plant species that included grasses, grass-like

Table 2: Rodents captured by live trapping in Short-duration (SDG), Heavy Continuous (HC) and Moderate Continuous (MC) grazing treatments on the Welder Refuge in 1984. Each trapping session comprised 15 successive nights of live trapping[a].

SESSION	DATE	# OF TRAP NIGHTS	SPECIES[b]	SDG	HC	MC
I	19 JUL- 2 AUG	2,205	1.Refu	1	0	0
			2.Bata	2	1	0
			3.Pele	0	0	1
II	2 SEP-16 SEP	4,500	1.Refu	1	0	0
			2.Sihi	1	0	0
III	14 OCT-18 OCT	1,500	1.Pele	0	0	1

[a] Live trapping abandoned after 5 days as all 3 grazing treatments inundated from rains on Oct. 19.

[b] Bata: *Baiomys taylori*; Pele: *Peromyscus leucopus*; Refu: *Reithrodontomys fulvescens*; Sihi: *Sigmodon hispidus*.

Table 3: Vehicle spotlight counts of cottontail rabbits/km observed in Short-duration (SDG), Heavy Continuous (HC) and Moderate Continuous (MC) grazing treatments on the Welder Refuge in 1984.

MONTHS	DAYS[a]	TOTAL KM	KM/ TREATMENT	RABBITS/KM (TOTAL) SDG	HC	MC
AUGUST	12	115.2	38.4	.52 (20)	.05 (2)	.23 (9)
SEPTEMBER	16	153.6	51.2	.72 (37)	.21 (11)	.19 (10)
OCTOBER	6	57.6	19.2	.94 (18)	.15 (3)	.10 (2)
NOVEMBER	11	105.6	35.2	.23 (8)	.11 (4)	.08 (3)
TOTAL	45	432.0	144.0	(83)	(20)	(24)
AVERAGE			36.0	.58	.14	.17

[a] 1 Day=am+pm

Table 4: Vehicle spotlight counts of cottontail rabbits/km observed in Short-duration (SDG), Heavy Continuous (HC) and Moderate Continuous (MC) grazing treatments on the Welder Refuge in 1985-1986.

		TOTAL	KM/	RABBITS/KM (TOTAL)		
MONTHS	DAYS[a]	KM	TREATMENT	SDG	HC	MC
JULY	8	76.8	25.6	.27 (7)	.19 (5)	.11 (3)
AUGUST	6	57.6	19.2	.15 (3)	.36 (7)	0 (0)
OCTOBER	13	124.8	41.6	.07 (3)	.05 (2)	.05 (2)
NOVEMBER	8[b]	38.4	12.8	.23 (3)	.15 (2)	.07 (1)
DECEMBER	3[b]	14.4	4.8	.21 (1)	0 (0)	0 (0)
JANUARY	3	28.8	9.6	.10 (1)	0 (0)	0 (0)
FEBRUARY	2[b]	9.6	3.2	0 (0)	.31 (1)	0 (0)
MARCH	4	38.4	12.8	.23 (3)	.15 (2)	.15 (2)
APRIL	1	9.6	3.2	.31 (1)	0 (0)	0 (0)
MAY	4	38.4	12.8	.31 (4)	.39 (5)	.47 (6)
TOTAL		436.0	145.0	(26)	(24)	(14)
AVERAGE			14.6	.19	.16	.09

[a] 1 Day=am+pm

[b] Counts=All night session

plants, forbs, woody plants, litter and bare ground were recorded for percent ground cover with a 20x50 cm Daubenmire frame (270 quadrats). Of these, only 18 species, litter and bare ground had sufficient sample size, in frequency of occurrence, to test for differences between grazing treatments. Occurrence of fifteen species, litter and bareground were significantly different between treatments (Table 5). Frequencies of meadow dropseed *(Sporobolus asper)* and mesquite were not significantly different between treatments either in summer or fall, and frequency of pink evening primrose *(Oenothera speciosa)* was not significantly different between treatments in the fall. The modal value for most of the species was category I, which is 0% cover (Table 6).

Visual obstruction data which measured percent visual obstruction of 10, 1 dm blocks for each profile pole sample site, yielded significant differences between treatments for strata 1, 2, 3 and 5 in summer, and for strata 1, 2, 3, 4 and 5 in fall (Table 7). These results were obtained for the frequencies of the grouped percent classes. There was more visual obstruction of the first 3 strata from ground in MC (78.3%, 35.4%, 24.2%) than SDG (46.8%, 20.3%, 12.8%) and HC (29.7%, 14.1%, 11.3%) grazing systems.

1985-1986

Percent ground cover, including vegetation, litter and bare ground was significantly different between treatments during all

Table 5: Chi-square test of significance of percent ground cover of plant species between Short-duration, Heavy Continuous and Moderate Continuous grazing treatments within each season on the Welder Refuge in 1984.

SPECIES	JUN-AUG CHI-SQUARE	PROB.	SEPT-DEC CHI-SQUARE	PROB
Marsilea macropoda	49.377	.000**	58.034	.000**
Bareground	23.611	.001**	21.512	.001**
Litter	23.856	.001**	26.250	.000**
Ruellia nudiflora	25.986	.000**	8.714	.069
Oenothera speciosa	23.333	.000**	insufficient #	
Aster spp.	10.769	.005**	16.887	.000**
Sporobolus asper	5.607	.230	6.336	.175
Carex spp.	16.387	.000**	8.005	.018*
Phyla spp.	36.228	.000**	41.220	.000**
Prosopis glandulosa	3.498	.478	0.912	.634
Ambrosia psilostachya	24.030	.000**	33.289	.000**
Ratibida columnaris	34.200	.000**	13.058	.001**
Buchloe dactyloides	21.898	.000**	52.496	.000**
Setaria spp.	17.085	.000**	26.131	.000**
Iva annua	37.493	.000**	24.657	.000**
Schizachyrium scoparium	10.996	.004**	19.658	.000**
Panicum obtusum	13.793	.001**	insufficient #	
Paspalam lividum	23.462	.000**	17.776	.000**
Desmanthus virgatus	absent		20.000	.000**
Bothriochloa saccharoides	absent		43.480	.000**

**p≤.01
*p≤.05

Table 6: Modal class (M) and frequency (F) of occurrence of plant species measured by 20x50 cm Daubenmire frame in cover classes 1=0%, 2=1-5%, 3=6-25%, 4=26-50%, 5=51-75%, 6=76-95%, 7=96-100%, on Short-duration (SDG), Moderate Continuous (MC) and Heavy Continuous (HC) grazing treatments within each season on the Welder Refuge in 1984.

	JUN-AUG						SEPT-DEC					
SPECIES	SDG		MC		HC		SDG		MC		HC	
	M	F	M	F	M	F	M	F	M	F	M	F
Marsilea macropoda	2	28	1	41	1	43	2	35	1	43	1	35
Bareground	4-7	15	4-7	15	1	21	1-2	20	4	16	1-2	24
Litter	7	18	7	18	7	37	3	16	2	22	4	29
Ruellia nudiflora	1	33	1	19	1	41	1	28	2	19	1	28
Oenothera speciosa	1	38	1	26	1	44	insufficient #					
Aster spp.	1	33	1	41	1	43	1	28	1	42	1	40
Sporobolus asper	1	25	1	26	1	23	1	24	1	33	1	25
Carex spp.	1	33	1	45	1	31	1	35	1	36	1	25
Phyla spp.	1	22	3	17	1	41	2	25	2	32	1	42
Prosopis glandulosa	1	37	1	32	1	34	1	38	1	35	1	38
Ambrosia psilostachya	1	43	1	29	2	23	1	45	1	38	1	23
Ratibida columnaris	1	39	2	30	1	36	1	40	1	29	1	41
Buchloe dactyloides	1	35	1	24	1	43	1	37	2	34	1	41
Setaria spp	1	43	1	29	1	40	1	23	1	27	1	44
Iva annua	1	41	1	35	1	15	1	42	1	38	1	23
Schizachyrium scoparium	1	38	1	42	1	30	1	29	1	40	1	44
Panicum obtusum	1	44	1	31	1	38	insufficient #					
Paspalam lividum	1	44	1	43	1	30	1	34	1	43	1	26
Desmanthus virgatus	absent						1	31	1	41	1	45
Bothriochloa saccharoides	absent						1	41	1	42	2	27

Table 7: Averages and chi-square test of significance of frequencies of cover-classes of individual stratum of profile pole measuring visual obstruction of vegetation between Short-duration (SDG), Moderate Continuous (MC) and Heavy Continuous (HC) grazing treatments for summer and fall 1984 on the Welder Refuge. Measurements are from ground level up to 100cm in height.

		JUNE-AUGUST			SEPTEMBER-DECEMBER		
STRATA	CM	SDG	MC	HC	SDG	MC	HC
ONE	0-10	46.8	78.3	29.7	56.4	58.8	21.9
TWO	10-20	20.3	35.3	14.1	16.3	17.7	8.9
THREE	20-30	12.8	24.2	11.3	9.6	12.2	6.1
FOUR	30-40	9.3	8.9	7.0	6.2	6.3	5.5
FIVE	40-50	6.4	6.5	5.0	2.9	5.3	4.9
SIX	50-60	5.0	3.5	4.7	1.9	2.7	5.2
SEVEN	60-70	3.7	1.3	4.5	1.1	0.9	4.7
EIGHT	70-80	3.1	0.8	4.3	0.6	0.4	4.4
NINE	80-90	2.8	0.5	4.3	0.6	0.3	4.3
TEN	90-100	2.5	0.3	4.1	0.8	0.1	4.1

		JUNE-AUGUST		SEPTEMBER-DECEMBER	
STRATA	CM	CHI-SQ	PROB	CHI-SQ	PROB
ONE	0-10	34.287	.000**	27.404	.000**
TWO	10-20	31.812	.000**	6.964	.031*
THREE	20-30	18.942	.001**	6.288	.043*
FOUR	30-40	2.031	.362	30.032	.000**
FIVE	40-50	7.699	.021*	15.500	.000**
SIX	50-60	4.230	.121	3.253	.197
SEVEN	60-70	1.195	.550	0.374	.830
EIGHT	70-80	1.852	.396	0.445	.800
NINE	80-90	0.445	.800	1.181	.554
TEN	90-100	1.502	.472	4.900	.086

**$p \leq .01$
*$p \leq .05$

seasons except for 'grasses' in winter and spring (Table 8). These results were obtained using frequencies of the grouped percent classes. There was a greater percent grass cover in SDG during all seasons except winter, greater percent forb cover in MC in summer and spring, and greater percent forb cover in HC in the fall and winter. MC had greater percent cover by litter except in winter. Percent bare ground was greater in HC in summer and spring, followed by MC in fall and SDG in winter.

Vertical structure of vegetation was significantly different between treatments for strata 1, 2, 3, 4, 6, 7, 9 and 10 in the summer. Strata 2, 4, 5, 6, and 7 were significantly different in the fall. In winter and spring only strata 1, 6, 7 and 9, and strata 7 and 8 were significantly different, respectively (Table 9). These results were obtained for frequencies of grouped percent classes. Overall, percent visual obstruction was greater for most strata in MC than SDG and HC.

DISCUSSION

The lack of small mammals and cottontail rabbits on the Welder Refuge has given rise to considerable speculation. Range condition at the Welder Refuge has been described as fair to good (Drawe et al. 1978) and although grazing practices could impact rodents, it is not likely that the scarcity of rodents at the Welder Refuge is an outcome of grazing practices alone. Most rodent species occurring in this region are associated with dense

Table 8: Averages and chi-square test of significance of frequencies of cover-class groups of percent ground cover (Grass=G, Forb=F, Litter=L, Bareground=B) between Short-duration (SDG), Moderate Continuous (MC) and Heavy Continuous (HC) grazing treatments within each season on the Welder Refuge in 1985-1986.

CATEGORY	JUN-AUG			SEP-NOV			DEC-FEB			MAR-MAY		
	SDG	MC	HC	SDG	MC	HC	SDG	MC	HC	SDG	MC	HC
G	53.9	15.1	38.2	51.0	33.9	46.7	16.3	15.9	18.0	19.4	10.9	7.5
F	11.3	39.4	25.9	20.9	14.2	26.9	24.4	49.9	56.4	15.0	21.2	8.7
L	8.6	41.7	8.1	45.8	47.1	15.3	45.2	26.0	15.9	42.3	79.4	70.9
B	26.7	16.2	48.7	12.9	30.6	26.0	17.2	15.5	7.9	17.1	9.7	26.9

CATEGORY	JUN-AUG		SEP-NOV		DEC-FEB		MAR-MAY	
	CHI-SQ	P	CHI-SQ	P	CHI-SQ	P	CHI-SQ	P
G	52.154	.000**	11.823	.019*	4.256	.373	4.209	.122
F	67.106	.000**	18.333	.001**	36.649	.000**	13.248	.010**
L	66.248	.000**	68.100	.000**	49.283	.000**	7.037	.030*
B	37.856	.000**	34.485	.000**	12.908	.012*	23.000	.000**

**$p \leq .01$
*$p \leq .05$

Table 9: Averages and chi-square test of significance of frequencies of cover-class groups of individual stratum, of profile pole measuring percent visual obstruction of vegetation between Short-duration (SDG), Moderate Continuous (MC) and Heavy Continuous (HC) grazing treatments within each season on the Welder Refuge in 1985-1986. Measurements are from ground level up to 100cm in height.

		JUN-AUG			SEP-NOV			DEC-FEB			MAR-MAY		
STRATA	CM	SDG	MC	HC	SDG	MC	HC	SDG	MC	HC	SDG	MC	HC
One	0-10	93	100	96	92	89	90	74	83	52	77	84	76
Two	10-20	77	100	84	65	58	43	27	32	18	28	48	27
Three	20-30	70	97	79	45	43	28	15	17	10	21	23	17
Four	30-40	55	87	66	27	33	9	3	6	3	14	8	8
Five	40-50	47	71	62	18	29	8	4	6	3	14	8	8
Six	50-60	33	47	50	14	24	5	4	4	1	10	5	6
Seven	60-70	24	19	35	13	22	6	3	4	2	10	2	4
Eight	70-80	16	8	17	13	17	5	3	3	1	11	1	4
Nine	80-90	9	2	9	13	15	3	2	2	1	12	3	4
Ten	90-100	7	0	6	13	15	1	3	2	0	11	3	4

	JUN-AUG		SEP-NOV		DEC-FEB		MAR-MAY	
CM	CHI-SQ	P	CHI-SQ	P	CHI-SQ	P	CHI-SQ	P
0-10	8.780	.012*	3.840	.147	17.006	.000**	2.252	.324
10-20	24.331	.000**	12.165	.002**	9.358	.053	7.662	.105
20-30	15.852	.000**	7.821	.098	3.913	.141	6.699	.153
30-40	15.882	.000**	9.572	.008**	4.967	.083	2.723	.256
40-50	4.845	.089	13.013	.011*	5.972	.050*	2.587	.274
50-60	13.784	.008**	12.211	.016*	9.130	.010**	0.988	.610
60-70	12.863	.012*	9.987	.041*	10.081	.006**	10.989	.004**
70-80	5.647	.059	6.594	.159	1.208	.547	6.472	.039*
80-90	12.857	.002**	8.196	.085	8.139	.017*	2.216	.330
90-100	10.909	.004**	8.541	.074	3.095	.213	0.885	.643

**$p \leq .01$

*$p \leq .05$

vegetative ground cover (Barry and Franq 1980, Black and Frischnecht 1971, Cleveland 1978, Joule and Cameron 1975, Kantak 1983, Kaufman et al. 1983, Stickel and Stickel 1949), a condition descriptive of the Welder site and the grazing treatments. It is also unlikely that all populations of the various rodent species suffered a natural crash at the time of this study. The above average rainfall that this region has been experiencing (Drawe, D. L., personal communication) might be a primary factor. High rainfall on very poorly drained Victoria clay soils results in extensive inundation for several weeks. This perhaps could drown and displace some small and medium sized mammals.

Exploratory live trapping (600 trap nights; 120 trap nights/plant community) in 5 plant communities other than the 3 primary grazing systems in 1985-1986 resulted in 4 rodent captures, 2 pygmy mice, 1 harvest mouse and 1 white-footed mouse. The 5 plant communities included gulf cordgrass (Spartina spartinea), riparian woodland, woodland-spiny aster (Aster spinosus), bunchgrass-annual forb and live oak (Quercus virginiana) -chaparral. In addition to the 600 live trap nights, a total of 200 trap nights of snap trapping (50 traps/night) along a railroad track adjacent to the Welder Refuge, in 1984, and within the 5 plant communities (150 trap nights), in 1985-1986, resulted in the capture of 1 least shrew (Cryptotis parva), 1 pygmy mouse and 2 white-footed mice. This exploratory trapping was carried out to further investigate the lack of rodents on the targeted grazing systems. The exploratory trapping revealed a paucity of rodents on major soil and vegetative types of the Welder Refuge and near vicinity. Extensive trapping for the same species in other regions with higher rodent populations using the same techniques provided evidence that the rodent species at the Welder Refuge should have been vulnerable to our trapping methods. Use of similar trapping techniques have proven effective at the Welder Refuge in earlier (Teer, J. G., personal communication) years when rodents were more abundant.

Barn owl (*Tyto alba*) pellets collected from nest boxes were analyzed to get an index on small mammal populations (Appendix B). These nest boxes have been installed on the Welder Refuge for use by black-bellied whistling ducks (*Dendrocygna autumnalis*). Barn owls are primarily a rodent-eating species (Burton 1973). Barn owls at the Welder Refuge had over 30% avian materials in their pellets. Rodents were seldom seen at night when I was spotlighting for cottontail rabbits. Clearly there was some factor or several factors affecting rodent numbers on the Welder Refuge.

CONCLUSION

The SDG system did not appear to negatively affect either the range condition or the rodent and cottontail rabbit populations.

The mammal numbers were extremely low on all 3 treatments - the SDG, HC and MC. It is not possible to draw meaningful conclusions on small mammals with so few captures per grazing treatment.

Predation on ground nesting birds would be a primary concern when the small mammal prey base is lacking. More than 90% of the losses of artificial nests, in a study conducted to evaluate the effects of SDG and continuous grazing on gamebird nesting (Bareiss et al., unpublished manuscript), resulted from predation. A continuation in analysis of barn owl pellets at the Welder Refuge would be an interesting and possibly good index to monitor the pulse of small mammal populations. More predator food habit studies would also provide a better appreciation of this problem.

CHAPTER TWO

SMALL MAMMAL RESPONSE TO A SHORT DURATION CELL GRAZING PASTURE AND CONTINUOUS GRAZING BY CATTLE AT THE ENCINO DIVISION OF THE KING RANCH

STUDY AREA

The Encino Division of the King Ranch (henceforth referred to as Encino), Brooks County, Texas, is located in the South Texas Plains biotic province (Fig 3). The soils survey for this county is still in progress, but on close scrutiny of soil surveys from surrounding counties, soils within the Encino study area most likely developed from the Beaumont and Lissie formations (Dean et al. 1960). Soils in the Encino study site were well drained, deep, level to undulating sands of the Sarita-Nueces Association and Falfurrias fine sand. Rainfall is distributed unevenly through the year with late summer and fall maxima (Table 10).

The vegetation was an association of gulf cordgrass, Texas pricklypear (*Opuntia lindheimeri*), seacoast bluestem (*Andropogon scoparius* var. *littoralis*), and threeawn (*Aristida* spp.) interspersed with mesquite and live oak mottes. The dominant forbs were crotons (*Croton* spp.), sunflowers (*Helianthus* spp.), and camphorweed (*Heterotheca* spp.) (Bareiss et al., unpublished manuscript).

METHODS

There were 2 grazing treatments sampled for rodents at the Encino area. An 8 paddock, 1,142 ha, short-duration cell grazing (SDG) pasture was established in 1983. The stocking rate was 7.3 ha/AU (.14 AU/ha) and the herd of cattle was rotated at the rate of 4-9 days per paddock. The continuous grazing (CG) pasture was

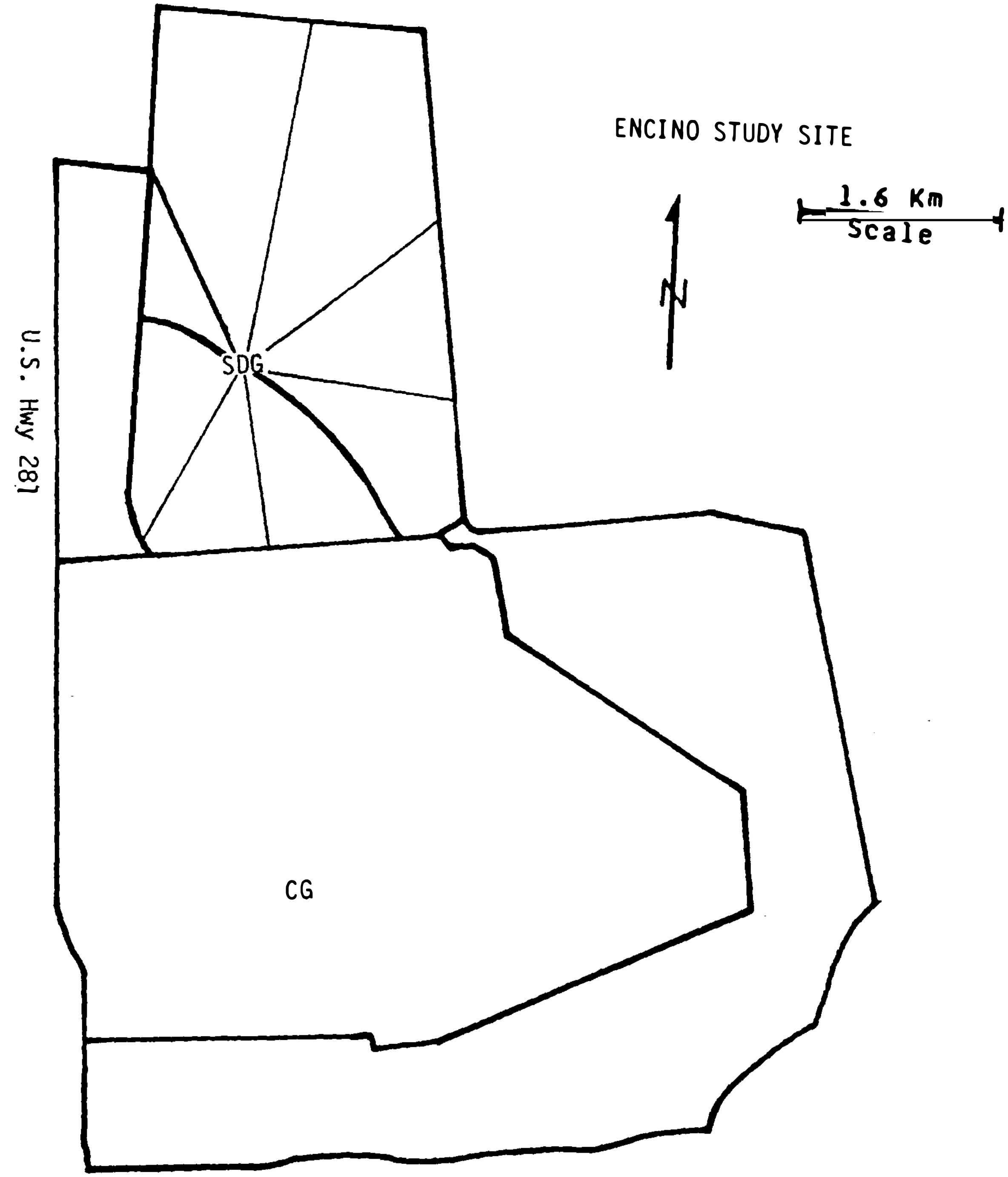


Fig. 3. ENCINO STUDY SITE showing Short-Duration Cell Grazing (SDG), and Continuous Grazing (CG).

Table 10: Rainfall averages for Encino study site in south Texas, 1985-1986.

MONTHS	AVERAGE (cm)
1985	
May	12.6
June	7.7
July	4.3
August	0.4
September	17.0
October	18.0
November	0.0
December	3.1
1986	
January	0.7
February	3.4
March	0.0
April	1.3
May	10.7

1,242 ha and was stocked at 7.3 ha/AU (.14 AU/ha).

Field season extended from June 1985 through May 1986. The Encino study site was established for the second field season (the first field season was from June through December 1984 and did not include the Encino study site) due to extremely low rodent densities at the Welder Refuge.

SMALL MAMMALS

Four 5x5 grids, each with 25 trap stations, were established on each treatment. A completely randomized design was used for grid location in each treatment and this was repeated every month. The distance between adjacent trap stations was 15 m. Both treatments were sampled simultaneously. Traps were operational for 4 successive nights each month totalling 800 trap nights per month.

Collapsible live traps, 7.6x8.9x22.9 cm (H. B. Sherman Traps, Inc., Tallahassee, FL), were used to trap small mammals. Traps were baited with "hen scratch", a mixture of grain sorghum and cracked corn, and lined with cotton to alleviate mammal exposure to adverse temperatures. Captured mammals were identified to species, sexed, aged, examined for reproductive status, toe clipped, and released.

VEGETATION

A 20x50 cm Daubenmire frame (quadrat) (Daubenmire 1959) was used to estimate percent ground cover by the following life form categories: grasses, grass-like plants, forbs, woody plants, litter and bare ground. Plant canopy coverage in 60 Daubenmire quadrats was estimated in each treatment per season. Sampling followed a completely randomized design. Sixty samples were distributed equidistantly along 10 transects, each 30 m long.

A 1 m high, 6.5 cm diameter, visual obstruction pole (Guthery et al. 1981) divided into 10 1 dm blocks served to measure vertical structure of vegetation. Percent visual obstruction of the profile pole by stratum caused by screening of vegetation, was estimated from a distance of 4 m (distance yielding maximum variation of vegetative obstruction as established in an earlier study at Encino). The readings were obtained along a N-S direction and in a kneeling position. Sixty profile pole readings were obtained from each treatment per season. Sampling followed a completely randomized design.

DATA ANALYSIS

Vegetative data were subjected to chi-square tests of significance (SAS 1985a). Statistical significance was established at the 0.05 and 0.01 level of probability . Whenever sample size was <5, data were re-grouped for statistical tests. Chi-square tests were run on all vegetation data as distributions of these data were not normal. Tests of significance identified treatment effects within each season. For the purpose of analyses, percent cover within each vegetation category and percent visual obstruction of each stratum of profile pole were grouped into cover classes ranging from 0% to 100% and the frequencies of these groups were subjected to chi-square tests. Averages of percent visual obstruction of each stratum and percent ground cover of each vegetation category have also been reported. Categories reported are grasses, forbs, litter and bareground. Grass-like vegetation and woody plants afforded insufficient sample size for statistical testing.

To estimate microhabitat differences between treatments, means of percentage classes of stratum 1, strata 1 and 2 and strata 1, 2 and 3 were subjected to chi-square tests.

Small mammals were reported as unique captures. Since actual counts, a discrete variable, were used to estimate relative abundance, PROC CATMOD (SAS 1985b) was employed to test for significant differences between treatments, seasons, and treatment-season interaction. PROC CATMOD is a procedure employing chi-square statistics to analyze categorical data.

Reproductive information has been reported as count data since sample size was insufficient for statistical testing.

RESULTS AND DISCUSSION

VEGETATION

The frequency of the cover classes for grasses was significantly different between treatments in fall and spring, for forbs in summer, winter and spring, for litter in the spring, and for bare ground in fall and winter (Table 11). Grass and litter coverage was generally greater in SDG, forbs and bareground in CG. Nevertheless, the differences were often non-significant or showed no clear pattern between seasons.

Analysis of visual obstruction data (frequencies of cover-class groups) measuring vertical structure of vegetation yielded an array of chi-square values (Table 12). Aside from strata 1 (0-10 cm) and 2 (10-20 cm), the other 8 strata were significantly different between treatments in summer, with greater visual obstruction occurring in SDG. In fall, strata 1, 2, 3 (20-30 cm), 4 (30-40 cm) and 6 (50-60 cm) were significantly different between treatments with greater visual obstruction occurring in SDG. Strata 8 (70-80 cm) and 9 (80-90 cm) were significantly different in winter with greater visual obstruction occurring in CG. Strata 7 (60-70 cm), 8, 9 and 10 (90-100 cm) were significantly different in spring with greater visual obstruction occurring in SDG. Chi-square values for frequencies of cover-class groups of averages of strata 1 and 2, and strata 1, 2 and 3 were significantly different only in the fall, and revealed no difference in summer, winter and spring (Table 13). Overall, greater visual obstruction occurred in SDG than CG.

SMALL MAMMALS

A total of 9,600 trap nights resulted in 1211 unique captures that included 9 species of small mammals (Table 14). True's

Table 11: Averages and chi-square test of significance of frequencies of cover-class groups of percent ground cover between Short-duration (SDG) and Continuous (CG) grazing treatments within each season on the Encino study site in 1985-1986.

	JUN-AUG		SEP-NOV		DEC-FEB		MAR-MAY	
CATEGORY	SDG	CG	SDG	CG	SDG	CG	SDG	CG
Grass	17.2	13.3	26.4	14.4	19.4	17.2	31.5	11.1
Forb	11.7	15.7	18.8	17.9	2.2	4.4	6.5	21.8
Litter	13.8	3.2	14.4	15.9	33.2	35.9	31.1	27.1
Bareground	67.0	76.7	57.4	67.2	60.3	48.7	47.8	48.0

	JUN-AUG		SEP-NOV		DEC-FEB		MAR-MAY	
CATEGORY	CHI-SQ	P	CHI-SQ	P	CHI-SQ	P	CHI-SQ	P
Grass	2.49	.477	16.87	.001**	0.55	.909	30.39	.000**
Forb	10.33	.016*	2.34	.504	4.18	.041*	29.26	.000**
Litter	3.61	.165	0.14	.931	6.12	.295	10.94	.012*
Bareground	5.43	.366	17.61	.007**	13.84	.031*	8.33	.215

**$p \leq .01$
*$p \leq .05$

Table 12: Averages and chi-square test of significance of frequencies of cover-class groups of individual stratum of profile pole measuring visual obstruction of vegetation between Short-duration (SDG) and Continuous (CG) grazing treatments within each season on the Encino study site in 1985-1986. Measurements are from ground level up to 100cm in height.

		JUN-AUG		SEP-NOV		DEC-FEB		MAR-MAY	
STRATA	CM	SDG	CG	SDG	CG	SDG	CG	SDG	CG
One	0-10	89.6	93.9	89.9	70.8	59.5	53.5	55.9	56.4
Two	10-20	65.3	61.9	63.8	43.8	16.6	16.9	17.9	20.6
Three	20-30	51.5	42.3	53.9	31.3	7.1	9.4	13.5	9.2
Four	30-40	36.2	21.5	37.3	21.8	2.4	4.5	7.5	3.2
Five	40-50	27.9	12.0	33.5	19.5	0.8	2.3	7.6	1.2
Six	50-60	15.6	3.2	23.7	11.1	0.5	0.9	4.4	1.5
Seven	60-70	10.2	1.4	17.5	9.0	0.3	0.8	5.7	1.9
Eight	70-80	8.5	1.1	12.1	5.7	0.2	0.7	5.2	1.8
Nine	80-90	6.3	1.2	7.2	5.7	0.1	0.6	5.5	1.8
Ten	90-100	5.2	0.6	6.2	5.6	0.1	0.4	3.9	1.8

	JUN-AUG		SEP-NOV		DEC-FEB		MAR-MAY	
CM	CHI-SQ	P	CHI-SQ	P	CHI-SQ	P	CHI-SQ	P
0-10	0.342	.559	11.878	.003**	2.369	.306	1.118	.572
10-20	0.325	.850	6.984	.030*	0.835	.361	1.310	.520
20-30	8.644	.013*	13.514	.001**	0.600	.439	1.521	.468
30-40	4.887	.027*	7.869	.005**	0.223	.637	1.294	.255
40-50	4.089	.043*	0.834	.361	0.240	.624	1.745	.189
50-60	11.925	.001**	7.603	.006**	3.733	.053	3.358	.067
60-70	10.568	.001**	1.815	.178	2.833	.092	8.336	.004**
70-80	6.171	.013*	2.228	.136	4.728	.030*	10.909	.001**
80-90	7.064	.008**	0.563	.453	5.783	.016*	9.130	.003**
90-100	4.093	.043*	0.069	.793	2.004	.157	6.508	.011*

**$p \leq .01$
*$p \leq .05$

Table 13: Averages and chi-sqare test of significance of frequencies of cover-class groups of HT1(stratum 1; 0-10cm), HT2 (average of strata 1 and 2; 0-20cm) and HT3 (average of strata 1, 2 and 3; 0-30cm) of profile pole measuring visual obstruction of vegetation between Short-duration (SDG) and Continuous (CG) grazing treatments within each season on the Encino study site in 1985-1986.

	JUM-AUG		SEP-NOV		DEC-FEB		MAR-MAY	
HEIGHT	SDG	CG	SDG	CG	SDG	CG	SDG	CG
HT1	89.6	93.9	89.6	70.8	59.5	53.5	55.9	56.4
HT2	77.5	77.9	76.7	57.3	38.0	35.2	36.9	38.5
HT3	68.8	66.0	69.1	48.6	27.7	26.6	29.1	28.7

	HT1		HT2		HT3	
SEASONS	CHI-SQ	PROB	CHI-SQ	PROB	CHI-SQ	PROB
JUN-AUG	0.342	.559	0.739	.864	2.567	.463
SEP-NOV	11.878	.003**	11.958	.008**	11.326	.010**
DEC-FEB	2.369	.306	5.715	.126	0.070	.966
MAR-MAY	1.118	.572	0.144	.931	0.061	.970

**$p \leq .01$
*$p \leq .05$

Table 14: Total number (N) of rodents captured (unique) in 9,600 trap nights during 1985-1986 on the Encino study site.

SPECIES	N	% COMPOSITION
Dipodomys compactus	333	27.5
Perognathus flavus	203	16.8
Perognathus hispidus	180	14.9
Peromyscus leucopus	178	14.7
Onychomys leucogaster	113	9.3
Baiomys taylori	112	9.2
Sigmodon hispidus	53	4.4
Reithrodontomys fulvescens	36	3.0
Neotoma micropus	3	0.002
TOTAL	1211	

kangaroo rats (Dipodomys compactus) and silky pocket mice (Perognathus flavus) occurred most frequently in both grazing treatments. These were followed by hispid pocket mice (Perognathus hispidus), white-footed mice, northern grasshopper mice (Onychomys leucogaster), northern pygmy mice, hispid cotton rats, fulvous harvest mice, and southern plains woodrats (Neotoma micropus).

There was a significant difference in the numbers of each species captured between treatments and between seasons. Treatment by time (season) interaction was also highly significant (Table 15). Further analyses revealed significant differences between treatments within seasons as well as between seasons for most species captured (Appendix A).

Both treatments had the same number of species in terms of diversity. But, a majority of these species occurred in greater numbers in SDG than CG (Table 16). It was observed that capture frequency increased considerably from winter into spring. This increased frequency in small mammal captures could be attributed to 2 factors: 1) recruitment of new individuals, and 2) a shortage in naturally-occurring food items resulting in an increase in seasonal acceptance of bait. During winter and spring, a change in vegetation was also observed, a shrinkage in vertical profile of vegetation, as well as a decrease in forbs and a corresponding increase in litter. Furthermore, there was a

Table 15: Analysis of variance of PROC CATMOD[a] of rodents captured in Short-duration (SDG) and Continuous (CG) grazing TREATMENTS from June 1985 through May 1986 on the Encino study site. The monthly trapping data were grouped under 4 TIME (seasons) periods.

SOURCE	DF	CHI-SQUARE	PROBABILITY
TIME	3	290.11	.0001**
TREATMENT	1	97.71	.0001**
TIME x TREATMENT	3	21.71	.0001**

[a] PROC CATMOD is a procedure that involves analysis of variance of categorical data (ref: SAS 1985a)

**$p \leq .01$

Table 16: Total number of rodents captured in Short-duration (SDG) and Continuous (CG) grazing treatments during each season[a] on the Encino study site in 1985-1986.

	SEASONS							
	JUN-AUG		SEP-NOV		DEC-FEB		MAR-MAY	
SPECIES[b]	SDG	CG	SDG	CG	SDG	CG	SDG	CG
Dico	39	8	40	12	62	48	103	21
Pefl	29	19	31	14	15	33	10	52
Pehi	32	5	18	11	21	21	21	51
Pele	5	0	1	0	70	33	44	25
Onle	5	0	5	0	47	10	35	11
Bata	2	1	1	2	32	15	37	22
Sihi	1	0	4	0	29	0	10	9
Refu	0	0	0	0	11	19	6	0
Nemi	0	0	0	0	0	2	1	0
Total	113	33	100	39	287	181	267	191

[a] 1200 trap nights per treatment per season

[b] Dico: *Dipodomys compactus*; Pefl: *Perognathus flavus*; Pehi: *Perognathus hispidus*; Pele: *Peromyscus leucopus*; Onle: *Onychomys leucogaster*; Bata: *Baiomys taylori*; Sihi: *Sigmodon hispidus*; Refu: *Reithrodontomys fulvescens*; Nemi: *Neotoma micropus*

general decrease in availability of seeds and green foliage as well as insects during winter and early spring (personal observation) that was associated with increased rodent trapability.

There was a higher frequency of occurrence of True's kangaroo rats in SDG than CG. The edaphic (adequate sandy and bareground areas) and vegetative characteristics at the Encino study site were highly suitable for the burrowing, food, and locomotory habits of the True's kangaroo rat (Inglis 1959). Two factors could explain the wide differences in capture rates between SDG and CG: 1) grass cover, and 2) bareground. Continuous grazing by cattle reduces cover drastically and seed producing plants are therefore made unavailable to seed-eating small mammals (Gust and Schmidly 1986). Overall, SDG had more grass cover than CG and would therefore provide better foraging grounds for True's kangaroo rats. Differences in bareground between treatments did not reveal any consistent pattern and are not supportive of the dramatic differences in kangaroo rat capture rates between SDG and CG. The Encino study site was also suitable for the burrowing and food habits of the silky pocket mouse and the hispid pocket mouse (Chapman and Packard 1974, Kritzman 1974). Greater numbers of silky pocket mice occurred in CG, but frequency of occurrence of hispid pocket mouse was similar between grazing treatments. These 2 species of pocket mice may actually have been competing with each other because of similar food habits (Chapman and Packard 1974), but I have no data to support this.

White-footed mice were captured more frequently in SDG than in CG. White-footed mice were captured more frequently in traps located in or near oak mottes, by decaying tree stumps, and by small trees. White-footed mice live in a wide variety of habitat types and several authors have noted the occurrence of white-footed mice in wooded areas (Barry and Franq 1980, Kantak 1983, Kaufman et al. 1983). Clark et al. (1987) found white-footed mice actively used grassland habitats as part of their established home range in a study conducted in Kansas. White-footed mice are omnivorous in their diet (Briggs 1986). Since vegetation and soil types in the grazing treatments were similar in this study, the SDG treatment likely provided a better habitat than the CG treatment for the white-footed mouse.

Northern grasshopper mice were captured more frequently in SDG than CG and in greater numbers in winter and spring. Seasonal increases in captures might have been the result of an increase in the species' seasonal acceptance of bait, when insect foods were in short supply (Chapman and Packard 1974). No measurements were recorded for insect populations in the grazing systems, and thus I am unable to say to what extent SDG was better than CG or vice versa in terms of insect availability to meet the grasshoppper mouse's needs. Inglis (1959), in a study conducted in Texas, observed the occurrence of grasshopper mice in areas ranging from fair to poor range conditions.

Northern pygmy mice and hispid cotton rats were almost twice and 5 times as high, respectively, in SDG than CG pasture. These 2 species of rodents occurred more frequently in areas of abundant vegetative cover (Stoddard 1932, Phillips 1936, Baker 1940, Stickel and Stickel 1949). Cleveland (1978) described the best general habitat of the hispid cotton rat to be a well-drained area with abundant vegetative cover, and in the SDG treatment at the Encino study site, hispid cotton rats occurred in highest frequencies in gulf cordgrass areas. The diet of the hispid cotton rat is primarily monocotyledonous foliage (84%) (Gust and Schmidly 1986). With the overall grass cover being greater in SDG it would be reasonable to expect a greater frequency of occurrence of hispid cotton rats in the SDG treatment.

Fulvous harvest mice occurred in habitats similar to the habitat of the preceding 2 species, but the capture frequencies between treatments were similar. Joule and Cameron (1975) found fulvous harvest mice and hispid cotton rats to be the co-dominant species of the Texas Coastal Bend. Packard (1968) described the habitat of the fulvous harvest mouse in the south-central United States as fallow fields or ecotones between grasses and deciduous or coniferous forests. Davis (1960) noted an abundance of fulvous harvest mice in broomsedge-pine wood ecotones, in Walker County, in eastern Texas. Black and Frischnecht (1971), while studying 3 rodent species in relation to grazing, discovered that fulvous harvest mice were invariably trapped where vegetative cover was most dense. Many authors report that hispid cotton rats, fulvous harvest mice, and northern pygmy mice prefer areas with dense grass cover (Goertz 1964, Powell 1968). Southern plains woodrats were captured too infrequently to be included in the analysis.

The vertical component of vegetation could be a crucial factor in determining the highly significant difference in numbers of rodents in the 2 grazing treatments. SDG had more visual obstruction than CG (Table 13) for heights that could be crucial for survival of small mammals such as kangaroo rats and pocket mice from predation (Rosenzweig and Winakur 1969).

Data on reproductive activity of all species suggests almost year round activity (Table 17). Reproductive activity also appeared staggered between certain species. In some cases, scrotal males were abundant while fecund or lactating females were almost totally lacking. Scrotal males are not necessarily indicative of an active reproductive season (Chaney, A. J., personal communication). Kangaroo rats and the 2 species of pocket mice were the only 3 species of small mammals out of the 9

TABLE 17: Observed reproductive activity of rodents captured (unique) per 800 trap nights at the Encino study site from June 1985 through May 1986. Within each month the first row represents fecund and/or lactating females ()[a] and the second row represents males with scrotal testes ().

				SPECIES[b]				
MONTHS	DICO	PEFL	PEHI	PELE	ONLE	BATA	SIHI	REFU
Jun	11(16)	6(8)	8(11)	3(3)	0(0)	2(2)	0(0)	0(0)
	14(15)	5(8)	11(12)	2(2)	1(1)	0(0)	1(1)	0(0)
Jul	8(8)	5(13)	2(3)	0(0)	0(2)	0(0)	0(0)	0(0)
	5(5)	7(9)	4(5)	0(0)	1(1)	0(0)	0(0)	0(0)
Aug	0(1)	1(4)	2(4)	0(0)	0(0)	0(1)	0(0)	0(0)
	2(2)	3(6)	2(2)	0(0)	1(1)	0(0)	0(0)	0(0)
Sep	9(11)	1(10)	1(4)	1(1)	2(2)	0(1)	0(1)	0(0)
	17(18)	7(13)	1(5)	0(0)	0(0)	0(0)	1(1)	0(0)
Oct	5(5)	7(10)	2(7)	0(0)	0(0)	1(1)	1(1)	0(0)
	8(8)	3(5)	2(2)	0(0)	0(0)	1(1)	0(0)	0(0)
Nov	7(7)	3(3)	1(4)	0(0)	0(1)	0(0)	0(0)	0(0)
	2(3)	3(4)	5(7)	0(0)	1(2)	0(0)	1(1)	0(0)
Dec	7(8)	2(16)	1(6)	7(12)	1(6)	1(7)	1(9)	1(1)
	8(11)	2(13)	1(9)	2(11)	1(4)	0(7)	1(12)	1(3)
Jan	26(28)	2(5)	3(12)	15(18)	7(13)	3(9)	0(0)	2(2)
	3(18)	2(3)	6(8)	13(24)	8(17)	1(6)	2(3)	1(2)
Feb	5(24)	1(5)	0(2)	7(14)	3(10)	5(11)	0(1)	7(10)
	4(21)	3(6)	5(5)	4(24)	3(7)	1(7)	0(4)	8(12)
Mar	3(33)	0(10)	0(8)	16(18)	9(9)	15(16)	2(4)	2(2)
	7(35)	10(16)	29(30)	12(28)	14(14)	0(20)	2(10)	1(4)
Apr	0(14)	0(7)	1(6)	9(10)	4(8)	8(8)	0(3)	0(0)
	2(19)	16(21)	14(14)	1(11)	1(6)	0(6)	1(2)	0(0)
May	1(15)	1(4)	4(7)	1(1)	6(6)	3(4)	0(0)	0(0)
	5(7)	4(4)	2(4)	1(1)	3(3)	3(5)	0(0)	0(0)

[a] total captures

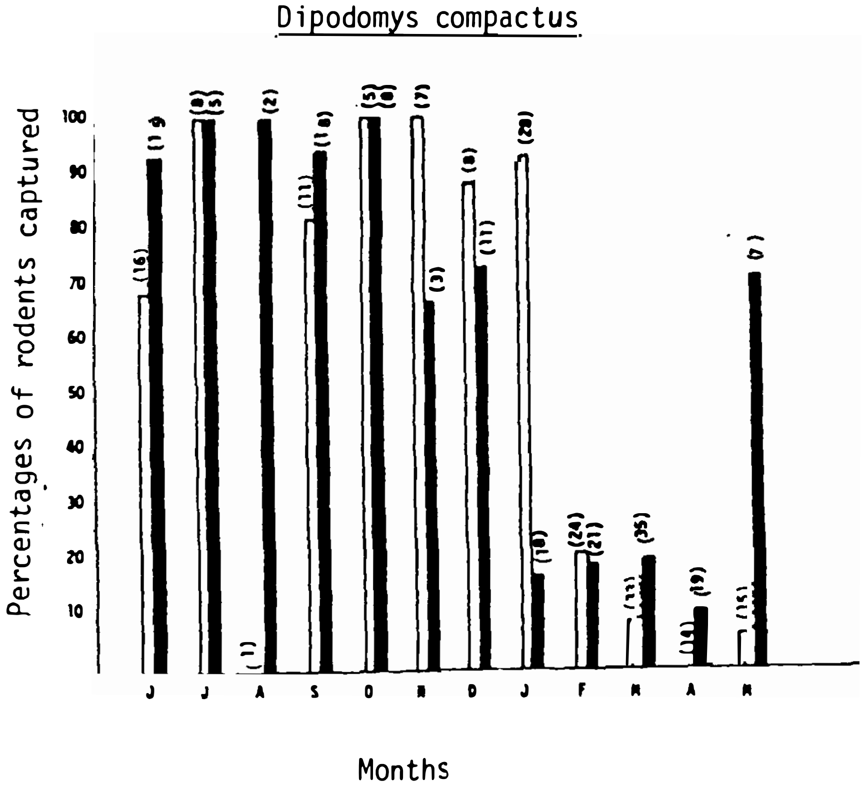
[b] BATA: *Baiomys taylori*; DICO: *Dipodomys compactus*; ONLE: *Onychomys leucogaster*; PEFL: *Perognathus flavus*; PEHI: *Perognathus hispidus*; PELE: *Peromyscus leucopus*; REFU: *Reithrodonomys fulvescens*; SIHI: *Sigmodon hispidus*

species (total) that were captured frequently enough during the study to evaluate a pattern in reproductive activity. Pregnant females peaked in June and January in kangaroo rats, June and October in silky pocket mice, and June in hispid pocket mice. Except in August 1985 and April 1986 pregnant female kangaroo rats were captured every month (Fig. 4). In a study conducted in Oklahoma adult male kangaroo rats were reproductively capable throughout the year (Hoditschek and Best 1983). Chapman and Packard (1974) have documented the breeding season for pocket mice in southeast Texas to last from April to November. Pregnant female pocket mice were captured almost all year round, with the exception of March and April for the silky pocket mouse, and February and March for the hispid pocket mouse.

CONCLUSIONS

The SDG treatment was established as recently as 1983 at the Encino study site. No vegetation and small mammal data were available prior to establishment of this grazing treatment on these study sites. There appeared to be more vegetative cover in SDG than CG. A significantly higher number of rodents was captured in the SDG than the CG treatment, but in order to assess the full impacts of the SDG treatment on small mammals, other wildlife and vegetation, longer term studies are essential.

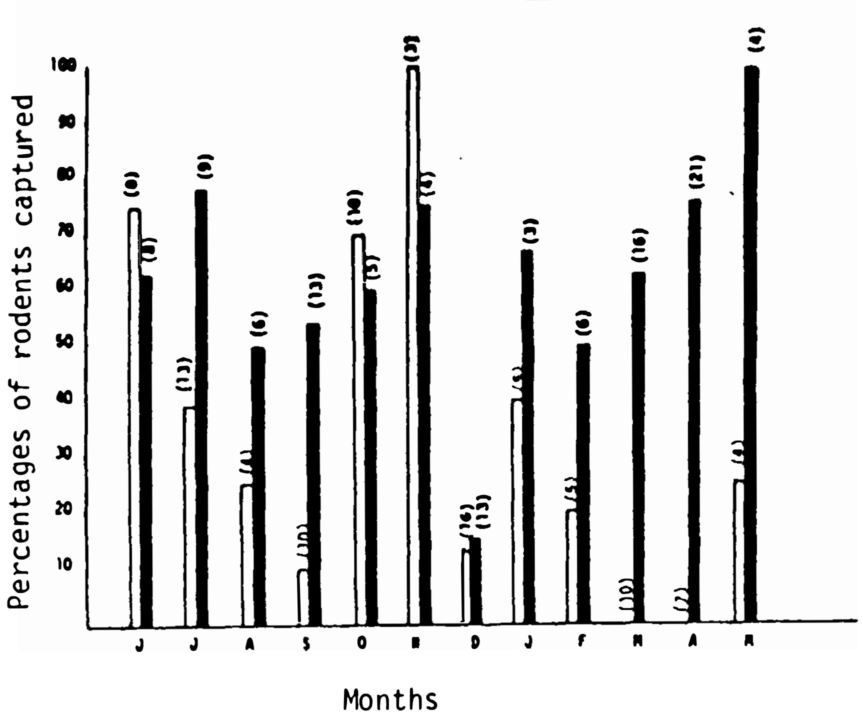
The SDG treatment did not negatively impact rodent numbers and appeared not to have a deleterious effect on vegetative



4(a)

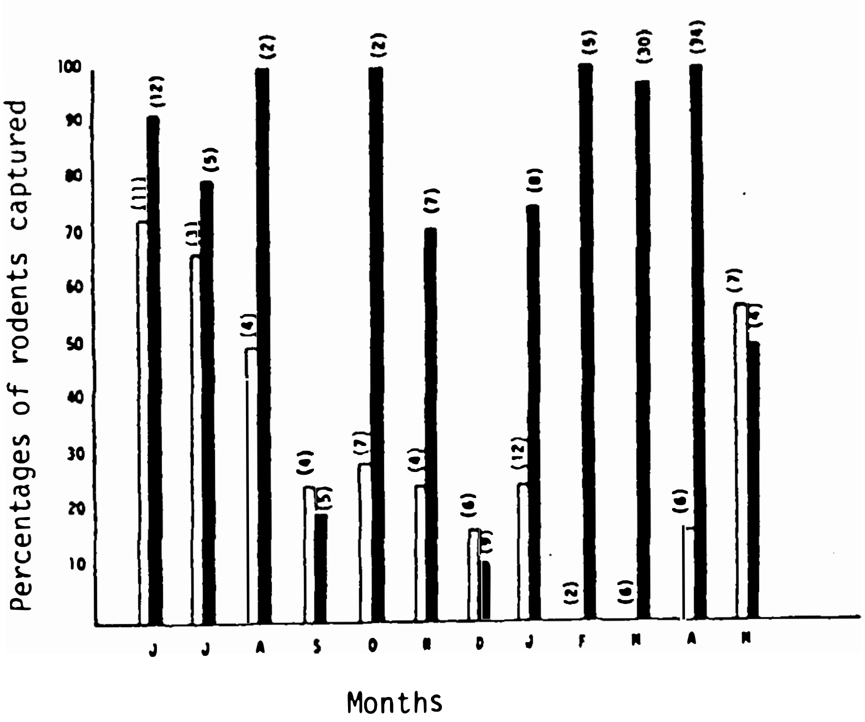
Fig. 4 (a), (b) and (c) (pg. 51). Reproductive activity (%) of 3 species of rodents captured between June 1985 and May 1986 at the Encino study site. Outlined bars are % females pregnant or lactating; solid bars are % males with scrotal testes. Total captures in parenthesis.

Perognathus flavus



4(b)

Perognathus hispidus



4(c)

ground cover. It would be worthwhile to pursue further research on the impact of the SDG system on wildlife species and establish a scientific basis to this grazing system. If SDG impacts rodents positively, an increased rodent population may be an important buffer to predation on managed species such as northern bobwhites and other upland game.

The results from this study are highly site specific (Hurlbert 1980), and extrapolation to other areas might be quite meaningless.

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APPENDIX A

Appendix A1: Analysis of variance of rodent captures by species using Procedure CATMOD (ref:SAS 1985b).

SPECIES	SOURCE	DF	CHI-SQUARE	PROB
Dipodomys compactus	Sum vs Fall	1	0.72	.3973
	Wint vs Spr	1	0.95	.3307
	Sum & Fall vs Wint & Spr	1	57.28	.0001**
	Trt 1 vs Trt 2 in Sum	1	16.66	.0001**
	Trt 1 vs Trt 2 in Fall	1	13.38	.0003**
	Trt 1 vs Trt 2 in Wint	1	1.77	.1831
	Likelihood Ratio	1	59.09	.0001**
Onychomys leucogaster	Sum vs Fall	1	0.00	1.0000
	Wint vs Spr	1	0.17	.6843
	Sum & Fall vs Wint & Spr	1	38.70	.0001**
	Trt 1 vs Trt 2 in Wint	1	19.75	.0001**
	Trt 1 vs Trt 2 in Spr	1	11.22	.0008**
	Likelihood Ratio	2	13.86	.0010**
Baiomy taylori	Sum vs Fall	1	0.00	.9442
	Wint vs Spr	1	1.64	.2007
	Sum & Fall vs Wint & Spr	1	43.05	.0001**
	Trt 1 vs Trt 2 in Fall	1	0.32	.5714
	Trt 1 vs Trt 2 in Wint	1	5.86	.0155*
	Trt 1 vs Trt 2 in Spr	1	3.34	.0535
	Likelihood Ratio	1	0.34	.5599
Peromyscus leucopus	Sum vs Fall	1	2.16	.1418
	Wint vs Spr	1	5.13	.0235*
	Sum & Fall vs Wint & Spr	1	41.68	.0001**
	Trt 1 vs Trt 2 in Wint	1	12.68	.0004**
	Trt 1 vs Trt 2 in Spr	1	5.09	.0240*
	Likelihood Ratio	2	8.32	.0156*
Perognathus flavus	Sum vs Wint	1	0.06	.8027
	Sum & Wint vs Fall	1	0.23	.6324
	Sum & Fall & Wint vs Spr	1	4.67	.0306*
	Trt 1 vs Trt 2 in Sum	1	2.05	.1520
	Trt 1 vs Trt 2 in Fall	1	6.09	.0136*
	Trt 1 vs Trt 2 in Wint	1	6.41	.0113*
	Likelihood Ratio	1	31.17	.0001**

(contd.)

Perognathus hispidus	Sum vs Wint	1	0.32	.5740
	Sum & Wint vs Fall	1	2.30	.1292
	Sum & Fall & Wint vs Spr	1	14.46	.0001**
	Trt 1 vs Trt 2 in Fall	1	1.66	.1981
	Trt 1 vs Trt 2 in Wint	1	0.00	1.0000
	Trt 1 vs Trt 2 in Spr	1	11.71	.0006**
	Likelihood Ratio	1	21.99	.0001**
Reithrodontomys fulvescens	Wint vs Spr	1	12.21	.0005**
	Trt 1 vs Trt 2 in Wint	1	2.08	.1491
	Likelihood Ratio	1	8.32	.0039**
Sigmodon hispidus	Wint vs Spr	1	2.06	.1509
	Trt 1 vs Trt 2 in Spr	1	0.09	.8186
	Likelihood Ratio	1	40.20	.0001**
Total	Sum vs Fall	1	0.03	.8698
	Wint vs Spr	1	0.02	.8905
	Sum & Fall vs Wint & Spr	1	291.98	.0001**
	Trt 1 vs Trt 2 in Sum	1	38.70	.0001**
	Trt 1 vs Trt 2 in Fall	1	24.88	.0001**
	Trt 1 vs Trt 2 in Wint	1	23.59	.0001**
	Trt 1 vs Trt 2 in Spr	1	12.49	.0001**

**p≤.01
*p≤.05

APPENDIX B

BARN OWL PELLET ANALYSIS

Barn Owl pellets were collected in July 1986, from 7 nest boxes, installed for use by black-bellied whistling ducks (*Dendrocygna autumnalis*). Mammal and bird skulls were separated from these pellets and grouped by individual nest boxes. Small mammal skulls occurred most frequently (56.8%) in owl pellets followed by bird skulls (32.3%), and then shrews (10.9%) (Table 19).

Barn owls are opportunistic in their dietary habits, but where rodent numbers have been high, barn owls occurring in such regions have been documented to include mostly rodents in their diet (Bunn et al. 1982, Burton 1973, Marti 1974). Birds constitute a low percentage, less than 5% annually, of the barn owl's diet (Burton 1973). Fritzell and Thorne (1984) described one instance of a barn owl feeding almost exclusively on birds; 98% of the pellets contained avian material and only 10% of the pellets contained mammalian fragments. Barn owls consume a variety of prey including insects, frogs, lizards and other creatures (Burton 1973), but are primarily a rodent-eating species. Owl number (4) (Table 19) had consumed 5 male and 5 female Great-tailed grackles (*Quiscalus mexicanus*) (USFWS band returns).

If, theoretically, there was a slump in the rodent populations on the Welder Refuge, the relatively higher presence

Appendix B1: Count (N) and percentage breakdown of skulls retrieved from pellets of barn owls nesting in nest boxes on the Welder Refuge in 1986.

OWL	RODENTS		SHREWS		BIRDS		TOTAL (N)
	N	%	N	%	N	%	
1.	37	30.1%	46	37.4%	40	32.5%	123
2.	114	64.4%	9	5.1%	54	30.5%	177
3.	90	55.2%	10	6.1%	63	38.7%	163
4.	133	53.8%	16	6.5%	98	39.7%	247
5.	89	89%	5	5%	6	6%	100
6.	7	41.2%	4	23.5%	6	35.3%	17
TOTAL	470	56.8%	90	10.9%	267	32.3%	827

of small mammal skulls compared to avian skulls occurring in the pellets that I examined could be explained. Barn owls have been documented to hunt as far as 2 miles from their nest site, and daytime roost sites have been up to 5 miles from the nest (ICI Americas Inc. Science Series). Barn owls at the Welder Refuge could have procured their small mammals from adjacent areas. It would be worth the effort and time to continue to monitor nest boxes used by barn owls at the Welder Refuge. Analysis of barn owl pellets would be a good index of prey items of barn owls as well as an index of small mammal populations or their lack thereof.