EFFECTS OF LIVESTOCK GRAZING ON A COMMUNITY OF SPECIES AT RISK OF EXTINCTION IN THE SAN JOAQUIN VALLEY, CALIFORNIA

Annual Report[1]

19 December 2003

Summary

This report contains a summary of results from the seventh year of plant and animal censuses on the Lokern Natural Area study site. In 2003, we again had below average rainfall, the fourth year in a row of dry conditions. Summer vegetation structure and biomass (residual dry matter) were low and virtually the same in control and treatment plots. Because there was little new grass growth this year, cattle again were not placed on the study site in 2003. Plant studies continue with no significant effect of treatment visible yet. The total number of nocturnal rodents caught was about the same as in the past 2 years, but more were caught on control than treatment plots. Short-nosed kangaroo rats decreased in abundance overall, but increased on control plots. Heermann's kangaroo rat numbers decreased on both control and treatment plots. San Joaquin pocket mice increased on all plots compared to last year. Although only 7 giant kangaroo rats were caught in 2003, this is the most captured since the study began. San Joaquin antelope squirrel numbers continued to increase and like last year, they were caught in greater numbers on control plots. In 2003 the number of sage sparrows declined on control plots but a few individuals were seen on treatment plots for the first time since 1999. Western meadowlarks were not found in 2003, but numbers of horned larks increased on both control and treatment plots. Side-blotched lizards and western whiptails continue to be found throughout the study area abundantly with little difference between treatment and control plots. Blunt-nosed leopard lizards also have become relatively abundant and were found in 3 of 4 sections, and virtually all were from treatment areas. Numbers of grasshoppers were much greater than last year, but ground invertebrates captured in pitfall traps remained low. In 2003 we continued radio-tagging studies of blunt-nosed leopard lizards. Because of insignificant differences in vegetation between control and treatment plots, San Joaquin antelope squirrels were not radio-tracked this year.

We will continue to gather information on the year-to-year variation in rainfall, plot condition, and relative abundance of plants and animals. We will also continue the radio tagging studies next year. Numbers of most of the focus species are at relatively high levels now and we just need several years of adequate rainfall to return the control plots to a grassy state. We can only hope that this unusually long stretch of dry years is broken this coming rain year. As we have indicated in the past, the success of this study

[1]Authors of this unpublished report are: Germano, D. J., G. B. Rathbun, E. Cypher, L. R. Saslaw, and S. Fitton.

depends on time, patience, and resources. The continuation of the field research on the Lokern requires about $72,000 per year, and this does not include the considerable in-kind support from cooperating agencies and organizations. We hope that all our cooperators and supporters will continue their devotion to the research.

Background

In 1995, the Bureau of Land Management (BLM) approached the US Geological Survey (then the National Biological Service) for assistance in developing a research project to help determine how livestock grazing on arid public lands in the southwestern San Joaquin Valley might be impacting several plant and vertebrate species that were listed by state and federal agencies as threatened or endangered. The Western Ecological Research Center (WERC) of the Biological Resources Division developed a research proposal to carry out the research in cooperation with several other agencies and organizations interested in the topic (see Cooperators Section below).

In 1997, a study site on the Lokern Natural Area in western Kern County was chosen and prepared for the research. This included fencing eight plots (Figure 1): four controls (each 62 acres or 29 hectares) each nested within four treatment pastures (one Section each or 640 acres or 259 hectares). Water was piped into each treatment plot for the cattle.

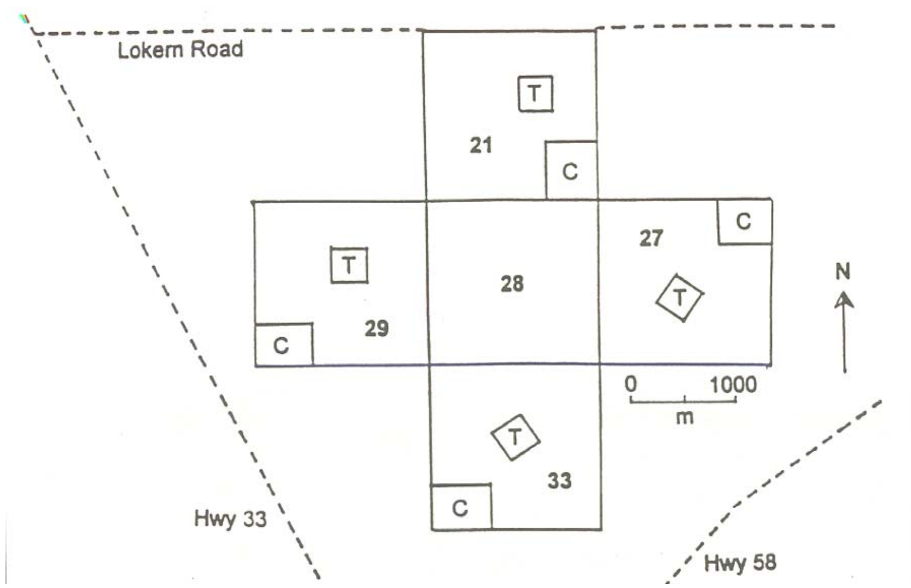


Figure 1. Lokern Study Area showing design of experimental and control plots.

Midway through the construction of cattle fencing in May 1997, an accidental wildfire burned through half of the study area. In order to reduce the confounding effect of this fire on the study design, the other half of the study area was intentionally burned in July

1997. Initial, baseline plant sampling was completed on the four treatment and four control plots before the burns in 1997, while baseline vertebrate sampling was completed on the eight plots after the burns in July and August 1997. A summary of these results, along with a copy of the research study plan, was included in the Annual Report for 1997 (we are in the process of constructing a new web page where reports will be available - in the meantime, please see http://www.werc.usgs.gov/sandiego/lokern/lokern.htm for past reports). Cattle were turned out onto the newly fenced treatment plots for the first time in February 1998. The yearly plot, vegetation, and animal sampling schemes were completed as planned in 1998, and the cattle were removed in July 1998, just prior to mammal trapping. In 1999, 2000, and 2001, a similar schedule was followed, although with progressively lower grazing intensity as conditions dried each successive year. No cattle were on the site in 2002 or 2003 as rainfall was well below average and minimum forage was not available.

Results

Rainfall

We maintain two rain gauges on the study site and recorded only 109.1 mm (4.30 inches) and 117.9 mm (4.64 inches) total rainfall for the 2002/2003 rainfall year (until 30 June 2003). Rainfall at the Buena Vista Water District in Buttonwillow in 2002/2003 was 144.8 mm (5.70 inches). The Lokern area has now experienced 4 straight dry years (Fig. 2). This follows 7 years of near average or wet weather (and 2 dry). As a measure of how unusual it is to have this many consecutive dry years, we examined rainfall data for the past 113 years in Bakersfield (65 km east of the study area). Only 32 years were dry (20 % below long-term mean) and 4 straight dry years happened only once (1953-1957). Five straight dry years never occurred.

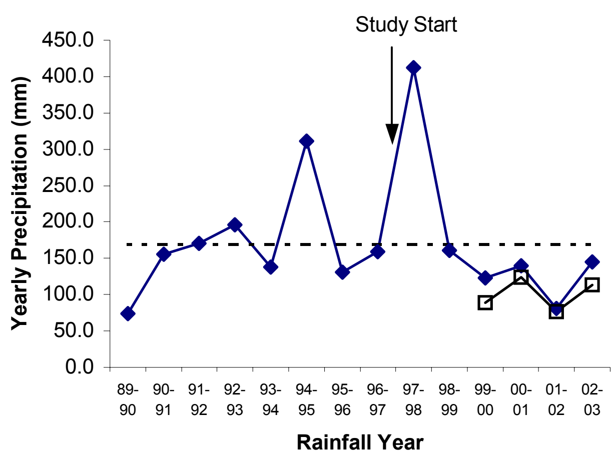


Figure 2. Rainfall in the Lokern area since 1989. Data from 1989-2003 from the Buena Vista Water District in Buttonwillow, California. The dotted line is the 20-yr mean of 169 mm. Average precipitation from rain gauges on the study site (squares) shown for the last 4 years.

Grazing Effects on Plots

No cattle were on the plots in 2003 and, because of low rainfall, have not been on the treatment plots since mid-2001 (and then only ≤ 1 month on each plot in 2001). Control and treatment plots are now virtually the same for measures of summer herbaceous vegetation, but there were significant differences among plots (Table 1). For residual dry matter (RDM), significant differences among plots (ANOVA: $F_{7, 232} = 6.29$, $P < 0.001$) were due to 29C having greater RDM than any of the other plots. For height of herbaceous plants, differences were due to short vegetation on 29T and tall vegetation on 29C (ANOVA: $F_{7, 232} = 13.30$, $P < 0.001$). There were significant differences among plots for summer cover (ANOVA: $F_{7, 232} = 17.61$, $P < 0.001$), and all of the controls had more summer cover than the treatments (Table 1). All measures of herbaceous plant growth were lower than in past years. This is especially true of RDM, which is now less than 300 lbs/acre on all but plot 29C (Fig. 3).

Table 1. Cattle stocking rates and vegetation characteristics of study plots in 2003. Average cover determined by percentage cover classes (100%, 95%, 75%, 50%, 25%, 0%).

		Vegetation		
Plots	Stocking Rates (AUM*)	RDM (lbs/acre)	Average Height (cm)	Average Cover (%)
21C	0	184	8.2	42.3
21T	0	194	7.2	16.3
27C	0	234	8.8	26.9
27T	0	262	6.7	7.9
29C	0	748	16.7	47.0
29T	0	159	7.3	8.4
33C	0	271	11.5	50.8
33T	0	48	4.8	6.1

* 1 AUM = one cow weighing 1000 lbs for one month. Stocking rate is for the entire 2003 grazing season. Cow/calf pairs used equaled 1 AUM.

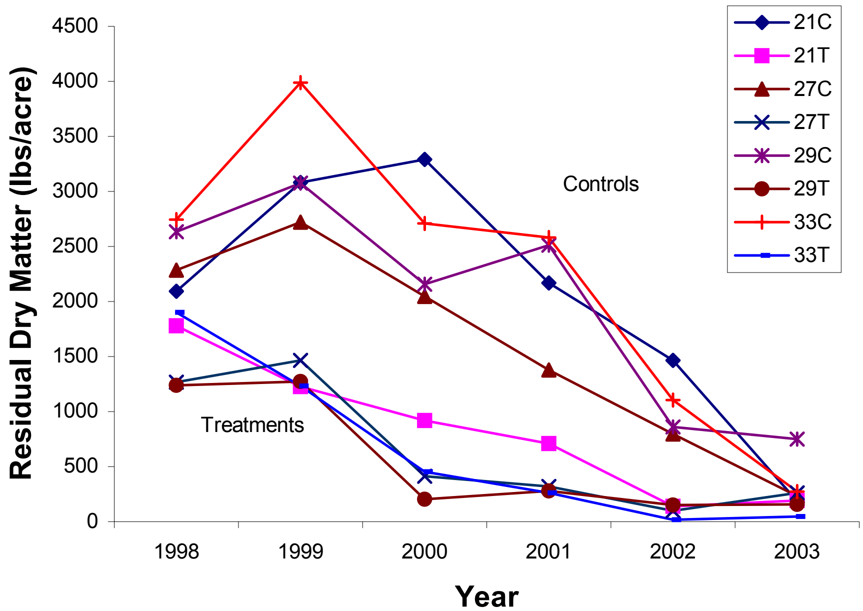


Figure 3. Estimates of residual dry matter (RDM) on the Lokern Study plots 1998 – 2003.

Vegetation Surveys

Data on Kern mallow (*Eremalche parryi* ssp. *kernensis*) were collected in March, April, and May 2003. The data reported for Kern mallow are those collected 14 - 15 May 2003 because the plants had reached their largest size by that time. Sampling of associated vegetation was conducted 24 – 29 March 2003. Reproductive density (the total number of buds, flowers, and fruits per meter^2) and fecundity (number of flowers per plant) of Kern mallow were recorded on all 80 permanent sampling belts (20 m long). Belt width was expanded to 1 m because of the low density of plants this year. Cover and composition of vegetation were determined on all 32 permanent transects. Data were pooled for each study plot.

The reproductive density and fecundity of Kern mallow (Table 2) were much higher than those observed in 2002, when Kern mallow was essentially absent from the study area. Overall, reproductive density and fecundity in 2003 were the highest observed since 1998, although the pattern was not consistent among individual study plots. The extended rainfall period in 2003 allowed Kern mallow plants to continue their growth and reproduction into May and caused a second flush of germination in April. Despite the favorable growing conditions, Kern mallow was still absent from Sections 27 and 33.

Herbaceous cover (Table 3) was much higher than it had been in 2002 due to the higher rainfall during the growing season of 2003, although it was still low compared to previous years of the study. The number of species encountered on each belt transect also was much higher than last year but was comparable to 2001. The non-native forb red-stemmed filaree (*Erodium cicutarium*) was dominant throughout the study area (Table 4), followed by the non-native grass red brome (*Bromus madritensis* ssp. *rubens*). These two species have been dominant or co-dominant species on all plots during the course of the study. Several native forbs constituted measurable cover in 2003, particularly valley popcorn flower (*Plagiobothrys canescens*) and shining peppergrass (*Lepidium nitidum*), which were found in both grazed and ungrazed plots. Shrub cover, which was virtually eliminated by the 1997 fire, continued to increase slightly in 2003 (Table 3). Spiny saltbush (*Atriplex spinifera*) was the only shrub with measurable cover, although a few individuals of common saltbush (*Atriplex polycarpa*) and bladderpod (*Isomeris arbore*a) also were observed in the study area.

Table 2. Mean reproductive density and fecundity (standard deviation) of Kern mallow (*Eremalche parryi* ssp. *kernensis*) on Lokern study plots, May 2003.

Study Plot/Treatment	Reproductive Density (Number of flowers/m^2)	Fecundity (Number of flowers per plant)
21C	3.6 (5.0) (n = 10)	22.3 (8.7) (n = 6)
21T	0.04 (0.1) (n = 10)	8.0 (N/A) (n =1)
27C	0 (n = 10)	N/A
27T	0 (n = 10)	N/A
29C	0 (n = 10)	N/A
29T	8.8 (19.1) (n = 10)	42.9 (11.2) (n = 4)
33C	0 (n = 10)	N/A
33T	0 (n = 10)	N/A
Overall	1.6 (7.3) (n = 80)	28.5 (15.0) (n = 11)

Table 3. Mean vegetation characteristics (standard deviation) over four transects on each Lokern study plot, spring 2003.

Study Plot/ Treatment	Herbaceous cover (%)	Number of species on belt	Shrub cover (%)
21C	35.8 (6.6)	12.8 (1.5)	2.0 (1.4)
21T	29.3 (3.9)	12.3 (2.2)	0
27C	41.8 (4.9)	14.5 (1.9)	0
27T	7.3 (5.2)	10.3 (4.2)	0
29C	24.5 (20.6)	10.8 (1.0)	3.5 (3.3)
29T	19.3 (2.1)	11.3 (2.4)	1.3 (1.3)
33C	38.0 (8.3)	8.0 (2.2)	0
33T	5.0 (3.7)	5.0 (0)	0
Overall	25.1 (15.2)	10.6 (3.4)	0.8 (1.7)

Table 4. Mean absolute percent cover of dominant species (standard deviation) over four transects on each Lokern study plot, spring 2003.

Study Plot/Treatment	*Bromus madritensis* ssp. *rubens*	***Erodium cicutarium***
21C	15.0 (1.4)	22.5 (6.5)
21T	4.3 (1.7)	21.8 (7.6)
27C	13.3 (2.2)	26.0 (2.4)
27T	1.0 (1.4)	3.0 (1.4)
29C	11.5 (7.0)	15.3 (15.1)
29T	2.3 (2.2)	15.0 (5.0)
33C	13.5 (7.6)	27.0 (7.5)
33T	0.3 (0.5)	4.8 (3.4)
Overall	7.6 (6.9)	16.9 (10.8)

Herbaceous plant cover in the study area was relatively high for the first five years of the study, even in grazed plots (Fig. 4). However, herbaceous cover dropped to very low levels in 2002 after several consecutive dry years, even though cattle were not present in the study area that year. Herbaceous cover rebounded somewhat in 2003 due to increased rainfall, but cover remained low enough that grazing was not necessary to control non-native grasses.

Throughout the study period, Kern mallow abundance has varied directly with rainfall (Fig. 5). Fecundity of Kern mallow was higher in 2003 than all other years of the study except 1998. Even though total rainfall during the 2003 growing season was comparable to that observed in the 2000 through 2001 growing seasons, the timing of rainfall differed. In 2003, rains continued through April, promoting the continued growth and reproduction of Kern mallow into May. In most previous years of the study, Kern mallow plants have senesced in early April because little rain fell after March. Despite its relatively high fecundity, the reproductive density of Kern mallow remained low in 2003 (Fig. 5) because few plants survived through the drier winter months. Although a second flush of germination occurred after the April rains, those plants produced few flowers before dessicating.

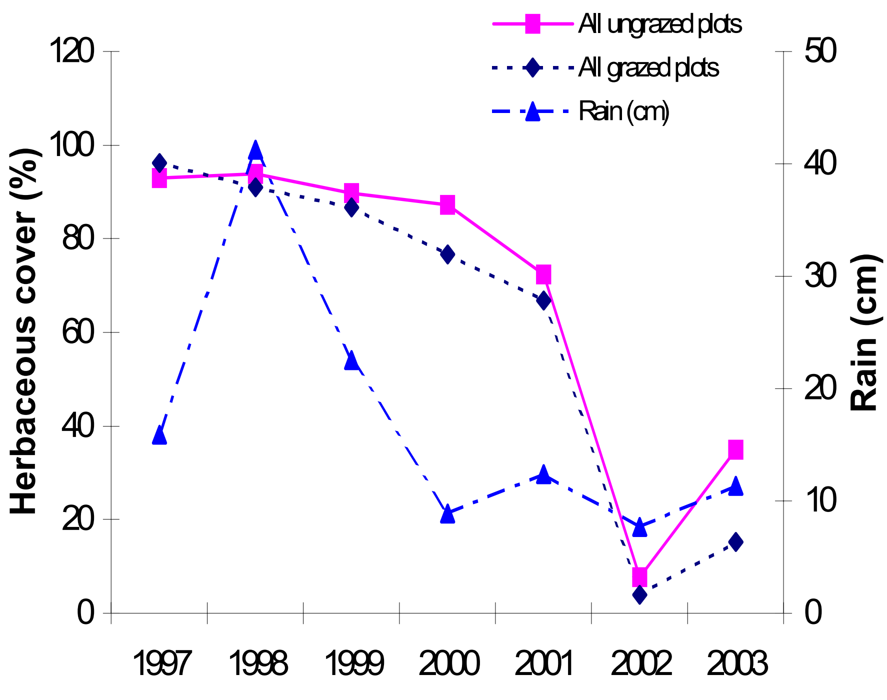
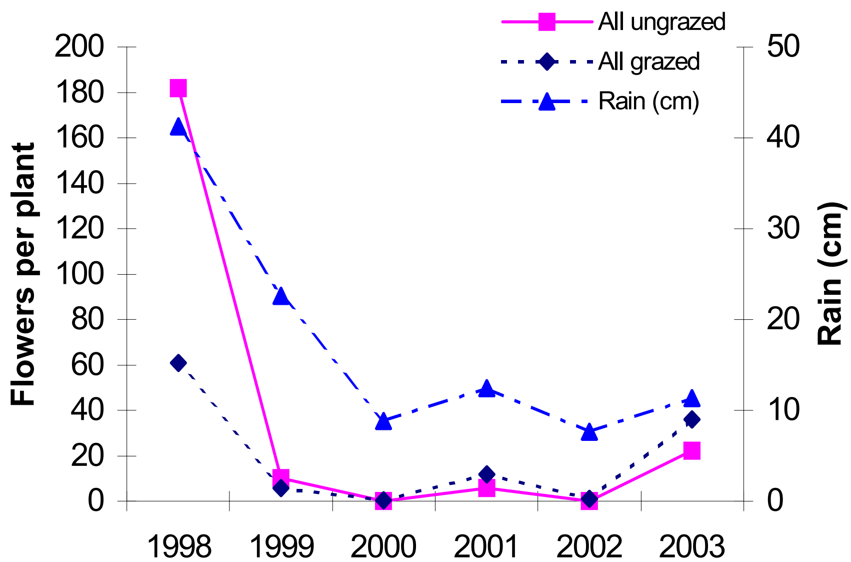


Figure 4. Herbaceous cover on vegetation transects in the Lokern study area.



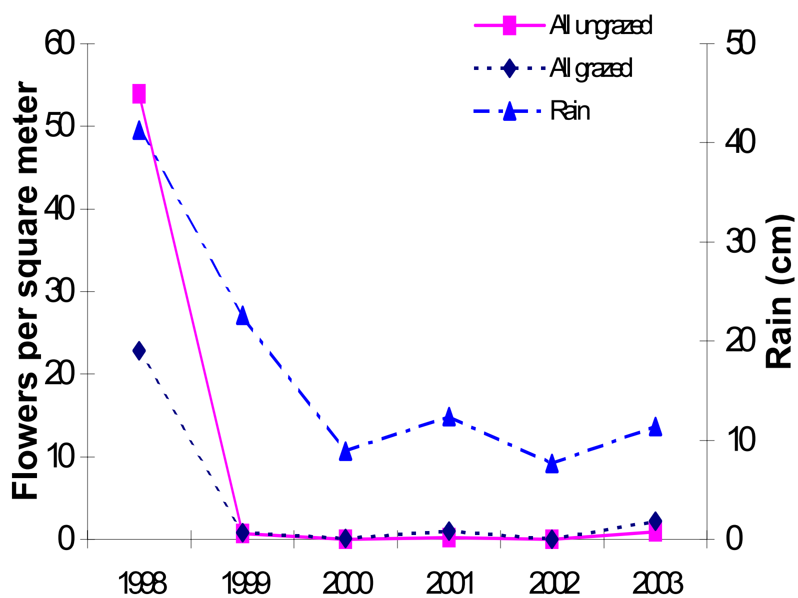


Figure 5. Abundance of Kern mallow at the Lokern study area each year based on fecundity (top) and reproductive density (bottom). Grazing had not yet begun at the time of data collection in 1998.

Mammal Surveys

The total number of individual nocturnal small mammals captured this year continued the increasing yearly trend (Table 5), as did San Joaquin antelope squirrels (*Ammospermophilus nelsoni*) (Table 6). Short-nosed kangaroo rats (*Dipodomys nitratoides brevinasus*) and Heermann's kangaroo rats (*Dipodomys heermanni*) contributed greatly to the total numbers of nocturnal mammals captured (Table 6), as in past years. However, if it were not for the large jump in captures of San Joaquin pocket mice (*Perognathus inornatus*), from 17 last year to 65 individuals this year (Table 7), the increasing overall trend would not be as strong. We suspect that the below average rainfall over the last four years (Fig. 2) may be starting to reduce the food supply (Fig. 3), which in turn may be causing the declining numbers of the larger Heermann's kangaroo rat; from 97 last year to 34 this year (Fig. 8). Yearly captures of giant kangaroo rats (*Dipodomys ingens*) have varied from none to a high this year of seven (Table 7). The other small mammals have always been captured in small numbers sporadically across years. This year, however, we captured a California pocket mouse (*Chaetodipus californicus*) for the first time on the study area (Table 7).

Variability in captured small mammals between plots continued to be high (Tables 6 & 7), but a trend may be developing with total numbers captured on control plots (pooled) becoming greater than on the pooled treatment plots (Fig. 6). This trend is especially evident with the antelope squirrels (Fig. 7) and short-nosed kangaroo rats (Fig. 9). We believe this shift reflects the similarity in the vegetation structure between all plots after four years of below average rainfall and low plant productivity, which has resulted in no cattle grazing on any of the treatments for the last two years.

Table 5. Total individual nocturnal small mammals captured on the control (C) and treatment (T) plots by year.

	1997	1998	1999	2000	2001	2002	2003
21C	0	12	10	4	33	34	58
21T	0	3	22	3	22	51	46
27C	1	20	111	65	87	80	105
27T	2	3	78	51	61	76	48
29C	0	1	0	12	51	68	65
29T	0	1	38	20	62	57	84
33C	0	2	4	0	38	53	67
33T	0	1	8	26	83	69	41
Total	3	43	271	181	437	437	514

Table 6. Total individual San Joaquin Antelope Squirrels captured on the control (C) and treatment (T) plots by year.

	1997	1998	1999	2000	2001	2002	2003
21C	4	5	2	1	4	10	14
21T	9	2	5	4	5	7	12
27C	3	8	2	5	13	21	21
27T	4	2	15	17	38	31	20
29C	5	0	0	1	9	20	41
29T	1	2	6	0	10	10	27
33C	6	5	7	9	26	16	26
33T	5	9	23	19	20	12	17
Total	37	33	60	55	125	127	178

Table 7. Total nocturnal mammal species* captured on the control (C) and treatment (T) plots in 2003. All numbers are of individuals captured.

	DH	DN	DI	PI	CC	PM	OT	RM	MM	Total
21C	1	41	2	13	0	0	1	0	0	58
21T	0	33	2	10	0	0	1	0	0	46
27C	0	87	0	17	0	0	1	0	0	105
27T	0	36	0	11	1	0	0	0	0	48
29C	28	37	0	0	0	0	0	0	0	65
29T	4	76	0	4	0	0	0	0	0	84
33C	1	64	0	0	0	0	2	0	0	67
33T	0	28	3	10	0	0	0	0	0	41
Total	34	402	7	65	1	0	5	0	0	514

*DH = *Dipodomys heermanni*, Heermann's Kangaroo Rat
DN = *Dipodomys nitratoides*, San Juaquin Kangroo Rat
DI = *Dipodomys ingens*, Giant Kangaroo Rat
PI = *Perognathus inornatus*, San Joaquin Pocket Mouse
CC = *Chaetodipus californicus*, California Pocket Mouse
PM = *Peromyscus maniculatus*, Deer Mouse
OT = *Onychomys torridus*, Souther Grasshopper Mouse
RM = *Reithrodontomys megalotus*, Western Harvest Mouse
MM = *Mus musculus*, House Mouse

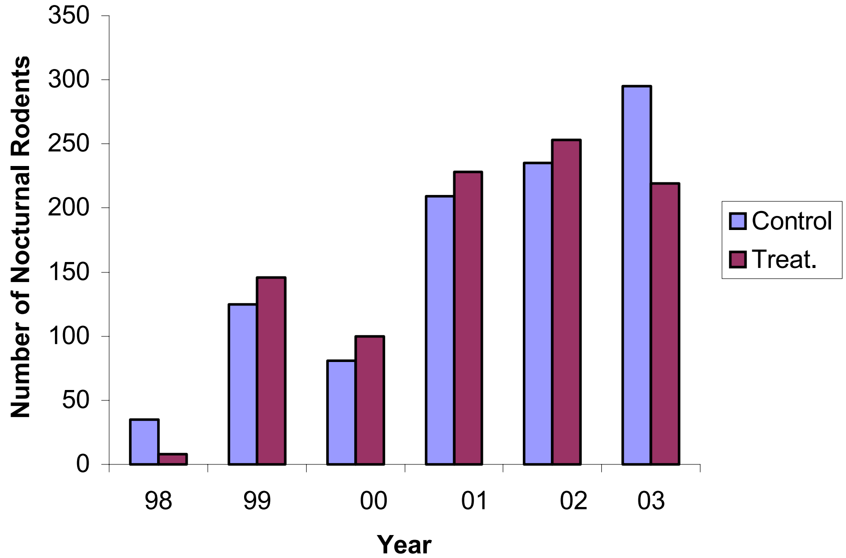


Fig. 6. Total number of individual nocturnal rodents captured on the control and treatment plots on the Lokern study site from 1998 through 2003 (only 3 rodent were captured in 1997 – see Table 5).

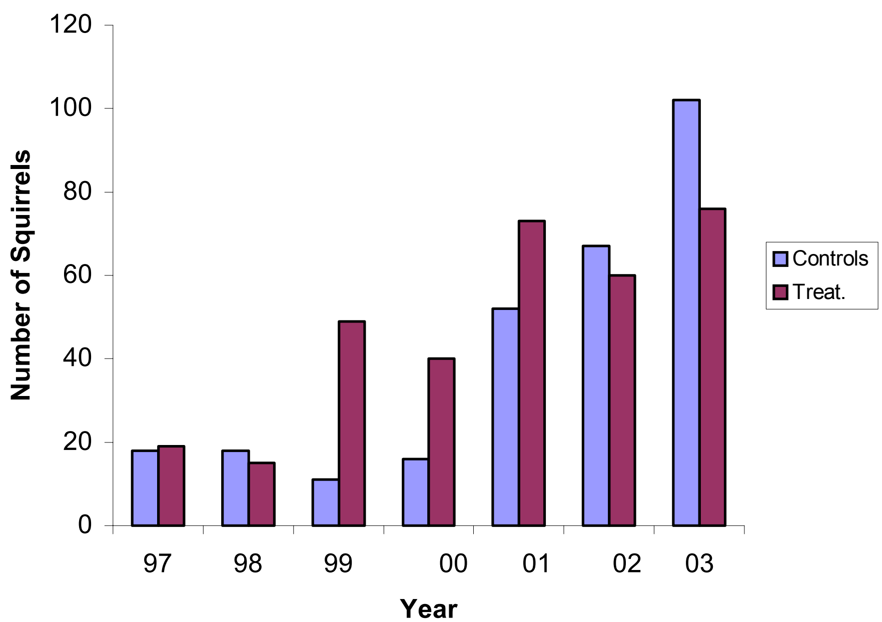


Fig. 7. Total number of individual San Joaquin antelope squirrels captured on the control and treatment plots on the Lokern study site from 1997 through 2003.

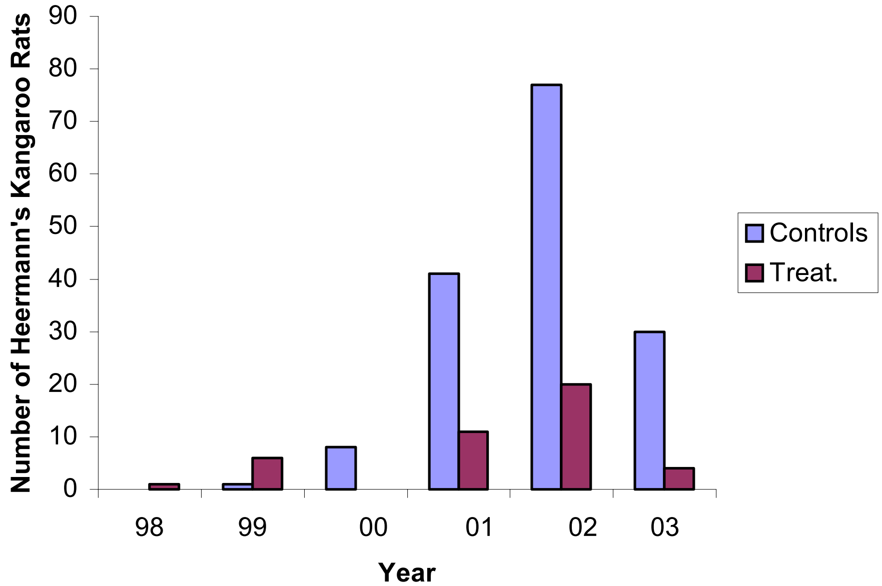


Fig. 8. Total number of individual Heermann's kangaroo rats captured on the control and treatment plots on the Lokern study site during 1998 through 2003.

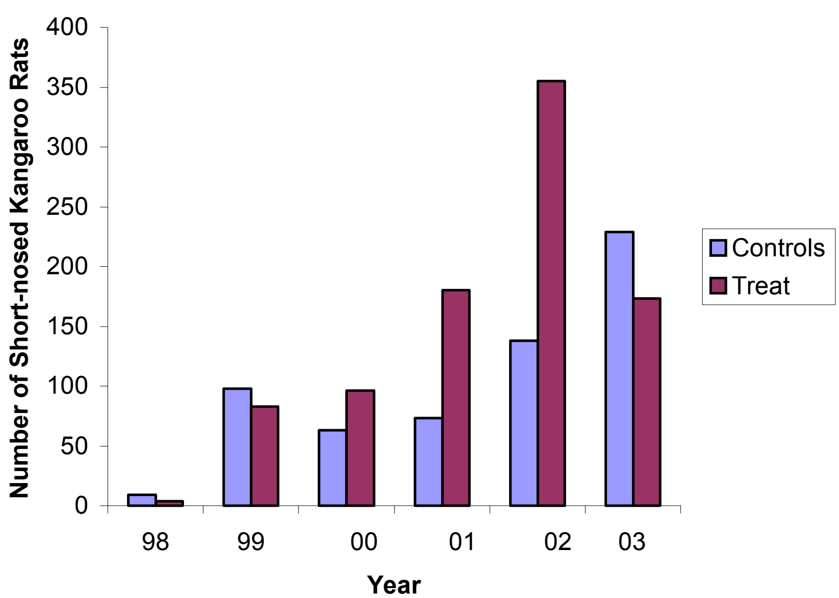


Fig. 9. Total number of individual Short-nosed kangaroo rats captured on the control and treatment plots on the Lokern study site from 1998 through 2003.

Bird Surveys

Six species of birds were detected within the 100m radius point counts in 2003 (Table 8). Sage sparrows have nearly disappeared from the study area, especially from the grazed plots because the 1997 fire largely destroyed their preferred habitat, an abundance of mature saltbush shrubs. Sage sparrow numbers were lower in 2003 than last year in control plots, but were found in grazed plots for the first time since 1999 (Fig. 10), where they are associated with drainages. Horned larks were generally more numerous on grazed plots than the control plots, but we found them within two of the control plots for the first time since 2000. The average number of horned larks in control plots was the highest since the study began in 1997 while the number in treatment plots was the second highest (Fig. 10). Western meadowlarks were not detected in either control or treatment plots for the first time, a testament to the very low herbaceous vegetation structure. The other three species detected during point counts in 2003 were only seen on one plot each (Table 8). Perhaps indicative of an increasing trend in saltbush height and density on part of the study area, we spotted two loggerhead shrikes during plot counts in the control plot of Section 29. During the small mammal trapping, we also observed three LeConte's thrashers (a species of concern) on the same plot.

Table 8. Average number of bird sightings made during point-counts at the Lokern study site in 2003.

Species[1]	21C	21T	27C	27T	29C	29T	33C	33T
CORA	0	0	0	0.5	0	0	0	0
HOFI	0.75	0	0	0	0	0	0	0
HOLA	2.0	1.5	1.5	3.5	0	2.75	1.0	1.75
LOSH	0	0	0	0	0.5	0	0	0
MODO	0.25	0	0	0	0	0	0	0
SAGSP	0.5	0	0	0.5	0	0.25	0	0

[1] CORA, common raven; HOFI, house finch; HOLA, horned lark; LOSH, loggerhead shrike; MODO, mourning dove; SAGSP, sage sparrow.

Counting fly-over species during point counts adds to the picture of which birds use the Lokern Study Area. This survey method documents the presence of species not landing within point count radii. In the past, common ravens have been the most numerous fly-over species, but this year only one was detected (Table 9). Cliff swallows were seen overhead 4 times with 5 individuals seen. One Brewer's blackbird was also seen.

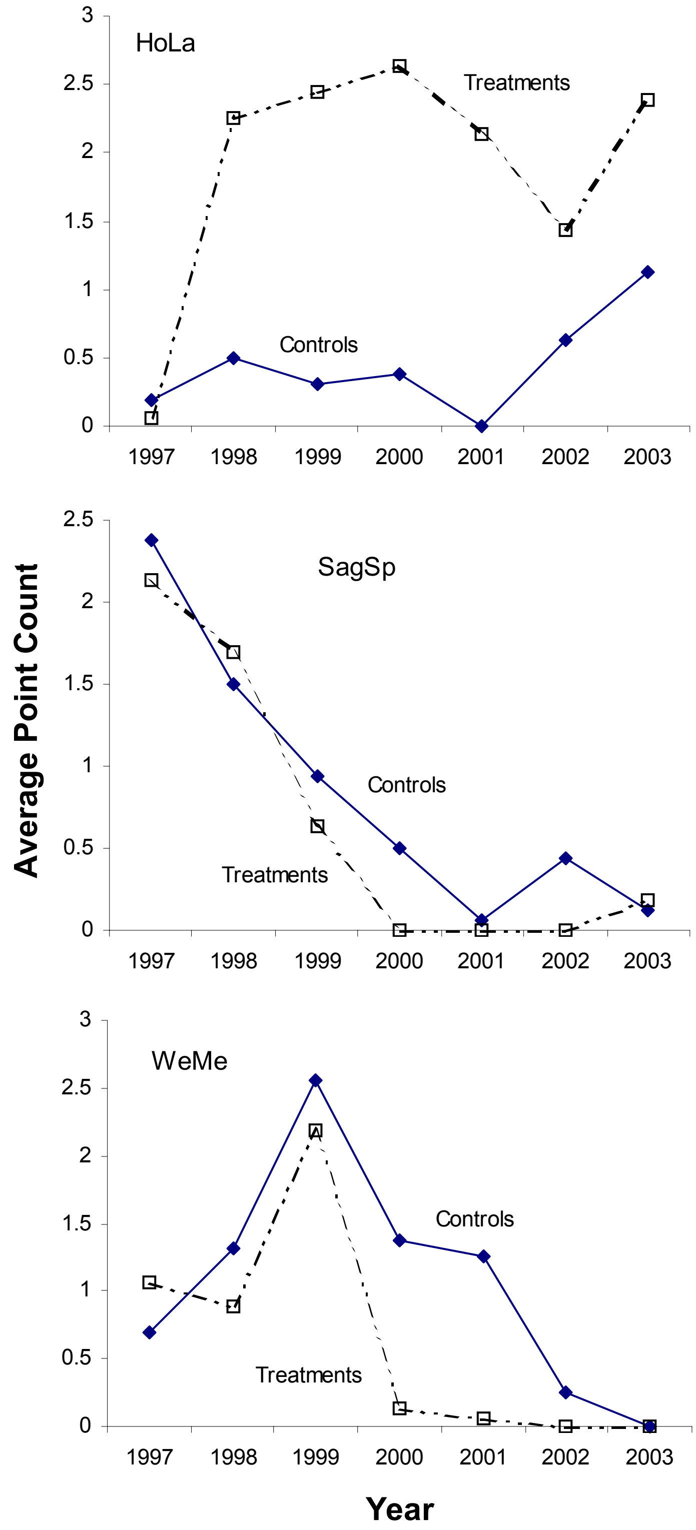


Figure 10. Average point count values by year for horned larks (HoLa), sage sparrows (SagSp), and western meadowlarks (WeMe), the three most abundant bird species found in the Lokern Study area.

Table 9. Total counts of birds observed flying overhead during point-counts in 2003.

Species	Control	Treatment
Brewer's Blackbird	1	0
Cliff swallow	2	3
Common raven	0	1
Horned lark	0	1

We also censused birds by recording species found within a 300 X 300 m area beyond the point count plots. This method assesses larger species of birds because the area of detection is larger than the other two census methods. However, these larger species do not necessarily breed on site, such as the common raven (Table 10). A whimbrel was detected for the first time in 2003 and a Say's phoebe was just outside the 300 m detection area and would have been new to the list of species seen during the survey.

Table 10. Number of times a species was detected in 2003 within a 300 X 300 m area (out of a possible 16 per controls or treatments), but not in point count plots.

Species	Controls	Treatments
Cliff Swallow*	1	1
Common Raven	4	2
Horned Lark	2	1
Loggerhead Shrike	1	0
Mourning Dove	1	0
Sage Sparrow	5	1
Western Meadowlark	6	0
Whimbrel	0	1

*Unlikely to breed in area

Lizard Surveys

During 10-day censuses in May – July 2003, we recorded the greatest number of adult blunt-nosed leopard lizards (*Gambelia sila*) during censuses since the study began (Fig. 11). Leopard lizards occurred on 3 of the 4 treatment plots (Table 11). Hatchling leopard lizards were also found in August during squirrel trapping in plots 27T and 29C, the first sightings of leopard lizards in a control plot since 1999 (Fig. 11). Besides finding leopard lizards during censuses and trapping, leopard lizards were found opportunistically while radio tracking (See section on Radio Tagging) and while driving roads in the study area. In the treatment areas of section 27, 29, and 33 (on and off plots), we captured 53 adult blunt-nosed leopard lizards (44 in section 27, 2 in section 29, and 7 in section 33) and 1 adult in the control plot in section 29. We also captured 17 juveniles in the treatment area of section 27 and 2 on the control plot in section 29. The total number of individual leopard lizards found at anytime in the study area (73) represents, by far, the greatest number we have seen during this study (Fig. 12). The population of leopard lizards is well on its way to becoming abundant in the study area, particularly on the grazed plots. It is not clear why leopard lizards have not been seen in section 21 since 1999, but the general increase of leopard lizards throughout the study area may mean we might find a few in 2004.

Side-blotched lizards (*Uta stansburiana*) and western whiptail lizards (*Cnemidophorus tigris*) were very abundant this year (Table 11). The number of sightings of side-blotched lizards (Fig. 13) and western whiptail lizards (Fig. 14) were the greatest we have ever recorded. Sightings of side-blotched lizards were about the same on control and treatment plots in 2003, but more western whiptails were found on control than treatment plots.

Table 11. Total number of sightings of blunt-nosed leopard lizards, side-blotched lizards, and western whiptail lizards on the study plots during a non-consecutive 10-day survey in May and June 2003.

Plot	Blunt-nosed Leopard Lizard	Side-blotched Lizard	Western Whiptails
21C	0	478	90
21T	0	983	45
27C	0	389	109
27T	22	137	169
29C	0	386	274
29T	2	291	125
33C	0	151	11
33T	8	78	19
Totals	32	2893	842

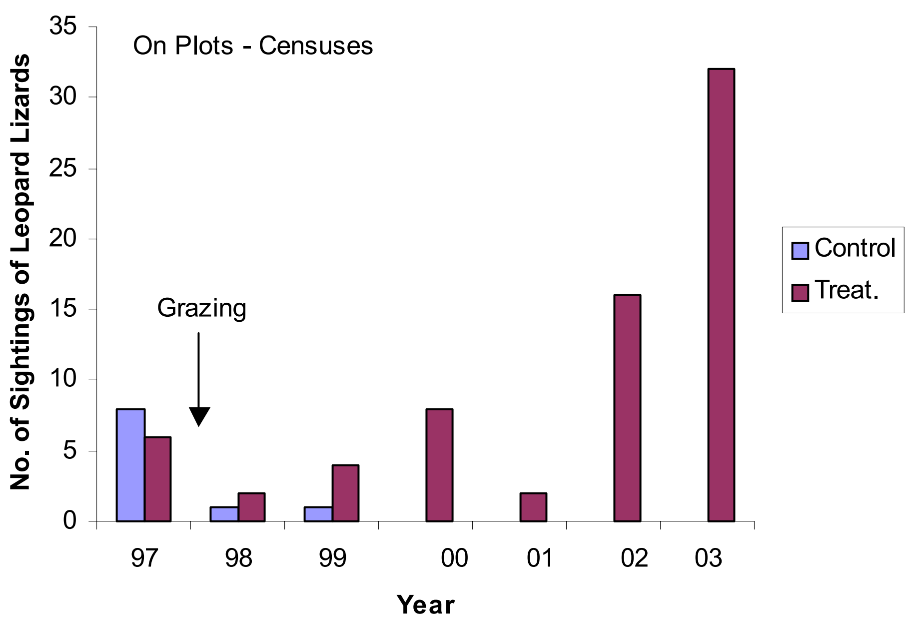


Figure 11. The number of sightings by year of blunt-nosed leopard lizards seen during 10-day censuses of 4 grazed (Treat.) and 4 un-grazed (Control) plots on the Lokern Study Area, Kern County, California. Grazing treatments started in spring 1998 but ended spring 2001 because of the lack of grass throughout the study area.

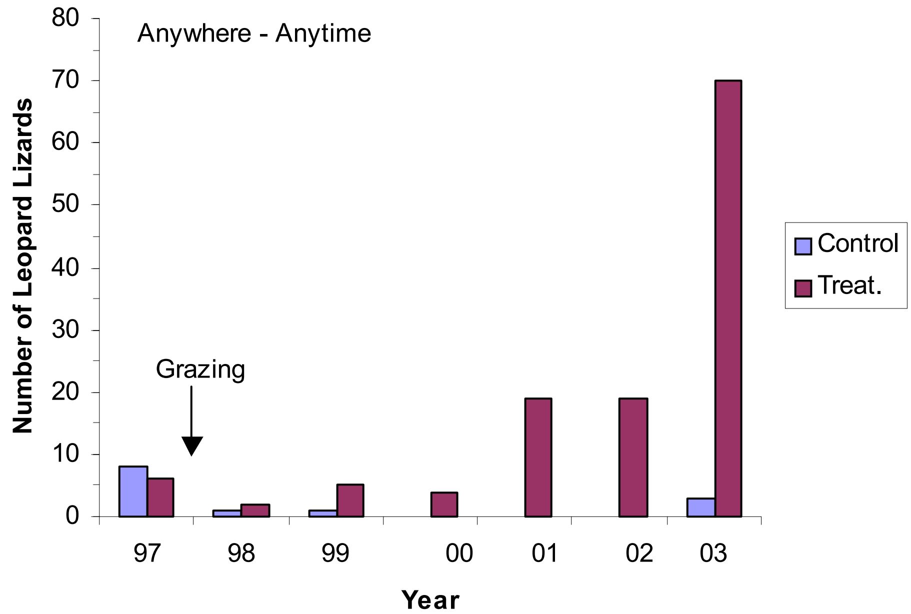


Figure 12. The number of individual blunt-nosed leopard lizards found anywhere on the Lokern Study Area, Kern County, California by year. Totals include lizards found during radio tracking, driving roads, and late summer sessions to trap squirrels.

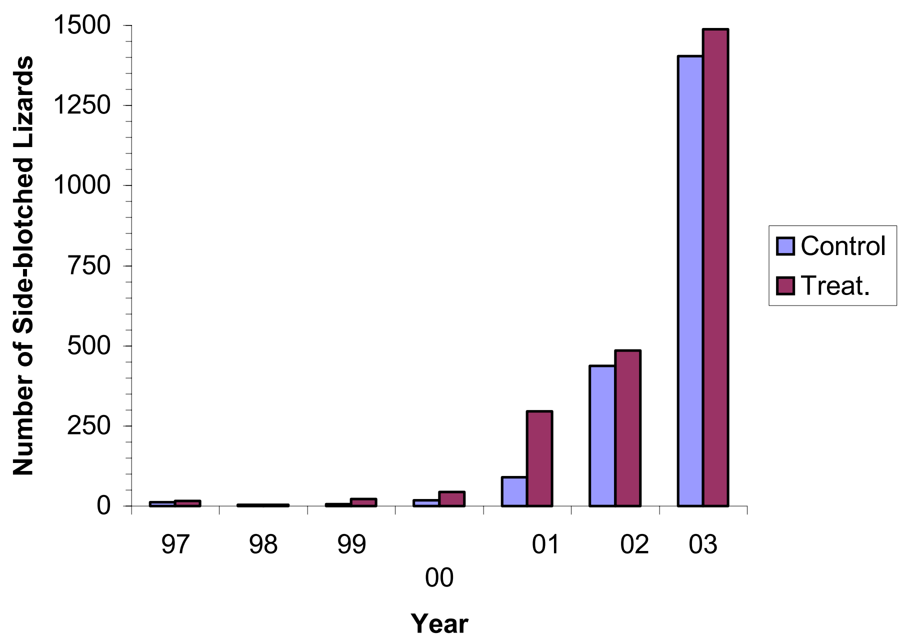


Figure 13. The number of sightings by year of side-blotched lizards seen during 10-day censuses of 4 grazed (Treat.) and 4 un-grazed (Control) plots on the Lokern Study Area, Kern County, California.

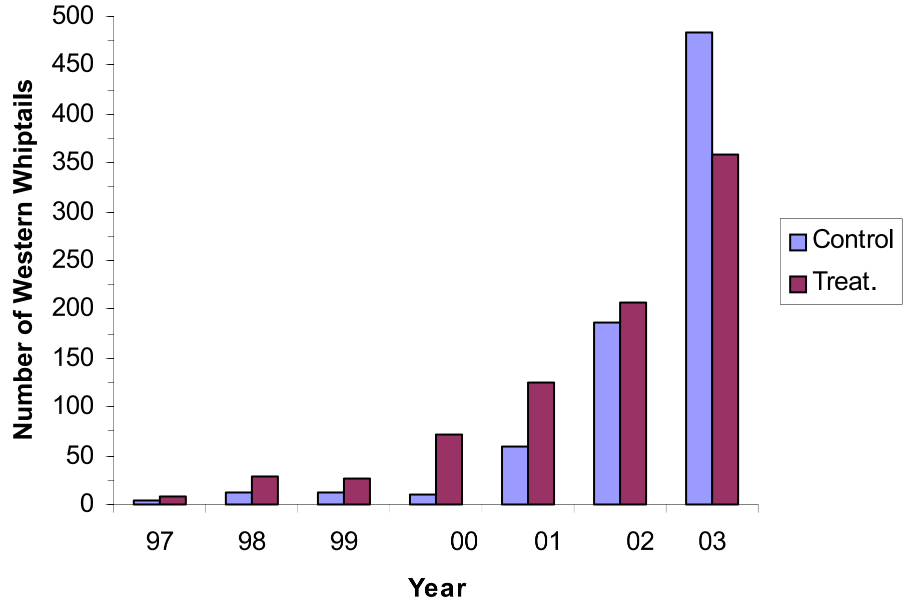


Figure 14. The number of sightings by year of western whiptail lizards seen during 10-day censuses of 4 grazed (Treat.) and 4 un-grazed (Control) plots on the Lokern Study Area, Kern County, California.

Invertebrate Studies

In 2003, mean numbers of grasshoppers counted per day during censuses for lizards were much greater than last year (Table 12), but not as high as in 1998 and 2001 (Fig. 15). Grasshoppers have followed a cyclical pattern of abundance that generally has a year with greater abundance following a year of low abundance (Fig. 15). Little difference has been seen between treatment and control plots.

Other terrestrial invertebrates were sampled with arrays of ten pitfalls on each of the eight plots, as in the past six years (see Annual Report for 1997). These traps were monitored during the same six days that mammals were trapped in August, also as done before. In 2003, the average number of invertebrates found per day in pitfall traps has remained similar for the past 3 years and ranged from 2.8 – 5.7 invertebrates per pitfall per day (Table 13). No differences in invertebrate numbers were found between controls and treatments.

Rodents and lizards were also captured in the pit-fall traps on the study site. Only 13 rodents (12 San Joaquin pocket mouse and 1 southern grasshopper mice) were found in pit-fall traps in 2003, and all but 1 pocket mouse were caught in traps next to treatment plots. Lizards were caught more frequently in 2003. In 6 days, 61 side-blotched lizards were caught in pitfall traps near control plots and 94 were caught near treatment plots, and 22 western whiptails were caught near controls and 6 near treatment plots.

Table 12. Mean number (standard deviation) of grasshoppers counted per day on plots during 10-day surveys for blunt-nosed leopard lizards.

Plot	1997	1998	19992000	20012002	2003		
21C	5.2	611.2	69.4	18.2	156.0	58.9	172.0
	(4.85)	(563.1)	(68.33)	(10.50)	(66.16)	(28.69)	(10.04)
21T	6.4	654.4	77.4	38.6	203.1	42.6	121.1
	(6.62)	(437.9)	(59.66)	(8.76)	(110.1)	(20.21)	(9.73)
27C	4.3	139.6	54.123.2	521.3	29.0	259.8	
	(3.40)	(50.35)	(53.98)	(4.39)	(129.0)	(10.11)	(39.78)
27T	4.9	192.0	211.2	33.1	239.7	26.3	126.9
	(4.70)	(64.96)	(189.5)	(5.17)	(52.08)	(6.83)	(16.30)
29C	10.6	136.7	329.5	19.2	968.8	24.5	342.0
	(5.15)	(130.9)	(248.2)	(5.94)	(469.0)	(9.26)	(55.69)
29T	11.9	473.8	39.1	41.8	466.6	37.0	513.1
	(7.84)	(475.8)	(15.44)	(8.64)	(133.9)	(16.51)	(137.5)
33C	11.2	55.3	27.1	5.6	139.9	15.8	84.9
	(12.8)	(53.11)	(12.21)	(4.01)	(85.75)	(6.86)	(7.83)
33T	12.7	131.0	65.6	16.5	166.3	14.8	52.6
	(11.1)	(114.6)	(36.28)	(9.22)	(64.00)	(9.27)	(5.74)

Table 13. Average number of invertebrates/pitfall/day on study plots by year. Numbers in parentheses are averages excluding ants.

Plots	1997	1998	1999	2000	2001	2002	2003
21C	3.9 (3.3)	11.1 (6.1)	1.3 1.5	2.4 (1.7)	3.3 (1.2)	3.1 (1.9)	
21T	4.2 (2.7)	15.0 (11.7)	4.7 1.4	6.7 (0.9)	3.1 (1.0)	5.7 (1.5)	
27C	4.2 (3.0)	24.7 (4.2)	2.9	1.4	1.6 (1.3)	4.8 (1.4)	2.8 (1.6)
27T	3.9 (2.9)	9.4 (2.2)	1.3 0.8	2.7 (0.5)	2.5 (2.2)	4.3 (1.7)	
29C	5.0 (3.5)	5.8 (3.7)	1.5 2.7	4.5 (2.0)	3.3 (1.6)	4.0 (1.5)	
29T	12.9 (5.1)	7.4 (3.9)	1.8 1.6	1.3 (1.0)	2.4 (1.0)	4.3 (0.7)	
33C	4.5 (4.3)	5.8 (5.0)	1.4 3.6	3.2 (1.9)	12.1 (2.3)	5.4 (3.0)	
33T	4.4 (3.0)	21.8 (9.5)	1.3 2.0	4.2 (1.0)	5.3 (1.5)	3.5 (1.2)	

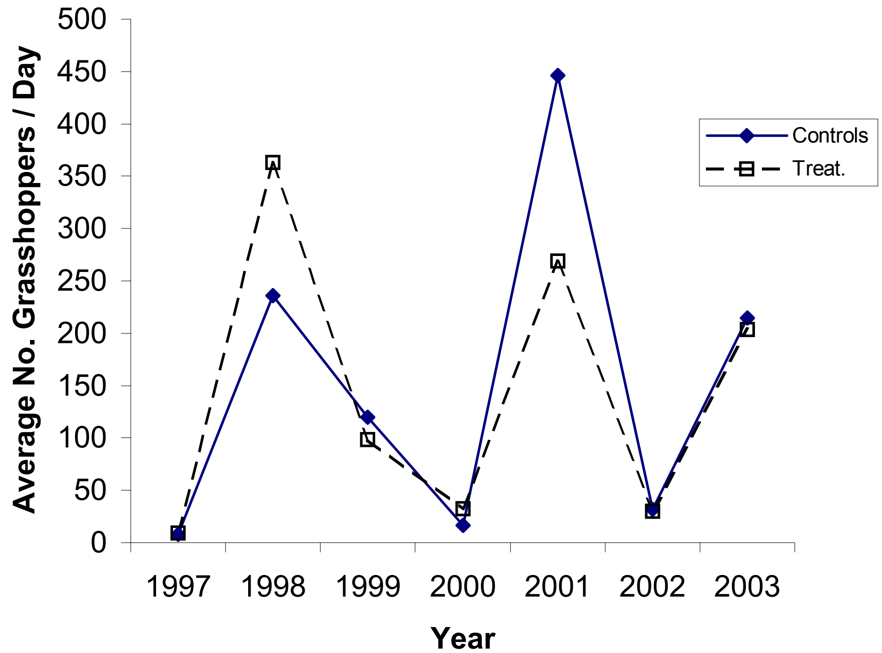


Figure 15. The average number of grasshoppers counted per day during 10-day censuses of blunt-nosed leopard lizards on the Lokern Study Area.

Burrow Studies

In 2003, we initiated a study to better understand the key environmental factors (temperature and humidity) that rodents and lizards experience under ground. It has been our working hypothesis that many of the cursorial vertebrates in the San Joaquin Valley require relatively open substrate to effectively forage and evade predation. With the introduction of exotic Mediterranean annual grasses, many areas have experienced a habitat conversion from relatively open saltbush (*Atriplex* spp.) scrub to annual grassland, especially in wet years that favor the exotic annual grasses. However, we realize that it is also possible that during particularly wet years the moisture content of the soil where rodents and lizards burrow has a more direct impact on these animals, rather than the relatively indirect effect of supporting a lush growth of annual grass. For example, it may be that when soil moisture is high, rodents and lizards that are more adapted to arid conditions (e.g., kangaroo rats, antelope squirrels, and leopard lizards) experience increased mortality from respiratory diseases. Or, increased soil moisture may result in the spoilage of stored grain (food), in the case of kangaroo rats.

Starting in late November 2003, we installed 40 temperature and relative humidity loggers (Hobo Pro RH/Temp H08-032-08) on the study site, split evenly between one control and one treatment plot. Because of the high expense of these units, we could not place loggers on all four replicated sites in sufficient numbers to also assess within plot variation. Therefore, we only used the paired treatment and control plots on Section 27. This section has had the highest consistent number of rodents in the last few years, it has the greatest amount of topographical relief, and the two plots are very similar in terms of soil and vegetation. Because of below-average rainfall the past few years, the grass cover is minimal on both plots. However, as soon as we have a year or two of above-average rainfall we believe that the cattle grazing treatment will be effective in distinguishing these two areas. We dug artificial slanting burrows that were 12.7 cm in diameter (so that the loggers would fit), about 115 cm deep and about 30-40 cm below the surface at the distal end. Into each excavation we inserted a 122 cm tube constructed of ¼-inch-mesh hardware cloth and blocked at each end to exclude rodents.

We used a combination of two methods to determine the location of each artificial burrow. First, we randomly picked twenty 20 x 20 meter squares within our leopard lizard/antelope squirrel grids (300 x 300 m square). Within each of these randomly chosen squares, we subjectively chose an active rodent burrow that was associated with other burrows and was located on slightly higher ground than the surrounding area to prevent rainfall runoff from channeling into the burrow. We then used a hand-operated soil auger to dig a straight artificial burrow exactly through the opening of the active burrow. Once our new burrow was made, we inserted the wire-mesh tube so that about 10 cm was exposed at the mouth. In cases were the mouth collapsed we covered the wire-mesh tube with a folded paper bag and covered this with about 5-10 cm of soil. We attached each data logger to the end of a 100 cm long 1.3 cm diameter PVC pipe and inserted this unit into each artificial burrow so that the relatively humidity port on the logger faced towards the bottom of the burrow.

We initially placed a single temperature logger programmed to read every 10 minutes for five days in an artificial burrow to determine sampling intervals. Based on this trial, we programmed the loggers on the study site to read quarterly per 24-hour period, starting at 1800 hours. With this sampling regime, the batteries in the loggers are estimated to last > 500 weeks. We checked 4 loggers after the first month to determine that they were indeed working and recording data. We will also check 4 loggers after the first heavy rain to ensure that they are functioning and have not become waterlogged. Once we are satisfied that the design described above is working, we will leave the 40 loggers to gather data for at least a full year that includes a rainfall winter that is normal or greater.

By gathering data on the daily temperature and humidity in artificial burrows we believe we eventually will be able to better understand the role of rainfall and vegetation on the sensitive vertebrate species that are the focus of our research.

Radio Tagging Studies

Last year we initiated radio-tagging studies of San Joaquin antelope squirrels and blunt-nosed leopard lizards. We have hypothesized that thick grasses and other herbaceous vegetation causes difficulties in movement of theses species, which leads to lower population levels in dense grass years. A correlate of this would be the use of space, with dense grass inhibiting the squirrels from using large areas. One measure of the effect of dense grass would be to determine if there are any differences in the sizes of home ranges of squirrels on treatment and control areas. Similarly, leopard lizards would probably also have smaller home ranges on the control areas, where exotic annual grasses are thicker in wet years.

We radio-tracked collared antelope squirrels on the Lokern study site last year and determined home range sizes in control and treatment plots. Unfortunately, the continuing lack of rainfall meant that control plots were not particularly grassier than treatment plots in 2003, so we did not radio tag any antelope squirrels this year. We did, however, radio tag a large number of blunt-nosed leopard lizards in the study area, and were able to determine home range sizes of male and female lizards. This information will be useful to determine the effect of grass cover on leopard lizards when rainfall increases and also provides general ecological information about this species.

Methods

We used Holohil Systems model BD-2G transmitters on leopard lizards (166 MHz). Beaded chain collars were used to attach the transmitters to the lizards (Harker et al. 1999). All loci for lizards were determined on foot using Communications Systems receivers (model R1000) and an H-Adcock or three-element Yagi receiving antenna. We determined the UTM (Universal Transverse Mercator) coordinates of all loci with a GPS receiver (Dell Axim Handheld Computer with a WorldNavigator GPS receiver) with differential and real-time correction with +/- 5-meter resolution. We used the software program ArcView (with Animal Movement Analysis and Biotas extensions) to calculate home range areas (using default settings).

Unlike last year, all blunt-nosed leopard lizards were caught on the study area. Leopard lizards were found in the study area by walking plots for 10-day censuses, a focused sweep of Section 27 and part of Section 33 by 6 people on foot spaced 10-30 m apart, and by driving roads. Additional leopard lizards were found once a few lizards were collared and tracking had begun. We concentrated on Sections 27 and 33 because we had collared 11 lizards there in 2002. This year, we collared 32 blunt-nosed leopard lizards (18 males, 14 females) between 5 May and 23 June 2003. Lizards were radio-located once a day, 3-5 times per week. We tracked lizards during daylight, usually in the morning, and we found them most often above ground. We also made an effort to take some locations during the early and late afternoon to determine at what temperatures leopard lizards retreated under ground. A GPS coordinate was taken exactly at the point were the lizard was located. Collars still on lizards at the end of study were removed between 23 July and 8 August 2003.

Results and Discussion

We gathered sufficient data ($\geq$ 25 locations/individual) to calculate home ranges for 26 blunt-nosed leopard lizards; 14 males and 12 females (Table 14). We gathered > 35 locations for most lizards, which were found throughout Section 27 and much of 33 (Fig. 16 and 17). Fixed Kernel home range size using 95% of each individual's loci varied between 1.20 and 17.0 ha for males and 1.63 and 21.4 ha for females (Table 15). Minimum Convex Polygon (MCP) home range estimates using 95% of fixes varied between 0.71 and 8.86 ha for males and 1.15 and 13.1 ha for females (Tables 15). Comparison of home range size between males and females using ANOVA showed no significant differences for mean estimates based on the Kernel method ($F_{1,24} = 2.186$, $P = 0.152$) or MCP ($F_{1,24} = 1.920$, $P = 0.179$). However, one female (#6.505, Section 33) had an unusually large home range compared to all other females (Table 14). If her estimates were removed, along with the largest male estimates of home range for each method of determining area, mean home range size of males were significantly larger than females for both the Kernel method ($F_{1,22} = 6.621$, $P = 0.017$) and for MCP ($F_{1,22} = 6.729$, $P = 0.017$).

Similar to last year, we again found acts of predation on collared blunt-nosed leopard lizards in 2003. We found 2 male and 1 female leopard lizards eaten by northern Pacific rattlesnakes (*Crotalus viridis oreganus*). In addition, the last female that we collared in late June unexpectedly moved over 500 m to the west in early August after having occupied a relatively small home range in Section 27 for 5 weeks. In two days she moved into Section 28 where she was seen still moving to the west. Her radio signal was not heard again until 3 days later when her shed collar was found above ground in Section 21, about 1 km NW of her home area.

We were able to gather many locations on a large number of blunt-nosed leopard lizards this year. We now have good estimates of home range size for male and female lizards in open habitat. We plan to continue this study. During other work we found blunt-nosed leopard lizards in Section 29, which has a good cover of saltbush. We plan to radio track lizards in these shrub areas and compare home range size to lizards in more areas. We also could determine the effect of dense grass growth on lizards if the coming year is wet.

Literature Cited

Harker, M., G. B. Rathbun, and C. A. Langtimm. 1999. Beaded-chain collars: a new method to radiotag kangaroo rats for short-term studies. Wildlife Society Bulletin 27:314-317.

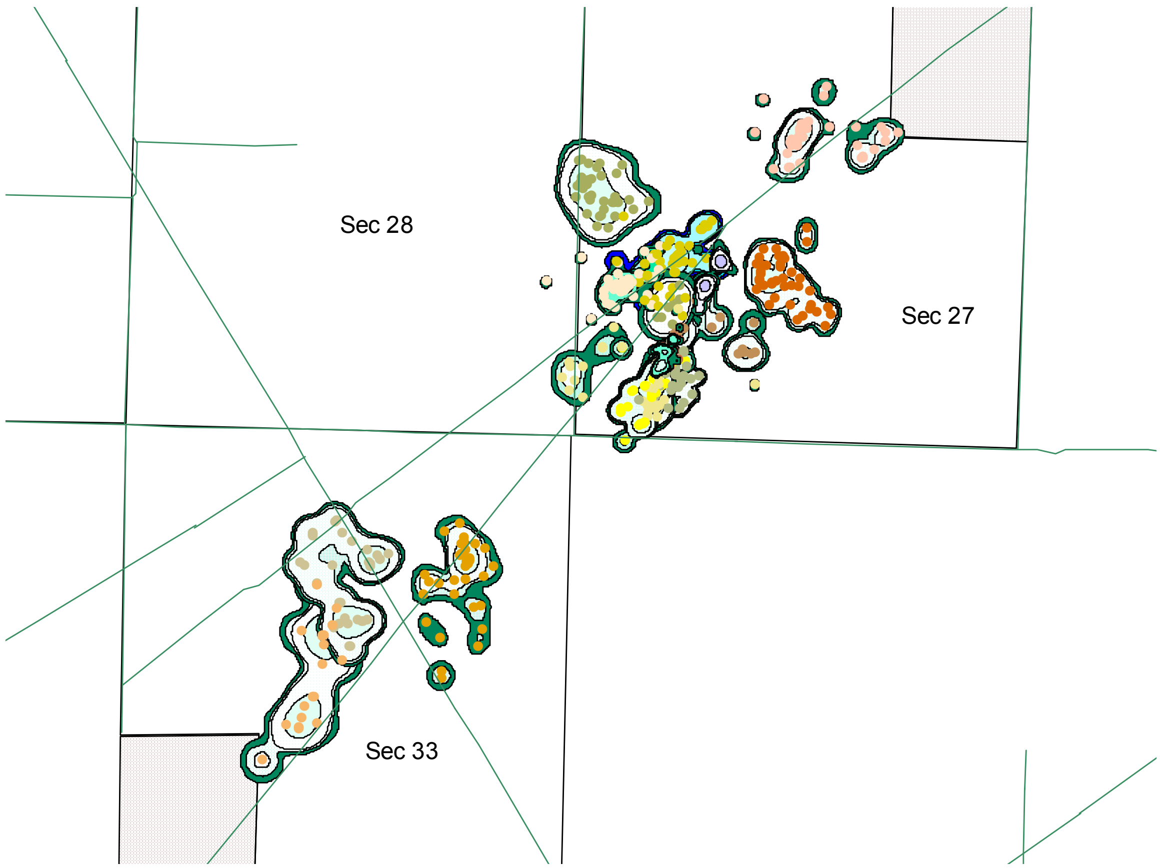


Figure 16. Kernel home range outlines (50, 85, 90, and 95% of loci) for 14 male blunt-nosed leopard lizards on sections 27 and 33 of the Lokern study site during May – August 2003 (see Tables 14 and 15 for further information). Shaded squares at the upper right and lower left are control pastures (500 m on a side).

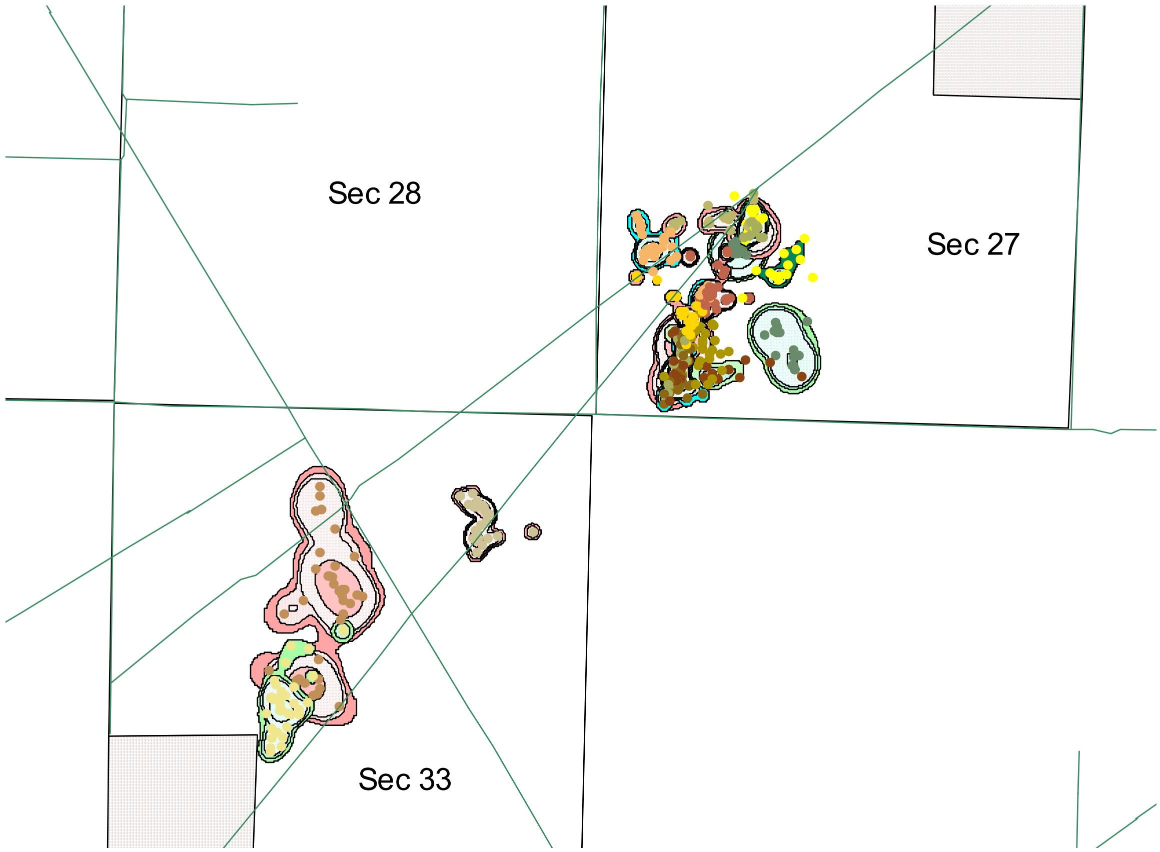


Figure 17. Kernel home range outlines (50, 85, 90, and 95% of loci) for 12 female blunt-nosed leopard lizards on sections 27 and 33 of the Lokern study site during May – August 2003 (see Tables 14 and 15 for further information). Shaded squares at the upper right and lower left are control pastures (500 m on a side).

Table 14. Home range areas of adult blunt-nosed leopard lizards on the Lokern during May - August 2003. Lizards with insufficient numbers of locations (< 25) were excluded. Home ranges are in hectares (10^6 m^2) using the Kernel (K) and Minimum Convex Polygon (MCP) procedures of the software program RANGES6, for 95%, 98%, and 100% of locations for each individual. Bolded estimates are the largest home ranges for males and females for each method.

	Males			Females	
ID	95% Kernel	95% MCP	ID	95% Kernel	95% MCP
6.060	**17.0261**	6.0802	4.119	2.6450	2.1107
6.100	15.2447	**8.8570**	6.078A	1.6318	1.4775
6.111	7.3375	3.2382	6.169	2.7288	1.7205
6.271	10.7571	6.4338	6.189	3.7866	3.2045
6.308	4.2410	3.6184	6.213	2.7788	1.2621
6.319	7.9408	6.7914	6.246	5.3746	3.9875
6.382	8.8460	5.5305	6.346	8.3068	3.5030
6.467	9.9399	8.4755	6.505	**21.3895**	**13.1290**
6.582	4.7771	2.2777	6.544	3.1365	3.3738
6.630	1.1956	0.7142	6.708	9.0330	3.0621
6.868	14.8969	7.4808	6.824	2.6646	1.1523
6.946	8.2596	7.7673	7.266	2.5000	3.0032
6.981	1.8547	0.9100			
7.068	6.6300	2.4591			

Table 15. Mean, sample size (n), standard error (SE), and low and high estimates of home range area of male and female blunt-nosed leopard lizards from the Lokern Study area May – August 2003. Home range estimates were made using the Kernel and Minimum Convex Polygon (MCP) methods using 95 % of locations.

	n	Mean (ha)	SE	Low (ha)	High (ha)
Males					
95% Kernel	14	8.50	1.29	1.20	17.0
95% MCP	14	5.05	0.75	0.71	8.86
Females					
95% Kernel	12	5.50	1.60	1.63	21.4
95% MCP	12	3.42	0.93	1.15	13.1

Funding

We have raised nearly $400,000 in cash for this research since 1997. This figure does not include nearly an equal amount of in-kind contributions from cooperators. It costs about $72,000 in cash per year (see below) to maintain the study site and carry out the sampling, which does not include on-going commitments for in-kind support. At present, we have funds to cover costs through mid 2005. We do not yet have sufficient funds for all of 2005 and beyond. We know this study has been in progress for many years, but we are now at the mercy of annual rainfall more than ever. We require several average or above-average rainfall years to buildup the exotic grass cover on the controls that has all but disappeared over the last several dry years. While we await wetter rain years, we will be relying on contributions from all of the participants to meet our funding needs.

Yearly Expenditures (does not include in-kind contributions):

Item	Cash Amount
Calif. State Bakersfield Foundation	$45,000
End. Species Recovery Program; Plant Studies	$15,000
Vehicle	$3,000
Travel	$3,000
Field Supplies/Repairs	$3,000
Total	$72,000
Radio Tagging Study (funded by Occidental of Elk Hills, Inc.)	$21,000

Cooperators

The Bureau of Land Management (BLM) has been the principal "client" of the Lokern Project, and their needs have driven much of the planning and design of the study. Numerous other agencies and organizations have realized that the research has broad applicability to their lands and interests, and they have participated in various aspects of the project.

We gained a major new supporter in 2003 just as the USGS stopped their active participation. The Bureau of Reclamation (BOR) has recently funded part of the study. Besides the BOR and BLM, the main supporters and participants in the Lokern Project include the Endangered Species Recovery Program (ESRP); the US Fish and Wildlife Service (USFWS); the California Department of Fish and Game (CDFG); the California State University, Bakersfield (CSUB); the Center for Natural Lands Management (CNLM); The National Fish and Wildlife Foundation (NFWF); the California Department of Water Resources (CDWR); Chevron Oil Company; ARCO Oil Company; Occidental of Elk Hills, Inc.; Clean Harbors; and Eureka Livestock Company.

The following investigators have been responsible for implementing the different aspects of the Lokern research. These scientists have also contributed summaries of data for this annual report:

Dr. Ellen Cypher, Research Ecologist, Endangered Species Recovery Program, PO Box 9622, Bakersfield, CA 93389-9622. Phone 661/398-2201. Ecypher@esrp.org. ***Vegetation and rare plant studies.***

Mr. Sam Fitton, Wildlife Biologist, Bureau of Land Management, 20 Hamilton Court, Hollister, CA 95023. Phone 831/830-5000. Sfitton@ca.blm.gov. ***Bird studies.***

Dr. David Germano, Associate Professor, Department of Biology, California State University, Bakersfield, CA 93311-1099. Phone 661/589-7846. Dgermano@csub.edu. ***Lizard, mammal, and invertebrate studies. Project coordination, report coordination and preparation. Blunt-nosed leopard lizard radio-tagging study.***

Dr. Galen Rathbun, Research Biologist, Department of Ornithology and Mammalogy, California Academy of Science, Golden Gate Park, San Francisco, c/o P.O. Box 202, Cambria, CA 93428. Phone 805/927-3893. Grathbun@calacademy.org. ***Mammal and invertebrate studies, San Joaquin antelope radio-tagging study.***

Mr. Larry Saslaw, Wildlife Biologist, Bureau of Land Management, 3801 Pegasus Drive, Bakersfield, CA 93308. Phone 661/391-6086. Lawrence_Saslaw@ca.blm.gov. ***Plot, soil moisture, and cattle studies.***

In addition, the following people and agencies assisted with field work in 2003: Kathy Sharum, John Moule, Nick Havlik, and Kathy Long (BLM); Brian Cypher (Endangered Species Recovery Program); Greg Warrick (Center for Natural Lands Management); Alex Brown, Jenelle Anderson, Kelly Lilburn, Belen Perez, Carol Register, Lindsey Bradley, and Rakel Fisher (CSU Bakersfield Foundation). We greatly appreciated the assistance from the following volunteers that participated in fieldwork: Joel Saslaw. Funding for Dr. Cypher was provided by ESRP and a LEGACI grant from the Great Valley Center.

PUBLICATIONS

One note was published in 2003 from activities on the Lokern in 2002. The note on predation of *Gambelia sila* follows on the next page.