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**POPULATION TRENDS OF
SAN JOAQUIN KIT FOX
(Vulpes velox macrotis)
AT CAMP ROBERTS
ARMY NATIONAL GUARD
TRAINING SITE, CALIFORNIA**

by

William H. Berry and William G. Standley

October 1992

This report is unclassified:

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Work performed for the U. S. Departments of the Army and Air Force
National Guard Bureau
Aberdeen Proving Grounds, Maryland 21010-5420
through an agreement with the U. S. Department of Energy,
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ABSTRACT

Population trends of a San Joaquin kit fox population (*Vulpes velox macrotis*) were investigated at Camp Roberts Army National Guard Training Site, California, from November 1989 through August 1991. Six semiannual livetrapping sessions and eight scent-station survey sessions were conducted. Livetrapping results and radiotelemetry data were used to calculate minimum population size, density, and distribution. A total of 175 individual foxes were trapped 463 times. The number of individuals trapped and minimum population size calculations showed a decline over time. The highest minimum population (109) was observed in winter 1988. Summer 1991 had the lowest minimum population size (45). No evidence was found to indicate that the apparent population decline was a result of military-authorized activities.

ACKNOWLEDGEMENTS

The assistance of the many people that collected data during this study is greatly appreciated. The following persons assisted with trapping, collaring and monitoring the fate of foxes: L. E. Briden, P. D. Caron, K. Charlton, O. A. Jones, C. G. Logan, M. R. M. Otten, E. A. Reese, K. A. Spencer, G. D. Warrick, and S. A. Woodward. J. Ando assisted with data storage and analysis. T. Kato and T. O'Farrell assisted with all phases of this study.

The cooperation and assistance of the following California Army National Guard personnel are gratefully acknowledged: Col. D. Baird, Col. W. Mongolo, Col. J. Scully, Lt. Col. E. Martzen, Maj. A. Vargas, Lt. D. Lee, Sgt. J. Noble, Sgt. G. Perry, Sgt. K. Remo, Mr. A. Davis, Ms. A. DeBevec, Mr. B. Duke, and Ms. J. Eliason.

Permission to trap, handle, and radiocollar San Joaquin kit foxes was granted by the U. S. Fish and Wildlife Service through permit PRT 683011 and a Memorandum of Understanding between the California Department of Fish and Game and EG&G Energy Measurements, Inc.

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1. INTRODUCTION

Understanding the population dynamics of an endangered species is critical to species management and recovery planning. The San Joaquin kit fox (*Vulpes velox macrotis* formerly *Vulpes macrotis mutica*; Dragoo et al. 1990) was listed as endangered by the U. S. Fish and Wildlife Service in 1967 (U. S. Department of the Interior 1967). San Joaquin kit foxes primarily inhabit the semi-arid habitats of the San Joaquin Valley, California, but populations do occur outside of the San Joaquin Valley. Previous studies have documented the presence of kit fox at Camp Roberts (Balestreri 1981, O'Farrell et al. 1987).

Knowledge of the abundance of kit fox on Camp Roberts is an important part of assessing the impacts of military activities on the population. It was believed that regular monitoring of the population over a three year period would provide a reliable means of detecting fluctuations in the population size. Changes in population size could result from natural causes or from military authorized activities. If military authorized activities could be linked to a decline in the fox population, the necessary steps could be taken to reduce or eliminate the causes.

The goal of this study was to estimate kit fox population size semiannually on Camp Roberts and evaluate the effects of military operations on the fox population.

2. STUDY AREA

Camp Roberts is a military training area operated by the California Army National Guard with funding from the National Guard Bureau. It is located approximately 43 km east of the Pacific Ocean, midway between Los Angeles and San Francisco along U. S. Highway 101 in San Luis Obispo and Monterey Counties (Figure 1). Camp Roberts encompasses 172 square kilometers of mostly gently rolling hills that form a transition zone between the Salinas River floodplain and the steep foothills of the Santa Lucia Mountains. Elevations range between 161 and 521 meters above sea level. Average annual rainfall is 28.5 cm and over 90% occurs between November and April (Nakata and Associates 1987). Fog is common in winter months. Dominant vegetation associations are grassland, oak (*Quercus* spp.) woodland, mixed chaparral, and riparian habitat. Kit foxes occur mainly in grassland and low to medium density oak woodlands, although they also occupy highly developed areas of the installation where they live under buildings (Reese et al. 1992). California ground squirrels (*Spermophilus beecheyi*) are abundant on the installation and are the most frequent item found in kit fox scats (Logan et al. 1992). Other predators that occur on Camp Roberts include coyote (*Canis latrans*), red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), bobcat (*Felis rufus*), badger (*Taxidea taxus*), and golden eagle (*Aquila chrysaetos*).

Military training activities occur throughout the year, with most occurring during the National Guard's Annual Training cycle (May - July). During this study, monthly utilization in terms of peak strength (number of individuals on the installation during the month) was lowest in January 1991 (1,214) and highest in June 1989 (13,784). Training activities include live-fire exercises from established ranges using weapons that range from .22 caliber rifles to 8-inch howitzers. Most live-ammunition firing is directed into an established impact area. Vehicles used during military activities range from motorcycles to M-1 tanks weighing over 66 metric tons. Although vehicle traffic mostly takes place along roads and tank trails, cross country travel does occur during certain training exercises.

Other activities authorized by the National Guard to occur on Camp Roberts include: 1) a livestock grazing program that allows restricted use by sheep and cattle during spring and summer, 2) controlled burning to reduce the spread of range fires, 3) a hunting and fishing program operated by the California Department of Fish and Game, 4) a limited amount of pest control is conducted to reduce rodent populations within buildings and at the sanitary landfill, and 5) a wood cutting program that allows woodcutters to remove downed dead trees.

Figure 1. Location of Camp Roberts, Monterey and San Luis Obispo Counties, California.

3. METHODS

3.1 LIVETRAPPING

Livetrapping was conducted semiannually to estimate kit fox population size, density, distribution, and to radiocollar foxes for other project tasks. Foxes were trapped in late November through early January (winter) to coincide with the breeding season, and in July through early October (summer) when most subadults disperse. Trapping schedules were influenced by military activities. Livetrapping was conducted for other purposes during the study and trapping occurred at Camp Roberts in 1986 and 1987 (O'Farrell et al. 1987); therefore, it was possible that previously marked animals would be encountered during trapping activities.

Twelve traplines of 14 to 19 traps each were established throughout the accessible portions of the installation, using a density of one trap per 65 ha (four traps/square mile; Figure 2). Trapping was not conducted in the dedicated impact area because of safety concerns. The total trapping area was 127 square kilometers (49 square miles). Depending on military activities, one to four traplines were operated each week. The number of weeks required to complete the trapping program varied between four and six weeks.

One double-door, wire-mesh collapsible trap (38 x 38 x 107 cm) was placed at an established location and operated for four consecutive nights. Although traps were double-door style, only one door was opened. Traps were covered with canvas tarps to minimize exposure of trapped animals to sun and rain. Traps were baited with canned mackerel. All traps were examined each morning.

Captured foxes were coaxed into a cloth handling bag to allow handling of the animal without anesthesia. Foxes were weighed, measured, sexed and newly captured foxes were fitted with uniquely numbered eartags for future identification (O'Farrell 1987). Selected animals were radiocollared (Telonics, Inc., Mesa, Arizona) to gather information on reproduction, mortality, and den use. All foxes were released at their capture site. Traps and tarps were cleaned after each capture with a dilute bleach solution and/or set out in bright sunlight to minimize the possibility of disease transmission among captured animals. Handling bags were heat sterilized daily.

3.2 POPULATION SIZE

Minimum population size was calculated for each trapping session by adding the number of individuals trapped to the number of foxes not trapped but known to have been alive at some time during the trapping session. The number of foxes known to have been alive was determined from radiotelemetry information and information obtained during subsequent trapping

Figure 2. Location of semiannual livetrapping sites and carnivore scent-station survey lines.

efforts. The assumption was made that animals caught more than once were present on the study area at all times between their first and last observations. Because new capture information potentially influenced the minimum population size of previous sessions, the minimum population size was recalculated for all previous sessions following the end of each trapping period. Naive density was calculated by dividing the minimum population size by the trapping area (127 square kilometers). A modified naive density was calculated using a reduced trapping area (105 square kilometers) that excluded portions of the installation that results of trapping efforts indicated were outside the distribution of the kit fox. It was believed that the modified naive density would be more representative.

3.3 SCENT-STATION SURVEYS

Scent-station surveys were conducted as described by Roughton and Sweeny (1982). Nine survey lines were located throughout Camp Roberts in a systematically random fashion (Figure 2). Each line consisted of 10 scent stations placed near the edge of a road. Stations were 0.5 km apart along a continuous 4.3 km route. Stations were alternated between left and right sides of the road to reduce influence of prevailing winds. Each scent station consisted of a circular 0.9 m diameter area cleared of all vegetation and debris. A thin layer of dust was sifted over the cleared area and a 2.5-cm plaster of Paris disk saturated with fatty acid scent attractant was placed in the center. Scent stations were checked for tracks the following morning and scent disks were removed. Scent-station surveys were conducted in March or April (spring), June or July (summer) and October (fall) of each year. Visitation indices were calculated using the following equation.

$$\text{INDEX} = \frac{\text{TOTAL NUMBER VISITS}}{\text{TOTAL NUMBER OPERABLE STATIONS}} \times 1000$$

Each station with at least one identifiable kit fox track was considered to have been visited. An operable station was defined as a scent station that was not disturbed in such a way that accurate identification of tracks was impossible. Comparisons of visitation indices over time are appropriate only within each season (Conner et al. 1983).

4. RESULTS

4.1 LIVETRAPPING AND POPULATION SIZE

Six trapping sessions (three winter, three summer) were conducted between November 1988 and August 1991. Each trapping session consisted of 784 trap-nights of effort except for winter 1988 and summer 1990 which had 783 trap-nights each because one trap was stolen during each session. A total of 175 individual foxes were trapped 463 times during the six sessions (Table 1). The number of captures, individuals trapped, and newly trapped animals for each session declined over time. The greatest number of captures and individuals trapped occurred during the initial session in winter 1988. The smallest number of captures and individuals trapped occurred during the final session in summer 1991.

The minimum population size for each session showed a decline over time from a high of 109 in winter 1988 to a low of 45 in summer 1991 (Table 1). The proportion of the minimum population that was untrapped ranged between 5.5% and 55.6%.

Estimated densities for the entire trapping area ranged between 0.86 per square kilometer in winter 1988 and 0.35 per square kilometer in summer 1991. Within the known distribution of the kit fox, the estimated densities declined from 1.04 per square kilometer in 1988 to 0.43 per square kilometer in 1991 (Table 1).

Nontarget species were captured during all trapping sessions. Capture results for predatory species are presented in Table 2. California ground squirrels (*Spermophilus beecheyi*), desert cottontail (*Sylvilagus audubonii*), yellow-billed magpies (*Pica nuttalli*), and scrub jay (*Aphelocoma coerulescens*) were also captured during trapping sessions. Because nontarget animals were not handled or marked, the number of individuals trapped could not be determined. Nontarget animals were released at their trap site with the exception of one rabid striped skunk (*Mephitis mephitis*) and the domestic cats (*Felis catus*). The skunk was killed and all domestic cats, except those believed to be household pets, were turned over to the San Luis Obispo County Department of Animal Regulation.

4.2 SCENT-STATION SURVEYS

Nine scent-station surveys were conducted during the study (Table 3). Condensation from dense fog in spring 1989 made tracks indistinguishable on all but two of the survey lines and results from these survey lines were deleted. Military activities prevented access to three of the survey lines in fall 1988, so only six of the nine survey lines were completed. The summer index showed a slight decline over the three years. The fall index dropped between 1988 and 1989 and then increased in 1990. Only two spring surveys were successfully completed. The index for the spring surveys decreased between 1990 and 1991.

Table 1. Trapping results and associated minimum population sizes for semiannual live trapping of San Joaquin kit fox at Camp Roberts from November 1988 to September 1991.

Session	Months	Duration (weeks)	Captures	Individuals	New Animals	Alive But Untrapped	Minimum Population Size	Naive Density (fox per km ²)	
								Entire Trapping Area (127 km ²)	Estimated Fox Distribution (105 km ²)
Winter 1988	Nov - Dec 1988	5	126	103	103	6	109	0.86	1.04
Summer 1989	Sep - Oct 1989	4	126	74	33	10	84	0.66	0.80
Winter 1989	Dec 1989 - Jan 1990	6	83	52	11	23	75	0.59	0.71
Summer 1990	Jul - Aug 1990	5	45	28	12	35	63	0.50	0.60
Winter 1990	Nov - Dec 1990	4	50	33	8	17	50	0.39	0.48
Summer 1991	Jul - Aug 1991	6	33	21	8	24	45	0.35	0.43
Total			463		175				

Table 2. Number of captures of selected non-target species during semiannual live-trapping for kit fox at Camp Roberts from November 1988 to September 1991.

Session	Striped Skunk (<i>Mephitis mephitis</i>)	Raccoon (<i>Procyon lotor</i>)	Opossum (<i>Didelphis virginianus</i>)	Gray Fox (<i>Urocyon cinereoargenteus</i>)	Red Fox (<i>Vulpes vulpes</i>)	Badger (<i>Taxidea taxus</i>)	Bobcat (<i>Felis rufus</i>)	Domestic Cat (<i>Felis catus</i>)
Winter 1988	86	12	16	4			2	11
Summer 1989	77	12	9	2		1		6
Winter 1989	54	12	1	8			2	1
Summer 1990	44	18	10	14		1		11
Winter 1990	20	29	5	3	1		4	4
Summer 1991	21	16	1				1	3
Winter 1991	35	10		1			3	7

Table 3. Kit fox visitation indices for scent-station surveys conducted at Camp Roberts, 1988 - 1991.

Year	Visitation Index		
	Spring	Summer	Fall
1988	--	--	237.3
1989	**	155.6	66.7
1990	224.7	144.4	122.2
1991	125.0	136.4	--

**** Weather conditions precluded surveys.**

With the exception of Fall 1990, comparisons between summer and fall visitation indices and the number of kit fox captures, individuals trapped, and the minimum population sizes for summer and winter trapping sessions all exhibited a declining trend (Figures 3 and 4).

Figure 3. Comparison of number of individuals trapped and minimum population size for summer trapping sessions with scent-station visitation indices for summer surveys.

Figure 4. Comparison of number of individuals trapped and minimum population size for winter trapping sessions with scent-station visitation indices for winter surveys.

5. DISCUSSION

Both livetrapping and scent-station results indicated that the fox population at Camp Roberts declined during the study. The number of individual foxes trapped each session declined for each successive session except for a small increase in winter 1990. Minimum population size also declined with each successive trapping session.

While population size indicators decreased over time, the number of untrapped foxes known to be alive during a trapping session varied. During two sessions, alive but untrapped foxes accounted for over half of the minimum population size. The number of animals known to be alive but untrapped was partially dependent on the number of animals radiocollared. The number of animals known to be alive but untrapped usually increases over time as previously marked animals are recaptured.

The variation in the number of untrapped animals known to be alive indicated that livetrapping results, in terms of number of captures and individuals, must be interpreted with caution. The number of individuals captured will probably always be substantially lower than the actual fox population. However, it appears that the decline in the number of individuals trapped did reflect a decrease in the population.

Although the trends in scent-station visitation indices were similar to the trends exhibited by trapping data, there are no established methods to equate visitation indices with population size. Trapping data provide actual numbers that can be useful in determining the actual fox population size. Scent-station survey results provide a relative abundance index. Scent station monitoring might not detect a decline until the population had reached a dangerously low level (Harris 1987).

There was no evidence to indicate that the decline in kit fox abundance was the result of military-authorized activities, but the reasons for this decline are unknown. Military-authorized activities caused the deaths of three of 94 foxes radiocollared during the study, and may have contributed to the death of a fourth (Standley et al. 1992). Low reproductive success observed during the study could not be linked to military-authorized activities (Spencer et al. 1992).

Disease may have contributed to the decline in population. Two radiocollared foxes were known to have died of rabies (Standley et al. 1992). San Luis Obispo County had the highest incidence of wildlife rabies cases of all counties in California during 1989 - 1991 (Barrett 1990, Reilly and Mangiamale 1992, Schultz and Barrett 1991). Most of the rabies cases have involved striped skunks which were the second-most frequently trapped species at Camp Roberts. A rabid skunk was trapped during the winter 1989 session. The number of striped skunk captures declined over time which could indicate a reduction in the skunk population size. It is possible that a rabies outbreak occurred in the skunk population and spread into the kit fox population.

The highest naive densities within the reduced trapping area (winter 1988 and summer 1989) are lower than the highest densities observed previously at the Naval Petroleum Reserve #1 (NPR-1) near Bakersfield, California (1.4 foxes per square kilometer for winter 1981 and summer 1982; 115 square kilometers trapped) and the adjacent Naval Petroleum Reserve #2 (NPR-2) (1.2 foxes per square kilometer for winter 1984; 1.6 per square kilometer for summer 1984; 122 square kilometers trapped) (EG&G/EM 1992). The naive densities observed at Camp Roberts were consistently higher than those observed at NPR-1 for the same periods, and similar or slightly lower than those recorded at NPR-2 (Table 4). Morrell (1972) reported a naive density of 2.3 foxes per square kilometer based on trapping a one square mile area in Buena Vista valley near NPR-1. O'Farrell (1983) reported an estimated density within suitable habitat of the San Joaquin Valley as 0.54 foxes per square kilometer in 1975 and 0.38 foxes per square kilometer prior to 1925.

Table 4. Comparison of San Joaquin kit fox naive densities calculated for semiannual livetrapping sessions at Camp Roberts and the Naval Petroleum Reserves #1 and #2, 1988 - 1991.

Season	Naive Density (foxes/km ²)		
	Camp Roberts (105 km ²)	NPR-1 (115 km ²)	NPR-2 (122 km ²)
Winter 1988	1.04	0.32	1.08
Summer 1989	0.80	0.43	0.93
Winter 1989	0.71	0.36	0.85
Summer 1990	0.60	0.25	0.64
Winter 1990	0.48	0.18	0.58
Summer 1991	0.43	0.10	0.35

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