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DISTRIBUTION AND POPULATION ESTIMATE OF THE MORRO BAY KANGAROO RAT, 1977[1/]

by

Aryan I. Roest[2/]

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ABSTRACT

A survey to define total occupied habitat and to determine aspects of the population and biology of the Morro Bay kangaroo rat (Dipodomys heermanni morroensis) was conducted from January to August, 1977. Areas of previous kangaroo rat activity in the restricted range south of Morro Bay in San Luis Obispo County, California, were examined. Currently active sites were live-trapped using Sherman traps on 200 ft. by 200 ft. quadrats or on standard trap lines. A total trapping effort of 2,542 trap-nights resulted in a population estimate of 1,500 to 2,000 kangaroo rats on a total of one half square mile of habitat, in a series of discontinuous populations. Kangaroo rats were most active from March to late July. The total occupied habitat has continued to decline since 1958, as has the total estimated population.

1/ Nongame Wildlife Investigations, Endangered Wildlife Program, E-1-1, Study V, Job 1.12 (December, 1977).

2/ California Polytechnic State University, San Luis Obispo.

DISTRIBUTION AND POPULATION ESTIMATE OF THE MORRO BAY KANGAROO RAT, 1977

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INTRODUCTION

The Morro Bay Kangaroo Rat (Dipodomys heermanni morroensis) has a very limited range on the south side of Morro Bay, California. During the past few years several studies have indicated that the habitat in which these animals are found has been decreasing, and associated with that decrease has been a decline in the kangaroo rat population (Stewart and Roest, 1960; Congdon, 1971; Roest, 1973; Congdon and Roest, 1975). As a result of these studies, the Morro Bay Kangaroo Rat is currently considered "endangered" by the California Department of Fish and Game, and "threatened" by the U. S. Fish and Wildlife Service.

This report presents the results of an investigation conducted from January to August, 1977. The work was authorized by the California Department of Fish and Game (Contract Number S-1312), with the author as primary contractor. The objectives of the investigation were to develop current information on the distribution and abundance of Morro Bay Kangaroo Rats, as well as to obtain information on their population dynamics and on the results of any translocation experiments.

METHODS

Data on distribution was obtained by carefully examining areas that have supported kangaroo rats in the past. If signs of rats were found, such as typical burrows or characteristic tracks showing tail drag marks, live traps were set to confirm the presence of the animals. Areas which are covered by a thick growth of dense brush (chaparral) were assumed to have no kangaroo rats. Areas supporting more suitable habitat in which no sign of rats could be found were also assumed to be unoccupied. Areas in which atypical burrows were found, but live traps produced no kangaroo rats, were also assumed unoccupied. Although these areas were assumed to support no kangaroo rats, a few may be present. In other words, the fact that no evidence of rats was discovered does not prove they are not there. Negative evidence does not prove their absence, although positive evidence always proves they are present. Negative evidence does suggest that either no rats are present, or if they are present, there are so few that the population is minimal.

Information on populations and other biological aspects was obtained from the animals captured in live traps. In one area three quadrats were

established. Each quadrat consisted of 25 traps, in five rows of five traps each. Traps were set at approximately 40 foot intervals. Each quadrat thus covered an area of about 200 by 200 feet, or slightly less than an acre. Relationship of the quadrats to each other, and to the local terrain, is shown in Fig. 2.

Traplines were also established in most areas which showed evidence of kangaroo rats being present. Traplines consisted of a series of stations spaced about 40 feet apart, with two traps at each station. The number of stations varied with each location, depending upon the terrain. Most traplines contained 25 traps (11 stations with two traps, one with three traps), since traps were packed in boxes of 25 each and this was a convenient way to transport them out into the field.

The live traps used were standard Sherman traps, about 3 x 3½ x 9 inches. During the entire study the only bait used was Quaker Old Fashioned Rolled Oats. Except in cold, damp weather the traps and bait were quite satisfactory for catching rats. In cold weather in March a fluff of cotton was placed in each trap to provide nesting material. However, the kangaroo rats did not use the cotton, pushing it aside or trampling it against the bottom of the trap. As a result, two animals died in the traps of exposure. In subsequent trapping it was found that if the traps were set deeply in the sandy soil, and additional sand was piled against the sides and over the top, sufficient insulation was provided to prevent trap losses. The two animals which died were prepared as study skins and are in the Mammal Collection of California Polytechnic State University.

Several kangaroo rats lost the skin from the ends of their tails as a result of the tail being caught in the live trap door. Although this did not seem to disturb them in any significant way, it could be prevented by using a slightly longer live trap.

All kangaroo rats captured in the quadrat area, and nearly all those captured elsewhere in traplines, were ear-tagged with numbered baby chick wing tags, so that individual animals could be identified. Information on sex, relative age, breeding condition, completeness of hip stripe, and any other individual feature were recorded when the animal was captured. A few kangaroo rats escaped before a tag could be attached, and a few more in some traplines were not tagged either.

Total trapping effort comprised 2542 trap-nights (one trap set out for one night equals one trap-night), spread throughout the eight month study. During this time, only 38 different kangaroo rats were captured.

DISTRIBUTION

Many areas which were examined failed to reveal any sign of kangaroo rat burrows or tracks. Stewart (1958) and Stewart and Roest (1960) have previously found kangaroo rats in all these areas. Congdon (1971) and Congdon and Roest (1975) found some areas still occupied, but others no

longer had kangaroo rats present. The areas which were investigated included the following: (See also MAP, Fig. 1)

* Spooner's Cove area - between Spooner's Cove and Hazard Canyon, in Montana de Oro State Park, along the top of the bluff above the ocean, and in sandy areas just back from the bluff. Stewart found rats here in 1958. The area was checked in June 1977, but no evidence of rats was found. However, Stewart visited the area in April 1977, and was certain he saw recent tracks and burrows (in conversation with the author, August 1977). The habitat still appears suitable, and a small population may be present.

Pecho area - area around the DUNES quadrat trapping area shown on MAP, Fig. 1, southward from Morro Bay and between Pecho Road on the east and the sand dunes on the west, and north of the eucalyptus groves near Hazard Canyon. Rats are still present in the DUNES area, but no evidence of their presence was found elsewhere. A trapline just east of the southern tip of the bay (Shark Inlet) failed to catch any rats. Most of this area is now covered with fairly heavy brush, as high as a man's head in some places. A few rats may still occur in scattered locations outside the boundary of the DUNES area.

Mountain area - south and east of the east end of Rodman Drive and the water tank there, southward to the summit of the mountain lying just north of the Hazard Canyon drainage. The area is now covered with very thick, dense chaparral. In 1958 Stewart found a few rats in a burned area near the summit of the mountain. Two years ago a resident at a home near the water tank told me that he occasionally saw kangaroo rats in the vacant lots nearby.

Roderson area - west of Roderson Avenue, between Highland and Travis Drives, and west to Pecho Road. More than half this area is covered with thick brush, the rest is either cleared and under cultivation, or has been built on. Congdon did not find rats here in 1971.

Bayview area - west of Bayview Drive, north to Highland and westward to Roderson Drive, and south to the summit of the ridge. Most of this area is now covered with thick brush, in which there are probably no kangaroo rats. About 50 acres of more open habitat remains, and still supports a fair population of kangaroo rats (MAP, Area BV).

Southeast area - both sides of upper Bayview Drive, lying east of the water tank where Bayview turns southeastward (marked WT on MAP), as far east as the sandpits above Los Osos Creek, north to Los Osos Valley Road, and south to the summit of the ridge. Many homes have been built in this area, or are currently under construction. Undeveloped land in the area

is covered with thick brush. Congdon found no kangaroo rats here in 1971.

Willow Drive area - north of Los Osos Valley Road, between the new Morro Bay-Los Osos Road and the Buckskin area (BK on MAP), northward to Sage Avenue, Junior High South (JS) and Easttern (E) areas. Many homes have been built in this area, and the drainage channels feeding Eto Lake are covered with a dense growth of live oaks, willows, and poison oak. Some vacant land still supports apparently suitable kangaroo rat habitat, but no sign of rats was found. Congdon reported rats here in 1971.

Nipomo area - north and south of Nipomo Avenue, between 11th Street on the west and the new Morro Bay-Los Osos Road on the east, north to Santa Ysabel Avenue and south to Los Osos Valley Road. Many new homes have been built in this area, or are still under construction; new roads have been extended to serve the homes. Undeveloped land in patches of various sizes and shapes remain which still appear to be suitable kangaroo rat habitat. However, most of these areas are small and are frequently disturbed by dogs, cats, children, vehicles, and similar factors; most are very close to occupied homes. Kangaroo rats were still present in an area just east and south of the Baywood Park water tank (W on MAP), but were not found elsewhere. Congdon found kangaroo rats in some of this area in 1971.

Bridge area - north of Santa Ysabel, to the shore of Morro Bay and eastward to the new Morro Bay-Los Osos Road. Homes and thick brush cover much of the area, but some apparently suitable habitat remains. A trapline (25 traps) was run here for three nights, but no rats were captured, and no burrows or tracks were observed. Congdon found no signs of rats here in 1971.

* Extension area - east of Los Osos Creek and south of Turri Road, on a low ridge of hills running east/west. In 1958 Stewart found a few kangaroo rats in isolated colonies here, and since then one rat was found dead on Turri Road. Suitable habitat still appears to be present, and burrows were found, but no tail drag tracks were seen. Fifteen traps set here for three nights caught no kangaroo rats. Congdon did not check this area in 1971.

(An asterisk - * - indicates the area is not shown on the MAP, Fig. 1.)

The remaining area within the original range of Morro Bay Kangaroo Rats - west of 11th Street, south of Santa Ysabel and Morro Bay itself, and north of Los Osos Valley Road - is so built up that even the vacant lots scattered through it apparently support no rats.

The remaining areas shown on the MAP (Fig. 1) had burrows present,

tail drag marks were found, and live trapping resulted in the capture of kangaroo rats. An effort was made to determine the exact boundaries of each of these areas, as judged by appropriate habitat, burrows, and tracks. These areas are indicated with a dashed red line on the MAP, Fig. 1, and each area is identified with one or two letters. A key to the identification symbols is presented in the KEY FOR MAP, page 6, and each area is briefly discussed below:

DUNES - this area between Pecho Road and the sand dunes involves about 22 acres. Vegetation is low, usually less than 2 feet high, and annual plants are present in moderate densities. Three quadrats were established in this area, and four trap lines were run near them. During the course of the study, seven different kangaroo rats were captured here (Nos. 910, 912, 917, 923, 924, 925, and 926), some of them repeatedly over a period of several months. Details of trapping patterns and trapping results are presented in Fig. 2 and Table 1.

BV - Bayview area - about 50 acres of this area lying west of Bayview Drive and south of Highland Drive is kangaroo rat habitat. Brush is scattered, varying in height from one to three feet, with annual plants present in slightly greater densities than in the DUNES area. Five different kangaroo rats were captured here in two traplines, three of which were given ear tags (Nos. 929, 930, 931). Trapping results from this area, and from the following areas (below) are presented in Table 1.

W - Watertank area - about 15 acres lying east and south of the main watertank supplying Baywood Park, which is about one block south of Santa Ysabel Avenue, near the end of 16th Street. Two kangaroo rats were captured here in one 25 trap trapline.

N - Northern area - less than 6 acres just north of Santa Ysabel Avenue and east of the new Morro Bay Los Osos Road. Scattered manzanita shrubs with very little annual vegetation. Burrows and one set of tracks suggest a few rats live here. No traps were set here.

SY - Santa Ysabel area - about 24 acres lying southeastward from near the east end of Santa Ysabel Avenue. This small valley is shielded from prevailing winds by a low ridge along its southwestern side, and is nearly completely ringed with low live oak woodland. To the east a row of tall eucalyptus trees mark the boundary. Vegetation is relatively lush, with an abundant growth of annual plants and good cover in the form of low Prunus type vegetation (deciduous, with an abundance of thick twigs, rarely over 18 inches high). A trapline set here produced a total of 12 different kangaroo rats (901, 903, 904, 905, 906, 907, 908, 914, 915, 916, 918, 922). This appears to be the best remaining area for kangaroo rats.

KEY FOR MAP

——— Route of new road from just north of Los Osos Creek Bridge to Los Osos Road

– – – – – Boundaries of areas where kangaroo rats were found, indicating approximate area of suitable habitat

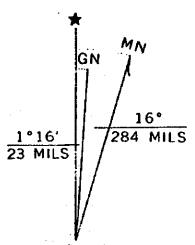
Trapline just east of Shark Inlet

Areas trapped by Stewart (1957-58)

Identification of kangaroo rat areas:

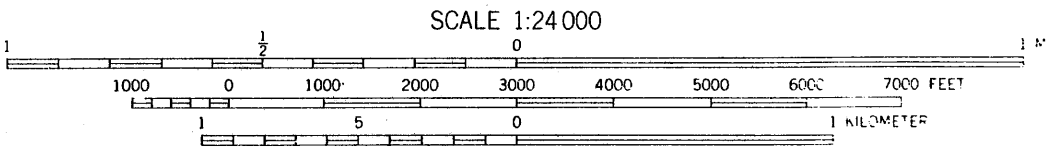
DUNES	Quadrat area east of sand dunes; 22 acres
BV	Bayview area; 50 acres
W	Watertank area; 15 acres
N	Northern area; 6 acres (not trapped)
SY	Santa Ysabel area; 24 acres
JN	Junior High North area; 7.5 acres
JE	Junior High East area; 33 acres
JS	Junior High South area; 11 acres
E	Eastern area; 18.5 acres
BK	Buckskin area; 44 acres

Total area occupied by kangaroo rats: 231 acres



UTM GRID AND 1965 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000



CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOWER LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 4 FEET

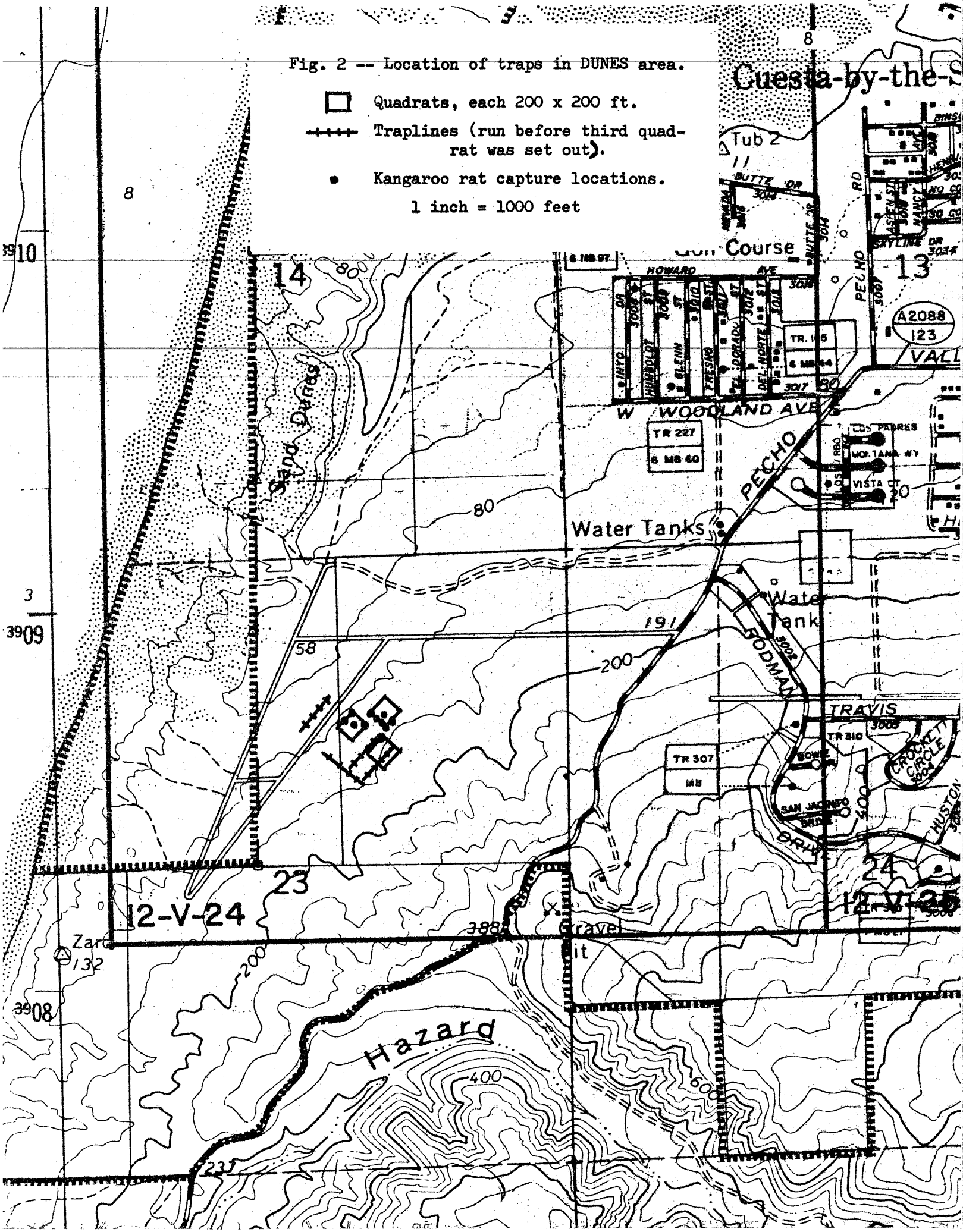
Fig. 2 -- Location of traps in DUNES area.

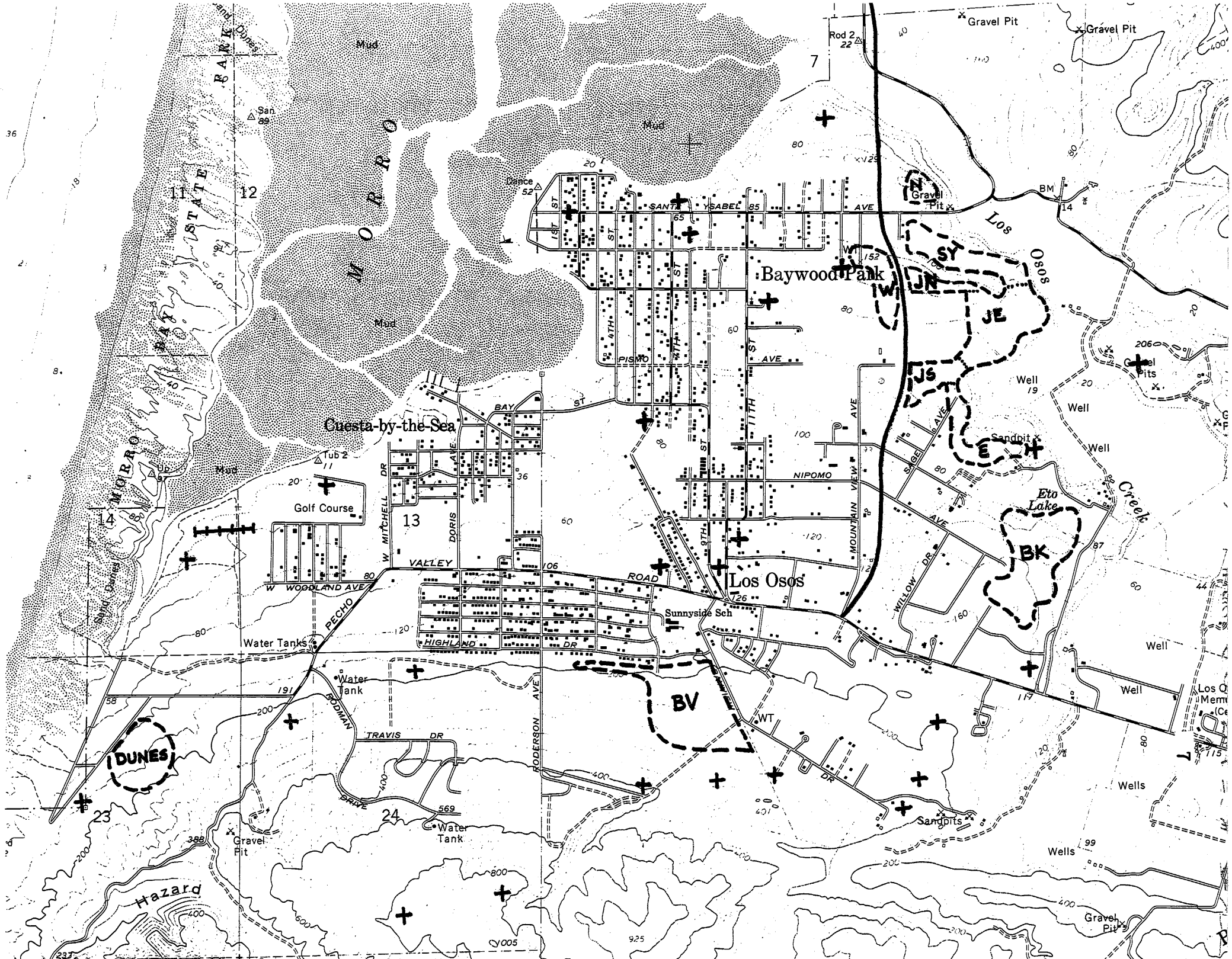
Quadrats, each 200 x 200 ft.

Traplines (run before third quadrat was set out).

Kangaroo rat capture locations.

1 inch = 1000 feet





Mud
Sand Dunes
MORRO BAY STATE PARK
MORRO
Baywood Park
Cuesta-by-the-Sea
Los Osos
Golf Course
Sunnyside Sch
Water Tanks
Water Tank
Gravel Pit
Sandpits
Eto Lake
Los Osos Creek
Hazard
Well
Wells
SANTA YSABEL AVE
PISMO AVE
BAY ST
NIPOMO AVE
VALLEY ROAD
W WOODLAND AVE
HIGHLAND DR
TRAVIS DR
RODMAN DRIVE
RODERSON AVE
W MITCHELL DR
DORIS AVE
PECHO
MOUNTAIN VIEW AVE
SAGE AVE
WILLOW DR
SY
JN
JE
JS
W
E
H
BK
BV
DUNES

JN - Junior High North area - 7.5 acres lying just north of the access road for the new Junior High School, along the top of the ridge. Two kangaroo rats were captured here in a 25 trap trapline. Vegetation is similar to the BV area, but somewhat more disturbed during the construction work for the Junior High.

JE - Junior High East area - about 33 acres lying east of the new Junior High School, extending eastward to the top of the low bluff above Los Osos Creek. Near the Junior High the vegetation is similar to that of JN and BV. A line of tall eucalyptus trees, some of which have recently been cut down, separates this area from the more eastern portion, which was formerly a cultivated field. The field is slowly developing a vegetation of lupines and annual plants. A trapline set here captured 2 kangaroo rats.

JS - Junior High South area - about 11 acres lying south of the new Junior High School and east of the new Morro Bay-Los Osos Road. Vegetation is sparse, with some patches of low brush; annual plants are not abundant. One kangaroo rat was trapped here.

E - Eastern area - about 18.5 acres running just above the live oak and willow woodland west of Los Osos Creek, to near the summit of a low ridge running eastward from Sage Avenue. Two kangaroo rats were captured here. Vegetation is similar to that in JE - a mixture of open field gone fallow and moderate brush growth.

BK - Buckskin area - about 44 acres lying north and east of the end of Buckskin Drive. Vegetation consists of thin brush and very scattered annual plants; the area appears to be very dry. Three kangaroo rats were captured here (Nos. 911, 920, 921).

The various areas listed above have a combined total of only 231 acres, which is approximately 0.36 square miles. In addition, some of the areas indicated as <u>not</u> supporting kangaroo rats (pages 3 and 4) may support small colonies which were missed during the present study. This is particularly possible for the Spooner's Cove, Pecho, Willow Drive, Nipomo, and Extension areas. Assuming that such colonies do exist, it is estimated that the total additional occupied area is probably less than 100 acres.

POPULATION ESTIMATE

Trapping periods and the results of trapping are indicated in Table 1, on page 9. Ratios of kangaroo rats captured per trap night, times 100, and of trap nights per kangaroo rat, are also presented. These figures provide the basis for developing population estimates on the various areas which still support kangaroo rats.

TABLE 1. Results of trapping for each trapping period, January through August, 1977, in areas which produced kangaroo rats.

Month/Day	Area Trapped	Trap Nights	Kangaroo Rats Trapped	Relative Abundance: $\frac{KR}{TN} \times 100$	Trap Nights per Kangaroo Rat TN/KR
1/29, 1/30	DUNES	100	0		
2/18, 2/19, 2/20	DUNES	150	0		
	Buckskin	60	0		
3/11, 3/12, 3/13	DUNES	150	1	0.6	150
	Buckskin	102	1	1.0	102
	Santa Ysabel	96	8	8.3	12
4/15, 4/16, 4/17	DUNES	150	3	2.0	50
	Buckskin	48	2	4.1	24
	Santa Ysabel	75	8	10.6	9
	Jr Hi South	48	1	2.1	48
5/24, 5/25, 5/26	DUNES	294	5	1.7	59
6/7, 6/8	DUNES	174	4	2.3	44
6/29, 6/30, 7/1	DUNES	225	5	2.2	45
7/8, 7/9, 7/10	Jr Hi North	75	2	2.6	38
	Jr Hi East	75	2	2.6	38
	Eastern	75	2	2.6	38
	Watertank	75	2	2.6	38
7/29, 7/30, 7/31	Bayview	150	5	3.3	30
8/7, 8/8, 8/9	DUNES	225	1	0.4	225

Although a great deal of trapping effort was expended (2542 trap nights total), very few kangaroo rats were captured during the eight month study. As a result, conventional techniques for calculating populations were felt to be inappropriate. The estimates developed below are felt to be reasonable on the basis of the data available.

One method of estimating the population is based on the assumed "territory" controlled by each kangaroo rat. Twelve different kangaroo rats were recaptured one or more times, usually in the same trap of original capture, but often in other traps. It was found that the average distance between recaptures, during a single trapping period of two or three days, was about 75-80 feet. In one case the animal moved over 200 feet, but the

vast majority of recaptures were in the same trap of original capture. On the basis of this information, the assumption was made that each kangaroo rat would not permit another kangaroo rat to establish a home burrow within 50 feet of its own burrow. This assumed "territory" for each kangaroo rat was thus a circle with a radius of 50 feet, covering an area of about 7850 square feet, or 0.18 acre. Further calculation produces a density value of 5.5 kangaroo rats per acre.

In comparison, Stewart (1958), dealing with much higher densities of kangaroo rats, calculated their home ranges in three different areas to be 0.08, 0.08, and 0.07 acres, respectively. Using the 0.08 acre home range as a standard, this provides a home range area of 3485 square feet, and provides a population density figure of about 12.5 rats per acre. These figures correlate well with other population information reported by Stewart.

If we assume that the "territory" estimate developed above is reasonable, then 5.5 kangaroo rats per acre, times 231 acres, produces a total population estimate of 1270 kangaroo rats.

A second method of estimating the total kangaroo rat population is to determine the number of kangaroo rats captured per acre on each area which was trapped. Since the number of rats captured varied from month to month in each area, only data from April and July seem to be comparable. See Table 2.

Table 2. Seasonal change in trapping success; kangaroo rats captured and kangaroo rats per trap night times 100 (in parentheses).

	Month:							
Area Trapped:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
DUNES	0	0	1(0.6)	3(2.0)	5(1.7)	4(2.3)	5(2.2)	1(0.4)
Buckskin			1(1.0)	2(4.1)				
Santa Ysabel			8(8.3)	8(10.6)				
Jr Hi South				1(2.1)				
Jr Hi North							2(2.6)	
Jr Hi East							2(2.6)	
Eastern							2(2.6)	
Watertank							2(2.6)	
Bayview							5(3.3)	

Each area had traps out which covered a particular acreage. The DUNES area, for example, caught kangaroo rats only in the three quadrats,

with a total acreage of about 3 acres. In the traplines, each station sampled an area of about 40 x 40 feet, since stations were 40 feet apart. Thus each station sampled 1600 square feet. From this it is simple to calculate the total square feet sampled by the trapline and convert it to acres, and then extrapolate this value to a density value of kangaroo rats per acre, as in Table 3. A total population of 1522 is developed this way.

Table 3. Density estimate based on actual trapping results.

Area Trapped	Month Trapped	Acreage Sampled	No. Rats Caught	Rats per Acre	Total Acres	Population Estimate
DUNES	April	3.0	3	1	22	22
Santa Ysabel	April	0.44	8	18	24	432
Buckskin	April	0.29	2	7	44	308
Jr Hi South	April	0.29	1	3	11	33
Jr Hi North	July	0.44	2	5	7.5	38
Jr Hi East	July	0.44	2	5	33	165
Watertank	July	0.44	2	5	15	75
Eastern	July	0.44	2	5	18.5	93
Bayview	July	0.88	5	6	50	300
				Totals:	225	1466
Northern	not trapped			est. 2	6	12
				Grand Total:	231	1478

A variation of this technique involves calculating the average number of kangaroo rats per acre (sum of Rats per Acre column = 57) and divide by the number of entries (10). This gives an average density of 5.7 rats per acre. Multiplied by the total number of acres (231), a population estimate of 1317 is developed.

Still a fourth way of developing a population estimate is to develop relative population densities into estimates of rats per acre. At the Santa Ysabel area, the trapping success suggests that densities are close to those encountered by Stewart in 1958. During April, 7 rats were trapped in a trapline covering 17600 square feet (11 stations, 1600 square feet per station), or approximately 2514 square feet per rat. At that density, an estimate of 17 rats per acre seems reasonable (acre/square feet per rat, or 43560/2514 = 17.3). The relative abundance figures for each area can then be converted to rats per acre figures, as shown in Table 4.

Table 4. Density and population estimate based on relative abundance values (kangaroo rats/trap night x 100) for each area. The basic ratio is developed from the Santa Ysabel area, which had 'normal' population density. In that area, the relative abundance value is about 10, which produces a population estimate of about 17 rats per acre: 10/17 basic ratio, which can be simplified to 0.588. Relative abundance values can then be converted to population estimates for each area by setting up a proportion:

$$\frac{10}{17} : \frac{\text{rel. abun. each area}}{x} \quad \text{OR} \quad x = \frac{\text{rel. abun.}}{0.588}$$

The result is that x is the population estimate for each area. Relative abundance values are for April and July, as before.

Area Trapped	Basic Ratio	Rel. Abun.	Rats/Acre	Acres	Pop. Est.
Santa Ysabel	0.588	10	17	24	408
Buckskin	0.588	4.1	7	44	308
Jr Hi South	0.588	2.1	3.6	11	40
Jr Hi North	0.588	2.6	4.4	7.5	33
Jr Hi East	0.588	2.6	4.4	33	145
Watertank	0.588	2.6	4.4	15	66
Eastern	0.588	2.6	4.4	18.5	81
Bayview	0.588	3.3	5.6	50	280
DUNES	0.588	2.1 (est)	3.6	22	80
Northern	(not trapped)		2 (est)	6	12
				Total:	1453

In order to simplify the results of the four different methods of estimating the total population given above, a brief summary is presented at this point.

Method 1 - based on assumed average territory size - estimate: 1270

Method 2 - based on rats captured per acre for each area: 1478

Method 3 - based on average number rats captured per acre: 1317

Method 4 - based on proportional relative abundance: 1453

Although each of these methods is somewhat unorthodox, the approaches and logic involved seem appropriate to the small amount of actual data available. The fact that all four estimates fall into the same general size range suggests that the actual total population, if it had been based on more abundant data, would probably be in the same general size range.

The estimates developed above involve only the areas in which kangaroo rats were actually captured. As mentioned previously (p. 8), small groups of kangaroo rats may still be present in areas which were thought to be unoccupied when examined during this study. As indicated, such areas might total an additional 100 acres. At an estimate of about 5 rats per acre for such areas, an additional 500 rats may still exist. This estimate should be added to any of the four estimates developed for known occupied areas.

As a final population estimate for Morro Bay Kangaroo Rats, based on information available at the conclusion of this study, the number is between 1500 and 2000 kangaroo rats.

Some additional comment should be made concerning the data obtained in 1977. This year is the second of two years with less than normal rainfall. Conditions throughout the area, and in the kangaroo rat range as well, are very dry. During this study the highest population was found in the Santa Ysabel area, which is shielded from wind and surrounded by trees. Plant growth was most abundant in this area, including both perennials and annuals, and as a result food for kangaroo rats was plentiful. In all other areas where rats were found, conditions were quite dry, and plant growth was considerably less than at Santa Ysabel. Even to an inexperienced observer, conditions were less suitable in the other areas. Although direct evidence is not available, it seems clear that in years of more normal rainfall, food abundance would be greater than it is in 1977. Kangaroo rat densities, and resulting populations, should also be greater in normal years.

BIOLOGICAL INFORMATION

The present study extended over a period of 8 months, and resulted in the repeated capture of several individual animals. A variety of information can be gleaned from the catch data.

Seasonal Activity - Table 2 (p. 10) presents information regarding seasonal changes in kangaroo rat activity. At the beginning of the study, in January and February, no rats were captured. At that time the weather was rather cold, dropping below 40° F. many nights. Most burrows were apparently not in use -- dirt partially filled most, and spider webs were seen across many of the remaining openings. No tracks were observed.

Activity commenced in March and continued at least through July. In August only the DUNES area was trapped, but only a single animal was captured. August is the beginning of summer dormancy for many organisms, and it would appear that kangaroo rats also become inactive. Food is scarce at this time, and will probably not become available again until after the first rains.

The data suggest an annual activity pattern which begins in early spring, continues through the summer months, and then subsides again in the fall. Later in the fall, when early rains bring out some plant

growth, activity probably commences again, except in particularly cold or wet weather. Details of this period (late summer through winter) are not certain, and should be checked in future studies.

Breeding Activity - Reproduction apparently follows the same pattern as that of Seasonal Activity. Juvenile kangaroo rats were captured each month from March through August, and adult lactating females also. Three juveniles were taken in March, and two in July, and only one every other month of the study. This suggests a major period of breeding early in the spring. Evidence obtained from other areas in this region (different subspecies of *D. heermanni*) shows a similar pattern, with a probable resurgence of breeding activity in the fall. Stewart (1958) also reported the strong probability of two peak reproductive seasons, spring and fall, with some young being born throughout the summer months.

Sex Ratios - Among the adult kangaroo rats captured, males predominated, with 17 adult males compared to 9 adult females. The ratio among juvenile kangaroo rats was 4 males and 6 females. The high number of males captured may be explained by the fact that they are more active aboveground, while females with young stay in their burrows more.

Age - Several kangaroo rats were recaptured one or more times after being tagged, providing an opportunity for developing information on their ages. This is summarized below:

Animal No.	904 F	tagged on 11 March;	last captured on 17 April:	37	days
	905 F	11 March	16 April	36	
	908 M	12 March	17 April	36	
	910 F	12 March	1 July	111	
	912 F	15 April	1 July	105	
	917 M	16 April	1 July	104	
	925 M	8 June	7 August	60	

All other rats captured and tagged were either never recaptured again, or were retrapped within two or three days, during the same trapping period. Numbers 910 and 912 apparently developed a real 'trap habit', being recaptured 10 and 6 times each, respectively. Number 917 was recaptured 4 times.

COMPARISON WITH PREVIOUS STUDIES

Congdon and Roest (1975) summarized the information on total area of suitable habitat and on population estimates as determined from earlier studies. Their Table 2 is repeated here, and corresponding data from the present study is added, as well as data on total population estimates and area of suitable habitat (Table 5, p. 15).

From the information in Table 5 it can be seen that the total range of the Morro Bay Kangaroo Rat has continued to decrease through the years. The value for 1977 (this study) was calculated by using a figure of 331 acres for the present total habitat area (231 acres as mapped, plus 100 acres of possible undetected area).

Table 5. Comparison of results obtained in different studies; in part from Congdon and Roest (1975). TN/KR = trap nights/kangaroo rat.

Study	Season	TN/KR Total Study	TN/KR Pecho Area	Population Estimate	Area of Occupied Habitat
Stewart, 1958	August November	7 9	18 8	8000	2.2 Sq. Mi.
Congdon, 1971	May-June	47	70	3000	1.4
Roest, 1973	August	133	330		
This study, 1977	Jan.-Aug.	67	209	under 2000	0.52

It should be noted that the effort necessary to capture a kangaroo rat (trap nights/kangaroo rat) seems always to be higher in August, as it was in this study (Table 1, p. 9). This is probably another way of recognizing the reduced activity that kangaroo rats appear to show in the late summer period. Spring activity is reflected well, and Stewart's study suggests the increased activity in late fall.

SUMMARY

1. The area still occupied by kangaroo rats totals 231 acres, plus an additional area of about 100 acres or less which may be occupied, although no rats were captured. Total area still occupied is about ½ square mile.

2. The population of kangaroo rats on known occupied areas lies somewhere between 1270 and 1478 animals. An additional maximum of 500 animals may be found on areas where no animals were captured. The total current population is estimated to be less than 2000 animals.

3. Seasonal activity patterns suggest that kangaroo rats are most active from about March until late July, then become less active until after the first fall rains. Activity is also reduced by low night temperatures or heavy rain. Activity patterns may affect trapping success.

4. Breeding probably occurs throughout the active periods of the year, but shows peaks in early spring and in the fall.

5. Kangaroo rats may continue to occupy a particular area for over three months.

6. Comparison with earlier studies indicate that the total occupied habitat of the Morro Bay Kangaroo Rat has continued to decline since 1958, as has the total estimated population.

LITERATURE CITED

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APPENDIX: Translocation experiment

Originally this study had been planned to include experiments in translocating kangaroo rats from areas which were scheduled for nearly immediate construction of homes, to other areas where such disturbance was unlikely. This aspect of the study was not conducted, for several reasons:

It was not possible to determine readily which new areas were to be built upon, hence the possibility of capturing animals in such locations was eliminated.

As the study progressed, it became clear that very few kangaroo rats would be captured for any purpose. Those few which were captured were released at the site where they were caught to provide further information as they were recaptured.

Perhaps because of the two-year drought which the area has suffered, apparently all populations were at a low level, probably marginal. If kangaroo rats were to be released in a suitable area which already had a population, the drain on available food might be such as to cause the death of translocated or resident animals.

If translocation is attempted in the future, care should be taken to give the translocated animals every chance for survival:

Provide an artificial burrow, even though very simple, into which the translocated animal can be released. Without this minimal cover, translocated animals are not likely to survive.

Do not translocate animals unless the area receiving them has abundant food resources. Translocation should not be attempted in cold or wet weather, or during the inactive period of late summer. Good times to attempt translocation would be in the spring or in late fall, after early rains have started the growth of vegetation.

APPENDIX: Other species of mammals trapped in this study

In the course of this study, the only other small mammals which were captured in the live traps were:

Peromyscus maniculatus, Deer Mouse. Several were captured at the Dunes area and at the Santa Ysabel area.

Peromyscus boylei, Brush Mouse. Several were captured at the Santa Ysabel area.

Lepus californicus, Black-tailed Jack Rabbit. One juvenile was found jammed into a live trap at the DUNES area.

APPENDIX: Rare plants of the Pecho area

Dr. Dirk Walters, botanist at California Polytechnic State University, visited the area between Pecho Road and the sand dunes (the Pecho area, as described on p. 3 of this report) in June, 1977. He reported a number of plants which have been recognized as 'rare' by the State Organization of the California Native Plant Society. These plants are listed below, with Dr. Walters' comments:

Arctostaphylos morroensis Morro Manzanita

Restricted to the southern portion of the area; may be elsewhere on very stabilized dunes.

Erigeron foliosus var. blochmanae Blockman's Leafy Daisy

Not specifically identified, but Hoover (The Vascular Plants of San Luis Obispo, California, 1969) states that it is relatively common on the dunes south of Morro Bay. It should be here, but is easily confused with other daisy-like composites.

Pholisma arenarium Pholisma

A parasitic plant that grows associated with the dominant plant Ericameria ericoides (Mock Heather). It is found throughout the area.

Senecio blochmaniae Dune Shrubby Groundsel

Prunus punctata Sand Almond

Monardella undulata var. undulata Morro Dune Western Pennyroyal

These three species are all locally abundant in the area. They are all listed as rare, but not considered endangered at this time.

Eriastrum densifolium var. patens Morro Dune Phlox

This variety is not listed on the state list, but is considered to be very restricted by Hoover in his S.L.O. County flora. It is a variety described for the first time by Hoover in that work. Its position needs to be evaluated.