# DISTRIBUTION AND ABUNDANCE OF SAN JOAQUIN KIT FOX

*Draft Final Report to the Department of Fish and Game*

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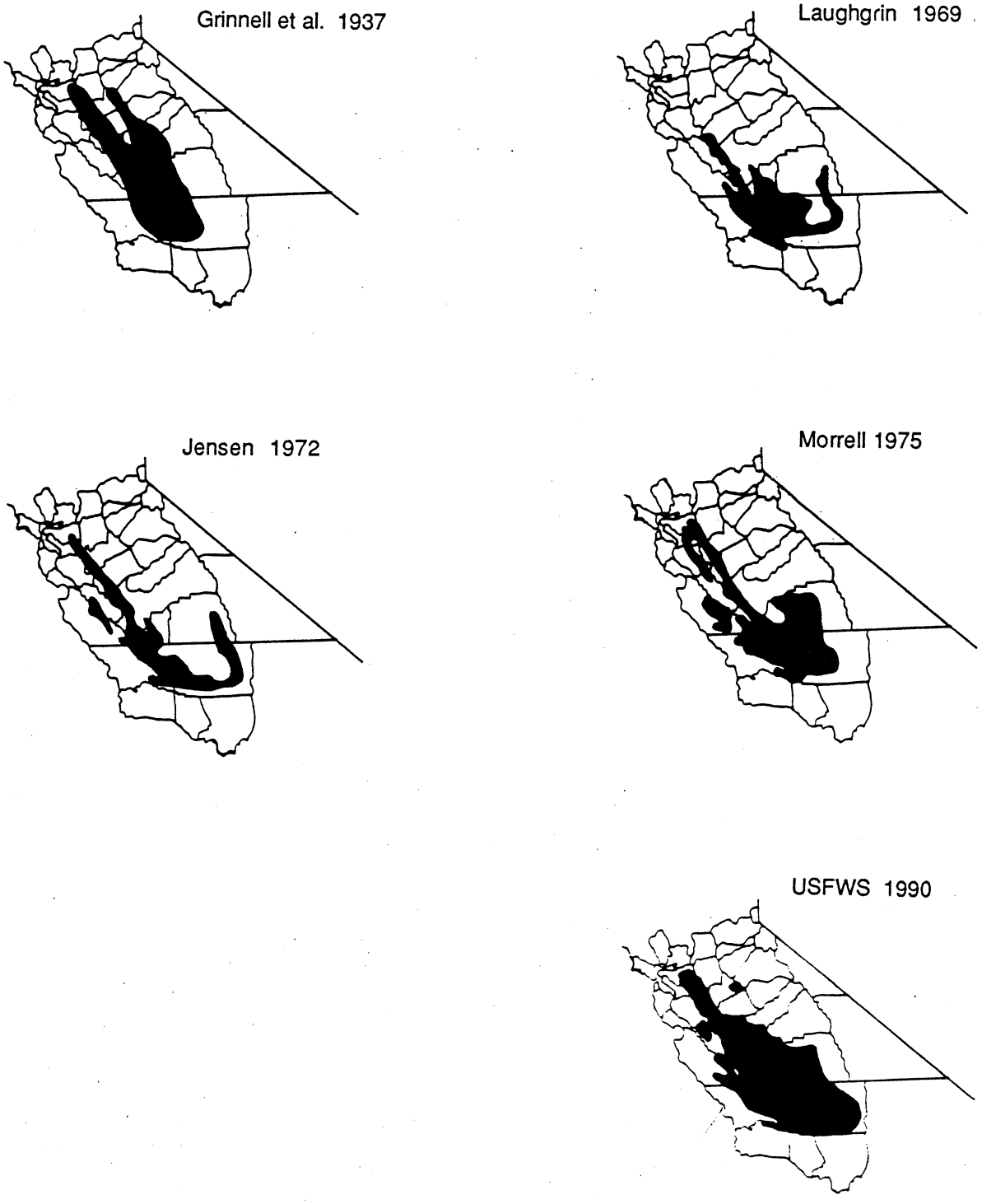
The San Joaquin kit fox (*Vulpes macrotis mutica*), a subspecies of kit fox which inhabits portions of the San Joaquin Valley, has been federally protected since 1967 when it was listed under the 1966 Endangered Species Preservation Act (Fig. 1). This subspecies has retained the status of "endangered" through the current Endangered Species Act (ESA) of 1973, and its amendments in 1978 and 1982. In 1971 the state of California listed the San Joaquin kit fox as rare under the state Endangered Species Act; it was relassified as threatened in 1982 when state categories were revised.

The published range of the San Joaquin kit fox has changed many times since the subspecies was named in 1902 by Merriam (as *Vulpes muticus*). The original range defined by Grinnell et al. (1937) encompassed much of the San Joaquin Valley but is significantly different from the range boundaries published by the US Fish and Wildlife Service (USFWS) in 1990 (Fig. 2). Information for range maps of the early 1900's was gathered from ranchers and farmers who snared and shot kit fox; considering them vermin. As native habitat continued to be altered and kit fox numbers decreased, the sources of information changed. The literature of the 1960's and early 1970's lists road kills, active dens identified by state personnel, and occasional reports of kit foxes by landowners. Additional information became available in the 1970's when the California Department of Fish and Game (CDFG) initiated quarterly night spotlight surveys along specified road transects to monitor trends in kit fox numbers. Radio-telemetry studies designed to gather information on home range size, and aerial surveys to count active dens for distribution and abundance estimates provided additional data. In the 1980's, biological surveys conducted for Environmental Impact Reports (EIR's), using night spotlight surveys, den searches, track stations, and baited or automatic camera stations, became yet another source of information on kit fox presence.

Figure 1. San Joaquin Valley and associated counties with USFWS SJKF range boundary.

Figure 2. San Joaquin kit fox range boundaries from 1937 - 1990.



The current distribution and abundance of the San Joaquin kit fox is not completely known, and although over 20 years of data are available from the CDFG road transect night spotlight surveys conducted in Fresno, Kern, Madera, and San Luis Obisbo Counties, these data were never analyzed nor this method's effectivness examined.

Two areas of California are the most uncertain as to current distribution and abundance. Neither of these areas were included in CDFG night spotlight road transect surveys. The first area is the east side of the San Joaquin Valley as it approaches the foothills of the Sierra Nevada, from the town of La Grange, in Stanislaus County, south into Fresno County (Fig. 1). This area is of interest because of two kit fox sightings in 1973 and 1989 near La Grange in the southwestern corner of Stanislaus County. It is not known whether these kit fox were isolated from the major population of kit foxes further south in Fresno County, or if there is a continuous, yet undocumented, range of kit fox along the east side of the San Joaquin Valley.

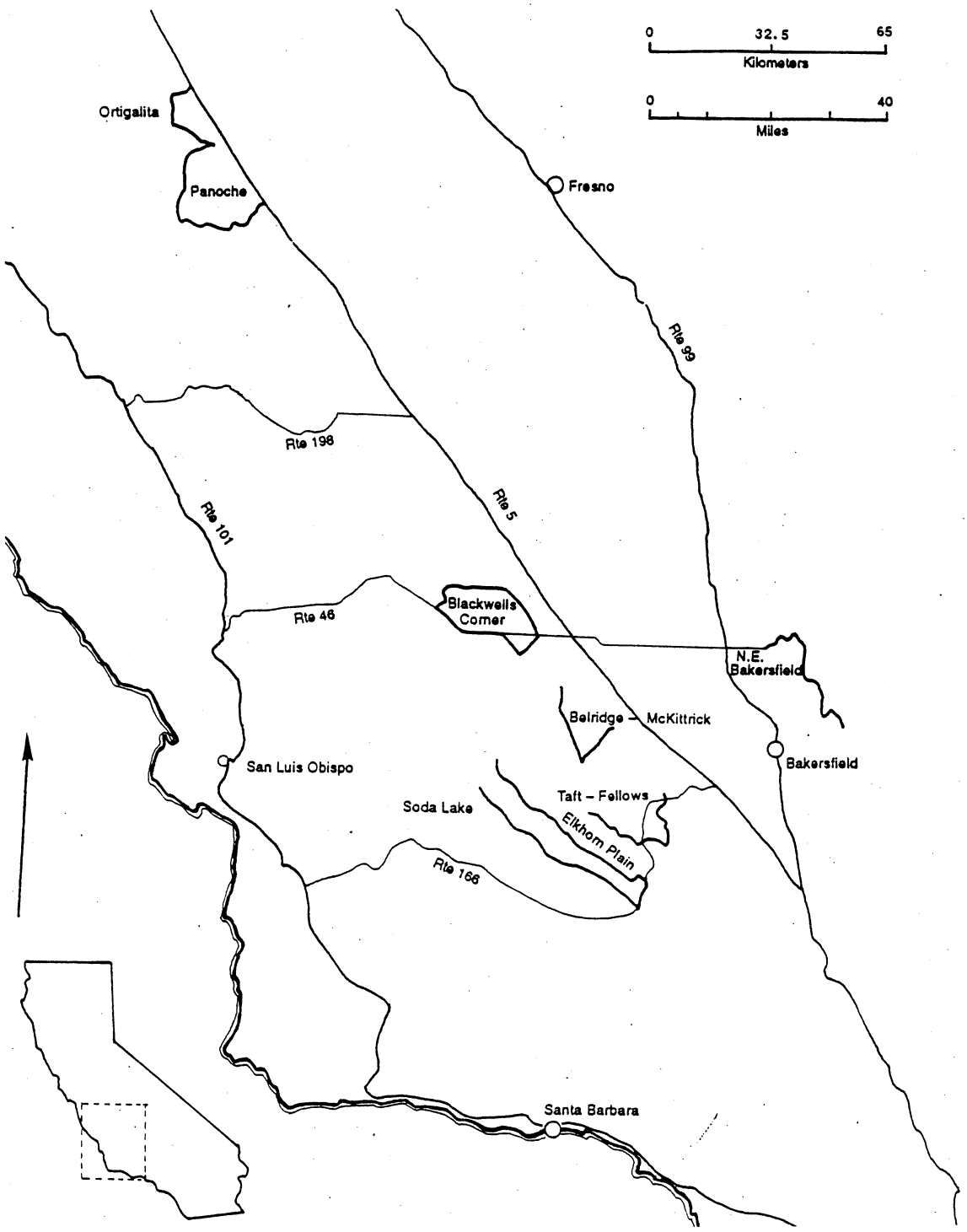
The second area encompasses eastern Contra Costa and Alameda Counties, and the western edge of San Joaquin County. Some of this area has come under extreme pressure from developers, with both grasslands and agricultural areas being converted to suburban homes and light industry.

In the spring of 1993, CDFG awarded us a contract to collect additional data on the distibution and abundance of the San Joaquin kit fox. We analyzed the CDFG spotlight survey data, conducted preliminary work for a series of kit fox surveys along the eastern side of the San Joaquin Valley, and planned and conducted kit fox surveys in Alameda and Contra Costa Counties. This report presents the results of our work.

ASSESSING KIT FOX ABUNDANCE BY SPOTLIGHT SURVEYS

Nocturnal spotlighting or nightlighting has been used to census a variety of wildlife species, including hares (Barnes and Tapper 1985), deer (Progulske and Duerre 1964) and red foxes (Stahl 1990, Stahl and Migot 1990, Weber et al. 1991). In 1970, the

Figure 3. Location of the seven original survey routes and the Soda Lake route added in 1989.



during the day and categorized sighting distances based on physical features (which remained constant over the entire survey period), visibility quality based on current vegetation, and the predominant vegetation type by half-mile intervals. The effect of physical features on sighting distance was scored in three categories: 1) <75 m visibility; 2) 75-250 m visibility, and 3) 250 m (to the limit of the light beam). "Visibility quality" was scored according to five classes of vegetative cover ranging from impenetrable with few or no openings (class 1, poorest visibility) to sparse, short, or no vegetation (class 5, highest visibility). The predominant vegetation was scored as either: 1) perennial shrubs (*Ephedra, Allenrolfea,* or *Atriplex*); 2) tall or bushy annual plants; 3) short annual plants or fallow; or 4) non-native grassland and perennial shrubs.

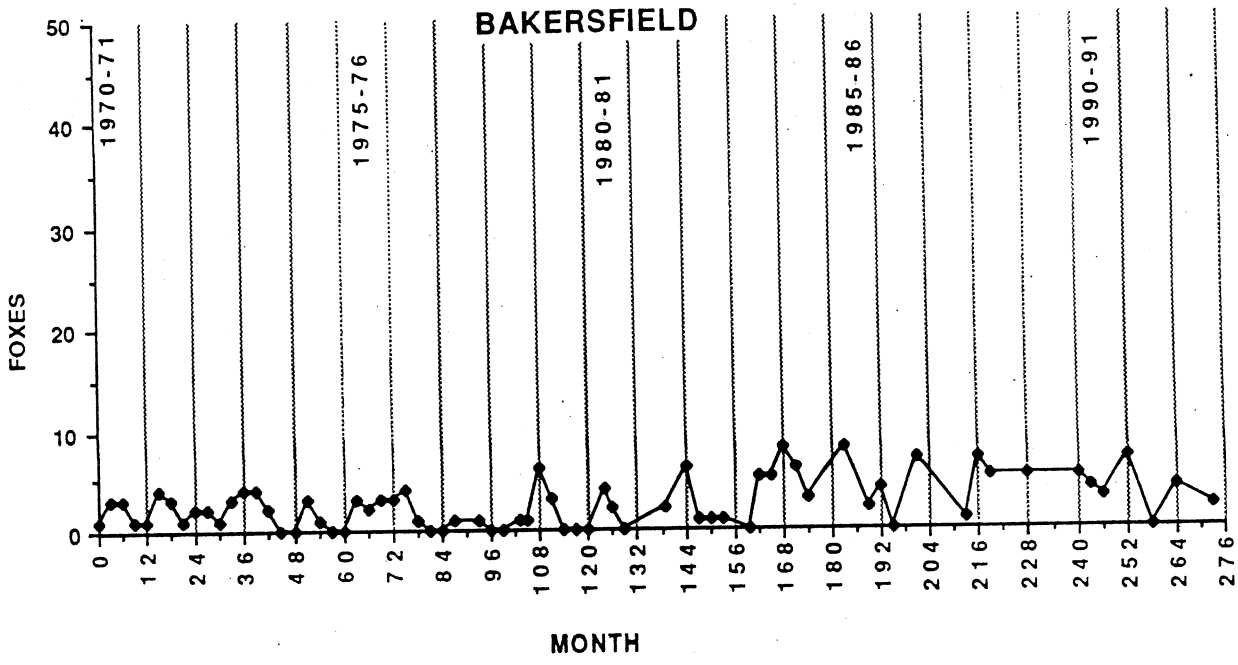
Annual precipitation data for the Elkhorn Plains route were recorded at the Washburn Ranch on Soda Lake Road, and was provided by the San Luis Obispo County Engineering Office.

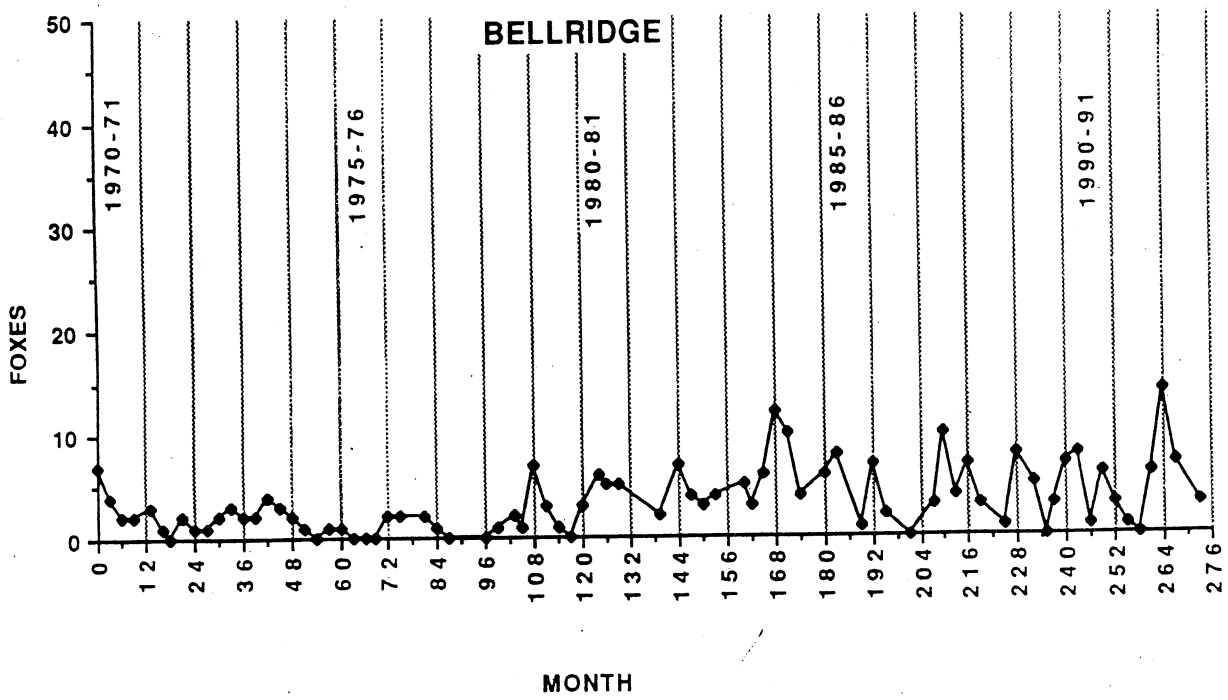
CDFG provided us with the survey data as a D-Base file. We summarized the data using D-Base, Lotus 123, and Excel spreadsheets, and used various numerical techniques for analysis. Some short computer programs were written in BASIC language as aids to the analysis.

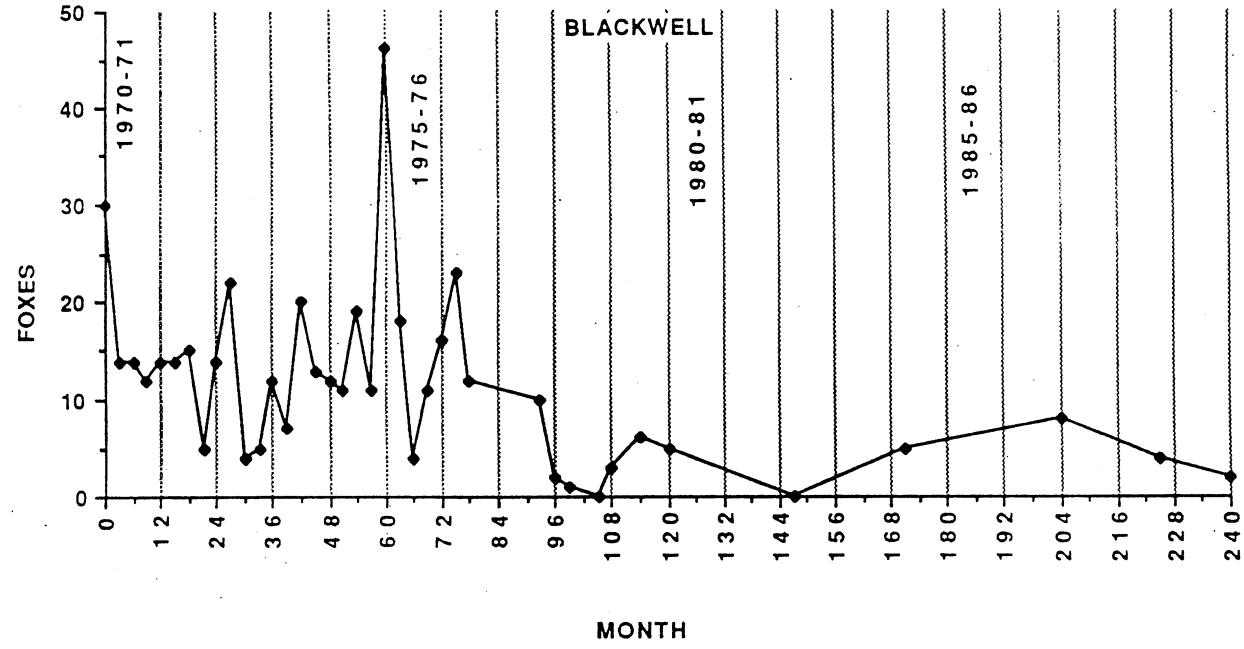
Results

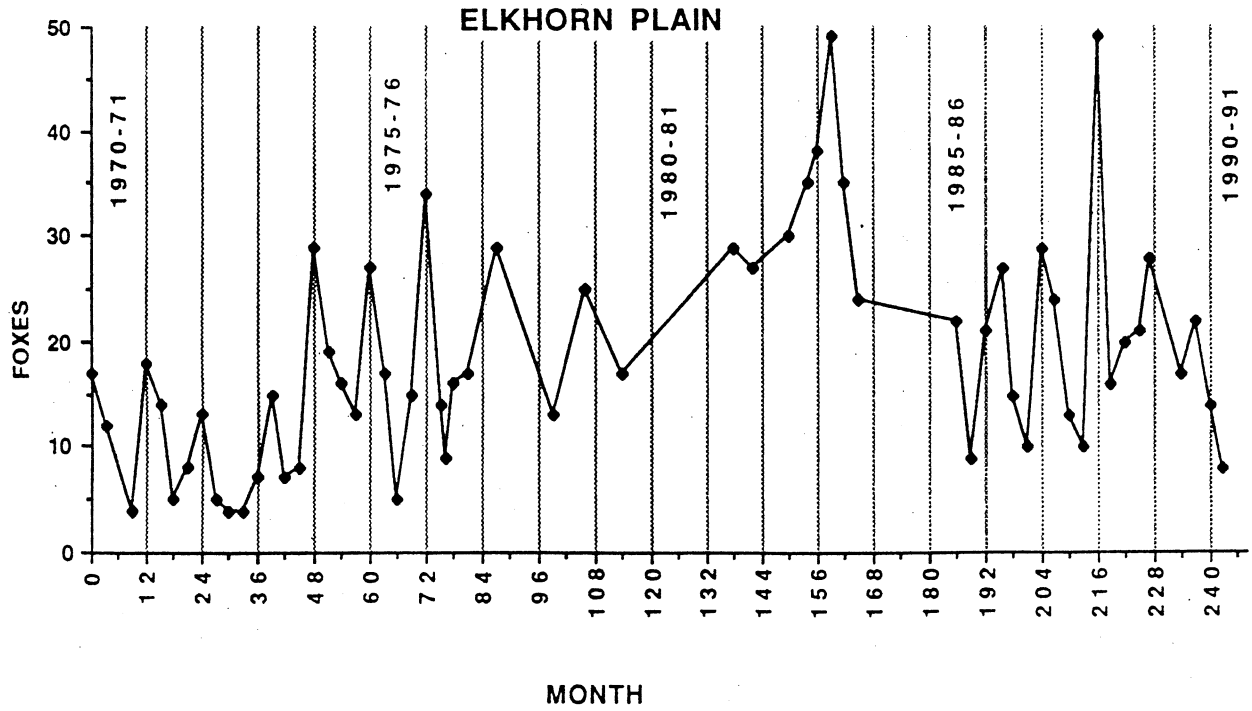
The survey data are plotted in figures 4 and 5. In many cases, the June survey showed the highest count. While the December count was usually the lowest. Small sample sizes, i.e. the low number of kit foxes seen per survey, resulted in erratic behavior of the counts, and there were numerous cases of missing data, i.e. one or more of the quarterly surveys was not conducted. More surveys were conducted during the dry season (summer and fall = 1239) than during the wet season (winter and spring = 883).

Figure 4. Plots of counts of kit foxes by year and route. The initial point for each plot is the June 1990 count; intervals of one year are shown by the vertical lines.




BLACKWELL
1970-71
1975-76
1980-81
1985-86
FOXES
MONTH
0
10
20
30
40
50
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
192
204
216
228
240


ELKHORN PLAIN
1970-71
1975-76
1980-81
1985-86
1990-91
FOXES
MONTH
0
10
20
30
40
50
0
12
24
36
48
60
72
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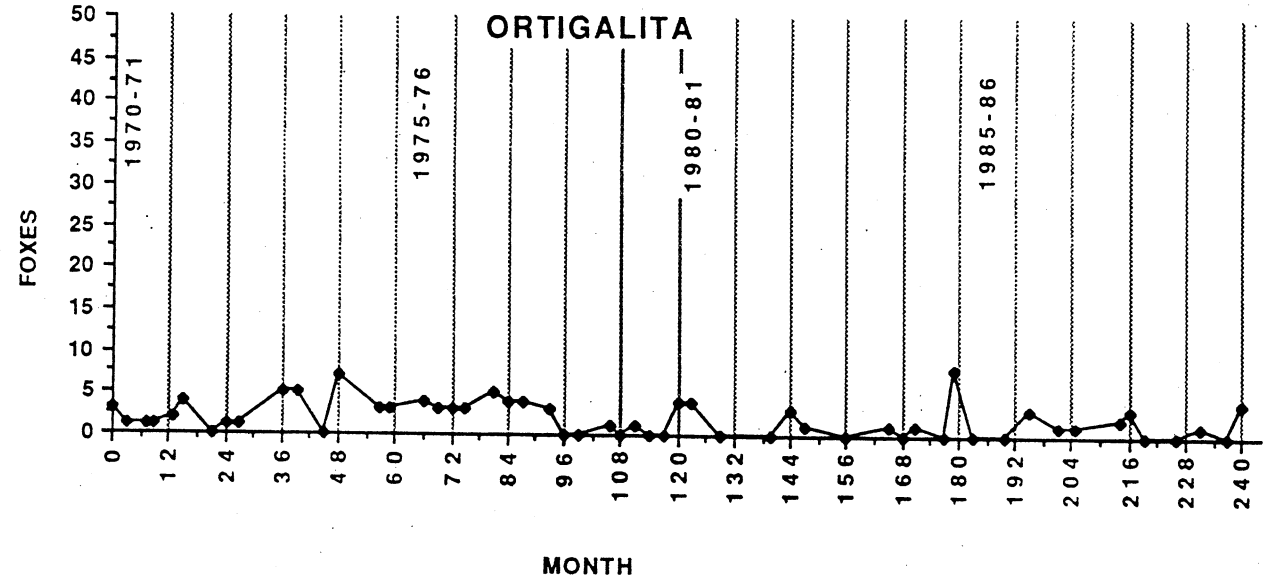
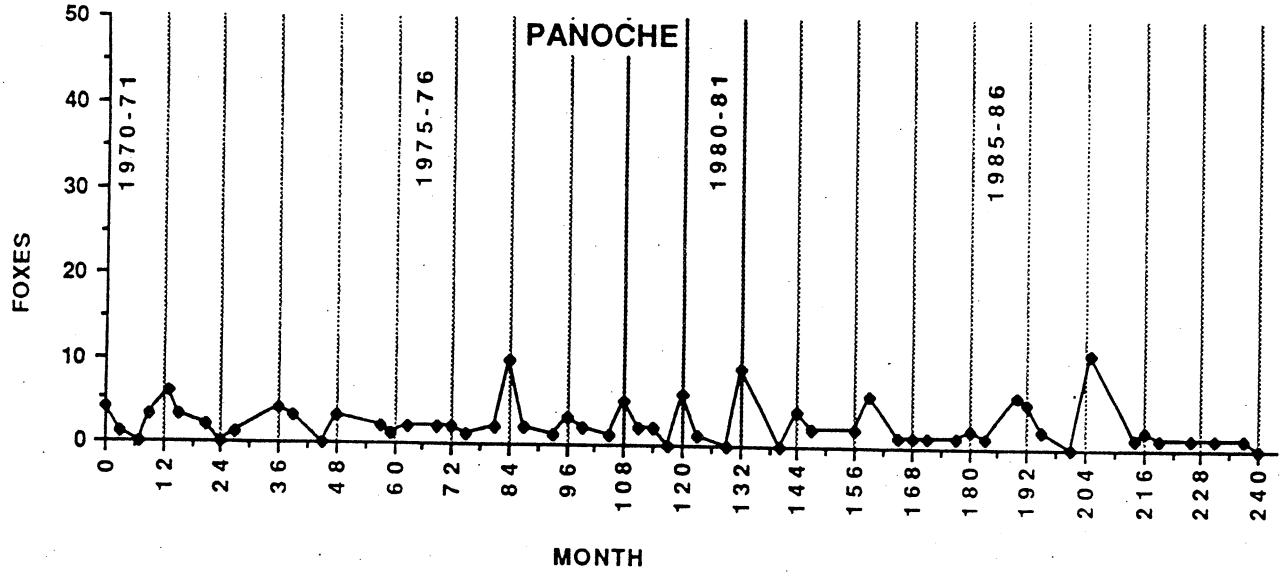

ORTIGALITA
FOXES
MONTH
1970-71
1975-76
1980-81
1985-86


PANOCHE
FOXES
MONTH
1970-71
1975-76
1980-81
1985-86

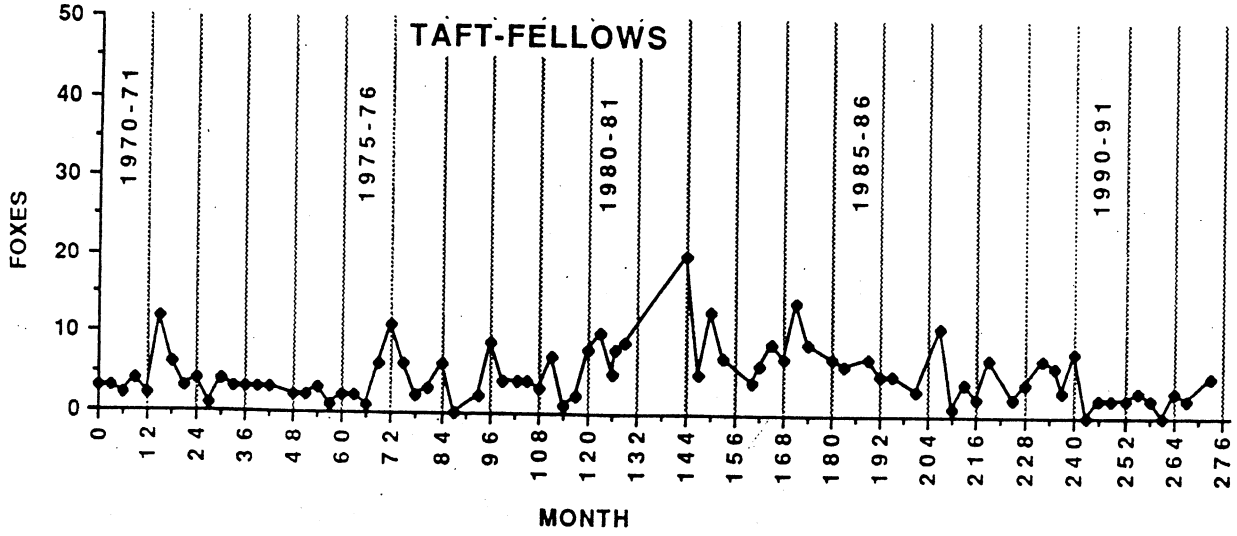
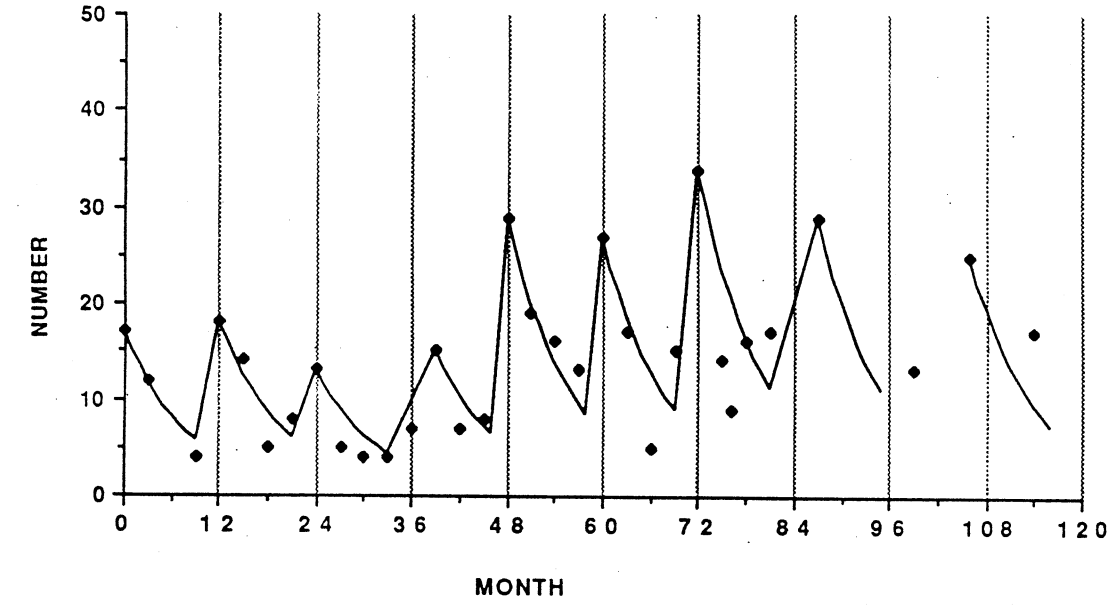
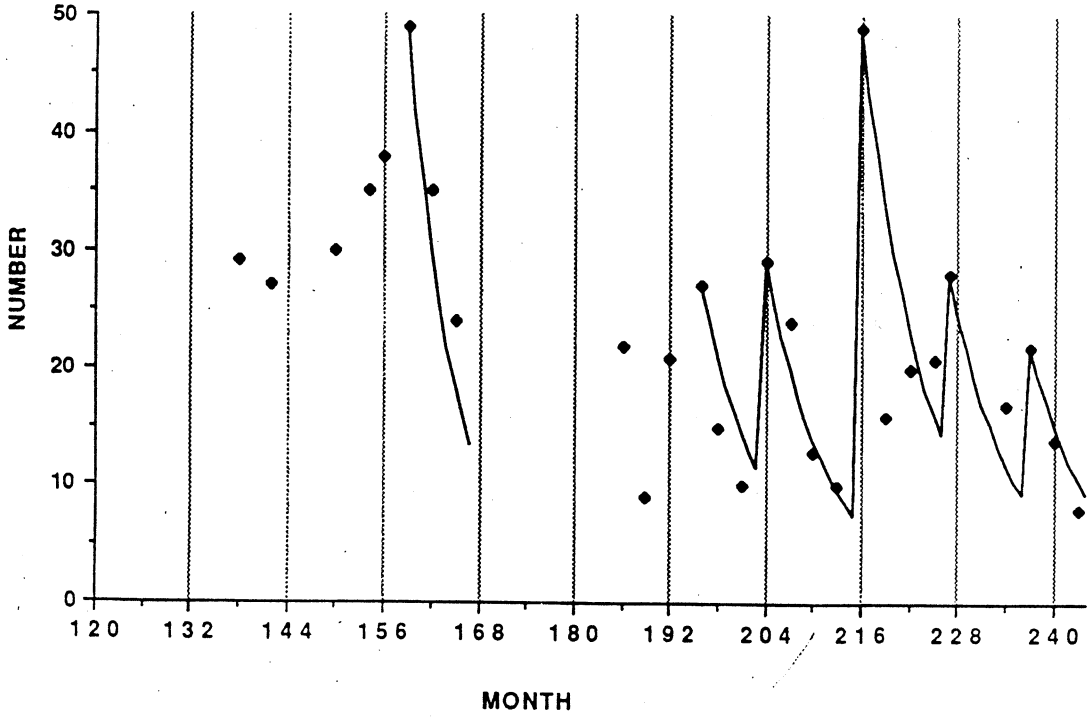

TAFT-FELLOWS
FOXES
MONTH
1970-71
1975-76
1980-81
1985-86
1990-91

Figure 5. Number of foxes seen on the Elkhorn Plain route during two ten-year periods. The initial point for each plot is a June count; intervals of one year are shown by the vertical lines. Curves are fitted by least-squares to represent an annual cycle of abundance.



Elkhorn Plains data.--Fox counts were highest on the Elkhorn Plains route (Fig. 4). We therefore used this data set to examine the apparent annual cycle of abundance, the effects of sighting distance, visibility quality, and of plant cover along the route, and the relationship between counts of foxes and potential prey species.

Annual cycle of abundance.--Figure 5 shows the kit fox sighting data for the Elkhorn route over two ten-year periods. To model a possible annual cycle of abundance, numbers counted at or near June of each year were assumed to be actual abundance at that time, and reduced by a constant survival rate per month (0.884) about the following April. The rate of change was obtained by a least-squares fit using the model $N_t = N_{June}s^t$ for the months of June to May (months 0 to 11), following the approach of Eberhardt (1987). Here, $N_t$ denotes the population at month t (the following September, December or March) and s denotes a rate of change. The value of s estimated by this method is appreciably below survival values obtained by Ralls and White during a radio-telemetry study of kit foxes on the adjacent Carrizo Plain (unpublished). We believe that this is due to the fact that June observations often include two or more foxes seen at one point along the route (family groups). When two or more foxes are together, the probability of sighting is certainly higher than for single foxes. Hence the June counts are proportionately higher in relation to actual density of foxes than are counts in other months. Consequently, the rate obtained underestimates actual survival by an unknown, but evidently substantial fraction. Consequently, we use it here only as a means of depicting the seasonal pattern of sightings. The next June observation is simply connected to month 11 (in some cases the peak was later than June). The time scale in the graphs starts in June, so each number on the horizontal axis represents June of a successive year, and the vertical lines denote a June date.

Effects of sighting distance, visibility quality, and predominant vegetation type.--A plot of the total number of foxes seen along each mile of the Elkhorn route during all

Figure 6. Number of foxes seen at one-mile intervals along the Elkhorn Plain route during the surveys conducted during successive three-year periods.

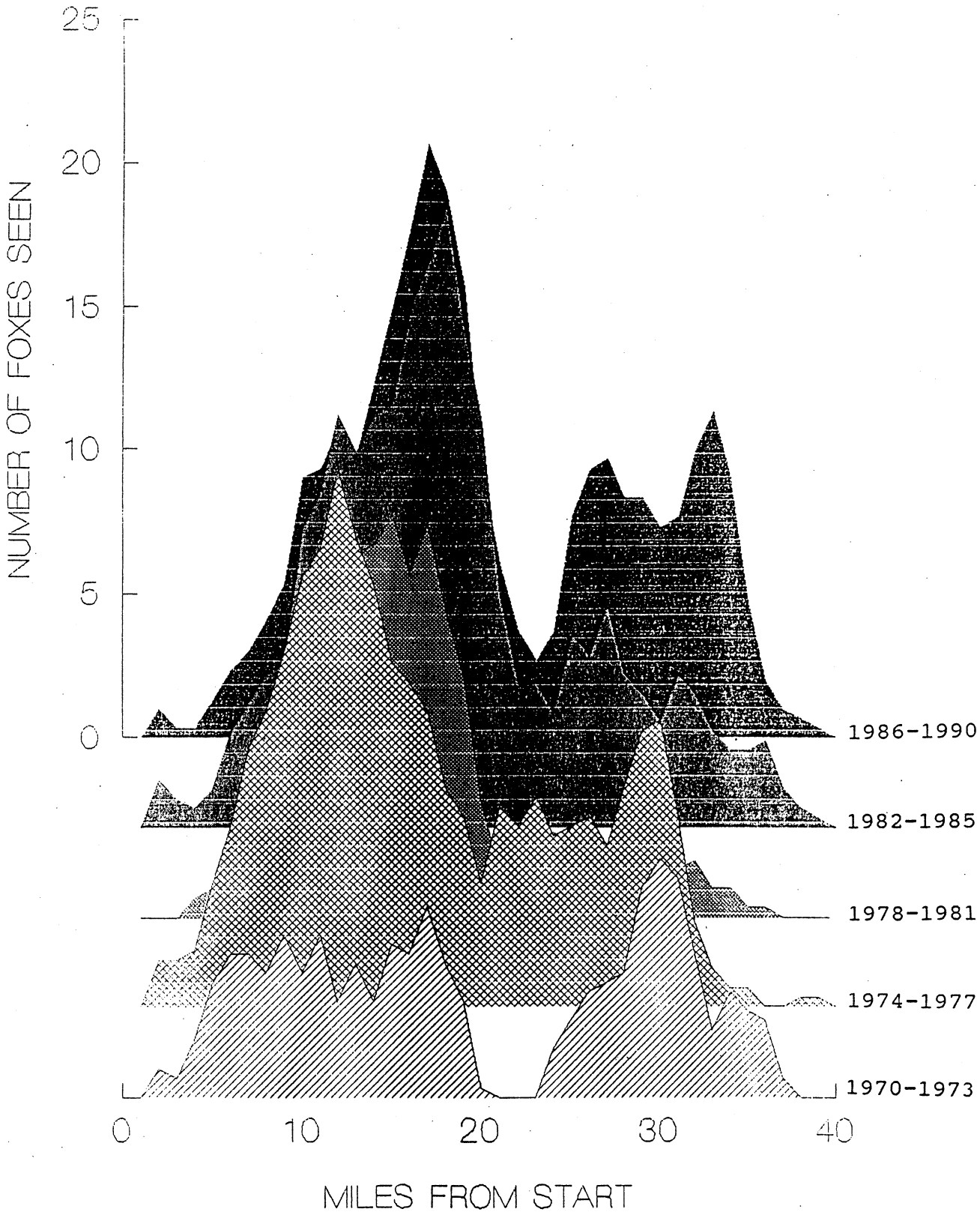
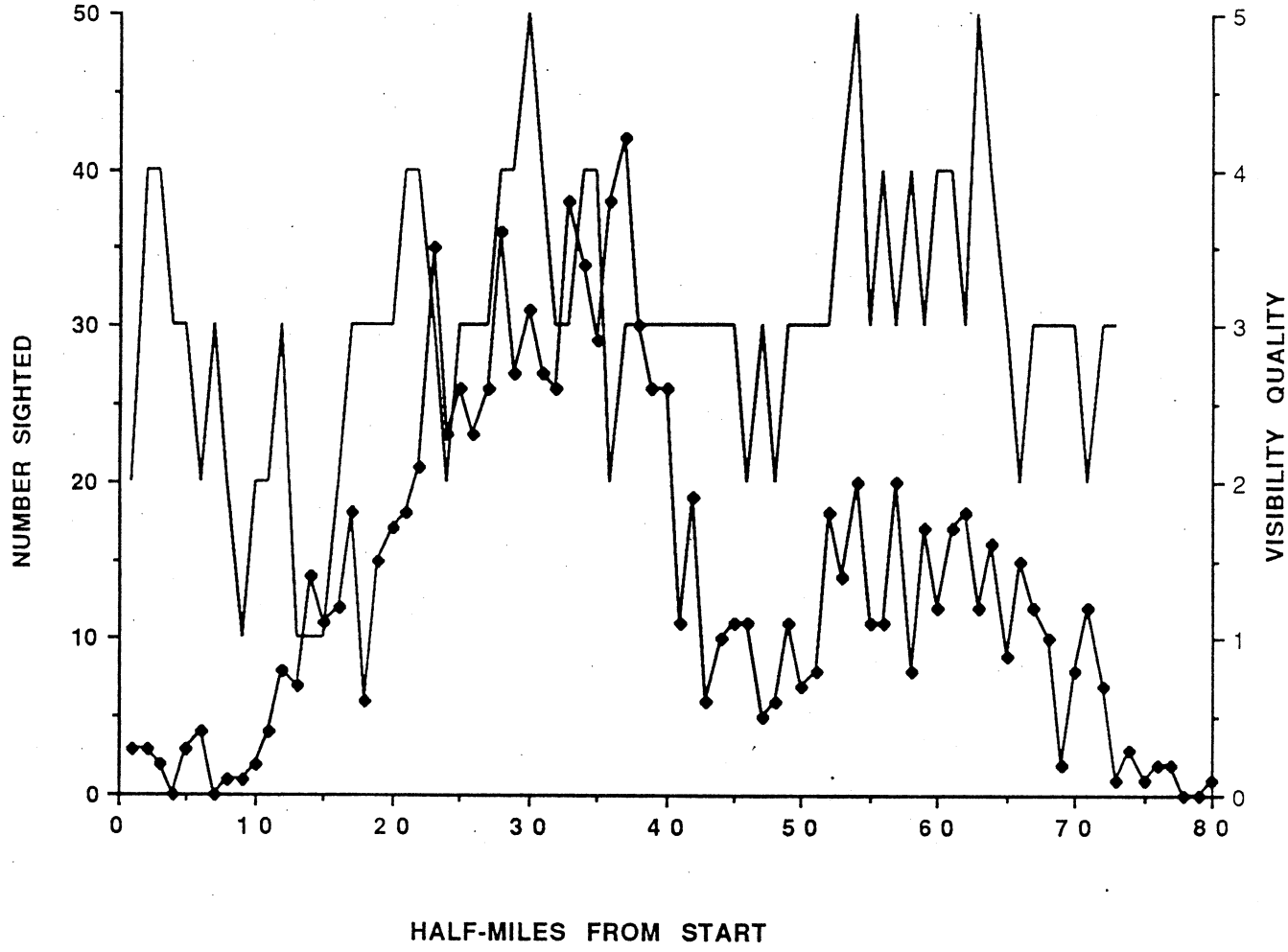


Figure 7. Number of foxes sighted (lower line; left-hand scale) versus visibility quality based on plant cover (upper line; right-hand scale ) on the Elkhorn Plain route.



most critical at a particular time of year, but plotting the high fox numbers in June against prey numbers in June also gave poor correlations.

Tests for trends in the data.--An important question about the spotlighting data is whether the year-to-year results provide evidence of trends in the local fox populations. Inasmuch as there is evidence of a seasonal fluctuation in numbers (Fig. 5), we studied trends by summing up the seasonal sightings to get a yearly total. Unfortunately there were many instances when individual routes were not run in a given season, so we used only those totals where at least 3 spotlight runs were made in a year. Two simple tests were used on data transformed by natural logarithms, on the basis of some population simulation trials conducted by Eberhardt (1992). One test was that of significance of linear regression (on the log scale). A log-linear relationship would be expected if the population were increasing or decreasing at a relatively constant rate. The other test used was a test for curvilinearity, which compares deviations from a fitted second-degree polynomial to those from the linear regression (again on a log scale). This test is described by Snedecor and Cochran (1967)(Table 1). The plots for the routes for which significant tests were obtained: Taft-Fellows, Bellridge, and Blackwell's Corner were created (Fig. 8). Except for the Elkhorn Plain route plot which is shown in figure 9.

Correlations with rainfall data.--Because kit fox population density on the adjacent Carrizo plain decreased from 1989 to 1991 due to a drought (White and Ralls 1993, Ralls and White in preparation), we compared kit fox counts on the Elkhorn Plain with annual precipitation, using precipitation data for the current year and total foxes sighted in that year. As indicated in Table 1, there was a significant trend in fox numbers with time in the Elkhorn area. Consequently, we used an adjustment for trend on the fox data before comparing fox abundance with precipitation. The adjustment is obtained by fitting a linear regression to logarithms of fox data against time. Deviations of the observed fox numbers from the fitted

Figure 8. Graphs of the annual data for the routes showing evidence of statistically significant trends in Table 1.

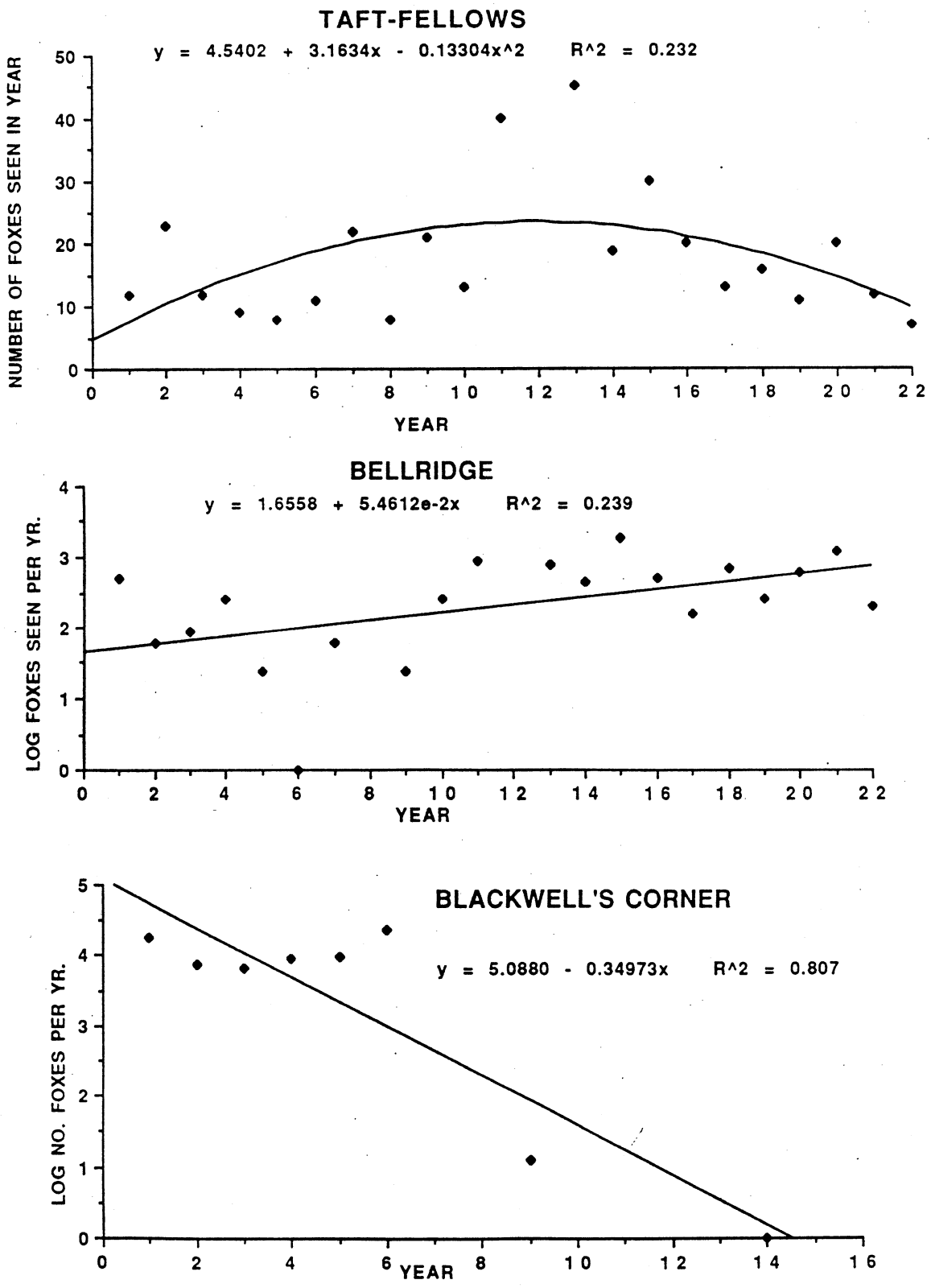
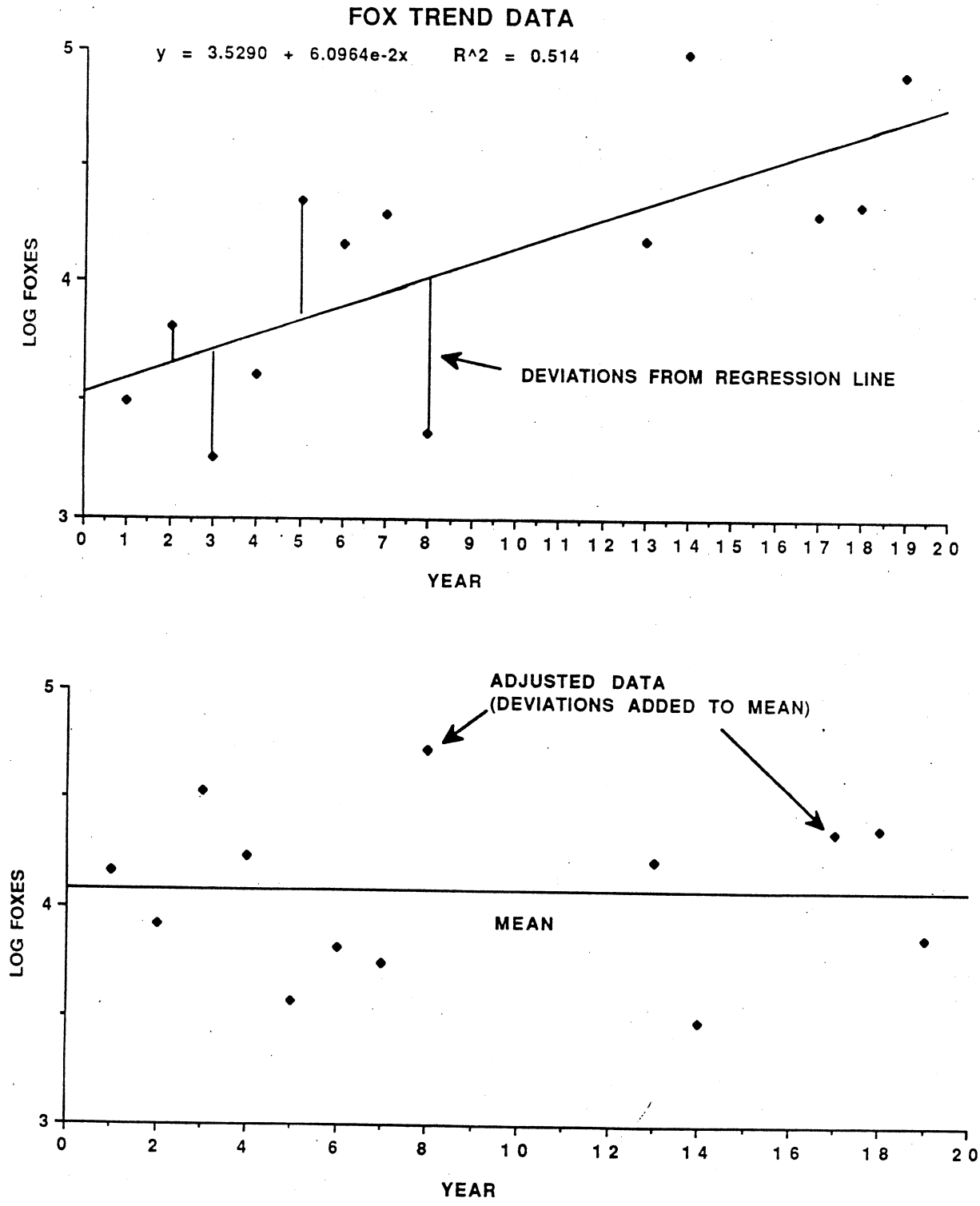


Figure 9. Illustration of the method used to adjust fox numbers along the Elkhorn Plains route for the overall trend in the number of foxes seen.



regression line are then added to a convenient population level (mean of the log fox numbers was used here) and the resulting data represent fox numbers adjusted for overall trend (Steel and Torrie 1960). In effect, the adjustment "takes out" the effect of growth in the fox population (Fig. 9). First the logarithm of fox numbers is regressed against time. The deviations from the fitted line are then added to a convenient base value (here taken as the overall mean of fox abundance). The adjusted fox numbers against annual precipitation suggests that fox numbers tend to vary around the overall trend line in concert with annual precipitation (Fig. 10).

Overall trend of the San Joaquin kit fox population.--Although the individual data sets are variable and have gaps in coverage, averaging over the entire set should give a fairly reliable estimate of overall trends. We have simply summed over the available data, in effect giving equal weight to each survey route. Plots of the monthly and yearly averages suggest no long-term trend in the number of foxes seen along the combined survey routes (Fig. 11).

Simulations of annual cycle and tests for trend.--A major problem with several of the data sets is that not enough foxes were typically seen in one night's spotlighting to provide adequate precision in the estimates, i.e., the data are too variable. This may well be responsible for the failure to detect trends in several of the data sets, however, there may not have been much change in those populations over time. Without better data, there is no way to distinguish between the two possibilities. Better data could be obtained by spotlighting on several nights within a month, and/or adding additional routes within an area. The simplest action, of course, is just to make additional "runs" of the same route during the month. This would have the advantage of giving something like "replicate" runs, without which it is difficult to devise adequate statistical tests.

We can gain some insight into the effect of the small sample sizes obtained with the current survey design by constructing a simple stochastic model based on

Figure 10. A comparison of annual precipitation levels with adjusted fox numbers along the Elkhorn Plain route.

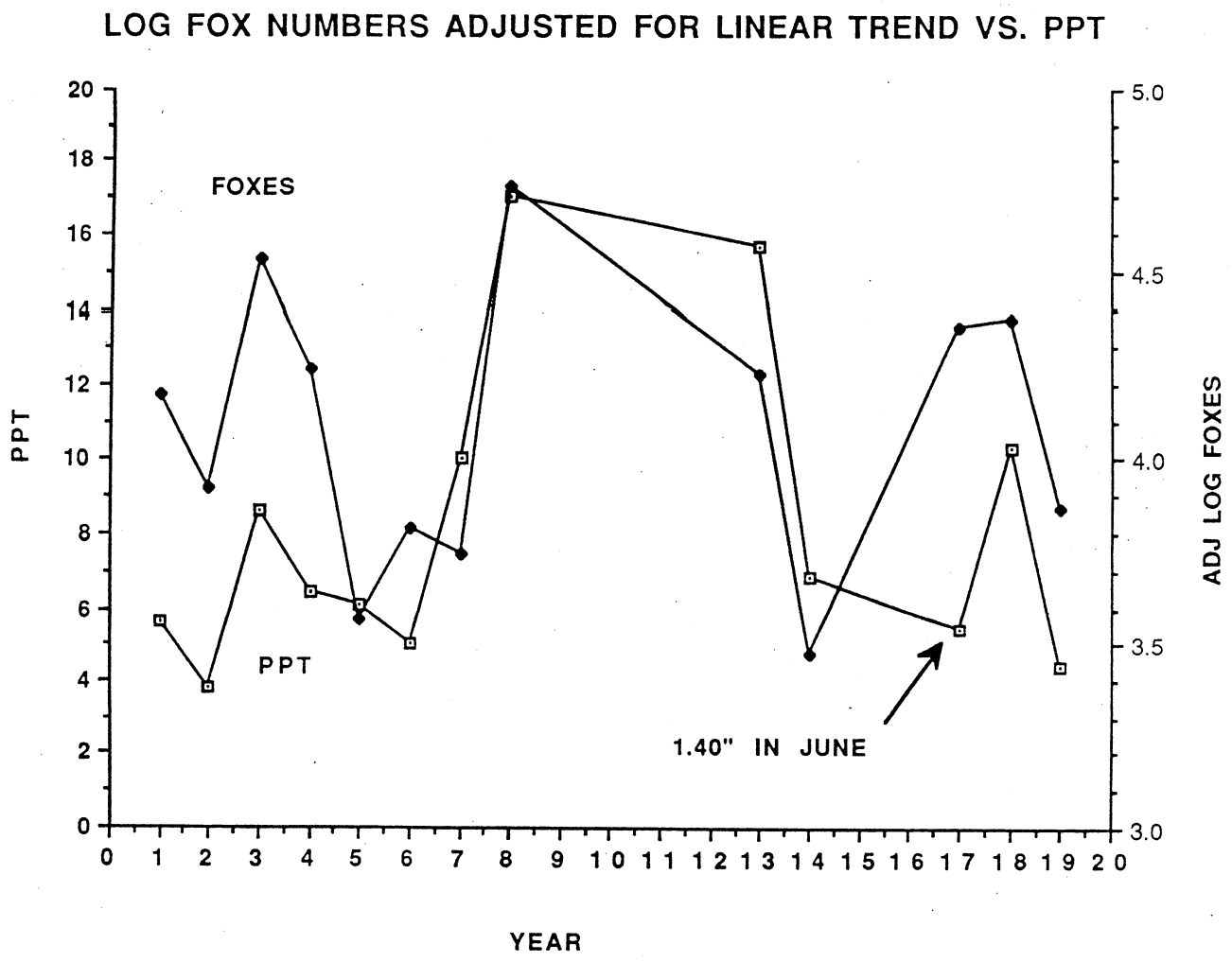
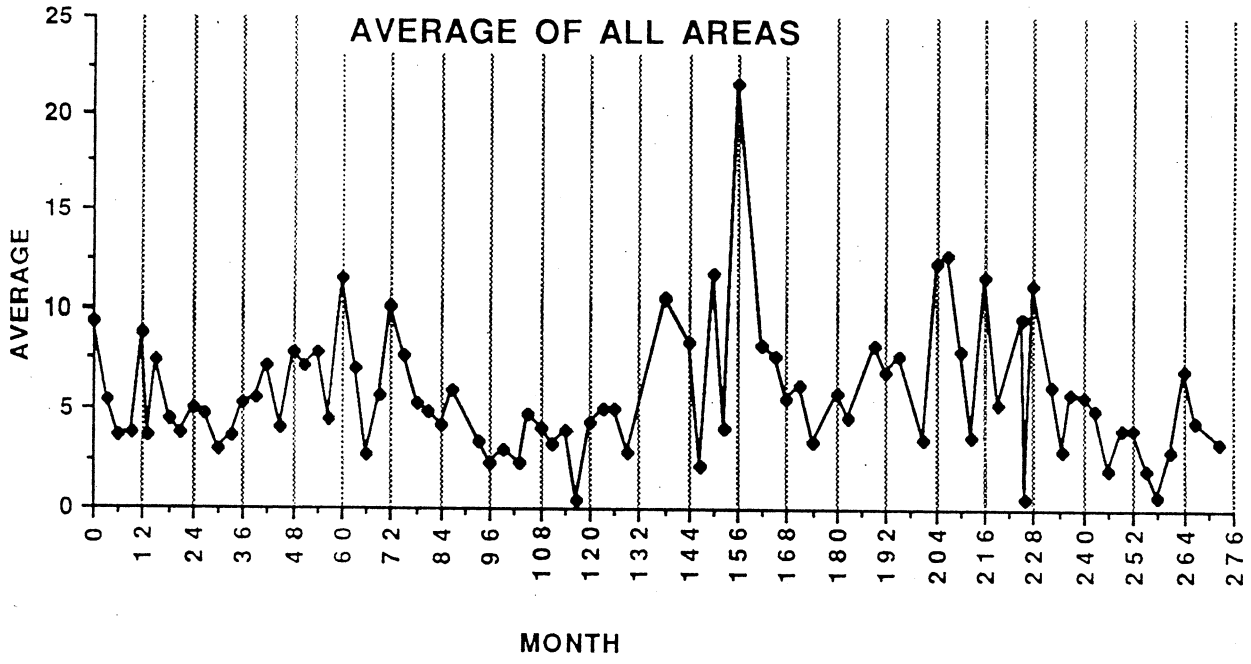
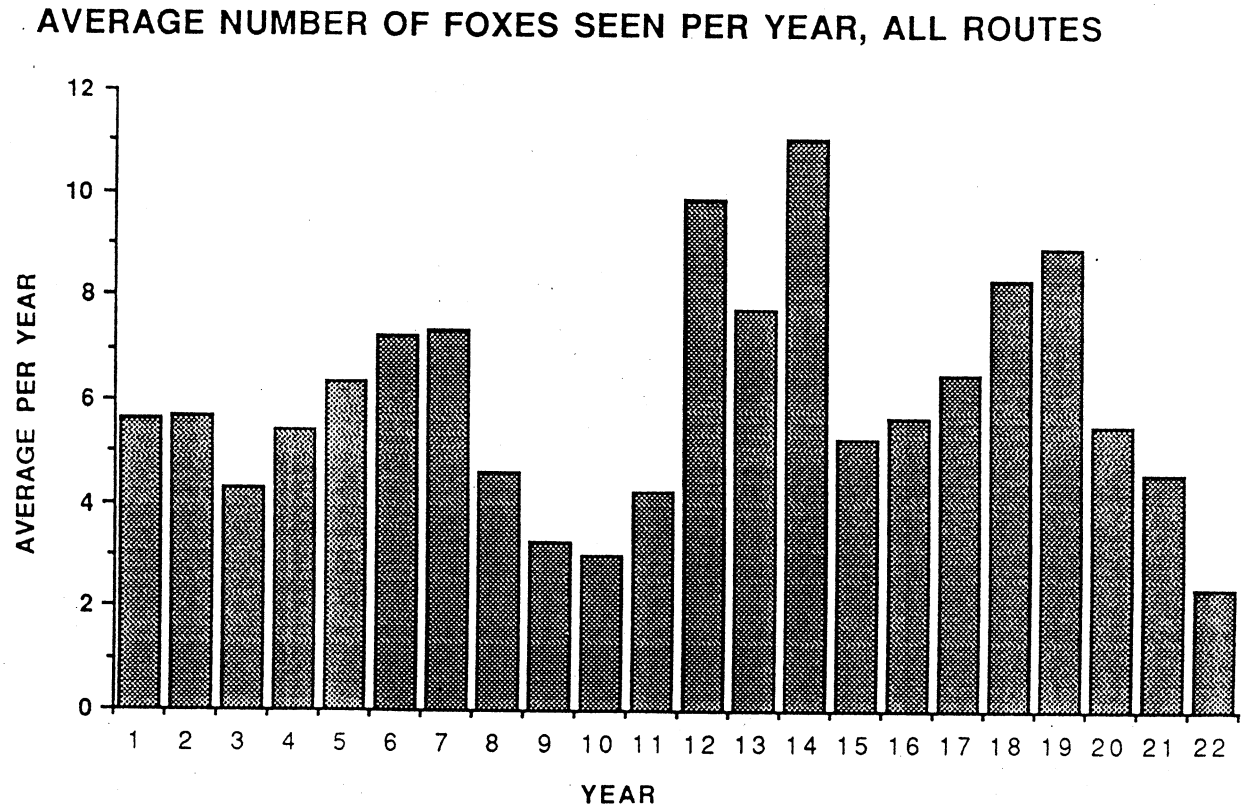


Figure 11. Total number of foxes seen per year averaged over all sites.



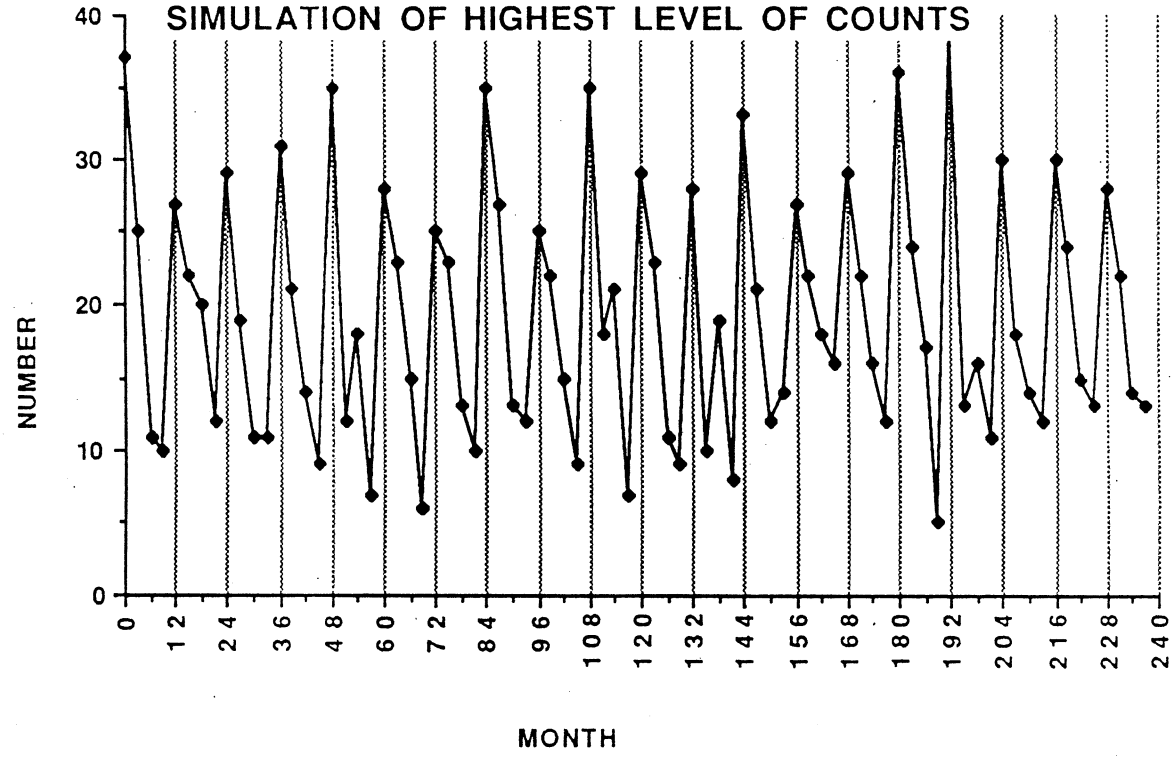



the annual cycle (Fig. 5). We used such a model to produce simulated results much like those of the actual data sets. Two sets of simulated data represent the highest typical counts (and presumably population level), such as those obtained on the Elkhorn Plain route, and a lower count (population level), such as those from the Panoche and Ortigalita routes (Fig. 12). These data were generated from a model having a constant population level; thus there is no trend in population size over time. However, due to the effect of randomness, one can nonetheless be led to believe that there might be a trend.

To study the effectiveness of count samples of the size simulated in detecting change in a population trend, we introduced a 10% per year decline in population level in the simulations, and simulated data for three initial population levels (high, intermediate, and low) with such a trend for 5, 7, and 10 years, producing 1,000 simulations for each case. The highest level simulated the count levels obtained on the Elkhorn Plain route and the lowest simulated those obtained on the Panoche and Ortigalita routes (Fig. 12). The log-linear regression test of significance described previously was then applied to these data, and the number of results judged significant at the 5% level was recorded.

Figure 13 shows the outcome in terms of "power of the test"; i.e., the proportion of times that the test reported a "significant" result, and thus detected the decreasing level of abundance. Even though the population actually did decrease at 10% per year, a significant change was detected in only 40% or less of all cases when only five years of data are collected, even at the highest population level (Fig. 13). Results improve if seven years of data are collected but statistical power becomes satisfactory only with ten years of data, and then only for the two higher population levels. It thus seems evident that larger samples are needed to detect kit fox population changes with any efficiency with spotlight surveys. As noted above

Figure 12. Simulated monthly population data for higher and lower population levels. Not needed in final ms.



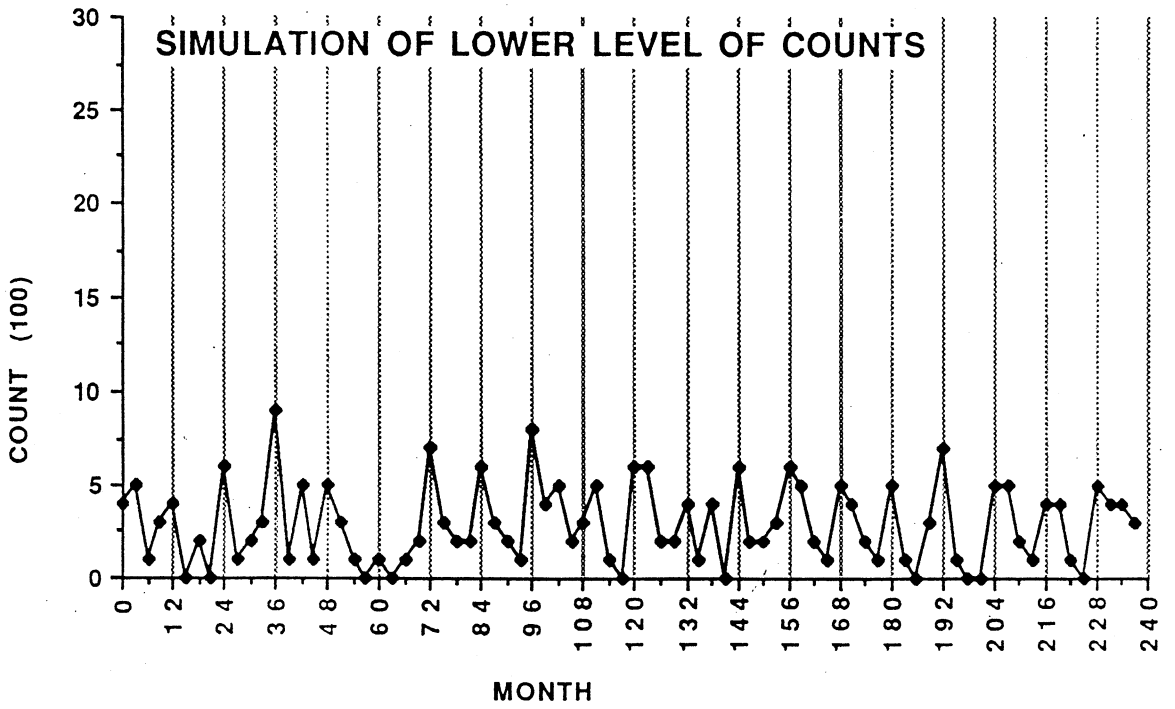
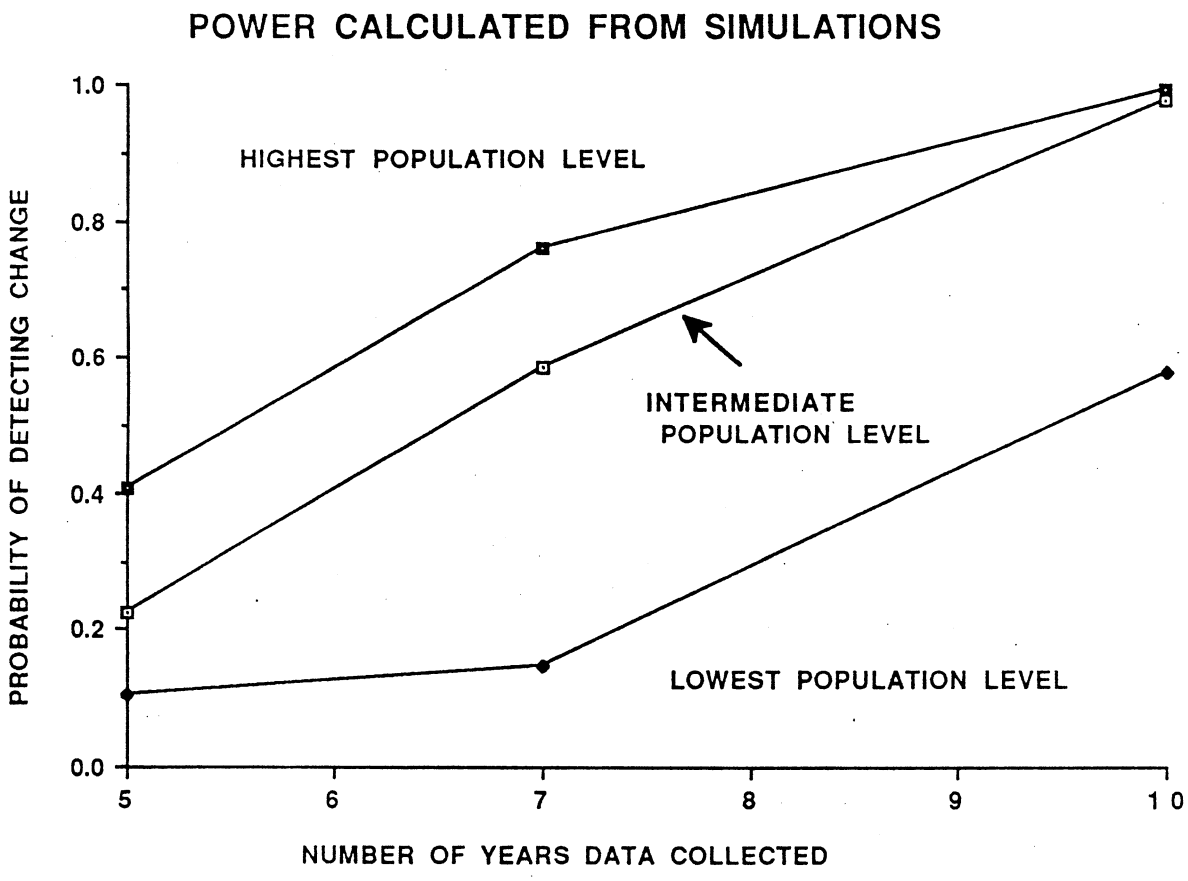



Figure 13. Results of tests of simulated data. The left-hand scale ("power") indicates how often the test reported a statistically significant change (in all cases a 10% per year rate of decrease existed). The test was applied to data generated for 5, 7, and 10 years.



these larger samples might be collected by repeated runs of individual routes in the same month.

Discussion

Annual cycle of abundance.--The annual cycle of kit fox abundance in the surveys, with high counts in June and low counts in December, reflects the annual cycle of kit fox reproduction. Kit foxes tend to be monogamous and both sexes help care for the young. Each female can give birth to a single litter of three to five pups each year, typically in late February or early March (O'Farrell 1987). Pups remain with their parents for four to five months and tend to disperse in the fall. Thus, the high June counts reflect the annual presence of pups with their parents and the low December counts the fact that most of the pups have dispersed. Weber et al. (1991) found a similar annual cycle of abundance in spotlight surveys of red foxes.

Variation in the number of kit foxes seen per mile.--We found that the number of kit foxes seen per mile along the Elkhorn Plain route was correlated with visibility quality and, to a lesser extent, on sighting distance. It is likely that numbers of foxes seen depend upon both visibility and habitat quality quality. Our categories of sighting distance based on physical features and visibility quality may be associated with habitat quality. In good habitat, there will be more foxes to see, and if good fox habitat is fairly open country with moderate terrain, then those foxes present will be easier to see. Hence there may be more foxes present in the areas of poorer visibility conditions, but it is doubtful that the sighting index could be adjusted by the above regressions, inasmuch as one would need an estimate of the actual number of kit foxes present in different areas in order to obtain unbiased correction factors. Nonetheless, it is interesting that an appreciable fraction of the variability in fox numbers seen along the Elkhorn Plain route is associated with habitat characteristics, and it might be worth making a similar classification of some of the other survey routes to see if this would lead to better understanding of the characteristics of good kit fox habitat. It should be

noted that the relationship of the two categories to fox numbers is likely nonlinear, rather than linear as assumed by multiple regression, so that it may be worth attempting transformations of the variables to see if they improve the correlations.

Correlations with prey abundance and annual precipitation.--We found that kit fox counts along the Elkhorn Plain route were correlated with annual precipitation but not with prey counts made during the surveys. The primary effect of drought on kit foxes is to decrease reproductive success due to a decline in prey availability (Egoscue 1975, White and Ralls 1993). The lack of correlation between kit fox counts and prey counts suggests that the surveys are not an effective method of assessing the availability of prey. The primary prey of kit foxes on the Carrizo Plain, adjacent to the Elkhorn Plain route, is nocturnal rodents and includes deermice and pocketmice in addition to kangaroo rats; kit foxes also consume substantial quantities of insects in this area (C. Vanderbilt-White, Doctoral student, pers. comm.). These various small mammals and insects are not adequately censused by spotlight surveys.

Overall trend in the San Joaquin kit fox population.--Only one route, Blackwell's Corner, showed a significant decline in the number of kit foxes seen over time, and this was likely due more to increasing difficulty of conducting the surveys adequately than to an actual decline in the fox population along the route. Because of increased traffic over time along this route, the observers found it too dangerous to drive at the slow speed necessary to detect foxes, and progressively more difficult to concentrate on spotting foxes while attending to traffic. Because of these problems, CDFG abandoned this route in 1990 and began a new route, Allensworth, in the same general area.

Plots of the average yearly number of kit foxes seen on all the routes combined (including the Blackwell's Corner route) did not suggest any long-term trend in the overall kit fox population.

Effectiveness of the survey design.--Small sample sizes, i.e. the low number of kit foxes seen per survey along most routes, resulted in erratic behavior of the counts, and

there were numerous cases of missing data, i.e. one or more of the quarterly surveys was not conducted. The most common reason for missing data was that some routes become impassable during the wet season (winter and spring). The small sample sizes and missing data, plus the fact that none of the surveys was replicated, i.e. run more than once in a given month, limited the statistical analysis and the interpretation of the results.

Statistical tests on simulated data similar to the data collected during the surveys indicated that larger samples would be needed to detect kit fox population changes with any efficiency using spotlight surveys. These larger samples could be collected by repeated runs of individual routes during the same month. The Soda Lake route added in 1989 may possibly be regarded as a replication of the Elkhorn Plain route (Fig. 3).

The surveys do not adequately sample prey availability but annual rainfall data may provide an adequate substitute for a measure of prey availability. Also, many parts of the kit fox range are not currently included in the survey design.

## PRELIMINARY WORK ON THE EAST SIDE OF THE SAN JOAQUIN VALLEY

Originally we were to conduct surveys on the east side of the San Joaquin Valley where there appears to be a major gap in the kit fox's range. This area includes parts of Fresno, Madera, Mariposa, Merced, Tuolomne and Stanislaus Counties. It stretches roughly from Fresno in the south to Stockton in the north; extends eastward to the grassy foothills of the Sierra Nevada, and also encompasses an apparently isolated population of kit fox near La Grange in southeastern Stanislaus County.

To survey this large area with the limited resources at our disposal, we planned to concentrate initial efforts on potential kit fox habitat near known kit fox populations (i.e. along the banks of the Friant Canal) and areas near historical sightings of kit foxes (the La Grange area). We began collecting information on locations of potential kit fox habitat and confirmed or unconfirmed sightings of kit foxes in order to develop a specific survey plan for each county.

On 16 December 1992 and 2 January 1993, we drove through the northern and southern parts of the study area, respectively, for an initial look at the specific habitat occurring at various locations, and the potential prey base (California ground squirrels, *Spermophilus beechyi*) available at these locations. We identified large areas of suitable habitat and their accessibility, and determined whether or not these areas were within the kit fox range as currently designated by the USFWS (USFWS 1990)(Fig. 1). With the help of a CDFG pilot and plane, on 17 March 1993 we obtained additional information on the scale and continuity of potential kit fox habitat by flying over the east side of the San Joaquin Valley.

In addition, we contacted CDFG regional offices and biologists, informed them of our intended study, and asked for information on potential kit fox habitat, kit fox sightings, prior surveys for kit fox, and the identity of cooperative landowners. We also received historical sightings from the Natural Diversity Data Base (NDDB).

Our preliminary investigations indicate that large tracts of potential kit fox habitat remain on the eastern side of the San Joaquin Valley. Sightings of kit fox in this area from the 1970's to date are plotted in figure 14 and listed in appendix 1 . Several of these sightings occured outside the 1990 USFWS range boundary for the San Joaquin kit fox.

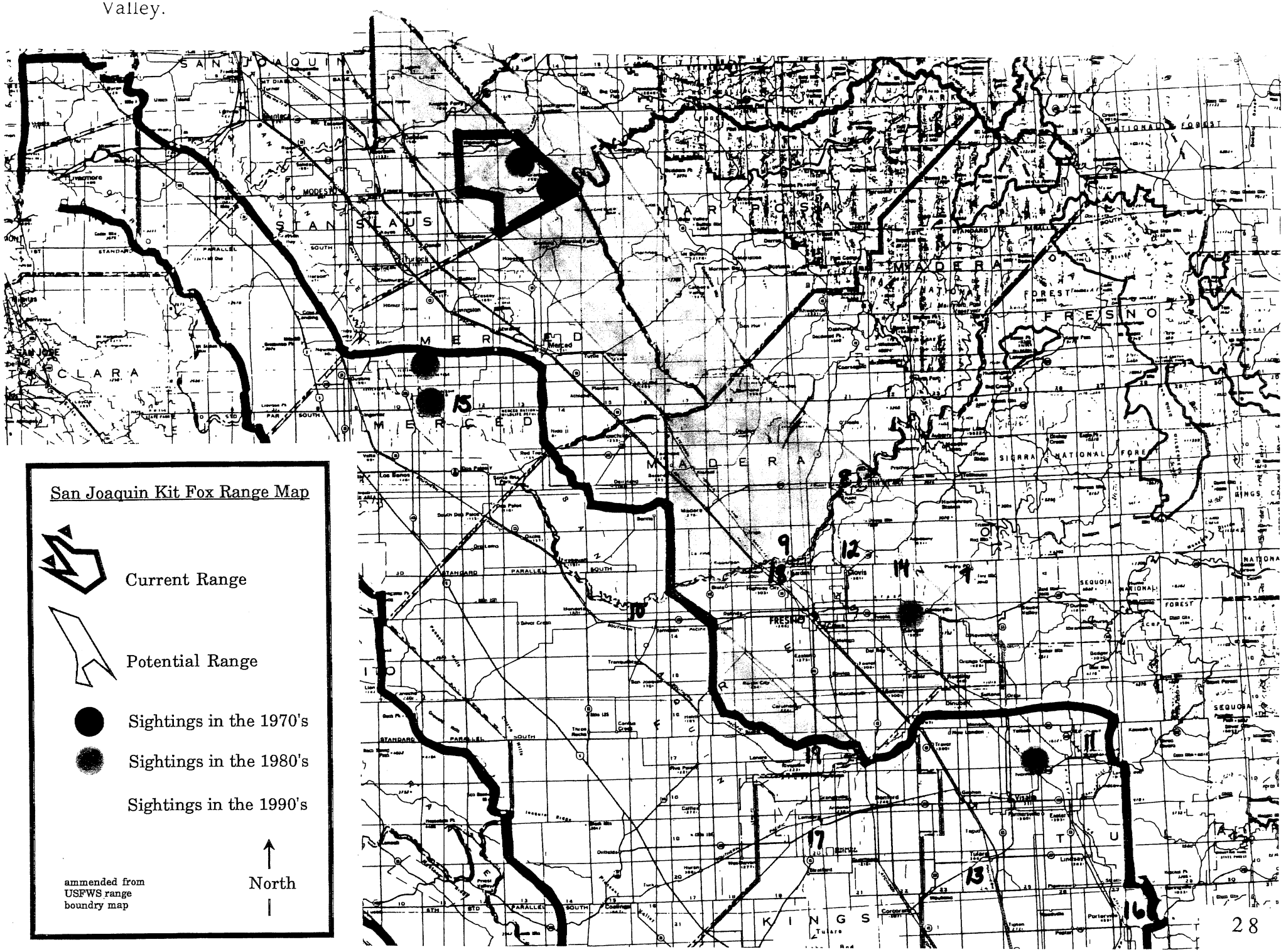
We did not conduct surveys on the east side of the San Joaquin Valley, as CDFG requested in late March 1993 that we change our study area to the northern-most portion of the kit fox's range which includes Alameda, Contra Costa and San Joaquin Counties. Having recently been surveyed for a county Habitat Conservation Plan (HCP), San Joaquin County was not included in our study.

## STATUS OF KIT FOX IN ALAMEDA AND CONTRA COSTA COUNTIES

### Historical distribution of kit fox in Alameda and Contra Costa Counties

Alameda and Contra Costa Counties, along with San Joaquin County, comprise

Valley.


San Joaquin Kit Fox Range Map
Current Range
Potential Range
Sightings in the 1970's
Sightings in the 1980's
Sightings in the 1990's
ammended from USFWS range boundry map
North
SAN JOAQUIN
STANISLAUS
MERCED
MADERA
FRESNO
MARIPOSA
KINGS
TULARE
SAN JOSE
SANTA CLARA
SIERRA NATIONAL FOREST
SEQUOIA NATIONAL FOREST
YOSEMITE NATIONAL PARK
15
9
12
14
10
19
11
17
13
16

the northern-most extent of the kit fox's range. Originally, kit fox populations in Alameda and Contra Costa Counties must have been contiguious with those found in western San Joaquin County.

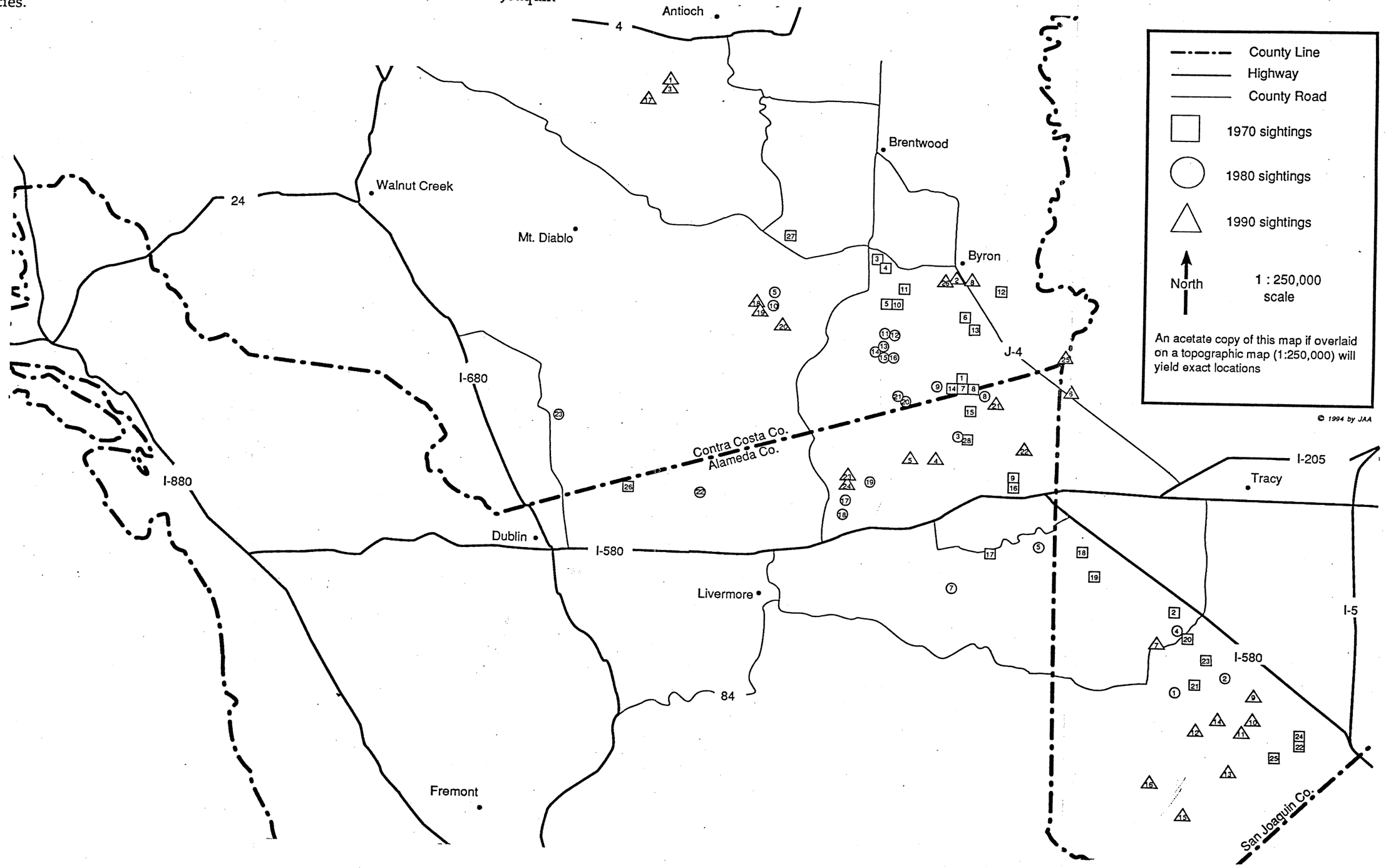
Prior to the 1960's very little data on kit fox in the northern range was recorded. However, it was in San Joaquin County near the city of Tracy, that the type specimen of this suspecies was collected by Merriam in 1902.

During the 1960's two "sightings" (a sighting may include more than one fox) of kit fox came from county agricultural deputies who were distributing poison for ground squirrel control on public and private lands. In 1968 an active den was observed near Camino Vaqueros Road in Contra Costa County, and a kit fox was later trapped on the border of Contra Costa and Alameda County near Brushy Creek.

In the 1970's reports by Swick (1973) and Morrell (1975) provided evidence that the kit foxes still occupied both Alameda and Contra Costa Counties. The map produced by Morrell, which included data from Swick's (1973) report, proposed a range based on sightings from the early 1960's to 1975. In 1975 the counties discontinued poisoning regional park lands, and in 1978 the landowners became responsible for poisoning; consequently decreasing the frequency of knowledgable personnel travelling throughout these counties. During the 1970's 13 kit fox sightings were reported in Contra Costa County and 6 in Alameda County; including 1 sighting at Camp Parks Reserve Forces Training Area, Dublin, CA (Fig. 15) (Appendix 2).

Throughout the 1980's most of the information on kit fox sightings came from the increasing number of biological surveys conducted for EIR's. The only state sponsored research on kit fox in this area was a radio telemetry study conducted by Hall (1983) on a family of kit fox at Bethany Reservoir in Alameda County. Only 2 juveniles females were thought to have survived beyond the one year study. During the 1980's 12 kit fox sightings were reported in Contra Costa County and 8 in Alameda County (Fig. 15).

Figure 15. Historical kit fox sightings in Alameda, Contra Costa, and San Joaquin Counties.



In the early 1990's developments were still being proposed in these two counties and EIR's again provided information on kit fox presence or absence. Additionally, the East Bay Regional Park District (EBRPD) contracted Heather Bell to conduct kit fox surveys at Round Valley Regional Park and Black Diamond Mines Regional Preserve; where kit fox were subsequently detected. The kit foxes detected at Black Diamond are the most northern sightings to date (Bell 1992). From 1990 to 1994 a total of 10 kit fox sightings were recorded in Contra Costa County and 6 in Alameda County (Fig. 15).

Surveys in Alameda and Contra Costa Counties

Developing survey plans.--The first phase of the work in Alameda and Contra Costa Counties was to develop a survey plan for each county, based on potential kit fox habitat and historical sightings of kit foxes in these areas. Using information from the USGS infrared vegetation map, ground reconnaissance by vehicle, and a flight over the area on 17 March 1993 using a CDFG pilot and plane, we mapped potential habitat within Alameda and Contra Costa Counties as defined roughly by areas that consisted of oak savannah and open grassland (Fig. 16).

We collected information on kit fox sightings from the NDDB, previous CDFG-sponsored surveys (Swick 1973), CDFG-sponsored status reports (Hall 1983), range designations (Morrell 1975), EBRPD surveys (Bell 1992), biological survey information from EIR's and personal contact with landowners, wardens, biologists, and private citizens thought to have seen kit foxes. We divided the sightings into three categories based on date: those from the 1970's, those from the 1980's, and those from the 1990's. Information on the date and location of each sighting, methods of the detection, individual who made the sighting, and any survey reports with additional information is summarized in Appendix 2. San Joaquin County sightings were also included as this county is considered a part of the kit fox's northern range.

Our initial survey plan for Contra Costa County is shown in table 2, where projected field activities are listed roughly in order of their priority. That is, we believed that

Figure 16. Potential habitat in Alameda and Contra Costa Counties.

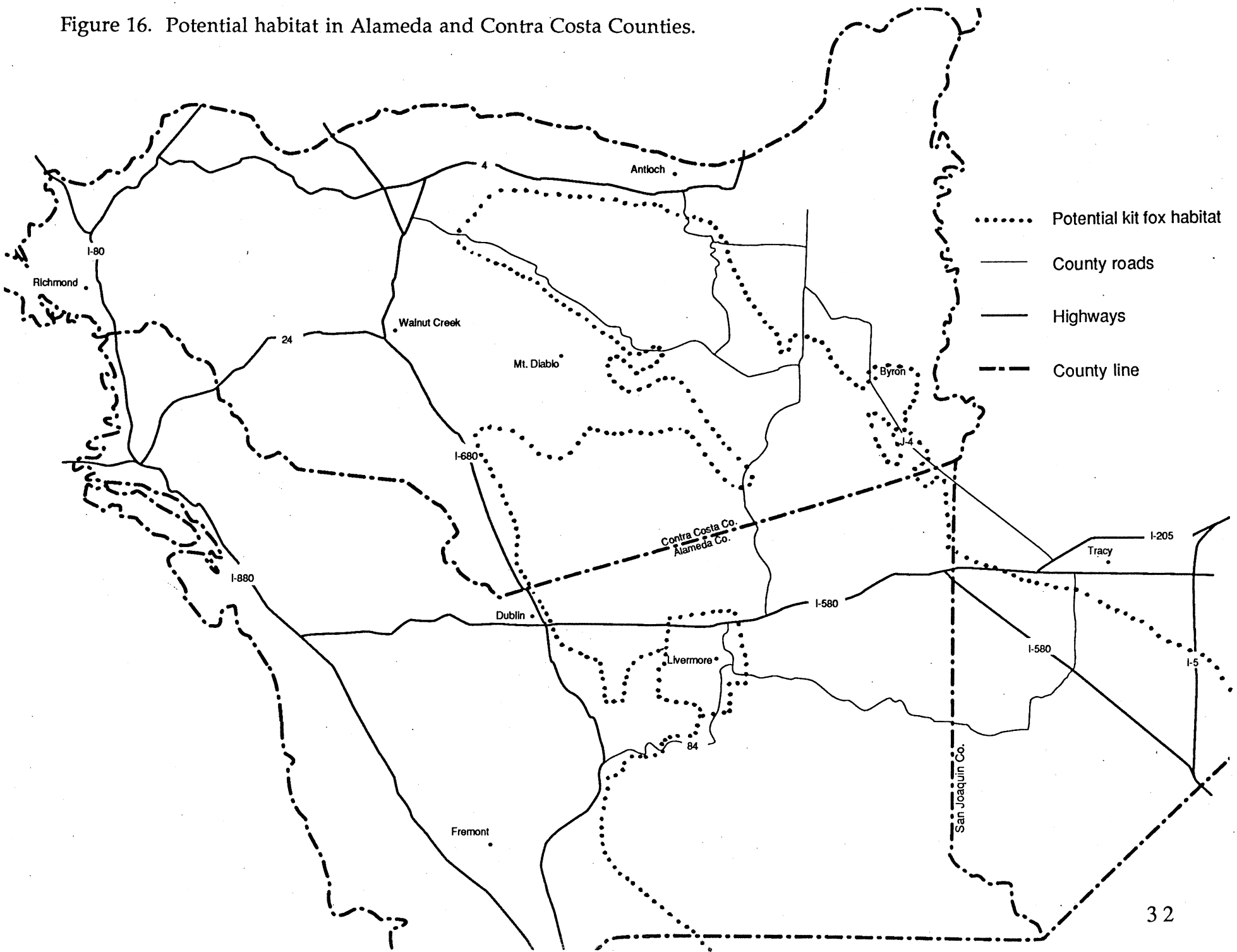


Table 2. Initial survey plan for Contra Costa County San Joaquin kit fox survey, February - October, 1993.

SURVEY PLAN FOR CONTRA COSTA COUNTY

1. Attempt to confirm presence of kit foxes in areas with recent (1990's) confirmed or unconfirmed kit fox sightings. Use cameras and track plates.

    -Round Valley
    -Black Diamond
    -Byron Highway
    -Byron Airport

2. Survey areas where kit foxes were sighted during the 1980's. Use all survey methods.

    -Herdlyn Watershed properties
    -Brushy Creek properties

3. Survey unprotected areas with suitable habitat. Use all survey methods.

    -Kruse Ranch
    -Moller Ranch
    -Cowell Ranch
    -Dougherty Valley
    -Tassajara Valley
    -Doolan Canyon

4. Survey protected areas with suitable habitat. Use all survey methods.

    -Tassajara Regional Park
    -Mt Diablo State Park
    -Contra Costa Water District

5. Conduct surveys along county roads traversing suitable habitat in areas where landowner permission cannot be obtained.

    -Deer Valley Rd.
    -Briones Valley Rd.
    -Horse Valley Rd.

the most useful information would result from the confirmation of the current presence of kit foxes in areas where they had been sighted in the past and surveys of unprotected areas of suitable habitat. We gave a lower priority to surveys of protected areas with suitable habitat and viewed surveys along county roads through areas where landowner permission could not be obtained as a less-desirable substitute for more complete surveys of land parcels in these areas.

Our initial survey plan for Alameda County is shown in table 3. Again, projected field activities are listed by priority. There were fewer recent kit fox sightings, and many more large areas of potential kit fox habitat for which no information from past surveys was available in Alameda County than in Contra Costa County. Surveys along roads provide a cost- and time-effective way to obtain initial indications of canid species present in an area (pers. obs.). We therefore gave a higher priority to road-transect surveys in Alameda County than in Contra Costa County.

Survey Methods.--In 1993 California State Senate Bill 779 was passed by the California Legislature. This bill denied CDFG personnel free access to private lands, except for law enforcement, and then only by a CDFG Warden. We, therefore, were required to obtained written permission from landowners before any survey could begin. Information was gathered on landowners with parcels of ≥ 100 acres or more within areas of potential kit fox habitat from both county's tax assessor offices. One hundred forty four properties, owned by 60 landowners, were identified. We sent those landowners a letter requesting permission to conduct a kit fox survey on the identified properties on 12 April 1993 (Appendix 3). Because we received only a few replies, a follow up letter was sent in May. Only 26% of the landowners replied to one of our letters and only 4% (2 landowners) granted permission for a survey on their property. Only one landowner provided access to their property during the 1993 survey period.

Table 3. Initail survey plan for Alameda County San Joaquin kit fox survey, February - October, 1993.

SURVEY PLAN FOR ALAMEDA COUNTY

1. Attempt to confirm presence of kit foxes in areas with recent (1990's) confirm or unconfirmed kit fox sightings. Use cameras and track plates.

    -Delta Mendota Canal
    -Old River Levy
    -Altamont Landfill
    -Laughlin and Dyer Rd. Properties
    -Bernal and I-680

2. Conduct surveys along roads traversing suitable habitat. Use spotlights and track plates.

    -Patterson Pass Rd.
    -Mines Rd.
    -Corral Hollow Rd.
    -Highway 84
    -Calaveres Rd.
    -Welsh Creek Rd.
    -Collier Canyon Rd.
    -Bruns Rd.
    -Altamont Pass Rd.

3. Survey unprotected areas of suitable habitat. Use all survey methods.

    -Patterson Pass properties
    -Altamont Pass properties
    -Corral Hollow properties
    -South Livermore properties

4. Survey protected areas with suitable habitat. Use all survey methods.

    -Camp Parks
    -Bethany Reservoir
    -San Antonio Reservoir

Additional efforts to obtain landowner permission for surveys included a letter to the Farm Bureau, Resource Conservation District, the Cattlemans Association, and selected landowner associations within the two county area, explaining the project in detail and the ramifications to landowners should a kit fox be detected or not during the survey (Appendix 4). Additionally, the letter stated that CDFG departmental staff would be available to meet with the Board and members to answer questions. CDFG staff members Ron Schlorff and Caitlin Bean subsequently met with the Resource Conservation District of Alameda County to discuss the project. We hoped that Board members would disseminate the information and that willing landowners would come forward and volunteer permission for a survey. Although the project is now more clearly understood by a number of landowners, none volunteered to participate in the project.

Our field techniques began with assessing the potential quality of the survey area, whether a road transect or a property, as suitable kit fox habitat. We hoped this assessment would identify which habitat characteristics might be associated with kit fox presence. Using habitat characteristics information from the habitat analysis for San Joaquin kit fox in the northern range, current land use, percentage of grassland, soil type/denning potential, evidence of potential kit fox predators, competitors and prey, and the proximity of historical kit fox sightings were recorded (Bell 1994).

Road transect surveys were conducted along 8 twelve-mile sections using both track plates and spotlights. Six baited track plates were placed on one half of the transect at intervals of 1 mile and monitored for six nights. During this same six night period the other half of the transect was surveyed using a two person team operating 2 spotlights (minimum 800,000 candlelight power); one from either side of a truck moving at 10-15 mph. Each nightly survey period was approximately two-three hours; the time it took to drive the section a minimum of two times. At the end of the six day period the procedure for each half of the transect was reversed. The work on each

transect was completed within a 14 day period. All species observed, and detected by tracks were recorded.

We adapted site survey methodology from the CDFG Region 4 Survey Methodology Guidelines for kit fox surveys. Night spotlighting was conducted for six nights within a 14 day period. Two observers using spotlights with a minimum candlelight power of 800,000, drove a survey vehicle ≤ 15 mph and along varied routes within the existing road networks on a survey site. Whenever eyeshine or animal movement was detected, the vehicle was stopped and the animal identified using binoculars (minimum ≥ 7x35). Sightings of all canids, predators, potential prey, competitors, and potential dens were recorded.

Scent stations consisted of either 1 meter square smoked aluminum track plates (Barrett 1983) or aluminum track plates covered with a fine layer of carpenter's chalk (Orloff et. al 1993). A minimum of 5 scent stations were placed per 640 acres and were operated for a minimum of 12 nights within a 14 day period. Based on behavioral responses of captive kit fox to various baits, fresh canned cat food was choosen for use on the scent stations (Appendix 5). Cat food was placed in the center of each plate every night. All tracks were identified and recorded.

We used baited camera stations, either triggered by an animal breaking an electronic beam (Trailmaster) or by the animal pulling on bait triggering the camera (Alvarez 1994). The success of the Trailmaster camera on forest carnivores has been documented by Barrett et al. (1993). The trigger cameras were tested in 1991 by Alvarez (1994) in an area known to have a kit fox, and multiple photos of kit fox were obtained (Fig. 17). These camera stations, baited with canned cat food or chicken legs, were set at a density of 5/640 acres and operated for a minimum of 12 nights within a 14 day period.

Survey Results.--The current status of surveys originally planned for Contra Costa and Alameda Counties is shown in tables 4 and 5, respectively. We were unable to

Figure 17. Kit fox trigger camera photos.

San Joaquin Kit Fox (Vulpes macrotis mutica)
Location: Corral Hollow Road @ I-580
Photo by trigger-camera system, 27 November 1991

Table 4. Results of survey plans for Contra Costa County San Joaquin kit fox survey, February - October 1993.

FINAL STATUS OF SURVEYS IN CONTRA COSTA COUNTY

1. Areas with recent (1990's) confirmed or unconfirmed kit fox sightings.

| | |
|---|---|
| -Round Valley | *survey completed* |
| -Black Diamond | *survey completed* |
| -Byron Highway | *dangerous driving conditions* |
| -Byron Airport | *currently monitored for kit fox* |

2. Areas where kit foxes were sighted during the 1980's.

| | |
|---|---|
| -Herdlyn Watershed properties | *permission denied* |
| -Brushy Creek properties | *permission denied* |

3. Unprotected areas with suitable habitat.

| | |
|---|---|
| -Kruse Ranch | *survey completed* |
| -Moller Ranch | *permission granted for 1994* |
| -Cowell Ranch | *permission pending* |
| -Dougherty Valley | *permission pending* |
| -Tassajara Valley | *permission pending* |
| -Doolan Canyon | *permission pending* |

4. Protected areas with suitable habitat.

| | |
|---|---|
| -Tassajara Regional Park | *survey completed* |
| -Mt Diablo State Park | *reevaluated* |
| -Contra Costa Water District | *permission granted for 1994* |

5. Surveys along county roads traversing suitable habitat in areas where landowner permission cannot be obtained.

| | |
|---|---|
| -Deer Valley Rd. | *survey completed* |
| -Briones Valley Rd. | *survey completed* |
| -Horse Valley Rd. | *permission granted for 1994* |

Table 5. Results of survey plans for Alameda County San Joaquin kit fox survey, February - October, 1993.

FINAL STATUS OF SURVEYS IN ALAMEDA COUNTY

1. Areas with recent (1990's) confirmed or unconfirmed kit fox sightings.

| | |
|---|---|
| -Delta Mendota Canal | *survey completed* |
| -Old River Levy | *permission denied* |
| -Altamont Landfill | *permission granted for 1994* |
| -Laughlin and Dyer Rd. Properties | *permission denied* |
| -Bernal and I-680 | *survey completed* |

2. Road transect surveys.

| | |
|---|---|
| -Patterson Pass Rd. | *survey completed* |
| -Mines Rd. | *roadside habitat not suitable* |
| -Corral Hollow Rd. | *dangerous driving conditions* |
| -Highway 84 | *dangerous driving conditions* |
| -Calaveres Rd. | *roadside habitat not suitable* |
| -Welsh Creek Rd. | *roadside habitat not suitable* |
| -Collier Canyon Rd. | *survey completed* |
| -Bruns Rd. | *survey completed* |
| -Altamont Pass Rd. | *survey completed* |

3. Unprotected areas of suitable habitat.

| | |
|---|---|
| -Patterson Pass properties | *permission denied* |
| -Altamont Pass properties | *permission denied* |
| -Corral Hollow properties | *permission denied* |
| -South Livermore properties | *permission denied* |

4. Protected areas with suitable habitat.

| | |
|---|---|
| -Camp Parks | *survey completed* |
| -Bethany Reservoir | *survey completed* |
| -San Antonio Reservoir | *survey completed* |

carry out some aspects of the initial plan; several of the targeted roads proved unsuitable for transect surveys due to dangerous driving conditions or unsuitable roadside habitat. Obtaining landowner permission to conduct surveys proved extremely difficult and we were unable to obtain access to several areas with historical kit fox sightings, as well as the majority of unprotected areas with suitable habitat.

Locations of survey sites and road transects are presented in figure 18 and the results are summarized in table 6. No kit foxes were detected, even in areas with historical kit fox sightings with apparently suitable habitat. In striking contrast, non-native red foxes were detected during 8 of the 10 surveys and were abundant in some locations (Fig. 19). CDFG Warden Jim Bond recorded 21 red foxes (including foxes in the black and cross phase) during a May night spotlighting survey of the 400 acre Bernal/I-680 site in Pleasanton, Alameda County (pers. comm.). Subsequently, we set up camera stations and determined that there were at least four adult red foxes and three litters at this site. Red foxes were also particularly numerous along the Patterson Pass Road transect in the northeastern part of Alameda County. We spotted 7 red foxes along this route in a single night. Coyotes, domestic dogs, and bobcats, all of which are also known to kill kit fox, were present in many of the survey areas.

Ground squirrels were absent along many of the road transect routes, such as Patterson Pass Road, Altamont Pass Road, Collier Canyon Road, and Deer Valley Road. Although no direct evidence was found, it is probable that these areas are or were poisoned. We did find evidence of ground squirrel poisoning at sites where historical kit fox sightings existed. Bait stations with "blue oats", possibly chloraphacinone or diphacinone, were found at the northern edge of the Bethany Reservoir site, and a dead ground squirrel with a blue oats in its mouth and a stomach lining stained blue was found in the southern section of the Bethany Reservoir site. In addition, empty bait stations were found adjacent to Delta-Medota Canal.

Figure 18. Location of survey sites and transects in Alameda and Contra Costa Counties.

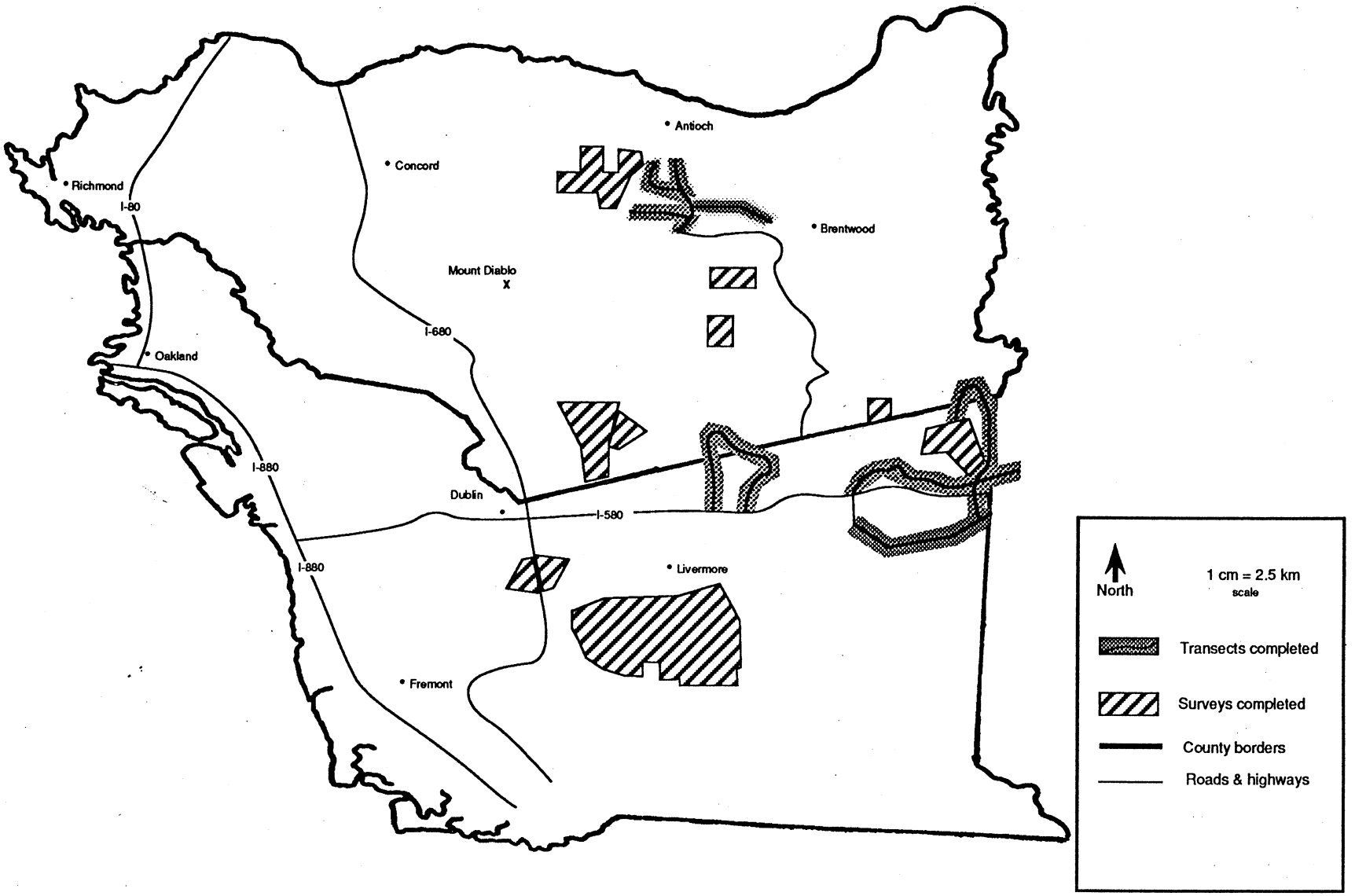


Table 6. Species found and habitat characteristics for sites surveyed for San Joaquin kit fox in Alameda and Contra Costa County, February - September 1993.

| | | SPECIES | | | | | | | | | | | | HABITAT CHARACTERISTICS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Predators/Competitors | | | | | | Other | | | | Potential Prey spp. | | | | | | | | | | | | | | | |
| | Site | Historical fox sighting | San Joaquin Kit Fox | Red Fox | Coyote | Bobcat | Domestic Dog | Badger | Domestic Cat | Opposum | Raccoon | Striped Skunk | Ground Squirrel | Small Rodents | Black-tailed Hare | Cottontail | Ground Birds | Reptiles | ≥ 50% Grassland | Denning Potential | Coyote Presence | Prey Availability (est.) | Land Use |
| ROAD TRANSECTS | #1 Patterson Alameda Co. | | | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | M | G |
| | #2 Bruns Alameda Co. | ● | | ● | ● | | | | ● | ● | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | M | A,G |
| | #3 Altamont Alameda Co. | ● | | | | | ● | | ● | | | ● | | ● | | ● | ● | | ● | ● | | M | A,G |
| | #4 Collier Alameda Co. | | | ● | | | ● | | ● | | | | | | ● | ● | ● | | ● | ● | | L | A,G |
| PROPERTIES | Tassajara Alameda Co. | | | ● | ● | | | | ● | ● | | ● | ● | ● | | ● | ● | ● | ● | ● | ● | M | G |
| | Round Valley CC Co. | ● | | | ● | ● | | | | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | H | G |
| | Bernal Alameda Co. | | | ● | | | | | ● | | | | ● | | | ● | ● | | ● | ● | | L | A |
| | Bethany #1 Alameda Co. | ● | | ● | | | | | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | | M | W,G |
| | Bethany #2 Alameda Co. | ● | | ● | | | | | ● | ● | | ● | ● | ● | | ● | ● | | ● | ● | | M | W,G |
| | Camp Parks both counties | | | ● | ● | ● | | ● | ● | | | ● | ● | ● | ● | ● | ● | | ● | ● | ● | H | O |

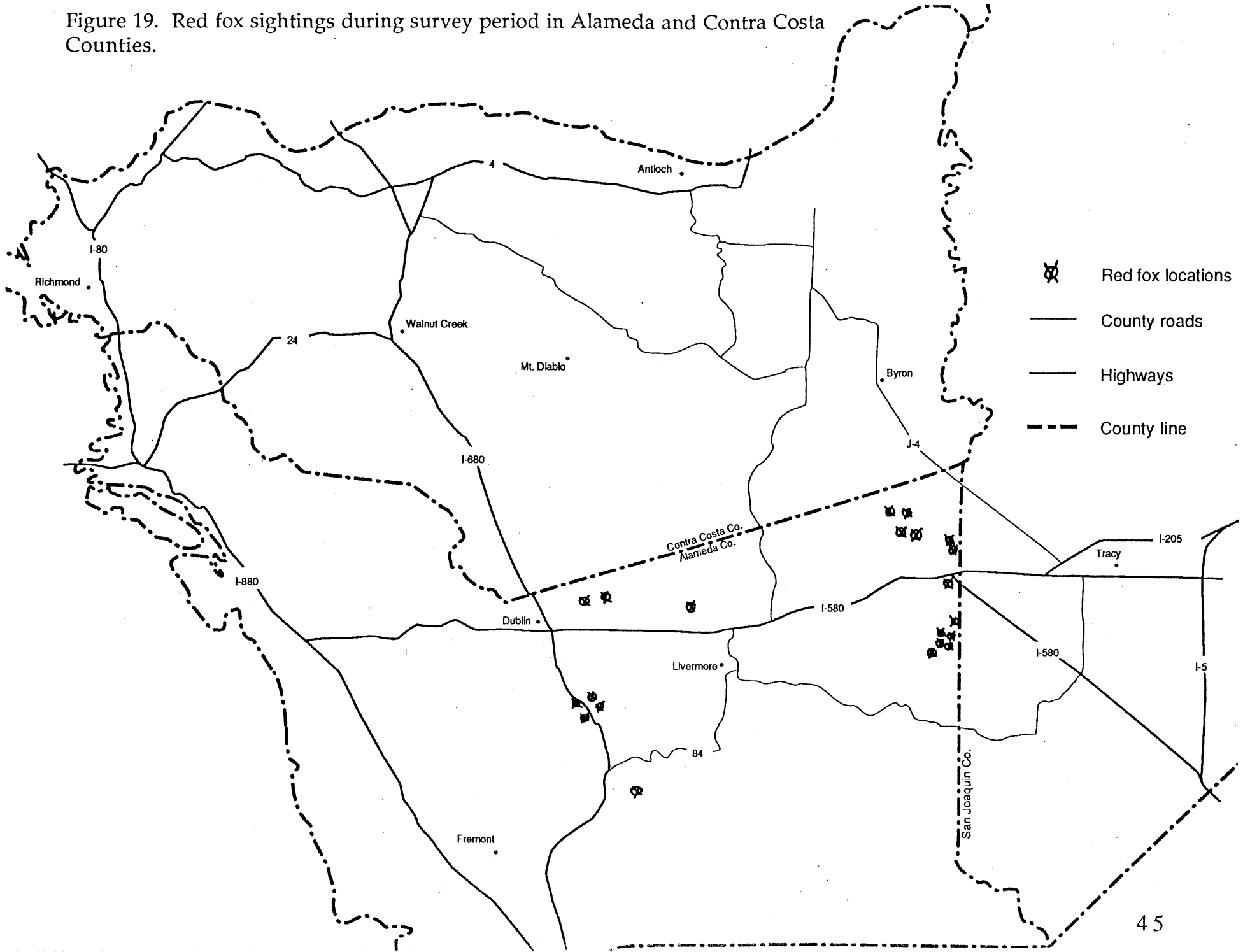
Prey Availabilty: H = High, M = Medium, L = Low.
Land Use: A = Agricultural, G = Grazing, W = Wind Power, O = Other.

Table 6 continued. Species found and habitat characteristics for sites surveyed for San Joaquin kit fox in Alameda and Contra C County, September - November 1993.

| | SPECIES | | | | | | | | | | | | | | | | | | | | HABITAT CHARACTERISTICS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Predators/Competitors | | | | | Other | | | | | Potential Prey spp. | | | | | | | | | |
| Site | Historical fox sighting | San Joaquin Kit Fox | Red Fox | Coyote | Bobcat | Domestic Dog | Badger | Domestic Cat | Opposum | Raccoon | Striped Skunk | Ground Squirrel | Small Rodents | Black-tailed Hare | Cottontail | Ground Birds | Reptiles | ≥ 50% Grassland | Denning Potential | Coyote Presence | Prey Availability (est.) | Land Use |
| ROAD TRANSECTS | | | | | | | | | | | | | | | | | | | | | | |
| Deer Valley CC Co. | | | | ● | | ● | | ● | ● | ● | ● | | | ● | ● | ● | | ● | | ● | L | G |
| PROPERTIES | | | | | | | | | | | | | | | | | | | | | | |
| Black Diamond CC Co. | ● | | | ● | | | ● | | ● | ● | ● | | ● | ● | ● | ● | | ● | ● | ● | H | G,O |
| Delta-Mendota Alameda Co. | ● | | ● | | | | | | | | | ● | | ● | ● | ● | | ● | ● | | H | O |
| Kruse CC Co. | | | | | | | | | | | | ● | | | | ● | | ● | ● | | M | G |
| SFWD Alameda Co. | | | ● | ● | ● | | | | ● | ● | ● | ● | ● | | ● | ● | ● | ● | | ● | M | G,O |

Prey Availabilty: H = High, M = Medium, L = Low.
Land Use: A = Agricultural, G = Grazing, W = Wind Power, O = Other.

Figure 19. Red fox sightings during survey period in Alameda and Contra Costa Counties.



Camera Comparison.--Two, distinctly different, types of remote photographic units were used to identify wildlife: the Trailmaster system; a commercial unit that uses a motion detection triggering devise, and a hand-made unit that used a bait-pulled triggering devise. Two Trailmaster units were purchased and used during the study for a total of 196 camera nights. During this period 191 of 343 photos (56%) revealed 9 species. Two of the 9 species photographed by the Trailmaster cameras, California ground squirrel and cow, comprised 122 (68%) of the 191 identifiable pictures taken.

Up to 10 trigger-cameras were used at any one time period during the study for a total of 560 camera nights. One hundred thirty eight of 160 photos (86%) revealed 14 species. The 9 species documented by the Trailmaster were also photographed by the trigger-camera. Although no kit fox were photographed, many other species were including: Turkey Vulture, Northern Harrier, badger, striped skunk, coyote, red fox, cat, cow, and deer (Figure 20).

Using the photographic units in addition to the two other methods (track stations and night spotlighting) allowed us confirm the occurrence species from which we had recorded tracks or seen directly. However, on at least 2 sites we photographed species that were not recorded from tracks or direct observation.

Discussion

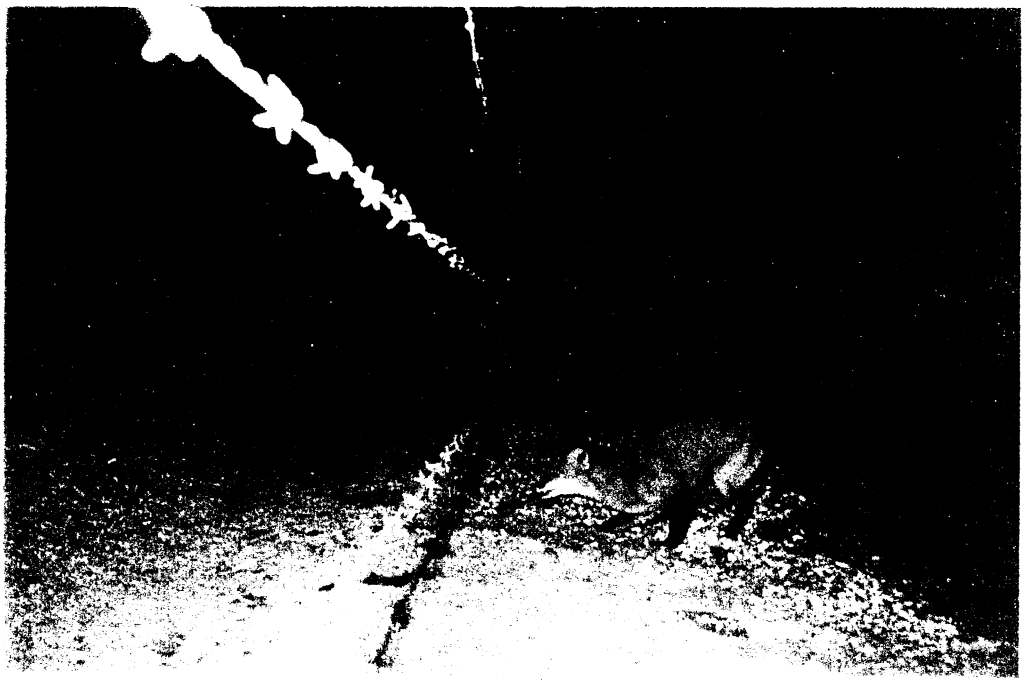
Although the areas surveyed to date represent only a small portion of the potential kit fox habitat in Alameda and Contra Costa Counties, our failure to detect a single kit fox strongly suggests that the current kit fox population in these counties is at a low level. Our results are consistent with the findings of other surveys conducted in 1993 in these counties by private consulting firms, all of which failed to detect kit fox. The only sightings of kit foxes in these two counties during 1993 were two separate sightings during construction of the Byron Airport in Contra Costa County (Larry Stromberg, Biological Consultant to the Byron Airport Manager, pers. comm.). Another kit fox was

Figure 20. Trailmaster photos: red fox pup, and cow and trigger-camera photos: red fox, striped skunk, coyote, and deer.

Trailmaster camera unit - Red fox pup

Trailmaster camera unit - Cow

Figure 20. continued.



Trigger camera system - Red fox

Trigger camera system - Striped skunk

Figure 20. continued.

Trigger camera system - Coyote

Trigger camera system - Black-tailed deer

reported at the southeastern corner of Clifton Court Forebay on the east side of Byron in San Joaquin County (Rick Knurshal, USFWS, pers. comm). Thus, all of the most recent sightings have been near Byron and Mt. House; areas of intense agricultural use.

Estimating trends in kit fox numbers is difficult even with the benefit of the CDFG quarterly road transect surveys, and Alameda and Contra Costa Counties have had no such program. It is not possible to estimate trends by counting the numbers of kit foxes reported over time, because the methods of detecting kit fox have changed tremendously over the last 24 years (Table 7).

In the 1970's, sightings were mainly reported by DOA personnel. Not until 1988 did consulting firms begin using kit fox survey protocol, developed by the CDFG Region 4 office, which provided consistency in survey methodology. In 1990 the USFWS adopted this protocol as the official survey methodology, thereby requiring an intensive search for kit fox on any land within the 1990 USFWS San Joaquin kit fox range boundary where a land use change was proposed.

However, kit foxes were still difficult to detect in Alameda and Contra Costa Counties, so in 1993 the USFWS developed a more intensive survey protocol for the northern range. Therefore, the level of search intensity, and in all probability the number of surveys conducted, has increased over the last 10 years. Given the increase in survey intensity over time, it is probable that the kit fox population in Alameda and Contra Costa Counties has decreased since the 1970's.

An area of particular interest to the continuing survival, success, and recovery of the kit fox in Alameda and Contra Costa County is eastern Alameda County south of I-580 and east of Livermore; which may link habitat in these counties with known habitat in San Joaquin County. In the 1970's there is a record of 1 kit fox in this area and in the 1980's 1 kit fox and 1 set of tracks. No sightings have been reported during the 1990's. However, kit fox have been seen to the southeast, in San Joaquin County, from

Table 7. Breakdown of kit fox observations over a three decade period.

| Decade | # of years | # of foxes | Survey intensity |
|---|---|---|---|
| 1970's | 10 years | 34 + pups | DOA personnel and landowner reports. |
| 1980's | 10 years | 23 + pups a "population" and 2 sets of tracks | 1988 Biological Consulting firms begin using Region 4 survey protocol. |
| 1990's | 3 years | 32 individuals 2 sets of tracks | 1990 USFWS offically adopted Region 4 survey protocol.<br>1993 USFWS issues a more intensive survey protocol for the northern range. |

the 1970's (9 kit fox, 1 active den, and 1 road kill) through the 1980's (2 kit fox and a "population"), and into the 1990's (9 kit fox and 1 set of tracks). The 1980 and 1990 sightings, however, are not near the border with East Alameda County, but from Corral Hollow Road along the west side of I-580 and I-5 to the Stanislaus County border (Fig. 15).

This area may provide the only corridor where kit fox from San Joaquin County may immigrate to Alameda and Contra Costa Counties. The effect of possible barriers to kit fox immigration in this area (i.e. I-580 and the red fox habitation) and habitat degradation (due to ground squirrel poisoning and development) may be limiting factors. At this time, however, without further evidence, it is our estimate that the kit fox population in Alameda and Contra Costa County is not yet isolated from the population in the San Joaquin Valley.

Potential reasons for the decline in kit fox sightings

Reasons for the decline in kit fox numbers in California have been mainly attributed to loss of kit fox habitat due to land use changes. We researched potential reasons for the decline of kit fox sightings over the last 23 years in Alameda and Contra Costa Counties considering both habitat loss and habitat degredation. Development, drought, rodenticide use, coyote presence, non-native red fox, and barriers to immigration/recolonization are thought to effect habitat, and thus may contribute to the decline in kit fox sightings.

Habitat Loss.--In 1975 Morrell published a map showing kit fox range and sightings in Alameda and Contra Costa Counties. The majority of these sightings were in the eastern sections of both counties and were contiguous with sightings in San Joaquin County. Few and scattered sightings occurred west of the Livermore Valley. Hence, even in the 70's the main area of kit fox habitat and range was the eastern sections of both counties. Investigation into land use changes in these counties over the last 20 years revealed that very little area has actually experienced land use change;

such as, agricultural conversion or other development attributable to destroying kit fox habitat. In fact only an insignificant portion of the potential kit fox habitat has been lost to agricultural conversion or development (Jim Cutler, Contra Costa Planner, pers. comm.)(Fig. 22). Additionally, large parcels of land in eastern Contra Costa County are under public ownership. Land use on these public lands includes: regional parks and preserves, wind farms, and watersheds (Fig. 23).

In contrast areas west of Livermore Valley have been heavily developed in the last 20 years and only islands of potential habitat still exist near the I-580 corridor. North and south of this corridor, large tracts of habitat still exist (San Antonio Reservoir and Dougherty Valley) and although kit fox sightings have been recorded in the Dougherty Valley area, these sites are not areas where kit fox were sighted historically with any regularity.

Drought.--It is likely that kit foxes in the northern range were negatively effected by a 6 year drought that occurred from 1987-1993. No specific studies on the effects of drought on kit fox and their prey exist for the northern range. Vanderbilt et al. (unpublished) report that at the Carrizo Plains a drought occurred from 1990 to 1991 coupled with a decrease in prey populations (Williams and Germano (1992) established that seed production declined with a corresponding decline in the nocturnal prey population levels) and that the primary effect of prey scarcity on kit fox was to decrease their reproductive success. Following one year of drought none of 9 radio-collared females reproduced.

Coyote presence.--Coyote presence noted during the surveys showed that coyotes were scattered throughout Alameda and Contra Costa Counties. Coyotes were most commonly seen singly and in pairs. Although we observed individuals and groups of 2, coyotes at Camp Parks were reported to travel in groups of up to six individuals (Commander Cab pers. comm.). The presence of coyotes and their effect on kit fox presence or absence was shown by Bell (1994) not to be significant. In fact, kit foxes were

Figure 22. Areas of habitat loss in Alameda and Contra Costa Counties.

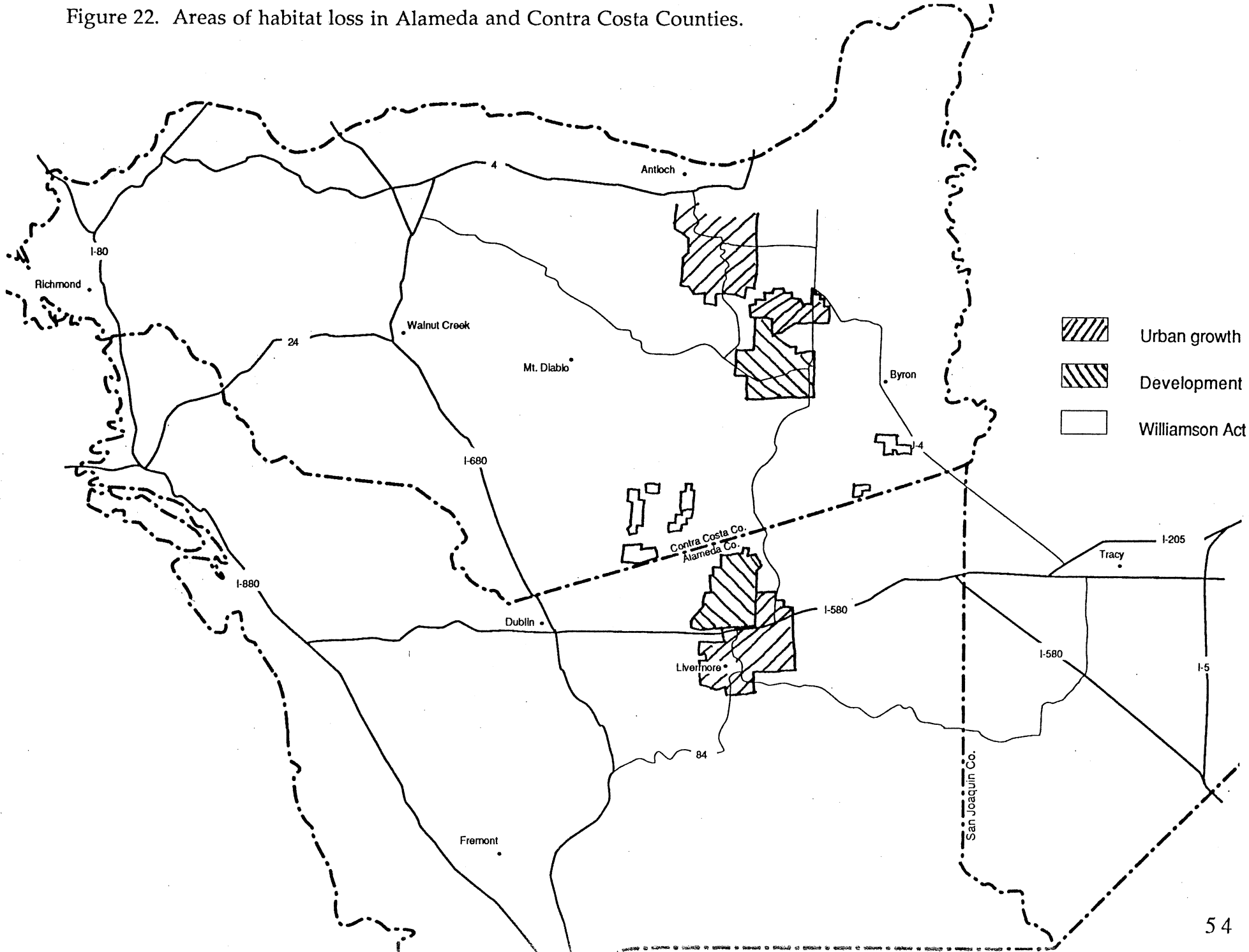
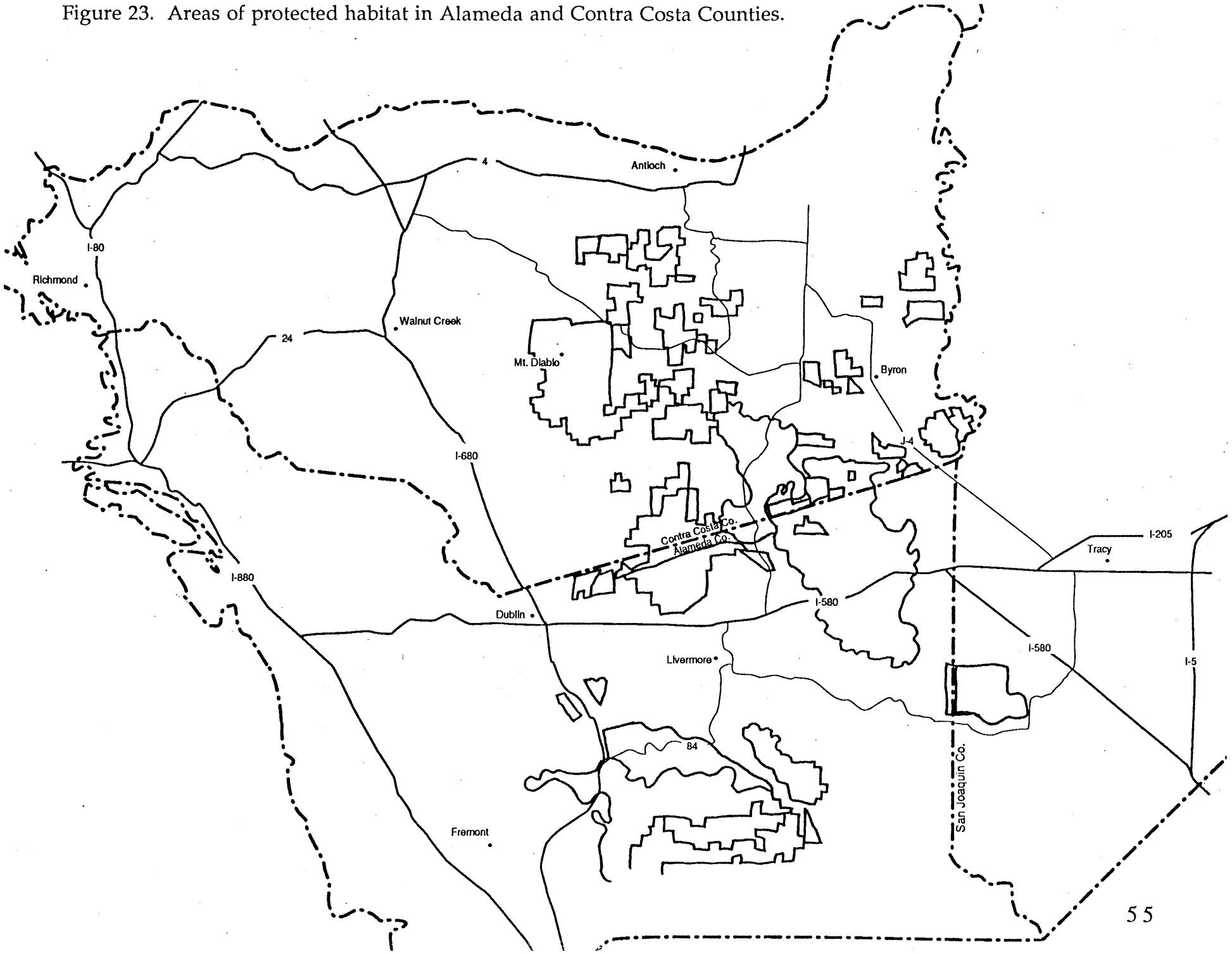


Figure 23. Areas of protected habitat in Alameda and Contra Costa Counties.



seen only in areas where coyotes had also been seen during the survey period, suggesting that the habitat occupied by the coyotes also offers attributes that were prerequisite to kit fox habitation (Bell 1994). Ralls and White (1991) provide information linking the mortality of kit fox at Carizzo Plains to predation by coyote (coyote predation was responsible for 70% of kit fox mortality). Home ranges of kit foxes were found within the home range of coyotes, suggesting that kit fox do not have the avoidance behavior that has been recorded in red fox-coyote interactions. No studies have been conducted on kit fox-coyote interactions in the northern range. Based on the limited information available about coyote populations and kit fox-coyote interactions in Alameda and Contra Costa Counties, it would be difficult to discern the impact coyote presence would have on kit fox populations. Although coyotes are responsible for upto 70% of kit fox annual mortality, they may also keep red foxes frin reaching high densities. Kit fox, having evolved with coyotes, may infact survive coyote predation more successfully than competing for prey with red fox.

Rodenticide use.--The California ground squirrel historically inhabited most of Alameda and Contra Costa Counties. This diurnal rodent has been considered an agricultural pest by ranchers who claim they compete with cattle for forage. Additionally, ground squirrels tunnel within stockpond burms, and irrigation ditches; create burrow entrances which can make footing unsafe; and was thought to carry foot and mouth disease. Today much of the undeveloped lands in the eastern sections of these two counties are still heavily grazed. Because ground squirrels are viewed as a threat to the ranchers profitability rodenticides have been used to control or eradicate them.

San Joaquin kit foxes eat ground squirrels (Hall 1983, Orloff et al. 1986). Kit fox also enlarge ground squirrel burrow systems for their own denning purposes. Since the mid-80's it has been suggested that the presence of ground squirrels is essential for kit fox to inhabit Alameda and Contra Costa Counties (Orloff et al. 1986). Current research

suggests that kit foxes may be detected in areas of ground squirrel habitation as well as areas were ground squirrels no longer occur; in the later case other rodent prey was available and denning opportunities were present (Bell 1994).

From 1991 to 1993 survey teams conducted surveys to determine San Joaquin kit fox presence in Alameda and Contra Costa Counties. During these surveys ground squirrel abundance was recorded. It became apparent that ground squirrels were not being seen in areas of suitable habitat.

Evidence of potentially dangerous pest control practices discovered during kit fox surveys in 1993 included poisoning of federal properties by a leasee where a family of kit foxes had been studied by Hall in 1982. This leasee allowed bait to spill out of the bait station and left ground squirrel carcasses unburied. Prompted by these observations, in the summer and fall of 1993 we interviewed the Department of Agriculture's (DOA) county deputies Bart Hossman (Contra Costa County) and John Guveya (Alameda County), and the Department of Pesticide Regulation Wildlife Biologist, John Shelgren focusing on the historical and present pest control programs. In addition, Contra Costa County's DOA Daily Use Reports were reviewed and applicable literature researched.

Historical rodenticide practices from 1950-1990 were extreme, according to Bart Hossman. From the 1950's thru the early 1970's there was tremendous pressure to eradicate the California ground squirrel from Contra Costa County. During this time the County DOA carried out the ground squirrel eradication campaign mainly using compound 1080 (Table 8).

During this same time period, Alameda County's DOA carried out a program of ground squirrel control using much the same methods (John Guveya, pers. comm.). The eastern and northeastern sections of the county were the most heavily poisoned areas, using compound 1080 and anti-coagulants. In addition thalium sulfate and carbon bisulphide were used throughout the 1960's and 1970's.

Table 8. Rodenticide explanation.

Common name, description of application type, and target species of rodenticides

- "Anti-coagulants": Usually a treated grain bait, interfers with the prothrombin rate, slowing the blood clotting ability of the circulatory system, the animal bleeds to death internally or externally.

  Chlorophacinone; depending on percentage of active ingredients, targeted to kill ground squirrels, house mice, norway and roof rats, deer mice, hares, muskrats, woodrats, and meadow voles.

  Diphacinone; depending on percentage of active ingredients, targeted to kill meadow voles.

  Other common names are Brodifacoum, Fumarin, Pivalyn, Prolin, and Warfarin.

- "Acute Rodenticides": Restricted materials, must contact Agricultural Commissioner regarding use.

  Sodium monofluroacetate, known as "Compound 1080" an acute rodentide which interferes with the animals kreb cycle, causing nerve deterioration or cardiac arrest. Prepared as a treated grain bait. Targeted to kill ground squirrels, house mice and rats.

  Zinc Phosphide is an acute rodenticide which turns into the toxic gas phosphine, once ingested. Targeted to kill ground squirrels, norway and black rats, woodrats, and meadow voles.

  Thalium Sulfate is an acute rodenticide. Not biodegradable, causes secondary poisoning. Targeted to kill ground squirrels.

- "Fumigants":

  Methyl Bromide is a toxic gas cartiridge used in burrows. Restricted material, must contact Agricultural Commissioner regarding use. Targeted to kill ground squirrels when used in burrow systems. When used in an enclosed area targeted to kill house mice, norway and black rats, pocket gophers, and moles.

  Carbon Bisulphide is a liquid biocide fumigant. Restricted material, must contact Agricultural Commissioner regarding use. Targeted to kill ground squirrels.

Table 8. continued

Smoke Bomb is a gas cartridge which suffocates the animal. Targeted to kill ground squirrels, moles, norway and black rats, pocket gophers, moles, skunks, and other burrowing rodents.

Phostoxin Tablet is an aluminum phosphide tablet which when in contact with the mosture of the burrow releases a toxic gas. Targeted to kill burrowing rodents.

Recommended use of rodenticides by the US Department of Agriculture mandates using grain or chopped baits containing (by weight) 0.05 to 0.1% compound 1080. The poison is commonly applied along with a blue dye additive to oat grain, known as "oat groat". It was suggested that the blue dye was added to discourage birds from consuming the grain directly off of the ground. An area of heavy ground squirrel concentration was located, County personnel then broadcasts the bait freely over the immediate area at a rate of 10 lbs/acre, or 2-3 kernals/$ft^2$. All application were supervised by the County Agricultural Commissioner (Leach 1976).

In 1975 research on the primary and secondary hazards to kit fox from compound 1080 and two other rodenticides (strychnine alkaloid and zinc phosphide) concluded that kit fox died after consuming kangaroo rats that had died from compound 1080 poisoning (Schitoskey 1975). It was estimated that a kit fox that consumed a kangaroo rat that had swallowed or stuffed its cheek pouches with 1 g of 1080 bait would theoretically have swallowed a kangaroo rat carcass that contained 1 mg of 1080. Kit foxes died when fed single dead kangaroo rats dosed with less than these amounts of compound 1080 (Schitoskey 1975).

In 1978 Contra Costa County gave responsibility for ground squirrel control to the landowners. Anti-coagulants, thought not to have secondary poisoning effects, had now become common for rodent control, but compound 1080 was still sold by the County DOA up through 1988 and stored bait may have been in use by landowners later than 1988 (John Selgren, Ca. Department of Pesticide Regulation, pers. comm.)(Table 9).

Beginning in the late 80's, maps indicating San Joaquin kit fox range have been presented annually to the County Agricultural Commissioners by the California State Department of Pesticide Regulation. Guidelines for rodenticide application are provided in the Vertebrate Pest Control Handbook, and on labels attached to the rodenticide by the Environmental Protection Agency indicating specific restrictions.

Table 9. Recent uses of compound 1080 in Contra Costa County.

| Date | Location | Amount | Concentration |
|---|---|---|---|
| 1986 | Souza & Vaquero Farms | 3,000 lbs | .05 % |
| 1987 | Cronin Ranch | 5,500 lbs | .02 % |
| 1988 | Silva Ranch | 700 lbs | .05 % |

Additionally, a state label, known as the 24C Label, dictates special local restrictions. On compound 1080 guidelines provided restrictions for use of compound 1080 not to be applied within 1 mile of an active kit fox den. No such buffer zone has been established for the use of anti-coagulants. However, following any application of a rodenticide, ground squirrel carcasses found above ground are to be picked up, burned or buried to prevent secondary poisoning.

Beginning January 1991 Rodenticide 100% Use-Reports became mandatory. This requires that all landowners report the use of nonrestricted rodenticides by township, range, and section number. Nonrestricted rodenticides do not have to be purchased from the county DOA and include anti-coagulants such as Diphacinone and Clorophacinone.

Contra Costa County's eradication program (1950-70's) was so successfull, that in some areas, particularly the northeastern section of the county, ground squirrels are still very rare. In southeastern Contra Costa County, near the county line, the numbers of ground squirrels have generally increased (B. Hosman pers. comm.). Contra Costa County still maintains a Departmental Posioning Program, and Daily Use-Reports are filed (Table 10). The program targets roadside control of ground squirrels, as well as railroad right of ways, and irrigation and stock pond burms. The majority of the bait, usually anit-coagulants, is broadcast from a spreader mounted on a truck. Landowners using rodenticides are required to place bait in a bait station which consists of a 3 inch PVC pipe with a 45° bend in the pipe infront of the bait repository. This practice should exclude larger mammals and birds from getting directly at the poison bait.

In promoting a control rather than an eradication program, Alameda County landowners still experience high numbers of ground squirrels on their lands. Landowners known to have used rodenticides in 1993 were recorded and mapped (Fig. 21).

Table 10. Contra Costa County Department of Agriculture Poisoning Program, Daily Use-Report information for east Contra Costa County, Sante Fe Railroad Properties not included.

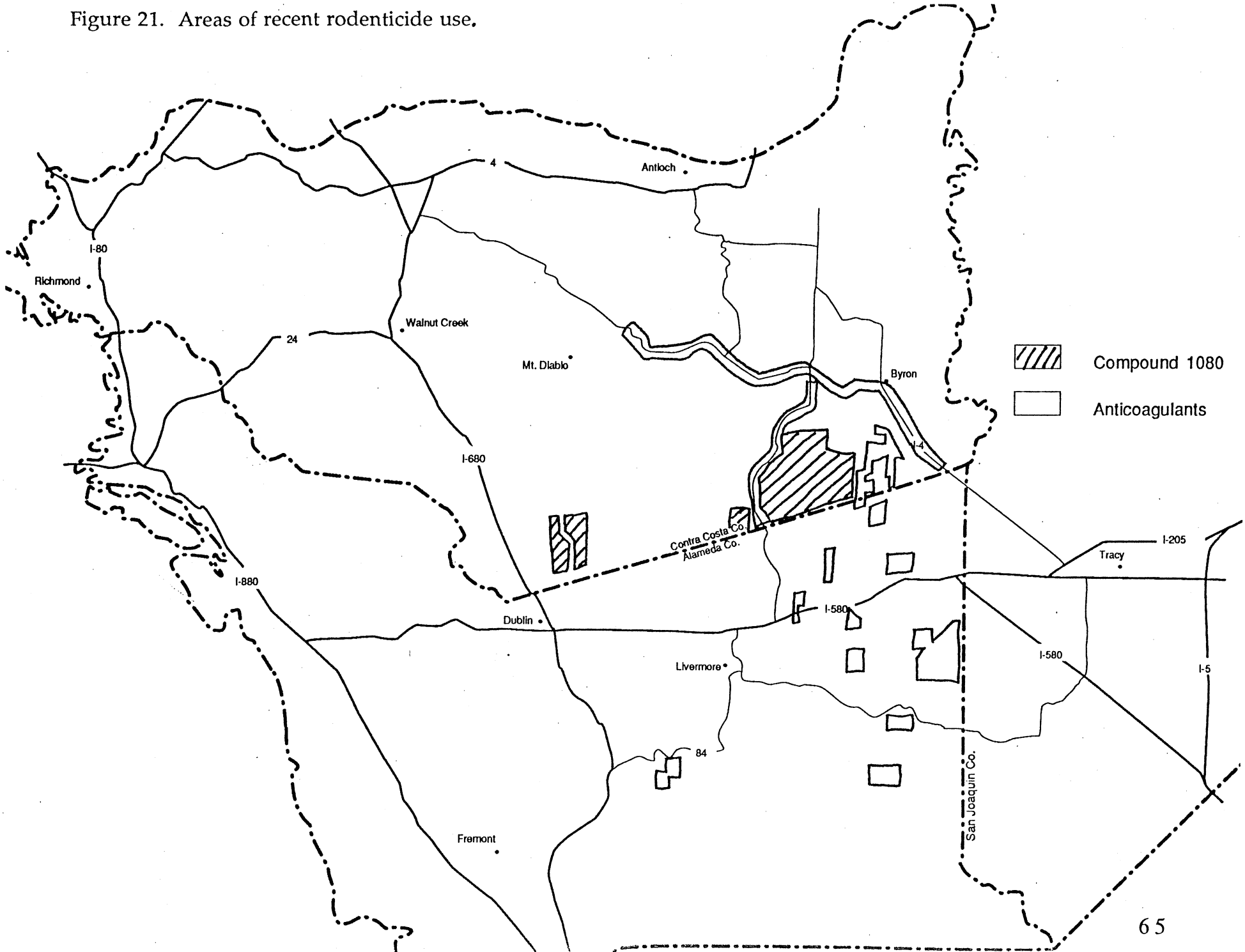
| Location | Poison | 1991 | 1992/93 |
|---|---|---|---|
| Marsh Creek Rd. | MethylBromide | 33 lbs | 6 lbs |
| | Smoke Bombs | 6 lbs | 17 lbs |
| | Phostoxin Tablets | | 250 lbs |
| | Chlorophacinone | 675 lbs | |
| | Diphacinone | | 1305 lbs |
| Kellogg Creek | Methyl Bromide | | 1.5 lbs |
| | Smoke Bombs | | 55 lbs |
| | Chlorophacinone | 145 lbs | |
| | Diphacinone | | 380 lbs |
| Byron Highway | Diphacinone | | 95 lbs |
| Byron Airport | Diphacinone | | 870 lbs |
| Byron Hot Springs | Chlorophacinone | 250 lbs | |
| | Diphacinone | | 255 lbs |
| Bruns Rd. | Chlorophacinone | 75 lbs | |
| | Diphacinone | | 195 lbs |
| Vasco Rd. | Zinc Phosphide | 100 lbs | |
| | Chlorophacinone | 250 lbs | |
| | Diphacinone | | 735 lbs |

Table 10. continued.

| Location | Poison | 1991 | 1992/93 |
|---|---|---|---|
| Armstrong Rd. | Zinc Phosphide | 50 lbs | |
| | Diphacinone | | 250 lbs |
| Camino Diablo Rd. | Chlorophacinone | 150 lbs | |
| | Diphacinone | | 270 lbs |

- Most applications are for roadside control of ground squirrels; the bait being broadcast from a spreader mounted on a truck.
- Bait stations were used by Tony Souza and the Bethany Irrigation District during 1993.

Figure 21. Areas of recent rodenticide use.



At least one case of secondary poisoning of kit fox by anti-coagulants now exists. Recent investigations into sources and rates of mortality of a kit fox population at Camp Roberts Army National Guard Training Site, San Luis Obispo County, CA, suggested the death of two kit foxes was due to the kit foxes comsuming ground squirrels who had died from Chlorophacinone (Standley et al. 1992). This anti-coagulant was being used to kill ground squirrels on private land adjacent to Camp Roberts.

Both Bart Hossman and John Guveya believe it is possible for kit foxes to have been killed by ingesting lethal doses of poison from eating dead ground squirrels. Ground squirrels that have been poisoned may die above or below ground, however John Guveya suggested that 80-90% of the ground squirrels poisoned die below ground. In either case, kit fox may consume carcasses as they travel or during the course of expanding a ground squirrel burrow into a den site.

Orloff et al. (1986) stated that large scale poisoning campaigns can drastically reduce kit fox prey. Extensive field observations suggest that the use of ground squirrel poisons severely reduced ground squirrel populations in Contra Costa County and may be greatly suppressing populations of kit fox by eliminating their primary prey species.

Not only has the prey base of the San Joaquin kit fox been jeapordized by the counties' pest control programs, but historical kit fox populations may have been effected as well as present. It is not known to what extent the control and eradication programs have played in the decline of kit fox abundance in Alameda and Contra Costa Counties, but it appears certain that the current distribution is now being effected.

Non-native red fox.--The red fox was brought from the mid-west to the Central Valley more than a century ago and raised in fur farms or released for hunting (Jurek 1992). Since the demise of these fur farms, red foxes that escaped or were released, reproduced and dispersed to such a degree that Hunt (1989) stated that the non-native red fox situation in California is currently "out of control". According to CDFG

Warden J. Bond the number of non-native red fox sighted in Alameda and Contra Costa Counties has increased over the last 20 years. The close proximity of these two counties to the San Joaquin Valley has made red fox invasion inevitable. Although most red fox sightings are not recorded, records of sightings were kept during our surveys in the northern range (Fig. 19). It was not uncommon to see red foxes on survey sites; particularly in areas of eastern Alameda County where multiple families of red foxes were observed.

Barriers to immigration/recolonization--Aqueducts, canals, freeways, steep topography, and expansive agricultural areas may be barriers to kit fox dispersal. However, a six year study of kit fox dispersal on the Naval Petroleum Reserve (NPR) suggested that kit foxes travel through agricultural and urban areas, across highways, aqueducts, railroads, and over a 1,196 m high mountain range (Scrivner et al. 1987).

Possible barriers in the northern range and their effects on kit fox movements were assessed. The Delta-Mendota Canal and the larger California Aqueduct cross the eastern part of the northern range (Fig. 15). Although kit fox have been reported to swim across canals (Reeder 1948) the sides of the Delta-Mendota and California Aqueduct are very steep, and the current very strong, and it is unlikely that a fox could successfully swim across. However, both the canal and the aqueduct are crossed by numerous public and maintenance bridges, and in some areas the canal runs underground for distances over 500 meters to pass under roadways. The aqueduct is also crossed by culverts to allow for surface water runoff, and a red fox was seen to cross the aqueduct by using such a culvert (pers. obs.). The presence of the canal and aqueduct may act as a diversion to movement, but is an unlikely barrier. Interestingly, some of the highest prey availability and denning potential for kit foxes occur along these waterways, as the soil is friable and poisoning of ground squirrels is limited.

Interstate 580 runs in an east-west direction roughly dividing Alameda and Contra Costa Counties and merges with Interstate 5 which runs north-south through

San Joaquin County. I-580 is 6 lanes and is divided by a cement barrier from the Livermore Valley through the Altamont Pass. Near the San Joaquin County border there are only 2 county roads that cross under the interstate. I-580 might be considered a barrier because of the limited number of over-crossings and heavy vehicular use. Additionally, there is a possibility that the cement barrier will be extended along the eastern section.

Interstate 580, as it turns south to merge with I-5, is 4 lanes and has many over-crossings for roads and creeks. Under many of these over-crossings, particularly over creeks, wildlife movement is apparent from tracks and scat. It is possible that kit foxes travel underneath these over-crossings, but less likely that they could cross the interstate successfully.

The northern range is an area of steep topography with elevations from 2 to 1300 meters, and slopes as steep as 50°. Much of this area is grazed, non-native annual grasslands and thus potential kit fox habitat. Although some of these hills are very steep, the ranges diverge in a linear arrangement from the northeastern corner of Contra Costa County out into the flat areas of the Central Valley in San Joaquin County. It is evident from our aerial survey that movement of kit fox from the low flat grasslands of San Joaquin County into the more hilly terrain of Alameda and Contra Costa County could be achieved by traveling parallel to the ranges.

Kit fox were thought to prefer flat terrain for denning (Morrell 1975), but in the northern range a kit fox was seen entering a den located near the top of a 50° slope (pers. obs.). Virginia Getz observed a pair of kit fox with pups in the hilly terrain of the Los Vaqueros Watershed, Contra Costa County (V. Getz, Jones and Stokes Assoc., pers. comm.). It seems unlikely that the steep terrain of the eastern section of Alameda and Contra Costa and the western section of San Joaquin County might prove a barrier to kit fox movement. In fact kit fox were sighted in 1992 at Black Diamond Mines Regional Preserve, an area north of the 1990 USFWS kit fox range boundary.

Irrigated agricultural lands within Alameda and Contra Costa Counties are localized in the area known as "Mountain House" in Alameda County. Contrary to statements indicating that irrigated agricultural areas are not frequented by kit fox, the most regular sightings of kit fox in the northern range have been in and around these areas. In the 1990's kit foxes were reported in grasslands adjacent to the agricultural areas at the Byron Airport, along the Byron Highway, and between the Delta-Mendota Canal and an irrigated alfalfa field. It is apparent from night spotlighting that these irrigated agricultural fields - commonly planted with alfalfa - are heavily populated with rodents and lagamorphs.

However, in San Joaquin County, intensive agricultural practices is the prevelant land use. Only the area west of I-580 and I-5 has remained grassland. It is in this area that the majority of recent San Joaquin County sightings have been recorded. The area surrounding the city of Tracy (the location of the type specimen) has had a history of extensive, irrigated agricultural use, but is currently being converted to light industry and medium density housing. Kit fox sightings in this area are now infrequent. It appears that the stronghold of the kit fox population in San Joaquin County resides west of I-580 and I-5; an area of flat to hilly terrain.

Red fox as barrier.--Red foxes appear to limit the range of another small fox, the arctic fox *Alopex lagopus* (Hersteinsson and Macdonald 1992). This may suggest that the southern limit of the artic fox's range is determined, not by their adaptation to extreme cold, but by interspecific competition with and possible predation by the red fox.

The effect of red fox on kit fox is not completely understood. Attributes of red fox life history appear to put it in direct competition with the kit fox. For instance, red fox and kit fox are denning carnivores that prey on nocturnal and diurnal rodents and lagamorphs. There are of course differences in these two species: red foxes, under certain conditions, may stay together as family units, heavily populating an area.

Densities of up to 40 red foxes per sq. mile have been reported (Lewis et al. 1993). Red foxes inhabit grasslands, woodlands, agricultural, industrial and urban areas, but do not appear successful in desert habitats, perhaps because of a need for free standing water.

Red foxes carry external and internal parasites and diseases including some which have not been reported in kit foxes. Red foxes are affected by sarcoptic mange, the viral infections of rabies and distemper, parasites including cestodes, hookworms, and heartworms, and the bacterial infection, leptospirosis (Samuel and Nelson 1982). It is not clear what effects these parasites and diseases may have on kit fox. Additionally, red fox are known to have killed at least one kit fox on the Carrizo Plains (Ralls and White 1991).

The ability of the red fox to; tolerate suburban and urban habitats and thrive at high densities; in addition trasmitting diseases and killing kit fox, may indicate that the red fox is a potential barrier to the immigration/recolonization of kit fox from San Joaquin County into Alameda and Contra Costa Counties.

Prospects for kit fox populations in Alameda and Contra Costa Counties

Estimates of optimal carrying capacity--During a CDFG aerial survey it appeared that the eastern sections of Alameda and Contra Costa Counties are the remaining areas of potential kit fox habitat. To estimate the acreage available to kit fox as potential habitat, information on current range and sightings was plotted on a 1:250,000 scale map (Fig. 15). Sections that fell within this plotted overlay were counted; excluding any areas known to be of unsuitable habitat due to extremely steep and wooded topography. The total acreage for Alameda County was 60,800 acres and Contra Costa County 47,360 acres, for a combined total of approximately 108,000 acres of potential kit fox habitat remaing in these two counties.

The carrying capacity of 108,000 acres (169 $mi^2$.) of potential kit fox habitat is not easily estimated. Though population density information ranges from approximately one kit fox per square mile (Morrell 1975) up to 6 kit fox per square mile (Ralls and

White, unpublished) in appropriate habitat in the southern range, no reliable estimates of the population density in the northern range are available. Orloff et al. (1986) suggested that population density initially appeared to be much lower in the northern range, and offered an estimate of northern range kit fox density to be 0.1 to 0.2 kit fox per square mile (pers. comm.). A radio telemetry study in 1983 at Bethany Reservoir suggests that a pair of kit fox had dens located throughout the 4 sq. mile study area (Hall 1983). It is not known whether this pair hunted or denned beyond the study area as they were not monitored off site. Hall's study area is contiguous with other grazed grasslands to the north, south, and west (the reservoir lies to the east), and it may be presumed that the pair ventured farther than the study area boundaries. Therefore it could be suggested that these two kit fox inhabited an area over 4 $mi^2$., or 0. 5 kit fox per square mile, much lower than southern range estimates.

Under ideal habitat conditions, one can approximate that the number of kit foxes that could inhabit the eastern sections of Alameda and Contra Costa Counties combined could range between 25 and 82 (169 x 0.15 and 169 x 0.5). The rarity of sightings would suggest that the low end of the range is the more likely population level existing at this time.

RECOMMENDATIONS

Spotlight Surveys

An improved and expanded kit fox spotlight survey program (i.e. larger sample size from repeated runs of individual routes during the same month) would be a cost-effective way of monitoring population trends throughout the range of this subspecies.

East side of the San Joaquin Valley

1) We propose conducting surveys for kit foxes in the eastern San Joaquin Valley during the 1995 field season to obtain a better understanding of the distribution and abundance of the species in the region. This should include mapping potential kit fox habitat in more detail by consultation with CDFG regional biologists and other

individuals with detailed knowledge of the study area. Focussing on the most promising habitats, the study plan should consider time and financial constraints when choosing road transect or site surveys. Due to the difficulty in obtaining landowner permission for site surveys, road transect surveys may be the most cost-effective means of surveying such a large area.

2) Red fox and coyote distribution and abundance should be recorded and their potential effect on kit fox presence discussed.

3) Comprehensive investigation into the current and historical rodent poisoning practices should be conducted.

Alameda and Contra Costa Counties

1) Set up a monitoring program for the kit fox patterned after the CDFG spotlight surveys conducted in the southern range, with the addition of repeated runs of individual routes during the same month.

2) Review EIR results on a yearly basis to gain additional information on kit fox presence, habitat use, red fox presence, and ground squirrel distribution and abundance.

3) Map potential habitat and monitor the aquisition and loss of acerage.

4) Assess the habitat quality to determine the need for, and use of, a travel corridor between San Joaquin Valley and Alameda and Contra Costa County.

5) Reevaluate the value of ground squirrel control in Alameda and Contra Costa Counties. Both bait stations and broadcast methods should be considered, and possibly more stringent restrictions should be implemented within the kit fox range.

6) Research the impact of red fox and coyotes on the kit fox and their recolonization of available habitat.

We recommend that CDFG, in consultation with the San Joaquin Valley Endangered Species Recovery Planning Program, consider these recommendations and design and implement a program of recovery for kit fox on both the east side of the San Joaquin Valley and the northern-most portion of their range.

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Appendix 1. Sightings of San Joaquin kit fox in the eastern San Joaquin Valley

| Site # | Year Sighted | Source of Detection | Name of Individual or Affiliation | Area of Sighting |
|---|---|---|---|---|
| **1970's** | | | | |
| 1. | '73 | 2 Sighted | Dan Williams | La Grange, ORV park |
| **1980's** | | | | |
| 2. | '80's | 1 Sighted | Henry Lamelle | Sanger |
| 3. | '86 | 1 Sighted | Greg Gerstenberg | San Luis NWR |
| 4. | '88 | 1 Trapped | Gail Presley | Ivanhoe |
| 5. | '88 | 1 Released | Steve Clifton | Kesterson |
| 6. | '89 | 1 Sighted | Steve Clifton | N. La Grange (Warnerville Rd.) |
| **1990's** | | | | |
| 7. | '90's | Pups sighted | Toni Revilla | Tivy Valley |
| 8. | '90's | 1 Sighted | Dale Mitchell | Friant |
| 9. | '90's | 1 Sighted | Ron Remple | SJ River & Ave 9 |
| 10. | '90 | 2 Sighted | Gail Presley | Firebaugh |
| 11. | '90 | 1 Sighted | Gail Presley | Woodlake |
| 12. | '91 | 1 (pet?) | Dale Mitchell | Clovis-Drycreek |
| 13. | '92 | Population | Gail Presely | Tulare |
| 14. | '92 | 1 Injured | USFS Personnel | Watts Valley |
| 15. | '92 | 1 Sighted | Sheri Mylantus | San Luis NWR |
| 16. | '92 | Population | Dana York | North of Stratford |
| 17. | '92 | 1 Dead | John Oldman | |
| 18. | '93 | Road Kill | Dan Williams | Herndon @ Highway 99 |
| 19. | '93 | Raod Kill | Dan Williams | Highway 41 @ Murphy Slough |

Appendix 2. Key to Figure 15. San Joaquin kit fox sightings in Alameda, Contra Costa, and San Joaquin Counties, 1970's, 1980's, and 1990's.

| Site # | Year Sighted | Source of Detection | Affiliation and Name of Individual | Report, Author and Year |
|---|---|---|---|---|
| 1970's | | | | |
| 1. | '70 | 1 Sighted<br>T1S,R3E SE1/4 sec 27 | Simms & Tucker | Jensen '72 |
| 2. | '71 | Road kill<br>T3S,R5E NE1/4 sec 18 | W. Maupin, SJ Ag. | Swick '73 |
| 3. | '72 | 2 Carcasses<br>T1S,R3E NW1/4 sec 6 | Gene Broom, land owner | Swick '73 |
| 4. | '72 | 1 Sighted<br>T1S,R3E NW1/4 sec 6 | DOA, Ottis Moss | Swick '73 |
| 5. | '72 | 1 Active den<br>T1S,R3E SE1/4 sec 7 | DOA, Ottis Moss | Swick '73 |
| 6. | '72 | 1 Carcass<br>T1S,R3E NE1/4 sec 15 | Landowner, John Adams | Swick '73 |
| 7. | '72 | 3 Carcasses<br>T1S,R3E NE1/4 sec 34 | DFG, Schulenberg, Jensen | Swick '73 |
| 8. | '72 | 1 Sighted<br>T1S,R3E NW1/4 sec 35 | DOA, Ottis Moss | Swick '73 |
| 9. | '72 | 1 Active den<br>T2S,R4E SW1/4 sec 18 | DOA, Otto Schmidt. | Swick '73 |
| 10. | '73 | 1 Sighted<br>T1S,R3E SE1/4 sec 7 | DOA, John Simmen | Swick '73 |
| 11. | '73 | 1 Sighted<br>T1S,R3E NW1/4 sec 8 | DOA, Moss, Simmen | Swick '73 |
| 12. | '73 | 1 Sighted<br>T1S,R3E NW1/4 sec 12 | DFG, Schulenberg, Swick | Swick '73 |
| 13. | '73 | 2 Sighted<br>T1S,R3E SW1/4 sec 14 | DOA, Moss & DFG, Swick | Swick '73 |

Appendix 2. continued

| Site # | Year Sighted | Method of Detection | Affiliation and Name of Individual | Report, Author and Year |
|---|---|---|---|---|
| 14. | '73 | 1 Active den<br>T1S,R3E NE1/4 sec 34 | DFG, Swick | Swick '73 |
| 15. | '73 | 1 Sighted<br>T2S,R3E NW1/4 sec 2 | DOA, DFG, DFA | Swick '73 |
| 16. | '73 | 1 Road kill<br>T2S,R4E NW1/4 sec 19 | DOA, DFG, DFA. | Swick '73 |
| 17. | '73 | 1 Sighted<br>T3S,R3E NW 1/4 sec 12 | DOA, DFG, DFA. | Swick '73 |
| 18. | '73 | 1 Sighted<br>T2S,R4E SW1/4 sec 34 | DOA, DFG | Swick '73 |
| 19. | '73 | Active den<br>T3S,R4E SW1/4 sec 3 | DOA, DFG | Swick '73 |
| 20. | '73 | 2 Sighted<br>T3S,R5E NE1/4 sec 19 | DOA | Swick '73 |
| 21. | '73 | 1 Sighted<br>T3S,R5E NW1/4 sec 32 | DOA, DFG | Swick '73 |
| 22. | '73 | 1 Sighted<br>T3S,R6E SW1/4 sec 7 | DOA | Swick '73 |
| 23. | '72-'75 | 1 Sighted<br>T3S,R5E SW1/4 sec 19 | Morrell | Morrell '75 |
| 24. | '72-'75 | 1 Sighted<br>T3S,R6E NW1/4 sec 7 | Morrell | Morrell '75 |
| 25. | '72-'75 | 1 Sighted<br>T3S,R5E NW1/4 sec 13 | Morrell | Morrell '75 |
| 26. | '72-'75 | 1 Sighted<br>T2S,R1W NW1/4 sec 28 | Morrell | Morrell '75 |
| 27. | '72-'75 | 1 Sighted<br>T1N,R2E NW1/4 sec 33 | Morrell | Morrell '75 |

Appendix 2. continued

| Site # | Year Sighted | Method of Detection | Affiliation and Name of Individual | Report, Author and Year |
|---|---|---|---|---|
| **1980's** | | | | |
| 1. | '82 | Act. natal den<br>T2S,R3E NE1/4 sec 10 | EIR, Hall | Hall '83 |
| 2. | '83 | Population<br>T3S,R5E NE1/4 sec 19 | Bio-Survey, Speigel | Bio-tech '83 |
| 3. | '83 | 1 Sighted<br>T1S,R2E SE1/4 sec 8 | DFG, Wernette | Jones & Stokes '89 |
| 4. | '83 | Road kill<br>T2S,R4E SW1/4 sec 32 | Sue Orloff | Orloff et al. '86 |
| 5. | '83 | Track<br>T3S,R3E SE1/4 sec 10 | Sue Orloff | Orloff et al. '86 |
| 6. | '87 | 1 Sighted<br>T1S,R3E NE1/4 sec 35 | Ron Eng, CDFA | NDDB |
| 7. | '87 | 4 Sighted<br>T1S,R3E NE 1/4 sec 33 | Terry Palmasano, CDFG | NDDB |
| 8. | '88 | 1 Sighted<br>T1S,R2E NE1/4 sec 17 | EIR, Getz | Jones & Stokes '89 |
| 9. | '88 | Act. natal den<br>T1S,R3E NE1/4 sec 19 | EIR, Getz | Jones & Stokes '89 |
| 10. | '88 | 1 Sighted<br>T1S,R3E NE1/4 sec 19 | EIR, Getz | Jones & Stokes '89 |
| 11. | '88 | 1 Sighted<br>T1S,R3E SW1/4 sec 19 | EIR, Getz | Jones & Stokes '89 |
| 12. | '88 | 1 Sighted<br>T1S,R3E SW1/4 sec 19 | EIR, Getz | Jones & Stokes '89 |
| 13. | '88 | 1 Sighted<br>T1S,R3E NE1/4 sec 30 | EIR, Getz | Jones & Stokes '89 |

Appendix 2. continued

| Site # | Year Sighted | Method of Detection | Affiliation and Name of Individual | Report, Author and Year |
|---|---|---|---|---|
| 1980's continued | | | | |
| 14. | '88 | 1 Sighted<br>T1S,R3E NE1/4 sec 30 | EIR, Getz | Jones & Stokes '89 |
| 15. | '88 | 1 Sighted<br>T2S,R2E NE1/4 sec 25 | Biological Survey | Harvey & Assoc. '88 |
| 16. | '88 | 1 Sighted<br>T2S,R2E SE1/4 sec 25 | Biological Survey | Harvey & Assoc. '88 |
| 17. | '88 | 1 Sighted<br>T2S,R3E NE1/4 sec 19 | Biological Survey | Harvey & Assoc. '88 |
| 18. | '89 | 1 Sighted<br>T1S,R3E SW1/4 sec 32 | EIR, Getz | Jones & Stokes '91 |
| 19. | '89 | 1 Sighted<br>T1S,R3E SW1/4 sec 32 | EIR, Getz | Jones & Stokes '91 |
| 20. | '89 | Tracks<br>T2S,R1E SW1/4 sec 25 | Sue Orloff | Sproul '93 |
| 1990's | | | | |
| 1. | '90 | 1 Sighted<br>T2N,R1E SW1/4 sec 27 | EBRP, Carol Richmond | Bell '92 |
| 2. | '90 | 1 Sighted<br>T2S,R1W NW1/4 sec 12 | Observation, K. Swaim | NDDB |
| 3. | '90-'93 | 3 Sighted<br>T1S,R3E SW1/4 sec 3 | Observations, Stromberg | Stromberg '91 |
| 4. | '91 | 1 Sighted<br>T2N,R1E NW1/4 sec 34 | EBRP, Carol Richmond | Bell '92 |
| 5. | '91 | 1 Sighted<br>T2S,R3E NW1/4 sec 16 | EIR, Leitner | Leitner-Leitner '92 |

Appendix 2. continued

| Site # | Year Sighted | Method of Detection | Affiliation and Name of Individual | Report, Author and Year |
|---|---|---|---|---|
| 1990's continued | | | | |
| 6. | '91 | 1 Sighted T2S,R3E NE1/4 sec 17 | EIR, Leitner | Leitner-Leitner '92 |
| 7. | '91 | 1 Track T1S,R4E NE1/4 sec 33 | Bio-Survey, McGinnis | McGinnis '91 |
| 8. | '91 | 1 Photo T3S,R5E SE1/4 sec 19 | J. Alvarez & H. Bell | NDDB |
| 9. | '91 | 1 Sighted T1S,R3E NW1/4 sec 10 | Observation, S. McGinnis | NDDB |
| 10. | '91 | 1 Sighted T3S,R5E SW1/4 sec 35 | Mullen/G. Beeman | NDDB |
| 11. | '91 | 1 Photo T3S,R5E SW1/4 sec 2 | Mullen/G. Beeman | NDDB |
| 12. | '91 | 1 Photo T3S,R5E NE1/4 sec 10 | Mullen/G. Beeman | NDDB |
| 13. | '91 | 1 Sighted T3S,R5E NE1/4 sec 8 | Ron Argenbright | NDDB |
| 14. | '91 | Track?? T3S,R5E SW1/4 sec 15 | Mullen/G. Beeman | NDDB |
| 15. | '91 | 2 Sighted T3S,R5E SE1/4 sec 4 | Mullen/G. Beeman | NDDB |
| 16. | '91 | 1 Photo T3S,R5E SW1/4 sec 29 | Mullen/G. Beeman | NDDB |
| 17. | '91 | 1 Photo T3S,R5E SW1/4 sec 19 | Mullen/G. Beeman | NDDB |
| 18. | '92 | 1 Sighted T2N,R1E SW1/4 sec 33 | Biological Survey, Bell | Bell '92 |

Appendix 2. continued

| Site # | Year Sighted | Method of Detection | Affiliation and Name of Individual | Report, Author and Year |
|---|---|---|---|---|
| 1990's continued | | | | |
| 19. | '92 | 1 Sighted T1N,R1E NW1/4 sec 17 | Biological Survey, Bell | Bell '92 |
| 20. | '92 | 6 Sighted T1S,R2E NW1/4 sec 17 | Biological Survey, Bell | Bell '92 |
| 21. | '92 | 1 Sighted T1S,R2E NW1/4 sec 21 | Biological Survey, Bell | Bell '92 |
| 22. | '92 | 1 Sighted T1S,R3E SW1/4 sec 36 | Steve Erlich | Orloff pers. comm. 93 |
| 23. | '92 | 1 Sighted T2S,R4E SW1/4 sec 7 | EIR, McGinnis, Hoffman | Hoffman, Assoc. '92 |
| 24. | '92 | 1 Sighted T3S,R2E NW1/4 sec 24 | EIR | Harvey & Assoc. '92 |
| 25. | '92 | 1 Sighted T2S,R2E NW1/4 sec 24 | EIR | Harvey & Assoc. '92 |
| 26. | '93 | 1 Sighted T1S,R3E NE1/4 sec 30 | Rick Knurshal, USFWS | NDDB |


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Appendix 3. Letter sent to land owners requesting permission to conduct San Joaquin kit fox surveys, April-October 1993.

April 12, 1993

Dear Lillian Thompson,

The California Department of Fish and Game (see enclosed authorization letter) is conducting a Kit Fox survey in Alameda and Contra Costa Counties during the Spring/Summer of 1993. Part of this study requires surveys on private properties. This would entail a survey over a two week time period during the month of May. A two person crew would place and check equipment during the day and survey at night using spot-lights. The members of the survey crew are: Heather Bell - Field Coordinator, Jeff Alvarez - Wildlife Biologist, and Sheila Larsen - Wildlife Biologist.

We request your permission to survey the following property(ies) designated by the tax assessors number: 10: 3-5, 7-8; 20: 2-7.

It is very important to this study that we receive your permission as soon as possible. To assist you, we have enclose a response form. Please mail the completed form to: **Heather Bell**
**4415 Walnut Blvd.**
**Walnut Creek, CA 94596**

If you have any questions about survey methods or the dates that we may be on your property please call Heather Bell -- (510) 933-1956.

Sincerely,

Katherine Ralls

Dr. Katherine Ralls
San Joaquin Kit Fox Study Coordinator

Appendix 4. Letter sent to Cattleman's Association, Farm Bureau, Resource Conservation District, and selected land owner associations requesting permission to conduct San Joaquin kit fox surveys, April-October 1993.

STATE OF CALIFORNIA—THE RESOURCES AGENCY — GEORGE DEUKMEJIAN, Governor

DEPARTMENT OF FISH AND GAME
POST OFFICE BOX 47
YOUNTVILLE, CALIFORNIA 94599
(707) 944-5500

July 6, 1993

Mr. Tom Brumleve, President
Cattlemen's Association
5554 Clayton Road
Concord, California 94521

Dear Mr. Brumleve:

1993 Kit Fox Study
Alameda and Contra Costa Counties

The Department of Fish and Game is writing to request your assistance in communicating the intent of our study on San Joaquin kit fox, Vulpes macrotis mutica, to the members of your association. The purpose of the study is to obtain data which would provide the biological basis for identifying kit fox distribution, habitat, and densities in this northern portion of its range. This information would allow the Department to properly and more accurately assess the resource values of sites proposed for land-use changes and more clearly define the limits of the species' range. The kit fox is Federally listed as an endangered species and State listed as a threatened species. The Department is required to collect this information so that recovery actions may be identified and implemented. This research is in no way associated with any surveys conducted by environmental consulting firms.

We are looking for volunteers in eastern Contra Costa and Alameda counties interested in participating in the study (i.e., landowners willing to allow access to their property). We would appreciate it if interested parties in the study area would cooperate to further the goal of this study. Landowners and governmental agencies are encouraged to allow researchers access to their properties so that survey methods designed to detect the kit fox may be implemented. Landowner cooperation is essential to the success of the project. The study will be conducted during the summer and fall of 1993.

Survey methods include spotlighting, placement of remote camera stations, and transect surveys for den sites. The research that we are proposing is a crucial step toward the eventual recovery of the kit fox and removal of the species from the threatened and endangered species list.

If kit foxes are observed on a site, the landowner would experience no constraint to ongoing activities other than those that already exist (i.e., restrictions on rodenticide application). The Department does not intend to utilize the results of this study for specific enforcement purposes, nor would it attempt to restrict routine agricultural activities as a result of the study. Kit fox sightings on a site would mean that the property thereafter would be considered within kit fox range. However, based on a number of recent kit fox sightings, the U. S. Fish and Wildlife Service (USFWS) now considers the entire San Joaquin Valley and adjacent grassland habitats (including eastern Alameda and Contra Costa Counties) to be within kit fox "range". This does not mean that all areas within the identified range represent kit fox habitat. The effects of kit fox sightings during the Departments study on a landowner's routine activities would be insignificant because the sighting would result in no change in regulatory requirements.

The only situation in which the results of the study might later be used for regulatory purposes would be if a landowner intends to develop his or her property or undertake a major land-use change. In such cases, the landowner would be required to comply with State and Federal Endangered Species Acts and likely mitigate for endangered species impacts if kit foxes are known to inhabit the site. But this requirement would apply whether or not the Department is permitted to survey for kit foxes. In fact, if future development of a particular site is anticipated and kit fox are observed during the Department's study, this would reduce the necessity of conducting costly kit fox surveys later on and would, therefore, work to the landowners' advantage (pers comm, Bill Lehman, USFWS). Negative findings by the Department's study would not preclude the necessity of later kit fox surveys if development is planned.

Additionally, if kit fox exist on or utilize a surveyed parcel, early identification will assure appropriate land-use planning. If a landowner intends to eventually develop the property, it is in his or her interest to determine all biological resource values of the site prior to initiating project design.

If you have questions regarding our comments, please contact Caitlin Bean, Environmental Specialist III, (707) 944-5570; or Carl Wilcox, Environmental Services Supervisor, at (707) 944-5525.

Sincerely

Brian Hunter
Regional Manager
Region 3

cc: Mr. Ron Schlorff

Ms. Heather Bell
4415 Walnut Boulevard
Walnut Creek, California 94596

Mr. Bill Lehman
U. S. Fish and Wildlife Service

Mr. Ron Darling
Contra Costa Water District

Appendix 5. Behavioral response of captive kit foxes(*Vulpes macrotis)* to various attractants.

Because kit foxes have proven difficult to detect in the most northern portion of their range (Alameda County, Contra Costa County, and the western edge of San Joaqiun County) intensive survey efforts and methods have been proposed recently by the USFWS (USFWS 1993). Two detection methods required by this survey protocol, camera stations (Alvarez 1994) and sooted aluminum track plates (Barrett 1983), use an attractant to lure the foxes in.

The aim of this study was to determine which, if any, attractant is preferred by kit foxes.

MATERIALS AND METHODS

The kit foxes used for these experiments were housed in wire cages at the California Living Museum (CALM), Bakersfield, California. Two female kit foxes were housed in a 6 x 9 foot wire cage in the quarantine area, in close proximity to red-tailed hawk (*Buteo jamaicensis*). The five males were housed in a larger observation area adjacent to red foxes (*Vulpes vulpes*), within visual distance of gray fox (*Urocyon cinereoargenteus*), bobcat (*Lynx rufus*), and mountain lion (*Felis concolor*), and within hearing distance of coyote (*Canis latrans*). The males were observed by the public six days a week, the females had only daily visits by the zookeeper. All the kit foxes sustained an injury of some type that precludes their release. Diet consisted of a once daily feeding of zoo carnivore diet (144 grams per fox) mixed with 1/2 cup dry dog food. The males were fed in separate bowls, the females in one bowl. Mice and 1 day old chicks are occasionally added to the diet.

Behavioral observations of both groups were video taped over a two day period, during daily feeding, randomly throughout the daylight hours, during feeding preference, and CDFG experimentation. Subsequent video tape behavioral analyses

were continuous recording to distinguish sequences of behavior, and behavior frequency and duration were calculated when feasible.

Attractant preference tests were conducted for set time periods using four small aluminum containers with perforations. Attractants chosen had either been historically used (strawberry jam), or are currently used (canned cat food, and raw chicken), during kit fox surveys . Each of three containers held a different attractant, and one was left empty as the control. Random order was selected and all containers were placed at ground level at two foot intervals outside the cage, along one side. Recording began immediately. Decisions on preference were made on the percent of time kit fox spent investigating (sniffing, pawing, biting, or marking) a particular attractant.

Also tested were the kit foxes response to wounded rabbit calls and coyote calls, responses to red fox urine, and their success at entering a 2 1/2 foot long, 4 inch diameter baited pipe. Additionally, kit fox height, tracks, stride length, and vocalizations were recorded.

RESULTS

During preliminary observations it was noted that one of the females made left hand circles almost continuously. It was unclear whether this behavior was due to the unusual presence of observers, passing workers, or was the fox's normal behavior. During the attractant preference study this same female began making left hand circles 22 seconds after the containers were introduced. She continued making left handed circles (25 total) throughout the remainder the 10 minute experiment. The second female spent only 13 seconds investigating the containers before lying down for remainder of experiment. Because of the positioning of the containers along one wall, the female kit fox making left handed circles always came into contact with the strawberry jam container first. For this reason, in addition to the possible aberrant

circling and the lack of interest by the second female, the test on the females was abandoned although behavior was recorded for use in developing an ethogram.

Preliminary observations of the male kit foxes yielded no such aberrant behavior. The foxes were most often observed resting in shelters or in depressions in dirt, with very little movement and no social behavior observed. Upon placement of the containers on the edge of the cage four of the males began investigative behavior. This behavior was seen throughout the experiment, although not continuously.

The attractant container which yielded the highest percentage of investigative behavior by the male kit foxes was the canned cat food (10.5%), second was the raw chicken (5.1%), third the control (3.3%), and fourth the strawberry jam (2.3%).

The investigative behavior by both groups of kit foxes to the red fox urine lasted much longer than either's response to any of the attractant containers. The mean investigative response to bait containers was 3 seconds (n = 4) for males and 4 seconds (n = 2) for females. The red fox urine investigative responses lasted a mean of 41 seconds (n = 2) for males, and 12 seconds (n = 2) for females.

Neither kit fox group responded actively to the wounded rabbit cry or the coyote call, although it was noted that the grey fox became very active during both calls, and the resident great horned owl (*Bubo virginianus*) and the red-tailed hawk responded with calls to the wounded rabbit cry.

For baseline information we observed and described the following behaviors prior to the attractant tests. All sessions were videotaped and reviewed, allowing detailed descriptions of behaviors.

Behavioral States--

Resting: usually in hollow log or depression in ground.

Eating

Sleeping: as in resting.

Events--

- Ear twitch: turning of ears separately or together,associated with attentive or investigative behaviors.

Run away: quick movement of animal to the farthest corner, associated with movement of people.

Approach: movement of animal toward a defined spot, associated with investigative behavior.

Pause: brief interruption in approach, ear twitching occurs, followed by resumed approach.

Sniffing: bringing the nose within 3 inches of object, associated with investigative and social behavior.

Pawing: one leg raised in a bent position, associated with investigative behavior.

Marking: urination or defecation oriented at specific objects, novel or landmark objects/odors, and may be repeated (Kleiman 1966). These can also occur when the animal is experiencing fear, or carrying out excretory functions.

Perking: vocalization reminiscent of a dripping water faucet, apparently associated with fear. (Morrell 1971)

Digging

Yawning

Stretching

Hip-slam: elevation of hindquarters and rapid movement laterally so that the hips slam into another individual, associated with agonistic behavior. Lehner 1978)

Dental display: lowering of shoulders, raising head and opening mouth, exposing teeth, ears laid back, and tail raised high and switched rapidly, associated with agonistic behavior.

Moving off: recipient of hip-slam or dental display moves back, associated with agonistic behavior.

DISCUSSION

Although the canned cat food container received over twice the percentage of investigative behavior as the next most preferred container (raw chicken) during the

experiment conducted with the male kit foxes, the inability to collect data from the female kit foxes lowered the sample size. Therefore, the males were tested three times in one day and habituation may have occurred.

Interestingly, the red fox urine elicited a much longer investigative response in the males and females than did the containers with food attractants, even though the males are housed next to two adult red fox. It is unclear if the red fox urine presents to the kit fox an intrusion into "home range" or as a predatory threat (one instance of red fox killing kit fox does exist, Ralls and White 1991). The males investigated the urine over three times longer than the females, but neither sex was observed marking (Peters and Mech 1975) over the urine.

Possibly the best use of attractants to bait the kit fox would be a combination of attractants, such as the canned cat food and the red fox urine. But it must be remembered that the investigative responses of wild populations of kit foxes has not been tested here, therefore field studies should be conducted before conclusions are drawn on the success of specific attractants.

Conducting the experiments on the captive kit foxes did provide an opportunity to record some of the foxes' daily behaviors and behavioral responses to novel objects, albeit the observation times were brief. As this is the only group of captive kit foxes in California, it is apparent that this group provides a unique opportunity to discover more about kit fox life history and behavior. Even this brief study revealed the dental display conducted by males that had not previously been described. Further studies with the captive group might include gestation length, mother/pup interactions, vocalization repertoire, and den digging ability.

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Appendix 6. List of vertebrate species found at sites surveyed for San Joaquin kit fox in Alameda and Contra Costa County, February - September 1993.

VERTEBRATE SPECIES LIST

| | |
|---|---|
| Western fence lizard | (*Sceloporus occidentalis*) |
| Common kingsnake | (*Lampropeltis getulus*) |
| Gopher snake | (*Pituophis melanoleucus*) |
| California quail | (*Callipepla californica*) |
| Mourning dove | (*Zenaida macroura*) |
| Horned lark | (*Eremophila alpestris*) |
| Western meadowlark | (*Sturnella neglecta*) |
| Virginia opossum | (*Didelphis virginiana*) |
| Coyote | (*Canis latrans*) |
| Red fox | (*Vulpes vulpes*) |
| Domestic dog | (*Canis familiaris*) |
| Raccoon | (*Procyon lotor*) |
| Badger | (*Taxidea taxus*) |
| Striped skunk | (*Mephitis mephitis*) |
| Bobcat | (*Lynx rufus*) |
| Domestic cat | (*Felis catus*) |
| California ground squirrel | (*Spermophilus beecheyi*) |
| Small rodent spp. | (*Perognathus, Reithrodontomys, Peromyscus, Neotoma, Microtus, Mus, Zapus*) |
| Audubon's cottontail | (*Sylvilagus audubonii*) |
| Black-tailed hare | (*Lepus californicus*) |