H. Giant Kangaroo Rat
(*Dipodomys ingens*)

1. Description and Taxonomy

Taxonomy.—*Dipodomys ingens* was described as *Perodipus ingens* by Merriam (1904*a*), who listed the type locality as Painted Rock, 20 miles SE Simmler, Carrizo Plain, San Luis Obispo County, California. The type locality was amended to 41 kilometers (25 miles) SE of Simmler by Williams and Kilburn (1991). The genus name *Perodipus* was used for several years to include all the kangaroo rats with five toes on the hind feet. Grinnell (1921) relegated *Perodipus* to a synonym of *Dipodomys*. This taxonomy has been sustained in the latest taxonomic review of the family Heteromyidae (Williams et al. 1993*a*).

Description.—The giant kangaroo rat is adapted for bipedal locomotion (two-footed hopping) (Eisenberg 1963). The hind limbs are large compared to the size of the forelimbs; the neck is short; and the head is large and flattened. The tail is longer than the combined head and body length and has a dorsal crest of long hairs towards the end of the tail, terminating in a large tuft (Figure 37). Large, fur-lined cheek pouches open on each side of the mouth. The pouches extend as deep invaginated pockets of skin folded inward along the sides of the head (Grinnell 1922).

Identification.—Giant kangaroo rats are distinguished from the coexisting species, San Joaquin kangaroo rat (*D. nitratoides*) and Heermann's kangaroo rat (*D. heermanni*), by size and number of toes on the hind foot. The hind feet of adult giant kangaroo rats each have five toes and are longer than 47 millimeters (1.85 inches) (Best 1993). The giant kangaroo rat is the largest of more than 20 species in the genus (Grinnell 1922, Hall 1981, Best 1993). Grinnell (1932*a*) reported a mean mass of 157.0 grams (5.54 ounces) for 15 adult males and 151.4 grams (5.34 ounces) for 7 adult females. Adult Heermann's kangaroo rats average 65 to 80 grams (2.29 to 2.82 ounces), with maximum weights not exceeding about 90 grams (3.17 ounces) (Williams 1992); the hind foot also has five toes but individuals' feet usually measure less than 45 millimeters (1.77 inches) (Best 1993). Average weight of San Joaquin kangaroo rats is less than 45 grams (1.59 ounces), and they have four toes on each hind foot. Length of the hind foot does not exceed 39 millimeters (1.54 inches) (Grinnell 1922).

Figure 37. Illustration of the giant kangaroo rat (drawing by Jodi Sears, based on photo © by D.F. Williams).

2. Historical and Current Distribution

Historical Distribution.—Up until the 1950s colonies of giant kangaroo rats were spread over hundreds of thousands of acres of continuous habitat in the western San Joaquin Valley, Carrizo Plain, and Cuyama Valley (Grinnell 1932*a*, Shaw 1934, Hawbecker 1944, 1951). The historical distribution of giant kangaroo rats encompassed a narrow band of gently sloping ground along the western edge of the San Joaquin Valley, California, from the base of the Tehachapi Mountains in the south, to a point about 16 kilometers (10 miles) south of Los Banos, Merced County in the north; the Carrizo and Elkhorn Plains and San Juan Creek watershed west of the Temblor Mountains, which form the western boundary of the southern San Joaquin Valley; the upper Cuyama Valley next to and nearly contiguous with the Carrizo Plain; and scattered colonies on steeper slopes and ridge tops in the Ciervo, Kettleman, Panoche, and Tumey Hills, and in the Panoche Valley (Figure 38). Within this circumscribed geographic range were about 701,916 to 755,844 hectares (1,734,465 to 1,867,723 acres), which included different estimates of the amount of nonhabitat depending on different assumptions. The most liberal estimate of historical habitat was about 631,724 hectares (1,561,017 acres; Williams 1992).

Current Distribution.—The species population is currently fragmented into six major geographic units: A) the Panoche Region in western Fresno and Eastern San Benito Counties; B) Kettleman Hills in Kings County; C) San Juan Creek Valley in San Luis Obispo County D) western Kern County in the area of the Lokern, Elk Hills,

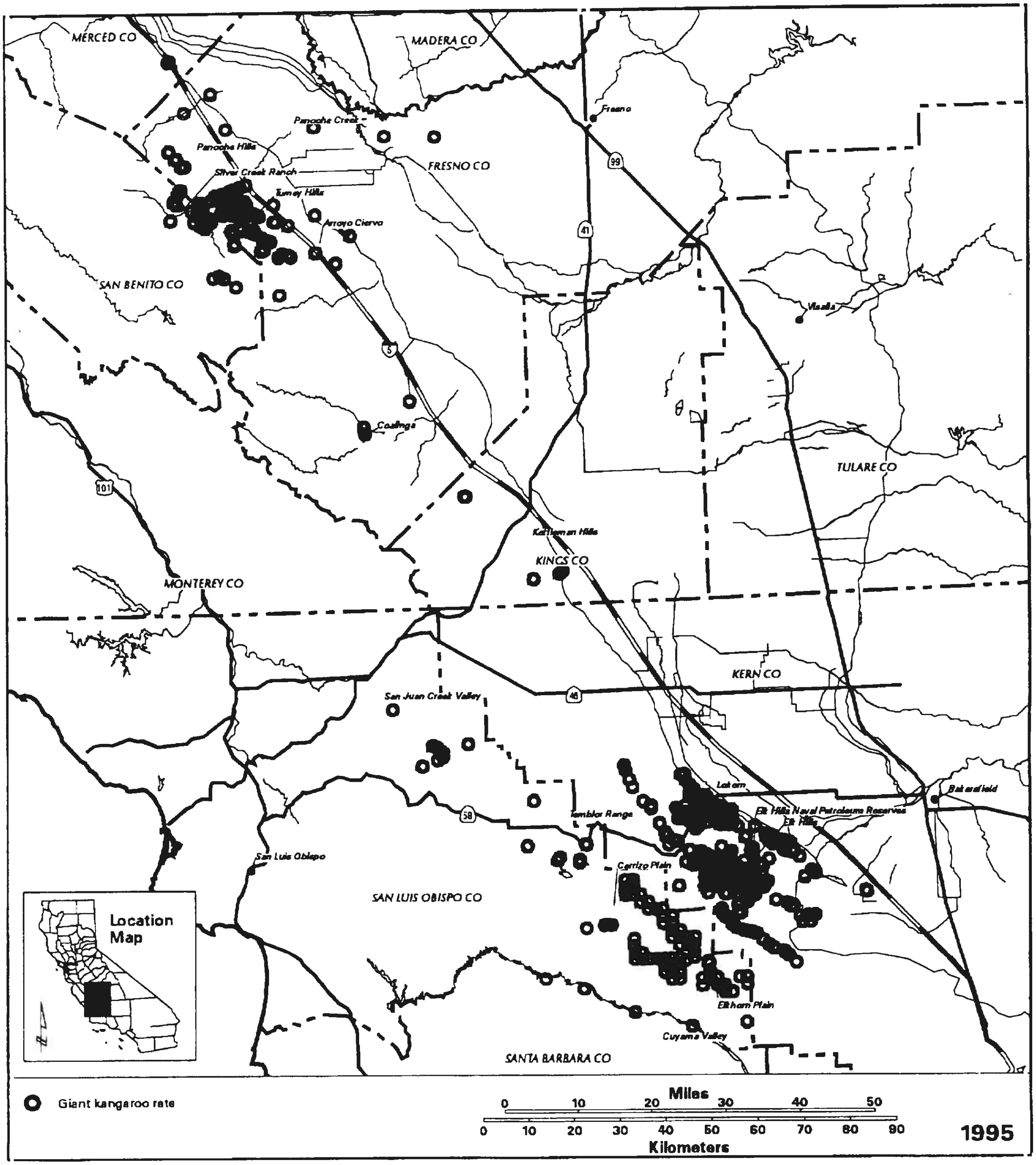

Figure 38. Distributional records of the giant kangaroo rat *(Dipodomys ingens).*

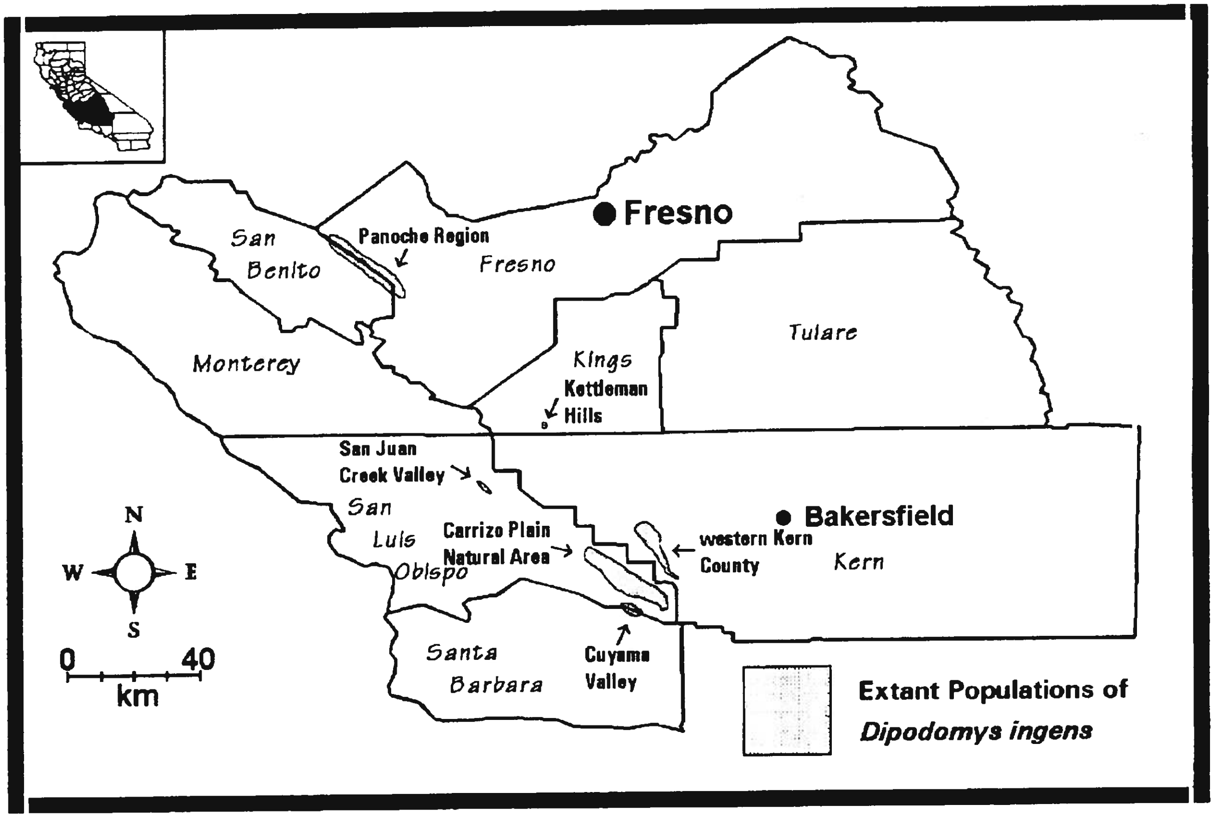

Figure 39. Locations of extant populations of giant kangaroo rats *(Dipodomys ingens)*.

and other uplands around McKittrick, Taft, and Maricopa; E) Carrizo Plain Natural Area in eastern San Luis Obispo County; and F) Cuyama Valley in Santa Barbara and San Luis Obispo Counties (Figure 39; Williams 1980, 1992, O'Farrell et al. 1987*a*, Williams et al. 1995). These major units are fragmented into more than 100 smaller populations, many of which are isolated by several miles of barriers such as steep terrain with plant communities unsuitable as habitat, or agricultural, industrial, or urban land without habitat for this species. Extant habitat was last estimated to be 11,145 hectares (27,540 acres), about 1.8 percent of historical habitat (Williams 1992).

Within the area of currently occupied habitat, populations of giant kangaroo rats have expanded and declined with changing weather patterns since 1979. At their peak in 1992 to 1993, there probably were about 6 to 10 times more individuals than at their low point in spring of 1991, when a majority of the 11,145 hectares (27,540 acres) probably was uninhabited and most of the rest was inhabited by less than 10 percent of peak numbers (Williams 1992, Williams et al. 1993*b*, Williams et al. 1995, Allred et al. in press, Williams and Nelson in press, D.F. Williams unpubl. data).

3. Life History and Habitat

Food and Foraging.—Giant kangaroo rats are primarily seed eaters, but also eat green plants and insects. They cut the ripening heads of grasses and forbs and cure them in small surface pits located on the area over their burrow system (Shaw 1934, Williams et al. 1993*b*). They also gather individual seeds scattered over the ground's surface and mixed in the upper layer of soil. Surface pits are uniform in diameter and depth (about 2.5 centimeters, 1 inch), placed vertically in firm soil, and filled with seed pods. After placing seeds and seed heads in pits, the animal covers them with a layer of loose, dry dirt. Pits are filled with the contents of the cheek pouches after a single trip to harvest seeds. Before being moved underground, the seeds, including filaree and peppergrass *(Lepidium nitidum)*, are sun-dried which prevents molding (Shaw 1934).

Individuals in many populations of *D. ingens* also make large stacks of seed heads on the surfaces of their burrow systems (Hawbecker 1944, Williams et al. 1993*b*). The material is cured, then stored underground. Amounts cached in surface stacks may not correspond with annual herbaceous productivity. No stacks were found in 1990, a year with no seed production, and 1991, a year with the second highest plant productivity between 1987 and 1994 (Williams and Nelson in press).

Grinnell (1932*a*, p. 313) examined three nursing females who had their cheek pouches "literally crammed with green stuff", and speculated that green foliage might be an important part of the diet during lactation. Other individuals, including a young female and adult males, were captured with foliage and fruits of peppergrass and foliage of filaree in their cheek pouches (Grinnell 1932*a*). In captivity, giant kangaroo rats have been maintained for periods from 2 weeks to more than 2 years on a diet of air-dried seeds, consisting primarily of millet, oat, and sunflower, occasionally supplemented with green plants. Of the green plants, captives preferred forbs to annual grasses, and usually ignored the blades of perennial grasses (Williams and Kilburn 1991). Shaw (1934) found a live insect of the bee and wasp family in the cheek pouch of a giant kangaroo rat. Eisenberg (1963) kept a giant kangaroo rat in captivity on a diet that included seeds, lettuce, and mealworm (darkling beetle) larvae (*Tenebrio* sp.).

Giant kangaroo rats forage on the surface from around sunset to near sunrise, though most activity takes place in the first 2 hours after dark. Foraging activity is greatest in the spring as seeds of annual plants ripen. Typically, plants such as peppergrass ripen first, and early caches, mostly in pits instead of stacks, consist of pieces of the seed-bearing stalks of this and other early-ripening species. The ability to transport large quantities of seeds and other food in cheek pouches and their highly developed caching behaviors, coupled with relatively high longevity of adults with established burrow systems, probably allow giant kangaroo rats to endure severe drought for 1 or 2 years without great risk of population extinction (Williams et al. 1993*b*, D.F. Williams unpubl. data).

Reproduction and Demography.—Results of studies conducted between 1987 and 1995 in colonies on the Elkhorn and Carrizo Plain indicated that giant kangaroo rats have an adaptable reproductive pattern that is affected by both population density and availability of food. During times of relatively high density, females have a short, winter reproductive season with only one litter produced and there is no breeding by young-of-the-year. This was true both in years of high plant productivity and drought. In contrast, populations at low densities continue to breed into summer during drought. In 1990, a year of severe drought and no seed production, most females appeared not to reproduce; the few that bred apparently failed to raise young. In most years, females were reproductive between December and March or April, but in colonies with low densities, reproduction extended into August or September (Williams et al. 1993*b*, Williams and Nelson in press, Endangered Species Recovery Program unpubl. data). Mating strategies are being studied on the Carrizo Plain by Dr. Jan Randall. Initial results indicate that mating strategies are flexible and may be responding to the age of males, proximity of females, and changes in sex ratios (Hekkala 1995).

Giant kangaroo rats can breed the year of their birth when environmental and social conditions permit (sufficient food and space). At the Soda Lake colony, juvenile females had their first litters at an estimated mean age of 5 months. Some females had two to three litters per year. This relatively high rate of reproduction probably was promoted by high plant productivity and low population density (Williams and Nelson in press).

Little information is available on age-specific litter size. The mean of known embryo counts and litter sizes is 3.75, probably a value higher than the number born (Williams and Kilburn 1991, D.F. Williams unpubl. data). Dr. Jan Randall's research showed that gestation was 30 to 35 days (Hekkala 1995). During a post-drought January through May breeding season, 44 percent of the litters contained two young. One female had a litter of three, the remaining 39 percent had a litter of one.

The major time for dispersal of giant kangaroo rats seems to be following maturation of young, about 11 to 12 weeks after birth. However in years of high density, when most or all burrow systems are occupied, most young appear to remain in their natal burrows until opportunity to disperse arises or they finally are driven off by the mother or one of the siblings. Under these circumstances, death or dispersal of the resident does not leave a burrow system vacant for long. Williams and Nelson (in press) found on a study site at Soda Lake, San Luis Obispo County that more females than males dispersed although males more often moved longer distances. Females had a nearly 60 percent greater survival rate than males. Dispersal of adults with established burrow systems was occasionally detected; one adult male moved more than 120 meters (131.2 yards) from his established home to take up a new residence in a new burrow system he constructed (Williams et al. 1993*b*, Williams and Nelson in press, Williams and Tordoff 1988).

Estimated home range size ranges from about 60 to 350 square meters (71.8 to 418.6 square yards). There is no significant difference in size of home range between sexes. The core area of the territory, located over the burrow system (*precinct*) is the most intensely used location in the home range (Braun 1985). Grinnell (1932*a*) and Shaw (1934) suggested that territories were occupied by a single animal. More recent studies indicate that multiple individuals may live in precincts. These appeared to be family groups of females and offspring of different ages (Randall 1997).

Estimates of density, employing both trapping and counts of precincts ranged from 1 to 110 animals per hectare (1 to 44 animals per acre) (Grinnell 1932*a*, Braun 1985, Williams 1992). Changes in density generally coincide with amount of rainfall and herbaceous plant productivity, though numbers in populations studied in 1989 remained high despite drought and low plant productivity (Figure 40). Large seed caches made in spring 1988 probably carried individuals through 1989 and 1990 during drought (Williams et al. 1993*b*, Williams and Nelson in press, D.F. Williams unpubl. data). The population on the Elkhorn Plain typically was at much higher density than other populations recently studied, and fluctuated less than populations elsewhere, suggesting that the habitat on this part of the Elkhorn Plain is some of the best remaining.

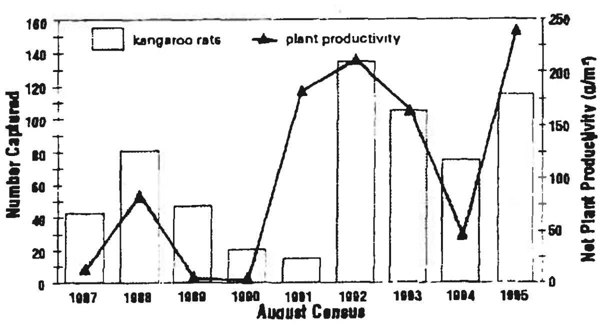

Figure 40. Numbers of giant kangaroo rats captured during August censuses, Elkhorn Plain. Census periods were 6 days in duration. The Y2 axis shows mean net plant productivity per square meter (Williams et al. 1993*b*, Endangered Species Recovery Program unpubl. data).

Population Genetics.—Partial results of on-going studies of population genetics of giant kangaroo rats provide guidance for designing a recovery strategy. The northern populations in Fresno and San Benito Counties are highly differentiated genetically from the southern populations on the Carrizo Plain Natural Area.

The genetic structure of the Carrizo Plain population differs from northern populations in that it has effectively acted as one large population, though the genetic data strongly suggest that the inhabited areas there have gone through episodes of substantial expansion and contraction in size (Mosquin et al. in press). This is consistent with recent observations from population censuses (Williams 1992, Williams et al. 1993*b*, Williams and Nelson in press, Allred et al. in press, D.F. Williams unpubl. data).

In the north, the population along the edge of the Valley at the eastern base of Monocline Ridge (San Joaquin Valley population) is substantially differentiated genetically from the other large population in the southeastern end of Panoche Valley (Figure 41). These two populations show little evidence of gene flow between them, and the San Joaquin Valley population is closer genetically to the Carrizo Plain population than any other of the semi-isolated northern populations. Clearly, this represents the remnant of the historical population that was distributed along the western edge of the Valley between Merced and Kern Counties. The two large, northern populations (San Joaquin Valley and Panoche Valley) appear to have been the sources of the small, semi-isolated populations on ridge-tops in the Ciervo and Tumey Hills. These latter populations are differentiated from both of the large populations, and from each other. They appear to have played the major role in gene flow between the Panoche Valley (Figure 41, see area B) and San Joaquin Valley populations. Interpopulation movements appear to have been achieved over relatively long periods in a stepping-stone manner between small populations on these ridge tops. Though small, they contain a significant proportion of the rare and unique genes of the northern population (Mosquin et al. in press).

The genetic studies show that *effective population size* (number of successfully-breeding individuals) in the

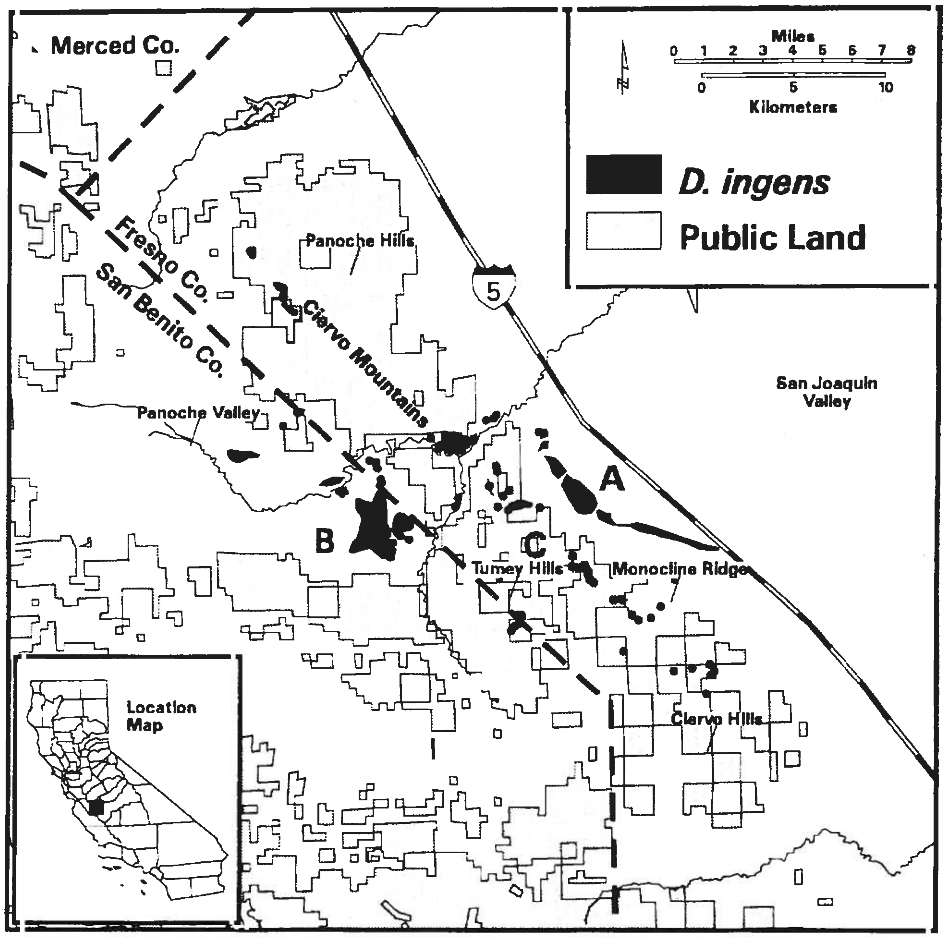

Figure 41. Distribution of extant colonies of giant kangaroo rats *(Dipodomys ingens)* in their northern geographic range (Williams et al. 1995). A—colonies along the eastern base of Monocline Ridge and the Tumey Hills; B—Panoche Valley colonies; C—colonies along the crest of the Ciervo Mountains.

north is smaller than current population size, indicating there has been a large increase in the northern population size very recently. This is consistent with the increase measured after the end of the drought in 1991 (Williams et al. 1995). In the south, estimated effective population size is slightly greater than current population size, indicating that current and historical population sizes are approximately the same (Mosquin et al. in press).

The genetic structure of giant kangaroo rat populations also shows that the *effective dispersal* distance of giant kangaroo rats (i.e., dispersal of genes) is much greater than predicted on the basis of capture-recapture and behavioral studies. Results from trapping of kangaroo rats show most movements are less than 100 meters (330 feet) and rarely as much as 1 kilometer (0.62 mile) (Jones 1988, 1989, Williams and Nelson in press). The genetic data suggest that effective distances are several times greater than 1 kilometer (0.62 mile). There are too few data, and analyses are too incomplete to make a precise estimate, but they do suggest effective dispersal over several kilometers and through highly inhospitable habitat in the northern population (Mosquin et al. in press).

Behavior and Species Interactions.—Little direct evidence exists on aggression by giant kangaroo rats, but they seem to be much more aggressive than the two co-occurring species. Wherever giant kangaroo rats were found by Grinnell (1932*a*), they dominated the community to the exclusion of other rodent species. Hawbecker (1944, 1951) and Tappe (1941) corroborated

Grinnell's observations, finding that giant kangaroo rats excluded all other nocturnal rodents from areas where they occurred.

Braun (1983), however, found that a population of giant kangaroo rats on the Carrizo Plain, San Luis Obispo County, did not exclude other species of rodents to the extent reported by others. Braun (1983) believed that the lack of exclusivity supported the hypothesis that this population was living in suboptimal habitat.

The giant kangaroo rat, by its relative abundance and burrowing activity, is a keystone species in grassland and shrub communities (Schiffman 1994, Goldingay et al. 1997). When abundant locally, giant kangaroo rats are a significant prey item for many species, including San Joaquin kit foxes (an umbrella species), American badgers (*Taxidea taxus*), coyotes (*Canis latrans*), long-tailed weasels (*Mustela frenata*), burrowing owls (*Athene cunicularia*), barn owls (*Tyto alba*), great horned owls (*Bubo virginianus*), and short-eared owls (*Asio flammeus*). Snakes seen within giant kangaroo rat colonies included the coachwhip (*Masti- cophis flagellum*), gopher snake (*Pituophis melano- leucus*), common king snake (*Lampropeltis getulus*), and western rattlesnake (*Crotalis viridis*; Williams 1992). Giant kangaroo rat burrows also are used by blunt-nosed leopard lizards and San Joaquin antelope squirrels. On the Carrizo Plain Natural Area, the endangered California jewelflower grows primarily on the burrow systems of giant kangaroo rats (Cypher 1994*a*). In spring, precincts show as distinct, evenly-spaced, dark green patches because of the more lush growth of herbaceous plants compared to intervening spaces (Grinnell 1932*a*). Measurements of plant productivity on and off precincts over an 8-year period show that when rainfall was sufficient to promote growth and fruiting of plants, the net productivity of herbaceous plants was two to five times greater on precincts than surrounding ground (Hawbecker 1944, Williams et al. 1993*b*, Williams and Nelson in press). Further, growth of herbaceous plants on precincts contained about 4 percent more protein than plants from surrounding ground. These differences were attributed directly to the presence and activities of the giant kangaroo rats (Williams et al. 1993*b*).

Activity Cycles.—Giant kangaroo rats are active all year and in all types of weather. They do not migrate or become dormant or torpid. Although primarily nocturnal, giant kangaroo rats have been seen above ground during daylight, including midday in the hottest part of the year (Williams et al. 1993*b*, Williams and Tordoff 1988). Giant kangaroo rats typically emerge from their burrows soon after sunset and are active for about 2 hours (time of first emergence to time of last disappearance). There usually is no second period of activity before dawn. Animals are above ground only for about 15 minutes per night. Activity patterns appear to be unaffected by distance from the home burrow, snow, rain, wind, moonlight, or season (Braun 1985).

Habitat and Community Associations.—Historically, giant kangaroo rats were believed to inhabit annual grassland communities with few or no shrubs, well-drained, sandy-loam soils located on gentle slopes (less than 11 percent) in areas with about 16 centimeters (6.3 inches) or less of annual precipitation, and free from flooding in winter (Grinnell 1932*a*, Shaw 1934, Hawbecker 1951). However, more recent studies in remaining fragments of historical habitat found that giant kangaroo rats inhabited both grassland and shrub communities on a variety of soil types and on slopes up to about 22 percent and 868 meters (2,850 feet) above sea level. This broader concept of habitat requirements probably reflects the fact that most remaining populations are on poorer and marginal habitats compared to the habitats of the large, historical populations in areas now cultivated. Yet these studies demonstrated that the preferred habitat of giant kangaroo rats still was annual grassland communities on gentle slopes of generally less than 10 percent, with friable, sandy- loam soils. Few plots in flat areas were inhabited, probably because of periodic flooding during heavy rainfall (Williams 1992, Williams et al. 1995, Allred et al. in press).

Below about 400 meters (1,300 feet) at Panoche Creek in western Fresno County and in the Lokern, Buena Vista Valley, and Elk Hills regions of the southern San Joaquin Valley, giant kangaroo rats are found in annual grassland and saltbush scrub. Scattered common and spiny saltbushes characterize areas where giant kangaroo rats are associated with shrubs. The most common herbaceous plants are red brome, annual fescue, and red-stemmed filaree (Williams 1992).

Upper Sonoran subshrub scrub associations support relatively large populations of giant kangaroo rats at elevations above about 400 meters (1,300 feet). In the southern portion of the extant geographic range of giant kangaroo rats, these communities are characterized by open stands of the dominant shrub, California ephedra. Annual grasses and forbs, particularly red-stemmed filaree, peppergrass, and Arabian grass dominate areas between shrubs. Giant kangaroo rats are most numerous where annual grasses and forbs predominate, with scattered ephedra bushes and fewer shrubs such as Anderson desert thorn *(Lycium andersonii)*, eastwoodia *(Eastwoodia elegans)*, and pale-leaf goldenbush *Isocoma acradenia* var. *bracteosa)* (Williams 1992).

Above about 600 meters (2,000 feet) in elevation, eastwoodia, California buckwheat, winter fat *(Krascheninnikovia lanata)*, and chaparral yucca (*Yucca whipplei*) are more common on steep slopes (greater than about 5 to 6 percent) and sandy ridgetops. Cheesebush *(Hymenoclea salsola)* and matchweed are common only in arroyos. Only satellite colonies of giant kangaroo rats or scattered individuals are found in these latter associations. In the northern portion of the geographic range of giant kangaroo rats, Anderson desert thorn is absent; otherwise, the woody shrubs comprising the ephedra community are the same or closely-related species (Williams 1992, Williams et al. 1995).

4. Reasons for Decline and Threats to Survival

Reasons for Decline.—Until the late 1960s and early 1970s, little land within the historical range of the giant kangaroo rat had been permanently cultivated and irrigated or otherwise developed. Completion of the San Luis Unit of the Central Valley Project and the California Aqueduct of the State Water Project resulted in rapid cultivation and irrigation of natural communities that had provided habitat for giant kangaroo rats along the west side of the San Joaquin Valley (Williams 1992, Williams and Germano 1993). Between about 1970 and 1979, almost all the natural communities on the western floor and gentle western slopes of the Tulare Basin were developed for irrigated agriculture, restricting occurrence of most species of the San Joaquin saltbush and Valley Grassland communities, including the giant kangaroo rat. This rapid habitat loss was the main reason for its listing as endangered. At the time of its listing, relatively little of its extant habitat was publicly owned or protected from possible destruction.

Use of rodenticide-treated grain to control ground squirrels and kangaroo rats also may have contributed to the decline of giant kangaroo rats in some areas. From the 1960s into the early 1980s rodenticides such as Compound 1080 were often broadcast over broad areas by airplane. Today, there are large areas in the Sunflower Valley (western corners of Kings and Kern Counties), Kettleman and Tent Hills in Kings County, and the eastern foothills of the Panoche Hills, Fresno County, that show characteristic features of giant kangaroo rat precincts, but are unoccupied by kangaroo rats. Williams (1992) believed that populations in these areas may have been eliminated by use of rodenticides.

Based on remarks by Grinnell (1932*a*) and Shaw (1934), giant kangaroo rats can survive in areas that have been grazed to a point where almost no plant material remains. It is not known, however, if they could survive indefinitely if those grazing intensities were sustained.

Destruction of natural communities to develop the infrastructure for petroleum exploration and extraction also has reduced habitat for giant kangaroo rats and contributed to their decline, especially in the area around Coalinga, Fresno County, and in the oil fields of western Kern County. The small cities and towns along the western edge of the San Joaquin Valley between Coalinga and Maricopa also have developed on what was once habitat for giant kangaroo rats. These developments, plus mineral extraction, roads and highways, energy and communications infrastructures, and agriculturally related industrial developments collectively have contributed to the endangerment of the giant kangaroo rat, but were not as important as loss of habitat by cultivation.

Threats to Survival.—Since listing as endangered (USFWS 1987), conversion of habitat for giant kangaroo rats has slowed substantially, because most tillable land has already been cultivated and because of a lack of water for irrigation. However, urban and industrial developments, petroleum and mineral exploration and extraction, new energy and water conveyance facilities, and construction of communication and transportation infrastructures continue to destroy habitat for giant kangaroo rats and increase the threats to the species by reducing and further fragmenting populations. Though many of these recent and future losses will be mitigated for by protecting habitat elsewhere, they still result in additional loss and fragmentation of habitat. Habitat degradation due to lack of appropriate habitat management on conservation lands, especially lack of grazing or fire to control density of vegetation (including shrubs) may be a threat to giant kangaroo rats (Williams and Germano 1993).

Though 60 population monitoring plots, range-wide, for giant kangaroo rats were established in 1995 by the Endangered Species Recovery Program (Williams and Kelly in litt. 1994*a*), there are no funds obligated to carry out a monitoring program in the future. Regular monitoring is important to any endangered species management program. Without monitoring, the effects of management prescriptions cannot be properly evaluated or altered in response to changes in populations due to both management actions and environmental variation. Perhaps no active management program is needed for giant kangaroo rat habitat, but that cannot be determined until after several years of range-wide monitoring and evaluation of effects of different land uses on populations.

The sale of Naval Petroleum Reserve #1 in Elk Hills to private interests (Henry 1995*a*, 1995*b*) could represent a threat to one of the three largest regional populations of giant kangaroo rats if rates of exploration and production are increased. The giant kangaroo rat population in western Kern County is isolated from all others, and though at times is fairly widespread, it seems especially sensitive to variable precipitation patterns, declining to only a few small areas during drought and after periods of heavy rainfall. Thus, its vulnerability to extinction by random catastrophic events (e.g., drought, flooding, fire) seems relatively high (B.L. Cypher pers. comm., T. Kato pers. comm., L. Spiegel pers. comm., Endangered Species Recovery Program unpubl. observ.). Any factor that would reduce substantially the amount of protected habitat in that region would pose a major threat to the population. The greatest value of the Naval Petroleum Reserves in California to giant kangaroo rats is the large extent of habitat of varying quality and its connectivity to adjacent habitat in the Lokern area. The publicly-owned portion of the Naval Petroleum Reserves in California ensures that giant kangaroo rat habitat will be protected during and after extraction of petroleum deposits.

Land in western Fresno County at the edge of irrigated ground provides an important area for recovery of the northern population of giant kangaroo rats (Williams et al. 1995) (Figure 39). The extant population on natural lands along the border of cultivated ground is split into two segments (Figure 41, see area A). One occupies only a narrow band about 6.44 kilometers (4 miles) long and from about 200 meters (660 feet) to 320 meters (1,050 feet) wide. The other, separated by only a few hundred meters, occupies about 250 hectares (617 acres) in an oval pattern about 2,400 by 1,200 meters (1.5 by 0.75 miles; Williams et al. 1995). Together, they support about 27 percent of the entire northern population in times of high population numbers, and probably more than 50 percent in times of lowest population numbers. This population represents the "up-slope" remnant of a formerly huge colony that stretched among the gentle slopes of the western edge of the Valley from around the alluvial fan of Laguna Seca Creek in Merced County, southward to Coalinga, a distance of about 97 kilometers (60 miles). During population irruptions it also is the "connector" population to small, scattered populations in the Ciervo and Tumey Hills, and along Panoche and Silver Creeks (Figure 41, see area C). The narrow band of habitat for this population is bisected lengthwise and degraded in quality by roads, power lines, and pipelines. Moderate levels of livestock grazing on this property probably have maintained nearly optimum conditions for giant kangaroo rats in what is only mediocre-quality habitat in comparison to historical habitat, but among the better-quality habitat remaining. Any additional loss or degradation of habitat from construction of permanent roads and energy conveyance facilities or cultivation could pose a substantial threat to the entire northern population.

Habitat for three of the six regional populations of giant kangaroo rats include no public or conservation lands (Figure 39). These are the populations in Cuyama Valley (about 194 hectares, 480 acres), Kettleman Hills (about 1 hectare, 2.47 acres), and San Juan Creek Valley (estimate unavailable because of lack of access to private land; Williams 1992). All are small and vulnerable to extinction from demographic and random catastrophic events (e.g., drought, flooding, fire), and inappropriate land uses that would degrade or destroy habitat.

5. Conservation Efforts

Designation as State (1980; Table 1) and federally (USFWS 1987) endangered has resulted in substantial habitat protection for giant kangaroo rats. Most significant has been protection on the U.S. Department of Energy Naval Petroleum Reserves in California in western Kern County (O'Farrell and Kato 1987, O'Farrell et al. 1987*a*, 1987*b*), and on USBLM-administered Federal properties (USBLM 1987, 1993). Acquisition of private property in the jointly managed Carrizo Plain Natural Area by the State of California, U.S. Government, and The Nature Conservancy (Table 2) has significantly reduced threats to the species from dryland cultivation and illegal use of rodenticides. It also has allowed for control of livestock grazing on this land by the change in ownership from private to public. Other significant acquisitions that have benefited conservation of giant kangaroo rats have been the land exchanges and purchases within western Fresno and eastern San Benito Counties by the USBLM, and compensation, donation, and acquisition of parcels in the Lokern area of western Kern County by the California Energy Commission, CDFG, and The Nature Conservancy (Table 2).

Substantial progress in understanding the current distribution, habitat associations, demography, and population genetics of giant kangaroo rats has been achieved by a series of research projects, mainly supported by USFWS section-6 funds and money from the Endangered Species Tax Checkoff Program and Environmental License Plate Program administered by the CDFG's Bird and Mammal Conservation Program (R. Schlorff pers. comm.). Additional funding and logistic support for research on giant kangaroo rats has been provided by the U.S. Bureau of Reclamation, USBLM, USFWS, and The Nature Conservancy. This research has been summarized in a series of reports and publications (Williams 1980, Williams 1992, Williams et al. 1993*b*, 1995, Allred et al. in press, Mosquin et al. in press, Williams and Nelson in press, Williams and Tordoff 1988). Additionally, substantial information on distribution, habitat, and population fluctuation has been provided by the U.S. Department of Energy through EG&G Energy Measurements for research conducted at the Naval Petroleum Reserves in California in western Kern County (O'Farrell and Kato 1987, O'Farrell et al. 1987*b*, EG&G Energy Measurements 1995*a,b*), and for the southern San Joaquin Valley (Anderson et al. 1991) and the Carrizo Plain Natural Area (Kakiba-Russell et al. 1991) by the California Energy Commission.

U.S. Environmental Protection Agency County bulletins governing use of rodenticides have greatly reduced the risk of significant mortality to giant kangaroo rat populations by State and county rodent-control activities. The California Environmental Protection Agency, California Department of Food and Agriculture, county agricultural departments, CDFG, and U.S. Environmental Protection Agency collaborated with the Service in the development of County Bulletins that both are efficacious and acceptable to land owners (R.A. Marovich pers. comm.).

6. Recovery Strategy

Recovery of giant kangaroo rats can be achieved when the three largest populations (western Kern County, Carrizo Plain Natural Area, and the Panoche Region) and the populations in the Kettleman Hills, San Juan Creek Valley and Cuyama Valley are protected and managed appropriately. Because the giant kangaroo rat is a keystone species, protection of the above areas will benefit many other listed species that share the same habitat types.

Information on reproductive rates and survivorship still is insufficient to adequately model population viability, though measured population growth strongly suggests that reproductive capacity of giant kangaroo rats is ample to rapidly rebuild depleted population numbers and to expand into newly available habitat. The principal factor in recovery of giant kangaroo rats is protection of existing habitat and key local populations within the three regional populations.

Current understanding of demographics, distribution (Williams 1992, Williams et al. 1993*b*, 1995, Allred et al. in press, Williams and Nelson in press), and population genetics (Mosquin et al. in press) of giant kangaroo rats is sufficient to presume that the species is not threatened by inbreeding, low reproductive rates, etc., though some small, isolated populations are at risk from these factors. Population responses to environmental variation seen during the last 16 years (Williams 1980, 1992, Williams et al. 1993*b*, Williams and Nelson in press, D.F. Williams unpubl. data) suggest that random catastrophic events (e.g., drought, flooding, prolonged rainfall) poses the greatest risk to long-term survival of the species. Protection from random catastrophic events requires both relatively large habitat areas with varying topography and habitat conditions, and land uses that provide optimum habitat conditions.

Recovery Actions.—Though substantial habitat for giant kangaroo rats is now in public ownership, recovering giant kangaroo rats requires additional habitat protection. Key to protection is an adequate understanding of compatible land uses and management prescriptions that provide optimum habitat conditions for giant kangaroo rats (Williams and Germano 1993). Several other listed species, including the California jewelflower, San Joaquin woolly-threads, blunt-nosed leopard lizard, San Joaquin antelope squirrel, and San Joaquin kit fox, seem to require the same or similar habitat conditions, so there is unlikely to be conflicts in habitat management prescriptions for most of the listed species where they coexist. Land acquisition, purchase of conservation easements, or other incentive mechanisms that will ensure that suitable habitat will be maintained in perpetuity also are needed to protect key local populations. Some existing public lands could be inhabited or support larger populations if suitably restored. Yet, available data are insufficient to know the types and amounts of compatible land uses or appropriate forms of habitat restoration and management. Recovery actions to protect habitat for giant kangaroo rats follow:

1. Of highest priority for habitat protection is proper land use and management on publicly-owned and conservation lands in the Carrizo Plain Natural Area, Naval Petroleum Reserves in California, Lokern Natural Area, and Ciervo-Panoche Natural Area. Where populations of giant kangaroo rats and associated, listed species appear to be robust, land use should not be changed when ownership or conservation status of parcels changes unless there are compelling reasons to do so. For land already in public and conservation ownership, historical uses that maintained habitat for giant kangaroo rats, such as livestock grazing, should be reestablished where appropriate.

2. Of equal priority is supporting research on habitat management and restoration, focusing on effects of livestock grazing on habitat quality, and habitat restoration on retired farmland, especially abandoned dryland farms.

3. Second in priority for habitat protection is the protection of additional land supporting key populations by acquisition of title, conservation easement, or other mechanisms. Areas to be protected are prioritized, as follows:

    a. (1) Land in the Lokern Area of western Kern County. The goal is to protect 90 percent of the existing natural land bounded on the east by natural lands just east of the California Aqueduct, on the south by Occidental of Elk Hills, on the west by State Highway 33, and on the north by Lokern Road;

    (2) Land in the Naval Petroleum Reserves in California of western Kern County. The goal is to maintain in a natural state (i.e., grassland and saltbush scrub communities) 90 percent of the existing natural land in Occidental of Elk Hills, and 80 percent of the natural land in Naval Petroleum Reserve in California No. 2, including all in the Buena Vista/McKittrick Valley between Elk Hills Road on the southeast and State Highway 33 on the northwest;

    b. Existing natural land providing habitat for giant kangaroo rats in western Fresno and eastern San Benito Counties. The goal is to protect all existing natural land on the Silver Creek Ranch, and existing habitat for this species along the eastern bases of Monocline Ridge and the Tumey Hills, between Arroyo Ciervo on the south and Panoche Creek on the north;

    c. Acquire and restore habitat on periodically farmed land with no or Class-3 irrigation water rights immediately east of occupied natural habitat along the strip described in 3.b, and west of Interstate Highway 5;

    d. Other natural land occupied by giant kangaroo rats in western Kern County. The goal is to protect 80 percent of existing habitat for giant kangaroo rats;

    e. Land occupied by giant kangaroo rats in the Cuyama Valley, Santa Barbara County;

    f. Land occupied by giant kangaroo rats in the Kettleman Hills, Kings County;

    g. Land occupied by giant kangaroo rats in the San Juan Creek Valley, San Luis Obispo County.

The above areas described in items e through g are important to the continued existence and recovery of other species, though it is not known if giant kangaroo rat populations have sufficient habitat in those areas to maintain viability indefinitely. Their keystone role in the ecosystem, however, makes it important to try to maintain these giant kangaroo rat populations.

A long-term program to periodically monitor populations range-wide is important to understanding population responses to random catastrophic events (e.g., drought, flooding, fire) and differing land uses, response to adaptive management, and to measure progress toward recovery. This program would measure responses of populations, key elements of their plant community, environmental variation, and soil erosion or formation to variation in climate and land uses (Williams and Kelly in litt. 1994*a*). Monitoring should be conducted annually for at least a 10-year period, and periodically thereafter at 5-year intervals.

I. Fresno Kangaroo Rat
(*Dipodomys nitratoides exilis*)

1. Description and Taxonomy

Taxonomy.—The Fresno kangaroo rat is one of three subspecies of the San Joaquin kangaroo rat. The type specimen of the Fresno kangaroo rat was collected from Fresno, California, in 1891. Merriam (1894) considered the Fresno and the Tipton kangaroo rats to be subspecies of Merriam's kangaroo rat (*Dipodomys merriami*), a widespread species occurring in the Mojave Desert of California and elsewhere in western North America. Yet, Grinnell (1921) noted that the populations of "*D. merriami*" from the San Joaquin Valley were distinct from other members of this species. Grinnell (1922) subsequently reclassified *exilis* as a subspecies of a new species, the San Joaquin kangaroo rat (*D. nitratoides*). Fresno and Tipton kangaroo rats are similar in overall structure and occupy contiguous geographic ranges on the floor of the Tulare Basin and southeastern half of the San Joaquin Basin in the San Joaquin Valley. A third subspecies, the short-nosed kangaroo rat, is found in the foothills and basins along the western side of the San Joaquin Valley south of Los Banos, Merced County on the north, and western portions of the Tulare Basin, the upper Cuyama Valley, and Carrizo Plain (Williams et al. 1993*a*).

Boolootian (1954) studied structural variation in populations of *D. nitratoides*, concluding that *exilis* did not merit recognition as a subspecies and regarded it to be a synonym of *nitratoides*. Hall and Kelson (1959) did not follow Boolootian's (1954) recommendation for reasons they attributed to the unpublished advice of Seth Benson (former Curator of Mammals, Univ. California, Berkeley, Museum of Vertebrate Zoology). In a master's thesis study of Fresno kangaroo rats, Hoffmann (1975) concluded that Benson erred in his determination of the identity of some San Joaquin kangaroo rats, but that *exilis* was identifiable as a subspecies. Williams (1985) agreed with Hoffmann's conclusions that the samples he regarded as *exilis* were distinguishable from those he had available of *nitratoides* and *brevinasus*, but noted that the subspecies were practically indistinguishable when samples of populations from localities intermediate to the geographic locations of Hoffmann's samples of *exilis* and *nitratoides* were included. DNA studies to resolve this issue are currently being conducted. Investigators using serum proteins (Johnson and Selander 1971, Patton et al. 1976, Best and Janecek 1992) and chromosome structure (Stock 1971, Patton et al. 1976) found substantial differences at the species level between *D. nitratoides* and *D. merriami*, supporting Grinnell's (1922) earlier species reclassification. Subspecies taxonomy of *D. nitratoides* was most recently reviewed by Williams et al. (1993*a*) and all were retained.

Description.—The San Joaquin kangaroo rat is similar in general appearance to the other 20 species of kangaroo rats, but is smaller, and differs substantially from all other species in several ways (Figure 42). Like all kangaroo rats, the San Joaquin kangaroo rat is adapted for survival in an arid environment. Adaptations for bipedal locomotion include elongated hind limbs, a long, tufted tail for balance, a shortened neck, and, compared to typical rodents, a large head. The skull is flattened from top to bottom, with enlarged *auditory bullae* (bony capsules containing the middle and inner ears). Other characteristics include large eyes placed near the top of the head and small, rounded ears. Forelimbs are comparatively short with stout claws that facilitate

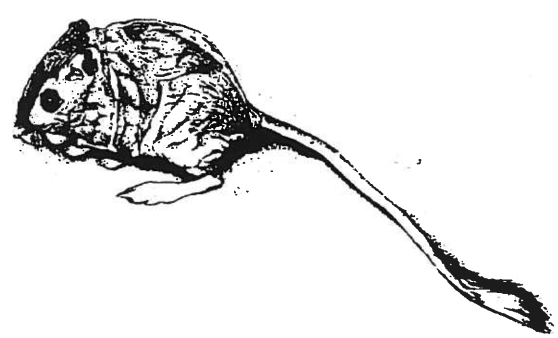

Figure 42. Illustration of a San Joaquin kangaroo rat (*Dipodomys nitratoides*) by Jodi Sears based on photo © by D.F. Williams.

digging burrows (Best 1991). Its total length averages about 231 millimeters (9.09 inches) for males and 225 millimeters (8.86 inches) for females (Hoffmann 1975). The hind foot usually is less than 36 millimeters (1.42 inches) in length. The fur is dark yellowish-buff dorsally and white ventrally (Knapp 1975). A white stripe extends across the hips, continuing for the length of the prominently tufted tail. The base of the tail is circumscribed by white. Dorsal and ventral sides of the tail are blackish. Dark whisker patches on each side of the nose are connected by a black band of fur (Grinnell 1922, Culbertson 1934, Williams 1985).

Identification.—The San Joaquin kangaroo rat can be distinguished from other kangaroo rats within its geographic range by the presence of four toes on the hind foot; the other species found in the same area have five toes. The Fresno kangaroo rat is the smallest of the three subspecies of *D. nitratoides*. Individuals of the three subspecies of *D. nitratoides* cannot be reliably distinguished without dissection unless the geographic origin of the individual is known. The Fresno kangaroo rat is distinguished from the other subspecies of the San Joaquin kangaroo rat by its smaller average measurements (in millimeters): length of hind foot for males 33.9 millimeters (1.33 inches), for females, 33.4 millimeters (1.31 inches); mean inflation of the auditory bullae for males, 21.4 millimeters (0.84 inch), for females, 21.2 millimeters (0.83 inch) (Hoffmann 1975) (see accounts of Tipton and short-nosed subspecies for corresponding average measurements).

2. Historical and Current Distribution

Historical Distribution.—The known historical geographic range of the Fresno kangaroo rat encompassed an area of grassland and chenopod scrub communities on the San Joaquin Valley floor, from about the Merced River, Merced County, on the north, to the northern edge of the marshes surrounding Tulare Lake, Kings County, on the south, and extending from the edge of the Valley floor near Livingston, Madera, Fresno, and Selma, westward to the wetlands of Fresno Slough and the San Joaquin River (Figure 43). Documentation of historical distribution is scanty. Boolootian (1954), Culbertson (1934, 1946), Hoffman and Chesemore (1982), Hoffmann (1974, 1975), Knapp (1975), Williams (1985), and Williams et al. (1993*a*) collectively provided a composite picture of the historical distribution and documentation of the loss and fragmentation of habitat. An estimate of the historical range, within the area as outlined above, is approximately 359,700 hectares (888,500 acres; Williams 1987). Not all this area would have been habitat for Fresno kangaroo rats.

Current Distribution.—There are no known populations within the circumscribed historical geographic range in Merced, Madera, and Fresno Counties. A single male Fresno kangaroo rat was captured twice in autumn 1992 on the Alkali Sink Ecological Reserve, west of Fresno. Trapping at the Reserve in 1993, 1994, and 1995 did not yield additional captures. Fresno kangaroo rats were previously trapped on the Alkali Sink Ecological Reserve in 1981 and 1985, and on adjacent privately owned land in 1981 (Hoffman and Chesemore 1982, Chesemore and Rhodehamel 1992). Though the Alkali Sink Ecological Reserve is now about 382.4 hectares (945 acres), suitable habitat there for Fresno kangaroo rats probably totals about 162 hectares (400 acres). Trapping at other sites in Merced, Madera, and Fresno Counties between 1988 and 1995 failed to locate other, extant populations within the area typically considered as the geographic range of the Fresno kangaroo rat (Chesemore and Rhodehamel 1992, Williams and Kilburn 1992, D.F. Williams unpubl. data).

Other areas of west-central Fresno County that were inhabited historically by Fresno kangaroo rats, and that were uncultivated in 1981, included nine separate sites. Two of the nine parcels now are partly cultivated but 715.7 hectares (1,768.4 acres) in two others were purchased by the State (now the Kerman Ecological Reserve). Fresno kangaroo rats have not been found at any of these sites during surveys between 1988 and 1996 (Endangered Species Recovery Program unpubl. data).

Populations of San Joaquin kangaroo rats have been found on about 150 hectares (371 acres) comprising five isolated parcels in Kings County, south of the historical river and slough channels of the Kings River and north of the Tulare Lake bed (Williams 1985, D.F. Williams unpubl. data). Staff of the Endangered Species Recovery Program last verified occurrence of two populations in 1994 and 1995. One site, 39 hectares (97 acres) in size, is located on Lemoore Naval Air Station. Whether these populations belong to the Fresno or Tipton subspecies is uncertain, but historically, they were geographically contiguous and probably periodically connected to populations identified as Fresno kangaroo rats. Genetic and morphometric studies (to measure the size of the feet and auditory bullae) of these populations are in progress (J.L. Patton pers. comm.).

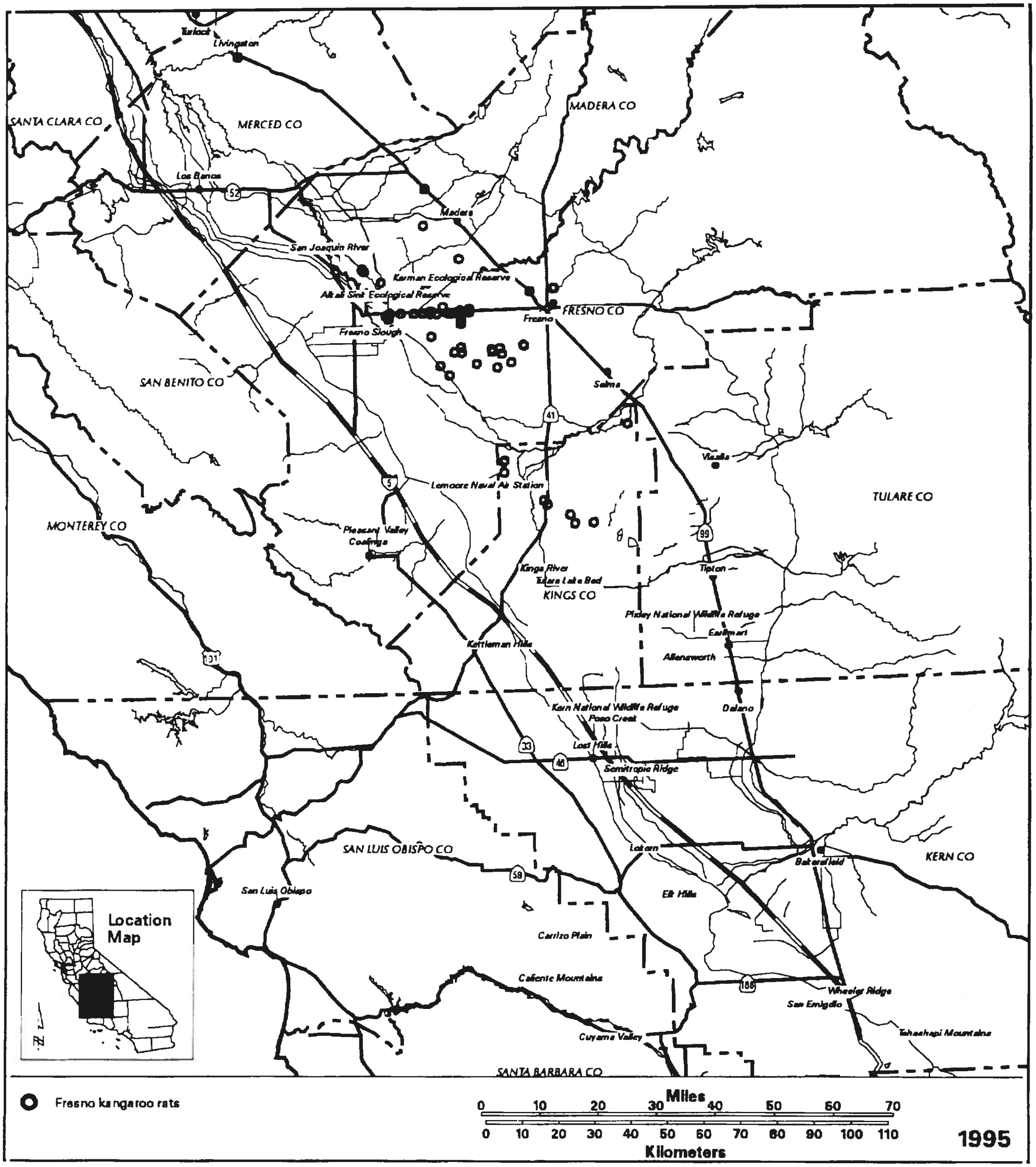

Figure 43. Distributional records for the Fresno kangaroo rat *(Dipodomys nitratoides exilis).*

Other areas with possibly extant populations of Fresno kangaroo rats include uncultivated grassland, alkali sink shrubland, and seasonally flooded wetlands within the historical range of the species, in Fresno, Madera, and Merced Counties. Trapping at selected sites in all three counties between 1988 and 1995 has failed to confirm presence, but lack of permission to trap on private lands has prevented a thorough search by staff of the Endangered Species Recovery Program. Populations of *D. nitratoides* occurred on the Mendota Wildlife Area, Fresno County, both east and west of the Fresno Slough, but the population west of Fresno Slough was regarded by Hoffmann (1975) as representing *D. n. brevinasus* rather than *exilis*, though they were intermediate to the two subspecies structurally (Boolootian 1954). Occurrence on the Wildlife Area has not been verified, despite trapping in 1981 and 1993.

San Joaquin kangaroo rats also have been taken recently in seasonally-flooded iodine bush *(Allenrolfea occidentalis)* shrublands in the South Grasslands Water District, Merced County. This population is located in an area historically considered part of the geographic range of the short-nosed subspecies. Individuals exhibit structural characteristics somewhat intermediate to *brevinasus* and *exilis*, but are found in the same habitat as *exilis* and have been tentatively assigned to *exilis* (Johnson and Clifton 1992, Williams et al. 1993*a*). These areas are privately owned lands included in the wetland waterfowl easement program of USFWS.

3. Life History and Habitat

Food and Foraging.—Fresno kangaroo rats collect and carry seeds in fur-lined cheek pouches. Seeds are a staple in their diet, but they also eat some types of green, herbaceous vegetation, and insects. A wide variety of seeds probably are consumed, depending on availability. Known foods include seeds of annual and perennial grasses, particularly wild oats, brome grasses (red and ripgut [*B. diandrus*] brome, soft chess [*B. hordeaceus*]), wild barley (*Hordeum* sp.), mouse-tail fescue, alkali sacaton, and saltgrass; and seeds of annual forbs such as filaree, peppergrass, common spikeweed (*Hemizonia pungens*), and shepherd's purse (*Capsella bursa-pastoris*) (Culbertson 1946, Koos 1979). Seeds of the woody and semiwoody shrubs, iodine bush and seepweed (*Sueda moquinii*), also are eaten (Koos 1979). Seeds of woody shrubs, especially saltbushes are diligently sought out by Tipton and short-nosed kangaroo rats, and also probably are important for Fresno kangaroo rats (D.F. Williams unpubl. observ.). Insects make up a small part of the diet, varying from about 2 to 10 percent frequency in fecal samples (Koos 1979).

Most kangaroo rats gather seeds when they are available and cache them for consumption later. Typically, caches are made in small pits that hold the contents of the two cheek pouches. Caches are located on the surface of the soil, and are typically scattered over the home range of the individual. A few, small, seed caches were found in excavated burrows of Fresno kangaroo rats (Culbertson 1946). These small caches also hold only about the contents of two cheek pouches. Culbertson (1946) speculated that Fresno kangaroo rats did not cache seeds in their burrows to the same extent as other kangaroo rats because the soil where they lived was damp much of the year. Seeds would spoil rapidly under such conditions. He also speculated that Fresno kangaroo rats therefore were obligated to forage on the surface year round to a greater extent than kangaroo rats that cached more food. In fall and winter, after the wet season commences, sprouts of seeds and tender new growth of grasses and forbs may be essential items in the diet of Fresno kangaroo rats. Green developing seed heads may be important in the spring months. Seeds, and perhaps insects, are the most important items in the diet in late spring, summer, and fall.

Reproduction and Demography.—Nothing is known about mating behavior or the mating system of Fresno kangaroo rats in the wild. Culbertson (1946) recorded observations of captive Fresno kangaroo rats, including young born in captivity, and Eisenberg (1963) and Eisenberg and Issac (1963) described mating behavior and care of young in a captive colony of short-nosed kangaroo rats. Mating probably takes place on the surface within the territory of the female. Culbertson (1946) did not locate nests in excavated burrow systems and wrote that captive, pregnant females usually did not make nests before giving birth. He thought that this was because they were greatly disturbed by capture and confinement shortly before giving birth.

Sexual maturity was attained in as little as 82 days after birth. Pregnant female Fresno kangaroo rats have been taken between February and March and June and September (Hoffmann 1974). Pregnancies between June and September might represent second or third litters for adult females, summer breeding by young females born in the spring, or both. Females are probably capable of breeding two or more times per year.

Breeding probably is initiated in winter after onset of the rainy season. Nothing is known about pair bonds in wild populations, but there probably are no lasting male-female pair bonds formed. Females may breed with more than one male during a breeding cycle, though typically a single male attains dominance for mating purposes with one or more females within his territory, as is true of closely related kangaroo rat species. Most females born the previous season probably do not give birth until mid-February or early March during years with average or below average rainfall. In captivity, gestation was 32 days and young were weaned at 21 to 24 days. Average litter size in captive Fresno kangaroo rats was about two (range, one to three) (Culbertson 1946, Eisenberg and Issac 1963).

Young are born in the burrow, probably within a nest of dried, shredded vegetation. Young remain continuously in the burrow until they are fully furred and able to move about easily. Culbertson (1946) believed that young Fresno kangaroo rats were not found out of the burrow and foraging for themselves until about 6 weeks old. This is consistent for estimates for Tipton and short-nosed kangaroo rats (D.F. Williams, unpubl. data).

Based on limited information, populations of Fresno kangaroo rats probably turn over annually with most individuals born in the spring or summer not surviving to breed the following spring (Hoffmann 1974, Williams et al. 1993*b*, D.F. Williams unpubl. data). In the only study of Fresno kangaroo rats, Hoffmann (1974) found that only 2 of 75 marked animals were present on study plots through four trapping periods between 10 February and 28 December. Numbers were lowest in April, prior to dispersal of spring-born young, and peaked in May. By June, juveniles comprised the majority of the population. Maximum longevity in natural populations is probably between 3 to 5 years, based on studies of short-nosed kangaroo rats (Williams et al. 1993*b*).

Reproductive potential of Fresno kangaroo rats is relatively low compared to most rodents. Limiting factors on populations are unknown, but availability of suitable sites for burrows, free from winter flooding, probably is a major factor. No specific information is available on limitations of food. Likewise, there is no information on the roles of disease and predation in the population dynamics of Fresno kangaroo rats. Under current conditions of small, isolated and potentially inbred populations, both disease and predation are major threats.

Home range size varies by habitat features, season, and sex. Warner (1976) found home ranges to be small overall at an average of about 566 square meters (677 square yards) at the Alkali Sink Ecological Reserve. Warner's data may underestimate the typical home range size based on reports of other kangaroo rats. For example, in the closely related species, *D. merriami*, size of home range averaged about 1.65 hectares (16,500 square meters, 4.06 acres) for males and 1.57 hectares (15,780 square meters, 3.9 acres) for females in a study in New Mexico (Blair 1943).

In one study, estimates of population densities varied from about 16.7 to 24.8 Fresno kangaroo rats per hectare (6.8 to 10.1 per acre) during a period from February through December (Hoffmann 1974). Other studies estimated densities from 2 to 29.3 Fresno kangaroo rats per hectare (0.8 to 11.9 per acre) at different sites and in different seasons (Warner 1976, Koos 1977, 1979). Hoffmann (1974) believed that competition with Heermann's kangaroo rat, a larger, more widely-distributed species that uses a broader range of plant communities, might be an important factor in elimination of Fresno kangaroo rats from sites impacted heavily by grazing.

Behavior and Species Interactions.—Fresno kangaroo rats shelter in ground burrows that are dug by them or their predecessors. Burrows usually are found in relatively light, crumbly soils in raised areas. The surface area covered by the burrow system of individual Fresno kangaroo rats generally varies from about 2.1 to 3.7 meters (7 to 12 feet) on a side. There are usually two to five burrow entrances that slant gently underground, and one or more holes that open from a vertical shaft. Tunnels are about 51 millimeters (2 inches) in diameter and extend about 30.5 to 38.1 centimeters (12 to 15 inches) below ground. There may be several interconnecting tunnels and numerous dead-end side branches. Nesting material or large food caches have not been found in the few burrows that have been excavated (Culbertson 1946).

The burrow system is the apparent focus of territoriality in San Joaquin kangaroo rats. Except for young associated with females, each burrow system is typically occupied by a single individual. Culbertson (1946) found that captive Fresno kangaroo rats always fought when placed together in a small cage, and concluded that individuals were intolerant of each other. Yet when given sufficient space, individuals in a captive breeding colony of short-nosed kangaroo rats were more tolerant of others than expected from the typical behaviors of other species (Eisenberg 1963, Eisenberg and Isaac 1963). The social relations of Fresno kangaroo rats in the wild are unknown.

Activity Cycles.— Fresno kangaroo rats are nocturnal and active year round. They do not hibernate and cannot recover unaided from hypothermia. Tappe (1941) reported seeing Tipton kangaroo rats emerge from their burrows and begin above-ground activities as early as seven minutes before sunset in early spring. Other kangaroo rats in the San Joaquin Valley are sometimes seen above ground by day in March and April (D.F. Williams unpubl. observ.), but this is considered to be rare and isolated deviations from the typical nocturnal activity. In one study, the peak period of capture of Fresno kangaroo rats occurred later after dark than that of the larger, more aggressive Heermann's kangaroo rats (Hoffman 1985).

Habitat and Community Associations.—Fresno kangaroo rats occupy sands and saline sandy soils in chenopod scrub and annual grassland communities on the Valley floor. Recently they have been found only in alkali sink communities between 61 to 91 meters (200 to 300 feet) in elevation. Topography is often nearly level, consisting of bare alkaline clay-based soils subject to seasonal inundation and are broken by slightly rising mounds of more crumbly soils, which often accumulate around shrubs or grasses. Associated plant species include seepweed, iodine bush, saltbushes, peppergrass, filaree, wild oats, and mouse-tail fescue (Culbertson 1946, Hoffmann 1974, Hoffman and Chesemore 1982).

Within the alkali-sink plant associations, Fresno kangaroo rats probably were the most numerous small mammal under natural conditions, based on observations of the *D. nitratoides* population in an alkali sink community in the South Grasslands area of Merced County (Endangered Species Recovery Program unpubl. observ.). As such, they were a keystone species, providing a major source of food for a variety of predators, including the endangered San Joaquin kit fox. Their burrows were used extensively by the endangered blunt-nosed leopard lizard and other reptiles (Culbertson 1946, Williams 1985). Their seed-caching behaviors may have been important in the dispersal and germination of some plants, and their burrowing and digging probably beneficially affected soil structure and fertility (Williams 1985).

4. Reasons for Decline and Threats to Survival

Reasons for Decline.—When the Fresno kangaroo rat was discovered in 1891, cultivation of its habitat already was threatening the species' existence (Merriam 1894). By the early 1900s, it was believed to be extinct (Grinnell 1920), only to be rediscovered in 1933 (Culbertson 1934). By 1974, known habitat for these animals had been reduced and fragmented into three major areas, encompassing approximately 5,920 hectares (14,629 acres) in Fresno County, primarily by agricultural developments, urbanization, and transportation infrastructures (Knapp 1975). With the exception of the Alkali Sink Ecological Reserve and adjacent private land, Hoffman and Chesemore (1982) reported that only 2,396 hectares (5,920 acres) of potentially suitable habitat remained in Fresno County. Of this total, they considered 2,072 hectares (5,120 acres) to be marginal because of heavy livestock grazing. Actual presence of Fresno kangaroo rats was not confirmed on any of the nine isolated parcels composing this total.

Threats to Survival.—In spring of 1986 a levee on the south side of the San Joaquin River broke, flooding the Alkali Sink Ecological Reserve and other important habitat. Water nearly a meter deep covered most of the area for several days.

The Alkali Sink and Kerman Ecological Reserves have not been actively managed since they were purchased as habitat for Fresno kangaroo rats and other species of the Alkali Sink communities. Livestock grazing that occurred prior to acquisition by CDFG was suspended after purchase, and some parcels now have heavy growths of herbaceous plants and deep mulch cover. The change in land use from grazing to no grazing may have been a factor in the apparent elimination and possible extinction of the Fresno kangaroo rats at the Alkali Sink Ecological Reserve. Yet, conclusive data on effects of livestock grazing on habitat quality for Fresno kangaroo rats is lacking. It is likely that seasonal grazing at levels considered good range-management have a beneficial effect on habitat quality for *D. nitratoides*.

Loss of habitat to cultivation, year-round grazing (which typically requires supplemental feeding), and conversion of land to other uses continue to diminish the size and quality of extant, historical habitat. Coupled with the resulting fragmentation and isolation of habitat, these developments increase the probability of extinction. Flooding poses a high risk to protected habitat in Fresno County because of its proximity to the San Joaquin River and because this land is the same or only slightly higher in elevation than the riverbed. If a population of Fresno kangaroo rats still is extant in the area, another break in the river levee could cause its extinction. Other potential threats are the illegal use of rodenticides, competition with Heermann's kangaroo rats, and disease and predation, any of which could eliminate small, isolated populations (Williams and Germano 1993).

5. Conservation Efforts

The Fresno kangaroo rat was listed by the State of California as Rare on June 27, 1971 (Title 14, Calif. Admin. Code, Sec. 670.5). It was subsequently changed by the State to Endangered status on October 2, 1980 (Title 14, Calif. Admin. Code, Sec. 670.5). The Fresno kangaroo rat was designated as a federally-listed endangered species on 30 January 1985 (Table 1; USFWS 1985*b*).

Accompanying the listing of the Fresno kangaroo rat as endangered was the designation of 347 hectares (857 acres) as critical habitat. In 1985, when it was designated as critical habitat, 9.3 hectares (23 acres) were a small part of the 4,343-hectare (10,732-acre) Mendota Wildlife Area, and 296 hectares (732 acres) comprised the contiguous Alkali Sink Ecological Reserve, both State-owned and managed. The remaining 41.3 hectares (102 acres) of critical habitat were in five privately-owned parcels (Figure 44). Critical habitat is defined as specific areas within and outside the geographic area occupied by a species at the time of Federal listing on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection.

Concern centering around the continued loss of extant natural communities within the geographic range of the Fresno kangaroo rat precipitated State listing and subsequent studies on the life history, distribution, and threats to remaining populations (Hoffmann 1974, Knapp 1975, Koos 1977, Hoffmann and Chesemore 1982). The State Wildlife Conservation Board began acquiring habitat in 1978 in the vicinity of Whitesbridge Road (Fresno County) for establishment of the Alkali Sink Ecological Reserve. The primary purpose of these acquisitions was protection of State-listed species and alkali sink communities. Between 1978 and 1985, the State purchased approximately 377 hectares (931.7 acres) at a cost of about $1.32 million (J. Gustafson pers. comm.). Another 1.3 hectares (3.3 acres) of previously cultivated land were added later to the Alkali Sink Ecological Reserve, making its current size 382.4 hectares (945 acres). Acquisitions to date include approximately 85 percent of the designated 347 hectares (857 acres) of critical habitat for the Fresno kangaroo rat. Remaining critical habitat outside of the Alkali Sink Ecological Reserve encompasses approximately 16.2 hectares (40 acres) in three separate parcels under private ownership in NE 1/4 NW 1/4 of Sec. 12, and 25 hectares (61.8 acres) in two separate privately owned parcels and approximately 9.3 hectares (23 acres) of State-owned lands in adjacent T14S, R15E, Sec. 11. This latter State parcel is a portion of the Mendota Wildlife Area, which is principally wetland waterfowl habitat subject to regular flooding.

The CDFG developed a draft management plan for the Alkali Sink Ecological Reserve in 1984 (finalized in 1990) (CDFG in litt. 1984). Management objectives were to be the protection of native alkali sink communities and the Reserve's listed biota. Measures addressed in this draft plan included controlling grazing, fencing of reserve boundaries, encouraging maintenance of native species, restricting collecting and hunting, and precluding any development.

Williams reported in 1989 (in litt.) that management objectives for the Reserve had not been met and significant harm to the population had occurred.

USFWS prepared a Land Protection Plan for securing habitat for Fresno kangaroo rats through conservation easement or purchase (USFWS 1985*b*). The Land Protection Plan specified protection of 1,066 hectares (2,635 acres) of lands contiguous to critical habitat for Fresno kangaroo rats, along the northern border of the Alkali Sink Ecological Reserve. This plan was never implemented.

In 1988, additional inventory work was undertaken for Fresno kangaroo rats on natural lands in Merced, Madera, and Fresno Counties. Additional sites in the South Grasslands Waterfowl Management Area of Merced County were found to be inhabited by this species, but its subspecific classification is uncertain. Lack of access to private lands hampered thorough inventories elsewhere, but no Fresno kangaroo rats were found on any parcels in Fresno County that had extant extinction. Flooding poses a high risk to protected habitat in Fresno County because of its proximity to the San Joaquin River and because this land is the same or only slightly higher in elevation than the riverbed. If a population of Fresno kangaroo rats still is extant in the area, another break in the river levee could cause its extinction. Other potential threats are the illegal use of rodenticides, competition with Heermann's kangaroo rats, and disease and predation, any of which could eliminate small, isolated populations (Williams and Germano 1993).

5. Conservation Efforts

The Fresno kangaroo rat was listed by the State of California as Rare on June 27, 1971 (Title 14, Calif. Admin. Code, Sec. 670.5). It was subsequently changed by the State to Endangered status on October 2, 1980 (Title 14, Calif. Admin. Code, Sec. 670.5). The Fresno kangaroo rat was designated as a federally-listed endangered species on 30 January 1985 (Table 1; USFWS 1985*b*).

Accompanying the listing of the Fresno kangaroo rat as endangered was the designation of 347 hectares (857 acres) as critical habitat. In 1985, when it was designated as critical habitat, 9.3 hectares (23 acres) were a small part of the 4,343-hectare (10,732-acre) Mendota Wildlife Area, and 296 hectares (732 acres) comprised the contiguous Alkali Sink Ecological Reserve, both State-owned and managed. The remaining 41.3 hectares (102 acres) of critical habitat were in five privately-owned parcels (Figure 44). Critical habitat is defined as specific areas within and outside the geographic area occupied by a species at the time of Federal listing on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection.

Concern centering around the continued loss of extant natural communities within the geographic range of the Fresno kangaroo rat precipitated State listing and subsequent studies on the life history, distribution, and threats to remaining populations (Hoffmann 1974, Knapp 1975, Koos 1977, Hoffmann and Chesemore 1982). The State Wildlife Conservation Board began acquiring habitat in 1978 in the vicinity of Whitesbridge Road (Fresno County) for establishment of the Alkali Sink Ecological Reserve. The primary purpose of these acquisitions was protection of State-listed species and alkali sink communities. Between 1978 and 1985, the State purchased approximately 377 hectares (931.7 acres) at a cost of about $1.32 million (J. Gustafson pers. comm.). Another 1.3 hectares (3.3 acres) of previously cultivated land were added later to the Alkali Sink Ecological Reserve, making its current size 382.4 hectares (945 acres). Acquisitions to date include approximately 85 percent of the designated 347 hectares (857 acres) of critical habitat for the Fresno kangaroo rat. Remaining critical habitat outside of the Alkali Sink Ecological Reserve encompasses approximately 16.2 hectares (40 acres) in three separate parcels under private ownership in NE 1/4 NW 1/4 of Sec. 12, and 25 hectares (61.8 acres) in two separate privately owned parcels and approximately 9.3 hectares (23 acres) of State-owned lands in adjacent T14S, R15E, Sec. 11. This latter State parcel is a portion of the Mendota Wildlife Area, which is principally wetland waterfowl habitat subject to regular flooding.

The CDFG developed a draft management plan for the Alkali Sink Ecological Reserve in 1984 (finalized in 1990) (CDFG in litt. 1984). Management objectives were to be the protection of native alkali sink communities and the Reserve's listed biota. Measures addressed in this draft plan included controlling grazing, fencing of reserve boundaries, encouraging maintenance of native species, restricting collecting and hunting, and precluding any development.

Williams reported in 1989 (in litt.) that management objectives for the Reserve had not been met and significant harm to the population had occurred.

USFWS prepared a Land Protection Plan for securing habitat for Fresno kangaroo rats through conservation easement or purchase (USFWS 1985*b*). The Land Protection Plan specified protection of 1,066 hectares (2,635 acres) of lands contiguous to critical habitat for Fresno kangaroo rats, along the northern border of the Alkali Sink Ecological Reserve. This plan was never implemented.

In 1988, additional inventory work was undertaken for Fresno kangaroo rats on natural lands in Merced, Madera, and Fresno Counties. Additional sites in the South Grasslands Waterfowl Management Area of Merced County were found to be inhabited by this species, but its subspecific classification is uncertain. Lack of access to private lands hampered thorough inventories elsewhere, but no Fresno kangaroo rats were found on any parcels in Fresno County that had extant

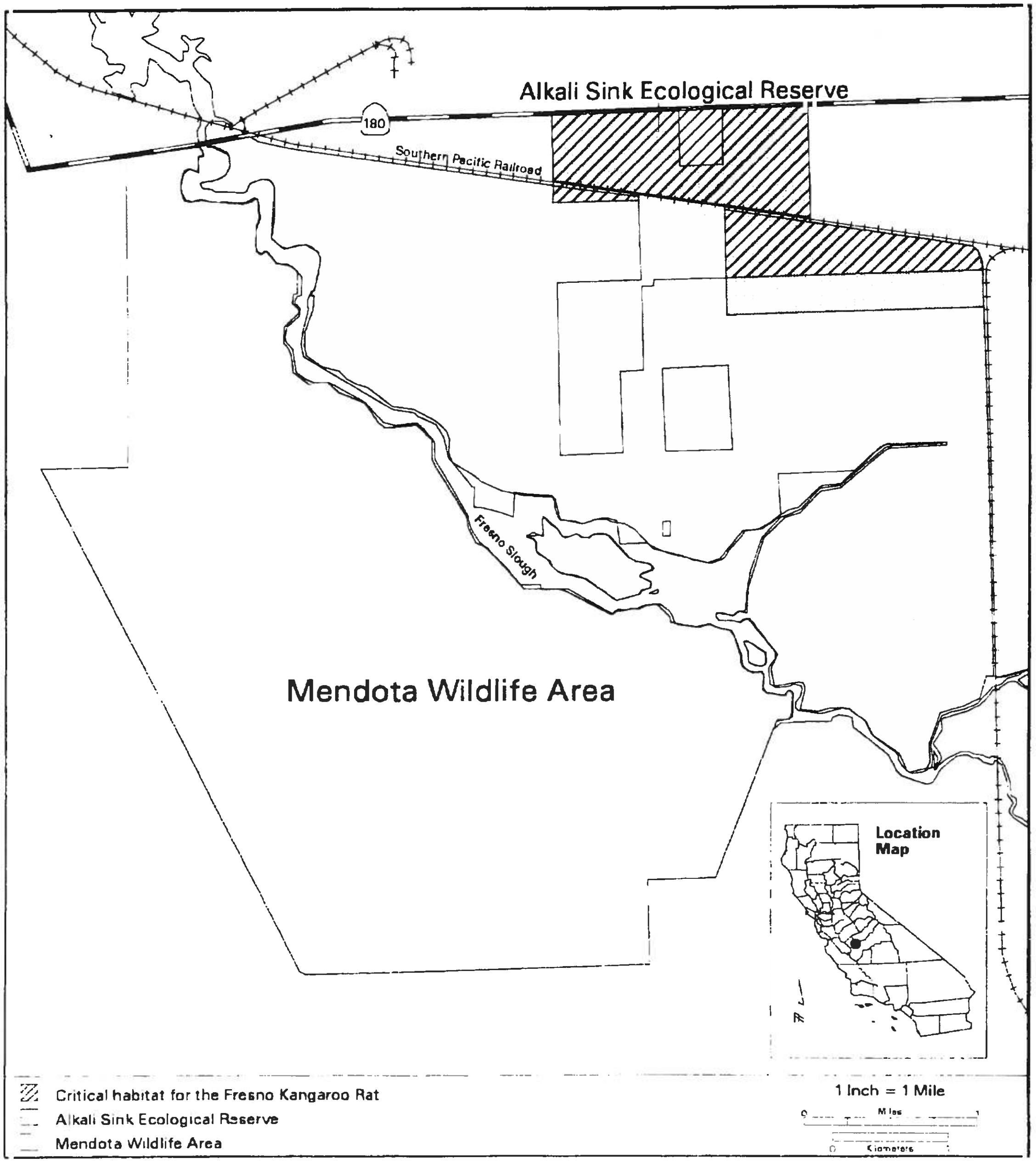

Figure 44. Designated critical habitat for the Fresno kangaroo rat.

populations in the 1970s and early 1980s. Attempts to locate Fresno kangaroo rats continued periodically in 1989, 1990, and 1991 without success (D.F. Williams unpubl. data).

In the *Biological Opinion for the Friant Division Water Contract Renewals*, habitat for the Fresno kangaroo rat was ranked highest in priority for protection by the Bureau of Reclamation (USFWS in litt. 1991). Before that could be accomplished, however, extant populations had to be located. Attempts to identify and inventory all potential habitat for Fresno kangaroo rats within their historical range, began in September 1992 and are continuing today. This effort was successful in finding only a single Fresno kangaroo rat, a male, on land already in State ownership. The Bureau of Reclamation also has funded a study of the population genetics and taxonomy of San Joaquin kangaroo rats. Principal objectives are to determine the range-wide genetic structure of the species and the degrees of differentiation of the various fragmented populations (Patton in litt. 1994). This work still is in progress.

The Endangered Species Recovery Program continued the search for extant populations of Fresno kangaroo rats and initiated management studies of kangaroo rats on the Kerman and Alkali Sink Ecological Reserves. Because there apparently are no extant populations on these reserves, the initial objectives are to measure population sizes of Heermann's kangaroo rats and vegetation characteristics on four plots, two on each Reserve. If future funds are provided, grazing could be initiated in future years and vegetation and population responses of Heermann's kangaroo rats measured. The goal would be to find a vegetation management regime that reduces populations of Heermann's kangaroo rats. Population responses to both grazing and burning are being tested in habitat for a small population of *D. nitratoides* on Lemoore Naval Air Station, funded by the Navy and conducted by the Endangered Species Recovery Program. Additional population and vegetation management studies on Pixley National Wildlife Refuge, directed at determining appropriate habitat management for Tipton kangaroo rats, are expected to provide some information needed to manage habitat for Fresno kangaroo rats. This strategy assumes that Fresno kangaroo rats will be available for translocation to the Alkali Sink and Kerman Ecological Reserves. This will require that a population be located or that one or more of the extant populations peripheral to the historical range of the Fresno kangaroo rat prove to be genetically and taxonomically inseparable from Fresno kangaroo rats (Williams and Kelly in litt. 1994*b*, 1994*c*).

U.S. Environmental Protection Agency County bulletins governing use of rodenticides have greatly reduced the risk of significant mortality to Fresno kangaroo rat populations by State and county rodent-control activities. The California Environmental Protection Agency, California Department of Food and Agriculture, county agricultural departments, CDFG, and the U.S. Environmental Protection Agency collaborated with the Service in the development of County Bulletins that both are efficacious and acceptable to land owners (R.A. Marovich pers. comm.).

6. Recovery Strategy

Several pressing issues must be attended to now concerning recovery of the Fresno kangaroo rat. Answering the questions these issues pose is an integral first step in addressing recovery:

1. The genetic relationships among extant isolated and scattered populations of San Joaquin kangaroo rats.

2. Location and size of any extant Fresno kangaroo rat populations.

3. How to manage natural lands to enhance habitat for Fresno kangaroo rats.

The second step to recovery involves instituting actions dictated by resolution of these issues, such as restoring and protecting of habitat, possibly translocating populations, and continuing management studies and population monitoring. The consolidation and protection of sufficient habitat for Fresno kangaroo rats to maintain a viable population cannot await the resolution of all these issues, though. There already is historical habitat in public ownership, though it is not sufficiently protected from catastrophes, such as flooding, nor appropriately monitored and managed for Fresno kangaroo rats. But, even with optimal habitat management, these parcels appear to be too small and vulnerable to both flooding and other catastrophes to provide the only refuges for the species. Thus, protection of the large block of natural land north of and between the Alkali Sink Ecological Reserve and the San Joaquin River and even larger blocks elsewhere is needed.

The largest existing block of natural land that was historical habitat for Fresno kangaroo rats is located in western Madera County (Williams 1990). Approximately 12,000 hectares (30,000 acres) are located in contiguous parcels. Fresno kangaroo rats still possibly exist on some part of this property, but access was given to Endangered Species Recovery Program to survey only two parcels comprising less than 10 percent of the total. Fresno kangaroo rats were not located on either parcel, though blunt-nosed leopard lizards, San Joaquin kit foxes, and palmate-bracted bird's beak were seen or known from the sites or general area (Williams 1990, D.F. Williams unpubl. data). Because this area provides the highest potential for containing an extant population of Fresno kangaroo rats, and also is an important element in the recovery of palmate-bracted bird's beak and blunt-nosed leopard lizards, protection and management of parcels there is considered of greater importance than elsewhere on parcels that are not known to be currently occupied.

The population of San Joaquin kangaroo rats at Lemoore Naval Air Station is the only one in public ownership in Kings County, and is endangered regardless of its taxonomic identity as the Fresno or Tipton kangaroo rat. Though the Navy has instituted habitat management studies on the parcel, it is too small to support a viable population indefinitely. The occupied site was formerly farmed, but then was retired to provide a motorcross track for Navy personnel. Kangaroo rats probably colonized the site by dispersing from the formerly-occupied land around a nearby runway. Restoration and enhancement of habitat next to the runway is not an option because this could attract birds and increase the probability of planes striking birds. Expansion of the existing habitat area by retiring land next to the motorcross site and managing it appropriately is important to maintaining the kangaroo rat population. Because the land is owned by the U.S. Government and is part of the air station, acquisition would not be needed, and the loss of revenue from the agricultural lease would be small compared to the cost of protecting habitat elsewhere. The amount of land needed cannot be calculated precisely now, but the initial addition of 32 to 65 hectares (80 to 160 acres) to the 38 hectares (97 acres) of existing habitat would provide space and habitat for an expanding population. The sooner this is accomplished, the greater the chances that the population can be saved.

Restoration of habitat and, if necessary, reestablishment of Fresno kangaroo rats on the Alkali Sink and Kerman Ecological Reserves also are elements of the recovery of the species, but until management issues, including protection from flooding, are resolved, these have lower priority. Reducing the accumulation of mulch and ground cover of weedy grasses has priority over other management issues on these reserves. Restoration to optimal conditions at the Kerman Reserve for Fresno kangaroo rats may also require establishment of saltbushes and other shrubs.

Size of occupied habitat areas for recovery ideally should be several thousand acres each, but no existing or potential habitat area comes near to the minimum desirable size. Therefore, criteria are scaled to size of existing and potential habitat areas. With habitat management, these parcels should be adequate to support populations. Three separate populations reduce the risk of extinction by environmental catastrophes, and considerably enhance the prospects of recovery. A larger number of separate populations is possible, but obtaining more than four large populations on public lands probably is not very practical given the amount and distribution of natural lands within the historic range of the species.

Recovery Actions.—Recognizing that genetic and taxonomic studies (Patton in litt. 1994, J.L. Patton pers. comm.) and habitat surveys already are in progress, critical recovery actions needed now are:

1. Complete the studies on relationships and taxonomic identity of isolated populations of San Joaquin kangaroo rats.

2. Intensify and continue efforts to locate populations of Fresno kangaroo rats within the historical range of the species. If a population is found, captive breeding should be considered as a recovery option depending on the size of the population.

3. Continue and increase habitat management studies.

4. Restore additional habitat for *D. nitratoides* at Lemoore Naval Air Station.

5. Protect natural land between the Alkali Sink Ecological Reserve and the San Joaquin River to the north (Sandy Mush Road/South Grasslands Area).

6. Begin discussion and planning for conservation of natural lands in western Madera County;

acquire title or easement to appropriate parcels from willing sellers.

Recovery actions that also are needed, but after critical actions are implemented or completed are:

7. Protect additional habitat for Fresno kangaroo rats in Kings County, where populations of the species are discovered. Habitat should be in blocks of at least 384 hectares (950 acres), preferably larger, with one block no less than 1,012 hectares (2,500 acres).

8. Work with landowners in western Madera County to determine presence or absence of the species there. If a population is found, assess translocating populations to public lands in Fresno County.

9. Restore habitat for Fresno kangaroo rats on the Alkali Sink and Kerman Ecological Reserves. Restoration should include manipulation of the plant community to favor Fresno kangaroo rats over Heermann's kangaroo rats.

10. Reintroduce Fresno kangaroo rats to restored and unoccupied habitats on ecological reserves and newly-protected parcels.

11. Monitor all populations and their supporting biotic communities annually for a 10-year period, then at 3-year intervals until recovery is achieved.

12. Manage habitat for Fresno kangaroo rats as needed.

J. Tipton Kangaroo Rat
(Dipodomys nitratoides nitratoides)

1. Description and Taxonomy

Taxonomy.—The Tipton kangaroo rat is one of three subspecies of the San Joaquin kangaroo rat. The type specimen of the Tipton kangaroo rat was collected from Tipton, Tulare County, California, in 1893 (Merriam 1894). See account of the Fresno kangaroo rat for a discussion of taxonomic history of *D. n. nitratoides*. Hafner (1979) examined samples of Tipton and short-nosed kangaroo rats, and, using detailed analyses, established better-defined boundaries between the two subspecies than those of previous researchers. He concluded that samples from populations northeast and east of Bakersfield, and in upland saltbush communities above the southern and eastern borders of the Tulare Basin floor were characteristic of populations of short-nosed kangaroo rats, typified by reference samples from the Carrizo Plain, San Luis Obispo County. Hafner's (1979) analyses showed that the subspecies boundary on the southwest in Kern County nearly coincided with the California Aqueduct, which is positioned just above the Valley floor along the edge of the more steeply sloping foothills in areas that do not flood extensively. The natural boundary between these two subspecies on the southwest was probably a narrow zone of seasonal and permanent wetlands around Kern and Buena Vista lakes and the Kern River channel that meandered north from the east edge of the Elk Hills to historical Goose Lake. Historical barriers between the two subspecies probably were intermittent in some spots. More recent flood control and diversion of waters from the Kern River for irrigation and other purposes removed these barriers and probably allowed for increased genetic exchange between the two subspecies. Today, the California Aqueduct and large expanses of irrigated cropland again have isolated these populations.

Description.—See account of the Fresno kangaroo rat for a general description of the species. On average, adult Tipton kangaroo rats weigh about 35 to 38 grams (1.23 to 1.34 ounces), have a head and body length of about 100 to 110 millimeters (3.94 to 4.33 inches) and a tail about 125 to 130 millimeters (4.92 to 5.12 inches) in length. The Tipton kangaroo rat is larger than the Fresno kangaroo rat and smaller than the short-nosed kangaroo rat.

Identification.—See the Fresno kangaroo rat account for distinguishing Tipton kangaroo rats from other co-occurring species. The Tipton kangaroo rat can be distinguished from the Fresno kangaroo rat by its larger average measurements: total length for males, 235 millimeters (9.25 inches), for females, 221 millimeters (8.7 inches); length of hind foot for males 34.7 millimeters (1.37 inches), for females, 33.6 millimeters (1.32 inches); mean inflation of the auditory bullae for males, 22.1 millimeters (0.87 inch), for females, 21.8 millimeters (0.86 inch) (Hoffmann 1975) (see accounts of Fresno and short-nosed subspecies for corresponding average measurements).

2. Historical and Current Distribution

Historical Distribution.— The historical geographic range of Tipton kangaroo rats (Figure 45) was estimated to cover approximately 695,174 hectares (1,716,480 acres) (Williams 1985). Tipton kangaroo rats were distributed within an area on the floor of the Tulare Basin, extending from approximately the southern margins of Tulare Lake on the north; eastward and southward approximately along the eastern edge of the Valley floor in Tulare and Kern Counties. The southern and western extent of their range was the foothills of the Tehachapi Mountains (south) and the marshes and open water of Kern and Buena Vista lakes, and the sloughs and channels of the Kern River alluvial fan. Farther north, the western boundary was approximately along the Buena Vista slough of the Kern River channel into Goose Lake. The approximate line on the northwest is marked by the city of Lost Hills, Kern County; Kettleman City, Kings County; and Westhaven, Fresno County. Prior to development of water-diversion and irrigation systems over the past several decades, this area bounded three large lakes, Tulare, Kern, and Buena Vista, together with marshlands that were unsuitable habitat for kangaroo rats (Boolootian 1954, Hoffmann 1974, Hafner 1979, Williams et al. 1993*a*, Williams 1985).

Current Distribution.—By July 1985, the area inhabited had been reduced, primarily by cultivation and urbanization, to about 25,000 hectares (63,000 acres), only about 3.7 percent of the historical acreage. Additional small parcels not surveyed by Williams (1985) have since been found to be inhabited. Tipton kangaroo rats also have reinhabited several hundred to a few thousand acres that were in crop production in 1985 but have since been retired because of drainage problems or lack of water, or acquired by State and Federal agencies for threatened and endangered species conservation. Most notable has been a mix of mostly agricultural and some natural land on the Kern Fan Element, some of which is now within the Kern Water Bank Habitat Conservation Plan area. This project provides over 4,000 hectares (10,000 acres) of habitat for threatened and endangered species, though a lesser, unknown amount actually has been naturally recolonized from adjacent natural land. Offsetting these gains has been the loss of several hundred to a few thousand acres of habitat that have been developed. Thus, the current acreage of occupied habitat is unknown, but probably does not differ much from the 1985 estimate.

Current occurrences are limited to scattered, isolated areas clustered west of Tipton, Pixley, and Earlimart, around Pixley National Wildlife Refuge, Allensworth Ecological Reserve, and Allensworth State Historical Park, Tulare County; between the Kern National Wildlife Refuge, Delano, and in natural lands surrounding Lamont (southeast of Bakersfield), Kern County; at the Coles Levee Ecosystem Preserve; and other, scattered units to the south in Kern County (Figure 45).

3. Life History and Habitat

Food and Foraging.—Tipton kangaroo rats eat mostly seeds, with small amounts of green, herbaceous vegetation and insects supplementing their diet when available. Most aspects of food and foraging of Tipton kangaroo rats are identical to those of Fresno kangaroo rats. See the account of the Fresno kangaroo rat for more information.

Reproduction and Demography.—Little specific information has been published on reproduction of Tipton kangaroo rats. Generally, this aspect of their biology is extremely similar to that of the Fresno kangaroo rat (see that account for details). Five Tipton kangaroo rats being held in captivity to prevent their death by permitted destruction of their habitats each gave birth to two young (D.J. Germano pers. comm., D.F. Williams unpubl. observ., S. Yoerg pers. comm.).

Reproduction commences in winter and peaks in late March and early April (Figure 46). Most females appear to have only a single litter, though some adult females have two or more, and females born early in the year also may breed (Endangered Species Recovery Program unpubl. data).

At the Paine Wildflower Preserve south of Kern National Wildlife Refuge, Clark et al. (1982) estimated a density of 2.6 Tipton kangaroo rats per hectare (1.05 per acre) in the "best" habitat above flood level, and 1.5 per hectare (0.61 per acre) in "poor" habitats subjected to flooding and disturbance by past disking of the soil. Hafner (1979) estimated relative densities of Tipton kangaroo rats at 13 sites representing areas from throughout the geographic range and most plant communities in which Tipton kangaroo rats were known to occur. Densities ranged from a low of 1 to 2 per hectare (0.4 to 0.8 per acre) in alkaline and terrace grasslands with a sparse cover of seepweed to a high of

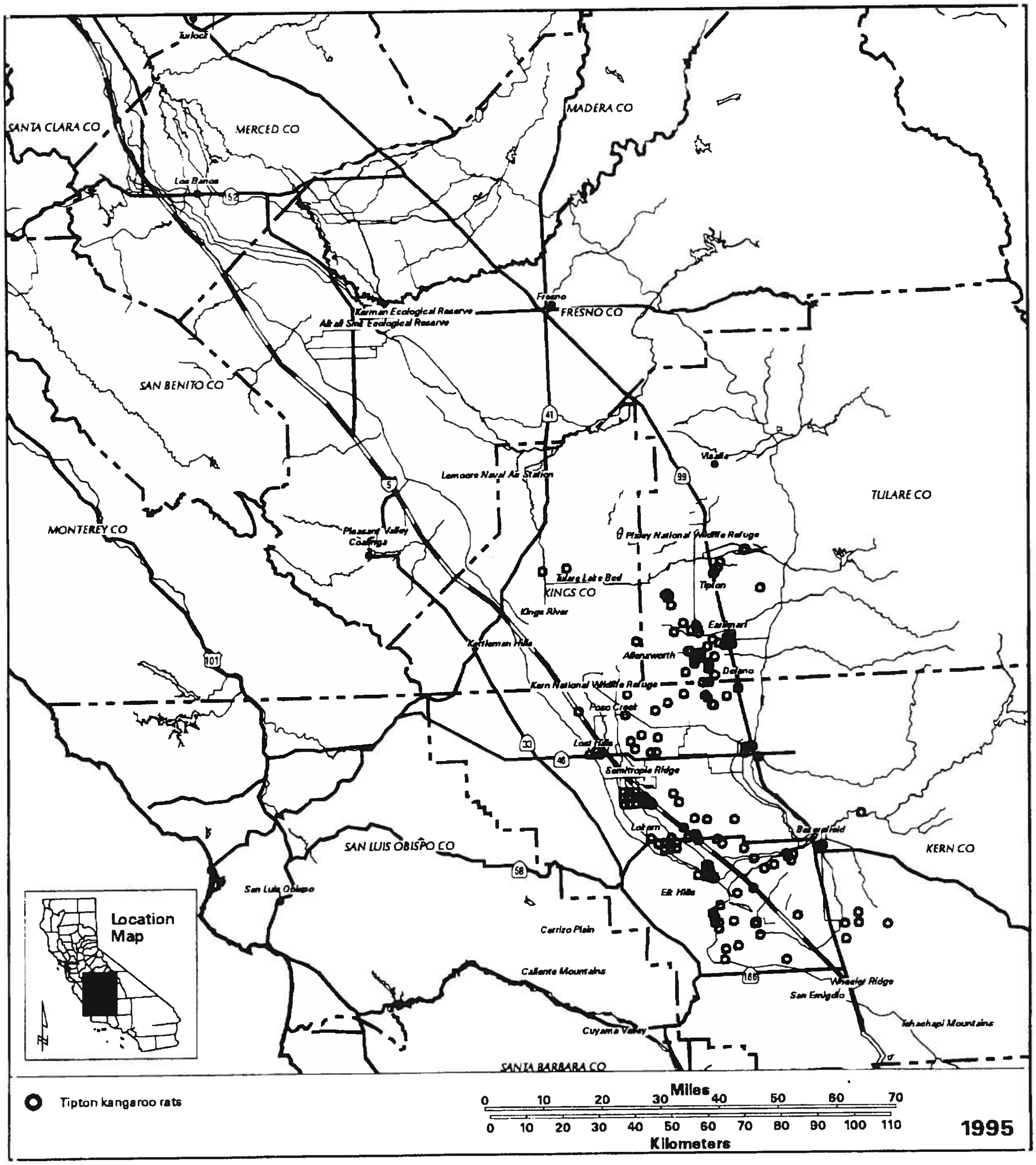

Figure 45. Distributional records for the Tipton kangaroo rat *(Dipodomys nitratoides nitratoides)*.

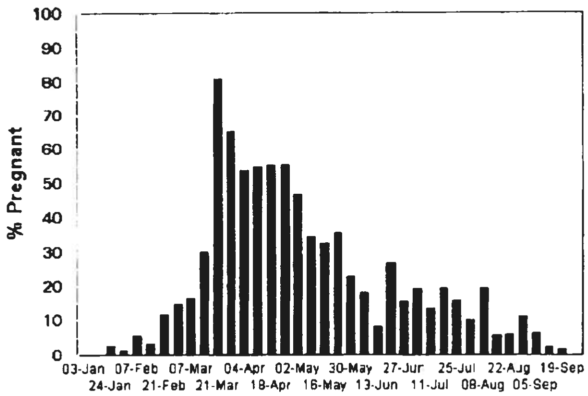

Figure 46. Percentage of reproductive female Tipton kangaroo rats. Based on weekly censuses at Pixley National Wildlife Refuge (Endangered Species Recovery Program unpubl. data); weeks 3 Jan. 1993 to 19 Sep. 1994.

about 7 to 9 per hectare (2.8 to 3.6 per acre) in saltbush scrub.

In 1985, surveys through the remaining extant habitat resulted in estimated densities, based on numbers of burrow systems, ranging from less than 1 per hectare to 50 per hectare (less than 0.4 to 20.2 per acre). Areas supporting very low densities had few noticeable features in common. Sites on the eastern perimeter of the geographic range in terrace grasslands had consistently low densities. Areas subjected to prolonged flooding also supported few kangaroo rats.

At Pixley National Wildlife Refuge on two plots, density estimates in June 1991 during drought were 3.0 to 3.8 Tipton kangaroo rats per hectare (1.2 to 1.5 per acre). After the end of a 5.5 year drought in April 1991, a population irruption occurred, and peaked in January 1993. Subsequently, density declined from the high of 88.2 per hectare (35.7 per acre) in January 1993 to a low of 1.1 per hectare (0.45 per acre) in April 1995. The shape of this population decline is illustrated by the number of Tipton kangaroo rats known to be alive each month in Figure 47 (Endangered Species Recovery Program unpubl. data). During the decline, annual rainfall was greater than average and little or no livestock grazing occurred in the pasture where the plot was located. Kangaroo rats could not use their usual defenses of speed and alertness, adaptations for habitats with sparse, low vegetation, and many may have been taken by predators. High rainfall also may have caused death from water penetrating burrows and drowning occupants, spoiling seed stores, or causing death from hypothermia or pneumonia-like diseases that have been observed to afflict these animals when placed in a cool, moist environment (Endangered Species Recovery Program unpubl. observ.).

Behavior and Species Interactions.—Tipton kangaroo rats live in ground burrows. Most burrows probably are dug by the occupant or a predecessor of the same species. Burrows are typically simple, but may be unbranched or branched, including interconnecting tunnels. Most burrows are less than 25 centimeters (10 inches) deep (Germano and Rhodehamel 1995). Nothing else specific to the behavior of the Tipton subspecies has been published (see Fresno kangaroo rat for a general discussion of behavior and species interactions).

Tipton kangaroo rats are food for a variety of predators: coyotes, San Joaquin kit foxes, long-tailed weasels, American badgers, owls, hawks (San Joaquin kangaroo rats infrequently emerge from their burrows during daylight; Tappe 1941, Williams et al. 1993*b*), various species of snakes, and probably others. Except for small, isolated populations, predation is unlikely to threaten Tipton kangaroo rats. The increasing fragmentation of the range of Tipton kangaroo rats, however, increases the vulnerability of small populations to predation.

Habitat and Community Associations.—Tipton kangaroo rats are limited to arid-land communities occupying the Valley floor of the Tulare Basin in level or

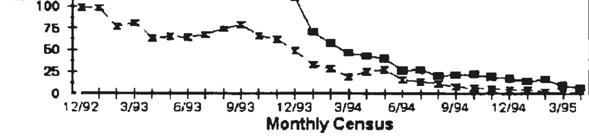

Figure 47. Number of Tipton kangaroo rats known to be alive each month. Endangered Species Recovery Program data are for plot at Pixley National Wildlife Refuge.

nearly level terrain. They occupy alluvial fan and floodplain soils ranging from fine sands to clay-sized particles with high salinity. Historically, populations apparently were most numerous and persistent in Relictual Interior Dune Grassland and Sierra-Tehachapi Saltbush Scrub communities. Today, much of the occupied remnants of their range have one or more species of sparsely scattered woody shrubs and a ground cover of mostly introduced and native annual grasses and forbs. Woody shrubs commonly associated with Tipton kangaroo rats are: spiny and common saltbushes, arrowscale (*Atriplex phyllostegia*), quailbush (*Atriplex lentiformis*), iodine bush, pale-leaf goldenbush, and honey mesquite (*Prosopis glandulosa* var. *torreyana*). A conspicuous semiwoody species is seepweed (Williams 1985).

Important existing communities for Tipton kangaroo rats are iodine bush shrubland (Valley Sink Scrub) and Valley Saltbush Scrub (Griggs et al. 1992). Winter rains and runoff from the surrounding mountain ranges (Sierra Nevada to the east, Tehachapi Mountains to the south, and Temblor Range to the west) flood much of these low-lying communities occupied by Tipton kangaroo rats. Areas with standing water during portions of winter and spring (vernal pools) become alkaline playas when the water has evaporated allowing Tipton kangaroo rats to recolonize these areas even though alkaline water lies close to the surface of the soil, year around. Presumably during flooding, individuals are either drowned or captured by predators after being forced from their burrows, or escape to higher ground (Williams 1985).

Although Tipton kangaroo rats occur in terrace grasslands devoid of woody shrubs, sparse-to-moderate shrub cover is associated with populations of high density. Typically, however, burrow systems are located in open areas; only in areas of dense shrub cover are burrows usually located beneath shrubs. Terrain not subject to flooding is important for permanent occupancy by Tipton kangaroo rats.

Burrows of Tipton kangaroo rats are commonly located in slightly elevated mounds, the berms of roads (where placed above ground level), canal embankments, railroad beds, and bases of shrubs and fences where windblown soils accumulate above the level of surrounding terrain. Soft soils, such as fine sands and sandy loams, and powdery soils of finer texture and of higher salinity are generally associated with greater densities of Tipton kangaroo rats than are less saline and alkaline, sandy-loam, loam, and clay-loam soils of portions of the eastern margins of their geographic range, supporting terrace grasslands. This may relate to how crumbly the soils are, the type of plant communities they support, or both (Williams 1985).

At Pixley National Wildlife Refuge, Tipton kangaroo rats are the most numerous small mammal. They dominate grazed annual grassland on the refuge, where they typically outnumber Heermann's kangaroo rats, the second most numerous species. Other common, small mammalian associates are San Joaquin pocket mice and deer mice (Williams and Germano 1991, D.F. Williams unpubl. data). Other common, mammalian associates include San Joaquin kit foxes, coyotes, American badgers, California black-tailed hares, California ground squirrels, harvest mice, and house mice.

4. Reasons for Decline and Threats to Survival

Reasons for Decline.—The principle reason for the decline of Tipton kangaroo rats was the loss of habitat due to agricultural conversion. Agriculture followed the gold rush of the 1850s, first developing on the nonsaline soils of the alluvial flood plains and forests of the eastern Valley. This probably only had a minor impact to habitat for Tipton kangaroo rats. The later construction of dams and canals produced a dependable supply of water for the Valley. This in turn allowed the cultivation of the alkaline soils of the saltbush and valley sink scrub and relictual dune communities, and was principally responsible for the decline and endangerment of the Tipton kangaroo rat.

As recently as the early 1970s, just after the completion of the Central Valley and State Water Projects, only about 1.4 million hectares (3.5 million acres) in the San Joaquin Valley were in irrigated cultivation—most of the total was in the San Joaquin Basin (approximately the northern half of the Valley). By 1978, however, only about 195,000 hectares (370,000 acres) out of a total of about 3.4 million hectares (8.5 million acres) on the San Joaquin Valley floor remained as non-developed land (Williams 1985).

An aerial survey conducted in late 1983, together with selected ground inspections and other sources of information provided an estimate of 44,562 hectares (110,031 acres) of undeveloped land out of a total of 1,035,296 hectares (2,556,288 acres) on the floor of the Tulare Basin (Werschkull et al. 1984). Ignoring minor differences between the boundaries of the 1983 survey and the investigations by Williams (1985), only about 30,549 hectares (75,430 acres) were undeveloped in June 1985. Remaining natural lands represented the least desirable for development in the basin.

The use of rodenticides to control California ground squirrels probably contributed to the decline or elimination of small populations of Tipton kangaroo rats, isolated and surrounded by agricultural land. Urban and industrial development and petroleum extraction all have contributed to habitat destruction, though not on a scale comparable to agricultural development (Williams 1985).

Threats to Survival.—Current threats of habitat destruction or modifications rendering areas unsuitable for Tipton kangaroo rats come from industrial and agriculturally-related developments, cultivation, the formation of heavy thatch by exotic grasses, and urbanization, and secondarily from flooding. Nearly every parcel of land in private ownership that is currently inhabited by Tipton kangaroo rats is surrounded by cultivated fields or urbanized land where these animals cannot live. Nearly all remaining natural land is of poor agricultural potential, having saline soils and high water tables, and more than half is subject to winter flooding (Williams 1985).

Because of the large amount of salts in soils on the Tulare Basin floor, lack of natural drainage to the ocean, and the desert climate, build up of salts in the soil and saline-saturated fields threatens agriculture over large areas (San Joaquin Valley Interagency Drainage Program 1990). Most of the remaining habitat of Tipton kangaroo rats is in areas that are already flooded periodically. Several parcels with extant natural lands in the 1970s now have private evaporation ponds into which salt-laden drain waters are being diverted. Unless other solutions are found for drainage problems, including land retirement, more habitat for Tipton kangaroo rats probably will be lost to this purpose (Williams 1985).

5. Conservation Efforts

In addition to being federally-listed as endangered in 1988 (USFWS 1988), the Tipton kangaroo rat was listed by the State of California as Endangered in 1989 (Table 1; Williams and Kilburn 1992). Mitigation actions and compensation funds to purchase natural lands providing habitat for Tipton kangaroo rats have resulted in preservation of portions of key areas in the Allensworth Ecological Reserve, Semitropic Ridge, Kern Fan areas, and more scattered parcels elsewhere (Table 2).

Habitat management studies on Pixley National Wildlife Refuge, which provides some of the best remaining habitat for Tipton kangaroo rats, were initiated in 1991 (Williams and Germano 1991), and expanded in 1992 (Engler and Chapin 1993). The CDFG also has begun to census its properties and investigate habitat management in the Allensworth Ecological Reserve (Potter 1993). The Bureau of Reclamation and USFWS have supported a study of population ecology of Tipton kangaroo rats at Pixley National Wildlife Refuge by the Endangered Species Recovery Program since December 1992 (Endangered Species Recovery Program unpubl. information). CDFG also has recently instituted habitat management investigations and experimentation on part of Allensworth Ecological Reserve (M. Potter and G. Presley pers. comm.).

U.S. Environmental Protection Agency County bulletins governing use of rodenticides have greatly reduced the risk of significant mortality to Tipton kangaroo rat populations by State and county rodent-control activities. The California Environmental Protection Agency, California Department of Food and Agriculture, county agricultural departments, CDFG, and the U.S. Environmental Protection Agency collaborated with the Service in the development of County Bulletins that both are efficacious and acceptable to land owners (R.A. Marovich pers. comm.).

6. Recovery Strategy

The major issues in recovering the Tipton kangaroo rat are habitat management and protection of blocks of their natural or restored habitat to maintain viable populations. The species' populations periodically irrupt to high levels and decline rapidly, often going extinct locally. Local extinctions or near extinctions may be caused by long-term drought, excessive amounts of precipitation, flooding, and perhaps other, less well known factors. When large expanses of connected habitat existed, local extinction was not a great problem because some surviving populations eventually irrupted and individuals recolonized areas where they had been eliminated. Contributing to this pattern of population dynamics is competition with Heermann's kangaroo rats, which are much larger, more general in their habitat requirements, and more successful in maintaining populations in a fragmented landscape. At times when the environment is poorly suited to Tipton kangaroo rats, competition with Heermann's kangaroo rats may cause elimination of the former. Because of the fragmentation and isolation of remaining habitat, when these natural processes ensue, local extinction without opportunity for later recolonization results. This process already has run or nearly run its course with Fresno kangaroo rats. There are several blocks of habitat for Fresno kangaroo rats left, ranging from about 16.2 hectares (40 acres) to several from about 259 to 2,023 hectares (640 to 5,000 acres), and one of about 12,141 hectares (30,000 acres), yet none are known to harbor Fresno kangaroo rats. Because the decline and fragmentation of Tipton kangaroo rat habitat has occurred much more recently, probably a similar fate awaits it unless there is management intervention, and conservation lands for this species are sufficiently large and diverse to reduce or eliminate the adverse effects of some environmental processes. Thus, the two key elements of a recovery strategy for Tipton kangaroo rats are:

1. Determining how to manage natural lands to enhance habitat for Tipton kangaroo rats that lessens the frequency and severity of population crashes and negative impact of competition with Heermann's kangaroo rats.

2. Consolidating and protecting blocks of suitable habitat for Tipton kangaroo rats to minimize the effects of random catastrophic events (e.g., drought, flooding, fire) on their populations.

These blocks should be of several thousand acres each with a core of at least 2,000 hectares (about 5,000 acres) of high quality habitat that is not subject to periodic flooding from overflowing streams or sheet flooding from torrential rain. They should provide topographic diversity and diversity of plant communities. The vegetation should be actively managed by an appropriate level of livestock grazing to prevent excessive accumulation of mulch and growing plants until such time as optimum management conditions are determined by scientific research.

The existing configuration of the natural land-developed land mosaic is such that it is impractical and too expensive to propose reconnecting the large blocks of land in Tulare and northern Kern and southern Kings Counties with the lands on the western edge of the Valley and the isolated blocks in the southern end of the Valley. Instead, by protection of additional natural land and restoration of contiguous agricultural land with drainage problems, sufficient habitat in three areas can be protected economically: the Kern Fan area; the Pixley National Wildlife Refuge-Allensworth Natural Area, and the Kern National Wildlife Refuge-Semitropic Ridge area.

Recovery Actions.—Needed recovery actions are:

1. Expand, coordinate, and continue habitat management studies of Tipton kangaroo rats at sites representing the range of existing habitat conditions for the species.

2. Initiate studies of competition between Tipton and Heermann's kangaroo rats, focusing primarily on how different habitat management prescriptions affect the population dynamics of the two species at sites of coexistence.

3. Design and implement a range-wide population monitoring program that measures population and environmental fluctuations at sites representative of the range of natural land sizes and habitat conditions for the species.

4. Inventory and assess existing natural land and drainage-problem parcels contiguous to and near existing protected natural lands and develop a protection plan that ranks parcels that may be available according to their size and potential for supporting Tipton kangaroo rats, with the objective of connecting and expanding:

   a. Pixley National Wildlife Refuge and the scattered parcels of the Allensworth Ecological Reserve;

   b. Kern National Wildlife Refuge and the scattered parcels of the Semitropic Ridge conservation lands;

   c. Kern River alluvial fan area including the Kern Fan Element, Cole's Levee Ecosystem Preserve, and other mitigation parcels.

   d. Additional lands which after inventory and assessment are identified as important to the two key elements of the recovery strategy for Tipton kangaroo rats.

5. Develop and implement research on restoration of habitat for Tipton kangaroo rats, including cost-effective mechanisms to protect both natural and restored habitat from flooding.

6. Restore habitat on retired agricultural lands as needed.

K. Blunt-Nosed Leopard Lizard (*Gambelia sila*)

1. Description and Taxonomy

Taxonomy.—The blunt-nosed leopard lizard was described and named by Stejneger (1890) as *Crotaphytus silus*, from a specimen collected in Fresno, California. Cope (1900), however, considered the blunt-nosed leopard lizard to be a subspecies of the long-nosed leopard lizard (*C. wislizenii*), and listed it as *C. w. silus*. Under this arrangement, leopard lizards and collared lizards were placed in the same genus. Smith (1946) separated the collared from the leopard lizards, placing the latter in the genus *Gambelia*. The bases for separation were differences in head shape, presence or absence of *gular* (throat area) folds, and differences in bony plates on the head. The subspecific status of *G. w. silus* was retained by Smith (1946). This generic split was not universally agreed upon and the status, both generic and specific, of the lizards remained controversial until Montanucci (1970) presented a solid argument for specific status based upon the study of hybrids between the long-nosed and blunt-nosed leopard lizards. Montanucci et al. (1975) again separated *Gambelia* from *Crotaphytus*, resulting in the name *Gambelia silus* (Jennings 1987). Frost and Collins (1988), Collins (1990), and Germano and Williams (1993) used the spelling *sila* to properly agree in gender with the genus *Gambelia*.

Description.—The blunt-nosed leopard lizard (Figure 48) is a relatively large lizard of the family Iguanidae, with a long, regenerative tail; long, powerful hind limbs; and a short, blunt snout (Smith 1946, Stebbins 1985). Adult males are larger than adult females, ranging in size from 87 to 120 millimeters (3.4 to 4.7 inches) snout-vent length (Tollestrup 1982). From snout to vent, females are 86 to 111 millimeters long (3.4 to 4.4 inches). Adult males weigh between 31.8 and 37.4 grams (1.3 to 1.5 ounces), and adult females weigh between 20.6 and 29.3 grams (0.8 to 1.2 ounces) (Uptain et al. 1985). Males are distinguished from females by their enlarged postanal scales, femoral pores (visible pores on the underside of the thigh), temporal and mandibular muscles (muscles on the skull that close the jaws), and tail base (Montanucci 1965).

Although blunt-nosed leopard lizards are darker than other leopard lizards, they exhibit tremendous variation in color and pattern on the back (Tanner and Banta 1963, Montanucci 1965, 1970). Background color ranges from yellowish or light gray-brown to dark brown depending on the surrounding soil color and vegetation association (Smith 1946, Montanucci 1965, 1970, Stebbins 1985). The under surface is uniformly white.

The color pattern on the back consists of longitudinal rows of dark spots interrupted by a series of from 7 to 10 white, cream-colored, or yellow transverse bands. In the blunt-nosed leopard lizard, the cross bands are much broader and more distinct than in other leopard lizards and extend from the lateral folds on each side to the middle of the back, where they meet or alternate along the midline of the back. With increasing age the cross bands may fade and the spots may become smaller and more numerous, particularly in males (Montanucci 1967, Smith 1946). Similarly colored bands or rows of transverse spots produce a banded appearance to the tail (Smith 1946). Juveniles have blood-red spots on the back that darken with age, becoming brown when sexual maturity is reached, although a few adults retain reddish centers to the spots (Montanucci 1967).

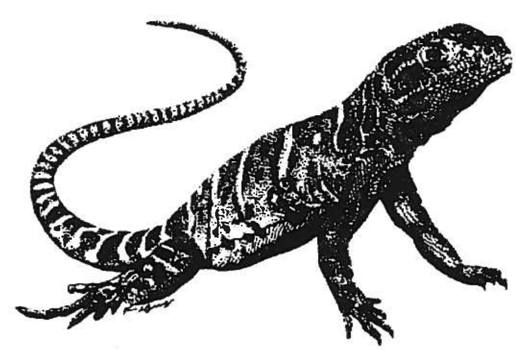

Figure 48. Illustration of a blunt-nosed leopard lizard. Drawing by Kristina Bocchini (© by CSU Stanislaus Foundation).

Except for the throat, undersides are uniformly white to yellow in immature lizards and prenuptial females. Nuptial females have bright red-orange markings on the sides of the head and body and the undersides of the thighs and tail. This color fades to pink or light orange by late July. Males in many populations develop a nuptial color during the breeding season that spreads over the entire undersides of the body and limbs. This salmon to bright rusty-red color may be maintained indefinitely (Montanucci 1965).

Identification.—The blunt-nosed leopard lizard can be distinguished from the long-nosed leopard lizard by its color pattern, truncated snout, and short, broad triangular head (Stejneger 1890, Smith 1946). The blunt-nosed leopard lizard has dark blotches on the throat instead of parallel streaks of the long-nosed leopard lizard. Other distinguishing characteristics are a significantly smaller number of maxillary and premaxillary teeth (this may be directly related to the shortened snout) and a smaller variation in the number of femoral pores (Smith 1946). In general, blunt-nosed leopard lizards can be distinguished from all other leopard lizards by their retention into adulthood of the primitive color pattern shared by all young leopard lizards (absence of ornamentation around the dorsal spots; retention of wide, distinct cross bands; presence of gular blotches; and fewer spots arranged in longitudinal rows) (Smith 1946, Montanucci 1970).

2. Historical and Current Distribution

Historical Distribution.—The blunt-nosed leopard lizard is endemic to the San Joaquin Valley of central California (Stejneger 1893, Smith 1946, Montanucci 1965, 1970, Tollestrup 1979*a*). Although the boundaries of its original distribution are uncertain, blunt-nosed leopard lizards probably occurred from Stanislaus County in the north, southward to the Tehachapi Mountains in Kern County (Figure 49). Except where their range extends into the Carrizo Plain and Cuyama Valley west of the southwestern end of the San Joaquin Valley, the foothills of the Sierra Nevada and Coast Range Mountains, respectively, define the eastern and western boundaries of its distribution. The blunt-nosed leopard lizard is not found above 800 meters (2,600 feet) in elevation (Montanucci 1970). The blunt-nosed leopard lizard hybridizes with the long-nosed leopard lizard where their ranges meet in Ballinger Canyon and others (Santa Barbara and Ventura Counties) in the Cuyama River watershed (Montanucci 1970, Le Fevre in litt. 1976).

Current Distribution.—Although the blunt-nosed leopard lizard has been listed as endangered for 30 years, there has never been a comprehensive survey of its entire historical range. The currently known occupied range of the blunt-nosed leopard lizard is in scattered parcels of undeveloped land on the Valley floor, and in the foothills of the Coast Range. Surveys in the northern part of the San Joaquin Valley documented the occurrence of the blunt-nosed leopard lizard in the Firebaugh and Madera Essential Habitat Areas (Williams 1990). Essential Habitat Areas were defined in previous recovery plan editions for this species as undeveloped wildlands containing suitable habitat for the blunt-nosed leopard lizard and essential to the continued survival of the species (USFWS 1980*a*, in litt. 1985).

In the southern San Joaquin Valley, extant populations are known to occur on the Pixley National Wildlife Refuge, Liberty Farms, Allensworth, Kern National Wildlife Refuge, Antelope Plain, Buttonwillow, Elk Hills, and Tupman Essential Habitat Areas, on the Carrizo and Elkhorn Plains, north of Bakersfield around Poso Creek, and in western Kern County in the area around the towns of Maricopa, McKittrick, and Taft (Byrne 1987, R.L. Anderson pers. comm., L.K. Spiegel pers. comm.). Personal observations by D.J. Gemano have been made at the Kern Front oil field, at the base of the Tehachapi Mountains on Tejon Ranch, and just west of the California Aqueduct on the Tejon and San Emizdio Ranches (D.J. Gemano, pers. comm.). Remaining undeveloped lands farther north that support blunt-nosed leopard lizard populations include the Ciervo, Tumey, and Panoche Hills, Anticline Ridge, Pleasant Valley, and the Lone Tree, Sandy Mush Road, Whitesbridge, Horse Pasture, and Kettleman Hills Essential Habitat Areas (CDFG 1985; Figure 47). The species is presumed to be present still in the upper Cuyama Valley, though no recent inventory is known for that area.

3. Life History and Habitat

Food and Foraging.—Blunt-nosed leopard lizards feed primarily on insects (mostly grasshoppers, crickets, and moths) and other lizards, although some plant material is rarely eaten or, perhaps, unintentionally consumed with animal prey. They appear to feed opportunistically on animals, eating whatever is available in the size range they can overcome and swallow. Which lizards are eaten is largely determined by the size and behavior of the prey. Lizard species taken as prey include: side-blotched lizards (*Uta stansburiana*),

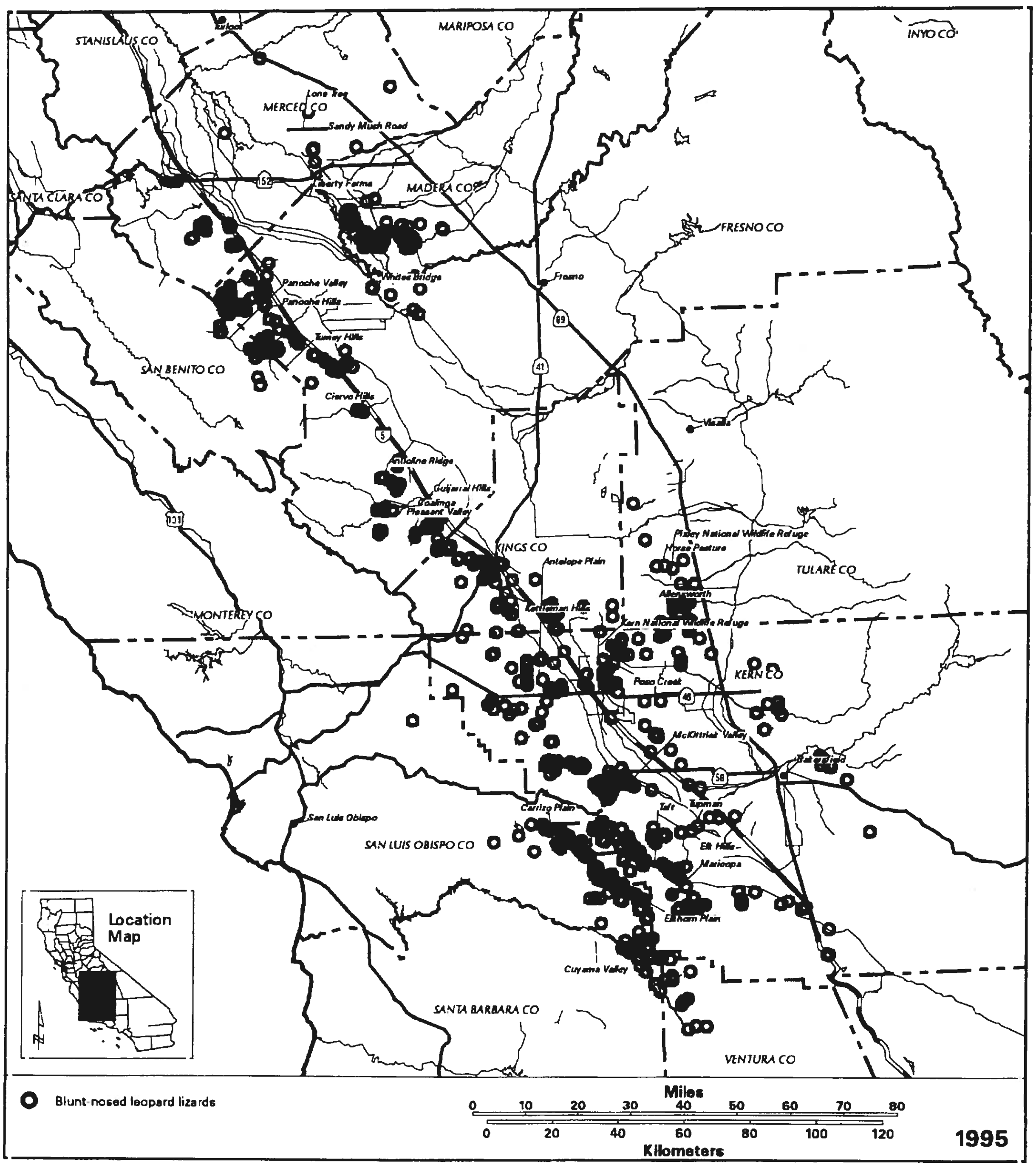

Figure 49. Distributional records for the blunt-nosed leopard lizard *(Gambelia sila)*.

coast horned lizards (*Phrynosoma coronatum*), California whiptails (*Cnemidophorus tigris*), and spiny lizards (*Sceloporus* spp.). Young of its own species also are eaten (Montanucci 1965, Kato et al. 1987*a*, Germano and Williams 1994*a*). Because they have similar diets, interspecific competition probably occurs between the blunt-nosed leopard lizard and California whiptail (Montanucci 1965, Tollestrup 1979*b*).

Reproduction and Demography.—Breeding activity begins within a month of emergence from dormancy and lasts from the end of April through the beginning of June, and in some years to near the end of June. During this period, and for a month or more afterward, the adults often are seen in pairs and frequently occupy the same burrow systems (Montanucci 1965, Germano and Williams 1994*b*). Male territories may overlap those of several females, and a given male may mate with several females. Copulation may occur as late as June (Montanucci 1965).

Two to six eggs averaging 15.6 by 25.8 millimeters (0.6 by 1.0 inch) are laid in June and July, and their numbers are correlated with the size of the female (Montanucci 1967). Under adverse conditions, egg-laying may be delayed 1 or 2 months or reproduction may not occur at all (Montanucci 1965, Tollestrup 1979*b*, 1982, Germano et al. 1994). Eggs are laid in a chamber either excavated specifically for a nest or already existing within the burrow system (Montanucci 1965, 1967). Females typically produce only one clutch of eggs per year, but some may produce three or more under favorable environmental conditions (Montanucci 1967, USFWS 1985*a*, Germano and Williams 1992, Williams et al. 1993*b*). After about 2 months of incubation, young hatch from July through early August, rarely to September, and range in size from 42 to 48 millimeters (1.7 to 1.9 inches) snout-vent length (Montanucci 1965, Tollestrup 1982). Before their first winter, young leopard lizards may grow to 88 millimeters (3.5 inches) in snout-vent length (Montanucci 1967).

Sexual maturity is reached in from 9 to 21 months, depending on the sex and environmental conditions (USFWS 1985*a*). Females tend to become sexually mature earlier than males, breeding for the first time after the second dormancy, while males usually do not breed until later (Montanucci 1965, 1967).

The relative proportions of the three age groups (adult, subadult, hatchling or young-of-the-year) change through the activity season as young are added to the population only in August or later and entry into dormancy and differential mortality affects the proportions in age groups above ground. Data based upon surface activity do not give an accurate estimate of the population age structure because the adults cease activity above ground from about 4 weeks before to about the same time as the eggs hatch. The best estimate of the relative proportions of adults and subadults (animals hatched the previous summer) may be made from data gathered in May because both groups are active on the surface then. In May the proportions were 85 percent adults and 15 percent subadults (Montanucci 1965). Montanucci (1965) believed that data gathered in August for subadults and hatchlings yielded the best estimate of their proportions because both groups were active. His data were about 2:1 hatchlings to subadults. Combining these numbers, the population consisted of about 67 percent adults, 11 percent subadults, and 22 percent hatchlings. The age structure of a population on Pixley National Wildlife Refuge consisted of 62 percent adults, 27 percent subadults, and 11 percent hatchlings in 1984 (Uptain et al. 1985).

Age structure of adults during a 7-year period on the Elkhorn Plain (Williams et al. 1993*a*, Endangered Species Recovery Program unpubl. data), was determined in 1995; percentages of 2, 3, 4, and 5 year-old males were 69.5, 21, 6.5, and 2, respectively. Percentages of females 2, 3, and 4 years old were 70, 22, and 7.5; none were recaptured older than 4 years. Parker and Pianka (1976) made estimates for the long-nosed leopard lizard based on their data for a Utah population, which are consistent with the age structure and reproductive situation described for the blunt-nosed leopard lizard. Maximum longevity would thus be 8 to 9 years with an annual survivorship of about 50 percent.

In several populations, and during most of the year, males appear to outnumber females by a ratio of 2:1 (Montanucci 1965, Uptain et al. 1985, Kato et al. 1987*b*). Mullen (1981) reported that the ratio of males to females was 3:1, whereas Montanucci (1965) found that the numbers in a Valley floor population were equal. Uptain et al. (1985) showed that, although 63 percent of the hatchlings in a population on Pixley National Wildlife Refuge were male, the male:female ratio varied seasonally from 2:1 in the spring, to 1:1 in the summer, and to 2:3 in the fall. These were all based on short-term studies. In contrast, populations on two plots on the Elkhorn Plain over several years typically had adult and subadult sex ratios of about 1:1 (1:1.04). Females outnumbered males more often than the reverse during census periods in May and June. Hatchling sex ratios, however, showed the opposite, with males outnumbering females, most censuses with ratios varying between about 1.5:1 and 2.5:1 male:female (Williams et al. 1993*b*, Germano and Williams 1994*b*, Endangered Species Recovery Program unpubl. data).

Male and female home ranges often overlap. The mean home range size varies from 0.1 to 1.1 hectares (0.25 to 2.7 acres) for females and 0.2 to 1.7 hectares (0.52 to 4.2 acres) for males (Tollestrup 1983, Kato et al. 1987*b*).

There are no current overall population size estimates for the species. Uptain et al. (1985) reported densities ranging from 0.3 to 10.8 lizards per hectare (0.1 to 4.2 per acre) for a population on the Pixley National Wildlife Refuge in Tulare County. In a previous study of this population, Tollestrup (1979) estimated an average density of 3.3 lizards per hectare (1.3 per acre). In 1991, after three previous years of severe drought, two 8.1-hectare (20-acre) plots had estimated densities of 6.7 and 7.0 lizards per hectare (2.7 and 2.8 per acre) on Pixley National Wildlife Refuge (Williams and Germano 1991). On the Elkhorn Plain, estimated population size on two 8.1-hectare plots of adult and subadult blunt-nosed leopard lizards in June (period of peak above-ground activity) varied between 0 in 1990 to more than 170 in 1993. Only subadult lizards were active above ground in April and no lizards were active by June 1990, the year of severest drought (Williams et al. 1993*b*, Germano et al. 1994, D. J. Germano and D.F. Williams unpubl. data). Turner et al. (1969) estimated that the average density of a southern Nevada population of the long-nosed leopard lizard was 3 lizards per hectare (1.2 per acre). Population densities in marginal habitat generally do not exceed 0.5 blunt-nosed leopard lizards per hectare (0.2 per acre) (Mullen 1981, Le Fevre in litt. 1976, Madrone Associates 1979).

Behavior and Species Interactions.—Social behavior is more highly developed in the blunt-nosed leopard lizard than in the long-nosed leopard lizard. For example, territorial defense and related behavioral activity are completely absent in the long-nosed leopard lizard, whereas blunt-nosed leopard lizards are highly combative in establishing and maintaining territories (Montanucci 1970). In addition, Tollestrup (1979, 1983) observed six distinct behavioral displays specific to the blunt-nosed leopard lizard. Behavioral displays of all types were more frequent during the breeding season.

Leopard lizards use small rodent burrows for shelter from predators and temperature extremes (Tollestrup 1979*b*). Burrows are usually abandoned ground squirrel tunnels, or occupied or abandoned kangaroo rat tunnels (Montanucci 1965). Each lizard uses several burrows without preference, but will avoid those occupied by predators or other leopard lizards. Montanucci (1965) found that in areas of low mammal burrow density, lizards will construct shallow, simple tunnels in earth berms or under rocks. While foraging, immature lizards also take cover under shrubs and rocks.

Potential predators of blunt-nosed leopard lizards include whipsnakes, gopher snakes, glossy snakes (*Arizona elegans*), western long-nosed snakes (*Rhinocheilus lecontei*), common king snakes, western rattlesnakes, loggerhead shrikes (*Lanius ludovicianus*), American kestrels (*Falco sparverius*), burrowing owls, greater roadrunners (*Geococcyx californianus*), golden eagles (*Aquila chrysaetos*), hawks, California ground squirrels, spotted skunks (*Spilogale putorius*), striped skunks (*Mephitis mephitis*), American badgers, coyotes, and San Joaquin kit foxes (Montanucci 1965, Tollestrup 1979*b*). Blunt-nosed leopard lizards are hosts to endoparasites such as nematodes, and ectoparasites such as mites and harvest mites (Montanucci 1965).

Activity Cycles.—Seasonal above-ground activity is correlated with weather conditions, primarily temperature. Optimal activity occurs when air temperatures are between 23.5 degrees and 40.0 degrees Celsius (74 and 104 degrees Fahrenheit) and ground temperatures are between 22 degrees and 36 degrees Celsius (72 and 97 degrees Fahrenheit) (USFWS 1985*a*, J. Brode pers. comm.). Some activity has been observed at temperatures as high as 50 degrees Celsius (122 degrees Fahrenheit) (O'Farrell and Kato 1980, Mullen 1981, Tollestrup 1976, Williams and Tordoff 1988). Body temperatures range from 32.2 to 42.0 degrees Celsius (90 and 108 degrees Fahrenheit) (Cowles and Bogert 1944, Mullen 1981). Because diurnal activity is temperature dependent, blunt-nosed leopard lizards are most likely to be observed in the morning and late afternoon during the hotter days (Tollestrup 1976). Smaller lizards and young have a wider activity range than the adults (Montanucci 1965). This results in the smaller, subadult lizards emerging from hibernation earlier than adults, remaining active later in the year, and being active during the day earlier and later than adults (Montanucci 1965). Adults are active above ground in the spring months from about March or April through June or July, with the amount of activity decreasing so that by the end of June or July almost all sightings are of subadult and hatchling leopard lizards (Williams et al. 1993*b*). Also, following the breeding season, the proportion of each sex active changes as males tend to cease surface activity sooner than females (Montanucci 1967, Williams and Tordoff 1988). Adults captured on the surface in August are about 70 percent females (Montanucci 1967). Adults retreat to their burrows to *brummate* (dormancy in *poikilothermic* vertebrates [having a body temperature that varies with the temperature of its surroundings]), beginning in August or September, but hatchlings are active until mid-October or November, depending on weather.

Habitat and Community Associations.—Blunt-nosed leopard lizards inhabit open, sparsely vegetated areas of low relief on the San Joaquin Valley floor and in the surrounding foothills (Smith 1946, Montanucci 1965). On the Valley floor, they are most commonly found in the Nonnative Grassland and Valley Sink Scrub communities described by Holland (1986). The Valley Sink Scrub is dominated by low, alkali-tolerant shrubs of the family Chenopodiaceae, such as iodine bush, and seepweeds. The soils are saline and alkaline lake bed or playa clays that often form a white salty crust and are occasionally covered by introduced annual grasses. Prior to agricultural development, Valley Sink Scrub was widespread around Kern, Buena Vista, Tulare, and Goose lakes and extended north to the Sacramento Valley along the trough of the San Joaquin Valley. Today, nearly all the remaining Valley sink scrub on the Valley floor is seasonally flooded fragments of this historical community. This community corresponds to two that Tollestrup (1976) described as *Allenrolfea* grassland and *Suaeda* flat.

Valley Needlegrass Grassland, Nonnative (Annual) Grassland, and Alkali Playa (Holland 1986) also provide suitable habitat for the lizard on the Valley floor. Valley Needlegrass Grassland is dominated by native perennial bunchgrasses, including purple needlegrass (*Nassella pulchra*) and alkali sacaton. Associated with the perennial grasses are native and introduced annual plants. Both the Valley Needlegrass Grassland and Nonnative/Annual Grassland occur on fine-textured soils and probably were widespread in the Valley before large areas were converted to agriculture. The Alkali Playa community occurs on poorly drained, saline and alkaline soils in small, closed basins. The small, widely spaced, dominant shrubs include: iodine bush, saltbushes, and greasewood (*Sarcobatus vermiculatus*).

Blunt-nosed leopard lizards also inhabit Valley Saltbush Scrub, which is a low shrubland, with an annual grassland understory, that occurs on the gently sloping alluvial fans of the foothills of the southern San Joaquin Valley and adjacent Carrizo Plain. This community is dominated by the chenopod shrubs, common saltbush (*Atriplex polycarpa*) and spiny saltbush (*Atriplex spinifera*), and is associated with non-alkaline, sandy or loamy soils. Tollestrup (1976) described this plant community as *Atriplex* grassland. Similar to this community, but dominated principally by common saltbushes, are the Sierra-Tehachapi Saltbush Scrub (extending from the southern Sierra Nevada north of Porterville to the Grapevine in the Tehachapi Mountains) and Interior Coast Range Saltbush Scrub. The latter ranges from Pacheco Pass to Maricopa but, for the most part, has been converted by grazing and fire to Nonnative/Annual Grassland. Other foothill communities that occur within the range of the blunt-nosed leopard lizard are Upper Sonoran Subshrub Scrub and Serpentine Bunchgrass (Holland 1986). In general, leopard lizards are absent from areas of steep slope, dense vegetation, or areas subject to seasonal flooding (Montanucci 1965).

4. Reasons for Decline and Threats to Survival

Reasons for Decline.—Since the 1870s and the advent of irrigated agriculture in the San Joaquin Valley, more than 95 percent of the original natural communities have been destroyed. This dramatic loss of natural communities was the result of cultivation, modification and alteration of existing communities for petroleum and mineral extraction, pesticide applications, off-road vehicle use, and construction of transportation, communications, and irrigation infrastructures. These processes collectively have caused the reduction and fragmentation of populations and decline of blunt-nosed leopard lizards (Stebbins 1954, Montanucci 1965, USFWS 1980*a*, 1985*a*, Germano and Williams 1993).

Farming began in the Valley as a direct response to increased demands for local food supplies, created by the migration of settlers to California during the 1849 Gold Rush (California Department of Water Resources 1974). Land conversion was accelerated in the 1920s with the advent of reliable electrical groundwater pumps and in the 1950s and 1960s with importation of water via Federal and State water projects (San Joaquin Valley Interagency Drainage Program 1979). By 1985, 94 percent of wildlands on the Valley floor had been lost to agricultural, urban, petroleum, mineral, or other development (USFWS 1985*c*, CDFG 1985).

Stebbins (1954) first recognized that agricultural conversion of its habitat was causing the elimination of the blunt-nosed leopard lizard. The cumulative effects of the dramatic decline in its available habitat and degradation of existing habitat by a variety of human activities have resulted in the lizard's present status as endangered.

In the first blunt-nosed leopard lizard recovery plan (USFWS 1980*a*), 20 Habitat Units were identified as "Essential" to the continued survival of the blunt-nosed leopard lizard, though these did not have any legal protection equivalent to critical habitat. Ten of these habitat units were recommended as having priority for protection (USFWS 1980*a*, in litt. 1985). Between 1977 and 1985, over 30,000 hectares (74,000 acres) of this important Valley-floor habitat were destroyed.

Threats to Survival.—Habitat disturbance, destruction, and fragmentation continue as the greatest threats to blunt-nosed leopard lizard populations. Construction of facilities related to oil and natural gas production, such as well pads, wells, storage tanks, sumps, pipelines, and their associated service roads degrade habitat and cause direct mortality to leopard lizards, as do leakage of oil from pumps and transport pipes, and storage facilities, surface mining, and off-highway vehicle traffic (Mullen 1981, USFWS 1985*a*, Kato and O'Farrell 1986, Madrone Associates 1979, Chesemore 1980). Dumping of waste oil and highly saline wastewater into natural drainage systems also degrades habitat and causes direct mortality, but these activities are no longer permitted. Lizards displaced by degraded or lost habitat may be unable to survive in adjacent habitat if it is already occupied or unsuitable for colonization (USFWS 1985*a*, Williams and Tordoff 1988). Direct mortality occurs when animals are killed or buried in their burrows during construction, killed by vehicle traffic on access roads, drowned or mired in pools of oil (Montanucci 1965, Mullen 1981, Kato and O'Farrell 1986, Kato et al. 1987*b*) and uncovered oil cellars (USFWS 1988), or fall into excavated areas from which they are unable to escape (O'Farrell and Sauls 1987).

Although lizards occur in areas of light petroleum development and recolonize oil fields that have been abandoned (O'Farrell and Kato 1980, Chesemore 1980, O'Farrell 1980, Williams in litt. 1989), their population densities decrease as oil activity increases (Jones 1980, O'Farrell and Kato 1980, Mullen 1981, Kato and O'Farrell 1986, O'Farrell and Sauls 1987). Eighty-three percent of the blunt-nosed leopard lizard population on Elk Hills Naval Petroleum Reserves in California inhabited areas where little or no petroleum-related activity had occurred (Kato and O'Farrell 1986). D.J. Germano (pers. comm.) reports relatively high numbers of blunt-nosed leopard lizards at the Kern Front Oil Fields despite the high level of oil activity.

Livestock grazing can result in removal of herbaceous vegetation and shrub cover, destruction of rodent burrows used by lizards for shelter, and associated soil erosion if the stocking rate is too high or animals are left on the range too long after annual plants have died (Chesemore 1981, Williams and Tordoff 1988). Unlike cultivation of row crops, which precludes use by leopard lizards, light or moderate grazing may be beneficial (USFWS 1985*a*, Germano and Williams 1993, Chesemore 1980). Chesemore (1980) suggested that 15 percent to 30 percent ground cover was optimal for leopard lizard habitat and greater than 50 percent was unsuitable. Researchers have hypothesized that leopard lizards prefer lightly grazed grasslands since these are dominated by Arabian grass, a low, sparsely growing, introduced annual grass, whereas ungrazed areas are dominated by red brome which is a taller, denser introduced grass (Mullen 1981, Chesemore 1980). However, domination by Arabian grass may be partly or predominately due to precipitation, soil structure, and other environmental variables instead of grazing intensity, based on long-term studies at several sites within the geographic range of the blunt-nosed leopard lizard (Williams et. al 1993*b*, Germano and Williams 1994*b*, Williams and Nelson in press, Williams and Germano 1991). On the Elkhorn Plain Ecological Reserve, high percentages of ground cover (nearly 100 percent in 1991–1993, 1995) may not have provided optimum habitat conditions, but grasshoppers and large moths and other prey for leopard lizards were abundant under these conditions. Blunt-nosed leopard lizards survived such conditions in similar proportions in grazed and nongrazed areas both in years of low and high plant productivity, though drought and lack of grazing during several years of the study makes results inconclusive (Williams et al. 1993*b*, Germano et al. 1994, Germano and Williams 1994*b*, Williams and Nelson in press, D.F. Williams unpubl. data).

The use of pesticides may directly and indirectly affect blunt-nosed leopard lizards (Germano and Williams 1993, Jones and Stokes 1977, California Department of Food and Agriculture 1984, Williams and Tordoff 1988). The insecticide malathion has been used since 1969 to control the beet leafhopper (California Department of Food and Agriculture 1984). California Department of Food and Agriculture treats areas on the west side of the San Joaquin Valley, from Merced to San Luis Obispo Counties, up to three times a year, depending on the seasonal densities of the sugar beet leafhopper and whether or not it is carrying the curly-top virus (H.L. Foote pers. comm.). Pretreatment surveys for blunt-nosed leopard lizards are conducted so that inhabited areas can be avoided, if possible.

Although the acute and chronic effects of malathion toxicity to leopard lizards are unknown (R.A. Marovich pers. comm.), Hall and Clark (1982) found that acute oral administration of malathion was relatively non-toxic to another lizard of the family Iguanidae. The most important effects of malathion on the blunt-nosed leopard lizard may be those associated with the reduction of insect prey populations (California Department of Food and Agriculture 1984). Because it degrades in approximately 48 hours, the direct effect of this insecticide on the abundance of prey species is thought to last for 2 to 5 days (California Department of Food and Agriculture 1984). Aerial application of malathion may reduce the availability of food for reproducing lizards in the spring, and later for hatchlings when they should be storing fat to sustain themselves during their first winter (Kato and O'Farrell 1986). During recent consultation with the Service, the California Department of Food and Agriculture's curly top virus control program was modified to increase protection measures, including increasing the use of biocontrol and integrated pest management techniques in blunt-nosed leopard lizard habitat (USFWS in litt. 1997*a*).

Blunt-nosed leopard lizard mortality is known to occur as a result of regular automobile traffic and off-road vehicle use (Tollestrup 1979*b*, Uptain et al. 1985, Williams and Tordoff 1988). Little information is available regarding the relative effect of this cause of mortality, but habitat fragmentation has accompanied the construction of roads. Typically roads surround and often bisect remaining fragments of habitat, increasing the risks of mortality by vehicles and strengthening the population effects of isolation.

5. Conservation Efforts

The blunt-nosed leopard lizard was listed as endangered by the U.S. Department of the Interior in 1967 (USFWS 1967) and by the State of California in 1971 (Table 1). A recovery plan was first prepared in 1980 (USFWS 1980*a*) and revised in 1985 (USFWS 1985*a*). Conservation efforts have included habitat and population surveys, studies of population demography and habitat management, land acquisition, and development of management plans for public lands that have benefitted blunt-nosed leopard lizards as well as other listed species (see the Introduction, 3. Conservation Efforts at the Community Level and Table 2).

Large-scale habitat surveys include those for the California Energy Commission's Southern San Joaquin Valley Habitat Preservation Program (Anderson et al. 1991), the Carrizo Plain Natural Area (Kakiba-Russell et al. 1991), Elk Hills Naval Petroleum Reserves in California (O'Farrell and Matthews 1987, O'Farrell and Sauls 1987, EG&G Energy Measurements 1995*a,b*), USBLM lands in Fresno, San Benito, and Monterey Counties (O'Farrell et al. 1981), and a survey of 12,000 hectares (30,000 acres) of natural land in western Madera County (Williams 1990). There also have been numerous smaller-scale preproject surveys as part of the Sec. 7 and 10(a) permit processes of the Endangered Species Act, and National Environmental Policy Act and California Environmental Quality Act laws and regulations. Most of these have taken place in the southern San Joaquin Valley in Kern and western Kings Counties.

The CDFG conducted aerial surveys between 1976 and 1985 to determine the extent of remaining natural lands in the San Joaquin Valley (USFWS 1980*a*, 1985*a*). Survey maps were compared with baseline maps hand drawn from EROS 45.7 by 45.7-centimeter color infrared high altitude photos, taken in August 1974. The loss of undeveloped land in each of 20 Essential Habitat areas was compared for the years 1983 and 1985, the years most recent surveys were conducted.

In 1985, USFWS (USFWS in litt. 1985) proposed that 3,345 hectares (8,265 acres) in the Firebaugh, Whitesbridge, and Pixley Refuge Essential Habitat areas be acquired using Land and Water Conservation Fund

Act funds. However, because of funding constraints, this plan has not been implemented.

Studies of population ecology and habitat management of leopard lizards have been conducted by several researchers funded by the USBLM, U.S. Department of Energy, Bureau of Reclamation, Service, and CDFG. The results of two research investigations of blunt-nosed leopard lizard food habits and home range size have been published since 1985 (Kato et al. 1987*b*, 1987*b*). Studies of demography and habitat management on the Elkhorn Plain have been on-going since 1987 (Williams et al. 1993*b*, Germano and Williams 1994*b*, Germano et al. 1994, Endangered Species Recovery Program unpubl. data). Similarly, since 1985, studies of demography have been ongoing at Pixley National Wildlife Refuge (Uptain et al. 1992, Williams and Germano 1991, Endangered Species Recovery Program unpubl. data). Other studies of habitat management and restoration have taken place at the Kern Fan Element by the California Department of Water Resources (J. Shelton and S. Juarez pers. comm.).

Though population viability analyses are an important aspect of conservation planning for this species, recent single-population analyses (Buechner 1989, Endangered Species Recovery Program studies in progress) are inadequate for two main reasons: (1) there are insufficient data on demographics of blunt-nosed leopard lizards from several sites representing the range of environmental conditions to which the species is exposed; and (2) the data are not representative of the temporal variation of the environment. Before modeling can become a useful tool for conservation planning, data needed to conduct metapopulation modeling must be gathered. These data include demographics of individual populations, the carrying capacity of the habitat of each, and their connectivity (rate of movement). Despite the shortcomings of current information, recent studies have shown that blunt-nosed leopard lizards can withstand severe, long term drought by remaining dormant for up to 22 months, and have the reproductive capacity for irruptive population growth when conditions are favorable (Williams et al. 1993*b*, Germano et al. 1994, Germano and Williams 1994*b*).

U.S. Environmental Protection Agency County bulletins governing use of rodenticides have greatly reduced the risk of significant mortality to blunt-nosed leopard lizard populations by State and county rodent-control activities. The California Environmental Protection Agency, California Department of Food and Agriculture, county agricultural departments, CDFG, and the U.S. Environmental Protection Agency collaborated with the Service in the development of County Bulletins that both are efficacious and acceptable to land owners (R.A. Marovich pers. comm.).

6. Recovery Strategy

The more important questions that must be addressed before or simultaneous with purchase of land or conservation easements, is how to preserve and enhance populations on existing habitat. Substantial habitat is in public ownership or a conservation program, but appropriate habitat management prescriptions for these parcels mostly are unknown. No parcel currently is being specifically managed to optimize habitat conditions for this species. Thus, the three most important factors in recovering the blunt-nosed leopard lizard are:

1. determining appropriate habitat management and compatible land uses for blunt-nosed leopard lizards;
2. protecting additional habitat for them in key portions of their range; and
3. gathering additional data on population responses to environmental variation at representative sites in their extant geographic range.

A population monitoring program and a range-wide population survey are needed to determine current population sizes and habitat conditions, track lizards' responses to environmental variation and changing land uses, and rank areas and parcels for protection by purchase of title or easement. Special attention must be directed to surveys in potential habitat in central Merced County, where ground surveys have not been conducted.

Also needed is an analysis of extinction patterns on different-sized, isolated blocks of natural land on the Valley floor to gain insight into the effects of habitat size and diversity on population viability. Because several important populations are isolated on fragmented natural land on the Valley floor and along its southern and western perimeter, ultimately, determining viable population size, genetic variation, and methods to enhance population movements and restore habitat on retired farmlands are needed to ensure recovery.

Recovery Actions.—Principal recovery actions for the blunt-nosed leopard lizard should focus on information needed to make informed decisions about land acquisition and habitat management and restoration, and measure progress toward recovery. Habitat protection is important, and in some portions of the geographic range of blunt-nosed leopard lizards, it has a high priority. Yet, while habitat protection goals may require many years to achieve, and some may never be reached, other actions must be implemented. Needed actions are:

1. Determine appropriate habitat management and compatible land uses for blunt-nosed leopard lizards.

2. Conduct range-wide surveys of known and potential habitat for presence and abundance of blunt-nosed leopard lizards.

3. Protect additional habitat for them in key portions of their range; areas of highest priority to target for protection are:

   a. Natural lands in western Madera County;

   b. Natural lands in the Panoche Valley area of Silver Creek Ranch, San Benito County;

   c. Agricultural and natural land between the north end of the Kettleman Hills and the Guijarral Hills and the Guijarral Hills and Anticline Ridge (western rim of Pleasant Valley, Fresno County) to restore and protect a corridor of continuous habitat for blunt-nosed leopard lizards and other species without the ability to move through irrigated farmland;

   d. Natural lands west of Highway 33 and east of the coastal ranges between the Pleasant Valley, Fresno County, on the north and McKittrick Valley, Kern County, on the south;

   e. Natural lands of the linear, piedmont remnants of their habitat west of Interstate Highway 5 between Pleasant Valley and Panoche Creek, Fresno County;

   f. Natural lands in upper Cuyama Valley.

4. Gather additional data on population responses to environmental variation at representative sites in its extant geographic range.

5. Design and implement a range-wide population monitoring program.

6. Protect additional habitat for blunt-nosed leopard lizards in the following areas (all are of equal priority):

   a. Natural and retired agricultural lands around Pixley National Wildlife Refuge, Tulare County, with an objective of expanding and connecting the Refuge units with each other and with the Allensworth Ecological Reserve;

   b. Natural land in and around the Elk Hills Naval Petroleum Reserves in California and Lokern Natural Area with the objective of expanding and connecting existing lands with conservation programs;

   c. Natural and retired agricultural lands in the Semitropic Ridge Natural Area, Kern County, with the objective of expanding and connecting existing reserves and refuges.

L. San Joaquin Kit Fox
(*Vulpes macrotis mutica*)

1. Description and Taxonomy

Taxonomy.—The kit fox, *Vulpes macrotis*, was described by C. Hart Merriam (1888). The area of the type locality, near Riverside in Southern California, is now highly urbanized. Eight subspecies were recognized historically (e.g., Hall 1981). *V. m. mutica*, the San Joaquin kit fox, was first described by Merriam (1902). Today, only *V. m. macrotis* and *V. m. mutica* are recognized (Mercure et al. 1993). The type locality is near Tracy, San Joaquin County, California.

Several different taxonomies for the species and subspecies of small, North American foxes have been proposed over the last 110 years (historical literature summarized by Hall 1946, Hall and Kelson 1959, Rohwer and Kilgore 1973, Waithman and Roest 1977, Hall 1981). Two recent studies examined the evolutionary and taxonomic relationships among small, North American foxes (Dragoo et al. 1990, Mercure et al. 1993). Dragoo et al. (1990) concluded that all North American arid-land foxes belonged to the species *V. velox* (swift fox). The subspecific statuses of the taxa historically regarded as subspecies of *V. macrotis* also were challenged by Dragoo et al. (1990), who recommended that all be synonymized under *V. velox macrotis*. Genetic work by Mercure et al. (1993) led them to conclude that, though there was evidence of hybridization between kit and swift foxes over a limited geographic area, they should be considered separate species. Further, Mercure et al. concluded that of the traditional subspecies of the kit fox, the San Joaquin Valley population is the most distinct and should be considered a subspecies (1993, p. 1323). Their data recognize the swift fox as a separate monotypic species, and two subspecies of kit foxes: *V. macrotis macrotis*, found throughout the remaining habitat within the historical range of the species, except the San Joaquin kit fox range; and *V. macrotis mutica*, the San Joaquin kit fox.

Description.—The kit fox is the smallest canid species in North America and the San Joaquin kit fox is the largest subspecies in skeletal measurements, body size, and weight. Grinnell et al. (1937) found a difference in body size between males and females: males averaged 80.5 centimeters (31.7 inches) in total length, and 29.5 centimeters (11.6 inches) in tail length; females averaged 76.9 centimeters (30.3 inches) in total length, and 28.4 centimeters (11.2 inches) in tail length. Kit foxes have long slender legs and are about 30 centimeters (12 inches) high at the shoulder. The average weight of adult males is 2.3 kilograms (5 pounds), and of adult females is 2.1 kilograms (4.6 pounds) (Morrell 1972).

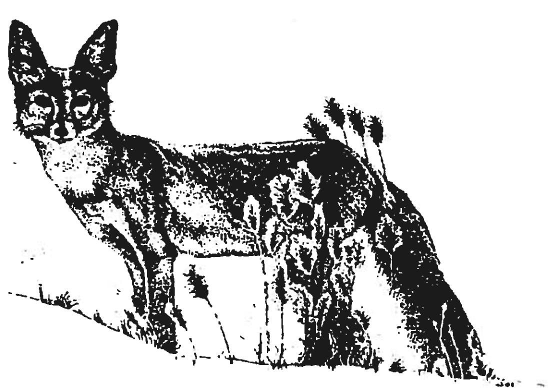

Figure 50. Illustration of a kit fox by Jodi Sears (© D.F. Williams)

General physical characteristics of kit foxes include a small, slim body, relatively large ears set close together, narrow nose, and a long, bushy tail tapering slightly toward the tip (Figure 50). The tail is typically carried low and straight.

Color and texture of the fur coat of kit foxes varies geographically and seasonally. The most commonly described colorations are buff, tan, grizzled, or yellowish-gray dorsal coats (McGrew 1979). The guard hairs on the back are black tipped, which accounts for the grizzled appearance (Bell 1994). Two distinctive coats develop each year: a tan summer coat and a silver-gray winter coat (Morrell 1972). The undersides vary from light buff to white (Grinnell et al. 1937), with the shoulders, lower sides, flanks and chest varying from buff to a rust color. The ear pinna (external ear flap) is dark on the back side, with a thick border of white hairs on the forward-inner edge and inner base. The tail is distinctly black-tipped.

Identification.—The foot pads of kit foxes are small by comparison with other canids. A sample of 21 tracks from throughout the San Joaquin Valley had an average length of 3.1 centimeters (1.2 inches) and an average width of 2.6 centimeters (1 inch) (Orloff et al. 1993). Other characteristics such as the degree to which the feet are furred and the size, shape, and configuration of the pads distinguish kit fox tracks from those of co-occurring canids and domestic cats (Orloff et al. 1993).

Because all three fox species that occur in the San Joaquin Valley are primarily nocturnal, identification of free-living, and often fast-moving, animals can be a challenge. The black-tipped tail and coat color differences usually distinguish kit foxes from red foxes (*V. vulpes*). At 4 to 5 kilograms (8 to 11 pounds), the red fox also is much heavier than the kit fox. Gray foxes (*Urocyon cinereoargenteus*) however are sometimes misidentified as kit foxes, especially in winter when the kit fox coat is thicker and has more gray. Both species have a black tail tip but gray foxes also have a distinctive black stripe running along the top of the tail. Gray foxes are more robust than kit foxes; they are heavier with an average body weight of about 3.6 kilograms (8 pounds) (Grinnell et al. 1937). However, San Joaquin kit foxes have longer ears, averaging 8.6 centimeters (3.4 inches) compared with 7.8 centimeters (3 inches) for gray foxes (Grinnell et al. 1937).

2. Historical and Current Distribution

Historical Distribution.—The historical range was first defined by Grinnell et al. (1937). Prior to 1930, kit foxes inhabited most of the San Joaquin Valley from southern Kern County north to Tracy, San Joaquin County, on the west side, and near La Grange, Stanislaus County, on the east side. These authors believed that by 1930 the kit fox range had been reduced by more than half, with the largest portion of the range remaining in the southern and western parts of the Valley (Figure 51), though they provided no indication for why they believed foxes had been eliminated from most of the east side and Valley floor.

Current Distribution.—Although the San Joaquin kit fox has been listed as endangered for over 30 years, there has never been a comprehensive survey of its entire historical range. And, despite the loss of habitat and apparent decline in numbers since the early 1970s, there has been no new survey of habitat that was then thought to be occupied (Morrell 1975).

Despite the lack of a comprehensive survey, local surveys, research projects and incidental sightings indicate that kit foxes currently inhabit some areas of suitable habitat on the San Joaquin Valley floor and in the surrounding foothills of the coastal ranges, Sierra Nevada, and Tehachapi Mountains, from southern Kern County north to Contra Costa, Alameda, and San Joaquin Counties on the west, and near La Grange, Stanislaus County on the east side of the Valley (Williams in litt. 1990), and some of the larger scattered islands of natural land on the Valley floor in Kern, Tulare, Kings, Fresno, Madera, and Merced Counties (Figure 51). Kit foxes also occur westward into the interior coastal ranges in Monterey, San Benito, and Santa Clara Counties (Pajaro River watershed), in the Salinas River watershed, Monterey and San Luis Obispo Counties, and in the upper Cuyama River watershed in northern Ventura and Santa Barbara Counties and southeastern San Luis Obispo County. Kit foxes are also known to live within the city limits of the city of Bakersfield in Kern County (Laughrin 1970, Jensen 1972, Morrell 1975, USFWS 1983, Swick 1973, Waithman 1974*a*, Endangered Species Recovery Program unpubl. data).

Some researchers have suggested that as San Joaquin Valley natural lands were cultivated or otherwise developed, displaced kit foxes colonized nearby valleys and foothills (Laughrin 1970, Jensen 1972); however, there is no concrete evidence to support this assertion. As early as 1925, Grinnell et al. reported kit fox specimens from the Panoche Creek area in the foothills of western Fresno County, and east of Rose Station (Fort Tejon) in southern Kern County at an elevation of 363 meters (1,200 feet) (Grinnell et al. 1937, USFWS 1983). Therefore, it is more probable that kit foxes have always occurred in these areas, possibly at low density.

The largest extant populations of kit foxes are in western Kern County on and around the Elk Hills and Buena Vista Valley, Kern County, and in the Carrizo Plain Natural Area, San Luis Obispo County. The kit fox populations of Elk Hills and the City of Bakersfield, Kern County (B.L. Cypher pers. comm.), Carrizo Plain Natural Area, San Luis Obispo County (White and Ralls 1993, Ralls and White 1995), Ciervo-Panoche Natural Area, Fresno and San Benito Counties (Endangered Species Recovery Program), Fort Hunter Liggett, Monterey County (V. Getz pers. comm.), and Camp Roberts, Monterey and San Luis Obispo Counties (W. Berry pers. comm.) have been recently, or are currently, the focus of various research projects. Though monitoring has not been continuous in the central and northern portions of the range, populations were recorded in the late 1980s at San Luis Reservoir, Merced County (Briden et al. 1987), North Grasslands and Kesterson National Wildlife Refuge area on the Valley floor, Merced County (Paveglio and Clifton 1988), and in the Los Vaqueros watershed, Contra Costa County in the early 1990s (V. Getz pers. comm.). Smaller populations and isolated sightings of kit foxes are also known from other parts of the San Joaquin Valley floor, including Madera County and eastern Stanislaus County (Williams 1990).

3. Life History and Habitat

Food and Foraging.—Diet of kit foxes varies geographically, seasonally, and annually, based on variation in abundance of potential prey. In the southern portion of their range, kangaroo rats, pocket mice, white-footed mice (*Peromyscus* spp.), and other nocturnal rodents comprise about one-third or more of their diets. Kit foxes there also prey on California ground squirrels, black-tailed hares, San Joaquin antelope squirrels, desert cottontails, ground-nesting birds, and insects (Scrivner et al. 1987*a*). Vegetation and insects occur frequently in feces. Grass is the most commonly ingested plant material (Morrell 1971, C.A. Vanderbilt-White pers. comm.). In the central portion of their geographic range,

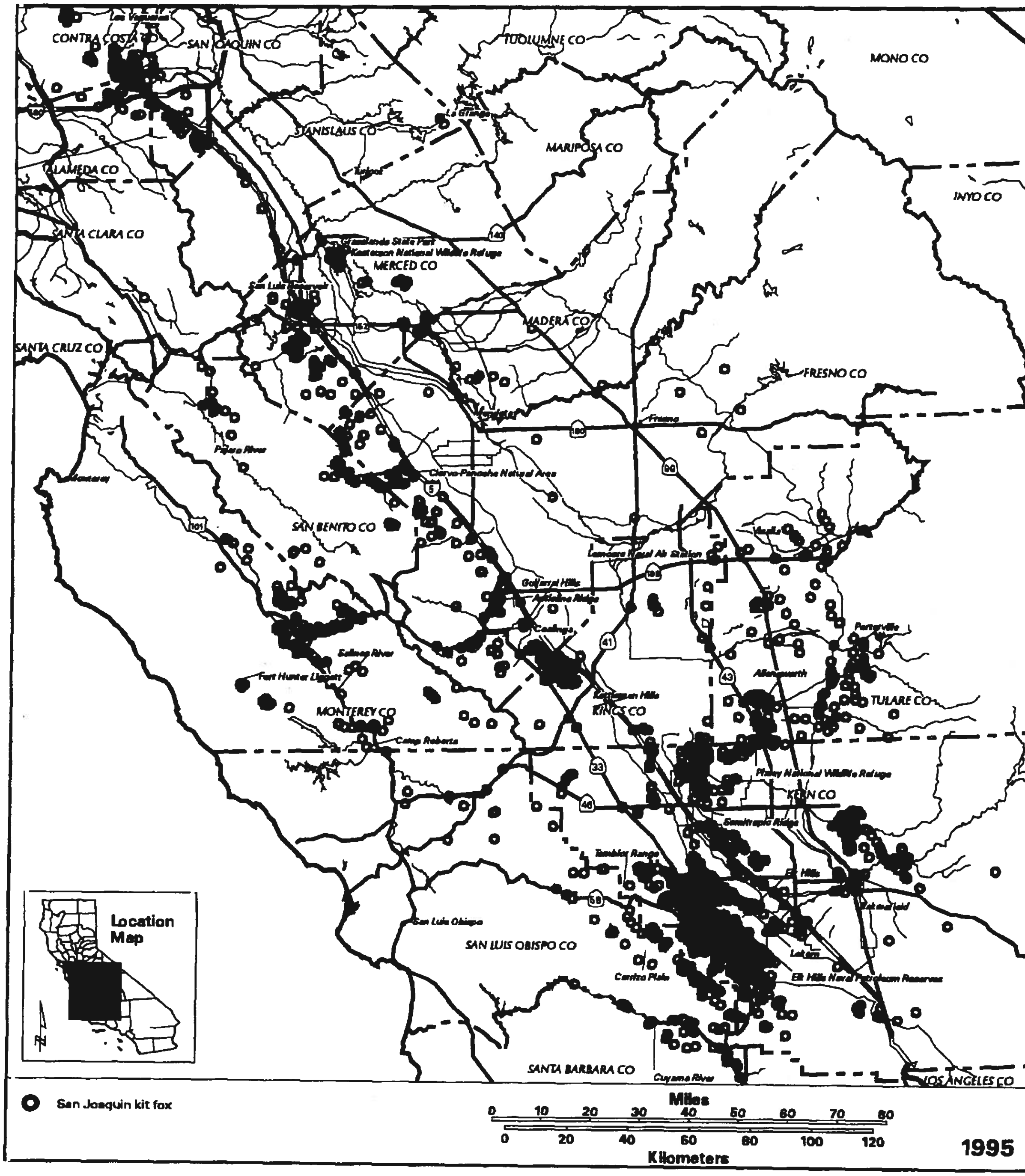

Figure 51. Map of distributional records for the San Joaquin kit fox *(Vulpes macrotis mutica)*.

defined here as Kings, Tulare, Fresno, Madera, San Benito, Merced, Stanislaus, and Monterey Counties, known prey species include white-footed mice, insects, California ground squirrels, kangaroo rats, San Joaquin antelope squirrels, black-tailed hares, and chukar *(Alectoris chukar)* (Jensen 1972, Archon 1992), listed in approximate proportion of occurrence in fecal samples. In the northern part of their range, defined here as San Joaquin, Alameda and Contra Costa Counties, kit foxes most frequently consume California ground squirrels (Orloff et al. 1986). Cottontails, black-tailed hares, pocket mice, and kangaroo rats also are eaten (Hall 1983, D.F. Williams unpubl. data). Though ground squirrels are diurnal and kit foxes are predominantly nocturnal, kit foxes are commonly seen during the day during late spring and early summer (Orloff et al. 1986).

Reproduction and Demography.—Kit foxes can breed when 1 year old, but may not breed their first year of adulthood (Morrell 1972). Adult pairs remain together all year, sharing the home range but not necessarily the same den (K. Ralls pers. comm.). During September and October, adult females begin to clean and enlarge natal or pupping dens (they select dens with multiple openings; Morrell 1972). Mating and conception take place between late December and March (Egoscue 1956, Morrell 1972, Zoellick et al. 1987*a*, Spiegel et al. in press). The median gestation period is estimated to range from 48 to 52 days (Spiegel et al. in press). Litters of from two to six pups are born sometime between February and late March (Egoscue 1962, Morrell 1972, Zoellick et al. 1987*a*, Spiegel et al. in press).

The female is rarely seen hunting during the time she is lactating. During this period the male provides most of the food for her and the pups. The pups emerge above ground at slightly more than 1 month of age. After 4 to 5 months, usually in August or September, the family bonds begin to dissolve and the young begin dispersing. Occasionally a juvenile female will remain with the adult female for several more months (O'Neal et al. 1992, Spiegel et al. in press). Offspring of both sexes sometimes remain with their parents through the following year and help raise a subsequent litter (White and Ralls 1993, Spiegel et al. in press, B.L. Cypher pers. comm.).

Reproductive success of kit foxes is correlated with abundance of their prey (Egoscue 1975). Success decreases when the density of prey species drops because of drought, too much rainfall, or other circumstances (White and Ralls 1993, Spiegel et al. in press, B.L. Cypher pers. comm., White and Garrott 1998).

During a 6-year study at the Elk Hills Naval Petroleum Reserves in California, pups dispersed an average of 8 ± 1.4 kilometers (5.0 ± 0.9 mile; Scrivner et al. 1987*b*). Maximum reported distances can vary considerably (Hall 1983). One individual traveled a minimum of 40 kilometers (25 miles) from its whelping den (V. Getz pers. comm.), and a prime adult male dispersed from Camp Roberts to the Carrizo Plain in 1989 (P.J. White pers. comm.). Adult and juvenile kit foxes radio-collared at the Elk Hills Naval Petroleum Reserves in California dispersed through disturbed habitats, including agricultural fields, oil fields, rangelands, and across highways and aqueducts. One pup crossed the Temblor Range into the Carrizo Plain (Scrivner et al. 1987*b*).

The average age of kit foxes in a Utah population was about 2 years (Egoscue 1975). One fox in another Utah study was estimated to be at least 7 years old (Egoscue 1962). Kit foxes at Camp Roberts are reported to be over 8 years old (P.J. White pers. comm.). Kit foxes on Naval Petroleum Reserve-1 in California are known to live as long as 8 years but such longevity is rare; animals less than 1 year old outnumber older foxes by 2.8:1 (Berry et al. 1987*a*). Annual survival rates of juvenile foxes have ranged from 0.26 on Naval Petroleum Reserve-1 in California (Berry et al. 1987*a*) to 0.21 to 0.41 on the Carrizo Plain (Ralls and White 1995). In captivity, kit foxes have lived up to 10 years (McGrew 1979, M. Johnson pers. comm.).

An annual adult mortality rate of approximately 50 percent has been reported (Morrell 1972, Egoscue 1975, Berry et al. 1987*a*, Ralls and White 1995, Standley et al. 1992). The annual mortality rate for juvenile kit foxes may be closer to 70 percent (Berry et al. 1987*a*). Predation by larger carnivores (e.g., coyotes) accounts for the majority of San Joaquin kit fox mortality. The effects of disease, parasites and accidental death are largely unknown, but were thought to account for only a small portion of mortality (Berry et al. 1987*a*). Drought plays a role in low reproductive success (i.e., pups are born but do not survive to weaning). Adults can maintain weight and body condition and females can give birth, but pairs apparently cannot catch enough prey to support pups (White and Ralls 1993, Spiegel et al. in press).

San Joaquin kit fox densities on the west side of the

San Joaquin Valley were estimated to be 0.4 per square kilometer (1.04 per square mile) prior to 1925, based on fur trapping efforts (Grinnell et al. 1937). In 1969, Laughrin (1970) estimated that range-wide kit fox densities were 0.2 to 0.4 per square kilometer (0.52 to 1.04 per square mile). Morrell (1975) estimated densities of 1.2 per square kilometer (3.11 per square mile) in optimal habitats in "good" years. In the 1983 recovery plan (USFWS 1983), Morrell's data was corrected for habitat loss and an estimate of 0.5 per square kilometer (1.30 per square mile) was obtained. The estimated mean density of trappable adult kit foxes was from 0.8 to 1.1 per square kilometer (2 to 2.8 per square mile) between 1980 and 1982 on the Naval Petroleum Reserves in California (O'Farrell 1984). More recently, kit fox densities at the Naval Petroleum Reserves were determined from annual live-trapping efforts (Enterprise Advisory Services, Inc., unpubl. data). On Naval Petroleum Reserve-1 in California, the mean density from 1981 to 1993 was 0.12 per square kilometer (0.31 per square mile) in winter, but varied from 0.72 per square kilometer (1.86 per square mile) in 1981 to 0.01 per square kilometer (0.03 per square mile) in 1991. On Naval Petroleum Reserve-2 in California, mean density from 1983 to 1993 was 0.38 per square kilometer (0.98 per square mile), and varied from 0.72 per square kilometer (1.86 per square mile) in summer 1983 to 0.1 per square kilometer (0.30 per square mile) in winter 1991. On the nearby Carrizo Plain Natural Area, kit fox densities were estimated to be 0.15 to 0.24 per square kilometer (0.39 to 0.62 per square mile) (White and Ralls 1993).

In the 1983 recovery plan (USFWS 1983) it was estimated that the population range-wide of adult kit foxes prior to 1930 may have been between 8,667 and 12,134 assuming an occupied range of 22,447 square kilometers (8,667 square miles) and densities of 0.4 to 0.6 per square kilometer (1.04 to 1.55 per square mile). The kit fox population in San Luis Obispo, Santa Barbara, Kings, Tulare and Kern Counties was estimated to be about 11,000 animals in the early 1970s based on limited aerial surveys of pupping dens and amount of historic habitat, but without correction for cultivated and urbanized lands (Waithman 1974*b*). Laughrin (1970) reported an estimated total population size of 1,000 to 3,000 foxes in 1969. Morrell (1975) conducted a more thorough investigation of kit fox abundance in 14 counties in which kit foxes were known to occur and estimated the total population at 14,832. In the 1983 recovery plan (USFWS 1983), Morrell's data was adjusted and a corrected estimate of 6,961 foxes in 1975 was obtained. When compared to the pre-1930 estimate, this represents a possible population decline of 20 to 43 percent. Approximately 85 percent of the fox population in 1975 was found in only six counties (Kern, Tulare, Kings, San Luis Obispo, Fresno, and Monterey), and over half the population occurred in two of those counties: Kern (41 percent) and San Luis Obispo (10 percent) (Morrell 1975).

Behavior and Species Interactions.—San Joaquin kit foxes use dens for temperature regulation, shelter from adverse environmental conditions, reproduction, and escape from predators. Though kit foxes are reputed to be poor diggers (Jensen 1972, Morrell 1972), the complexity and depth of their dens do not support this assessment (USFWS 1983). Kit foxes also modify and use dens constructed by other animals, such as ground squirrels, badgers, and coyotes (Jensen 1972, Morrell 1972, Hall 1983, Berry et al. 1987*b*), and human-made structures (culverts, abandoned pipelines, and banks in sumps or roadbeds) (Spiegel et al. in press, B.L. Cypher pers. comm.).

Den characteristics vary across the San Joaquin kit fox's geographic range. In the southernmost portion, dens with two entrances are most frequently found. Natal and pupping dens, in which pups are born and raised, tend to be larger with more entrances (2 to 18) (Morrell 1972, O'Farrell and Gilbertson 1979, O'Farrell et al. 1980, O'Farrell and McCue 1981, Berry et al. 1987*b*). Entrances are usually from 20 to 25 centimeters (8 to 10 inches) in diameter and normally are higher than wide. Ramp-shaped mounds of dirt from 1 to 2 meters (3 to 6 feet) long are deposited at some den entrances (Morrell 1972). Most hillsides where kit fox dens are found (95 percent) have a slope of less than 40 degrees (Reese et al. 1992). Natal and pupping dens are found on flatter ground with slopes of about 6 degrees (O'Farrell and McCue 1981, O'Farrell et al. 1980). The entrances of pupping dens show more evidence of use, such as fox scat, prey remains, and matted vegetation. In the central portion of their geographic range, dens also have several openings; however, instead of a mound of dirt in front of the opening, the dirt is more often scattered into a long tailing ramp, generally with a runway down the middle. In areas of tall grass, matted grass in front of the entrance is obvious. In western Merced County, most dens are found on slopes of less than 10 degrees, but a few are found on slopes of up to 55 degrees (Archon 1992). In the northern portion of the kit fox range, dens appeared to be placed higher than most surrounding ground compared to areas farther south, perhaps reflecting the topography of the area. Dens most often are located on the lower section of the slope (Orloff et al. 1986), yet foxes are sometimes seen entering dens on the upper part of a slope (Bell 1992). Most dens lack the ramp or runway characteristic of dens in the southern and central portions of the Valley. No evidence has been found to indicate that kit foxes in this area construct their own dens (Hall 1983). Kit foxes probably enlarge California ground squirrel burrows (Orloff et al. 1986), but they also may construct their own dens.

Kit foxes often change dens and numerous dens may be used throughout the year. However, evidence that a den is in use may be absent (V. Getz pers. comm.). Reese et al (1992) found that 64 percent of the dens used by radio-collared kit foxes at Camp Roberts during 1988-1991 exhibited no sign of kit foxes. Foxes change dens four or five times during the summer months, and change natal dens one or two times per month (Morrell 1972). One family of 7 kit foxes used 43 dens; the maximum number used by 1 individual was 70 (Hall 1983). Foxes on the Carrizo Plain Natural Area changed dens much more frequently than indicated by Morrell's study (White and Ralls 1993). Radiotelemetry studies indicate that foxes use individual dens for a median of 2 days (mean of 3.5 days) before moving to a different den. One fox was tracked to 70 different dens during a two year study (K. Ralls pers. comm.). Den changes have been attributed to depletion of prey in the vicinity of the den or to increases in external parasites such as fleas (Egoscue 1956). Avoidance of coyotes is a more probable reason for frequently changing dens because kit foxes can easily search their home range in one night for prey, and parasites are unlikely to build to intolerable levels in 2 or 3 days (K. Ralls pers. comm.)

Nightly movements on the Elk Hills Naval Petroleum Reserves in California averaged 15.4 kilometers (9.6 miles) during the breeding season and were significantly longer than the average nightly movements of 10.2 kilometers (6.3 miles) during the pup-rearing season. Movements during the breeding season also were significantly longer than those made during the pup-dispersal season (10.4 kilometers, 6.5 miles) (Zoellick et al. 1987*b*).

Home ranges of from less than 2.6 square kilometers (1 square mile) up to approximately 31 square kilometers (12 square miles) have been reported by several researchers (Morrell 1972, Knapp 1978, Zoellick et al. 1987*b*, Spiegel and Bradbury 1992, White and Ralls 1993, Paveglio and Clifton 1988). The maintenance of large and relatively non-overlapping home ranges, as noted on the Carrizo Plain, may be an adaptation to drought-induced periods of prey scarcity that are episodic and temporary on the Carrizo Plain (White and Ralls 1993). Differences in home range size among study sites tend to be related to prey abundance (White and Ralls 1993, White and Garrott 1998).

Kit foxes are subject to predation or competitive exclusion by other species, such as the coyote, nonnative red foxes, domestic dog *(Canis familiaris)*, bobcat *(Felis rufus)*, and large raptors (Hall 1983, Berry et al. 1987*a*, O'Farrell et al. 1987*b*, White et al. 1994, Ralls and White 1995, CDFG 1987). Coyotes are known to kill kit foxes, though an experimental coyote-control program at the Elk Hills Naval Petroleum Reserves in California did not result in an increase in survival rate for kit foxes, nor did coyote-induced mortality decrease (Cypher and Scrivner 1992, Scrivner and Harris 1986, Scrivner 1987). The extent to which gray and kit foxes compete for resources is unknown. The need for similar den sites and prey species probably place nonnative red foxes in direct competition with the much smaller kit fox. Nonnative red foxes are expanding their geographic range in central California (Orloff et al. 1986, Lewis et al. 1993), and competition with or predation on kit foxes may be a factor in the apparent decline of kit foxes in the Santa Clara Valley (T. Rado pers. comm.), and perhaps elsewhere in the northwestern segment of their range. Coyotes aggressively dominate encounters with red foxes and will pursue and kill both red and gray foxes (Sargeant and Allen 1989), as well as kit foxes. Coyotes may reduce the negative impacts of red foxes on kit foxes by limiting red fox abundance and distribution, but details of interactions between the two species and the extent to which coyotes might slow or prevent the invasion of red foxes into kit fox habitats are unknown (White et al. 1994, Ralls and White 1995).

Activity Cycle.—San Joaquin kit foxes are primarily active at night (i.e., nocturnal), and active throughout the year (Grinnell et al. 1937, Morrell 1972). Adults and pups sometimes rest and play near the den entrance in the afternoons, but most above-ground activities begin near sunset and continue sporadically throughout the night. Morrell (1972) reported that hunting occurred only at night. Yet predation on ground squirrels, which are active during the day (i.e., diurnal), by some populations indicates that kit foxes are not strictly nocturnal, adapting to the activities of available prey (Balestreri 1981, Hall 1983, Orloff et al. 1986, O'Farrell et al. 1987*b*, Hansen in litt. 1988).

Habitat and Community Associations.—Kit foxes prefer loose-textured soils (Grinnell et al. 1937, Hall 1946, Egoscue 1962, Morrell 1972), but are found on virtually every soil type. Dens appear to be scarce in areas with shallow soils because of the proximity to bedrock (O'Farrell and Gilbertson 1979, O'Farrell et al. 1980), high water tables (McCue et al. 1981), or impenetrable hardpan layers (Morrell 1972). However, kit foxes will occupy soils with a high clay content, such as in the Altamont Pass area in Alameda County, where they modify burrows dug by other animals (Orloff et al. 1986).

Historically, San Joaquin kit foxes occurred in several native plant communities of the San Joaquin Valley. Because of extensive land conversions and intensive land use, some of these communities only are represented by small, degraded remnants today. Other habitats in which kit foxes are currently found have been extensively modified by humans. These include grasslands and scrublands with active oil fields, wind turbines, and an agricultural matrix of row crops, irrigated pasture, orchards, vineyards, and grazed annual grasslands (nonirrigated pasture). Other plant communities in the San Joaquin Valley providing kit fox habitat include Northern Hardpan Vernal Pool, Northern Claypan Vernal Pool, Alkali Meadow, and Alkali Playa. These are found as relatively small patches in scattered locations. In general, they do not provide good denning habitat for kit foxes because all have moist or waterlogged clay or clay-like soils. However, where they are interspersed with more suitable kit fox habitats they provide food and cover.

In the southernmost portion of the range, the kit fox is commonly associated with Valley Sink Scrub, Valley Saltbush Scrub, Upper Sonoran Subshrub Scrub, and Annual Grassland. Kit foxes also inhabit grazed grasslands, petroleum fields (Morrell 1971, O'Farrell 1980), urban areas (B. Cypher pers. comm.), and survive adjacent to tilled or fallow fields (Jensen 1972, Ralls and White 1991). In the central portion of the range, the kit fox is associated with Valley Sink Scrub, Interior Coast Range Saltbush Scrub, Upper Sonoran Subshrub Scrub, Annual Grassland and the remaining native grasslands. Agriculture dominates this region where kit foxes mostly inhabit grazed, nonirrigated grasslands, but also live next to and forage in tilled or fallow fields, irrigated row crops, orchards, and vineyards. In the northern portion of their range, kit foxes commonly are associated with annual grassland (Hall 1983) and Valley Oak Woodland (Bell 1994). Kit foxes inhabit grazed grasslands, grasslands with wind turbines, and also live adjacent to and forage in tilled and fallow fields, and irrigated row crops (Bell 1994).

Kit foxes use some types of agricultural land where uncultivated land is maintained, allowing for denning sites and a suitable prey base (Jensen 1972, Knapp 1978, Hansen 1988). Kit foxes also den on small parcels of native habitat surrounded by intensively maintained agricultural lands (Knapp 1978), and adjacent to dryland farms (Jensen 1972, Kato 1986, Orloff et al. 1986).

4. Reasons for Decline and Threats to Survival

Reasons for Decline.—Numerous causes of kit fox mortality have been identified, though these have probably varied considerably in relative importance over time. Researchers since the early 1970s have implicated predation, starvation, flooding, disease, and drought as natural mortality factors. Shooting, trapping, poisoning, electrocution, road kills, and suffocation have been recognized as human-induced mortality factors (Grinnell et al. 1937, Morrell 1972, Egoscue 1975, Berry et al. 1987*a*, Ralls and White 1991, Ralls and White 1995, Standley et al. 1992).

By the 1950s the principal factors in the decline of the San Joaquin kit fox were loss, degradation, and fragmentation of habitats associated with agricultural, industrial, and urban developments in the San Joaquin Valley (Laughrin 1970, Jensen 1972, Morrell 1975, Knapp 1978). Extensive land conversions in the San Joaquin Valley began as early as the mid-1800s with the Arkansas Reclamation Act, and by 1958 an estimated 50 percent of the Valley's original natural communities had been lost (USFWS 1980*a*). In recent decades this rate of loss has accelerated rapidly with completion of the Central Valley Project and the State Water Project, which diverted and imported new water supplies for irrigated agriculture (USFWS in litt. 1995*a*). From 1959 to 1969 alone, an estimated 34 percent of natural lands were lost within the then-known kit fox range (Laughrin 1970). By 1979, only about 6.7 percent of the San Joaquin Valley floor's original wildlands south of Stanislaus County remained untilled and undeveloped (USFWS 1980*a*).

Such land conversions contribute to kit fox declines through displacement, direct and indirect mortalities, and reduction of prey populations.

Threats to Survival.—Loss and degradation of habitat by agricultural and industrial developments and urbanization continue, decreasing carrying capacity of remaining habitat and threatening kit foxes. Livestock grazing is not thought to be detrimental to kit foxes (Morrell 1975, Orloff et al. 1986), but may alter the numbers of different prey species, depending on the intensity of the grazing. Livestock grazing may benefit kit foxes in some areas (Laughrin 1970, Balestreri 1981), but grazing that destroys shrub cover and reduces prey abundance may be detrimental (O'Farrell et al. 1980, O'Farrell and McCue 1981, USFWS 1983, Kato 1986).

Petroleum field development in the southern half of the San Joaquin Valley affects kit foxes by habitat loss due to grading and construction for roads, well pads, tank settings, pipelines, and settling ponds. Habitat degradation derives from increased noise, ground vibrations, venting of toxic and noxious gases, and release of petroleum products and waste waters. Traffic-related mortality is also a factor for kit foxes living in oil fields. The cumulative and long-term effects of these activities on kit fox populations are not fully known, but recent studies indicate that areas of moderate oil development may provide good habitat for kit foxes, as long as suitable mitigation policies are observed (O'Farrell et al. 1980, Spiegel et al. in press). The impacts of oil activities at the Elk Hills Naval Petroleum Reserves in California on kit fox population density, reproduction, dispersal, and mortality appeared to be similar in developed and undeveloped areas of the Reserve (Berry et al. 1987*a*). The most significant impact on kit fox abundance in developed oil fields appears to be mediated through habitat loss. However, the relationship between habitat loss and population size in western Kern County is unclear: the Midway-Sunset oil field is highly developed with about 70 percent ground disturbance yet fox abundance is about 50 percent that of the undeveloped Lokern area (Spiegel et al. in press).

Other developments within the kit fox's range include cities and towns, aqueducts, irrigation canals, surface mining, road networks, non-petroleum industrial projects, power lines, and wind farms. These developments negatively impact kit fox habitat, but kit foxes may survive within or adjacent to them given adequate prey base and den sites. Kit foxes have been documented denning along canals and in levees (Jones and Stokes 1981, Hansen 1988), adjacent to highways (ESA Planning and Environmental Services 1986*b*, Hansen 1988), near wind farms (Hall 1983, Orloff et al. 1986), along power line corridors (Swick 1973), and at sanitary land fills (R. Faubion pers. comm.). Kit foxes also are known to live in and adjacent to towns such as Tulare (G. Presley pers comm.), Visalia (Zikratch pers. comm.), Porterville (Hansen 1988), Maricopa, Taft, and McKittrick (J.M. Sheppard pers. comm.) and the City of Bakersfield (Jones and Stokes 1981, B.L. Cypher pers. comm.). Bakersfield foxes (living in the Kern River Parkway) are reported to behave differently from animals in more remote populations: they often scavenge food from parking lots and dumpsters, have small foraging ranges, often are diurnal, and are relatively tame. This may be an expression of their ecological plasticity (e.g., Grinnell et al. 1937, p. 411, T. Murphy pers. comm., B.L. Cypher pers. comm.).

All these influences combine to compress and constrict the kit fox into fragmented areas, varying in size and habitat quality. The fragmentation of these areas coupled with the suspected high mortality during dispersal may limit movement to and habitat of these lands. As the human population of California continues to grow, the amount and quality of habitat suitable for kit foxes will inevitably decrease. Continued habitat fragmentation is a serious threat to the survival of kit fox populations.

The use of pesticides and rodenticides also pose threats to kit foxes. Pest control practices have impacted kit foxes in the past, either directly, secondarily, or indirectly by reducing prey. In 1925, near Buena Vista Lake, Kern County, seven kit foxes were found dead within a distance of 1 mile, having been killed by strychnine-poisoned baits put out for coyotes. It was suspected that hundreds of kit foxes were similarly destroyed in a single season (Grinnell et al. 1937). In 1975 in Contra Costa County (where the main prey item of kit foxes is the California ground squirrel), the ground squirrel was thought to have been eliminated county wide after extensive rodent eradication programs (Bell et al. 1994). In 1992, two kit foxes at Camp Roberts died as a result of secondary poisoning from rodenticides (Berry et al. 1992, Standley et al. 1992). The Federal government began controlling the use of rodenticides in 1972 with a ban of Compound 1080 on Federal lands pursuant to Executive Order. Above-ground application of strychnine within the geographic ranges of listed species was prohibited in 1988. Efforts have been underway to greatly reduce the risk of rodenticides to kit foxes (USFWS in litt. 1993).

Invasion and occupation of historical and potential kit fox habitats by nonnative red foxes may limit opportunities for kit foxes. Exclusion of kit foxes by competing red foxes, direct mortality, and potential for disease and parasite transmission all are issues that have not yet been researched. Therefore, we know neither the historical impacts to the kit fox, nor to what extent the continuing expansion of the range of nonnative red foxes will have on kit foxes.

Accidents and disease, though not well documented, are thought to play a minor role in kit fox mortality (USFWS 1983), however, at Camp Roberts rabies accounted for 6.3 percent of deaths of radio-collared kit foxes (Standley et al. 1992) and there is concern that rabies may be a contributing factor in the recent decline of kit foxes at Camp Roberts (P.J. White pers. comm.). Random catastrophic events such as drought or flooding present a significant threat. Drought, with a corresponding decline in prey availability, results in a decrease in kit fox reproductive success (White and Ralls 1993, Spiegel et al. in press). How extended periods of drought may affect kit fox populations is unclear, but local extinctions are likely in some isolated areas. Recently, small mammal populations have declined rapidly and severely, apparently due to the above average rainfall in the 1994-1995 precipitation year. In the Elk Hills region, relatively few pupping dens were found in 1995, and only a small proportion of kit fox pairs apparently raised pups (B.L. Cypher pers. comm., L.K. Spiegel pers. comm.).

5. Conservation Efforts

The San Joaquin kit fox was listed as endangered by the U.S. Department of the Interior in 1967 (USFWS 1967) and by the State of California in 1971 (Table 1). A recovery plan approved in 1983 proposed interim objectives of halting the decline of the San Joaquin kit fox and increasing population sizes above 1981 levels (USFWS 1983).

Conservation efforts subsequent to the 1983 recovery plan have included habitat acquisition by USBLM, CDFG, California Energy Commission, Bureau of Reclamation, USFWS, and The Nature Conservancy. Purchases most significant to conservation efforts were the acquisitions in the Carrizo Plain, Ciervo-Panoche Natural Area, and the Lokern Natural Area. A multi-agency acquisition is underway which would secure 60,000 acres straddling western Merced, Stanislaus, and eastern Santa Clara Counties. Other lands have been acquired as mitigation for land conversions, both temporary and permanent (Table 2). Mitigation in the form of management and research was granted to the California Energy Commission, U.S. Department of Energy (Naval Petroleum Reserves in California), Army National Guard (Camp Roberts), and Department of Defense (Fort Hunter Liggett). Most of the current research literature arises from these sources and The Smithsonian/Nature Conservancy-sponsored research on the Carrizo Plain Natural Area (White and Ralls 1993, White et al. 1994, Ralls and White 1995, White et al. 1996).

For over 15 years EG&G Energy Measurements has conducted research into the ecology of the kit fox population on the Naval Petroleum Reserves in California, Kern County. Reports have covered such topics as dispersal (Scrivner et al. 1987*b*), mortality (Berry et al. 1987*a*), and movements and home range (Zoellick et al. 1987*b*). Additionally, they have evaluated habitat enhancement, kit fox relocation, supplemental feeding (EG&G Energy Measurements 1992), and coyote control (Cypher and Scrivner 1992) as means of enhancing recovery. Other life history information has come from studies sponsored in whole or in part by CDFG, California Department of Water Resources, USFWS, Smithsonian Institution, Department of the Army and Air Force, California Energy Commission, and The Nature Conservancy (Hall 1983, Archon 1992, Spiegel and Bradbury 1992, White and Ralls 1993, White et al. 1994, 1996). Following the 1983 recovery plan, only three surveys for distribution have been conducted, two in the northern range of the fox (Orloff et al. 1986, Bell et al. 1994), and one in western Madera County (Williams 1990).

Large-scale habitat surveys have been conducted on the Carrizo Plain (Kato 1986, Kakiba-Russell et al. 1991) and the southern San Joaquin Valley (Anderson et al. 1991). A preliminary aerial survey for potential habitat was conducted along the east side of the Valley (Bell et al. 1994). There also have been numerous smaller-scale preproject surveys as part of the section 7 and 10(a) permit process of the Endangered Species Act, National Environmental Protection Act, and California Environmental Quality Act laws and regulations.

A population viability analysis was prepared for USFWS using RAMAS/a, a Monte Carlo simulation of the dynamics of age-structured populations (Buechner 1989). Since this analysis, deficiencies in the database have been identified and a metapopulation analysis has been completed (Kelly et al. 1995). This analysis, however, is preliminary and will be updated as new information is collected.

The U.S. Environmental Protection Agency County Bulletins governing use of rodenticides have greatly reduced the risk of direct mortality to San Joaquin kit fox populations by State and county rodent-control activities. The California Environmental Protection Agency, California Department of Food and Agriculture, county agricultural departments, CDFG, and U.S. Environmental Protection Agency collaborated with the USFWS in the development of County Bulletins that are both efficacious and acceptable to land owners (R.A. Marovich pers. comm.).

6. Recovery Strategy

Though the kit fox has been listed for over 30 years, its status throughout much of its current range is poorly known. This is partly because so much of its historical range in the San Joaquin Valley is in private ownership. Similar gaps in information are common to many of the other listed and candidate species being addressed in this recovery plan. However, recovery actions for the kit fox are also considered critical to the recovery of many of these other species in the San Joaquin Valley. The kit fox's occurrence in the same natural communities as most other species featured in this plan and its requirement for relatively large areas of habitat mean its conservation will provide an umbrella of protection for many of those other species that require less habitat. Therefore, a conservative recovery strategy is appropriate for this species and the following regional (or ecosystem level) recovery actions should be given high priority.

Given the importance and urgency of the situation, the recovery strategy for the kit fox needs to operate on two distinct but equally important levels: the continuation and expansion of recovery actions initiated subsequent to the original recovery plan using existing information; and, the development of new information in concert with expansion of existing information, which is currently inadequate for some aspects of recovery management.

Level A Strategy.—The goal of this strategy is to work toward the establishment of a viable complex of kit fox populations (i.e., a viable metapopulation) on private and public lands throughout its geographic range. Although the exact dimensions of a viable kit fox metapopulation cannot be predicted in advance, there are general principles from conservation biology that can and must be applied for recovery of the San Joaquin kit fox (with due consideration to the current, inadequate knowledge about the animal's life history, distribution, and status). Because kit foxes require large areas of habitat and have dramatic, short-term population fluctuations, one cannot rely on a single population to achieve recovery. Preliminary population viability analyses suggest that the Carrizo Plain population, the largest remaining, is not viable by itself nor is it viable in combination with populations in western Kern County and the Salinas Valley.

Conserving a number of populations, some much more significant than others because of their large sizes or strategic locations, therefore, will be a necessary foundation for recovery. The areas these populations inhabit need to encompass as much of the environmental variability of the historical range as possible. This will ensure that maximal genetic diversity is conserved in the kit fox metapopulation to respond to varying environmental conditions, and that one environmental event does not negatively impact to the same extent all existing populations. Also, connections need to be established, maintained, and promoted between populations to counteract negative consequences of inbreeding, random catastrophic events (e.g., droughts) and demographic factors.

A sound, conservative strategy hinges on the enhanced protection and management of three geographically-distinct core populations, which will anchor the spine of the metapopulation. A number of smaller satellite populations (number and location yet to be determined, probably 9 to 12 or more) will be fostered in remaining fragmented landscapes through habitat management on public land and conservation agreements with private land owners.

The three core populations are:

1. Carrizo Plain Natural Area in San Luis Obispo County;

2. Natural lands of western Kern County (i.e., Elk Hills, Buena Vista Hill, and the Buena Vista Valley, Lokern Natural Area and adjacent

natural land) inhabited by kit foxes; and

3. The Ciervo-Panoche Natural Area of western Fresno and eastern San Benito Counties.

These three core populations each are distinct. The western Kern County and Carrizo Plain populations, although geographically close, are separated by the Temblor Range. Although both locations have high fox densities from time to time, they also have different environmental conditions, which are reflected in the fact that their population dynamics are not always synchronous (B.L. Cypher pers. comm., Endangered Species Recovery Program unpubl. observ.). These differences amongst the core populations are important considerations in conservation planning. Also, preliminary population viability analyses indicate that extinction probabilities increase dramatically if either the Carrizo Plain or western Kern County population is eliminated. Finally, both of these locations have large amounts of land in public ownership, lowering the burden on private land owners to assist in recovery of the kit fox. The Carrizo Plain and western Kern County populations are important for kit fox recovery.

The Ciervo-Panoche Natural Area population is located more than 160 kilometers (100 miles) northwest of the other two core populations. As with the other core populations, it has significant numbers of foxes, at least it had historically and it still may from time to time, and large expanses of land are in public ownership. It also experiences a different environmental regime from the other two. Finally, preliminary metapopulation viability analyses indicate that recovery probabilities increase if a population is established or maintained in this area, apparently because of its different environmental regime.

In addition to basing the choice of these three core populations on the above criteria, this particular metapopulation configuration has an additional important advantage over combinations of other fox populations. These three populations are more or less connected to each other by grazing lands, although they are steep and rugged in many places. Kit foxes occur at varying densities in the areas between the core populations (e.g., Kettleman Hills), providing linkages between core populations, and also probably with smaller, more isolated populations in adjacent valleys.

Important kit fox populations in the Salinas-Pajaro Region (herein defined as the area of the Salinas River and Pajaro River watersheds with habitat for kit foxes; Figs. 1 and 51) are located at Camp Roberts and Fort Hunter Liggett in the Salinas River Watershed. Though there are natural connections between the Salinas-Pajaro Region, the Carrizo Plain Natural Area, and the San Joaquin Valley, the amount of movement of kit foxes between the Salinas-Pajaro Region and these areas is unknown, though one fox is known to have moved from Camp Roberts to the Carrizo Plain (K. Ralls pers. comm.).

Other lands in the San Joaquin Valley that have kit foxes, or the potential to have them, include refuges and other lands managed by the CDFG, California Department of Water Resources, Center for Natural Lands Management, Lemoore Naval Air Station, Bureau of Reclamation, and USFWS, as well as those on private lands in western Madera County, central, western, and eastern Merced County, eastern Stanislaus County, northern Kings County, around Pixley National Wildlife Refuge and Allensworth Ecological Reserve in Tulare County, Semitropic Ridge Natural Area and around the Bakersfield metropolitan area of Kern County (Figure 51).

Many of these more isolated natural lands exhibit symptoms of ecosystem fragmentation such as degradation of natural communities and loss of biodiversity. Nevertheless, some fragments have resident kit foxes by virtue of their proximity to other populations, and others serve as important corridors between kit fox populations. For example, the California Department of Water Resources's Kern Fan Element provides an important linkage between kit foxes along the Kern River Parkway in Bakersfield and the western Kern County core population.

Yet, many of these areas, despite having suitable habitat, have become so degraded over time, reduced in size, and isolated from extant kit fox populations that they rarely have kit foxes today. When they do, these small, isolated populations are very susceptible to local extinction. It is likely that the degree of isolation from larger, more stable kit fox populations is the primary reason for absence or very low densities of kit foxes on some of the larger parcels of natural land remaining on the Valley floor (e.g., central Merced County, western Madera County, and the Mendota area, Fresno County; Williams 1990).

Connecting larger blocks of isolated natural land to core and other populations, thus, is an important element of recovery of kit foxes. Connecting large blocks will help reduce the harmful effects of habitat loss and fragmentation. To enhance these connections, conservation lands on the Valley floor could be increased in size through acquisition of title or conservation easements, or a combination of both.

Another complementary approach is to reduce the level of isolation by promoting conservation of kit foxes on agricultural lands through "safe harbor" and other initiatives. New procedures and regulations must ensure that farmers are not penalized and farming not disrupted by enhancing use of farmland by kit foxes. The goal should be specific incentive programs to encourage farmers to maintain, enhance, or create habitat conditions for kit foxes. The ideal situation would be to establish a small number of breeding kit foxes in farm lands. A proposal to address habitat fragmentation in this way has already been developed by the American Farmland Trust (Scott-Graham 1994). Those lands could then serve as bridges between the more isolated refuges and reserves and the larger populations along the spine of the metapopulation, on the west side of the San Joaquin Valley.

Concurrently, strategic retirement of agricultural lands that have serious drainage problems will help reduce the effects of widespread habitat fragmentation of populations. Land retirement for reducing or eliminating drainage problems has been authorized by both State and Federal governments. In particular, the Central Valley Project Improvement Act of 1992 has provisions and funding for such land retirement. If land retirement proves not to pose a contaminant issue, the program can greatly boost recovery of kit foxes and other listed species and species of concern in the San Joaquin Valley. If large blocks (ideally, no less than 2,023 to 2,428 hectares [5,000 to 6,000 acres]) of drainage-problem lands are retired from irrigated agriculture, the retired farmland can be converted to habitat for kit foxes, kangaroo rats, blunt-nosed leopard lizards, and other listed and sensitive species. Those land blocks can provide more than just habitat. They can also reduce isolation and its detrimental effects. If strategically located, they can provide "stepping stones" for movement of kit foxes between Valley floor and west side populations. Strategic irrigated land retirement and subsequent establishment as habitat conservation areas is the most cost effective and rapid route to recovery of kit foxes.

Level B Strategy.—While land retirement and habitat restoration and management get under way, other urgent recovery needs, which are primarily research-related or informational in nature, must be addressed. The acquisition of new and better information will permit refinement of the viability models and land-use optimization models that are under development for the kit fox. In turn these models will assist in management of kit fox populations.

Needed is information on distribution and status throughout most of its current and historical range. Much better information on the distribution, status and movements of kit foxes is needed, particularly in the Salinas-Pajaro Region and the northern and eastern San Joaquin Valley.

Good data also are needed on the use of agricultural lands by kit foxes. Better demographic information is needed for kit foxes living in natural, agricultural, residential, and industrial lands throughout their range. Most of the existing data are for the southern part of the Valley where the environmental regime is more arid, and destruction of former fox habitat has been much more recent. Better data on the relationship between prey populations and kit fox population dynamics also are needed. A better understanding is needed of how kit foxes interact with red foxes, the indirect impacts of rodenticide use, and the influence of predator control activities.

Recovery Actions.—Recognizing that recovery requires a dual track with simultaneous actions, recovery actions are ordered in two lists, each of approximately equal priority to the other: a) habitat protection and population interchange, and, b) population ecology and management. Habitat protection and enhancement requires appropriate land use and management. To do so often requires purchase of title or conservation easement, or another mechanism of controlling land use. However, until needed research is completed, if listed species occur on an acquired parcel, the general rule of thumb should be that no dramatic changes in land use be made until appropriate management prescriptions have been determined. Many elements of management must first be determined by scientific research; thus the concept of adaptive management (monitoring and evaluating outcomes, then readjusting management directions accordingly) is operative here. A high priority therefore is the research required to determine appropriate habitat management and other recovery actions.

a. Habitat Protection and Population Interchange:

i. Protect natural lands in western Kern County.

ii. Protect natural lands in the Ciervo- Panoche Natural Area of western Fresno and eastern San Benito Counties.

iii. Expand and connect existing refuges and reserves in the Pixley-Allensworth and Semitropic Ridge natural areas through acquisition of existing natural land and farmland with drainage problems, and by safe harbor initiatives.

iv. Expand and connect (physically or by "stepping stones") existing natural land in the Mendota area, Fresno County, with the Ciervo-Panoche Natural Area, through restoration of habitat on retired, drainage-problem farmland.

v. Maintain and enhance connecting corridors for movement of kit foxes between the Kettleman Hills and the Valley's edge through the farmed gap between the Kettleman and Guijarral Hills, and between the Guijarral Hills and Anticline Ridge.

vi. Maintain and enhance connecting corridors for movement of kit foxes around the western edge of the Pleasant Valley and Coalinga in Fresno County, and between this area and natural lands on the western edge of the Coastal Range in Kings and Kern Counties.

vii. Maintain and enhance movement of kit foxes through agricultural land between the Lost Hills area and the Semitropic Ridge Natural Area by strategic retirement of drainage-problem farmland, acquisition, and safe harbor initiatives.

viii. Maintain and enhance habitat and movement corridors around the south end of the Valley between the Maricopa area on the west and Poso Creek area on the northeast through easements, zoning agreements, and safe harbor initiatives. One south Valley component is already in place. Kern Fan Element provides valuable conservation lands that serve as an important bridge between the Bakersfield area and the Elk Hills-Lokern core area. This design is being maintained by the new project owners, the Kern Water Bank Authority.

ix. Maintain and enhance movement of kit foxes between the Mendota area, Fresno County, natural lands in western Madera County, and natural lands along Sandy Mush Road and in the wildlife refuges and easement lands of Merced County. Specifically, maintain and enhance the Chowchilla or Eastside Bypass and natural lands along this corridor through acquisition, easement, or safe harbor initiatives.

x. Link natural lands in the Sandy Mush Road area of Merced County with the population of kit foxes on natural lands to the east by a safe harbor initiative on farmland.

xi. Protect natural land on the eastern base of Ortigalita Mountain and maintain and enhance a potential movement corridor through farmland between the base of Ortigalita Mountain, Merced County, and natural land to the north along the edge of the Diablo Range through Santa Nella by zoning and cooperative safe harbor initiatives.

xii. Protect and enhance existing kit fox habitat in the Salinas-Pajaro Region, centered on Camp Roberts and Fort Hunter Liggett.

xiii. Protect and enhance corridors for movement of kit foxes through the Salinas-Pajaro Region and from the Salinas Valley to the Carrizo Plain and San Joaquin Valley.

xiv. Protect existing kit fox habitat in the northern, northeastern, and northwestern segments of their geographic range and existing connections between habitat in those areas and habitat farther south.

b. Population Ecology and Management:

i. Determine habitat restoration and management prescriptions for kit foxes. Such studies should focus on factors that promote populations of prey species, including several that are included in this recovery plan. Appropriate habitat management for those species is one of the highest priority issues in their recovery, and thus, indirectly in recovery of kit foxes.

ii. Determine current geographic distribution and population status of kit foxes, with special emphasis on potential habitat in eastern Madera, Merced, Stanislaus, and San Joaquin Counties and the Salinas-Pajaro Region.

iii. Establish a scientifically valid population monitoring program range-wide at representative sites, and periodically monitor the status of these populations.

iv. Determine use of farmland by kit foxes. Studies should determine types of crops and cultural practices providing foraging habitat; structures and landscape features providing denning opportunities and promoting movement of kit foxes through agricultural land and between natural and agricultural land; demography of kit foxes in agricultural land; and red fox/kit fox interactions in an agricultural setting (the latter topic is discussed further in a subsequent action).

v. Measure population movements between the three core areas and the Salinas-Pajaro Region through genetic investigations and expansion and coordination of existing population studies. Ongoing studies at Elk Hills (Naval Petroleum Reserve #2 in California - U.S. Department of Energy and its contractors, and Occidental of Elk Hills - Occidental Petroleum), Fort Hunter Liggett (U.S. Army), Camp Roberts (CA Army National Guard), and the Panoche Region (Endangered Species Recovery Program, USFWS, Bureau of Reclamation), should be expanded and their objectives redefined and coordinated. An additional population study should be initiated on the Carrizo Plain Natural Area and coordinated with these other studies. Important common objectives of all studies should be: population estimates applicable to each region and not just the facility (e.g., western Kern County, Salinas-Pajaro Region); dispersal distance and success; fluctuations in vital rates and spatial parameters of populations compared to environmental fluctuations (i.e., population demography, including reproduction, mortality, survivorship, recruitment into the population and dispersal); and interactions of canid species (i.e., kit foxes, red foxes, coyotes, free-ranging dogs).

vi. Determine direct and indirect effects of rodent and rabbit control programs on kit foxes, and the economic costs and benefits of control programs versus kit fox enhancement programs for controlling ground squirrels and rabbits.

vii. Measure genetic features and degree of isolation of agricultural "island" populations and effective population movement between core populations using DNA techniques.

viii. Determine the nature of interactions between kit foxes, red foxes, coyotes, and free-ranging dogs on both farmland and grazing land. One element of this study should be to determine which fox species benefits more from enhancement of farmland habitat for wildlife, and what this means to survival of kit fox populations in farmland. Another element should be to determine if coyote control benefits red foxes to the detriment of kit foxes.

M. State Listed, Federal Candidates and Other Animal Species of Concern

1. Dune Community Insects

Three species of sand-dwelling beetles are not candidates for listing, but are of special interest. Though each has a different pattern of distribution, all occur in similar, rare habitats in the northwestern portion of the San Joaquin Valley. There are several common elements in their recovery, particularly protecting their habitats and learning more about distribution, life history, and population status. First, individual accounts are presented, then a composite conservation strategy is presented for them and their supporting biotic communities.

a. Ciervo Aegialian Scarab Beetle (*Aegialia concinna*)

Taxonomy.—The Ciervo aegialian scarab beetle (*Aegialia concinna*) was described by Gordon and Cartwright (1977) from the type locality 29 kilometers (18 miles) southwest of Mendota, Fresno County, California. This beetle is a member of the Order Coleoptera, the Family Scarabaeidae, Subfamily Aphodiinae, and Tribe Aegialiini (Gordon and Cartwright 1988).

Description.—The Ciervo aegialian scarab beetle is a flightless, pale brownish-yellow to reddish-brown beetle, with the upper surface always paler than the underparts (Figure 52). This beetle ranges in length from 3.25 to 4.0 millimeters (0.13 to 0.15 inch), and from 1.70 to 2.0 millimeters (0.07 to 0.08 inch) in width (scientific measurement of insects is universally in metric units).

The small size, pale color, and slender, smooth hind legs distinguish the Ciervo Aegialian scarab beetle from others in the same genus (Gordon and Cartwright 1977, 1988).

Historical and Current Distribution.—The Ciervo aegialian scarab beetle is known from only four localities in Contra Costa, Fresno, and San Benito Counties (Gordon and Cartwright 1988), and San Joaquin County (USFWS in litt. 1992*a*) (Figure 53).

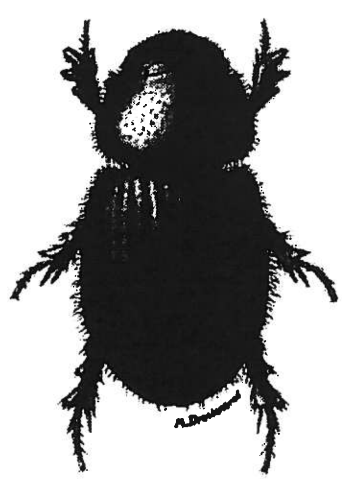

Fig. 52. Drawing of the Ciervo aegialian scarab beetle (*Aegialia concinna*). Adapted from Gordon and Cartwright, 1977.

Life History and Habitat.—Little is known about the specific life history and habitat of the Ciervo aegialian scarab beetle. In general, beetles of the Family Scarabaeidae, Subfamily Aphodiinae, eat dung and other decaying organic materials. Most adults tunnel and form a dung ball underground for larva. Some larvae live in soil or sand, feeding on organic materials or plant roots (White 1983). The Ciervo aegialian scarab beetle has been associated with Delta and inland dune systems, and sandy substrates (Gordon and Cartwright 1988, Miriam Green Associates 1993). Plant associations specific to this species are unknown.

Reasons for Decline and Threats to Survival.—Suitable habitats for species associated with dune systems in the San Joaquin Valley are limited and highly fragmented. Dune systems have been destroyed or severely degraded by agricultural development, flood control, water management, and off-road vehicle use (Gordon and Cartwright 1977, Miriam Green Associates 1993). As a result, populations of the Ciervo aegialian scarab beetle are locally isolated, making them highly vulnerable to disturbances.

b. San Joaquin Dune Beetle (*Coelus gracilis*)

Taxonomy.—The genus *Coelus* Eschscholtz, 1829, of the family Tenebrionidae (Coleoptera, Tentyriinae) includes five species of burrowing beetles that are mostly restricted to sand dunes in western coastal states of North America. The San Joaquin dune beetle (*Coelus gracilis*) was described by Blaisdell (1939) from the specimen type collected near Antioch, Contra Costa County, California.

Description.—The San Joaquin dune beetle is the smallest species (average body length) of dune beetles, with the male beetle averaging about 85 percent the size of the female (Doyen 1976). In general, the body is sturdy, inflated on top, and ranges in color from pale yellowish-brown to dark brownish-black (Figure 54).

Historical and Current Distribution.—The San Joaquin dune beetle historically inhabited inland sand dunes from Antioch, Contra Costa County, in the north to the Kettleman Hills, Kings County, in the south (Figure 53) (Doyen 1976). Currently, this beetle is restricted to small isolated sand dunes (250 to 10,000 square meters; 275 to 11,000 square yards) along the western edge of the