ENHANCEMENT OF SATELLITE AND LINKAGE HABITATS TO PROMOTE SURVIVAL, MOVEMENT, AND COLONIZATION BY SAN JOAQUIN KIT FOXES

PREPARED FOR THE U.S. BUREAU OF RECLAMATION
SOUTH-CENTRAL CALIFORNIA AREA OFFICE
1243 N STREET, FRESNO, CA 93721
AGREEMENT NO 07FG200141

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January 18, 2011

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EXECUTIVE SUMMARY

Due to profound habitat loss and fragmentation throughout its range, the endangered San Joaquin kit fox (*Vulpes macrotis mutica*) persists in a meta-population consisting of 3 "core" and several smaller "satellite" populations. Connectivity between these populations is variable, and genetic and demographic exchange between many areas may be inhibited by suboptimal conditions within linkage habitats. Such conditions can lead to local population extirpation with limit opportunity for recolonization, particularly within the smaller satellite areas.

Dens are a critical habitat component for kit foxes. In areas where kit foxes occur in low densities or only intermittently, natural dens tend to absent or rare. Kit foxes readily use artificial dens, and the installation of such dens can increase survival, movement, and colonization potential in satellite and linkage areas. This will reduce extinction potential for kit foxes and contribute significantly to recovery and long-term conservation.

In 2008 and 2009, we collaborated with managers of conservation lands to install artificial dens for kit foxes in satellite and linkage areas. A total of 110 artificial dens of 2 designs were installed in 6 areas, and in 2010, materials for another 25 dens were provided to managers at another site. The installation sites were located in Merced, Tulare, and Kern Counties. Collaborators supported this effort through contributions of funding, staff time, field equipment, and administrative support. The installation of artificial dens hopefully will facilitate kit fox movement between populations thereby increasing occupancy rates and population persistence and contributing to range-wide recovery efforts.

ACKNOWLEDGMENTS

The U.S. Bureau of Reclamation provided funding for this project. Additional support was provided by the U.S. Bureau of Land Management. Field equipment and staff were provided by the U.S. Bureau of Land Management, U.S. Fish and Wildlife Service, and California Department of Parks and Recreation. We greatly appreciate the efforts of Steve Laymon, Carl Kraft and Kimberly Cuevas of the U.S. Bureau of Land Management; Erin Tennant and Jake Smith of the California Department of Fish and Game; Pam Williams and Andy Curtsinger of the U.S. Fish and Wildlife Service; Joanne Carlton and Glyne Johnson of California Department of Parks and Recreation; Ned Gruenhagen of the U.S. Bureau of Reclamation; Greg Warrick and Deborah Rogers of the Center for Natural Lands Management; and Christine Van Horn Job, Craig Fiehler, Samantha Bremner-Harrison and Graham Biddy of California State University-Stanislaus, Endangered Species Recovery Program. Dave Germano arranged storage space for den materials at the Facility for Animal Care and Treatment at California State University-Bakersfield.

INTRODUCTION

The historic range of the San Joaquin kit fox (*Vulpes macrotis mutica*) extended from southern Kern County north to eastern Contra Costa County and eastern Stanislaus County (U.S. Fish and Wildlife Service 1998). It is listed as Federally Endangered and California Threatened, primarily due to profound habitat loss and degradation throughout its range. Remaining habitat is significantly fragmented and kit foxes currently persist within 3 "core areas" and a number of "satellite areas" (U.S. Fish and Wildlife Service 1998). The current population structure may best be described as that of a meta-population (Schwartz et al. 2005). Maintaining genetic and demographic exchange between these areas is critical to long-term viability of kit foxes in the San Joaquin Valley.

Core areas support self-sustaining populations that exhibit high degrees of genetic robustness and temporal stability, whereas satellite areas typically exhibit lower population numbers and levels of genetic diversity and are generally more susceptible to environmental stochasticity and localized extinction events. Thus, satellite populations probably rely heavily on movement corridors to sustain gene flow or even recolonization via dispersal of individual foxes.

Large-scale human development of the central valley has not only resulted in the loss and fragmentation of important core habitat, but also in a reduction of the quality and availability of satellite and linkage habitat. Loss of linkage habitat may be a factor in the failure of at least two satellite areas to be recolonized following catastrophic population declines. Fox populations have yet to reestablish at the Camp Roberts Army National Guard Base in San Luis Obispo county following a possible disease epidemic in the mid-1990s (White et al. 2000), or in the Pixley-Allensworth area in Tulare County following a precipitous crash in kangaroo rat abundance in the late 1990s (California Department of Fish and Game, unpublished data). The maintenance of suitable corridor habitat for kit foxes is identified as an essential goal in multiple tasks in the recovery plan for the San Joaquin kit fox (U.S. Fish and Wildlife Service 1998).

Den availability may be a significant impediment to use of satellite and linkage areas by kit foxes. Dens are a critical habitat component for kit foxes. Kit foxes use dens on a daily basis for daytime resting, avoiding temperature extremes, conserving body water, avoiding predators, and bearing and rearing young. Kit foxes establish dens throughout their home ranges and each fox uses 11different dens per year on average (Koopman et al. 1998). In satellite and linkage areas, kit foxes may occur at low densities or only intermittently. Thus, dens may be in low abundance or even absent. This is particularly true in linkage areas that may be used only during annual or even multi-annual dispersal events, and in satellite areas where kit foxes are extirpated. Low den availability could severely inhibit kit fox survival, movement, recolonization, and reproductive success in these areas.

The installation of artificial dens in satellite and linkage areas could significantly enhance use of these areas by kit foxes. Based on previous research conducted by the California State University-Stanislaus, Endangered Species Recovery Program (ESRP), kit foxes readily use artificial dens, including for rearing young (Bjurlin et al. 2005; B. Cypher, ESRP, unpublished data). Thus, installing these dens would constitute a significant habitat enhancement that

could facilitate movements between areas, recolonization of areas, and survival and reproduction within these areas. This will provide further security for fox populations and provide connectivity between populations.

The goal of this project was to enhance habitat for San Joaquin kit foxes in satellite and linkage areas by installing artificial dens. Such enhancement will hopefully facilitate use of these areas by kit foxes thereby increasing genetic and demographic exchange between populations and also population persistence and viability in satellite areas. If successful, these actions will increase the security and long-term viability of the San Joaquin kit fox meta-population.

METHODS

We originally identified 15 sites for potential installation of artificial kit fox dens (Figure 1, Table 1). These sites all occur on lands managed for conservation and are within satellite or linkage areas for kit foxes (U.S. Fish and Wildlife Service 1998). Most sites are on public lands.

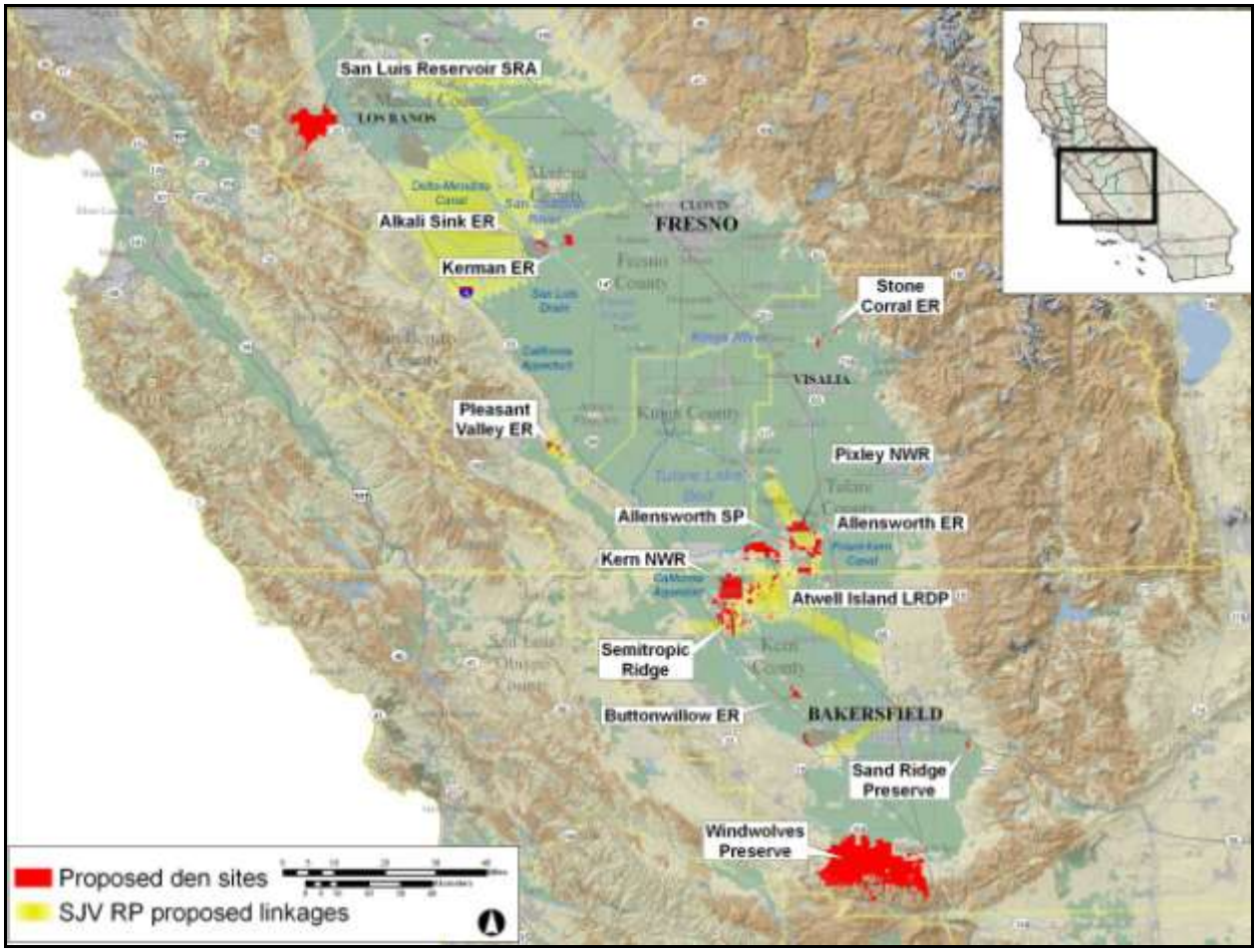

Figure 1. Proposed locations for the installation of artificial dens for San Joaquin kit foxes relative to proposed habitat linkages in the recovery plan (U.S. Fish and Wildlife Service 1998).

Table 1. Proposed locations for the establishment of artificial dens for San Joaquin kit foxes. Locations are shown in Figure 1.

Location[1]	County	Landowner[2]	Type Area
San Luis Reservoir SRA	Merced	CDPR	Linkage
Alkali Sink ER	Fresno	CDFG	Satellite
Kerman ER	Fresno	CDFG	Satellite
Pleasant Valley ER	Fresno	CDFG	Linkage
Stone Corral ER	Tulare	CDFG	Linkage
Allensworth ER	Tulare	CDFG	Satellite
Allensworth SP	Tulare	CDPR	Satellite
Pixley NWR	Tulare	USFWS	Satellite
Atwell Island LRDP	Tulare/Kings	BLM	Linkage
Kern NWR	Kern	USFWS	Satellite
Buttonwillow ER	Kern	CDFG	Linkage
Tule Elk SR	Kern	CDPR	Linkage
Windwolves Preserve	Kern	WC	Linkage
Sand Ridge Preserve	Kern	CNLM	Linkage
Semitropic Ridge	Kern	CDFG/CNLM	Satellite

[1] SRA = State Recreation Area, ER = Ecological Reserve, SP = State Park, NWR = National Wildlife Refuge, LRDP = Land Retirement Demonstration Project, SR = State Reserve

[2] CDPR = California Department of Parks and Recreation, CDFG = California Department of Fish and Game, USFWS = U.S. Fish and Wildlife Service, BLM = U.S. Bureau of Land Management, WC = Wildlands Conservancy, CNLM = Center for Natural Lands Management.

Two types of dens were installed: subterranean chambered and surface escape dens (Figure 2, Figure 3). Subterranean dens consisted of an underground chamber accessed by 2 tunnels and are designed to encourage long-term habitation by kit foxes. The chamber consisted of a commercial irrigation valve box buried approximately 1-m deep with access holes cut into opposite sides. The floor of the chamber was bare earth. The tunnels consisted of 3-m lengths of 20-cm diameter high-density polyethylene pipe (single-walled leech line) which connected the chamber with the ground surface. The interior of the pipe was corrugated and afforded traction for ease of ascent. Surface escape dens are designed for easy access and provide kit foxes a temporary refuge from predators. Escape dens consisted of 3-m lengths of 20-cm diameter high-density polyethylene pipe placed on the surface of the ground. These pipes were covered with approximately 0.5 m of soil to secure the dens in place and provide some thermal insulation.

To discourage entry by kit fox predators, particularly coyotes (*Canis latrans*) and red foxes (*Vulpes vulpes*), sections of rebar were placed vertically in front of the entrances of dens such that the entrances were reduced to a width of 10-12 cm. This still allowed entry by kit foxes but should inhibit entry by larger predators.

Generally, subterranean dens were only used in areas that were not subject to seasonal flooding, where soil type allowed easy excavation, and prey sign was evident. These areas were usually classed as satellite habitats that could potentially support kit foxes for extended periods of time. Surface dens were installed along with chambered dens in satellite habitats and also in linkage areas to facilitate safe passage.

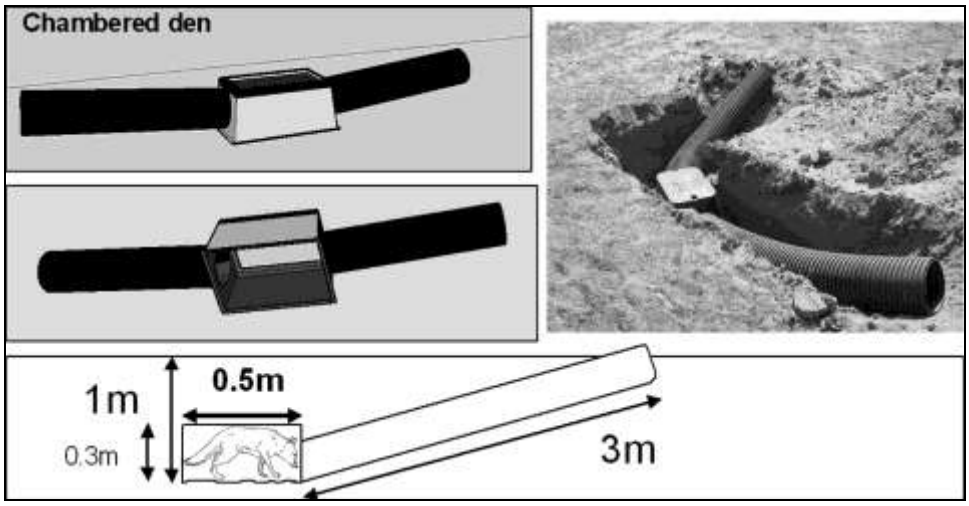

Figure 2. Schematic and field example of subterranean chambered den for kit foxes.

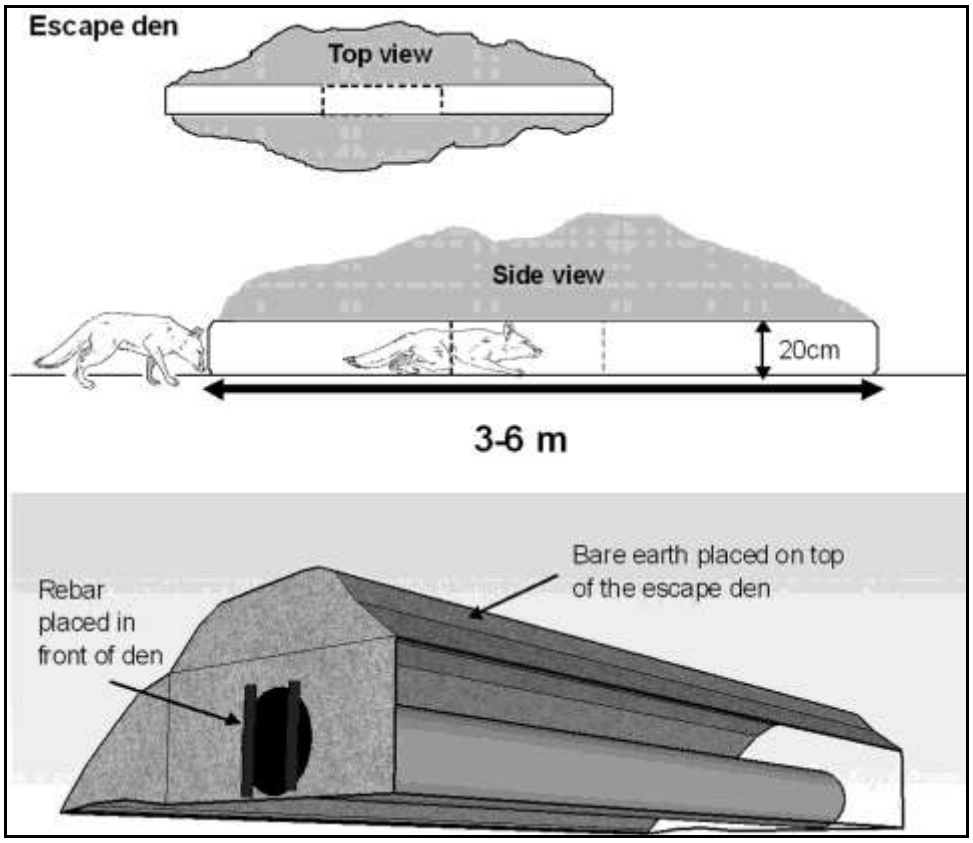

Figure 3. Schematic and field example of surface escape den for kit foxes.

RESULTS

In 2008 and 2009, 110 artificial dens were installed for kit foxes at six project sites (Table 2, Figure 4, Appendix A). In addition, materials for another 25 chambered dens were provided to The Wildlands Conservancy, which then installed the dens at the Wind Wolves Preserve in 2010.

Den installations had been proposed for 5 additional CDFG ecological reserves. However, CDFG subsequently requested that den installations be focused in the region between the Semitropic and Allensworth Ecological Reserves in northern Kern County and southern Tulare County. The CDFG recently has acquired numerous properties in this area through the Metropolitan Bakersfield Habitat Conservation Plan in an effort to create a linkage between these 2 ecological reserves. Many of these properties are fallow agricultural lands with few if any suitable dens for kit foxes. Thus, installing artificial dens in these areas significantly enhanced the habitat quality for kit foxes.

The installation of dens also had been proposed for 2 state parks and a second national wildlife refuge. However, the decision was made to focus den installation efforts on the Kern National Wildlife Refuge, and the California Department of Parks and Recreation was unable to secure internal approvals necessary for installing dens on park lands.

Table 2. Artificial dens installed for San Joaquin kit foxes by region and site.

			Dens		
Region	**Site**	**Date**	**Chambered**	**Escape**	**Total**
Northern San Joaquin Valley	San Luis Reservoir SRA	2008	7	-	7
Tulare Lake Basin	Allensworth Ecological Reserve	2009	5		5
	Atwell Island LRDP	2008	17	37	54
	Kern NWR	2008	6	8	14
	Semitropic Ecological Reserve	2008	5	14	19
Southern San Joaquin Valley	Sand Ridge Preserve	2008	4	7	11
Total			**44**	**66**	**110**

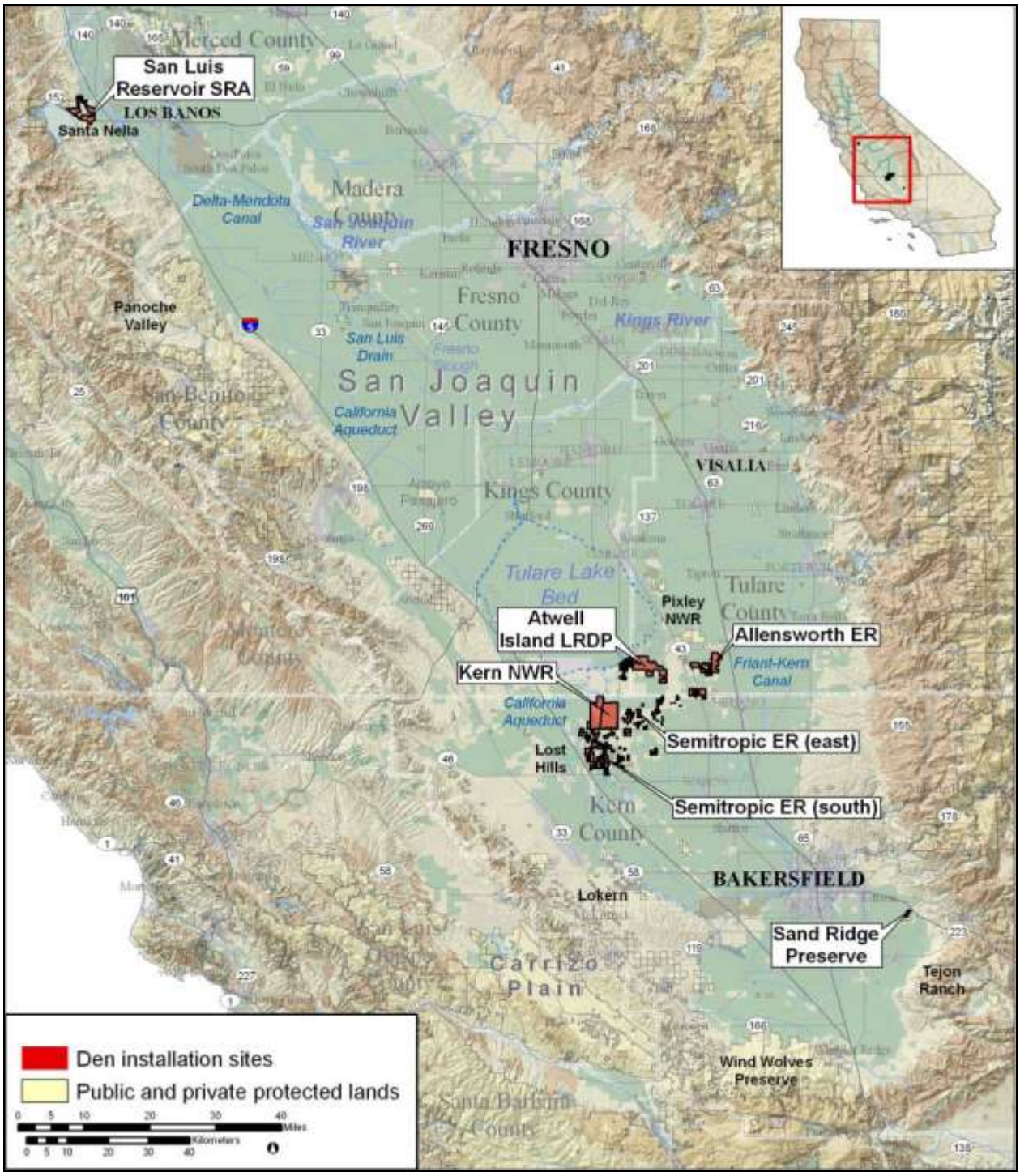

Figure 4. Sites where artificial dens for San Joaquin kit foxes were installed.

INSTALLATION SITES

Atwell Island Land Retirement Demonstration Project (LRDP)

Atwell Island LRDP consists of ca.7,000 acres of restoration land managed by the U.S. Bureau of Land Management. It is located south of the town of Alpaugh, Tulare County, and is proximal to the Pixley National Wildlife Refuge, Kern National Wildlife Refuge and Allensworth State Historic Park and Ecological Preserve (Figure 4).

A total of 9 areas of Atwell island LRDP were identified as potential sites for the installation of artificial kit fox dens (Figure 5, Figure 6). Dens installed included a mixture of chambered subterranean and surface escape dens. The most optimal potential kit fox habitat was located in Area 7 (Figure 6) with a good prey base, (established population of Tipton's kangaroo rats; *Dipodomys nitratodies nitratodies*) and a ridge of light sandy soil that was ideal for den excavation. Areas 8 and 9 (Figure 6) also possessed good soil structure but are not at present known to support kangaroo rat populations. A total of 17 chambered dens and 37 escape dens were installed throughout the Atwell Island LRDP site (Figure 6).

Dens were situated in such a way as to encourage any kit foxes dispersing onto the Atwell Island LRDP site to safely pass through (and not remain in) Areas 1-6, using escape dens as cover from predators. A concentration of chambered dens in the northwestern and western regions of the site could potentially encourage foxes to establish home ranges in these more suitable areas (Areas 7-9).

The Atwell Island LRDP provided additional funding which resulted in a larger number of dens being installed on that area. Also, Atwell Island LRDP provided field staff and a backhoe with operator, which greatly facilitated installation efforts.

Figure 5. Chamber and escape den installation at Atwell Island LRDP, Tulare County, CA.

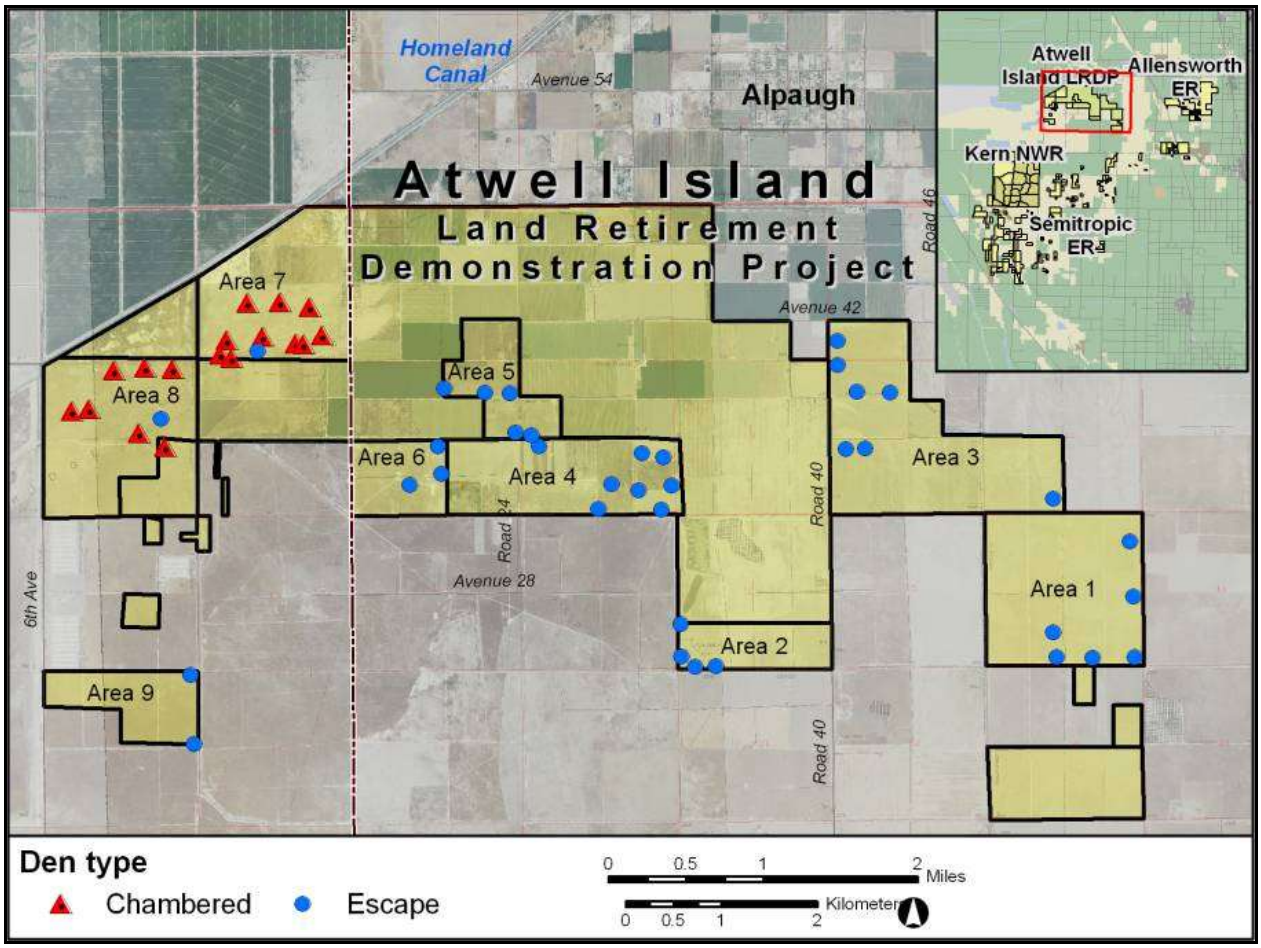

Figure 6. Location of artificial kit fox dens at Atwell Island LRDP, Tulare County, CA.

Kern National Wildlife Refuge

Kern National Wildlife Refuge is located approximately 32 km west of the city of Delano in northwestern Kern County, California (Figure 4). It is approximately 4,552 ha in size. For a detailed description of the vegetative cover of the site, see Tomlinson et al. 2008. Goose Lake canal provides a linear structure that bisects the Refuge in an approximately north/south direction. Portions of the Refuge adjacent to the canal are seasonally flooded to create wetland habitat for wildfowl.

Dry Nahrub clay and Nahrub clay-Lethent Silt Loam complexes that are relatively easy to excavate dominate the northwestern portions of the Refuge, including Unit 15 (Figure 8). In addition, Heerman's Kangaroo rats (*Dipodomys heermanni*) have been trapped on Unit 15, (Tomlinson et al. 2008) and were observed during the pre-den installation survey (Harrison, personal observation).

A total of 8 escape dens were installed on the western side of Goose Lake Canal adjacent to the southern boundary of Unit 15 to facilitate movement of dispersing foxes into the more desirable northern portions of the refuge. The installation of chambered dens (6) was limited to suitable habitat located in Unit 15 and 3 sites in the northwestern portion of the refuge (Figure 7, Figure 8).

Kern NWR provided staff, a backhoe, and a backhoe operator to assist with den installation efforts.

Figure 7. Installation of a chambered den on unit 15, Kern NWR, Kern County, CA.

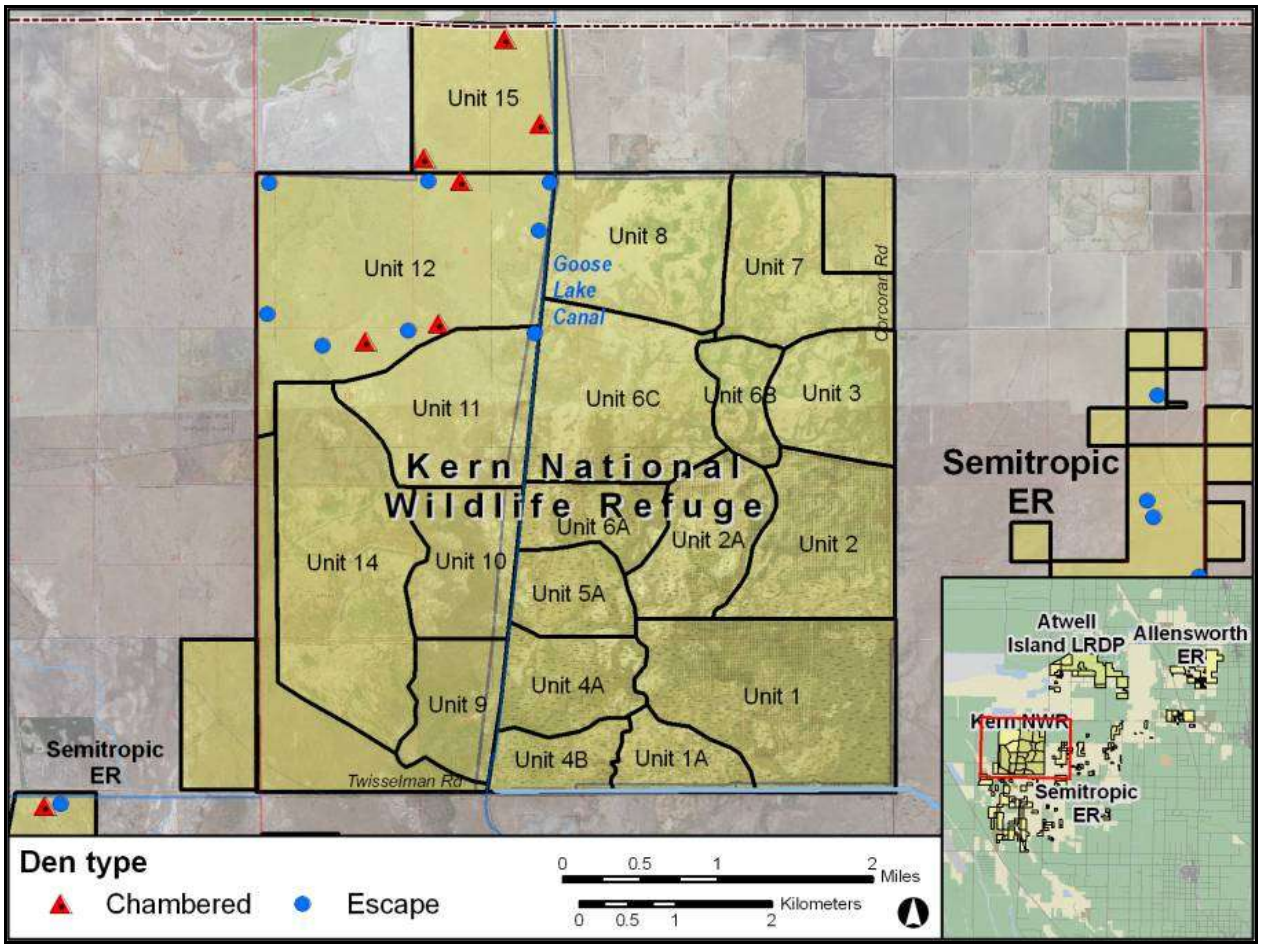

Figure 8. Locations of artificial kit fox dens at Kern National Wildlife Refuge, Kern County, CA.

Semitropic Ridge

Installation of artificial kit fox dens on lands managed by the California Department of Fish and Game was focused on those parcels in the Semitropic Ridge area purchased through the Metro Bakersfield Habitat Conservation Plan (MBHCP). These lands would facilitate kit fox movement between the Semitropic and Allensworth Ecological Reserves. The area is generally flat due to historic farming practices and is prone to seasonal flooding. As with KNWR, soil types in low-lying area are largely comprised of compacted heavy clay complexes. Low-lying vegetative structure is dominated by iodine bush (*Allenrolfea occidentalis*) and seepweed (*Suaeda spp.*).

A total of 14 escape dens and 10 chambered dens were installed on these properties at three distinct locations: Semitropic Ecological Reserve south of Kern NWR (Figure 9),Semitropic Ecological Reserve along the Garces Highway (Figure 11) and Allensworth Ecological Reserve (Figure 12). Chambered dens were installed in areas of high ground with abundant signs of rodent activity (Figure 10).

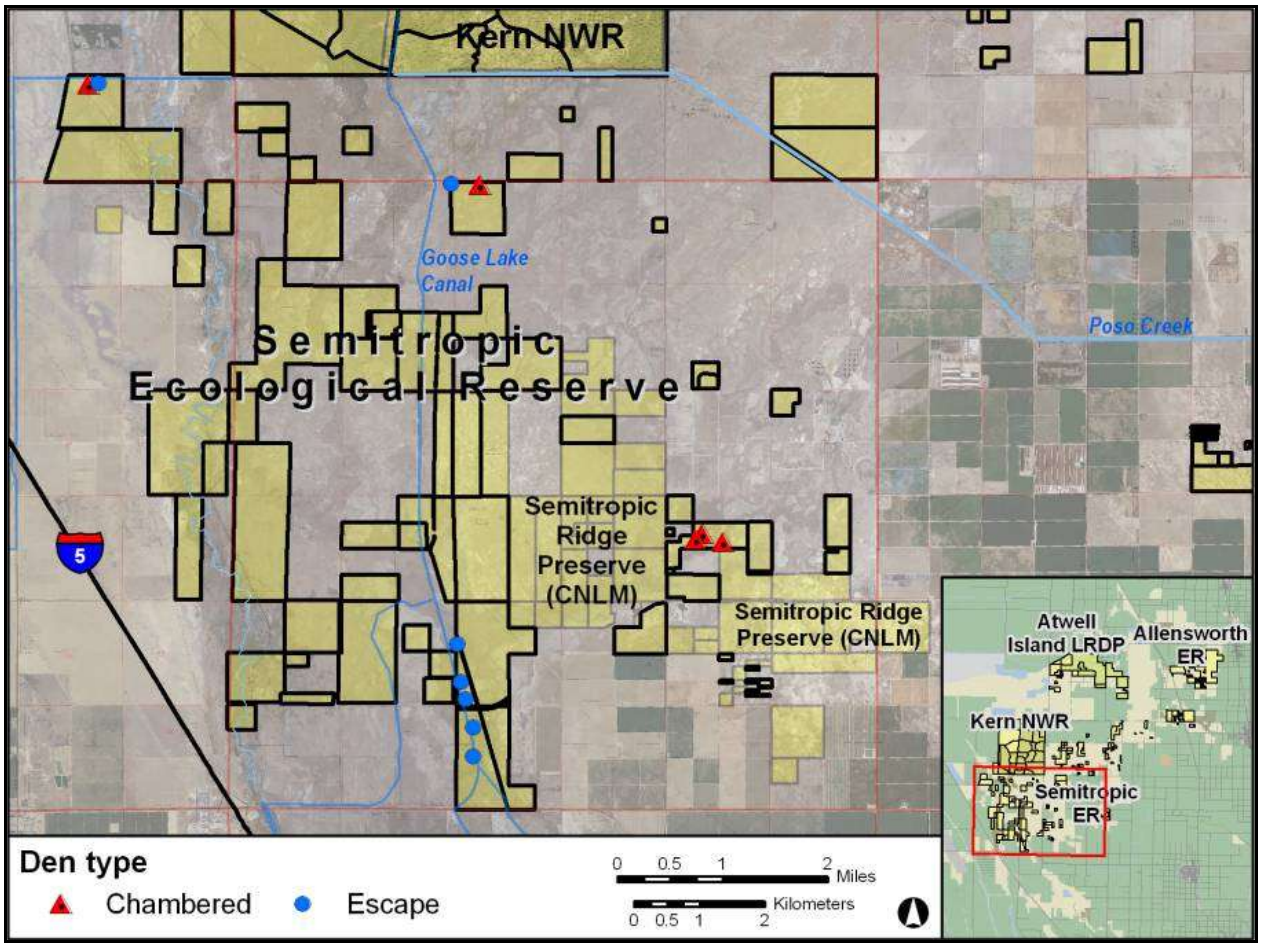

Figure 9. Location of artificial kit fox dens installed on CDFG lands in the southern part of the Semitropic Ecological Reserve, Kern County, CA.

Figure 10. Installation of chambered dens in the Semitropic Ecological Reserve area, Kern County, CA.

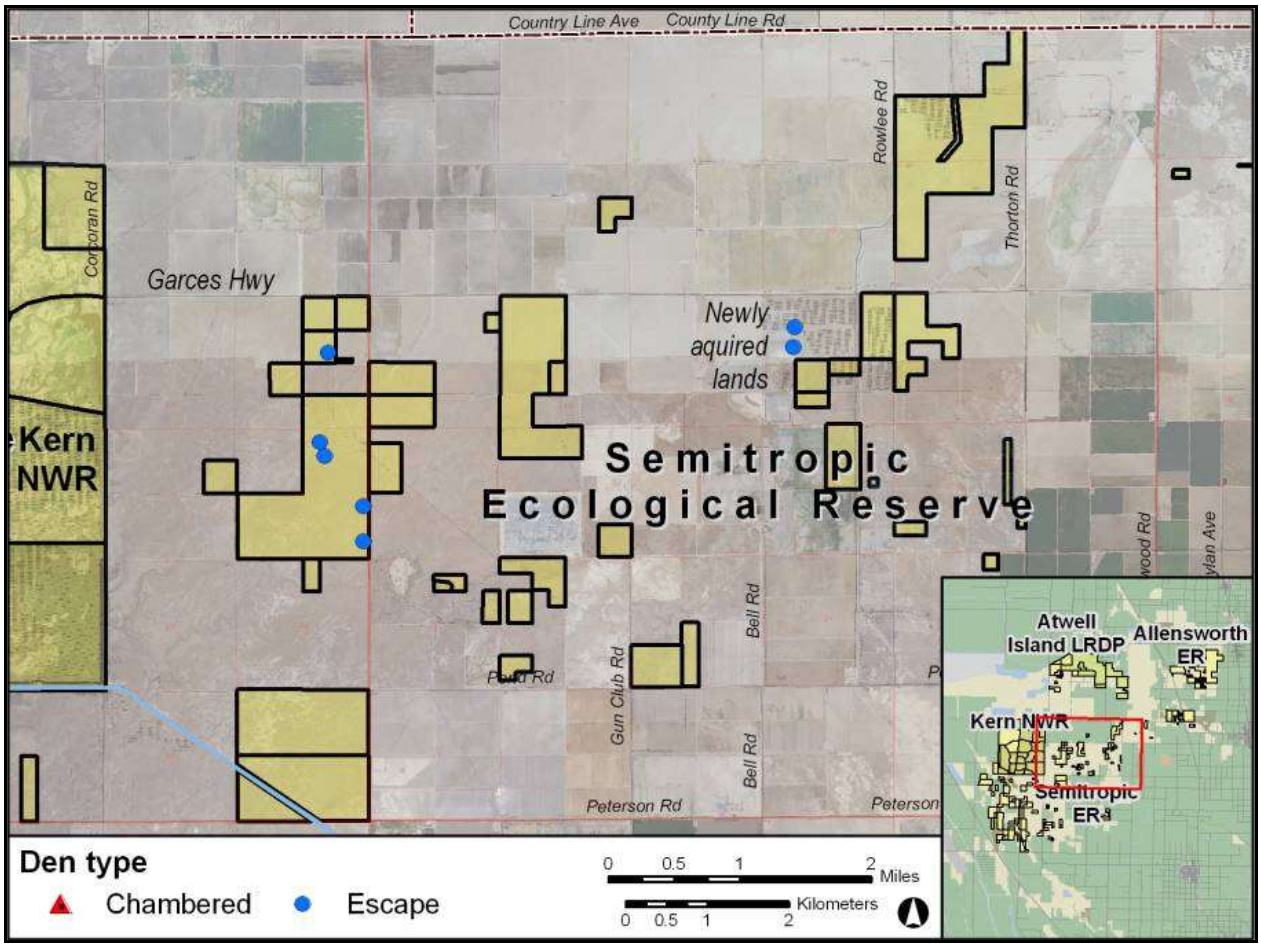

Figure 11. Location of artificial kit fox dens installed on CDFG lands in the Garces Highway area of the Semitropic Ecological Reserve, Kern County, CA.

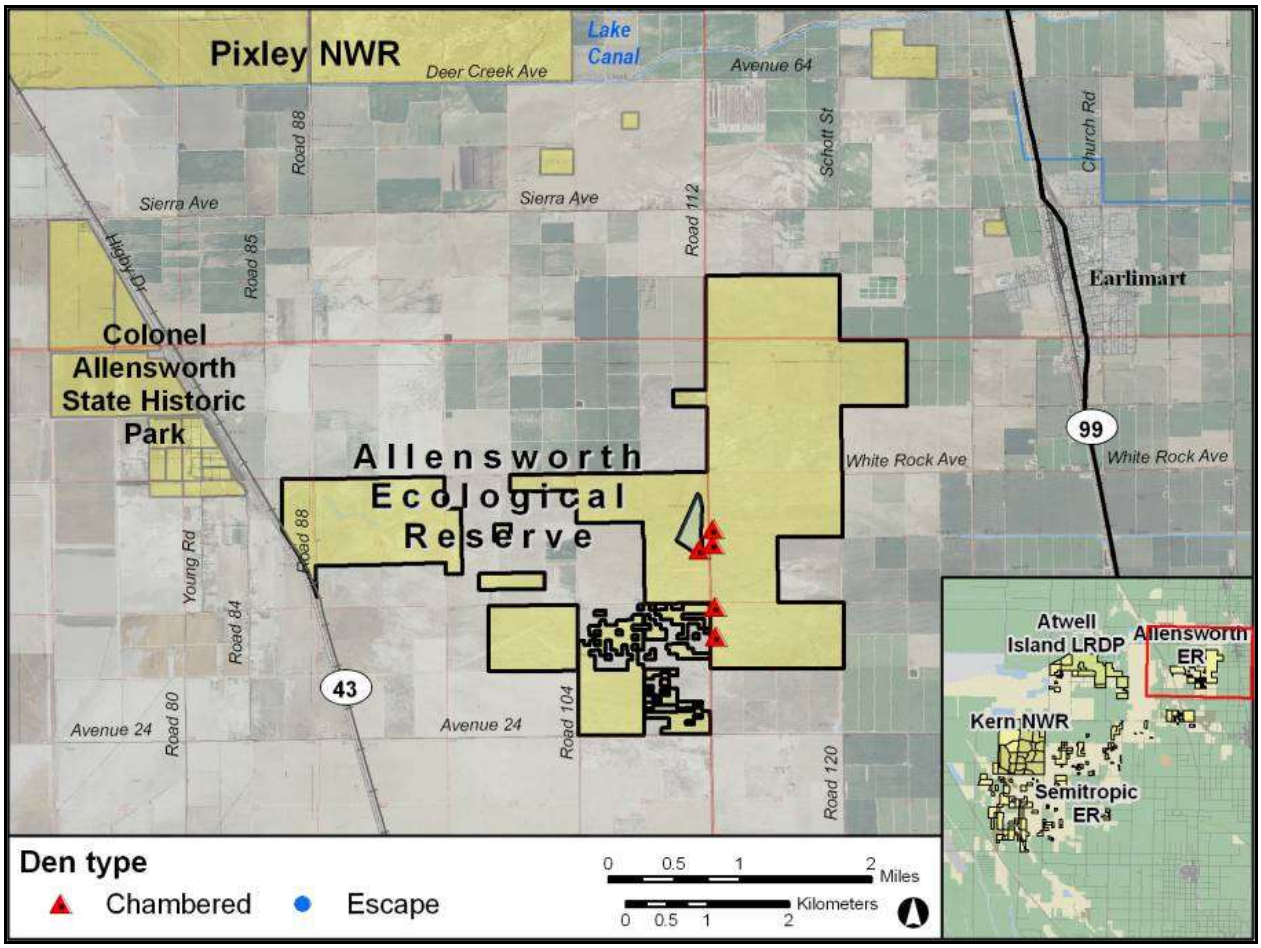

Figure 12. Location of artificial kit fox dens installed at the Allensworth Ecological Reserve, Tulare County, CA.

San Luis Reservoir State Recreation Area (SLRSRA)

The San Luis Reservoir State Recreation Area is located on Highway 152, approximately 10 km west of Interstate 5 in western Merced County. The area is owned by the U.S. Bureau of Reclamation and managed under contract by the California Department of Parks and Recreation. A Total of 7 subterranean chambered dens were installed around the O'Neil Forebay area (Figure 13, Figure 14) to mitigate the loss of potential kit fox habitat due to installation of new safety structures and disabled visitor facilities on the SLRSRA (U.S. Fish and Wildlife Service 2008).

The California Department of Parks and Recreation provided a backhoe, backhoe operator, and several staff to assist with the den installation effort. Staff from the U.S. Bureau of Reclamation and U.S. Fish and Wildlife Service also assisted with the effort.

Figure 13. Installation of chambered dens at San Luis Reservoir State Recreation Area, Merced County, CA.

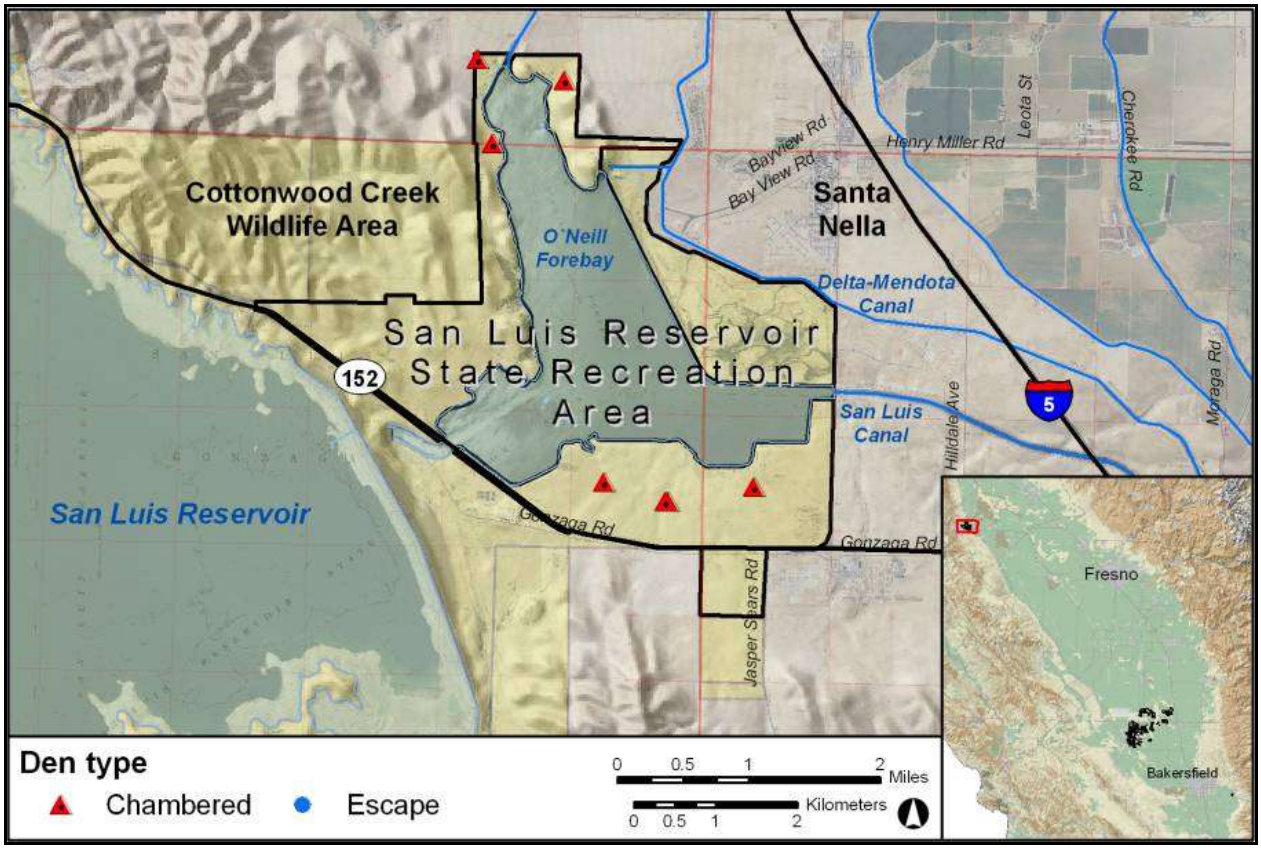

Figure 14. Locations of artificial kit fox dens installed at San Luis Reservoir State Recreation Area, Merced County, CA.

Sand Ridge Preserve

Sand Ridge Preserve is 110 ha in size and managed by the Center for Natural Lands Management. The Preserve is located in Kern County just south of State Highway 58 and approximately 24 km east of the city of Bakersfield.

Sand Ridge can be described as an integration zone between valley shrub land and desert ecotypes. It supports a relatively unique assemblage of both San Joaquin Valley and Mojave Desert species. Dominant shrubs include Mormon tea (*Ephedra spp.*), brittlebush (*Encilia farinose*), bladderpod (*Isomeris arborea)*, common saltbush (*Atriplex polycarpa*), and cheesebush (*Hymenoclea salsola*). The Sand Ridge area may provide valuable linkage habitat along the southeastern range of the San Joaquin kit fox.

Soil substrate was light and easy to excavate with ample evidence of rodent activity. A mixture of 4 chambered and 7 escape dens was installed along the floodplain of Caliente Creek on the eastern side of the ridge (Figure 15, Figure 16). Chambered dens were installed on ridges of higher ground that would be less exposed to flooding.

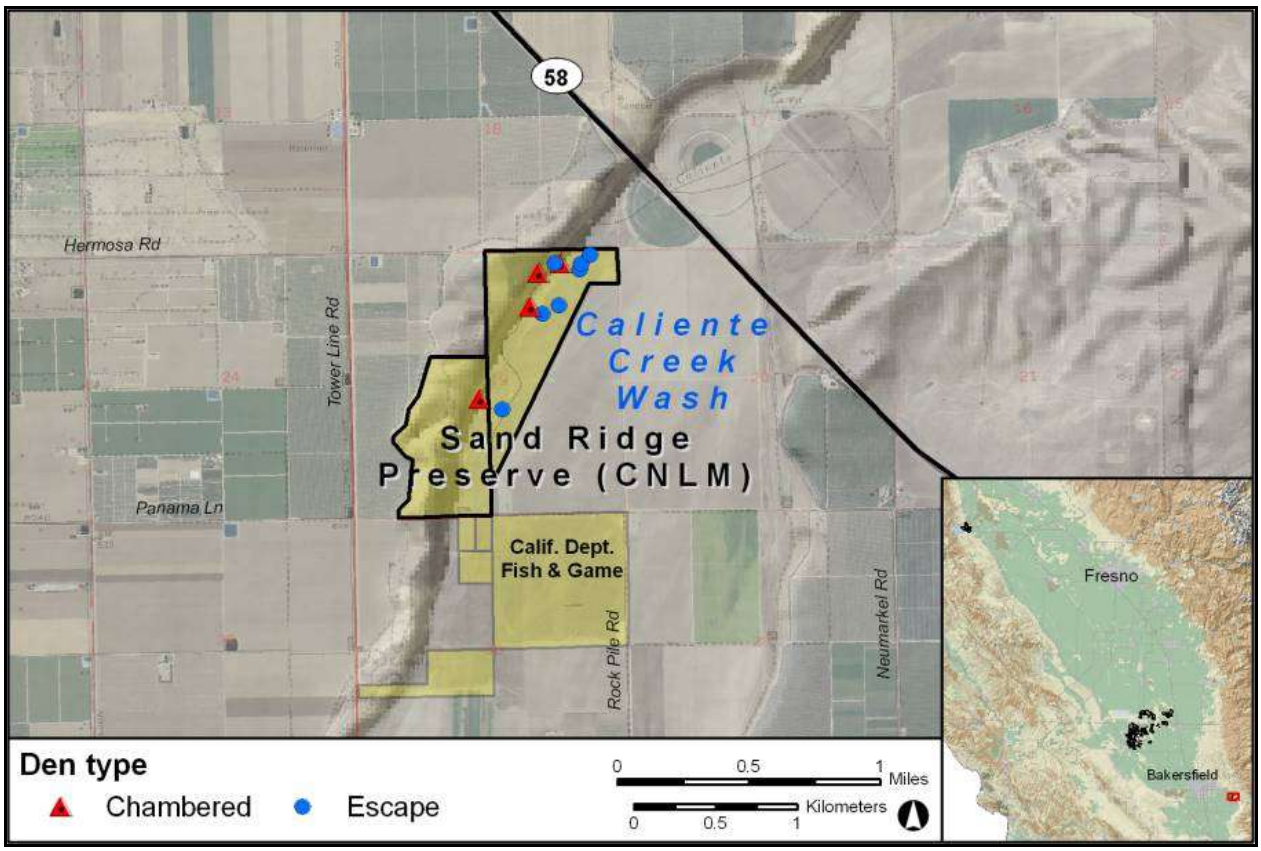

Figure 15. Locations of artificial kit fox dens installed at Sand Ridge Preserve, Kern County, CA.


Figure 16. Installation of chambered and escape dens for kit foxes at Sand Ridge Preserve, Kern County, CA.

Wind Wolves Preserve

Arrangements were not completed during the field portion of this project to install artificial dens at the Wind Wolves Preserve. However, the Preserve was indeed very interested in having such dens on their lands. Therefore, materials that had been set aside for the Preserve were transported to the Preserve in September 2010. Using a combination of Preserve staff and volunteer labor, the Preserve is in the process of installing 25 chambered dens, primarily in the northwestern portion of the Preserve. In addition to providing the den materials, ESRP staff also provided guidance on installation procedures.

DISCUSSION

During this project, a total of 110 artificial kit fox dens were installed on conservation lands, most public, in the San Joaquin Valley. The dens were all installed in areas considered to be satellite population areas or movement corridors for kit foxes. Thus, the dens hopefully will significantly facilitate genetic and demographic exchange between population areas.

Various partners and collaborators contributed significantly to this project either by providing staff or equipment to assist with the den installations, or providing administrative support. These in-kind contributions significantly reduced the overall cost of the project to the U.S. Bureau of Reclamation, and also constituted an excellent example of a collaboration to further the conservation and recovery of an endangered species.

DEN DESIGN

The den types used for this project were relatively inexpensive and of simple design for ease of transport and installation. The basic design can be expanded upon and altered as the situation necessitates. A simple alternative to the full-chambered den would be to bury a length of tubing into the ground at an angle such that one end of the tube remains exposed at

ground level. This would allow foxes to further excavate chambers and additional access tunnels at their own discretion (Figure 17), and would lower den material costs significantly.

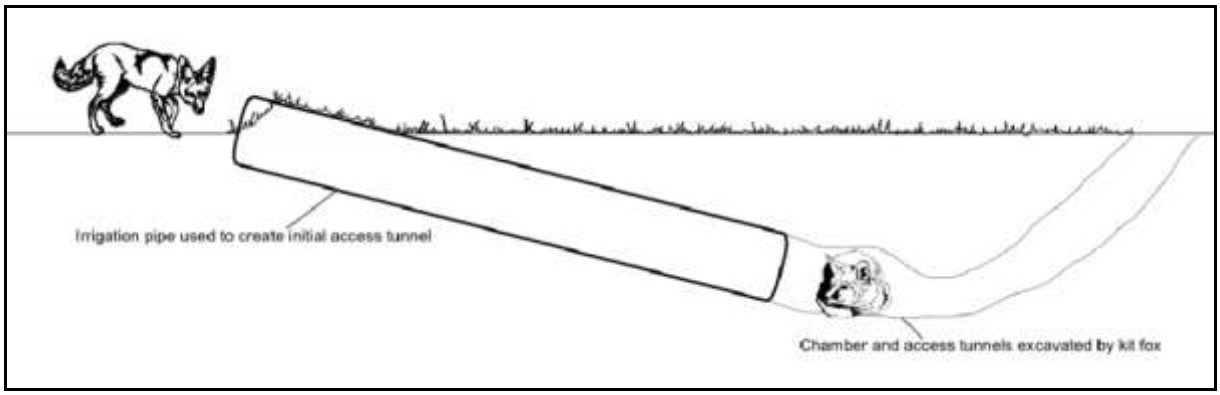

Figure 17. Alternative den design using a single length of irrigation pipe.

POST-INSTALLATION MONITORING

Post-installation monitoring of artificial kit fox dens has been carried out at all sites where dens were installed. Most sites were visited one year or more after installation. Only a subset of the dens was visited at each site, except for the SLRSRA where all 7 dens were inspected. The visits were conducted primarily to assess the general condition of the dens and to determine whether they were still accessible to kit foxes. All of the dens inspected appeared to be in good shape, except for the dens at the SLRSRA. Several of these dens were impacted to the point where they could not be accessed by kit foxes. The surface ends of the den tunnels were found sticking 0.25-1.0 m above the surface of the ground (Figure 18). Possible causes for this could include excessive soil subsidence, compaction by cattle, or a combination of the two. The portions of the tunnels extending above the ground were cut off at ground-level in the hopes that this would rectify the problem.

Figure 18. Tunnel entrances for a chambered artificial kit fox den extending above ground level at the SLRSRA, Merced County, CA.

A number of site managers have reported loss of substrata covering escape dens, thereby exposing the plastic tubing body of the dens to the elements. This could have been caused by natural soil settling, wind or water erosion, or digging by animals. Solutions to this include placing a thicker covering of soil over the dens or covering them with heavier substrate (e.g., rocks; Figure 19).

None of the dens visited exhibited any use by kit foxes. However, such use can be very difficult to detect without more intensive monitoring methods (e.g., camera stations, track stations) or if foxes only used the dens for a short duration. All land managers are encouraged to periodically inspect dens for signs of use, particularly in the spring (March-June) when any use by kit fox family groups would be obvious.

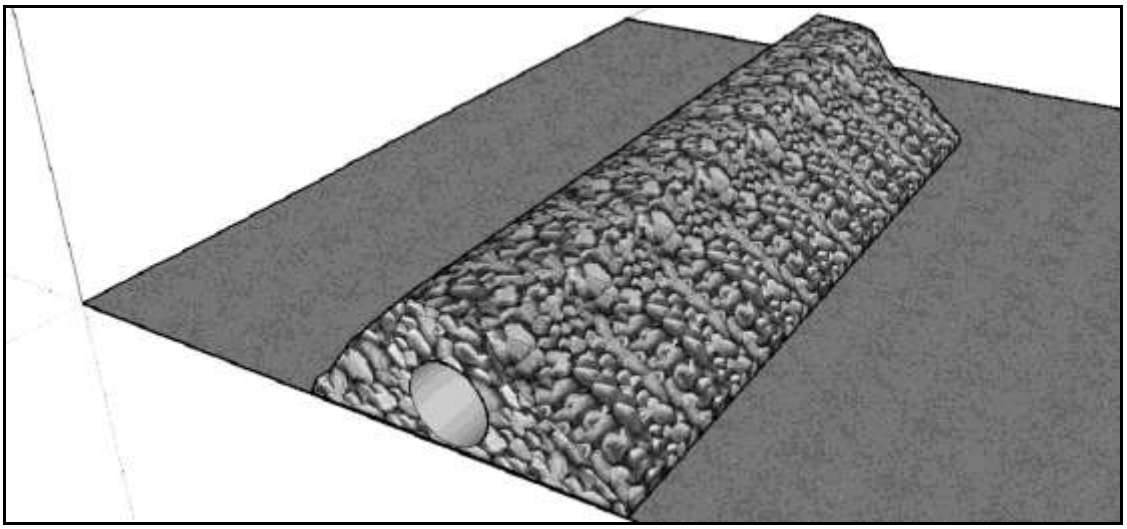

Figure 19. Heavy substrate such as rocks can be used to cover escape dens and thus prevent livestock from exposing the structure to the elements.

LITERATURE CITED

Bjurlin, C. D., B. L. Cypher, C. M. Wingert, and C. L. Van Horn Job. 2005. Urban roads and the endangered San Joaquin kit fox. California State University-Stanislaus, Endangered Species Recovery Program, Fresno, California.

Koopman, M. E., J. H. Scrivner, and T. T. Kato. 1998. Patterns of den use by San Joaquin kit foxes. Journal of Wildlife Management 62:373-379.

Tomlinson, K. R., B. L. Cypher, and P. A. Kelly. 2008. Reptile and small mammal surveys in upland habitats on Kern National Wildlife Refuge's Unit 15, Kern County, California. California State University-Stanislaus, Endangered Species Recovery Program, Fresno, California.

U.S. Fish and Wildlife Service. 1998. *Recovery Plan for Upland Species of the San Joaquin Valley, California*. United States Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service. 2008. Formal consultation for recreation and safety improvements at San Luis Reservoir State Recreation Area. Report 81420-2008-F-1483. United States Fish and Wildlife Service, Sacramento, California.

White, P. J., W. H. Berry, J. J. Eliason, and M. T. Hanson. 2000. Catastrophic decrease in an isolated population of kit foxes. The Southwestern Naturalist 45:204-211.

APPENDIX A. LOCATIONS OF ARTIFICIAL DENS INSTALLED FOR KIT FOXES.

Den ID	Region	Site	Den type	Date	Latitude	Longitude	Accuracy
SLR-C-01	N. San Joaquin Valley	San Luis Reservoir SRA	Chambered	2008-11-12	37.06208	-121.03905	0-80m
SLR-C-02	N. San Joaquin Valley	San Luis Reservoir SRA	Chambered	2008-11-12	37.06205	-121.03945	0-80m
SLR-C-03	N. San Joaquin Valley	San Luis Reservoir SRA	Chambered	2008-11-12	37.06378	-121.02728	0-80m
SLR-C-04	N. San Joaquin Valley	San Luis Reservoir SRA	Chambered	2008-11-12	37.06410	-121.04795	0-80m
SLR-C-05	N. San Joaquin Valley	San Luis Reservoir SRA	Chambered	2008-11-12	37.11052	-121.06601	0-80m
SLR-C-06	N. San Joaquin Valley	San Luis Reservoir SRA	Chambered	2008-11-12	37.10125	-121.06381	0-80m
SLR-C-07	N. San Joaquin Valley	San Luis Reservoir SRA	Chambered	2008-11-12	37.10821	-121.05396	0-80m
SER-C-01	Tulare Lake Basin	Allensworth ER	Chambered	2009-06-17	35.84796	-119.32116	0-80m
SER-C-02	Tulare Lake Basin	Allensworth ER	Chambered	2009-06-17	35.84474	-119.32106	0-80m
SER-C-03	Tulare Lake Basin	Allensworth ER	Chambered	2009-06-17	35.85433	-119.32326	0-80m
SER-C-04	Tulare Lake Basin	Allensworth ER	Chambered	2009-06-17	35.85494	-119.32136	0-80m
SER-C-05	Tulare Lake Basin	Allensworth ER	Chambered	2009-06-17	35.85663	-119.32137	0-80m
ATW-C-01	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-16	35.86494	-119.54124	0-80m
ATW-C-02	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-16	35.86417	-119.54425	0-80m
ATW-C-03	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-16	35.86479	-119.54812	0-80m
ATW-C-04	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-16	35.86756	-119.54264	0-80m
ATW-C-05	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-17	35.86802	-119.54613	0-80m
ATW-C-06	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-17	35.86801	-119.54982	0-80m
ATW-C-07	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-17	35.86448	-119.55228	0-80m
ATW-C-08	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-17	35.86315	-119.55301	0-80m
ATW-C-09	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-17	35.86285	-119.55168	0-80m
ATW-C-10	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-17	35.86406	-119.54337	0-80m
ATW-C-11	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-17	35.86182	-119.55852	0-80m
ATW-C-12	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-17	35.86197	-119.56169	0-80m
ATW-C-13	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-17	35.86173	-119.56530	0-80m
ATW-C-14	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-17	35.85808	-119.56815	0-80m
ATW-C-15	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-17	35.85789	-119.57021	0-80m
ATW-C-16	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-17	35.85579	-119.56243	0-80m
ATW-C-17	Tulare Lake Basin	Atwell Island LRDP	Chambered	2008-09-17	35.85449	-119.55941	0-80m
ATW-E-01	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-16	35.86412	-119.48168	0-80m
ATW-E-02	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-16	35.86191	-119.48166	0-80m
ATW-E-03	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-16	35.85934	-119.47944	0-80m
ATW-E-04	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-16	35.85925	-119.47562	0-80m
ATW-E-05	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-16	35.85398	-119.48079	0-80m
ATW-E-06	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-16	35.85401	-119.47853	0-80m
ATW-E-07	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-16	35.85435	-119.51616	0-80m
ATW-E-08	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-16	35.85542	-119.51704	0-80m
ATW-E-09	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-16	35.85570	-119.51889	0-80m
ATW-E-10	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-16	35.85937	-119.51948	0-80m
ATW-E-11	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-16	35.85948	-119.52240	0-80m
ATW-E-12	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-16	35.85984	-119.52706	0-80m
ATW-E-13	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-17	35.86345	-119.54856	0-80m
ATW-E-14	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-17	35.85712	-119.55976	0-80m
ATW-E-15	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-17	35.83304	-119.55647	0-80m
ATW-E-16	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-17	35.82657	-119.55612	0-80m
ATW-E-17	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-18	35.83458	-119.49987	0-80m
ATW-E-18	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-18	35.83359	-119.49832	0-80m
ATW-E-19	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-18	35.83364	-119.49586	0-80m
ATW-E-20	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-18	35.83761	-119.49991	0-80m
ATW-E-21	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-18	35.85370	-119.50429	0-80m
ATW-E-22	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-18	35.85331	-119.50180	0-80m
ATW-E-23	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-18	35.85061	-119.50086	0-80m
ATW-E-24	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-18	35.84837	-119.50208	0-80m
ATW-E-25	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-18	35.85017	-119.50470	0-80m

Den ID	Region	Site	Den type	Date	Latitude	Longitude	Accuracy
ATW-E-26	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-18	35.85080	-119.50780	0-80m
ATW-E-27	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-18	35.84843	-119.50937	0-80m
ATW-E-28	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-18	35.85443	-119.52780	0-80m
ATW-E-29	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-18	35.85185	-119.52746	0-80m
ATW-E-30	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-18	35.85085	-119.53111	0-80m
ATW-E-31	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-22	35.84922	-119.45689	0-160m
ATW-E-32	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-22	35.84516	-119.44802	0-160m
ATW-E-33	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-22	35.83996	-119.44770	0-160m
ATW-E-34	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-22	35.83429	-119.44754	0-160m
ATW-E-35	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-22	35.83419	-119.45243	0-160m
ATW-E-36	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-22	35.83428	-119.45655	0-160m
ATW-E-37	Tulare Lake Basin	Atwell Island LRDP	Escape	2008-09-22	35.83661	-119.45692	0-160m
KER-C-01	Tulare Lake Basin	Kern NWR	Chambered	2008-12-10	35.78043	-119.62025	0-80m
KER-C-02	Tulare Lake Basin	Kern NWR	Chambered	2008-12-10	35.78837	-119.62429	0-80m
KER-C-03	Tulare Lake Basin	Kern NWR	Chambered	2008-12-10	35.77719	-119.63367	0-80m
KER-C-04	Tulare Lake Basin	Kern NWR	Chambered	2008-12-10	35.77506	-119.62950	0-80m
KER-C-05	Tulare Lake Basin	Kern NWR	Chambered	2008-12-10	35.76166	-119.63208	0-80m
KER-C-06	Tulare Lake Basin	Kern NWR	Chambered	2008-12-10	35.75998	-119.64054	0-80m
KER-E-01	Tulare Lake Basin	Kern NWR	Escape	2008-12-10	35.76072	-119.62090	0-80m
KER-E-02	Tulare Lake Basin	Kern NWR	Escape	2008-12-10	35.76100	-119.63550	0-80m
KER-E-03	Tulare Lake Basin	Kern NWR	Escape	2008-12-10	35.75964	-119.64541	0-80m
KER-E-04	Tulare Lake Basin	Kern NWR	Escape	2008-12-10	35.76260	-119.65178	0-80m
KER-E-05	Tulare Lake Basin	Kern NWR	Escape	2008-12-10	35.77497	-119.65147	0-80m
KER-E-06	Tulare Lake Basin	Kern NWR	Escape	2008-12-10	35.77505	-119.63315	0-80m
KER-E-07	Tulare Lake Basin	Kern NWR	Escape	2008-12-10	35.77493	-119.61914	0-80m
KER-E-08	Tulare Lake Basin	Kern NWR	Escape	2008-12-10	35.77039	-119.62036	0-80m
SER-C-01	Tulare Lake Basin	Semitropic ER	Chambered	2008-12-10	35.70234	-119.61146	0-80m
SER-C-02	Tulare Lake Basin	Semitropic ER	Chambered	2008-12-10	35.71644	-119.67767	0-80m
SER-C-03	Tulare Lake Basin	Semitropic ER	Chambered	2008-12-11	35.65405	-119.57408	0-80m
SER-C-04	Tulare Lake Basin	Semitropic ER	Chambered	2008-12-11	35.65324	-119.57513	0-80m
SER-C-05	Tulare Lake Basin	Semitropic ER	Chambered	2008-12-11	35.65282	-119.57052	0-80m
SER-E-01	Tulare Lake Basin	Semitropic ER	Escape	2008-12-10	35.70255	-119.61612	0-80m
SER-E-02	Tulare Lake Basin	Semitropic ER	Escape	2008-12-10	35.71666	-119.67580	0-80m
SER-E-03	Tulare Lake Basin	Semitropic ER	Escape	2008-12-11	35.62343	-119.61284	0-80m
SER-E-04	Tulare Lake Basin	Semitropic ER	Escape	2008-12-11	35.63126	-119.61411	0-80m
SER-E-05	Tulare Lake Basin	Semitropic ER	Escape	2008-12-11	35.63365	-119.61492	0-80m
SER-E-06	Tulare Lake Basin	Semitropic ER	Escape	2008-12-11	35.63895	-119.61544	0-80m
SER-E-07	Tulare Lake Basin	Semitropic ER	Escape	2008-12-11	35.62739	-119.61284	0-80m
SER-E-08	Tulare Lake Basin	Semitropic ER	Escape	2009-06-18	35.75501	-119.48607	0-80m
SER-E-09	Tulare Lake Basin	Semitropic ER	Escape	2009-06-18	35.75721	-119.48592	0-80m
SER-E-10	Tulare Lake Basin	Semitropic ER	Escape	2009-06-18	35.75467	-119.54916	0-80m
SER-E-11	Tulare Lake Basin	Semitropic ER	Escape	2009-06-18	35.74320	-119.54974	0-80m
SER-E-12	Tulare Lake Basin	Semitropic ER	Escape	2009-06-18	35.74475	-119.55042	0-80m
SER-E-13	Tulare Lake Basin	Semitropic ER	Escape	2009-06-18	35.73760	-119.54449	0-80m
SER-E-14	Tulare Lake Basin	Semitropic ER	Escape	2009-06-18	35.73377	-119.54450	0-80m
SRP-C-08	S. San Joaquin Valley	Sand Ridge Preserve	Chambered	2008-09-25	35.31045	-118.79326	0-80m
SRP-C-09	S. San Joaquin Valley	Sand Ridge Preserve	Chambered	2008-09-25	35.30995	-118.79477	0-80m
SRP-C-10	S. San Joaquin Valley	Sand Ridge Preserve	Chambered	2008-09-25	35.30810	-118.79537	0-80m
SRP-C-11	S. San Joaquin Valley	Sand Ridge Preserve	Chambered	2008-09-25	35.30306	-118.79883	0-80m
SRP-E-01	S. San Joaquin Valley	Sand Ridge Preserve	Escape	2008-09-25	35.31012	-118.79194	0-80m
SRP-E-02	S. San Joaquin Valley	Sand Ridge Preserve	Escape	2008-09-25	35.31041	-118.79185	0-80m
SRP-E-03	S. San Joaquin Valley	Sand Ridge Preserve	Escape	2008-09-25	35.31089	-118.79121	0-80m
SRP-E-04	S. San Joaquin Valley	Sand Ridge Preserve	Escape	2008-09-25	35.31047	-118.79361	0-80m
SRP-E-05	S. San Joaquin Valley	Sand Ridge Preserve	Escape	2008-09-25	35.30815	-118.79334	0-80m
SRP-E-06	S. San Joaquin Valley	Sand Ridge Preserve	Escape	2008-09-25	35.30772	-118.79449	0-80m
SRP-E-07	S. San Joaquin Valley	Sand Ridge Preserve	Escape	2008-09-25	35.30247	-118.79727	0-80m