STATUS OF THE BUENA VISTA LAKE SHREW (*SOREX ORNATUS RELICTUS*)

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ABSTRACT

We review the distribution, habitat associations, and population status of the Buena Vista Lake shrew, Sorex ornatus relictus*, an endemic of the Tulare Basin, San Joaquin Valley, California. The Buena Vista Lake shrew is thought to have historically occupied seasonal and permanent wetlands and riparian communities on the floor of the southern Tulare Basin. By the time* S. o. relictus *was described in 1932, habitat for shrews had been significantly reduced by water diversions and cultivation of former wetlands. For more than 50 years it was known only from the type locality at Buena Vista Lake, where it was presumed to be extinct because all habitat had been destroyed by draining and cultivating the lake bed and surrounding wetlands. The shrew was rediscovered at Kern Lake Preserve in 1986, on private property, and at Kern National Wildlife Refuge in 1992, where its taxonomic identity was uncertain. The Buena Vista Lake shrew was recently proposed for federal listing as threatened or endangered. We trapped for shrews at six sites in the Tulare Basin with suitable habitat and where we could gain access for field work. We were unable to access the Kern Lake Preserve and other properties where suitable habitat may still exist. We reconfirmed the occurrence of Buena Vista Lake shrews at Kern National Wildlife Refuge and discovered them at two new sites, the Kern Fan water recharge area, owned by the city of Bakersfield, and Coles Levee Ecosystem Preserve, owned by Aera Energy Corporation. We caught 16 Buena Vista Lake shrews—all were taken in areas with thick ground cover of plant litter or herbaceous vegetation and moist soil. We recommend additional field studies to better document its habitat associations and population status and to develop a detailed strategy for its conservation. We also provide recommendations to land and resource managers for conserving wetland habitat for non-volant, terrestrial species and enhancing habitat connectivity between isolated wetland communities in the Tulare Basin.*

INTRODUCTION

The Buena Vista Lake shrew (*Sorex ornatus relictus*) is a subspecies of the ornate shrew (Grinnell 1932), a species confined to western California and the Baja California peninsula (Hoffmann and Owens 1983). Historically, Buena Vista Lake shrews probably were distributed throughout the Tulare Basin, San Joaquin Valley, California, though they were only documented from the type locality at Buena Vista Lake (Grinnell 1932, Hall and Kelson 1959).

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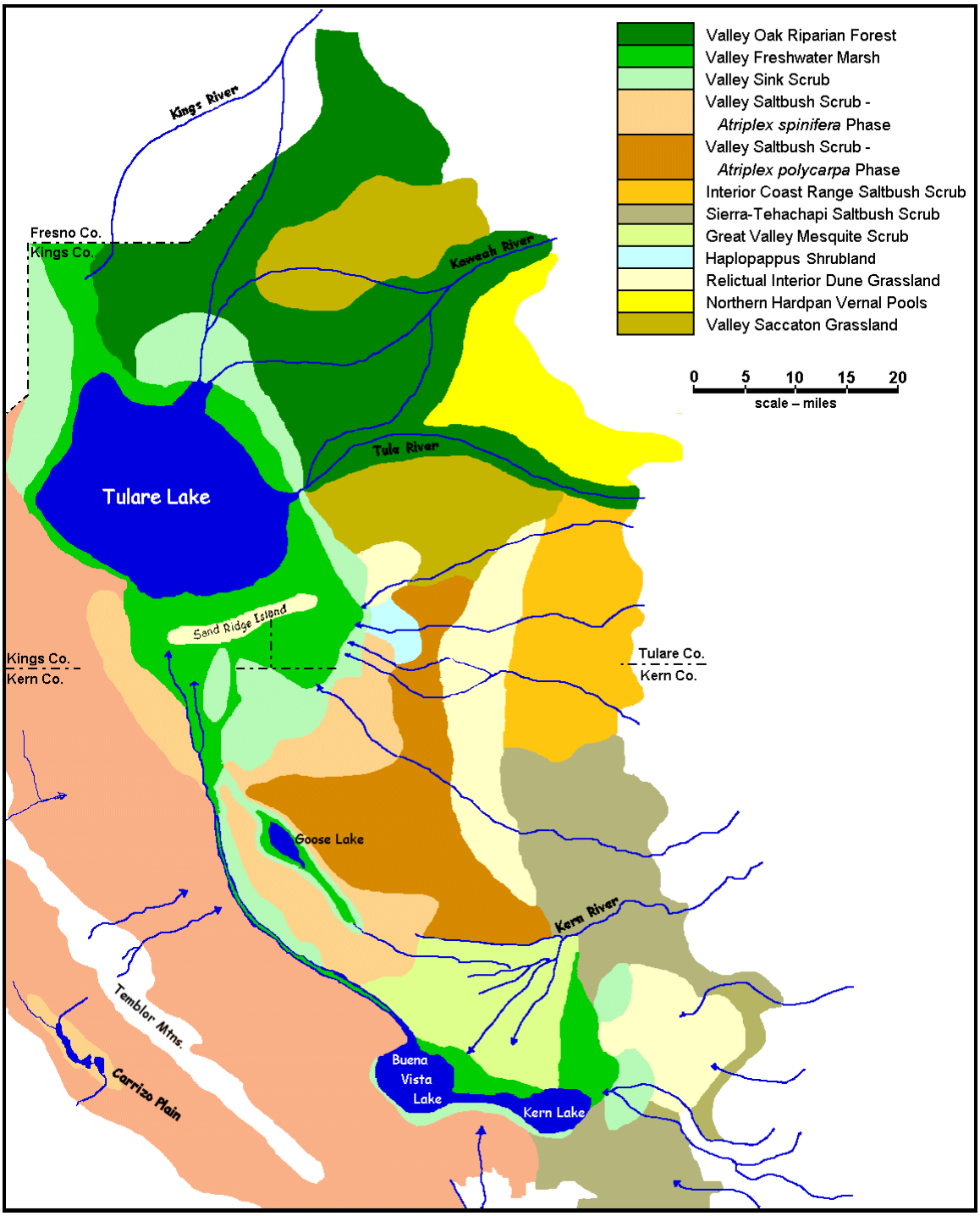

Figure 1. *Historical distribution of native vegetation on the floor of the Tulare Basin and foothills to the west. Modified from Griggs et al. (1992).*

The Tulare Basin, essentially occupying the southern half to the San Joaquin Valley, had no regular outlet to the ocean and contained three large lakes—Buena Vista, Kern, and Tulare—interconnected by hundreds of square miles of tule marshes and other permanent and

seasonal lakes, wetlands, and sloughs (Figure 1). Tulare Lake was the largest freshwater lake in the U.S. west of the Mississippi River. Today the lakes and wetlands have been drained and converted to irrigated agricultural fields, though portions of the historical lake beds fill with water in years of extraordinary runoff (Williams and Kilburn 1992).

At the time it was described and named (Grinnell 1932), populations of Buena Vista Lake shrews already were restricted in distribution—they started to decline when rivers were first impounded and diverted, lakes were drained, and the wetland and riparian areas around them were destroyed for agriculture (Grinnell 1933). A population of Buena Vista Lake shrews was discovered at the site of historical Kern Lake, Kern County, in 1986 by Robert Hansen, then with The Nature Conservancy (Williams and Kilburn 1992). This site, at Gator Pond, consists of approximately 12 hectares (about 30 acres) of degraded wetland and alkali sink scrubland without a permanent source of water to maintain the communities. Ornate shrews also were found at Kern National Wildlife Refuge (NWR), Kern County, in 1992 (Engler 1994), and later were tentatively identified as Buena Vista Lake shrews based on mitochondrial DNA and allozymes (Maldonado et al. 1998). Nothing else was known about the current and historical distributions of Buena Vista Lake shrews.

The geographic range of the Buena Vista lake shrew (Figure 2) is surrounded by that of the ornate shrew (*Sorex ornatus ornatus*; Grinnell 1932, Hall and Kelson 1959). Ornate shrews are known to use a variety of habitats from wetland and riparian communities to more arid fallow farmland, upland scrub, woodland, and forest, yet they are only common in riparian and wetland communities (Williams 1991, unpubl. data). Although there is no documentation that Buena Vista Lake shrews occur anywhere but wetland communities of the Valley floor, we suspect that they use a broader range of habitats and that the two subspecies interbreed and intergrade structurally at the boundaries of their geographic ranges.

Structural features differ slightly between *S. o. relictus* and *S. o. ornatus*. The type specimen of *relictus* has darker brown to black-colored pelage whereas *ornatus* is lighter brown. *S. o. relictus* also is said to have a shorter tail and smaller third and fifth unicuspid teeth than *S. o. ornatus* (Grinnell 1932). There has been no comprehensive morphological analyses published for the subspecies of ornate shrews, although Jesus Maldonado (pers.comm.) has a manuscipt in preparation on structural relationships of ornate shrews. Yet, with only a few Buena Vista Lake shrews preserved in museums, the kinds and amounts of structural variation that may characterize this subspecies are mostly unknown. Recently published evolutionary studies have focused on mitochondrial DNA and allozyme variation of this and other subspecies of ornate shrews. Tissue samples from shrews from Kern Lake and Kern National Wildlife Refuge (NWR) are more similar in the mtDNA loci and allozymes than either are to samples of ornate shrews from other localities, including the upper Kern River area around Lake Isabella, and the wetlands of Merced County, though DNA systems studied are not greatly different among geographic neighbors of the Buena Vista Lake shrew (Maldonado et al. 2001).

Because of the large-scale conversion of natural communities to agriculture, particularly the massive loss of wetland communities, and the shrew's apparent rarity and restricted

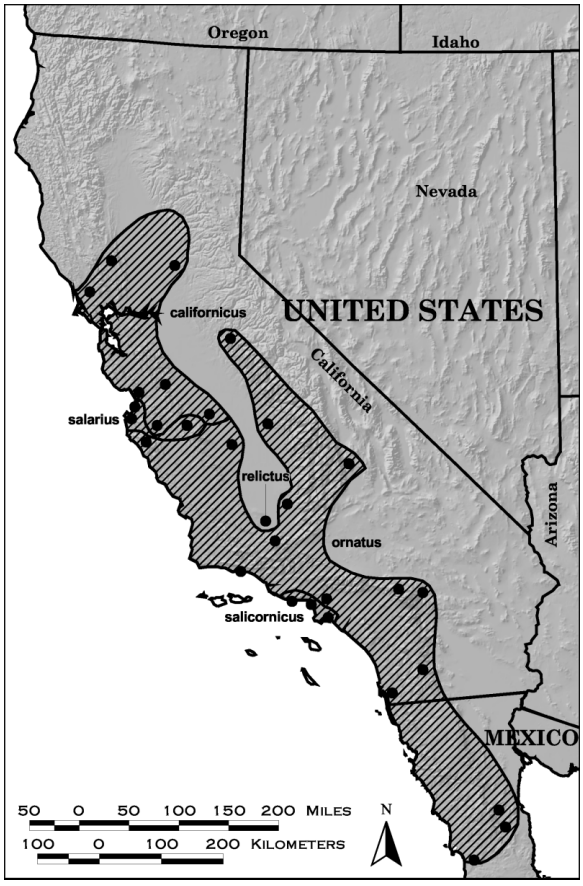

Figure 2. *Distribution of* Sorex ornatus *in California and northern Baja California. The species also occurs on Santa Catalina Island and in the Cape region of Baja California. Some subspecies of restricted distribution are not labeled. Based on Hall and Kelson (1959).*

distribution, the Buena Vista Lake shrew was listed as a Species of Concern by the California Department of Fish and Game (Williams 1986) and proposed for U.S. listing as endangered (U.S. Fish and Wildlife Service 2000).

We undertook field studies in 1999 to determine the extant distribution and population status of the Buena Vista Lake shrew. We concentrated our efforts in permanent and seasonal wetland and riparian communities in the Tulare Basin where we were granted access to trap for shrews. Areas to which we had access included the known remnants of the historical lakes and wetlands, and a portion of the Kern River riparian community.

Our principal objectives were to locate extant populations of Buena Vista Lake shrews, determine their habitat associations, assess inhabited areas for their potential to sustain populations, obtain tissue samples of shrews for future genetic analyses, and develop management recommendations for existing populations. Our main goal for trapping was to locate shrews rather than estimate population numbers. To estimate numbers would have required a much greater trapping effort at any one site and subject shrews to repeated trapping. Mortality rates typically are high for shrews confined in traps and we wished to minimize the

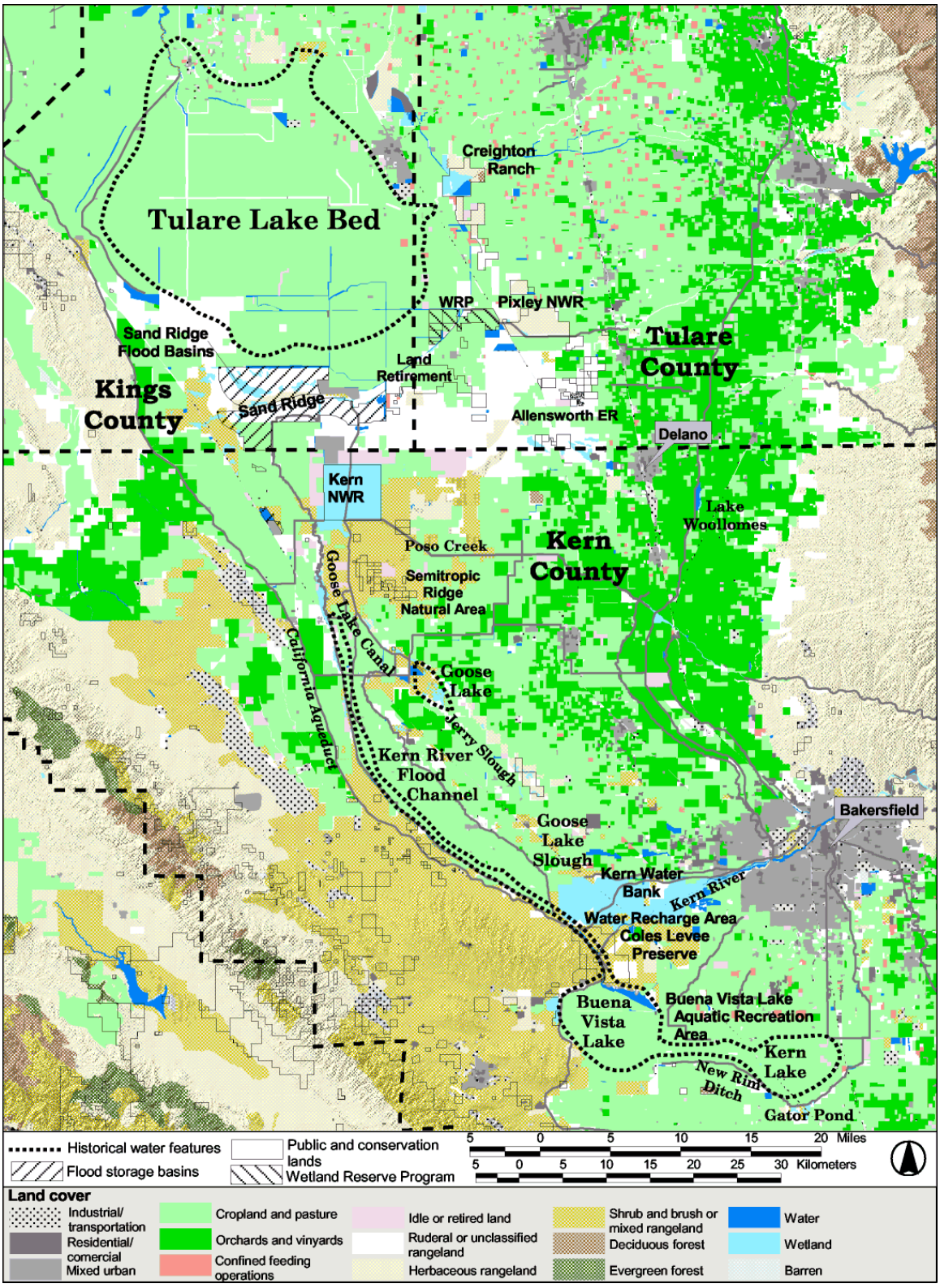

Figure 3. *Lakes, waterways, natural lands, and conservation areas in the Tulare Basin, California. Buena Vista, Kern, and Tulare lakes have been drained and converted to farmland. Kern NWR is flooded seasonally and Kern Water Bank is flooded only in wet years.*

chances of mortality during trapping.

METHODS

We trapped and assessed habitat for shrews at six sites in the Tulare Basin in Tulare and Kern counties (Figure 3). These sites each provided substantial potential habitat for shrews and were accessible for surveys. Some other areas, mostly much smaller in size and in private ownership, also had potential habitat but were not surveyed because of lack of access (Figure 3). Site descriptions of the parcels we surveyed follow.

Pixley National Wildlife Refuge.—Located in Tulare County (lat. 35.908, long. –119.393, 65 m), this wildlife refuge contains an area of 6,192 acres, with an approved boundary of about 8,800 acres (U.S. Fish and Wildlife Service 1984). The majority of Pixley NWR consists of valley grassland plant communities dominated by exotic annual grasses and forbs. A wetland impoundment of 950 acres is divided into a series of units and managed principally for the greater sandhill crane. The wetlands were not regularly flooded until about 1993 because of lack of a permanent water supply. In years of high runoff water was provided from Deer Creek by the Pixley Irrigation District to inundate approximately 100 acres. A well on the property now supplies water for the seasonal wetland when water from Deer Creek is unavailable.

The southern boundary of the main unit of Pixley NWR is bounded by Deer Creek. The creek is channelized through the refuge. A small strip of riparian vegetation approximately 0.5 km long and 30 to 45 m wide, primarily of Fremont cottonwoods (*Populus fremontii*) exists on the north bank of Deer Creek.

Trapping was conducted near the south end of the refuge adjacent to Deer Creek, where a parking lot was planned for construction. Plant communities within the area trapped consisted of brome grasses (*Bromus* spp.), wild barley (*Hordeum* sp.), saltgrass (*Distichlis spicata*), prickly lettuce (*Lactuca serriola*), yellow starthistle (*Centaurea solstitialis*), common sunflower (*Helianthus annuus*), stinging nettles (*Urtica dioica*), sweet clover (*Melilotus* sp.), narrow-leaved milkweed (*Asclepias fascicularis*), fiddleneck (*Amsinckia* sp.), alkali heath (*Frankenia salina*), and Russian knapweed (*Centaurea repens*).

Lake Woollomes.—Lake Woollomes (lat. 35.746, long. –119.171, 122 m elevation) is an equalizing reservoir for the Friant-Kern Canal, about 3 miles SE of Delano, Kern County. The lake was created in 1951, and is surrounded by irrigated cropland. Traps were set in a narrow strand of wetland approximately 2.4 km in length along the eastern shore of the reservoir. Vegetation consisted primarily of cattails (*Typha latifolia*), rushes (*Juncus* spp.), bulrush (*Scirpus* sp.), and saltgrass.

Kern National Wildlife Refuge.—Located south of historical Tulare Lake in Kern County (lat. 35.723, long. –119.619, 65 m elevation) near the terminus of channelized Poso Creek, Kern NWR has 3,850 acres of wetland communities on the approximately 10,618-

acre refuge (U.S. Fish and Wildlife Service 1986). Much of this wetland acreage is seasonally flooded. Dominant plants included bulrushes, cattails, rushes, spike rush (*Heleocharis palustris*), and arrowhead (*Sagittaria longiloba*). Riparian areas next to creeks and sloughs comprised approximately 125 acres, less than 1% of the refuge. Fremont cottonwoods and various species of willows (*Salix* spp.) were the dominant woody plants in riparian areas. Other plant communities on the Refuge that possibly support Buena Vista Lake shrews were Valley iodine bush scrub, dominated by iodine bush (*Allenrolfea occidentalis*), suaeda (*Suaeda* sp.), and alkali heath, and salt-cedar scrub dominated by *Tamarix* sp.. Both of these communities occupy sites with moist, alkaline soils. Iodine bush scrub often has poorly drained soils, the first few inches of which are often dry during the long, hot season.

At Kern NWR we surveyed different areas than were trapped in previous surveys (Maldonado et al. 1998). This was done to broaden the knowledge of distribution and habitat of shrews on the Refuge. Plant communities along survey transects consisted of mostly wetland-related plants, including willows, poison hemlock (*Conium maculatum*), stands of cattails and rushes, saltgrass, wild mustard (*Brassica* spp.), and rumex (*Rumex* sp.).

Kern Fan Water Recharge Area.—The Kern Fan water recharge area consists of a 2,800-acre recharge facility owned by the City of Bakersfield (lat. 35.327, long. –119.207, 101 m elevation), and the contiguous Kern Water Bank, a 19,900-acre area owned by the Kern Water Bank Authority, both in Kern County. Portions of the recharge area are flooded sporadically, forming pockets of wetland communities. Also, narrow strips of riparian communities exist on both sides of the Kern River.

The plant communities of the Kern Water Recharge Area include a mixture of Valley saltbush scrub, Great Valley mesquite scrub, and some remnant riparian areas. The Valley saltbush scrub is characterized by the presence of Valley saltbush (*Atriplex polycarpa),* alkali heath, goldenbush (*Isocoma acradenia),* and common spikeweed (*Hemizonia pungens)*. The soils in this area are sandy to loamy with no surface alkalinity. These areas are found in dissected alluvial fans having low relief. This community seems to intergrade with the Great Valley mesquite scrub. This is an open scrubland dominated by mesquite *(Prosopis juliflora.),* Valley saltbush, and goldenbush. The soils also are sandy loams of alluvial origin. The climate for both communities is a dry, hot summer with moist, foggy winters (Holland 1986).

The remnant riparian areas are found throughout the water bank area, but mainly located near the main channel of the Kern River. These areas are dominated by Fremont cottonwood, willow species (*Salix* spp.), stinging nettle, creeping wild rye (*Leymus triticoides*), mulefat (*Baccharis salicifolia*), and narrow-leaved milkweed.

The dominant species found in the trapping locations included Fremont cottonwood, stinging nettle, creeping wild rye, and salt grass. The areas under cottonwoods were thick with leaf litter or with the creeping wild rye, which tended to grow in thick mats. Some low-lying land had little vegetation and mostly bare soil, whereas some of the higher sites contained lush patches of creeping wild rye. Traps were set in clusters along 3,545 m of the

northern shore of the Kern River. The furthest trapping station from the shore was 180 m.

Coles Levee Ecosystem Preserve.—This 6,059 acre preserve (lat. 35.273, long. –119.299, 90 m elevation), in Kern County, was established in 1992, in an agreement between ARCO oil company and California Department of Fish and Game. It currently is owned by Aera Energy Corporation. It serves as a mitigation bank to compensate for take of habitats for listed upland species.

The site is mostly highly degraded upland saltbush and mesquite scrub, interlaced with slough channels for the historical Kern River fan where it entered Buena Vista Lake from the northeast. Most slough channels are dry except in times of heavy flooding, every several years. The preserve contains 3.2 km of very degraded riparian communities along the Kern River.

Located on the Preserve is a human-made pond that was formed less than 5 years ago. Water from the adjacent oil fields is constantly being pumped into the basin. Vegetation noted included bulrushes, stinging nettle, mulefat, salt grass, quailbush (*Atriplex lentiformis*), and poison hemlock. There were a few willows and Fremont cottonwoods scattered throughout the area. This site runs parallel to the Kern river bed. All traps were set close to the water's edge around the pond. Traps were placed in areas with very little canopy cover.

Buena Vista Lake Aquatic Recreation area.—In 1973, the northern portion of Buena Vista Lake bed (lat. 35.23063, long. –119.28890, 90 m elevation), Kern County, was converted into two human-made lakes that make up 873 acres of surface water. These serve as an equalizing reservoir for the California Aqueduct. The Recreation Area is owned by the County of Kern and the State of California, and managed by the County of Kern Department of Parks and Recreation. Primary management is for recreation purposes. Very few areas of wetland vegetation existed within the recreation area during our field work there.

In the canal area the dominant species were cattails and tules (*Scirpus acutus*). Bermuda grass (*Cynodon dactylon*) also was dominant in the under story of the willows and growing within the tules. On the shores of the two lakes the vegetation zone was very narrow and the soil was highly compacted. The dominant vegetation in these areas were cattails, Baltic rush (*Juncus balticus*), and poison hemlock. There were a few willows, cottonwoods, and a tamarisk tree (*Tamarix*) along the shoreline, located in patches. In the adjacent upland area there were a number of goldenbushes growing. The vegetation there was very sparse.

Surveys were conducted to maximize the chances of captures during time spent trapping. The size and configuration of potential habitat areas dictated the number and arrangement of traps. No attempt was made to standardize trap numbers, spatial arrangement, or trapping effort between sites because of these considerations and because our primary objective was to locate additional populations. Capture rates of shrews in the San Joaquin Valley typically are too low to yield estimates of population size that have acceptable levels of precision, so comparisons between sites and times can best be made on a per-unit of effort basis. We first visually surveyed sites to locate potential habitat and determine where to place trap stations.

Table 1. *Areas surveyed for* Sorex ornatus relictus *during 1999-2000.*

Site	Date	Number of Traps	Trap Nights
Pixley NWR	11-13 April, 2000	58[1]	174
Lake Woollomes	2-5 February 1999	79	316
Kern NWR	1-3 March 1999	80	240
Kern Fan	28-30 March 2000	105	315
Coles Levee Ecological Preserve	15, 17, 18 March 1999	65	195
Buena Vista Lake Recreation Area	19-20 April 1999	50	100

[1] includes 22 extended length, large Sherman traps

Areas with damp or wet soil and a cover of herbaceous or woody plants was considered the best habitat. Understory areas with drier soil but with abundance of plant litter as ground cover also were considered potential habitat.

Numbers of traps set and duration of trapping at six separate sites are given in Table 1. Small Sherman traps (16 cm x 6.5 cm x 5 cm) were used at all sites. Additionally, 22 Large, extended Sherman traps (7.62 cm x 9.53 cm x 30.48 cm) were set at Pixley NWR. Trapping at Lake Woollomes was with pairs of Sherman and pitfall traps (approximately 19 cm high by 17.1 cm diameter at the top, 1.9-l capacity). Some pitfalls filled with water, rendering them potential kill traps and forcing us to close or remove them. Mealworms were used as bait in all traps; oatmeal and peanut butter also were used at some sites. Trapping efforts were kept modest to ensure that captured shrews and rodents could be processed expeditiously before they became unduly stressed or died in the trap.

Animals captured were identified, weighed, aged to a category (juvenile, adult), and sexed. A small patch of fur on the rump was clipped to mark animals so that they could be recognized as previously captured upon recapture in subsequent nights. Shrews that were captured had approximately 2-3 mm of the distal end of the tail amputated for genetic analyses. These samples were stored in 95% ethanol. Blood and fecal samples also were collected at some study sites.

RESULTS

A total of 16 Buena Vista Lake shrews were captured at 3 of the 6 sites surveyed (Table 2). Two shrews died during trapping. Additionally, 159 rodents of 5 species were captured a total of 261 times (Table 2). Site specific descriptions of habitat features and results of trapping of shrews follow.

No shrews were captured at Pixley NWR (Table 2). Other than the managed seasonal wetlands and the short, narrow strand of riparian vegetation along Deer Creek, there is little potential habitat for shrews on Pixley NWR, which is managed primarily for upland species,

Table 2. *Total numbers[1] of small mammals captured during surveys for Buena Vista Lake shrews in Kern and Tulare County, California. Abbreviated species names are:* S. o., Sorex ornatus; P. m., Peromyscus maniculatus; R. m., Reithrodontomys megalotis; M. c., Microtus californicus; M. m., Mus musculus; D. h., Dipodomys heermanni.

Site	Species					
	S. o.	***P. m.***	***R. m.***	***M. c.***	***M. m.***	***D. h.***
Pixley NWR		6 (2)	5		1	3 (3)
Lake Woollomes			6 (2)		37 (38)	
Kern NWR	5	20 (11)	2	1	5 (2)	
Kern Fan Recharge Area	2 (2)	27 (15)	8 (3)	1		
Coles Levee Ecological Preserve	9 (1)	27 (17)	2	3	3	
Buena Vista Lake Recreation Area				1	1	
Total	16 (3)	80 (45)	23 (5)	6	47 (40)	3 (3)

[1] Numbers in parentheses are recaptures.

including blunt-nosed leopard lizards, mountain plovers, Tipton kangaroo rats, and San Joaquin kit foxes. Our trapping efforts were too confined to declare shrews absent from the refuge and it is possible that additional field work will find them, though the refuge has a history of long periods without water for the managed wetlands. Likewise, no shrews were captured at Lake Woollomes, although the vegetation fringing the Friant-Kern equalizing reservoirs appears to be suitable habitat for shrews.

Five Buena Vista Lake shrews were caught at Kern NWR during this trapping effort. Shrews were caught in traps placed under or near willow trees, among poison hemlock, stands of cattail, and rushes. The remainder of the traps were set in areas composed primarily of rushes, poison hemlock, mustard, cattails, buckwheat, saltgrass, and in deep leaf litter under willows.

Two shrews were caught on the Kern Fan water recharge area (City of Bakersfield property). Plant species that dominated the site where we captured Buena Vista Lake shrews included a willow species, stinging nettles, and a thick mat of creeping wild rye. This site had no standing water within 100 m of the location where the shrews were caught.

Nine shrews were captured along a nature trail that is adjacent to a slough at Coles Levee Ecosystem Preserve. All traps were set close to the waters edge where there was abundant ground cover but little or no canopy cover.

DISCUSSION

Potential Habitat for Buena Vista Lake Shrews

Only 10 small, degraded and scattered remnants of the vast wetland and riparian

communities still exist on the floor of the Tulare Basin (Figure 3). Four of these sites are in public ownership: Pixley and Kern National Wildlife refuges: the City of Bakersfield water recharge area near the terminus of the Kern River at Buena Vista Lake; and one equalizing reservoir system (two connected reservoirs) owned by the State of California (Department of Water Resources) and managed by Kern County as the Buena Vista Aquatic Recreation Area. No part of the Buena Vista Aquatic Recreation area currently is managed for wildlife or sensitive species. The other six sites are in private ownership, although two—Coles Levee Ecosystem Preserve and Kern Water Bank—have nature conservation as one of their management objectives. Two others were formerly managed by The Nature Conservancy as preserves although they have reverted to private management. Sites surveyed are described in Methods; descriptions of the sites not surveyed follow.

Sand Ridge Flood Basins.—Located at the southern shore of historical Tulare Lake, the Sand Ridge area is connected to a northern-flowing channel of the Kern River that occasionally carried water to Tulare Lake in time of great flooding. Today this area contains four large flood storage basins (one north, three south of Sand Ridge), owned by the Boswell Corporation. They take flood waters, mostly from the northeast via the Homeland Canal, and the south from the Kern River Flood Canal. Usually, they receive water during high runoff and flood years. Most of the area consists of actively farmed land with small areas of degraded, exotic annual grassland and alkali scrub. The perimeters of the ponds support little or no wetland vegetation and provide little or no cover for shrews.

Goose Lake.—Located about 10 miles south of Kern NWR is the lake bed of historical Goose Lake. The area consists of approximately 4,000 acres of former marshes and wetlands and over 4,000 acres of upland communities. Goose Lake is owned and managed by the Semitropic Water District as a ground-water recharge basin. There currently are no conservation agreements covering this land. Water from the California Aqueduct is transferred to the Goose Lake bottoms in years of abundant water, where it is allowed to recharge the aquifer that is used for irrigated agriculture. Small, degraded examples of freshwater marsh and riparian communities still exist in the area of Goose Lake and Jerry Slough, which is a portion of historical Goose Slough, an overflow channel of the Kern River. Suitable habitat for Buena Vista Lake shrews is found in the Goose Lake area although no shrews have been captured (Germano and Tabor 1993).

Creighton Ranch.—This former conservation area consists of 3,280 acres of seasonal wetlands, permanent water impoundments, riparian communities, and small amounts of annual grassland communities. It is located near the eastern shore of historical Tulare Lake in Tulare County. The ranch was formerly managed by The Nature Conservancy for the Boswell Corporation, but it no longer has any conservation status and is managed by the landowners. Shrews are unknown from Creighton Ranch, but should be expected to occur there, although they might be *S. ornatus ornatus* rather than *S. o. relictus.*

Kern Lake.—The lake today consists of Gator Pond, a small wetland and seasonal pond at the site of historical Kern Lake in Kern County. Kern Lake Preserve was formerly managed by The Nature Conservancy for the Boswell Corporation, but no longer has any conservation

status and is managed by the landowners. Most of the site (about 20 acres) supports alkali sink scrub dominated by perennial and annual saltbushes (*Atriplex* spp.) and saltgrass. Surrounding Gator pond and other low-lying areas is a more mesophytic community with Fremont cottonwood, willows, Baltic rush, pickleweed (*Salicornia subterminalis*), and creeping wild rye. This mesophytic community exists as three small areas surrounded by more xerophytic associations.

Habitat Associations

Buena Vista Lake shrews were discovered at Kern Lake Preserve in 1986 when two fell into a trench being dug for a pipeline to supply Gator Pond (D.F. Williams, unpubl. data). The site where the shrews were found was in the more xerophytic community of saltbushes and saltgrass. Later K. Freas studied this population in 1988 and 1989, capturing 25 Buena Vista Lake shrews (Center for Conservation Biology 1990). All shrews she found were in the low-lying, mesophytic associations with an overstory of cottonwoods and willows, abundant ground litter, and moist soil.

Engler (1994) reported on three Buena Vista Lake shrews that were found on Kern NWR in 1992 and 1994. One shrew was found dead under a sprinkler stand on the lawn of the refuge headquarters, one was found dead in a livetrap set in a residence at the refuge headquarters, and another was found dead under the sink of the same building. Maldonado et al.(1998) reported the capture of two additional Buena Vista Lake shrews at Kern NWR in 1998—both were captured in mesic riparian vegetation along Poso Creek at the southern boundary of the refuge. Capture sites were under willows in deep leaf litter, with saltgrass, alkali heath, and rushes nearby. Both captures were within 30 cm of water. The five shrews we captured in this investigation at Kern NWR also were taken under or near willow trees, among poison hemlock, stands of cattail, and rushes, with an abundance of ground litter or dense herbaceous cover.

Likewise, the two shrews we captured on the Kern River recharge area were taken under willows among stinging nettles in a thick mat of creeping wild rye. Unlike other sites, there was no standing water close by. At Coles Levee Ecosystem Preserve the nine shrews were captured close to the water's edge where there was abundant ground cover but little or no canopy cover.

From these observations, the best habitat for Buena Vista Lake shrews appears to be in riparian and wetland communities with an abundance of leaf litter (humus) or dense herbaceous cover. Although moist soil in areas with an overstory of willows or cottonwoods appears to be favored, we doubt that these are essential habitat features.

Generally, ornate shrews tend to be associated with the structure of the plant community rather than with species composition (Owen and Hoffmann 1983). In an investigation of habitat relationships of ornate shrews in the southern Sierra Nevada, Williams (1991) found that ornate shrews were distributed from the blue oak/digger pine woodlands and blue oak savanna through the yellow-pine zone, and were the only shrew species found in blue oak

savanna, blue oak/dipper pine woodlands, chaparral, and yellow pine forests below about 1,200 m in the southern Sierra Nevada. In general, those community features that defined the riparian zone—exposed rocks, an abundance of shrubs or other ground cover, and nearness to water—were most often significantly associated with capture of ornate shrews. Yet, ornate shrews were taken in smaller numbers in all successional stages of woodland and forest communities and at sites remote from water or wetlands. Likewise, in the San Gabriel and San Bernardino mountains of southern California, ornate shrews were found to be widespread in mixed conifer and white fir/lodgepole pine communities, but most commonly associated with riparian deciduous and wetland communities at all elevations (Williams 1983).

That ornate shrews are not confined to riparian and wetland communities also is indicated by our capture of an ornate shrew in a pitfall trap on the Elkhorn Plain Ecological Reserve, San Luis Obispo County, and the finding of an ornate shrew by William Vanherweg (pers. comm.) in a saltbush scrub community near McKittrick, Kern County. The capture on the Elkhorn Plain was near an *Ephedra californica* shrub in an Upper Sonoran Subshrub Scrub community dominated by California ephedra and exotic annual grasses and forbs, several miles from any permanent water source (Williams et al. 1993). We stress that these events were extremely rare in areas where trapping for small mammals occurred over many tens of thousands of trap nights.

We expect that shrews of the Buena Vista Lake subspecies also rarely will be found in more arid, upland communities. Yet upland natural communities also are extremely reduced and isolated in small parcels on the Valley floor of the Tulare Basin. Historically these remnants of upland communities were once mostly seasonal wetlands and frequently flooded sand dunes and low ridges in the delta of the Kern River. After impounding and diverting streams, draining marshes and lakes, and widespread land-leveling and cultivation on the floor of the Tulare Basin, those few, now water-deprived parcels have become occupied by more xeric-tolerant species. Thus, while the remaining parcels supporting upland natural communities might provide extremely low quality habitat for Buena Vista Lake shrews, they do not provide the linkages between fragments of more suitable habitat to ensure connectivity of the historical gene pool of Buena Vista Lake shrews.

Of unknown significance in defining habitat associations, ranking habitat quality, and evaluating population connectivity for Buena Vista Lake shrews is our discovery of ornate shrews on recently retired farmland south of Mendota, Fresno County. There we captured 22 ornate shrews in pitfall traps on the Land Retirement Demonstration plots in 1999 and 18 in 2000 (Selmon et al. 2000, Uptain et. al. 2001). In 1999, one shrew was captured on ground that had been fallowed for more than 5 years; the others were captured on ground that was planted to sugar beets (8 shrews) and cotton (13 shrews) in 1998. A cover crop of barley was planted and harvested in 1999 on approximately 1,200 acres before sampling in 2000—the other 446 acres of the Demonstration Project that had been fallow longer than 5 years and had a cover of weedy, mostly exotic, annual plants.

Because this site is surrounded by intensively farmed, irrigated cropland, the shrews either persisted on the site during cultivation of irrigated row crops or along the irrigation

ditches through the fields. Alternately, they dispersed to the site sometime since the first parcels were fallowed more than 5 years ago. Most irrigation ditches in the area are kept essentially free of vegetation through the use of broad-spectrum herbicides and soil sterilents. In any case, the presence of shrews on the Demonstration Project lands suggests that ornate shrews may reside on actively farmed ground, or may have greater vagility (power of dispersal) than we imagined, dispersing through seemingly poor quality habitat in cultivated fields, or both.

The Demonstration Project lands are located in the trough of the Valley floor in what was historically classified as seasonal wetlands. The site is underlain directly by flood basin deposits derived from overbank deposition from the Fresno Slough, which drained the Tulare Basin in the wettest years, and the San Joaquin River, into which Fresno Slough drains (Selmon et al. 2000).

Ornate shrews from the Demonstration Project site have not been identified to subspecies. On geographic grounds they are from an area intermediate to two subspecies, *S. ornatus ornatus* and *S. ornatus californicus* (Hall and Kelson 1959).

Distribution

During this investigation we have documented the occurrence of Buena Vista Lake shrews at two new sites and reconfirmed their occurrence at a third (Figure 4). The two new sites are close to the type locality and other historical collecting localities at Buena Vista Lake, where shrews may be extinct, and the previously known, currently-occupied site at Kern Lake. The most remote site, at Kern NWR, was historically connected to Buena Vista Lake by riparian and wetland communities formed by the meandering flood channels between the Kern River and Tulare Lake (Figure 3). This might have been the historical extent of the distribution of Buena Vista Lake shrews—the riparian and wetland communities of the southern Tulare Basin. Yet it seems more probable that there were populations of Buena Vista Lake shrews around the shores of historical Tulare Lake. They still may be found along the eastern side of the Lake bed—we continue to seek access to properties in that area in order to trap for shrews.

Taxonomic Issues

The Buena Vista Lake shrew belongs to a genetically closely-related clade of populations residing in the central part of the species range in the San Joaquin Valley and contiguous western slope of the Sierra Nevada, and the central California coast south of San Francisco Bay. Taxonomically, members of this clade have been assigned to the subspecies *S. ornatus californicus, S. o. ornatus, S. o. salarius,* and *S. o. relictus.* This clade differs substantially in its mtDNA and allozymes from populations of *S. o. californicus* and *S. o. sinuosus* from north of Suisun Bay and the Sacramento-San Joaquin Delta, and *S. o. ornatus* and other subspecies south of the Transverse Range at the southern end of the San Joaquin

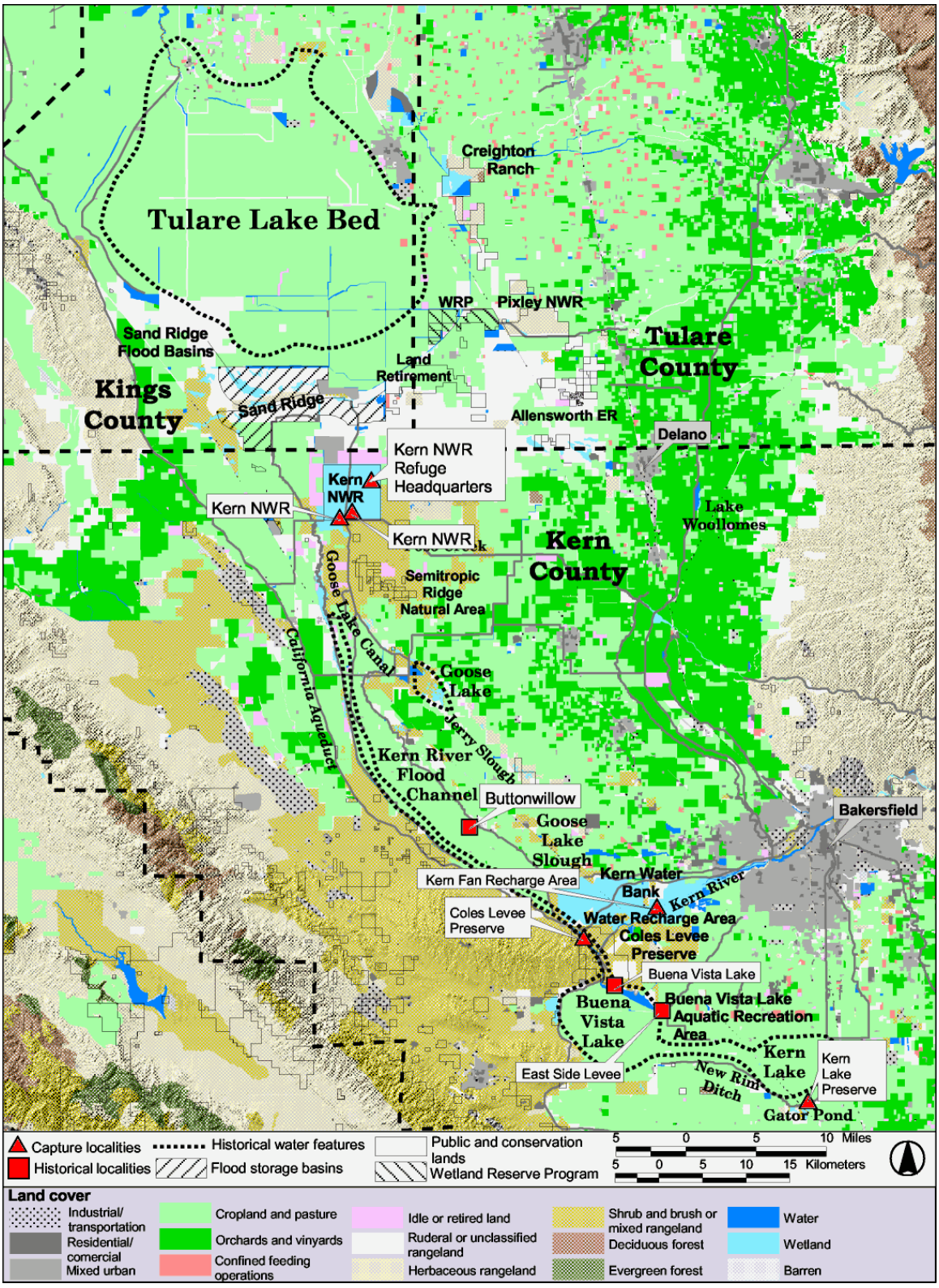

Figure 4. *Historical and recent (captures since 1986) distributional records for Buena Vista Lake srhews* (Sorex ornatus relictus). *The type locality was given as "Buena Vista Lake, 290 ft., Kern Co., California" (Grinnell 1932).*

Valley (Maldonado et al. 2001). Maldonado et al. (2001) did not have specimens to examine genetically between the Merced County wetlands and Kern NWR, Kern County, nor in the Transverse ranges, though the species occurs at many sites in both areas (ESRP unpubl. data).

Current taxonomy does not reflect phylogenetic nor geographic relationships of ornate shrews (Maldonado et al. 2001). Until structural analyses are performed and coupled with genetic and geographic information, the taxonomic identity of *ornatus*-group shrews must be considered unsettled. This does not mean, however, that the Buena Vista Lake shrew is taxonomically invalid. That shrews on the floor of the southern Tulare Basin have differentiated in color and structure demonstrates phylogenetic differentiation from populations living on the surrounding slopes and plateaus. Regardless of the taxonomic significance of this differentiation, measures to conserve and enhance their populations are justified.

Population Status and Connectivity

Status.—Our investigations demonstrate that Buena Vista Lake shrews are somewhat more widespread than previously documented, and their persistence is not nearly so jeopardized as we formerly believed. Populations have persisted in historical outflow areas of the Kern River around Buena Vista and Kern lakes and farther north in the historical wetlands formed from overflow channels of the Kern River and Poso Creek at Kern NWR. We do not have insight into the size and extent of those populations yet, but we do not believe that Buena Vista Lake shrews are endangered now, nor are there foreseeable threats to remaining populations in the near future. Indeed, several initiatives in the Tulare Basin to preserve and enhance seasonal wetlands and to develop wetlands in water recharge areas hold great promise for greatly enhancing populations of Buena Vista Lake shrews. Possible development of permanent wetlands in the Kern Water Bank on Kern Fan is the most promising (Kern Water Bank Authority 2000). Restoration of wetlands in the Goose Lake bottoms (Germano and Tabor 1993) also may provide habitat for Buena Vista Lake shrews if provisions are made for their habitat needs.

Potential Connectivity.—Despite our current belief that the Buena Vista Lake shrew is not endangered, the long-term persistence of Buena Vista Lake shrews depends upon maintenance of riparian and wetland communities in the southern Tulare Basin (south of Tulare Lake bed) and enhancing the size and connectivity between the small and mostly isolated habitats where the shrews currently are found. This can be accomplished in part simply by being sensitive and attentive to the habitat needs of wetland-dependent, non-volant terrestrial species, including shrews, in restoring wetlands for migratory waterfowl, developing water recharge facilities, and maintaining and managing flood channels, sloughs, and drainage ditches in the Tulare Basin.

Some habitat and population connectivity must exist along the main channel of the Kern River between the City of Bakersfield's recharge area and Coles Levee Ecosystem Preserve. However unless Buena Vista Lake shrews live successfully in cultivated row crops, which we regard as a possibility, we doubt that this population currently has any genetic interchange

with the Kern Lake population or the population at Kern NWR.

Opportunity for restoring connectivity seems to be poor between the Kern River-Coles Levee population and that at Kern Lake. Historically, Buena Vista and Kern lakes were connected by a broad slough and wetland. Remnants of this slough, called Connecting Slough, may still exist but provide no habitat linkage to the Gator Pond area of historical Kern Lake. Most of the pieces of the Connecting Slough shown on maps have been filled and cultivated. However, at the southern boundary of the broader historical connecting wetlands is found the water-conveyance structure, New Rim Ditch—it is connected to and immediately adjacent to Old Rim Ditch, and together they connect the beds of Buena Vista and Kern lakes. Other canals connect these ditches to the Buena Vista Aquatic Recreation Area at the north edge of Buena Vista Lake bed. There is no appropriate habitat along these canals and ditches to currently provide population connectivity between the two lake beds. However, restoring appropriate habitat in the Buena Vista Aquatic Recreation Area and along the Inlet Canal between the Recreation Area and Coles Levee Ecosystem Preserve could be accomplished on public lands with relatively little cost. It would take a broader group of cooperators and involve private entities to accomplish habitat connectivity with Kern Lake, yet preservation of both populations may depend on this connectivity, and preservation is critical to the long-term conservation of the Buena Vista Lake shrew (U.S. Fish and Wildlife Service 1998).

Reestablishing connectivity between the Goose Lake, Kern NWR, and other potential habitat areas for Buena Vista Lake shrews around the Tulare and Goose lake beds with the Kern River-Coles Levee Ecosystem Preserve area is more problematic unless actively farmed ground is inhabited. Although there are several canals and sloughs in the corridor area, to our knowledge no combination is particularly suitable for restoring habitat connectivity. The Kern River flood channel that used to empty into Tulare Lake, known now as the Kern River Flood Canal or the Buena Vista Slough, is the only continuous structure in existence. This former slough is channelized as a narrow canal for most of its length. Parts are dry for several years at a time and offer no mesic plant communities as habitat for shrews. Other parts routinely carry salt-laden drain water with relatively high concentrations of toxic compounds. We think that it is possible that shrews will be found along some segments of this flood channel, such as where California Highway 46 crosses the channel.

Goose Lake Canal and various historical channels of the Kern River between Goose Lake and Kern NWR perhaps also provide opportunity for reestablishing population connectivity between these two areas and increasing the size and distribution of the Buena Vista Lake shrew population in that area. It is possible that shrews still are extant in the Jerry Slough-Goose Lake bed today. If not, opportunity for reconnecting these areas with Kern NWR and reestablishing shrew populations should be sought in light of current plans for additional water storage in the Goose Lake area (Germano and Tabor 1993).

Recommendations for Management

This reports fulfills the recommendation in the Recovery Plan to reassess the status of the

Buena Vista Lake shrews within 3 years of the plan's approval (U.S. Fish and Wildlife Service 1998). However, we do not know yet if the criterion of having at least 2,000 acres of occupied habitat in three or more disjunct sites has been met, though we have demonstrated occupancy at three disjunct sites. Other conservation-recovery criteria that have yet to be met include approved management plans for those sites that feature survival of the species as an objective, implementation of those plans, and implementation of a periodical monitoring plan that demonstrates continuing presence of Buena Vista Lake shrews at occupied sites (U.S. Fish and Wildlife Service 1998). Thus, we recommend the following to further the conservation of Buena Vista Lake shrews and eliminate the need for formal listing as threatened or endangered.

Develop Agreements with Private Entities to Assess Areas with Potential Habitat.—Of highest priority for meeting conservation goals is gaining access to trap shrews and estimate population sizes and distribution in the Goose Lake-Jerry Slough Area (Semitropic Water District) and the Kern Water Bank. Other areas that are potentially inhabited by Buena Vista Lake shrews are Creighton Ranch (Boswell Corporation), Sand Ridge Flood Retention Basins (Bowell Corporation) and various remnant river channels, canals, sloughs and wetlands between the main channel of the Kern River and the Goose Lake bed. Each of these areas should be surveyed and assessed for their potential to contribute to the conservation and recovery of Buena Vista Lake shrews, including potential habitat linkages between known populations.

Estimate Population Sizes at Existing and Potentially Inhabited Sites.—We believe the shrews found at Coles Levee Ecosystem Preserve and Kern Fan water recharge area represent portions of a single population, which we refer to as the Kern Fan population. The population sizes and distributions of shrews on Kern NWR, the Kern Fan, and the former Kern Lake Preserve should be estimated using capture-recapture population estimation models. This will require developing access agreements between researchers, Kern NWR, City of Bakersfield, the Kern Water Bank Authority (for access to the Kern Water Bank), and Boswell Corporation (Kern Lake Preserve), and using a trap that minimizes chances of mortality (Hays 1998). Though the sizes of areas to be monitored differ dramatically, we believe it advisable to standardize the time of year, bait, type of traps, and set a standard number of traps per unit of area for monitoring in different communties or areas that might support shrews on each site. Temporarily marking individuals by clipping fur would allow the application of capture-recapture population models to estimate population sizes.

Investigate Potential Occurrence of Buena Vista Lake Shrews on Irrigated Farmland.—The potential for Buena Vista Lake shrews to occur on irrigated farmland also should be investigated. Selected, cultivated sites that historically were wetlands in southern Tulare Basin should be trapped to determine if they are occupied by shrews. Information from this investigation should be combined with information from studying shrews in natural areas in determining the conservation status of the Buena Vista Lake shrew.

Periodically Monitor Existing Populations and Assess Population Status.—Periodic population monitoring at sites known to be occupied, using the same protocol that is used for

estimating population sizes, should be carried out every 3-5 years to document status. Change in status, if any, can be used to determine if any conservation measures that are adopted are working appropriately or need adjustments. These data, together with information on the geographic extent and isolation of subpopulations can be used to estimate their viability.

Develop Management Plans and Agreements with Land Owners and Managers.— Long-term conservation of Buena Vista Lake shrews requires that their habitat be maintained at sufficient size and quality to ensure persistence. We currently do not know how large an area or the minimum population size required to ensure persistence, but the preceeding recommendations on population censusing and monitoring, if implemented, should provide information for estimating viability. Maintaining presistence on private lands will require developing conservation easements, memoranda of understanding, or other vehicles that ensure the availability of a suitable water supplies for maintaining plant communities that provide habitat for shrews . For state and federal properties, it will require adoption of management goals and practices that ensure maintenance of habitat for shrews. For example, the California Dept. of Water Resources and Kern Co. should cooperate on creating and enhancing habitat for shrews and other wetland terrestrial species at the Buena Vista Lake Aquatic Recreation Area. More generally, opportunities should be aggressively sought to ensure water supplies sufficient to maintain the wetland and riparian communities and promote preservation, protection, and expansion of wetlands in the Tulare Basin, particularly the Valley-floor sloughs, channels, and lakes of the Kern River.

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