5-YEAR REVIEW
Buena Vista Lake ornate shrew (*Sorex ornatus relictus*)

GENERAL INFORMATION

Species: Buena Vista Lake ornate shrew (*Sorex ornatus relictus*)
Date listed: March 6, 2002
Federal Register (FR) citation: 67 FR 10101 (Service 2002)
Classification: Endangered

State Listing: Buena Vista Lake ornate shrew is not listed by the State of California.

BACKGROUND

Species overview:
The Buena Vista Lake ornate shrew (shrew) is one of nine subspecies of ornate shrew, a small mammal belonging to the long-tailed shrew family Soricidae. The shrew is similar in size and appearance to a mouse but with bead-like eyes, a longer and more pointed snout, and five toes rather than four on the front feet (Service 2011, p. 2; Cypher et al. 2017, p. 9). The subspecies' pelage is predominantly black with a brown speckling pattern and a pale underbelly (Grinnell 1932, p. 389; Burt and Grossenheider 1964, p. 9). They have high metabolic rates and energy needs, so they feed during both day and night on insects, small vertebrates, and plant matter (McNab 1991, p. 35; Service 2011, p. 2; Burt and Grossenheider 1964, p. 8). Life expectancy for ornate shrews is 12 to 16 months, so annual turnover is high, and abundance may change rapidly depending on habitat conditions (P. Collins, Santa Barbara Natural History Museum, *in litt*. 2000, p. 8).

The Buena Vista Lake ornate shrew occurs in perennial and intermittent wetland habitats along riparian corridors and marshes in the southern San Joaquin Valley of California, including Fresno, Kings, Tulare, and Kern Counties (Service 2013, p. 39845). Based on analyses of the ornate shrew genetic structure, surveys only consider shrews observed south of the communities of Tranquility and Helm in Fresno County to be the Buena Vista Lake ornate shrew (Maldonado et al. 2017, pp. 4, 27; Cypher et al. 2017, p. 1). The shrew is typically found near open water in riparian habitat with moist soil, such as areas with a dense vegetative understory or deep layer of leaf litter (Service 2013, p. 39845; Service 2017, p. 15; Cypher et al. 2017, p. 12). The shrew is also found in drier habitat types such as grassland, alkali desert scrub, and alkali sink scrub when a water source or moist soil is available nearby (Service 2017, pp. 14–15).

Depending on hydrology and temporal changes, habitats may support shrews throughout the year or serve as areas in which shrews can temporarily expand into when conditions are appropriate (Service 2017, pp. 14–15). For example, habitats may provide moist soil and dense vegetation only during the wet season of December to April, and shrews may move into these areas to find resources and mates, establish a territory, or expand their home range (Cypher et al. 2017, p. 20). Habitats may also become suitable for shrews through management activities (Cypher et al. 2017, p. 20). The dynamic habitat use contributes to the difficulty of surveying and studying the Buena Vista Lake ornate shrew, along with the subspecies' elusive nature, semi-fossorial behavior, and small size (Cypher et al. 2017, p. 20; Maldonado et al. 2017, p. 3).

Most recent status review:

[Service] U.S. Fish and Wildlife Service. 2020. 5-Year Review: Buena Vista Lake ornate shrew (*Sorex ornatus relictus*). U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Sacramento, California. 6 pp.

We did not recommend a status change in the 2020 status review.

FR notice citation announcing this status review:

[Service] U.S. Fish and Wildlife Service. 2024. Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Status Reviews for 59 Pacific Southwest Species. Federal Register 89:83510–83514.

We did not receive information from the public regarding Buena Vista Lake ornate shrew in response to the notice.

ASSESSMENT

Information acquired since the last status review:

This 5-year review was conducted by the U.S. Fish and Wildlife Service's (Service) Sacramento Fish and Wildlife Office. Data for this review were solicited from interested parties through a Federal Register notice announcing this review on October 16, 2024. We also contacted species experts and land managers, performed a literature search, and reviewed information and permit reports in our own files. New information about distribution since the last status review is addressed in **Distribution and abundance** and new studies that have been conducted since the previous status review, including on survey methodologies, habitat preference and use, and genetics, is discussed in **Conservation**.

Distribution and abundance:

Historically, the Buena Vista Lake ornate shrew occurred in permanent and seasonal lakes, wetlands, and sloughs around Buena Vista Lake and, presumably, throughout the Tulare Basin (Grinnell 1931, p. 389; Williams and Harpster 2001, p. 1). The subspecies was likely distributed throughout the network of wetlands around Kern, Buena Vista, Goose, and Tulare Lakes, but these lakes and associated riparian areas were already drained and converted for agriculture by the time the subspecies was described in 1932 (Williams and Harpster 2001, p. 1). For over 50 years, the shrew was only known from the type locality at Buena Vista Lake and was presumed to be extinct due to rapid conversion of its wetland habitat to residential and agricultural lands (Williams and Harpster 2001, pp. 2–3; Service 2011, p. 6). The shrew was rediscovered in 1986 at Kern Lake Preserve and in 1992 at Kern National Wildlife Refuge (Kern Refuge) (Williams and Harpster 2001, p. 3).

At the time of listing in 2002, the shrew was known from four isolated sites along a 113-kilometer (70-mile) stretch along the west side of the Tulare Basin (Service 2002, p. 10102). The four sites are Kern Refuge, Kern Fan recharge area, Kern Lake (formerly Kern Lake Preserve when it was managed by The Nature Conservancy), and Coles Levee Ecosystem Preserve (Service 2001, p. 10102; Williams and Harpster 2001, p. 3). There were fewer than 30 known individuals across these four disjunct sites, which comprised of 233 hectares (ha) (575 acres (ac)) of suitable habitat (Service 2001, p. 10110).

The proposed and final listing of the Buena Vista Lake ornate shrew prompted additional surveys in suitable habitat in the historical subspecies range. Along with improved survey methodology, the subsequent surveys have discovered additional occupied sites, but habitat availability for the shrew in the southern San Joaquin Valley remains highly restricted and disjunct. At the time of the 2011 status review, surveys for the shrew had been conducted at 21 sites, and the shrew was detected at eight of them (Williams and Harpster 2001, p. 10; Newman et al. 2005, p. 14; Service 2011, p. 6). The eight sites included the previous four sites (Kern Refuge, Kern Fan recharge area, Kern Lake, and Coles Levee Ecosystem Preserve) and four new sites at Lemoore Wetland Preserve, Atwell Island, Main Drain Canal, and Goose Lake (Service 2011, p. 6). Population size and health could not be estimated with the available data but, based on the scarcity of suitable habitat and low number of shrews located in areas with high quality habitat, the subspecies was assumed to still be extremely rare (Service 2011, p. 8).

At the time of the 2020 Species Status Assessment, the shrew was considered present at an additional seven sites, for a total of 15 occupied sites (Service 2020b, p. 10). The additional seven sites are Naval Air Station Lemoore, Pixley National Wildlife Refuge (Pixley Refuge), Poso Creek, Semitropic Ecological Reserve, Kern River overflow canal at Semitropic canal crossing, Wind Wolves Preserve – Twin Fawns site, and Wind Wolves Preserve – The Willows site (B. Cypher, Endangered Species Recovery Program, *in litt*. 2017; Cypher et al. 2017, pp. 13–14; Stantec Consulting Services, Inc. 2019, pp. 1, 3; Cypher et al. 2011, p. 13).

Overall, the current distribution of the Buena Vista Lake ornate shrew is similar to as described in the 2020 Species Status Assessment (see Service 2020b, pp. 6–11). The shrew has been detected at 16 sites, 13 of which detected the shrew within the previous 11 years and are considered currently occupied (see Table 1). Since the Species Status Assessment, camera trap surveys were conducted between 2019 and 2022 at 13 sites (Cypher et al. 2023, pp. 1–7). Shrews were detected at one new site, Lone Tree Mitigation Site, that is west of and adjacent to Kern Refuge (Cypher et al. 2023, pp. 5–6). The 66-ha (162-ac) Lone Tree Mitigation Site is a privately owned duck club that is managed as a conservation easement for wetland preservation as off-site compensatory mitigation for California's High-Speed Rail Train Project (Cypher et al. 2023, p. 6; Westervelt 2024, p. 1). At this site, shrews were initially detected in 2019 in the single created and managed wetland area (Westervelt 2024, p. 2). Three additional wetlands and associated upland habitat areas were created in 2021, and shrews were detected in all four sections of Lone Tree Mitigation Site in surveys in 2024 (Westervelt 2024, p. 10; see **Conservation**). In April and May 2024, shrews were detected 20 times across six cameras in both moist and dry habitats (Westervelt 2024, p. 9).

The 2019–2022 surveys also confirmed shrew presence at Atwell Island, Pixley Refuge, and Goose Lake (Cypher et al. 2023, p. 5). Surveys were also conducted at Coles Levee Ecosystem Preserve, where shrews were detected in 2005 but not detected in three recent surveys in 2016, 2020, and 2021 (Cypher et al. 2023, p. 6). This site has an abundance of undisturbed, suitable habitat, and water is available year-round, so the lack of shrew detection despite deployment of ten camera traps for a week in 2020 and 20 camera traps for a week in 2021 is concerning (Cypher et al. 2023, pp. 5–6). Cypher et al. (2023, p. 16) suggests that the habitat area of 2 ha (5 ac) is too small to fully support a population, and shrews may migrate in and out of the area to meet resource and territory needs.

Table 1. Surveys and occupied sites for the Buena Vista Lake ornate shrew (Newman et al. 2005, p. 14; Cypher et al. 2011, p. 13; Cypher *in litt*. 2017; Cypher et al. 2017, pp. 13–14; Stantec Consulting Services, Inc. 2019, pp. 1, 3; Cypher et al. 2023, p. 5; Westervelt 2024, p. 10; Service *in litt*. 2024a). For the 2025 status, a site is considered occupied if a positive detection occurred within the previous 11 years, to be inclusive of the surveys conducted in 2014. The number of occupied sites has increased from four sites at the time of listing to 13 sites in 2025. The shrew has been detected at least once at a total of 16 sites.

Site name (listed north to south)	**Considered occupied during 2002 listing**	**Considered occupied during 2011 status review**	**Considered occupied during 2020 Species Status Assessment**	**Considered occupied during 2025 status review and recent survey results**
Naval Air Station Lemoore	Not surveyed	Not surveyed	Yes	Yes, last detected in 2017
Lemoore Wetland Preserve	Not surveyed	Yes	Yes, but no recent surveys	No, last detected in 2005. Surveys should be conducted
Pixley Refuge	Not surveyed	No	Yes	Yes, last detected in 2022
Atwell Island	Not surveyed	Yes	Yes	Yes, last detected in 2021
Lone Tree Mitigation Site	Not surveyed	Not surveyed	Not surveyed	Yes, last detected in 2024
Kern Refuge	Yes	Yes	Yes	Yes, last detected in 2024
Poso Creek	Not surveyed	Not surveyed	Yes	Yes, last detected in 2019
Semitropic Ecological Reserve	Not surveyed	Yes	Yes	Yes, last detected in 2014
Main Drain Canal (also referred to as Kern River overflow canal at Freeway 5 and Highway 46)	Not surveyed	Not surveyed	Yes	Yes, last detected in 2014
Goose Lake	Not surveyed	Yes	Yes, but no recent surveys	Yes, last detected in 2022

Site name (listed north to south)	Considered occupied during 2002 listing	Considered occupied during 2011 status review	Considered occupied during 2020 Species Status Assessment	Considered occupied during 2025 status review and recent survey results
Kern River overflow canal at Semitropic canal crossing	Not surveyed	Not surveyed	Yes	Yes, last detected in 2017
Kern Fan recharge area (also referred to as City of Bakersfield water recharge area)	Yes	Yes	Yes	Yes, last detected in 2014, but 2019 surveys did not detect the subspecies
Coles Levee Ecosystem Preserve	Yes	Yes	Yes, but not found during recent surveys	No, last detected in 2005. Surveys in 2016 and 2020 did not detect the species
Kern Lake	Yes	Yes	Yes, but no recent surveys	No, subspecies was last detected before 1993, and additional surveys should be conducted
Wind Wolves Preserve – Twin Fawns	Not surveyed	No	Yes	Yes, last detected in 2014
Wind Wolves Preserve – The Willows	Not surveyed	No	Yes	Yes, last detected in 2014

Six other sites (Lake Woollomes, Tumblin Lake, Semitropic Water Storage District Overflow, Tule Elk Reserve, Hart Park, Panorama Vista Preserve, and California State University Bakersfield) contain suitable habitat and have been surveyed, but shrews were not detected (Cypher et al. 2017, p. 13; Cypher et al. 2023, p. 5). As discussed in **Species overview**, the shrews are sensitive to changes in hydrology and microhabitat conditions and are difficult to detect, so negative survey findings do not necessarily indicate that the subspecies is not present. In addition to these challenges, the shrew's brief life span and high turnover makes it difficult to measure abundance and deduce population dynamics from the surveys. Multiple years of intensive surveys incorporating both trapping and camera traps may allow for more insight about changes in abundance and population structure (see **Recommendations for Future Actions**). Occurrence data are also available in the California Natural Diversity Database maintained by the California Department of Fish and Wildlife. However, the shrew records have not been updated since 2000, and more recent information is available in the survey reports referenced in Table 1.

Threats:
At the time of listing, the primary threats to the Buena Vista Lake ornate shrew were identified as habitat loss and modification, including unnatural hydrological conditions, caused by agricultural activities (Service 2002, p. 10101). Other threats that contributed to the listing of the Buena Vista Lake ornate shrew as endangered include uncertainty of water availability and delivery to support riparian and marsh habitat, incompatible water management practices, possible toxic effects of selenium poisoning, modification or loss of genetic integrity from introgression (i.e., hybridization), loss of populations caused by random naturally occurring events, and possible impacts of pesticides on the shrew's reproductive success and insect prey base (Service 2002, pp. 10101, 10110).

The 2011 status review confirmed that habitat loss due to industrial, agricultural, and urban development, limited water allocation to riparian and wetland areas, and selenium toxicity continued to impact the subspecies (Service 2011, p. 16). The 2011 status review also identified climate change, mortalities due to scientific trapping, and limited gene flow as new threats to the shrew (Service 2011, pp. 12, 15–16). The 2020 Species Status Assessment and status review identified the threats of agricultural and urban development, insufficient water supply, changing climate as a contributor to insufficient water supply, selenium contamination, and pesticide contamination as driving the endangered status of the subspecies (Service 2020a, p. 2; Service 2020b, p. 69). The 2020 Species Status Assessment provides an in-depth assessment of these threats and discusses how these threats may affect the subspecies through 2050 (see Service 2020b, pp. 18–85). Each of these threats is still present throughout the shrew's range, and the effects of these threats on the subspecies remain similar to as described in the 2020 Species Status Assessment.

Conservation and research:
As the Buena Vista Lake ornate shrew is highly elusive, conservation activities for the subspecies are focused on research and surveys to gather information about its biology, habitat use, population dynamics, and genetics. Testing of various survey methodologies have determined that camera trap surveys are one of the most effective, cost-efficient, and safe techniques to detect the shrew (Tennant et al. 2020, entire). Habitat condition assessments conducted concurrently during surveys concluded that the shrew prefers areas near standing water or with moist mud cracks and dense vegetation or litter cover and that the shrew quickly moves in response to microhabitat condition changes (Cypher et al. 2017, entire; Cypher et al. 2023, entire).

Survey methodologies
As conventional live-trapping surveys of shrews have low capture and high mortality rates, Tennant et al. (2020, entire) explored the effectiveness of three noninvasive survey methods for the shrew: track tubes, scat tubes, and camera traps. The track and scat tubes were constructed from polyvinyl chloride (PVC) pipes baited with mealworms that collected track prints using an ink pad and white notecards or collected scats (Tennant et al. 2020, p. 611). The camera traps tested different camera models attached to a metal t-post at a bait station (Tennant et al. 2020, p. 612). The track tubes were ineffective due to the difficulty of differentiating shrew tracks from other small mammals that entered the tubes (Tennant et al. 2020, p. 613). The scat tubes had slightly higher success and were easier to construct than the track tubes; however, shrew scats could not always be reliably distinguished from other small mammals, and shrews were observed

on camera to enter the tubes without depositing scat, resulting in a potential for false-negative results (Tennant et al. 2020, p. 613).

Cameras traps were highly effective at detecting shrews, especially models with close-focus capability that rapidly captured multiple photos to allow for identification of shrews versus other small mammals (Tennant et al. 2020, pp. 613–614). Effectiveness of the camera traps increased when the surrounding vegetation was trimmed to prevent false triggers and obstruction in the images (Tennant et al. 2020, p. 614). The most attractive bait station for the cameras was a partially buried container of live mealworms to attract shrews with scent and sound with dried mealworms on top as both a lure and reward (Tennant et al. 2020, pp. 613–614). Individual shrews repeatedly returned to the bait station for more mealworms, providing multiple opportunities to capture images for identification (Tennant et al. 2020, p. 614).

Camera traps were also much more effective at detecting shrews than the aluminum Sherman live-traps typically used for rodent surveys (Tennant et al. 2020, p. 615). When camera traps and live-traps were concurrently tested, camera traps detected shrews at 24 locations, but live-traps only captured one shrew out of the 62 times that a shrew entered a trap (Tennant et al. 2020, p. 615). While camera traps are a better option for detection, effectiveness, and safety of shrews, live-trapping may still be necessary for mark-recapture, telemetry, morphological studies, and sample collection (Tennant et al. 2020, p. 615). Selecting the most appropriate methodology for the study needs will increase chances of detection, decrease incidental shrew mortalities, and increase the cost-effectiveness of data collection, thereby furthering conservation of the subspecies.

Habitat conditions assessment

Characterizing suitable and preferred habitat types for the Buena Vista Lake ornate shrew informs subspecies management and conservation actions, including identifying optimal areas for further surveys and by guiding water management and habitat restoration. Cypher et al. (2017, pp. 19–20; 2023, p. 13) attempted to draw conclusions about preferred shrew habitat conditions during the 2014–2017 surveys by recording plant species and quantifying vegetation density, litter depth, and distance to open water. They detected shrews in riparian areas, marshes, wetlands, sloughs, and canal banks with moist soil, with many detections occurring within 1 to 2 meters (m) (3.3 to 6.6 feet (ft)) of standing water (Cypher et al. 2017, p. 19). Shrews seem to prefer areas with high cover provided by dense vegetation or deep leaf litter, such as dense patches of rushes, sedges, and cattails with thick mats of stems or areas with deep leaf litter under cottonwood and willow trees (Cypher et al. 2017, p. 19). Cypher et al. (2023, pp. 13–14) repeated this habitat assessment during the 2019–2022 surveys and arrived at similar conclusions to the previous study regarding shrew habitat preferences. The study also found that where dense vegetation was not present, mud cracks more than 20 centimeters (7.9 inches) deep seemed to provide the same functions of a moist microhabitat that supports invertebrate prey and protects shrews from predators (Cypher et al. 2023, p. 13).

Both studies were only able to draw general conclusions due to the elusive nature of the shrew, similarity between locations where shrews were and were not detected, and high temporal and spatial variability of shrew habitat (Cypher et al. 2017, pp. 19–20; Cypher et al. 2023, p. 13). To investigate the temporal patterns of shrew presence, Cypher et al. (2023, p. 14) also conducted several longer seasonal surveys at Kern Refuge, Lone Tree Mitigation Site, and Atwell Island. At

each site, camera stations were set up near standing water to study whether and how quickly shrews moved to stay within wetland margins as the water line recedes (Cypher et al. 2023, p. 14). At all sites, shrews exhibited the same movement pattern of spreading outwards to the wetland margins during flooding and, as the water recedes, rapidly recolonizing the recently flooded areas where soils are moist (Cypher et al. 2023, p. 14). A similar follow-up camera trap study at Kern Refuge determined that shrew detections increased after flooding of seasonal wetlands (Service *in litt*. 2024b, p. 3). Prior to the flooding event, between November 2022 and March 2023, six shrews were detected in four out of 13 camera trap station sites set up in a portion of the refuge (Service *in litt*. 2024b, p. 2). After the flooding event, between November 2023 and March 2024, 46 shrews were detected across eight out of those same13 camera trap station sites (Service *in litt*. 2024b, p. 2).

In contrast to the above evidence that shrews select habitat based on proximity to water, shrews were recently detected much farther from water sources in the uplands of Kern Refuge than previously recorded (Service *in litt*. 2024c, p. 1). In August 2024, 36 cameras were deployed across the refuge at varying distances from the seasonal wetlands area (Service *in litt*. 2024c, p. 1; A. Calistri-Yeh, Kern National Wildlife Refuge, *in litt*. 2025, p. 34). By December 2024, shrews were detected by 10 of the cameras and up to 1,665 m (5,463 ft) from an active water source (Service *in litt*. 2024c, p. 1). Additionally, shrews were detected up to 1,089 m (3,573 ft) from the nearest seasonal water source, which did not contain water at the time of shrew detection but contains water at some point in the year (Service *in litt*. 2024c, p. 1; Calistri-Yeh *in litt*. 2025, pp. 49–51). The study is also assessing upland site characteristics such as grass density, ground cover, and shrub cover to further evaluate upland habitat associations (Service *in litt*. 2024c, p. 1). Preliminary results indicate that shrew occupancy in the uplands decreases with a higher proportion of bare ground and increases with amount of vegetative cover (Calistri-Yeh *in litt*. 2025, pp. 69–70). These correlations may be due to the importance of cover to protect shrews from predators and to provide prey for shrews (Calistri-Yeh *in litt*. 2025, pp. 69–70). The study will continue for at least one full year to assess seasonal differences in shrew detection and habitat preferences (Service *in litt*. 2024c, p. 2).

Besides temporal patterns, shrew presence may be influenced by attributes that were not measured, such as movement patterns, larger scale home range attributes, population density, mortalities, competition, temperature, moon phase, and prey distribution (Cypher et al. 2023, p. 13). This is indicated by inconsistent detection of shrews at single camera trap stations where measured habitat conditions remained the same over a brief period (Cypher et al. 2023, p. 13). Nuñez (2024, entire) explored correlations between the positive detections from Cypher et al. (2017, entire) and Cypher et al. (2023, entire) and other abiotic and biotic factors. Of the considered abiotic factors of ambient air temperature, precipitation, relative humidity, and dew point temperature, ambient air temperature was the best predictor of shrew detection; the probability of detection increased as air temperature decreased (Nuñez 2024, p. 22). Relative humidity also had a significant positive effect on shrew detection, while precipitation and dew point temperature did not significantly predict detection (Nuñez 2024, pp. 24–25). In contrast, the 2022–2024 study at Kern Refuge found that neither air temperature nor precipitation correlated to detection rates (Service *in litt*. 2024b, p. 3). These results may inform predictions of how the shrew's population resiliency will change with climate change, but further studies are needed to draw conclusive results.

Nuñez (2024, pp. 43–54) also assessed potential competition between shrews and two co-occurring small mammals, the North American deer mouse (*Peromyscus maniculatus*) and the western harvest mouse (*Reithrodontomys megalotis*). This study concluded interspecific competition between these animals is unlikely as there is little evidence of temporal partitioning of their active periods, indicating that there is little competition for resources, and no aggressive interactions were captured by the cameras (Nuñez 2024, pp. 50–51). More intensive research should be conducted to fully understand the shrew's suitable habitat conditions and limiting factors and to apply this information to management and conservation actions (see **Recommendations for Future Actions**).

Genetics

Maldonado (2023, entire) developed a whole genome sequence for the Buena Vista Lake ornate shrew and conducted analyses from genetic samples extracted from scats collected in scat tubes. The study demonstrates that a noninvasive sample collection and analysis technique is effective in identifying subspecies, sex, and population genetic variability, structure, and connectivity (Maldonado 2023, pp. 29–31; Cypher et al. 2023, p. 20). To develop the whole genome sequence, Maldonado (2023, p. 27) sequenced preserved genetic samples extracted from Buena Vista Lake ornate shrew tissue samples that were collected and used in previous studies. These sequences were referenced to the common shrew (*S. araneus*), after which single nucleotide polymorphisms (SNPs) were identified (Maldonado 2023, p. 27). SNPs, changes in single nucleotides within a gene sequence, are a type of genetic variation within a taxonomic group that can determine characteristics such as physical traits and vulnerability to disease. Measures of genetic health such as heterozygosity and inbreeding coefficients can also be calculated through the proportion of specific SNPs in a population (Maldonado 2023, p. 28). After SNPs were identified in the shrew genome, complementary gene segments called baits were used to capture and amplify the SNPs-containing segments of interest in the scat samples (Maldonado 2023, pp. 27–28).

This new targeted sequencing method, referred to as in-solution deoxyribonucleic acid (DNA) hybridization capture, was more sensitive in identifying subspecies than the traditional method of amplifying mitochondrial genes through polymerase chain reactions (PCR) (Maldonado 2023, p. 28). Maldonado (2023, p. 29) was also able to more accurately determine sex than with morphological observations, since immature males without visible testes may be misidentified as females. The study found that the Buena Vista Lake ornate shrew has a much larger effective population size, higher levels of heterozygosity, and lower inbreeding coefficients than the rare Catalina Island shrew (*S. o. willetti*), which the study used as an outgroup for comparison (Maldonado 2023, p. 29). While there was not enough information to infer recent demographic dynamics, the data showed oscillating population size through time, which may attribute to the difficulty of surveying the subspecies (Maldonado 2023, pp. 29–30). Additional analyses that may be conducted with this technique are discussed in **Recommendations for Future Actions**.

Habitat restoration

The Buena Vista Lake ornate shrew has successfully colonized created and restored wetlands, such as at Atwell Island, Lone Tree Mitigation Site, and Kern and Pixley Refuges, demonstrating that habitat restoration is an important conservation activity for the subspecies (Cypher et al. 2023, p. 18). At Lone Tree Mitigation Site, 2019–2021 surveys detected the shrew in a managed wetland portion of the site that was created in the early 2000s for waterfowl hunting (Westervelt

2024, p. 2). In 2021, the other portions of the site were restored as shrew habitat through the creation of three managed wetlands surrounded by upland habitat (Westervelt 2024, p. 3). The underground pipe system that delivers well water to the original created wetland was expanded to support the three new wetlands, and native vegetation was seeded or planted to provide cover (Westervelt 2024, pp. 2–3).

For the first five years (2022–2027), annual monitoring is being conducted at Lone Tree Mitigation Site for habitat suitability and shrew presence (Westervelt 2024, p. 4). Shrews were not detected during 2022 and 2023 surveys (Westervelt 2023, pp. 9–11). During 2024 monitoring, habitat assessments found that the sites are dominated by annual plants with little to no leaf litter and that soil cracks were present, but the majority had low soil moisture (Westervelt 2024, pp. 11–12). The wetlands are flooded in late fall and are dry by early May (Westervelt 2024, p. 12). Despite the seemingly less than optimal conditions, camera trap stations operated in April and May 2024 detected shrews in all four wetland areas, demonstrating an expansion of shrew habitat use from the initial wetland due to habitat restoration (Westervelt 2024, p. 10). It is unknown why shrews were not detected in 2022 and 2023 after restoration efforts, but it may be due to shrews not yet expanding into the newly restored areas.

In 2022, Kern Refuge proposed the Shrew Slough Restoration Project to improve and create shrew habitat on 16 ha (41 ac) (Service 2022, p. 2). Prior to restoration, only 0.19 ha (0.46 ac) of this area provided dense cover and moist soils to support shrews, and shrews were detected in this area in 1999, 2016, and 2021 (Service 2022, p. 6). The remaining area held water during the winter and had sparse vegetation and dry soil in the summer, making it unsuitable for shrews (Service 2022, p. 6). Through restoration, Kern Refuge aimed to expand the shrew habitat area by changing the hydrology so that water conveyance is more efficient and reliable and by increasing tree cover density to be more suitable for shrews (Service 2022, p. 7). The mostly completed project involved the rehabilitation and development of swales, formation of five riparian side channels, and planting of native trees along the slough and riparian channels (Service 2022, p. 2). The swale previously could not efficiently convey water through the area, so it was restored and deepened (Service 2022, p. 2). The side channels were constructed with a naturally meandering form, which will help the existing channel hold water for longer and expanded the riparian footprint of the area (Service 2022, p. 2). The tree planting, which is ongoing, will provide cover for shrews. Further surveys are needed to determine whether restoration will result in expansion of shrew use from the original habitat area.

Recovery criteria:
There are currently no recovery criteria for the Buena Vista Lake ornate shrew. The Recovery Plan for Upland Species of the San Joaquin Valley, which was finalized when the shrew was a candidate for listing but not yet listed, provides three criteria for long-term conservation of the subspecies (Service 1998, p. 192). We provide an assessment of progress towards these criteria below. As more information about the distribution, habitat use, and genetics of the subspecies is available, a recovery plan with recovery criteria should be developed (see **Recommendations for Future Actions**).

Criterion 1: Secure and protect from incompatible uses three or more disjunct occupied sites collectively with at least 2,000 ha (4,940 ac) of occupied habitat.
This criterion was met at the time of the 2020 status review. Seven sites encompassing 5,269 ha (13,020 ac) were considered occupied with habitat protection for wetlands, including: Naval Air Station Lemoore, Lemoore Wetland Preserve, Pixley Refuge, Atwell Island, Kern Refuge, Wind Wolves Preserve – Twin Fawns, and Wind Wolves Preserve – The Willows. Out of 15 occupied sites, 12 sites had some form of habitat protection. Of these, five sites were considered minimally protected (i.e., critical habitat designation on private land or provisions that prevent development but do not protect wetlands in areas with low water stability), so these sites do not contribute to meeting this criterion, and there are seven sites remaining.

Currently, this criterion is met. Areas are considered secured and protected when they are (1) protected for open space purposes through fee title ownership or conservation easement and (2) secured from incompatible uses with the shrew. Occupied habitat areas are derived from the analysis in the 2020 Species Status Assessment and updated with recent satellite imagery (see Service 2020b, pp. 20–50). Seven sites encompassing 4,561 ha (11,270 ac) are considered currently occupied, protected, and secured: Naval Air Station Lemoore, Pixley Refuge, Atwell Island, Lone Tree Mitigation Site, Kern Refuge, Wind Wolves – Twin Fawns, and Wind Wolves – The Willows. These are the same sites as in 2020, except for the removal of Lemoore Wetland Preserve, which is not considered currently occupied, and the addition of Lone Tree Mitigation Site. Kern Refuge has 4,093 ha (10,113) ac of occupied habitat, which makes up most of the occupied, protected, and secured area.

While Semitropic Ecological Reserve is protected by the California Department of Fish and Wildlife, it is managed primarily for upland habitat with no supplemental water delivery in drought years (J. Battistoni, California Department of Fish and Wildlife, *in litt*. 2019). Similarly, the City of Bakersfield requires that the Kern Fan recharge area remain undeveloped, but the primary management objective is not for open space or conservation (City of Bakersfield 2014, p. 44). Therefore, these two sites are protected but do not contribute to meeting this criterion. Since this criterion focuses on occupied habitat, the status of the criterion may change in the future if occupancy changes due to factors such as the subspecies' oscillating population dynamics and response to habitat condition and management changes.

Criterion 2: Approved and implemented management plan that includes Buena Vista Lake ornate shrew survival as an objective for all protected areas.
This criterion was partially met at the time of the 2020 status review. Of the seven sites discussed above, two sites have an approved and implemented management plan that includes the shrew's survival as an objective. Naval Air Station Lemoore has an approved Integrated Natural Resources Management Plan, and Kern Refuge has a Comprehensive Conservation Plan (Naval Air Station Lemoore 2014, pp. 3–52; Service 2005, pp. 84–85). Pixley Refuge has a management plan that discusses riparian and wetland areas, but the plan does not include the shrew's survival as an objective (Service 2005, pp. 94–95).

Currently, this criterion is partially met, and three protected areas have management plans. In addition to the two management plans discussed above, Lone Tree Mitigation Site operates under an approved management plan that includes the shrew's survival as an objective (see High-Speed Rail 2021, entire). Specifically, the management plan requires annual monitoring of shrew

presence as a performance standard (High-Speed Rail 2021, p. 44). The monitoring will also document shrew habitat associations and components that will be considered the appropriate baseline conditions for the subspecies (High-Speed Rail 2021, p. 45). Future habitat monitoring results will be compared to the baseline conditions to determine when adaptive management, such as restoration or a change in flooding regime, is appropriate (High-Speed Rail 2021, p. 45).

Criterion 3: Population monitoring shows continuing Buena Vista Lake ornate shrew presence at known occupied sites.
This criterion was not met at the time of the 2020 status review because no occupied location was regularly monitored for shrew presence. Currently, this criterion is partially met. Kern Refuge is the only occupied site with consistent shrew monitoring and detections indicating continuing presence. Camera trap stations were deployed at Kern Refuge in 2016 and 2018–2024 and shrews were detected in all eight years (Service 2024a, entire). Besides Kern Refuge, Pixley Refuge and Lone Tree Mitigation Site are monitored more recently and frequently than the other occupied sites; however, additional years of monitoring are needed to determine whether shrew presence is consistent. Camera trap stations were deployed at Pixley Refuge in 2021, 2022, and 2024, with shrew detections in 2021 and 2022 (Service 2024a, entire). Camera trap stations were deployed at Lone Tree Mitigation Site in 2019 and 2022–2024, with shrew detections in 2019 and 2024 (Westervelt 2023, pp. 11–12; Westervelt 2024, p. 10). In 2022, a shrew was detected on the property north of the Lone Tree Mitigation site but not within the mitigation property (Westervelt 2023, p. 9).

Conclusion:
After reviewing the best available scientific information, we conclude that the Buena Vista Lake ornate shrew remains an endangered subspecies. The evaluation of threats affecting the subspecies under the factors in 4(a)(1) of the ESA and analyses of the status of the subspecies in the 2020 Species Status Assessment (Service 2020b, entire) and 2020 status review (Service 2020a, entire) remain an accurate reflection of the subspecies' current status.

RECOMMENDATIONS FOR FUTURE ACTIONS

Here we propose several management, conservation, and research recommendations which will aid in the recovery and conservation of the Buena Vista Lake ornate shrew. Some of these recommendations have already been discussed in previous recovery documents (Service 2011, pp. 17–20; Service 2020, pp. 4–5) and remain valid.

1. *Protect, manage, and restore habitat that is currently occupied, is unoccupied and within the subspecies' historical range, and provides connectivity between populations.* All native occurrences of the shrew should be protected and secured from incompatible uses through land acquisition, conservation easement, or other means. Additional unoccupied habitat within the subspecies' historical range should be protected and restored as colonization opportunities or dispersal habitat for the shrew. The Service and other partners should collaborate with private landowners to protect their land for open space purposes through a conservation easement or voluntary Conservation Benefit Agreement that contributes to shrew conservation. This will enhance the size and connectivity of the isolated areas where the shrew is currently found. Habitat connectivity is essential to the recovery of the subspecies as it allows for migration among populations, increases

genetic variation between populations, and reduces inbreeding. Adaptive and site-specific management of occurrences should be implemented under long-term management plans with a focus on maintaining suitable habitat conditions, especially for vegetative cover, water availability, and soil moisture. Long-term management plans should be based on habitat assessment findings and successful restoration projects and should include recommended practices such as slowly changing water levels and keeping soils moist when standing water is not present (Cypher et al. 2017, p. 23).

2. *Determine distribution and population dynamics through regular monitoring.* Regular monitoring of known occupied and other suitable habitat areas should occur through a combination of camera trap surveys and live trapping. Camera trap surveys should first be used to detect presence as they are more cost-effective and less labor-intensive. Camera trap stations should be operated for at least three nights, but preferably seven nights, to increase likelihood of detection (Cypher et al. 2023, p. 19). After shrew presence is confirmed, live trapping can facilitate telemetry and capture-recapture models to estimate population sizes, oscillations through time, and change in response to change in conditions. Standardization of the time of year, bait, type of traps, and standard number of traps per unit of area for each of the areas should be established to help ensure unbiased data and a higher likelihood of success. Temporarily marking individuals by clipping fur would allow the application of capture-recapture population models to estimate population sizes. Other dimensions of the subspecies' population dynamics and life history, such as survival rates, sources of mortality, reproductive attributes, and dispersal distances, should also be investigated (Cypher et al. 2023, p. 19). Finally, Tennant et al. (2020) suggests that acoustic surveys should be explored as a noninvasive survey method for the shrew (p. 615). This method has successfully detected small mammals such as brush mice (*P. boylii*) (see Petric and Kalcounis-Ruepell 2013, entire). It is unknown whether the Buena Vista Lake ornate shrew produces vocalizations, but several other species of *Sorex* produce ultrasonic acoustic vocalizations that allow them to be detected through acoustic monitoring (see Zsebők et al. 2015, entire).

3. *Continue to conduct studies on habitat preferences and associations.* Further studies on preferred shrew habitat types and microhabitat conditions should be conducted to inform survey locations, habitat acquisition, management, and restoration. The studies should consider the primary variables of vegetation composition, vegetation structure and density, litter type and depth, soil moisture, presence of soil cracks, distance to standing water, and invertebrate abundance (Cypher et al. 2017, p. 23). Additional variables that may determine shrew presence are shrew movement patterns, larger scale home range attributes, population density, mortalities, competition, temperature, moon phase, prey distribution, ambient air temperature, relative humidity, and precipitation (Cypher et al. 2023, p. 13).

4. *Apply in-solution DNA hybridization capture method to further explore genetic health and demographic history.* Apply the genetic techniques discussed in **Conservation** to explore the subspecies' genetic health, such as evidence of deleterious mutation accumulation or allelic purging (Maldonado 2023, p. 31). Use the resulting information to inform habitat protection and restoration plans to increase connectivity among populations that would benefit from genetic exchange. Additionally, the new genetic

techniques can be used to estimate the level of genetic differentiation between the Buena Vista Lake ornate shrew and the other subspecies to further clarify taxonomy (Maldonado 2023, p. 31).

5. *Develop recovery plan with recovery criteria.* As more information about the subspecies has been acquired since the subspecies was listed and since the publication of the Recovery Plan for Upland Species of the San Joaquin Valley, a recovery plan should be developed so that recovery criteria can replace the long-term conservation criteria. The recovery criteria should consider minimum sizes for protected areas rather than solely the total size, which can result in many small habitat blocks that are insufficient in meeting all shrew needs. The protected areas criterion should also consider shrew territory sizes and dispersal distance. The recovery criteria should incorporate water reliability, which is a core component in shrew habitat suitability. Additionally, the recovery criteria should describe the relationship between detection and occupied area, i.e., how much of the surrounding suitable habitat area should be considered occupied when a shrew is detected at a location.

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