Buena Vista Lake Ornate Shrew
Species Status Assessment



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GENERAL SUMMARY

In this Species Status Assessment (SSA) we (the US Fish and Wildlife Service (FWS)) assess the current and future viability of the Buena Vista Lake ornate shrew (BVLOS, "the shrew," *Sorex ornatus relictus*). "Viability" refers to the ability of a species or subspecies to avoid extinction. Three factors contribute to viability: resiliency, redundancy, and representation. These refer to the ability of populations to withstand environmental and demographic stochasticity and disturbances, the ability of the species to recover from catastrophic losses, and the ability of the species to maintain representative genetic variation, thereby allowing it to adapt to novel environmental changes (Shaffer and Stein 2000, pp. 308-311).

The BVLOS is a small mammal known from 11 sites in the southern portion of the San Joaquin Valley, California (the Tulare Basin). They require moist soils, dense groundcover, and diverse prey populations of insects, earthworms, and other small invertebrates. The known occupied sites constitute remnant patches of wetland and riparian habitat, which were considerably more extensive prior to development of the region for agriculture in the early-1900s. We listed the BVLOS as endangered in 2002 and designated critical habitat for it in 2013.

Important stressors influencing the viability of the subspecies include agricultural and urban development, insufficient water supply, potentially toxic levels of selenium in various water sources, pesticides, and inbreeding depression.

Despite these stressors, BVLOS currently shows greater redundancy and representation than what was known at the time of listing.

In the future, resiliency is likely to decrease generally due to changing climate, insufficient water, selenium, pesticides, and inbreeding depression. Redundancy also appears likely to decrease due to population losses from changing climate, insufficient water, and additional development. If the populations lost include those supporting important diversity within the subspecies, then representation will decrease in the future as well.

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LIST OF ACRONYMS AND ABBREVIATIONS

Agencies:

BLM: U.S. Bureau of Land Management.
CalTrans: California Department of Transportation
Corps: U.S. Army Corps of Engineers.

FWS: U.S. Fish and Wildlife Service.
NRCS: National Resources Conservation Service.
USBOR: U.S. Bureau of Reclamation.

Biological:
BVLOS: Buena Vista Lake ornate shrew ("the shrew," *Sorex ornatus relictus*).
DNA: Deoxyribonucleic acid. Molecules in cells that carry genetic information used to direct physiological and behavioral development.
spp.: Refers to multiple species. So "*Juncus spp.*" refers to several species in the *Juncus* genus.
SSA: Species Status Assessment. This report is an SSA for the BVLOS.

Citations:
et al.: "Et alia" ("and others").
et seq.: "Et sequens" ("and what follows").
in litt.: "In litteris" ("in correspondence").
p.: Page.
pers. comm.: "Personal communication" (something told to the note taker verbally).
pp.: Pages.

Geographic Areas:
CA: California.
CH: Critical habitat
NAS: Naval Air Station
NWR: National Wildlife Refuge
U.S.: United States of America.

Statutes and Regulations:
ESA: The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.)
C.F.R.: Code of Federal Regulations (official documents in which Federal regulations are collected and organized).
CWA: The Clean Water Act (33 U.S.C. 1344 *et seq*.)
NEPA: The National Environmental Policy Act (42 U.S.C. 4371 *et seq*.)
FIFRA: The Federal Insecticide, Fungicide, and Rodenticide Act.
CVPIA: The Central Valley Project Implementation Act (Public Law 102-575).
CEQA: The California Environmental Quality Act (Public Resources Code Sec. 21000–21177).
U.S.C.: U.S. Code (official documents in which U.S. statutes are collected and organized).

1. STATUS ASSESSMENT FORMAT

We begin this viability status assessment by summarizing the basic background information available for the BVLOS (Section 2). We use that information as a starting point to identify things needed by BVLOS individuals for survival and reproduction (Section 3), and also things needed by the subspecies as a whole to avoid extinction (Section 4). We also consider what potential stressors could interfere with the ability of BVLOS populations to obtain their needs (Section 5).

Having identified BVLOS needs and potential stressors, we then move on to a consideration of the current condition of the subspecies by analyzing the extent to which each potential stressor is currently affecting BVLOS populations (Section 6). We conclude the section by summarizing how the needs and stressors interact to affect the current viability of the subspecies.

Next we consider predictable changes and trends in the stressors, and how those changes are likely to affect subspecies viability over the next 50 years (to 2070). Such a timeframe allows reasonable extrapolation of current trends while still including a large number of future BVLOS generations. In order to help account for uncertainty, we consider optimistic and pessimistic scenarios for each stressor, and then choose an outcome that we consider most likely. We conclude the section by summarizing the most likely overall impacts of the stressors, and thereby characterizing the future viability of the subspecies.

We characterize viability based on the resiliency, redundancy, and representation of BVLOS populations (the three Rs) (Wolf *et al*. 2015, entire).

- **Resiliency** is the ability of a species to withstand environmental stochasticity (normal, year-to-year variations in environmental conditions such as temperature, rainfall), periodic disturbances within the normal range of variation (fire, floods, storms), and demographic stochasticity (normal variation in demographic rates such as mortality and fecundity) (Redford et al. 2011, p. 40). Resiliency is positively related to population size and growth rate and may be influenced by connectivity among populations. Generally speaking, populations need abundant individuals within habitat patches of adequate area and quality to maintain survival and reproduction in spite of disturbance.

- **Redundancy** describes the ability of the subspecies to withstand catastrophic events. Catastrophes are stochastic events that are expected to lead to population collapse regardless of population heath and for which adaptation is unlikely (Mangal and Tier 1993, p. 1083). We can best gauge redundancy by analyzing the number and distribution of populations relative to the scale of anticipated species-relevant catastrophic events. The analysis entails assessing the cumulative risk of catastrophes occurring over time. Redundancy can be analyzed at a population or regional scale, or for narrow-ranged species, at the species level.

- **Representation** is the ability of a species to adapt to both near-term and long-term changes in its physical (climate conditions, habitat conditions, habitat structure, etc.) and biological (pathogens, competitors, predators, etc.) environments. This ability to adapt to new environments-- referred to as adaptive capacity--is essential for viability, as species need to continually adapt to their continuously changing environments (Nicotra et al. 2015, p. 1269). Species adapt to novel changes in their environment by either [1] moving to new, suitable environments or [2] by altering their physical or behavioral traits (phenotypes) to match the new environmental conditions through either plasticity or genetic change (Beever et al. 2016, p. 132; Nicotra et al. 2015, p. 1270). The latter (evolution) occurs via the evolutionary processes of natural selection, gene flow, mutations, and genetic drift (Crandall et al. 2000, p. 290-291; Sgro et al. 2011, p. 327; Zackay 2007, p. 1).

  We can best gauge representation by examining the breadth of genetic, phenotypic, and ecological diversity found within a species and its ability to disperse and colonize new areas. In assessing the breadth of variation, it is important to consider both larger-scale variation (such as morphological, behavioral, or life history differences which might exist across the range and environmental or ecological variation across the range), and smaller-scale variation (which might include measures of interpopulation genetic diversity). In assessing the dispersal ability, it is important to evaluate the ability and likelihood of the species to track suitable habitat and climate over time.

2. SUBSPECIES BACKGROUND

2(1) Taxonomy and Morphology

The BVLOS is one of nine subspecies of ornate shrew (*S. ornatus*) (Maldonado *et al.* 2001, p. 128; Maldonado 2004, p. 887). It is endemic to California, as are six of the other ornate shrew subspecies. The remaining two subspecies live in Baja California (Maldonado *et al.* 2001, p. 128). It is a member of the shrew family (Soricidae), and of the "red-toothed" shrew subfamily (Soricinae), so called because members of this subfamily have a reddish pigment on their teeth (Figure 1, below). The pigment results from iron incorporated into the enamel, particularly on the grinding surfaces, which presumably increases the resistance of the teeth to wear (Strait and Smith 2006, p. 700).



Figure 1:
Sorex ornatus lower jaw (Myers *et al.* 2019, p. 1)

The BVLOS was first described by Joseph Grinnell from a type specimen collected near the original area of Buena Vista Lake, in the southern San Joaquin Valley (Grinnell 1932, entire). He gave it the subspecific name "relictus" because he considered it a relic of wildlife that was being lost at the time due to conversion of the original marshy habitat for agriculture (Grinnell 1932, p. 389).

The BVLOS is about the size of a mouse, but with smaller eyes, a longer more pointed snout, and five toes rather than four on the front feet (FWS 2011, p. 2; Cypher *et al.* 2017, p. 9). Shrews also lack the large, continuously growing front teeth that mice and other rodents use for gnawing (Churchfield 1990, pp. 2–3).

Ornate shrews are generally grayish brown with a pale underbelly (Burt and Grossenheider 1964, p. 9). BVLOS are grayish black rather than brown, and are slightly larger than their neighboring subspecies, the Southern California ornate shrew (*S. o. ornatus*) (Grinnell 1932, p. 389; FWS 2002, p. 10101).

2(2) Behavior and Diet

Ornate shrews maintain high minimum (4.5 Kcal/day) and maximum (6.0 Kcal/day) metabolic rates, requiring them to feed every few hours (Genoud 1988, p. 173; McNab 1991, p. 35; Collins *in litt.* 2000, p. 8). They are thus active during both day and night, but are rarely seen due to their small size and cryptic behavior. (Burt and Grossenheider 1964, p. 8; FWS 2011, p. 2).

The specific feeding and foraging habits of the Buena Vista Lake shrew are not well known (FWS 2013, p. 39846; Cypher *et al*. 2017, p. 24). However, the vagrant shrew (*S. vagrans*), which is closely related (Maldonado *et al*. 2001, p. 136) and also occupies marshy habitats, eats insects, sow bugs, centipedes, spiders, earthworms, slugs, springtails, small frogs and salamanders, and some vegetable and fungal matter (Burt and Grossenheider 1964, p. 8; Aitchison 1987, p. 17).

2(3) Habitat

BVLOS have most commonly been found near open water, in areas with a dense vegetative understory or a deep layer of leaf litter (Collins *in litt.* 2000, p. 8; FWS 2013, p. 39845; FWS 2017 p. 15). Such areas have moist soil and dense cover from riparian or emergent marsh vegetation such as rushes (*Juncus spp.*), sedges (*Carex spp.*), or cattails (*Typha spp.*) (Williams and Harpster 2001, p. 12; Cypher *et al.* 2017, p. 22). The dense vegetation provides protection from predators for the shrew and also supports prey items such as insects and other invertebrate species (FWS 2017, p. 15). Other invertebrate prey species, such as earthworms, burrow in soil, and so are more prevalent and more accessible to the shrew where soils are moist. Downed logs and branches may also be important, since they are common at sites where BVLOS have been found and tend to attract prey species (Collins *in litt.* 2000, p. 8). We refer to large areas of such habitat as "optimal".

BVLOS have also occasionally been found in drier areas with fairly dense vegetation consisting of grassland, alkali desert scrub, alkali sink scrub, or (less frequently) disturbed habitats (FWS 2017, p. 14). Such areas typically have a seasonal or artificial water source within several hundred feet, or a high water table, that maintains fairly moist soils at or just below surface level (FWS 2017, pp. 14–15). In cases where soil moisture is below surface level, rodent burrows or cracks in the soil surface may provide BVLOS with access to the moist areas and the invertebrate prey those areas support (FWS 2013, p. 39846; FWS 2017, p. 16). Some such areas, such as Atwell Island (FWS 2013, p. 39846) may support BVLOS throughout the year, whereas others may serve as areas into which BVLOS populations can expand temporarily (FWS 2017 pp. 14–15). We refer to large areas of this sort of habitat as "sub-optimal".

Finally, large areas with somewhat dense vegetative cover and soils moist enough to support a marginal prey base, may be important to BVLOS for movement and dispersal (FWS 2017, p. 15). BVLOS may also use more narrow corridors of optimal or suboptimal habitat for this purpose. We refer to this such habitat as "dispersal habitat".

2(4) Reproduction and Life History

Little is known specifically about the reproduction and mating system of the BVLOS, but ornate shrews in general typically breed from early spring through May with some limited late summer and early fall breeding by individuals born late in the previous year, or during the early part of the previous spring (Owen and Hoffmann 1983, p. 3; Collins *in litt.* 2000, p. 8; FWS 2013, p. 39846; see Figure 2). Such late-season breeding is likely restricted to optimal habitat with abundant water (FWS 2017, p. 14). The gestation period is typically 21 days, after which females give birth to a litter of four to six young (Collins *in litt.* 2000, p. 8). Nursing likely lasts about 22 to 25 days (based on studies of the common shrew (*Sorex araneus*) a species in the same genus as BVLOS), after which the young disperse and attempt to establish territories (Churchfield 1990, pp. 55, 56). Juveniles typically disperse only as far as is necessary to find an area of unoccupied habitat in which to establish a territory (Churchfield 1990, p. 56). Observed dispersal distances for individuals of the *Sorex* genus have ranged from a few meters to, in one case, approximately 800 m (0.5 mi) (Churchfield 1990, p. 56). This is much less than the

distance between known BVLOS populations (see Figure 4, below), but occasional migration and genetic exchange between BVLOS populations may potentially be possible due to longer-distance dispersal along unlined canals, and the establishment of short-lived populations at intermediate distances between the known populations during wet years (Cypher pers. comm. 2019, p. 2; Tennant pers. comm. 2019a, p.1).

Females typically stay in their territories for life, but males may abandon them during the breeding season in order to search for more females (Churchfield 1990, p. 56). Males are not known to contribute to care of the young, and in *Sorex araneus* males are aggressively driven away by females shortly after copulation (Churchfield 1990, p. 28). Life expectancy for most ornate shrews is 12 to 16 months, so annual turnover is high (Collins *in litt.* 2000, p. 8).

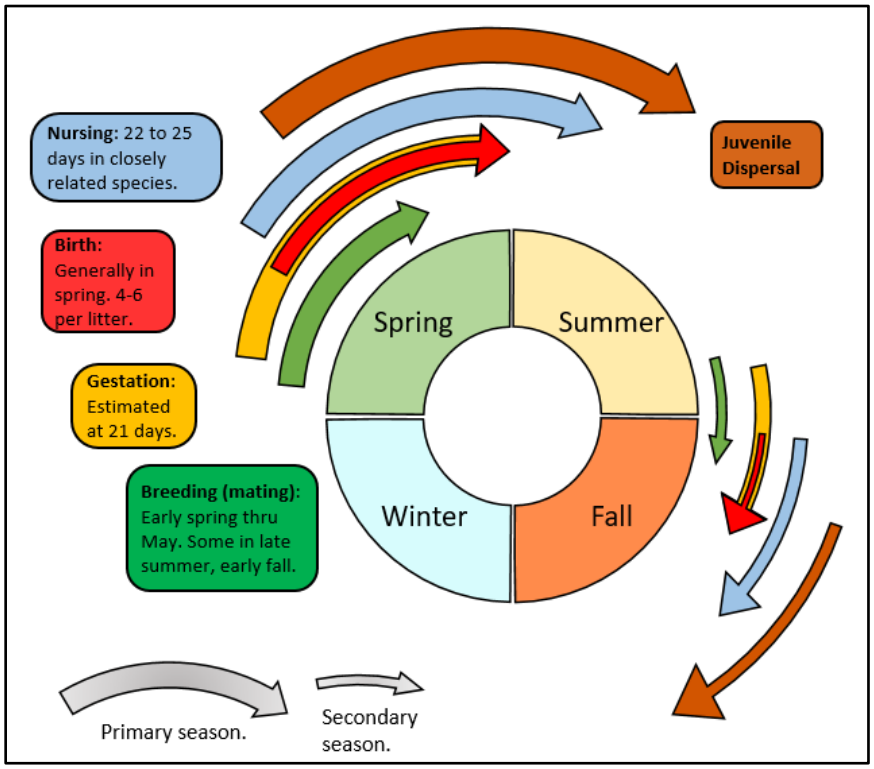


Figure 2: Rough timing of major life history events. Lifespan is typically 12 to 16 months.

Specific information is also lacking regarding the territory size and population densities of BVLOS (FWS 2011, p. 3). Shrews are typically solitary except as necessary for mating or raising young (Churchfield 1990, pp. 28, 55). Vagrant shrews (*Sorex vagrans*), which are closely related to BVLOS and live in the Sierra Nevada mountains of California, have an average home territory size of approximately 372 square meters (m^2) (4,000 square feet (ft^2)), with breeding males occupying larger territories than breeding females (Hawes 1977, p. 360). The distribution and size of a shrew's territory varies according to the availability of food (Ma and Talmage 2001, p. 133). Shrews in the Sorex genus typically defend their territories against other members of their species (Hawes 1977, pp. 354, 362; Churchfield 1990, p. 58).

2(5) Distribution and Abundance

Historical Distribution

BVLOS historically occurred in wetlands around Buena Vista Lake, and presumably in wetland and riparian areas throughout the Tulare Basin (Grinnell 1932; FWS 2011, p. 5). The Tulare Basin, which encompasses the San Joaquin Valley floor from its southern end to roughly Fresno and Mendota, had no regular outlet to the ocean. It was thus home to three lakes (Buena Vista, Kern, and Tulare Lakes), and their surrounding wetlands (FWS 2011, p. 5). These lakes were fed by the Kern, Kaweah, Tule and Kings rivers and their tributaries, and were interconnected by hundreds of square miles of tule marshes and other permanent and seasonal lakes, wetlands, and sloughs (Williams and Harpster 2001; FWS 2011, pp. 5–6).

The shrew presumably occurred in the moist habitat surrounding wetland margins in the Kern, Buena Vista, Goose, and Tulare Lakes on the valley floor below elevations of 350 feet (ft.) (107 meters (m)) (Grinnell 1932, p. 389; Hall 1981, p. 38; Williams and Kilburn 1984, p. 953; Williams 1986, p. 13; FWS 1998, p. 163). With the draining and conversion of the majority of the Buena Vista Lake shrew's natural habitat from wetland to agriculture, and the channelization of riparian corridors for water conveyance structures, the vegetative communities associated with the Buena Vista Lake shrew were lost or degraded, and nonnative plant species replaced those associated with the shrew (Grinnell 1932, p. 389; Mercer and Morgan, 1991 p. 9; Griggs 1992, p. 11; FWS 1998, p. 163).

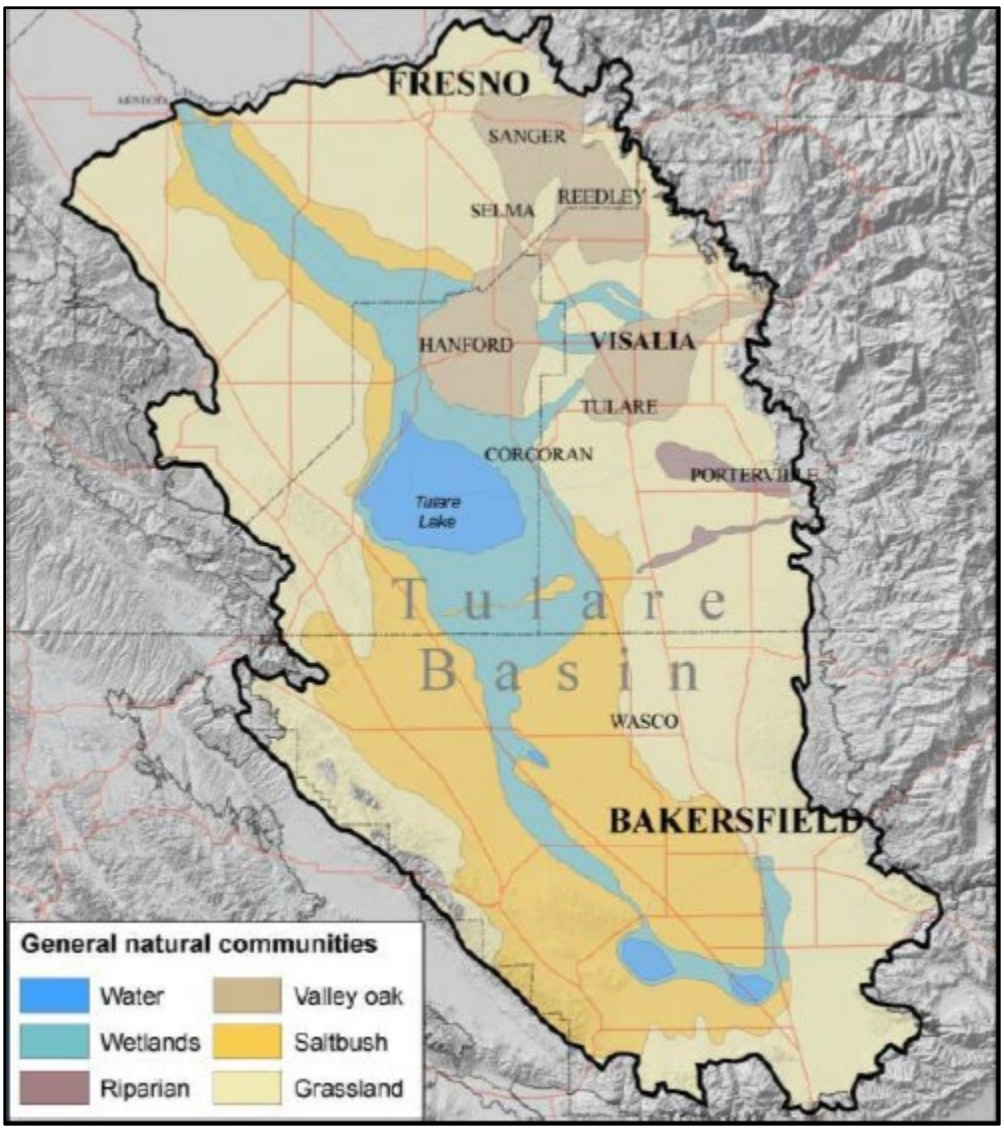


Figure 3: Original habitat communities of the Tulare Basin (from Cypher 2017, p. 7)

When Joseph Grinnell first described the BVLOS in 1932 based on three specimens from near Buena Vista Lake, available habitat was already in sharp decline due to the diversion and impoundment of rivers, the draining of lakes, and the destruction of the wetland and riparian habitat surrounding these water features for agricultural and urban development (Grinnell 1932, pp. 389–390; FWS 2011, pp. 3, 5–6). Grinnell gave the shrew its subspecific name "relictus" to indicate it was a relic of the original but disappearing wetland ecosystem (Grinnell 1932, p. 389).

Current Distribution

After its initial description in 1932, the shrew was not seen again for over fifty years, and was presumed extinct (FWS 2011, p. 6). However, in 1986 it was rediscovered in the area formerly called the Kern Lake Preserve (which is no longer a preserve, and

so referred to here as the Kern Lake site or simply Kern Lake – see section 6(2) Effects of Agricultural and Urban Development, below). It has subsequently been identified at a total of 15 locations (see Table 1 and Figure 4, below). Based on genetic analyses, only shrews found south of Helm are considered BVLOS (Cypher *et al.* 2017, p. 1).

Occupied locations constitute small remnant patches of natural habitat in and around the margins of a landscape that is otherwise dominated by agriculture (FWS 2013, p. 39848). Information is lacking regarding the size of these populations (FWS 2002, p. 10102; FWS 2017 p. 14).

Below, we show the mapped positions of surveyed areas where BVLOS have (and have not) been found (Figure 4); a table of surveyed locations showing whether BVLOS were considered present at the location at three recent time periods (Table 1); and aerial photos showing the landscape around each of the 12 sites currently considered occupied (Figures 5–21).

The aerial photos (Figures 5–21) were taken from April through July, 2016, and include FWS annotations indicating the locations of BVLOS sightings (where known), and the acreage and ground extent of likely optimal habitat, or of critical habitat as applicable. Approximate bounds of apparent habitat are colored blue for habitat with some form of protection against development, red for unprotected habitat, and green for designated critical habitat. Information regarding protections is also provided by the annotations. We provide further discussion of the specific habitat protections (if any) at each site in Section 6(1) Agricultural and Urban Development.

Note that because many of the aerial photos were taken in summer they may show habitat that is drier and less optimal for BVLOS than it would be at other times of the year.

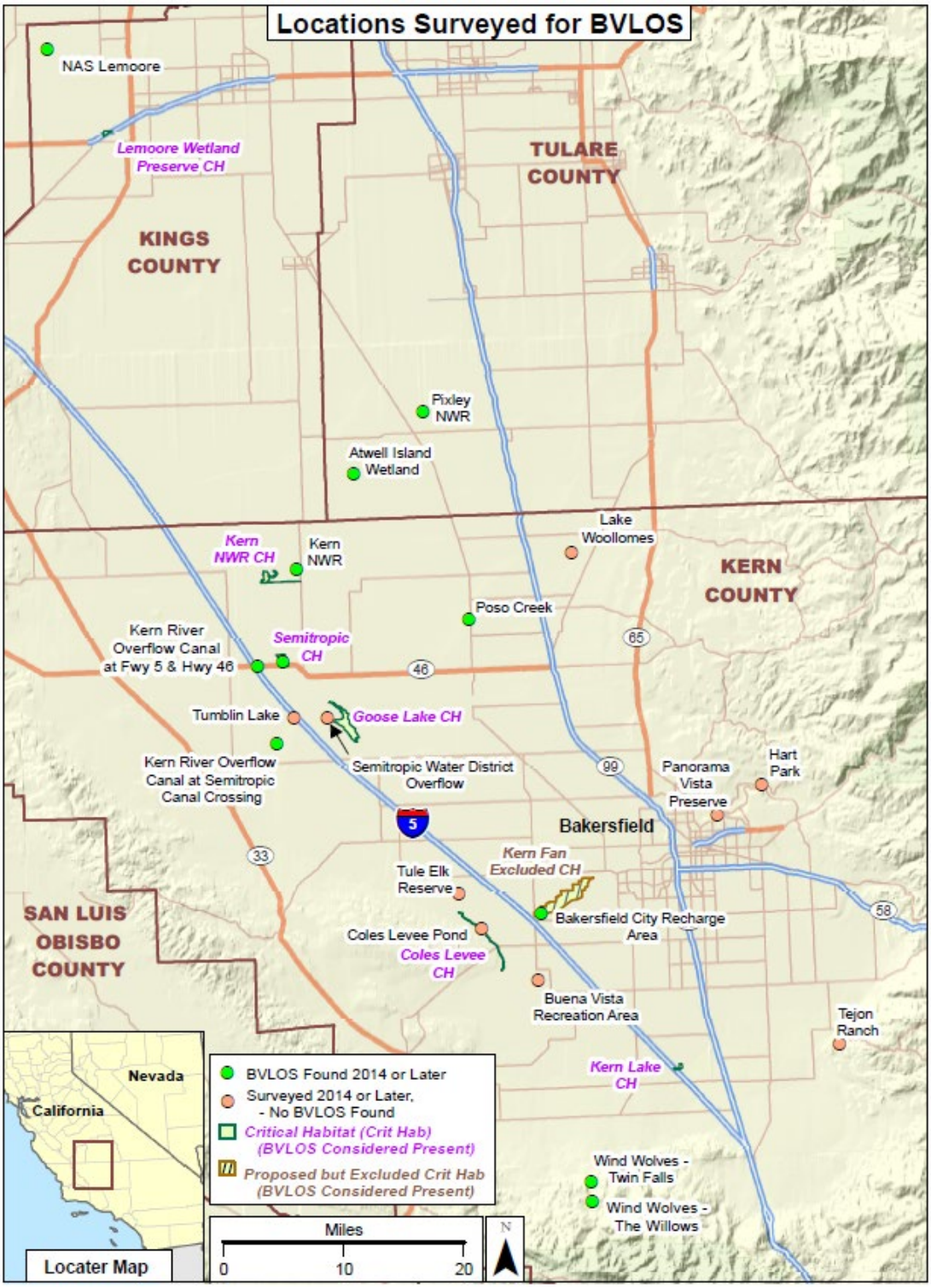


Figure 4: Map of Locations Surveyed, with BVLOS Presence or Absence Noted (sources as per Table 1, below).

Location (Listed N to S)	Considered Present at Time of Listing in 2002? (4 areas) [1]	Considered Present When Critical Habitat Designated in 2013? (8 areas) [2]	Considered Present in 2020? (15 areas) [3]
NAS Lemoore	No – not surveyed	No – not surveyed	Yes
Lemoore Wetland Reserve	No – not surveyed	Yes (Critical Habitat Unit 7)	Yes, but no recent surveys*
Pixley NWR	No – not surveyed	No[4]	Yes
Atwell Island	No – not surveyed	Yes (but habitat suboptimal - not critical habitat)	Yes, (newly created optimal habitat)
Lake Woollomes	No – not surveyed	No[4]	No
Kern NWR	Yes	Yes (Critical Habitat Unit 1)	Yes
Poso Creek	No – not surveyed	No – not surveyed	Yes
Semitropic Ecological Reserve	No – not surveyed	Yes ("Main drain canal") (Critical Habitat Unit 6)	Yes
Kern River Overflow Canal at Fwy 5 & Hwy 46	No – not surveyed	No – not surveyed	Yes
Semitropic Water District Overflow	No – not surveyed	No – not surveyed	No
Tumblin Lake	No – not surveyed	No – not surveyed	No
Goose Lake	No – not surveyed	Yes (Critical Habitat Unit 2)	Yes, but no recent surveys*
Kern River Overflow Canal at Semitropic Canal Crossing	No – not surveyed	No – not surveyed	Yes
Hart Park	No – not surveyed	No – not surveyed	No
Panorama Vista Preserve	No – not surveyed	No – not surveyed	No
Tule Elk Reserve	No – not surveyed	No[4]	No
Kern Fan Water Recharge Area	Yes	Yes (Critical Habitat Unit 3)	Yes
Coles Levee Ecological Preserve	Yes	Yes (Critical Habitat Unit 4)	**Yes, but not found by recent survey**** (Additional surveys needed).
Buena Vista Recreation Area	No – not surveyed	No[4]	No
Tejon Ranch	No – not surveyed	No – not surveyed	No
Kern Lake	Yes	Yes (Critical Habitat Unit 5)	Yes, no recent surveys*

[1] FWS 2002, p. 10102
[2] FWS 2013, pp. 39846, 39861–39867
[3] NAS Lemoore: Cypher *in litt.* 2017, p. 2. Poso Creek: Stantec 2019, pp. 1, 3. Wind Wolves – Twin Fawns Site: Cypher *et al.* 2011, p. 13. All other locations: Cypher *et al.* 2017, pp. 13–14
[4] FWS 2011, pp. 6, 26–27

Wind Wolves Preserve – Twin Fawns Site	No – not surveyed	No[4]	Yes
Wind Wolves Preserve – The Willows Site	No – not surveyed	No[4]	Yes

Table 1: BVLOS Locations Currently and Historically Known

Color Shading and Asterisks: BVLOS considered present (yellow); considered present despite lack of recent surveys in area (orange with an asterisk); or present despite negative recent survey results (red with two asterisks).

3. BVLOS INDIVIDUAL NEEDS

Based on the best available information, individual BVLOS appear to need the following habitat and genetic characteristics to maximize their chances of survival and reproduction, thereby contributing to resilient populations.

- Individual BVLOS require suitable habitat in which to set up territories. Such habitat is important both to support a sufficient prey base (discussed as a separate individual need below), and because it provides cover against BVLOS predators. The habitat must in turn be supported by sufficient water to provide perennial open water bodies (optimally) or a perennial high water table providing accessible moistened soil (suboptimally). The water must also be clean enough for shrews and their prey to drink without ill effects.

  We are not aware of any studies directly indicating the necessary size of BVLOS territories. In the absence of better data, we estimate that such territories should be about the size of those for vagrant shrews in the Sierra Nevada mountains (section 2(4), above). Based on that assumption, an average-sized territory for an adult BVLOS would need to be about 372 sq. m (4,000 sq. ft.). We assume that territories must typically consist primarily of optimal habitat, and that areas consisting mostly of suboptimal habitat are useful as expansion areas during wet months. Suboptimal areas may also be useful to males moving through them while searching for females during the breeding season.

- Dispersing young need corridors of dispersal habitat to reach new areas of optimal habitat of sufficient size to support a territory.

- BVLOS of all ages require a large and diverse base of invertebrate prey that is safe to eat (see Behavior and Diet, above). While sufficient habitat is necessary to support such a prey base, it is not sufficient, since other factors such as pesticides can also affect it. Pesticides and other contaminants such as selenium can also potentially affect the quality of prey items as safe for BVLOS to consume.

- BVLOS of all ages also need diverse genomes in order to avoid congenital defects resulting from inbreeding.

4. BVLOS POPULATION AND SUBSPECIES NEEDS

4(1) Resiliency

The resiliency of a population refers to its ability to maintain itself and recover from non-catastrophic, deleterious chance events. Such events involve relatively common fluctuations from the environmental baseline that tend to injure or kill individuals, or to remove individual needs (discussed above). Examples might include a local fire or flood, or the temporary loss of habitat due to a moderate drought.

Several demographic and habitat-based factors contribute to population resiliency. Demographic factors include the population's size and degree of isolation from other populations. Smaller populations are less resilient simply because they have fewer individuals to lose, whereas isolated populations are less likely to regain members through immigration. The genetic diversity and lack of deleterious alleles in the gene pool also contribute to resiliency by helping to prevent inbreeding depression.

Environmental factors contributing to resiliency include the extent, quality, and stability of the environmentally-based individual needs discussed above. For instance, a large area of optimal habitat, with few environmental contaminants, and protected from development, would provide greater resiliency for BVLOS than would a smaller area of suboptimal habitat, near to an area of high pesticide use or selenium concentration, and potentially subject to development or loss of surface water. Similarly, the extent and stability of dispersal habitat also contributes to resiliency, as does the extent, diversity, stability, and nutritional safety of prey populations

In section 6(12), below, we compare the general availability of these demographic and environmental factors at each of the known BVLOS population sites.

Several factors can potentially affect resiliency sufficiently to "stress" the population (see POTENTIAL STRESSORS, below). We discuss the current impacts of each potential stressor in the CURRENT CONDITIONS section, and summarize which of them constitute actual (as opposed to merely potential) stressors near the end of the section. We then present a graphic representation (Figure 9) of how the various stressors are affecting resiliency, redundancy, and representation and thereby impacting overall BVLOS viability. In the FUTURE CONDITIONS section, we examine the extent to which current conditions and impacts to resiliency are likely to change over time.

4(2) Redundancy

Subspecies redundancy is the ability of a subspecies (such as BVLOS) to withstand catastrophic events by occupying a larger geographic area than the most serious impacts of the catastrophe. Redundancy is typically accomplished by having several widely-distributed, resilient populations. Recolonization and inbreeding avoidance are made possible through migration between the populations.

To maximize viability, BVLOS thus need several resilient populations, distributed throughout their range, with migration between them.

4(3) Representation

Subspecies representation involves maintaining those portions of the subspecies that are representative of the genetic and environmental differences across the range, thereby providing the greatest chances for adaptation to conditions that may be changing systematically rather than merely undergoing stochastic or catastrophic deviations from the norm. As discussed and mapped in section 6(9), below (Inbreeding Depression and Hybridization), BVLOS populations fall into three genetically-similar clusters. Maintaining the viability of the subspecies thus involves maintaining representatives from each of those clusters. It also involves maintaining representation from across the range, which stretches north to south across the Tulare Basin. This means assigning additional importance to the conservation of the Lemoore and Wind Wolves populations, which represent the northernmost and southernmost ends, and to the Kern Lake population, which is the sole representative of one of the three clusters.

5. POTENTIAL STRESSORS

A population stressor is some factor that tends to undermine the resiliency of a population. In this section we provide a general overview of potential stressors, and group them according to the five listing factors specified in the Endangered Species Act (16 U.S.C. 1533(4)(a)). We address the current and future impacts of such potential stressors (and thereby distinguish potential from actual or likely stressors) in the Current Conditions and Future Conditions sections, below.

Current stressors (as opposed to "potential") are summarized in subsection 6(10). Future stressors are summarized in the introduction to section 7.

5(1) Potential Stressors Involving Habitat Loss

Agricultural and Urban Development

Agricultural and urban development converts suitable BVLOS habitat into areas that BVLOS can neither live in nor disperse through. It does so by removing open water (except in vegetation-free canals and ditches), lowering the water table, lowering the prey base, and removing vegetative cover. It can also subject BVLOS to more direct impacts, such as from pesticide applications or direct injury from heavy equipment used in agriculture or for habitat conversion.

Insufficient Water Supply

Diversion and impoundment of rivers and streams for agricultural and urban uses can prevent that water from sustaining remaining wetland areas during years of low precipitation, thereby removing optimal and suboptimal habitat (FWS 2011, p. 11;

FWS 2017 p. 11). Canals used to carry water for agricultural irrigation are typically steep-sided and kept free of vegetation, so do not qualify as optimal, suboptimal or dispersal habitat (FWS 2011, p. 11).

Changing Climate

If the likelihood or severity of droughts in the range of the BVLOS has increased, or is likely to increase due to changing climate, then the dependability of water delivery to maintain optimal and suboptimal habitat may have decreased, or may decrease in the future. This could result in loss of that habitat and in consequent losses to the resiliency and number of populations.

5(2) Potential Stressors from Overutilization

Trapping

The species has no known commercial or recreational value; therefore, overutilization for these uses does not appear to be a threat at this time. (FWS 2011, p. 12). Trapping of small animals in general for scientific research does occasionally occur, however, and so could potentially have some impact on population abundance.

5(3) Potential Stressors from Disease and Predation

Disease

At the time of listing there were no reported cases of disease related to the shrew documented, and none have been identified since (FWS 2011, p. 12; FWS 2017, p. 17). However, if a serious communicable disease were to become prevalent in some part of the range, the restricted distributions and apparent low population sizes of most occupied locations would tend to make each population vulnerable to serious losses in abundance (FWS 2011, p. 12; FWS 2017 p. 17). BVLOS are also potential hosts to numerous internal and external parasites, such as round worms, mites, ticks, and fleas, which may infest individuals and local populations in varying degrees with varying adverse effects (Churchfield 1990 p. 39; FWS 2002, p. 10107).

Predation

Predators of small mammals in the Tulare Basin include coyotes (*Canis latrans*), foxes (*Vulpes spp.*), long-tailed weasels (*Mustela frenata*), raccoons (*Procyon lotor*), feral cats (*Felis cattus*), and dogs (*Canis familiaris*), hawks (*Buteo spp.*), owls (*Strigidae spp.* and *Tytonidae spp.*), herons (*Ardea spp.*), jays (*Corvidae spp.*), and egrets (*Egretta spp.*) (FWS 2011, p. 12). Brown rats (*Rattus norvegicus*) are also potential predators of shrews (Byrd and Norvell 1993, p. 53). While many predators find shrews unpalatable because of the distasteful secretion and offensive odor from their flank glands and feces, several of the avian predators, such as barn owls (*Tyto alba*), short-eared owls (*Asio flammeus*), longeared owls (*Asio otus*), and great horned

owls (*Bubo virginianus*), have a poor sense of smell and are known to prey on shrews in general, probably including BVLOS (FWS 2002, p. 10107). Other predators may kill BVLOS without eating them, as part of their instinctual hunting behavior. For instance, a study of domestic cats found that only 28 percent of prey items were consumed (Wildlife Management Institute 2012, p. 2), and shrews at Kokechik Bay, Alaska, were killed but left uneaten by foxes (Byrd and Norvell 1993, p. 53).

5(4) Potential Stressors from Inadequacy of Regulatory Mechanisms

See List of Acronyms and Abbreviations (above) for full names and citations of the statutes referred to in this section:

The ESA

The BVLOS is listed pursuant to the ESA as an endangered species (a term defined to also include taxonomic subspecies such as the BVLOS) (50 C.F.R. 17.11; 16 U.S.C. 1532(6)). Section 9 of the ESA generally prohibits "taking" endangered animals, where "take" is defined to include harassment, harm, and killing. Section 7 prohibits Federal agencies from jeopardizing the continued existence of endangered species, or adversely modifying their critical habitat. Federal agencies must consult with the FWS to ensure that any projects they authorize, fund, or carry out do not violate those prohibitions. At the end of the consultation process, the FWS typically issues a biological opinion stating that that the project (with specified terms and conditions) is, or is not, likely to violate Section 7 by jeopardizing the species or adversely modifying critical habitat. If it is not likely to jeopardize or adversely modify, then "take" of individual members of the species, incidental to the project, is exempted from the prohibitions of Section 9. Section 10 provides a similar process of exemption for "take" incidental to projects for which a Federal agency is not involved. Section 10 also includes provisions under which direct "take" may be authorized for scientific or conservation purposes, or (on rare occasions) for undue economic hardship.

The CWA

Section 404 or CWA regulations requires applicants to obtain a permit from the U.S. Army Corps of Engineers (the Corps) for projects that involve the discharge of fill material into waters of the United States, including wetlands. Note that this in turn will trigger section 7 of the ESA, discussed above, requiring the Corps to insure the permitted action does not jeopardize BVLOS or adversely modify critical habitat. However, many farming activities do not require a permit due to their exemption under the CWA (53 FR 20764; EPA 2019, p. 1). Also, the Corps will only carry out or enforce terms or conditions in a biological opinion that are applicable to waters of the United States. Terms and conditions applicable to other portions of a large project must be carried out by the permit applicant directly (FWS 2017, pp. 3–4, Corps *in litt.* 2017, p.1). Projects that are subject to regulation may qualify for authorization to place fill material into headwaters and isolated waters, including wetlands, under

several nationwide permits (FWS 2011, p. 13). The use of nationwide permits by an applicant or project proponent is normally authorized with minimal environmental review by the Corps. No activity that is likely to jeopardize the continued existence of a threatened or endangered species, or that is likely to destroy or adversely modify designated critical habitat of such species, is authorized under any nationwide permit. An individual permit may be required by the Corps if a project otherwise qualifying under a nationwide permit would have greater than minimal adverse environmental impacts.

NEPA

NEPA requires Federal agencies to analyze projects they undertake, authorize, or fund, for potential impacts to the human environment, including natural resources (FWS 2011, p. 14). In cases where that analysis reveals significant environmental effects, the Federal agency must propose mitigation alternatives that would offset those effects (40 CFR 1502.16). These mitigations usually provide some protection for listed species (FWS 2011, p. 14). However, NEPA does not require that adverse impacts be fully mitigated, only that impacts be assessed and the analysis disclosed to the public.

FIFRA

The registration and application of pesticides is regulated under the authority provided by the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and its implementing regulations (7 U.S.C. 136 *et seq*.; 40 C.F.R. Parts 150 *et seq*.). More specific regulation of the application of each registered pesticide is provided for by the label specific to that pesticide. Adherence to the label requirements is intended to minimize or eliminate unacceptable risks to the environment from the application of a pesticide, including minimizing or eliminating risks from pesticide drift.

CEQA

Like NEPA, this California state law requires a full disclosure of the potential environmental impacts of proposed projects (FWS 2011, p. 14). Section 15065 of the CEQA Guidelines, as amended, requires a finding of significance if a project has the potential to ``reduce the number or restrict the range of a rare or endangered plant or animal.'' Once significant effects are identified, the lead agency has the option of requiring mitigation for effects through changes in the project or to decide that overriding considerations make mitigation infeasible (CEQA Sec. 21002). In the latter case, projects may be approved that cause significant environmental damage, such as destruction of listed endangered species and/or their habitat (FWS 2011, p. 14). Protection of listed species through CEQA is, therefore, dependent upon the discretion of the agency involved.

CVPIA

The CVPIA establishes habitat protection as a purpose equivalent in priority to municipal and agricultural uses for water delivered by the Central Valley Project, a water-delivery system of canals, reservoirs, and dams established in the 1930s and managed by the Bureau of Reclamation (USBOR) (FWS 2005, p. 27; USBOR 2017, p. 1). To this end, the CVPIA sets specific water delivery allocation goals for wildlife habitat at national wildlife refuges (CVPIA 3406(d)(1–2), FWS 2005, p. 27). Water to meet those goals is obtained from various sources, including 25 year contracts (CVPIA 3404), but is subject to droughts and other overall supply issues.

5(5) Potential Stressors from Other Natural or Manmade Factors

Selenium

The soils on the western side of the San Joaquin Valley have naturally elevated selenium concentrations (FWS 2011, p. 15). Due to extensive agricultural irrigation, selenium has been leached from the soils and concentrated in the shallow groundwater along the western side of the San Joaquin Valley. In areas where this groundwater reaches the surface or subsurface, selenium can accumulate in both plants and animals. Selenium can then enter the food chain of the shrew by becoming concentrated in insects that forage on the vegetation or reside in soils that concentrate these salts and result in adverse effects to growth, reproduction, and survival of the shrew (Saiki and Lowe 1987, pp. 664–666; Moore *et al*. 1989, pp. 4, 6, 7, 15, 16).

Pesticides

Because BVLOS are distributed among small patches of habitat in a landscape otherwise dominated by agriculture, they could be exposed to lethal or unhealthy concentrations of pesticides sprayed on nearby crops, or of herbicides sprayed on roadsides and canal banks (FWS 2011, p. 15). Pesticides could also affect BVLOS indirectly by lowering their prey base (Ma and Talmage 2001, p. 11).

Inbreeding Depression

Inbreeding depression is caused by the loss of genetic diversity in small populations due to genetic drift, leaving deleterious alleles as the only remaining variants of some genes (Soule 1980, pp. 157–158). It also results from increased mating between closely related individuals in small populations, thereby increasing the likelihood that both parents pass on the same recessive deleterious alleles to their young (Lande and Barrowclough 1987, p. 96). It can result in abnormal sperm, congenital defects, and lowered disease resistance (Soulé 1980, pp. 157–158; Gilpin 1987, p. 132; O'Brien 2003, pp. 62–63).

Migration between populations can help prevent inbreeding depression by reducing genetic isolation and thereby raising the effective population size. If it occurs at all, however, migration among BVLOS populations is likely limited to years of high

rainfall when creeks or ponds expand to temporarily produce additional habitat (Cypher pers. comm. 2019, p. 2; Tenant pers. comm. 2019a, p. 1).

A population typically requires an "effective" population size of at least 100 reproducing adults to avoid inbreeding depression (Frankham *et al*. 2014, p. 58). The "effective size" of a population ("Ne") refers to the number of breeding individuals in an "ideal" population (with characteristics that minimize loss of alleles) (Lande and Barrowclough 1987, pp. 88–89). Because most populations lack many of the characteristics of ideal populations, the actual (census) size of a population ("N") is often much greater than its effective size. Various estimates of Ne as compared to N, (Ne/N), across different species range from averages of 0.10 to 0.19 (Palstra and Ruzzante 2008, p. 3,431; Frankham *et al*. 2014, p. 60), and medians of 0.12 to 0.23 (Palstra and Fraser 2012, p. 2,360; Frankham *et al*. 2014, p. 60). This would translate to census populations of roughly 625 reproductive individuals for isolated populations (Ne/N = 0.16), and somewhat less (maybe 500, depending on migration levels) for populations in which genetic exchange is possible due to connecting dispersal habitat.

Hybridization

The range of the BVLOS is almost completely surrounded by that of the Southern California ornate shrew (*S. o. ornatus*) (FWS 2002, p. 10102). Grinnell (1932, p. 390) noted that Southern California ornate shrews occupied the uplands along streamside habitat, and intergraded with the lowland Buena Vista Lake shrews along the lower courses of the streams that enter the Kern-Tulare basin. BVLOS interbreeding with Southern California ornate shrews is therefore possible. If it occurs at a high rate, and if hybrids are successful and also tend to interbreed with BVLOS, then BVLOS populations could potentially be replaced by hybrids that eventually become indistinguishable from Southern California ornate shrews. Natural selection would tend to oppose such a loss of distinctiveness, to the extent that differences between the two subspecies constitute adaptations to their respective environments (Haig *et al.* 2006, p. 1591), so the amount of interbreeding required to remove BVLOS's distinctive characteristics is unclear.

6. CURRENT CONDITION

In this section we characterize the general quality of habitat at each of the occupied sites, based on extent of optimal wetland habitat at the site and of dispersal habitat around the site (and potentially connecting to other sites). We then consider the degree to which each of the potential stressors may be affecting the resiliency of the populations by limiting individual or population needs. We conclude the section by addressing the current viability of the subspecies generally. Potential stressors that are currently causing negative impacts will be referred to after this section as "stressors" or "current stressors," and summarized in section 6(13).

6(1) Current Habitat Quality

We characterize the quality of habitat at the various occupied locations according to the ability of that habitat to provide for population resiliency. This in turn depends on the extent of contiguous optimal and suboptimal habitat in the area, and on the extent to which corridors of dispersal habitat may connect the population location to other occupied locations or to other large areas of optimal habitat. Related issues such as protections against development, and the stability of the water supply, and the availability of nutritionally safe prey, are covered below in sections 6(2), 6(3) respectively.

Generally speaking, larger areas of habitat can support larger BVLOS populations, thereby increasing the potential resiliency of those populations. We can estimate the maximum population sizes that a given area of habitat can support based on our earlier estimate of 372 sq. m (4,000 sq. ft., 0.09 ac, 0.036 ha) as an average territory size for a single reproductive individual (see section 3. BVLOS INDIVIDUAL NEEDS, above). We assume the percentage of optimal habitat in an individual's home range should be high; perhaps 90 percent (0.08 ac (0.032 ha). We also have estimates (section 5(4) Inbreeding Depression) of the minimum population size needed to avoid inbreeding depression (625 reproductive individuals in an isolated population, or 500 in a population that can exchange migrants with other populations). Accordingly, we estimate the minimum habitat size required to support an isolated population that can avoid inbreeding depression to be 625 * 0.09 = 56 ac (22.7 ha), of which 90 percent (50 ac (20.2 ha)) should be optimal. Minimum habitat size needed for a non-isolated population (able to exchange migrants with at least one other population) would be 500 * 0.09 = 45 ac (18.2 ha), of which 41 ac (16.6 ha) should be optimal.

Given that individual BVLOS are only likely to disperse about 0.5 mi at most (see section 2(4) Reproduction and Life History, above), but that small, short lived intermediate populations of dispersers might be possible, we consider an occupied area "isolated" if separated from other occupied areas by 0.5 mi of suboptimal habitat or by 2.5 mi of optimal habitat.

Areas larger than the minimum sizes discussed above (say double the above minimums required to avoid inbreeding depression) could support larger populations that would be better able to survive relatively minor deleterious chance events. Areas twice as large as that would stand a good chance at surviving more major deleterious chance events.

We therefore consider isolated areas less than 56 ac in size or with less than 50 ac optimal habitat to be "poor" quality; larger isolated areas less than 112 ac in size or with less than 100 ac optimal habitat to be "moderate" quality; and still larger isolated areas to be "good" quality.

For non-isolated occupied areas, poor quality would be less than 45 total acres or less than 40.5 optimal habitat acres; moderate quality would be from 45 to 90 total acres (or 40.5 to 81 optimal habitat acres), and good quality would be greater than 90 total acres (with greater than 81 optimal habitat acres).

NAS Lemoore: This site consists of approximately 60.1 ac (24.3 ha) of contiguous habitat, all of which is on wetlands, but most of which appears to lack dense vegetation (Figure 5, below). Suboptimal habitat to the northeast, separated from the site by a road, connects the site to smaller wetland and ponded areas nearby. This site is 8.3 mi (13.4 km) from the next closest occupied site (Lemoore Wetland Reserve). A canal with wetland bank habitat covers most of the distance between the two sites, but about 2 mi (3.2) of the route appear to require travel across open agricultural fields or along cement-lined canal. The next closest occupied site (Pixley NWR) is over 40 mi (64 km) away.

Summary: An isolated area with (apparently) less than 50 ac optimal habitat.

Habitat quality: Poor.

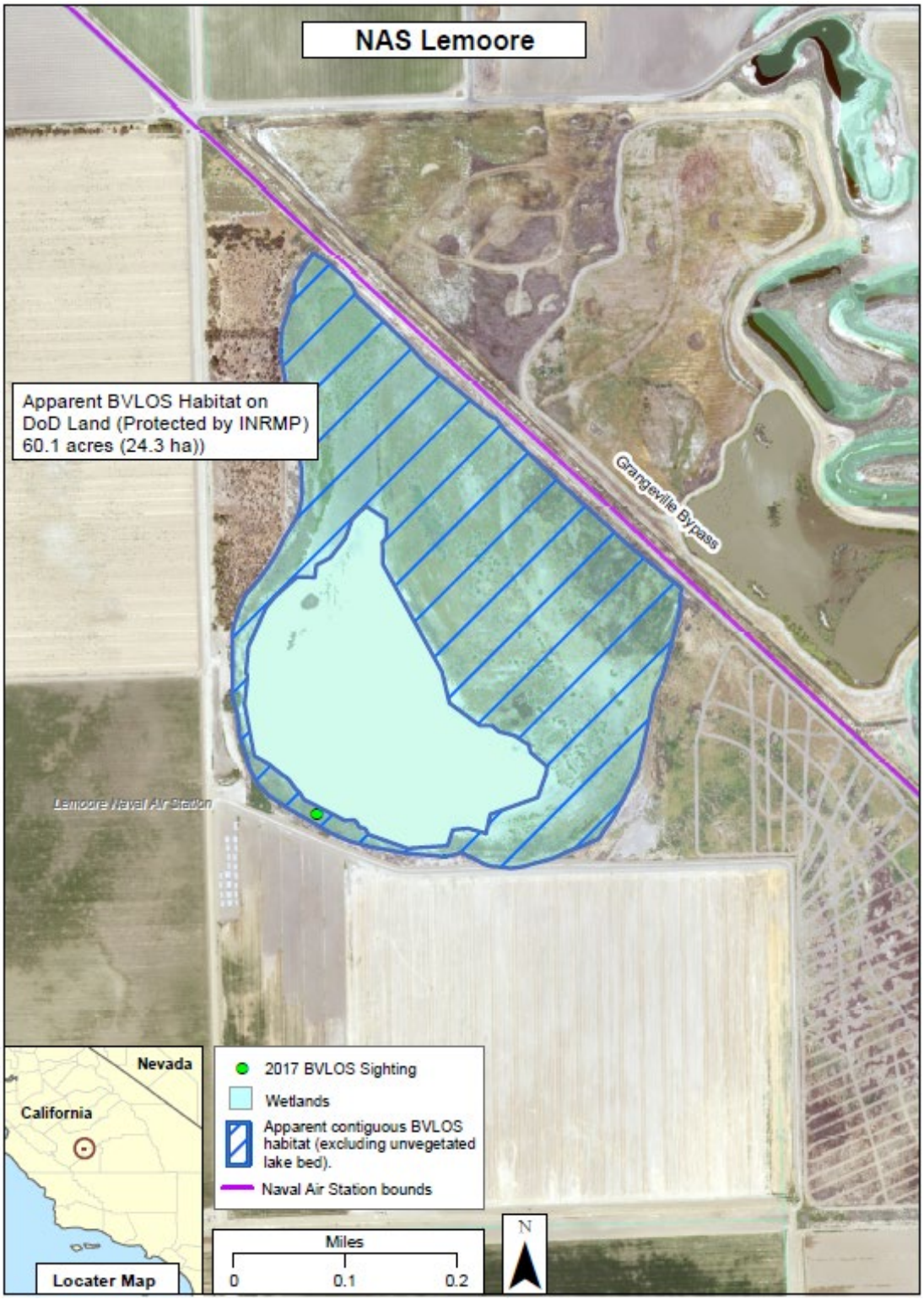


Figure 5: NAS Lemoore

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Lemoore Wetland Reserve (Critical Habitat Unit): This site consists of approximately 97 ac (39 ha), but only a small portion is optimal wetland habitat (Figure 6, below). The site is just east of a relatively large wetland area following an unlined canal. The canal covers much of the distance (8.3 mi (13.4 km)) to the next closest occupied site (NAS Lemoore), but about 2 mi (3.2) of the route appears to require travel across open agricultural fields or along cement-lined canal. The second-closest site (Pixley NWR) is about 35 mi (56 km) away.

Summary: An isolated area with less than 50 ac optimal habitat.

Habitat quality: Poor.

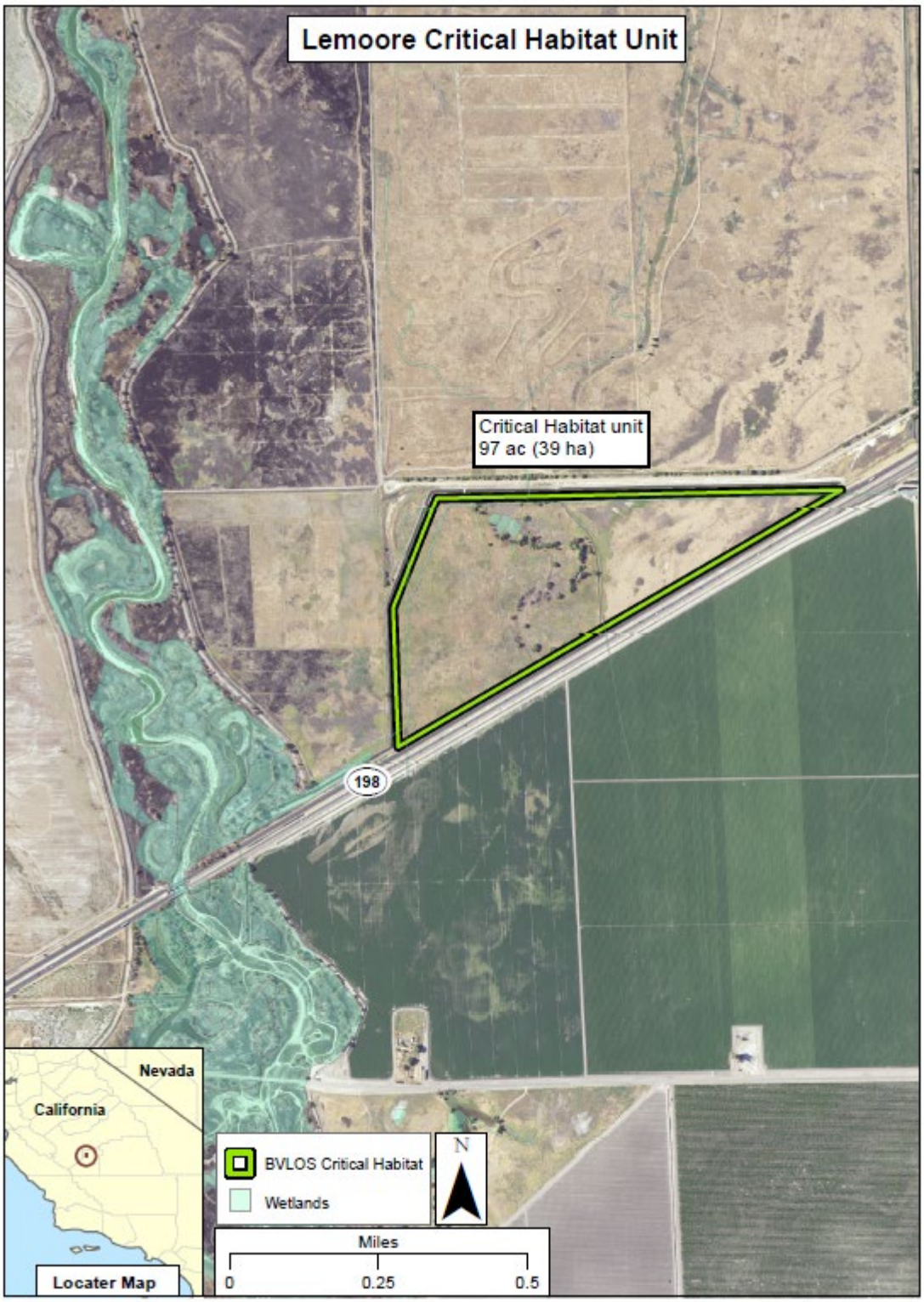


Figure 6: Lemoore Wetland Reserve Critical Habitat Unit

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Pixley NWR: This site consists of approximately 776.8 ac (314.4 ha), almost all of which is optimal wetland habitat (Figure 7, below). Additional suboptimal habitat lies to the east, west, and in portions of the north, but there is no obvious dispersal habitat connecting the site to other wetland sites or to the closest known occupied location (Atwell Island, 7.7 mi (12.4 km) away).

Summary: An isolated area with more than 112 ac total habitat, and more than 100 ac optimal habitat.

Habitat quality: Good.

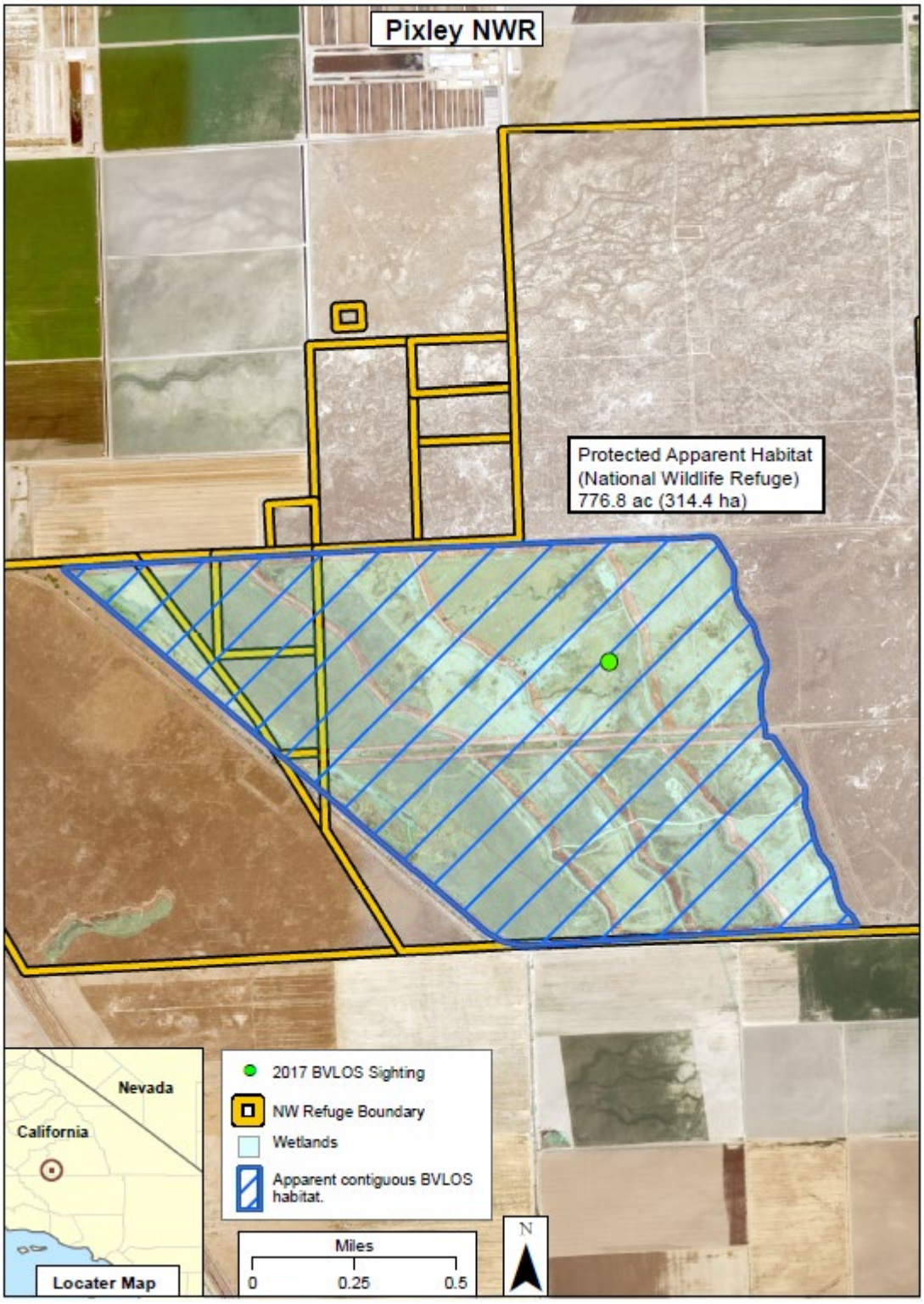


Figure 7: Pixley National Wildlife Refuge

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Atwell Island: This site consists of approximately 105.5 ac (42.7 ha) of wetland habitat (Figure 8, below). The wetland area was artificially created in 2009 by the BLM and NRCS as a demonstration project to provide habitat for wetland species. (Cypher *et al*. 2017, p. 19). As such it does not show up as mapped wetland habitat in the National Wetlands Inventory database (see Figure 8, below). The surrounding area is primarily agricultural lands, but also includes suboptimal habitat where BVLOS have apparently lived for many years by exploiting surface cracks in the ground giving them access to moist soil just below the surface (FWS 2013, p. 39846).

Summary: An isolated area with between 56 and 112 ac total habitat, and between 50 and 100 ac optimal habitat.

Habitat quality: Moderate.

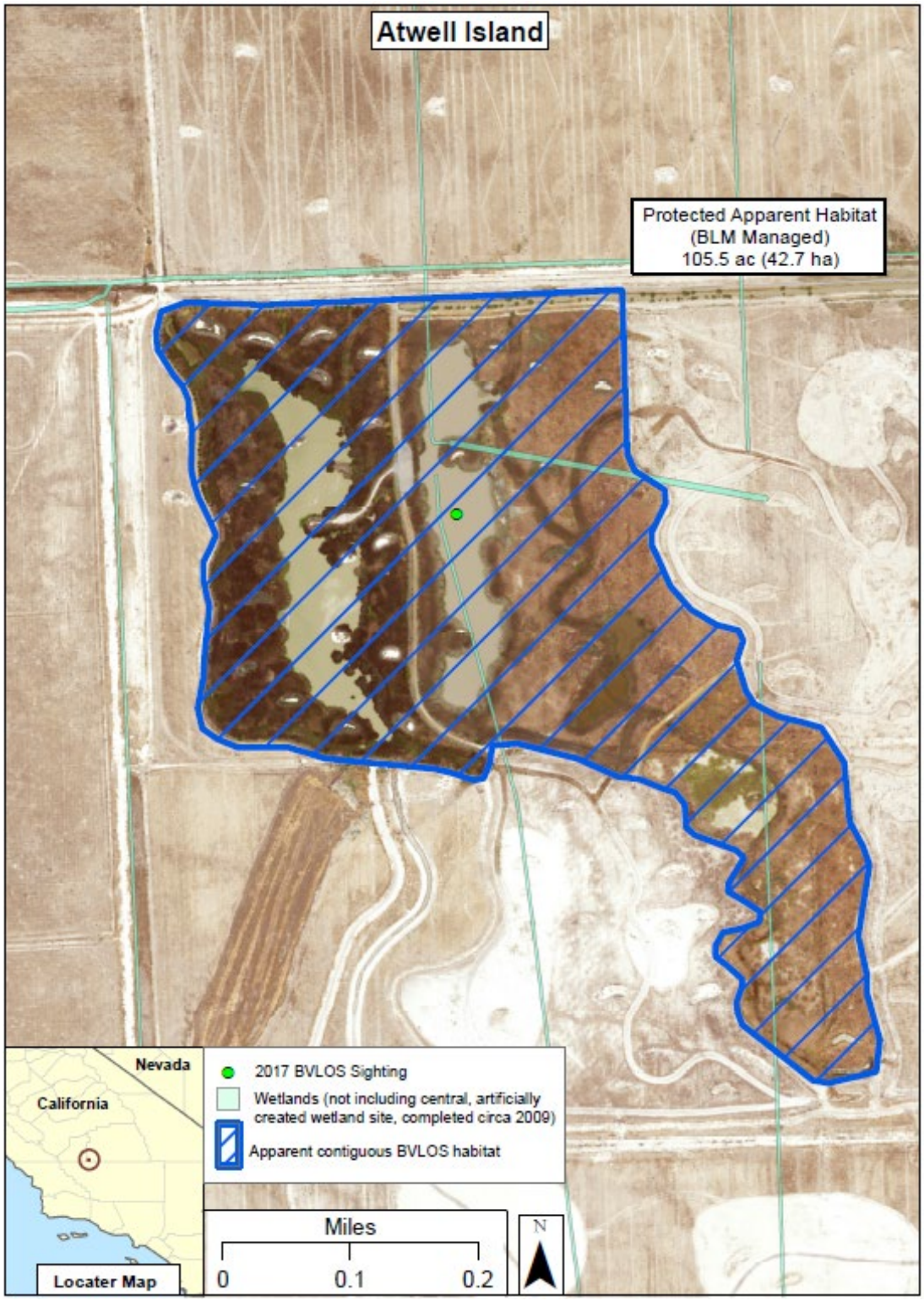


Figure 8: Atwell Island

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Kern National Wildlife Refuge: This site consists of approximately 11,907 ac (4,819 ha) of optimal wetland habitat (Figure 9 below). Most of the wetland habitat is within the refuge boundaries, but some extends beyond those boundaries to the south. The site also encompasses approximately 387 ac (157 ha) of designated critical habitat (see Figure 9, below).

The surrounding area is primarily suboptimal habitat. The Kern River Overflow Canal links the Kern NWR to an occupied site referred to here as "Kern River Overflow Canal at Fwy 5 & Hwy 46," approximately 5 mi (8 km) to the south (see below). However, although the area of this canal is categorized as wetlands in the National Wetlands Inventory database, it has been dry and lacking wetland vegetation since about 2015, at least at the "Fwy 5 and Hwy 46" end (Tennant *in litt.* 2020, p. 1). Another smaller channel connects Kern NWR to the Poso Creek site approximately 13.3 mi (21.4 km) away (see below), but that channel runs primarily through agricultural lands and shows little evidence of wetland habitat except near the occupied Poso Creek site (see below).

Summary: An isolated area with more than 112 ac total habitat, and more than 100 ac optimal habitat.

Habitat quality: Good. (Possibly the best of all occupied sites (Tennant pers. comm. 2019b, p.1)).

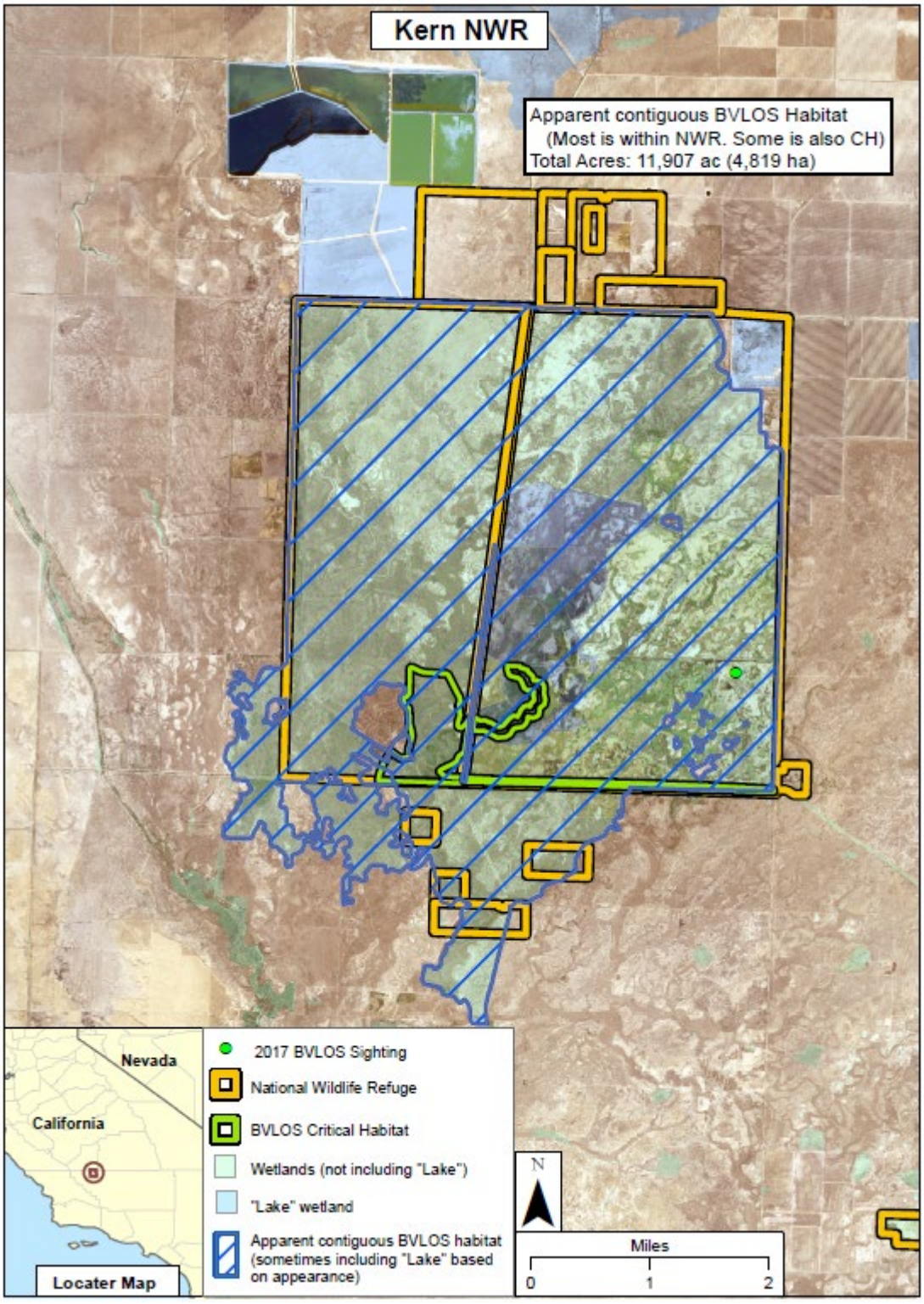


Figure 9: Kern National Wildlife Refuge

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Poso Creek: This site consists of approximately 20.5 ac (8.3 ha) primarily of suboptimal habitat, but with interspersed areas of wetland habitat, on the banks of Poso Creek near Hwy 43 (Figure 10, below). The habitat runs in thin strips on either side of the creek, and is bounded by agricultural lands. Poso Creek at that location is normally dry, except for years of high rainfall (Berry 2017, p. 6). As discussed above, Poso Creek itself continues on to eventually meet the Kern NWR about 13.3 mi (21.4 km) away. Except in the vicinity of the indicated sighting area, however, the creek banks along the route appear to lack wetland vegetation.

Summary: An isolated area with less than 56 ac total habitat and less than 50 ac optimal habitat.

Habitat quality: Poor.



Figure 10: Poso Creek

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Semitropic Ecological Reserve: This site is designated as critical habitat for the shrew, and consists of approximately 372.6 ac (150.8 ha), primarily of suboptimal habitat (Figure 11, below). The National Wetlands Inventory database shows some small wetland areas on the site, but these may now be gone due to changes in water flows to the site since about 2017 (see section 6(3) Insufficient Water Supply, below). Based on aerial photos, additional suboptimal habitat extends to the north of the reserve, as well as to the south on the other side of Hwy 46. The nearest known occupied site is the "Kern River Overflow Canal at Fwy 5 & Hwy 46" about 1.8 mi (2.9 km) directly west, but the most direct route between those sites is blocked by agricultural lands.

Summary: An isolated area with less than 50 ac optimal habitat.

Habitat quality: Poor.

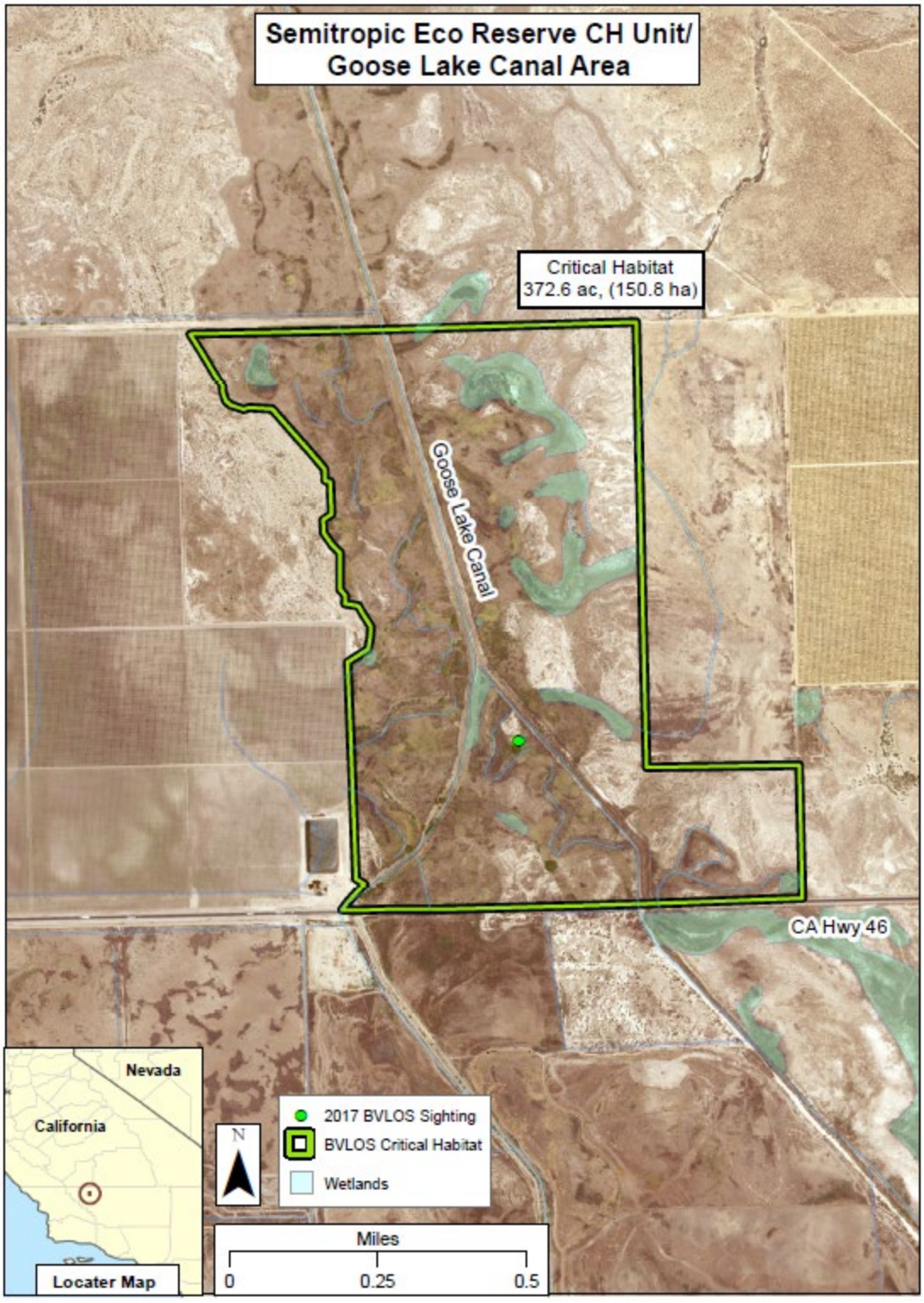


Figure 11: Semitropic Ecological Reserve Critical Habitat Unit

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Kern River Overflow Canal at Fwy 5 & Hwy 46: This site consists of approximately 48.8 ac (17.7 ha) within or along the banks of the Kern River Overflow Canal (Figure 12, below). The Kern River Overflow Canal (also known as the Buena Vista Slough), originally channeled extra water from Buena Vista Lake to Tulare Lake during wet years (Cypher *in litt*. 2020, p. 1). Despite the indication of wetland habitat on Figure 12, most of the habitat is now suboptimal due to changes in water flows to the site since about 2015 (see section 6(3) Insufficient Water Supply, below). Additional habitat, likely also currently suboptimal, extends north to the Kern NWR approximately 5 mi (8 km) away. The canal also connects the "Fwy 5 and Hwy 46" site with the "Kern River Overflow Canal at Semitropic Canal Crossing" site, about 6.7 mi (10.8 km) to the south. The route south includes both suboptimal and mapped wetland habitat, and crosses under both Hwy 46 and Fwy 5. We lack information regarding the extent to which the mapped wetland habitat in the canal to the south of Fwy 5 and Hwy 46 may also have converted to suboptimal habitat due to water supply changes.

Summary: An isolated area with less than 50 ac optimal habitat.

Habitat quality: Poor.



Figure 12: Kern River Overflow Canal at Fwy 5 & Hwy 46

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Goose Lake Critical Habitat Unit: This site encompasses 1,278.8 ac (517.4 ha), most of which is categorized as wetlands by the National Wetlands Inventory (Figure 13, below). Based on aerial photos, much of the area appears to lack dense vegetation. Biologists conducting recent BVLOS surveys have not had permission to enter the area, but habitat visible from public locations did not appear to be optimal for BVLOS (Tennant pers. comm. 2019b, p.1). However, given the total size of the area, and the extent of wetlands as mapped by the National Wetlands Inventory database, it is likely to contain at least 50 ac of optimal habitat.

The delineated bounds of the critical habitat area is surrounded by a buffer of non-agricultural lands, some of which are also categorized as wetlands. This could provide additional area for the BVLOS population to move or expand into in response to local flooding or fires. The Goose Lake Critical Habitat Unit also appears fairly well connected by a corridor of non-agricultural lands to the Semitropic Ecological Reserve about 4.5 mi (7.2 km) to the north. Almost none of the connecting lands are categorized as wetlands, however.

Summary: An isolated area with more than 112 ac total habitat, and between 50 and 100 ac optimal habitat.

Habitat quality: Moderate.

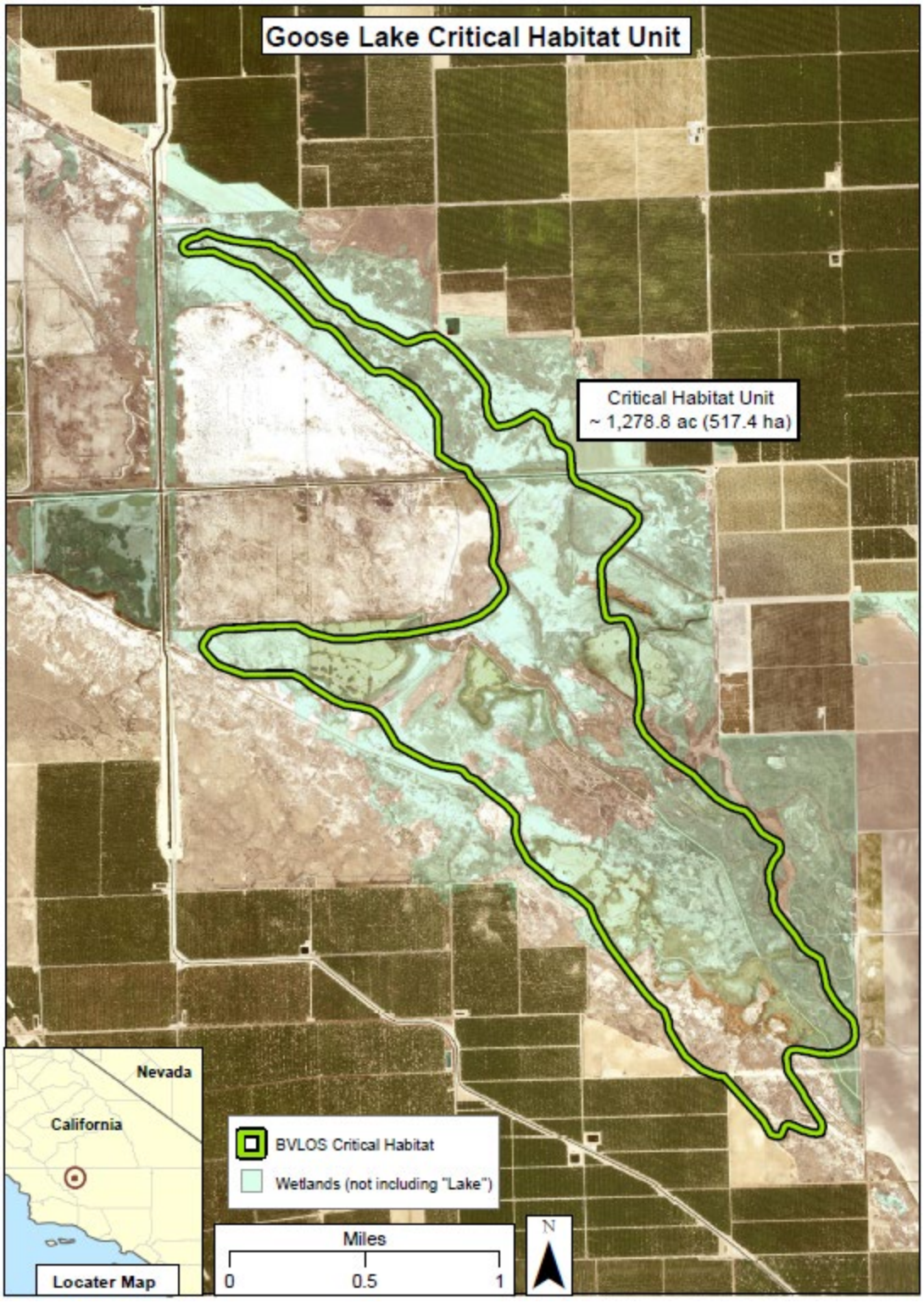


Figure 13: Goose Lake Critical Habitat Unit

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Kern River Overflow Canal at Semitropic Canal Crossing: This site consists of approximately 128.1 ac (51.8 ha) of habitat identified as "wetland" by the National Wetlands Inventory, in a fairly narrow strip within and along the banks of the Kern River Overflow Canal (Figure 14, below). The canal itself is often dry, however, and is often bulldozed to improve flows, leaving little wetland or riparian vegetation except during wet years (Tennant pers. comm. 2019b, p.1). The site is largely surrounded by agricultural lands except for an even narrower strip of undeveloped land (about 125 ft. wide) running north and south from the site along the Kern River Overflow Canal. This strip eventually connects the site to the "Kern River Overflow Canal at Fwy 5 and Hwy 46" site about 6.7 mi (10.8 km) away, crossing under Interstate 5 and Hwy 46 to do so.

Summary: An isolated area with between 50 and 100 ac optimal habitat in most years.

Habitat quality: Poor.

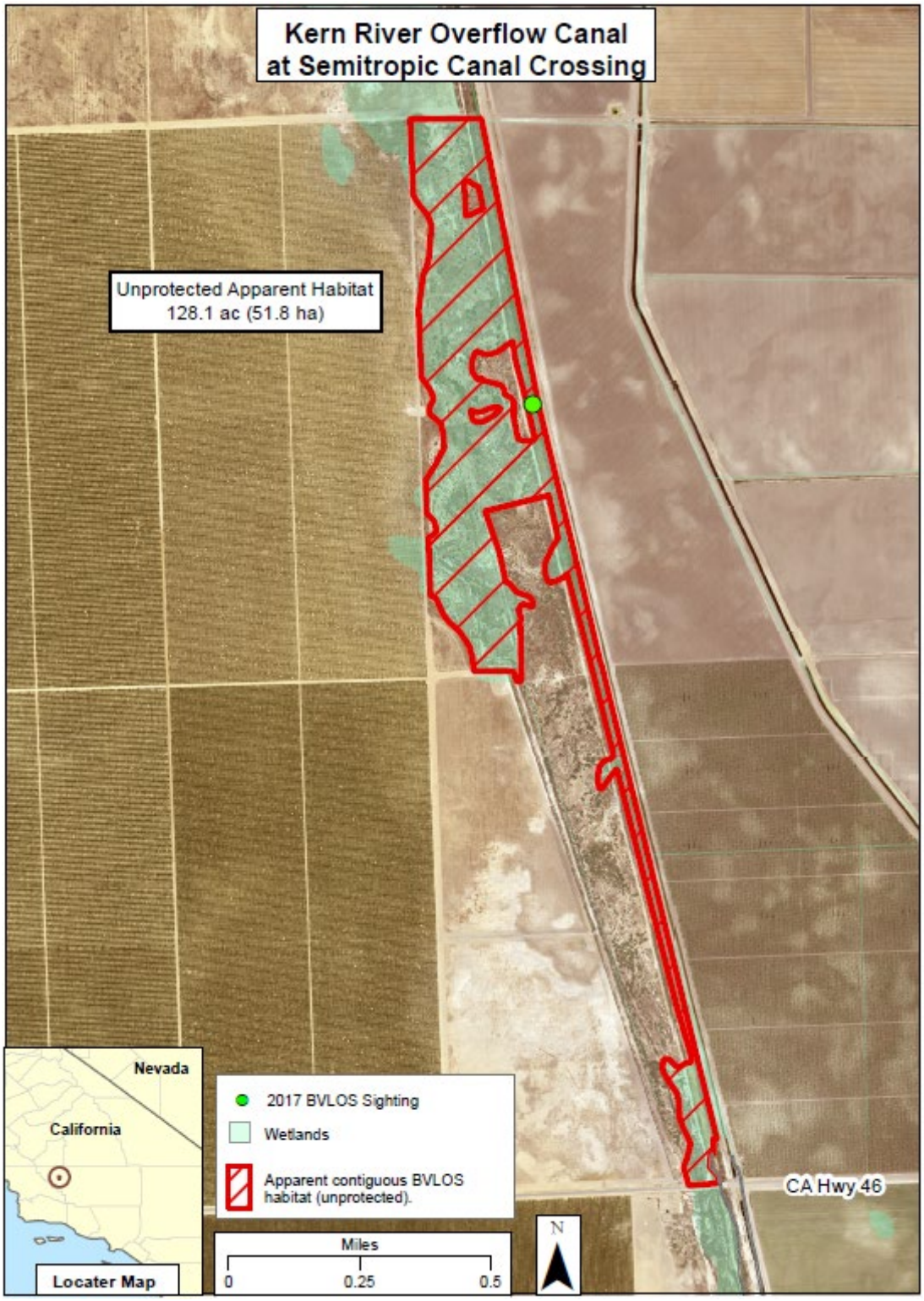


Figure 14: Kern River Overflow Canal at Semitropic Canal Crossing

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Kern Fan Water Recharge Area: This site is used by the City of Bakersfield to spread excess water as needed, thereby helping to prevent downstream flooding and to recharge the groundwater aquifer. It was proposed as critical habitat for the shrew, but excluded from designation in favor of a management plan for the area adopted by the City (see section 6(3) Applicability and Effects of Insufficient Water Supply, below). The site encompasses approximately 2,687.5 ac (1,087.6 ha), but most of it consists of suboptimal, non-wetland habitat, except during years of high precipitation (Cypher pers. comm. 2019, p.1) (Figure 15, below). A 2014 survey found that the area where BVLOS had previously been seen was completely dry (Cypher *et al*. 2017, p. 18). The survey report commented that the area was unlikely to support shrews in most years. Surveyors did locate BVLOS on a thin strip of riparian habitat remaining within the area.

The stream channel exiting the southwest corner of the site continues on as a narrow wetland channel (though likely dry at most times), uninterrupted except by its crossing under Interstate 5. After about 4 mi (6.4 km) it reaches the Coles Levee Critical Habitat Unit south of the Coles Levee pond.

Summary: An isolated area with less than 50 ac optimal habitat in most years.

Habitat quality: Poor.

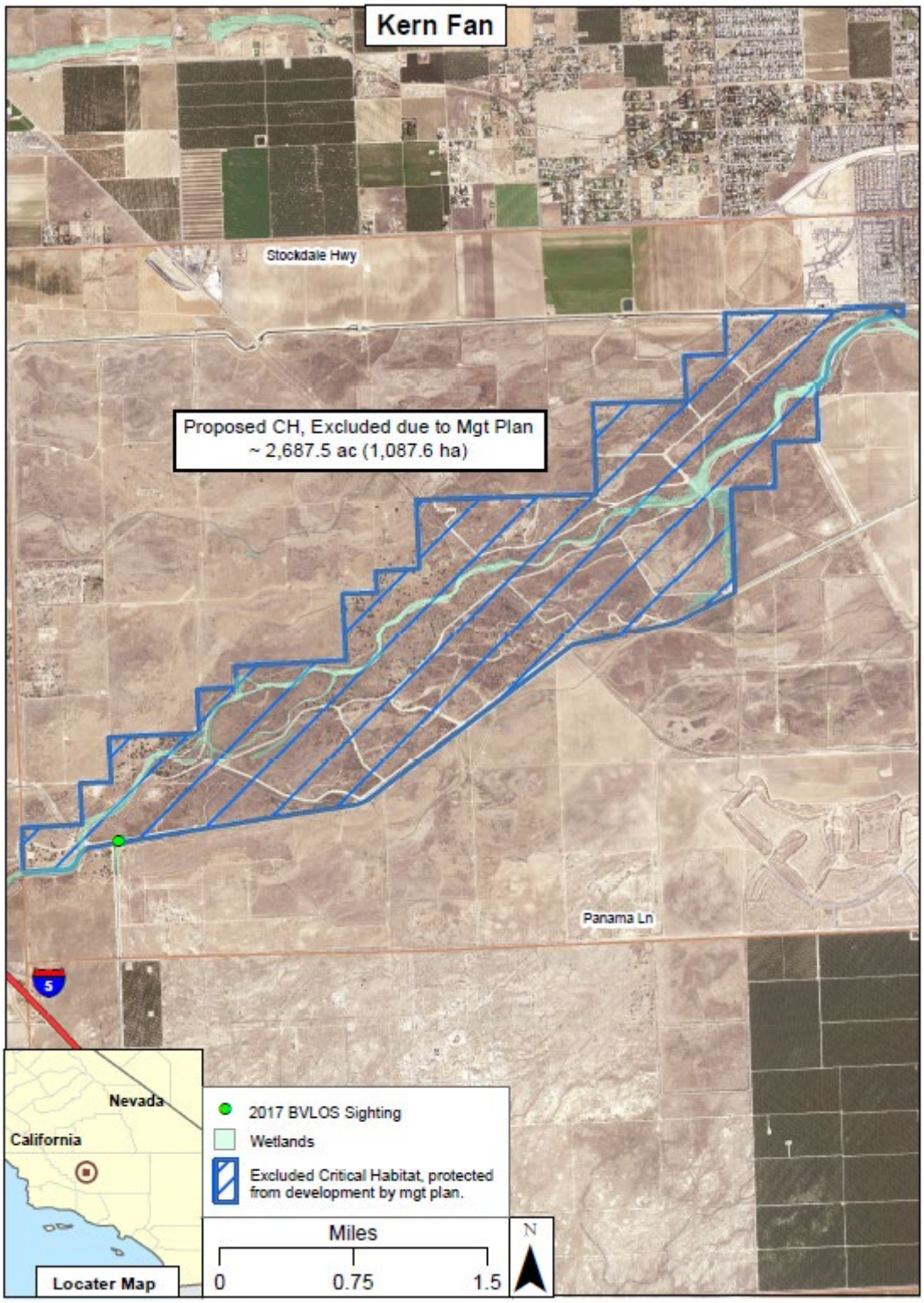


Figure 15: Kern Fan Water Recharge Area

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Coles Levee Critical Habitat Unit: This site (269.8 ac, (109.2 ha)) runs along the east bank of a cement-lined canal (the California Aqueduct), and primarily includes suboptimal, non-wetland habitat (Figure 16, below). Trees and vegetation in the majority of the preserve died in 2015 due to drought, and were bulldozed out (Tennant pers. comm. 2019b, p.1). The exception is the Coles Levee Pond; about 15.4 ac (6.2 ha) of perennial wetland habitat located roughly in the middle of the larger site (Figure 17, below). The pond and all but 46 ac (18.6 ha) of the larger site are on the Coles Levee Ecosystem Reserve, managed by AERA Energy (see section 6(2) Agricultural and Urban Development, below). The remaining 46 ac (18.6 ha) is on State lands within the Tule Elk Reserve (FWS 2012, p. 40718). The site is connected by a stream channel to the Kern Fan Water Recharge Area about 4 mi (6.4 km) away. The site is also located just south of the Tule Elk Reserve, although no BVLOS have been found at the Reserve by recent surveys (see Table 1, above). Shrew surveys were also conducted on the Reserve in the early 1990s, but no BVLOS were detected (Maldonado *in litt.* 2020, p. 40).

Summary: An isolated area with less than 50 ac optimal habitat.

Habitat quality: Poor.



Figure 16: Coles Levee Critical Habitat Unit

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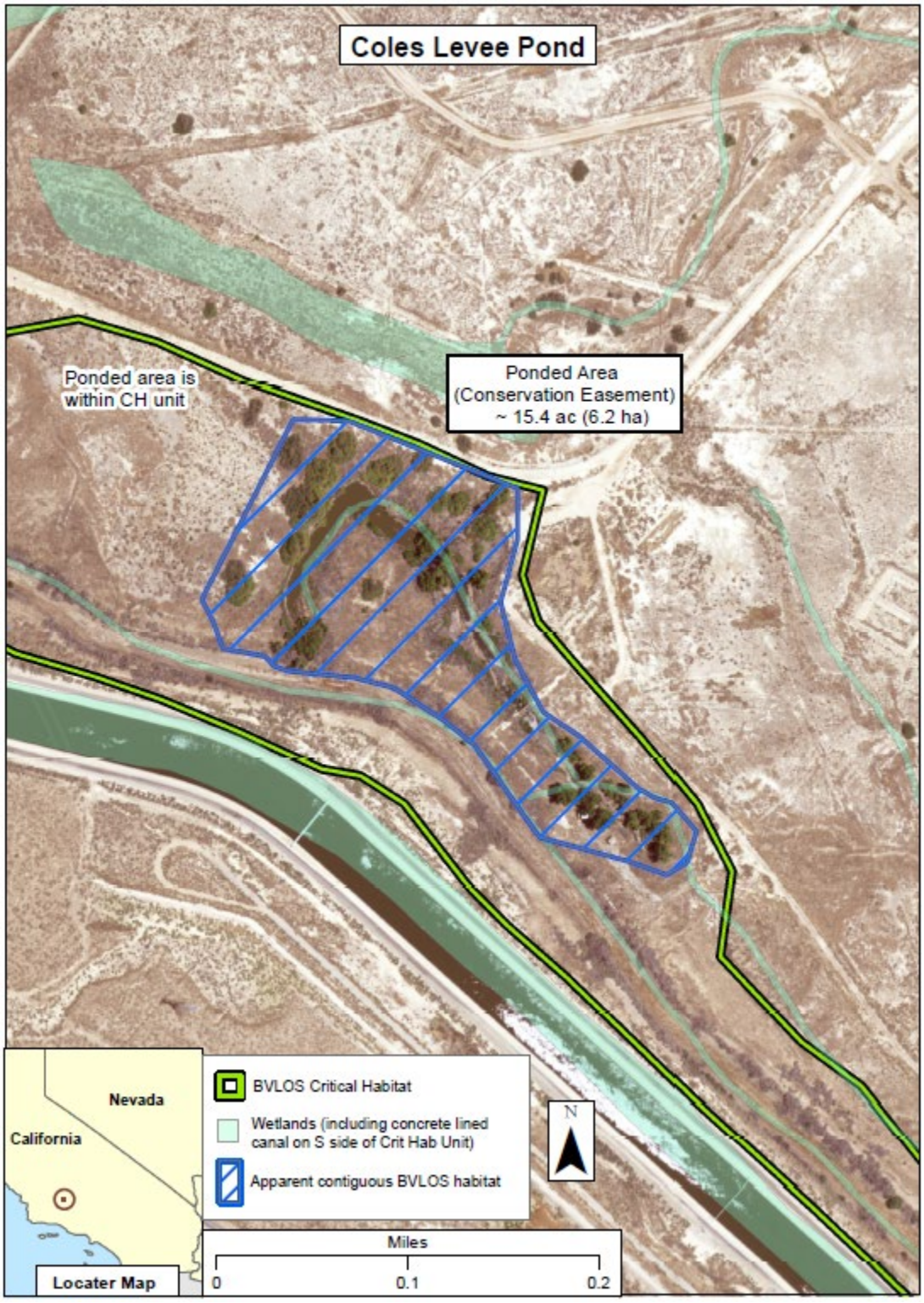


Figure 17: Coles Levee Pond

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Kern Lake Critical Habitat Unit: This site consists of two adjacent subunits totaling 84.8 ac (34.3 ha) (Figure 18, below). Wetlands cover about half of one of the units, while the other consists entirely of suboptimal habitat. Agricultural lands surround the site to the north, east, and west, but to the south, on the other side of a cement-lined canal additional wetlands extend south about 0.5 mi (0.8 km) on average. The site is about 11.7 mi (18.9 km) from the next closest occupied site (Wind Wolves – Twin Fawns), but there is no apparent corridor of optimal or suboptimal habitat connecting the two.

Summary: An isolated area with less than 50 ac optimal habitat.

Habitat quality: Poor.

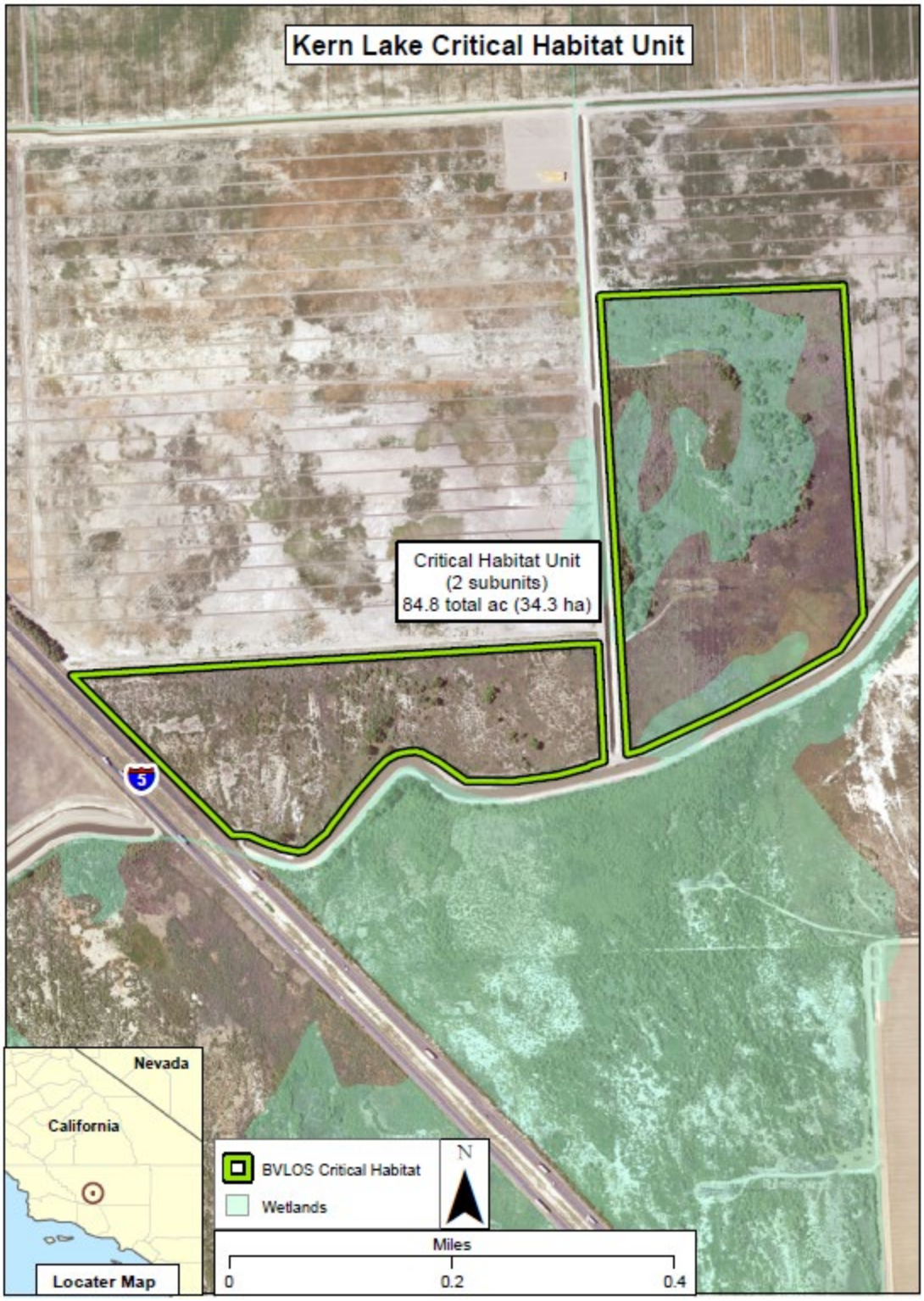


Figure 18: Kern Lake Critical Habitat Unit

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Wind Wolves Preserve: "Twin Fawns" and "The Willows" Sites: Twin Fawns (Figure 20, below) is the smaller and more northern of the two known occupied sites on the Wind Wolves Preserve (Figure 19, below). It supports about 18.3 ac (7.4 ha) of optimal wetland habitat. The Willows (Figure 21, below) is over twice as large, at about 55.5 ac (22.5 ha) of wetland habitat. The two sites are both on San Emigdio Creek and are separated by about a mile (1.6 km). San Emigdio Creek provides a corridor of optimal habitat connecting the two sites. Both sites are surrounded by extensive suboptimal habitat, but very little apparent nearby wetland habitat other than the Creek. The sites are over 11 miles (17.7 km) from the next closest occupied site (Kern Lake).

Twin Fawns Summary:

A non-isolated area with less than 45 ac total habitat and less than 41 ac optimal habitat.

Habitat quality: Poor.

The Willows Summary

A non-isolated area with between 56 and 100 ac total habitat, and between 50 and 100 ac optimal habitat.

Habitat quality: Moderate.

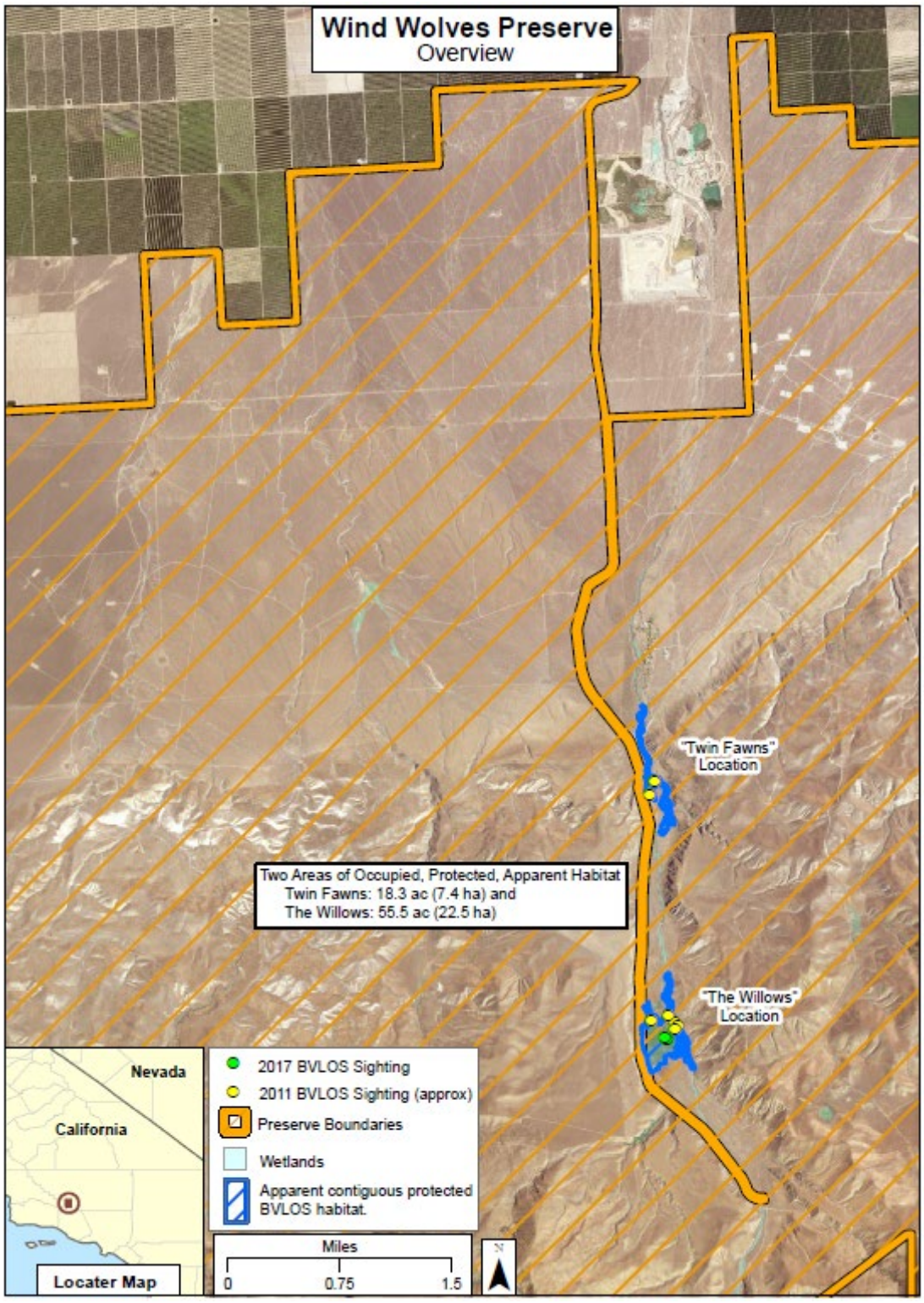


Figure 19: Wind Wolves Preserve

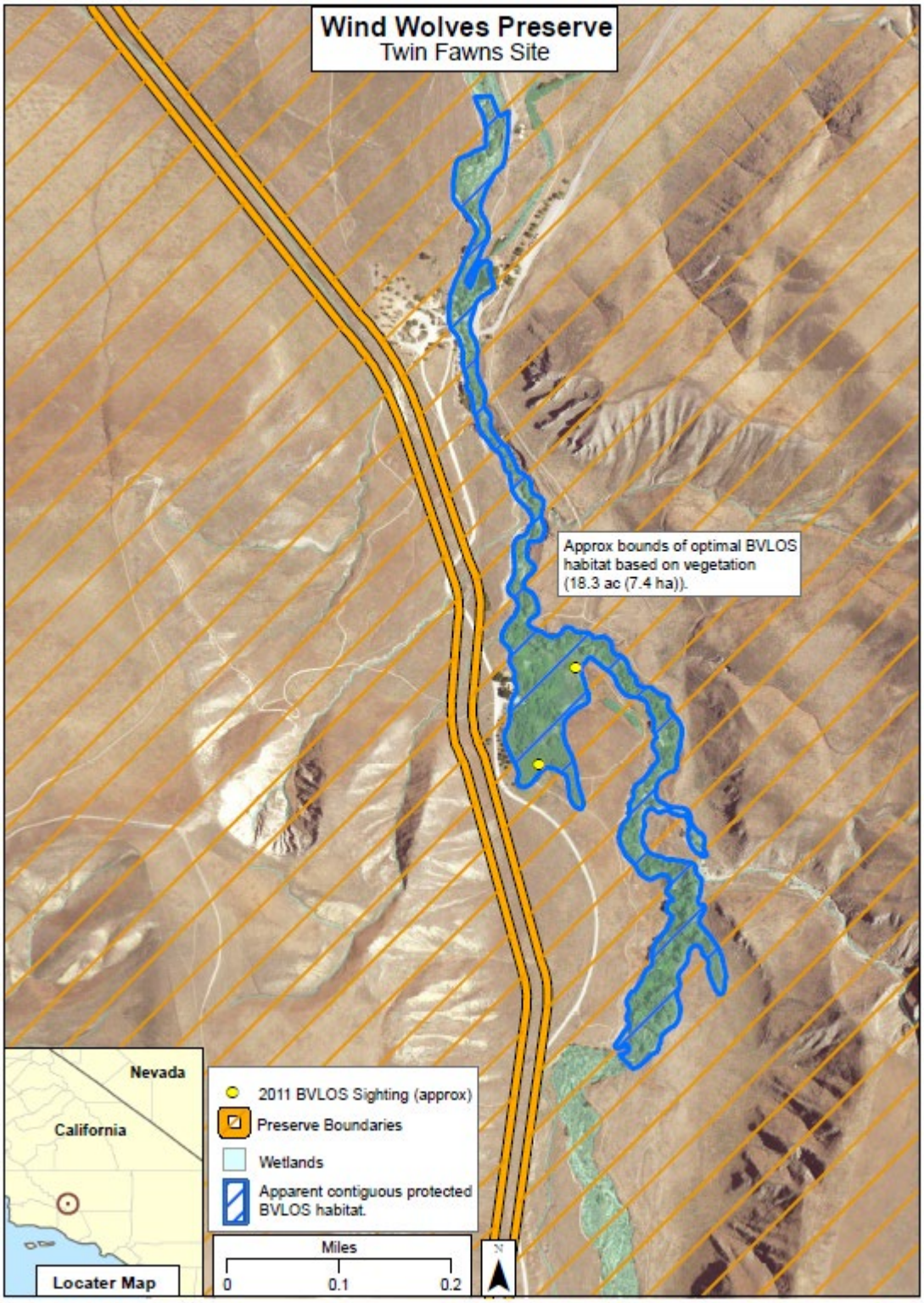


Figure 20: Wind Wolves Preserve – Twin Fawns Site

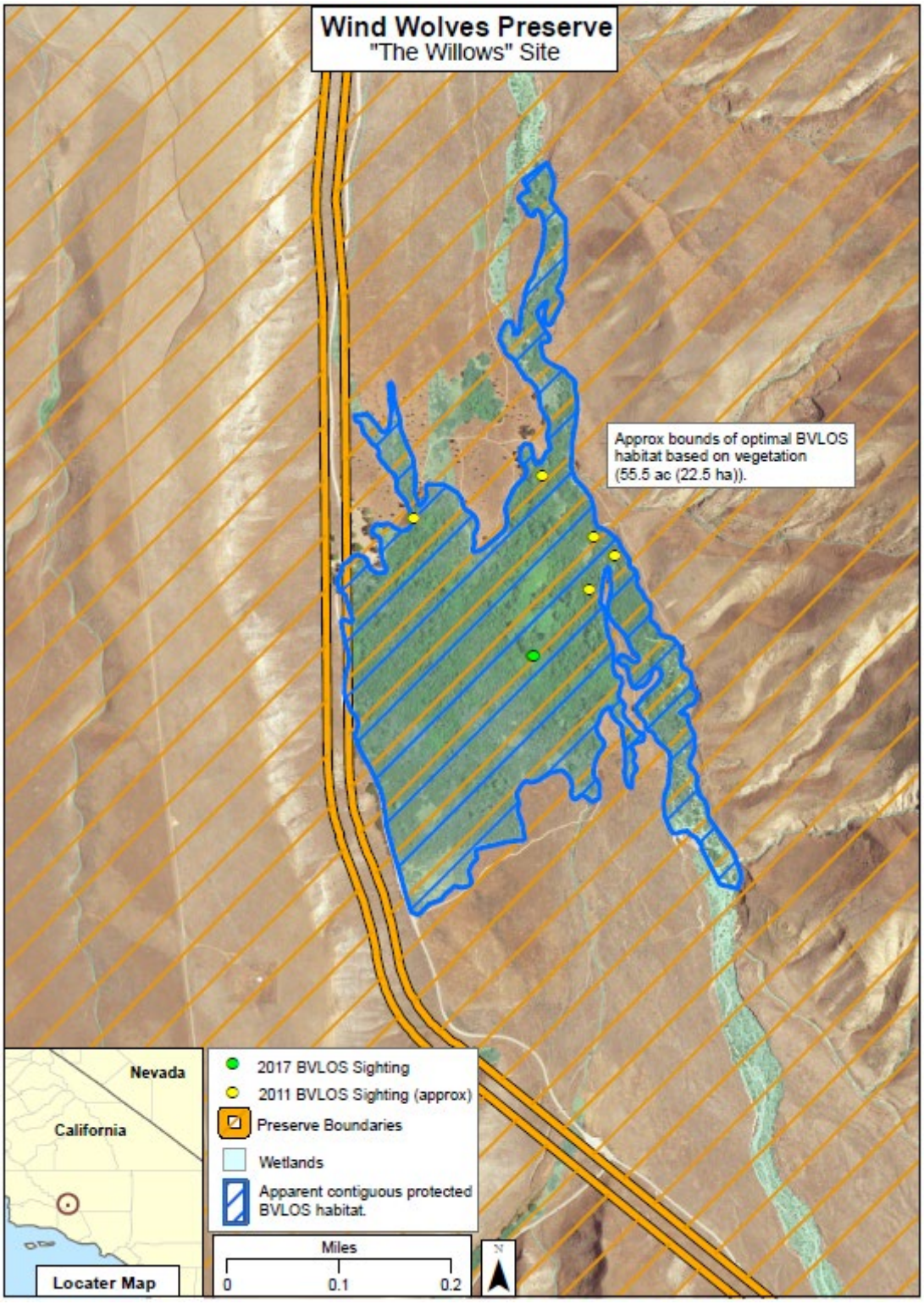


Figure 21: Wind Wolves Preserve – "The Willows" Site

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6(2) Effects of Agricultural and Urban Development

Since the early 1900s, agricultural and urban development has severely reduced and fragmented native habitats throughout the San Joaquin Valley (Mercer and Morgan 1991, pp. 10, 22–25). Historically, the former Tulare, Buena Vista, Goose, and Kern lakes, along with their respective overflow marshes, covered 19 percent of the Tulare Basin in the southern San Joaquin Valley (Werschkull *et al*. 1992) (see Figure 3, above). Around the turn of the 20th century, the Tulare Basin had 104,890 ha (259,189 ac) of valley fresh water marsh, 177,005 ha (437,388 ac) of valley mixed-riparian forests, and 105,333 ha (260,283 ac) of valley sink scrub, for a total of 387,229 ha (956,860 ac) of potentially suitable Buena Vista Lake shrew habitat (FWS 1986). By the early 1980s, the combined total had been reduced to 19,019 ha (46,996 ac), less than 5 percent of the original habitat (FWS 1986; Werschkull *et al*. 1992). As of 1995, intensive irrigated agriculture comprised 1,239,961 ha (3,064,000 ac) or about 96 percent of the total lands within the Tulare Basin (FWS 2017 p. 17).

The FWS is currently consulting with federal agencies on potential impacts to BVLOS habitat for three projects (a high-speed rail line, a canal refurbishment, and repairs to a levy) (FWS 2017, pp. 1–3; Stantec 2019, pp. 1–2, 6; Berry pers. comm. 2019, p. 1). Of those, only the levy repair work (on Poso Creek just outside the bounds of the Kern NWR) has potential to affect a known occupied location (Berry pers. comm. 2019, p. 1). Estimates of likely impacts are not yet available for that project.

The following list discusses habitat protections at the known sites considered to be occupied (see Figures 4–21 and Table 1, above). Note that protections discussed are specific to the sites listed, and do not include such protections as may be provided to the BVLOS itself under the ESA.

- NAS Lemoore. The Naval Air Station has an approved Integrated Natural Resources Management Plan (INRMP) that includes a management strategy to benefit BVLOS. The INRMP was last revised and signed in 2014 (NAS Lemoore 2014, 4-53 to 4-54).

- Lemoore Wetland Reserve: The Wetland Reserve has been designated critical habitat for the shrew and is managed as protected wetlands by the Natural Resources Conservation Service (NRCS) (FWS 2013, p. 39853).

- Pixley National Wildlife Refuge: Protected and managed for wildlife habitat by FWS.

- Atwell Island: This area supports a recently-created wetland managed for wetland communities by the U.S. Bureau of Land Management (BLM) (Cypher *et al.* 2017, pp. 17, 19).

- Kern National Wildlife Refuge: Protected and managed for wildlife habitat by FWS.

- Poso Creek: There are no current habitat protections at this site.

- Semitropic Ecological Reserve: This is protected and "managed passively as natural lands" by the California Department of Fish and Wildlife (CDFW) (CDFW 2018, p. 1). The area is also designated as critical habitat for the shrew. CDFW does not actively manage the area for BVLOS, however, and has no independent assurances or rights to water in times of low supply (Battistoni *in litt.* 2019, p. 1).

- Kern River Overflow Canal at Fwy 5 & Hwy 46: No current habitat protections, and habitat at the location of a 2014 BVLOS sighting has been removed due to construction on a Hwy 46 overpass (Cypher *et al.* 2017, p. 13; Tennant pers. comm. 2020, p. 1).

- The Goose Lake Critical Habitat Unit (Unit 2): This area is protected for the shrew as critical habitat, but it consists of private land and is not managed to support BVLOS (FWS 2013, p. 39850; Cypher *et al.* 2017, p. 17).

- Kern River Overflow Canal at Semitropic Canal Crossing: This area is an unprotected site managed by the Buena Vista Water Storage District (Cypher *et al.* 2017, p. 17).

- Kern Fan Water Recharge Area: The City of Bakersfield uses this area to spread water, as available, to recharge groundwater aquifers and help prevent downstream flooding (FWS 2013, p. 39856). The City operates the area under a habitat management plan intended to provide a conservation benefit to the shrew. The plan does not require specific management, however, other than that the area remain undeveloped (Cypher pers. comm. 2019, p.1).

- Coles Levee Ecosystem Preserve: This area was designated as critical habitat for the shrew (Unit 4). Coles Levee is also protected by a conservation easement administered by AERA Energy (FWS 2013, p. 39839; Battistoni *in litt.* 2019, p.1). However, the easement was not designed to protect wetland or riparian species such as the shrew.

- Kern Lake: This area on the original bed of Kern Lake was once an ecological preserve managed by the Nature Conservancy, but is currently protected only by its status as critical habitat for the shrew (Unit 5) (FWS 2013, p. 39852).

- Wind Wolves Preserve: This area is operated by the Wildlands Conservancy for conservation values, although much of the area lacks formal protection under a conservation easement (Cypher *et al.* 2017, p. 17).

6(3) Applicability and Effects of Insufficient Water Supply

Diversion of water for agricultural and urban uses has left insufficient water to maintain natural riparian or wetland characteristics at many San Joaquin Valley locations during years of low rainfall (Griggs *et al.* 1992, p. 111). We summarize the stability of water supplies for BVLOS habitat during drought years at the various occupied locations, below. We characterize water supply stability according to the following scale (repeated in Table 4, below):

Low Water Supply Stability: Water for wetlands is highly limited except during wet years.

Moderate Water Supply Stability: Water for wetlands is available most years.

High Water Supply Stability: Water for wetlands is available except during bad droughts.

Note that an area may have high water stability but still have relatively little optimal wetland habitat.

- NAS Lemoore (managed by DoD): Moderate water supply stability.

  Municipal, industrial, and agricultural uses at NAS Lemoore rely on water deliveries from the Westlands Water District (NAS Lemoore 2014, p. 2-12). Agricultural uses are also supplemented by groundwater. However, "[w]ater availability for habitat development is lower on the priority list of water uses," and "[i]n some years, wetlands at NAS Lemoore are threatened by limited water availability." (NAS Lemoore 2014, p. 4-22).

  To help counteract this, the INRMP includes several management objectives likely to benefit BVLOS habitat at the occupied location (an area referred to as Natural Resource Management Area (NRMA) 2):

  - "Implement strategies specific to plant communities that are at risk and/or have recognized conservation value, such as wetland and aquatic habitats" (NAS Lemoore 2014, p. 4-24)
  - "Ensure the availability of adequate water to meet natural resource management objectives including habitat enhancement in NRMAs" (NAS Lemoore 2014, p. 4-25).
  - "Investigate opportunities to secure water for habitat enhancement, particularly for existing wetlands. This could include stormwater from the Habitat Linkage Corridor and developing other available sources" (NAS Lemoore 2014, p. 4-26).

- Lemoore Wetland Reserve (managed by NRCS): High water supply stability.

  Wetland habitat is located on the banks of the Kings River, which delivers water for wetlands except during serious long-term droughts (Kraft *in litt.*

2019, p. 1). When flood waters are available, additional areas can be inundated.

- Pixley NWR (managed by FWS): High water supply stability.

  Pixley has developed about 300 ac (121 ha) of wetlands using well water (FWS 2005, p. 29). Under the CVPIA it is also allocated 6,000 acre feet of water from the Kern-Friant canal, but has not yet constructed connecting canals or pipelines to convey that water to the refuge (FWS 2005, pp. 29–30).

  Water is typically placed in the wetland pond complexes in the fall and winter and then dries up in the late spring and summer, although generally with persistently moist soils in enough areas to provide for BVLOS (Cypher *et al.* p. 18). Managers sometimes have difficulties obtaining enough water for BVLOS needs during drought years, however (Tennant pers. comm. 2019b, p. 1).

- Atwell Island Wetland (managed by BLM): High water supply stability.

  Atwell Island uses overland runoff in wet years, and has a single well to supply water during drought years. They have had difficulties in the past getting the well and pump system to work correctly (Tennant pers. comm. 2019b, p. 1), but are in the process of constructing a second well (Ludwick pers. comm. 2019, p. 1).

- Kern NWR (managed by FWS): High water supply stability.

  Under provisions of the CVPIA, Kern Refuge was provided an annual allocation of 25,000 acre-feet of water, originating at Lake Shasta, for wetland management purposes (FWS 2005, p. 27; Cypher *et al*. 2017, p. 18). This is sufficient to flood 3,000 to 6,400 acres sequentially over a 3 to 5 month period beginning in mid-August (FWS 2005, p. 27). As with the Pixley NWR, the wetlands largely dry out in late spring and summer, but with some moist soils persisting (Cypher *et al.* 2017, p. 18).

- Poso Creek (managed by the Semitropic Water Storage District): Low water supply stability.

  Except during years of high rainfall, Poso Creek is normally dry at the sighting location due to upstream diversions (Cypher 2016, p. 2, Berry 2017, p. 6).

- Semitropic Ecological Reserve (managed by CDFW): Low water supply stability.

  Semitropic Ecological Reserve is managed primarily for upland habitat, not for BVLOS. It has no expectation of additional water in drought years, except

that, in past years, some water being delivered to other locations such as Kern NWR has crossed Semitropic and thereby supported shrew habitat at the location (Battistoni *in litt.* 2019, p. 1). In 2018 and 2019, however, managers sent the water through an alternative canal, bypassing the primary area known to support shrews (Tennant pers. comm. 2019a, p. 1). Habitat quality in the reserve has decreased, and invasive knapweed (*Centauria spp.*) is beginning to replace native vegetation.

- Kern River Overflow Canal at Fwy 5 and Hwy 46 (managed by the Semitropic Water District): Low water supply stability.

  There are no protections or assurances of a continuing water supply at this location, and the canal has been largely dry since about 2017 (Tennant pers. comm. 2020, p. 1).

- Goose Lake Critical Habitat Unit (managed by the Semitropic Water District): Low water supply stability.

  This area is managed as a groundwater recharge basin (FWS 2004, p. 51423). It has no applicable conservation agreements.

- Kern River Overflow Canal at Semitropic Canal Crossing (managed by the Buena Vista Water Storage District): Low water supply stability.

  There are no protections or assurances of a continuing water supply at this location (Cypher *et al.* 2017, p. 17).

- Kern Fan Water Recharge Area (managed by the City of Bakersfield): Low water supply stability.

  This area is maintained to allow extra surface water to percolate down into the groundwater supply for storage and later use (City of Bakersfield 2014, p. 4-4). Accordingly, the area can be expected to remain dry during droughts when extra surface water is unavailable. Although two BVLOS were identified in this area in 1999 (Williams and Harpster 2001, p. 10), the portion of the property where they were found is now completely dry in most years and unlikely to support shrews (Cypher *et al.* 2017, p. 18). However, shrews were found recently in a thin strip of riparian habitat on the southwest edge of the area.

- Coles Levee Ecosystem Reserve (managed by Aera Energy): High water supply stability (but for a relatively small area).

  The area includes an artificial pond supplied with water from nearby oil extraction activities, as well as approximately 2 mi (3.2 km) of degraded natural riparian communities along the Kern River (FWS 2004, p. 51424). The

ponded area and much of the surrounding natural riparian habitat was designated as critical habitat for the shrew in 2013, but except during years of heavy precipitation, the area is mostly dewatered outside the immediate area of the pond. It likely maintains moist soils and optimal to suboptimal BVLOS habitat in most years, however. The water supply to the pond is extremely stable and the pond has never dried out since its creation in approximately 2000 (FWS 2004, p. 51424; Torres Garcia *in litt.* 2019, p. 1).

- Kern Lake Critical Habitat Unit (managed by J. G. Boswell Co.): High water supply stability.

  The area receives both surface and underground runoff from the surrounding hills, which collects at "Gator Pond" near the shoreline of the original Kern Lake (FWS 2013, p. 39852). The underground runoff surfaces through artesian springs directly at the pond, and so would likely support optimal or at least suboptimal habitat during most droughts, unless the aquifer is tapped by wells for agricultural purposes.

- Wind Wolves Preserve – Twin Fawns and The Willows sites (managed by The Wildlands Conservancy): High water supply stability

  Both occupied areas are on San Emigdio Creek, which has high water stability resulting from a large and little-developed watershed that collects water from higher elevations in the San Emigdio Mountains. The preserve is owned and managed by The Wildlands Conservancy for conservation values, although much of the preserve is not under formal conservation easement.

6(4) Effects of Changing Climate

Since the beginning of the 20th century, annual average air temperatures have increased in California by about 0.84 ºC (1.5ºF) (Bales 2013, p. 2; Romero-Lankao *et al*, 2014, pp. 1452–1453). This has produced an irregularly increasing trend of drought severity during that time period (Cook *et al*. 2004, p. 1016). The most recent drought in the southern San Joaquin Valley area lasted for five years, from February 2012 to February 2017 (Kim and Lauder 2017, pp 2–45). For 3 years, (from January 2014 to January 2017), the drought in the area was characterized as "exceptional," the highest level designated.

Droughts lower the quality of BVLOS habitat by drying soil and bodies of open water. The extent of such drying is commensurate with the duration and severity of the drought. The severity of droughts in western North America, as measured by the averaged percentage of area undergoing a drought during a given year, has roughly doubled from about 20 percent in 1900 to about 40 percent in the early 2000s (Cook *et al*. 2004, p. 1016), presumably in response to climate change.

6(5) Applicability and Effects of Trapping

This is unlikely to constitute a stressor due to the small number of known losses (two in the most recent rangewide survey) (Cypher *et al.* 2017, p. 16).

6(6) Effects of Disease and Predation

At this time, we have no information regarding instances of disease in BVLOS. Studies on European shrew populations of the same genus as BVLOS (*Sorex*) have demonstrated significant burdens of ticks and tick-borne diseases (Bown *et al.* 2011, p. 947), as well as tapeworms (Zasityte 2001, p. 19). However, the impacts of such parasites on population numbers was not estimated.

BLVOS are typically found in dense vegetative groundcover (Cypher *et al.* 2017, p. 2), at least in part because it provides cover from predators (FWS 2013, p. 39846). Accordingly, although we lack information regarding overall predation impacts on BVLOS population abundance, we consider predation to be a major factor limiting BVLOS to the specific types of habitat (optimal, suboptimal, and dispersal) discussed above. It also is a major factor in distinguishing the relative values of those habitat types, since suboptimal habitat generally has less cover than optimal, for instance.

6(7) Applicability and Effects of Inadequacy of Regulatory Mechanisms

We typically consider inadequacy of existing regulatory mechanisms to be a stressor only if some regulatory mechanism is not working as designed. We are not aware of any such cases applicable to the shrew.

6(8) Effects of Selenium

In many areas of the Tulare Basin, water used for crops cannot easily flow to the San Joaquin River and the ocean (EPTC 1999, p. 6). Instead, it flows across soil surfaces and through shallow groundwater aquifers, dissolving selenium and other salts along the way, and then collects in specially constructed evaporation ponds (RWQCB 2015, p. I-2). The water evaporates from the ponds but the dissolved selenium and other salts stay behind and accumulate. Some of the highest selenium levels in the western United States have been measured from shallow groundwater within the southern San Joaquin Valley (Seiler *et al*. 1999, p. 22), and in drainwater evaporation ponds located near to several known BVLOS populations (EPTC 1999, p. 12). Selenium levels in shallow groundwater are closely correlated to levels in the root zone (close to the surface) (Howitt *et al.* 2009, p. 3-31).

In 1983, selenium poisoning from agricultural runoff resulted in high numbers of dead and deformed waterfowl at the Kesterson National Wildlife Refuge, in the San Joaquin Valley north of the range of the Tulare Basin (Kosloff 1985, p. 2). Waterfowl reproductive efforts were particularly affected, with about 1 in 5 nests producing deformed embryos (USBOR 1998, p. 145). Four waterbird species at the refuge produced no healthy chicks at all. There have been no well documented cases of similar effects in wild mammals (Clark 1987, p. 147; USBOR 1998, p. 168), but selenium poisoning has

resulted in anemia, liver damage, and jaundice in livestock (Halverson *et al.* 1970, p. 151; USBOR 1998, p. 139). Selenium can bioaccumulate (become more concentrated in animals higher on the food chain) (USBOR 1998, pp. 139, 170).

Because BVLOS are predators with high food intakes, and because they live in close association with wetlands, some of which may be affected by high selenium levels in agricultural runoff or shallow groundwater, BVLOS are likely candidates among wild mammals, for selenium-related impacts. We recognized this in 2002 when we listed the subspecies, and mentioned selenium poisoning as a possible threat (67 FR 101010). However, we are not aware of any studies that have directly investigated selenium-related impacts to BVLOS or other shrew populations. We therefore consider selenium-related impacts to be likely but not demonstrated. In Table 5, below, where we compare potential impacts of various stressors at different population locations, we attempt to account for this uncertainty by assigning half values to effects on BVLOS resiliency from both selenium and pesticides.

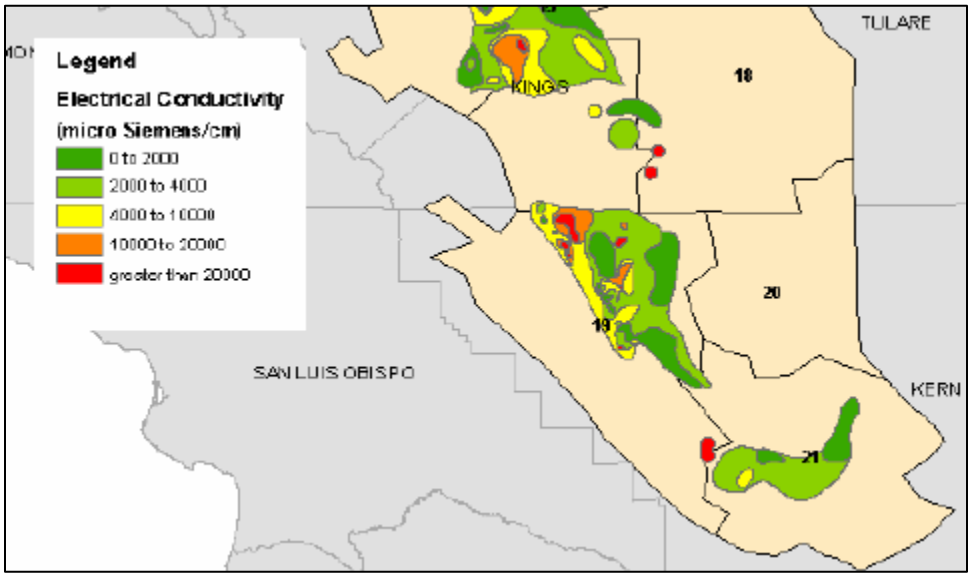


Figure 5a: Salinity levels (indicative of elevated selenium) in shallow groundwater (Howitt *et al.* 2009, p. 3-32).

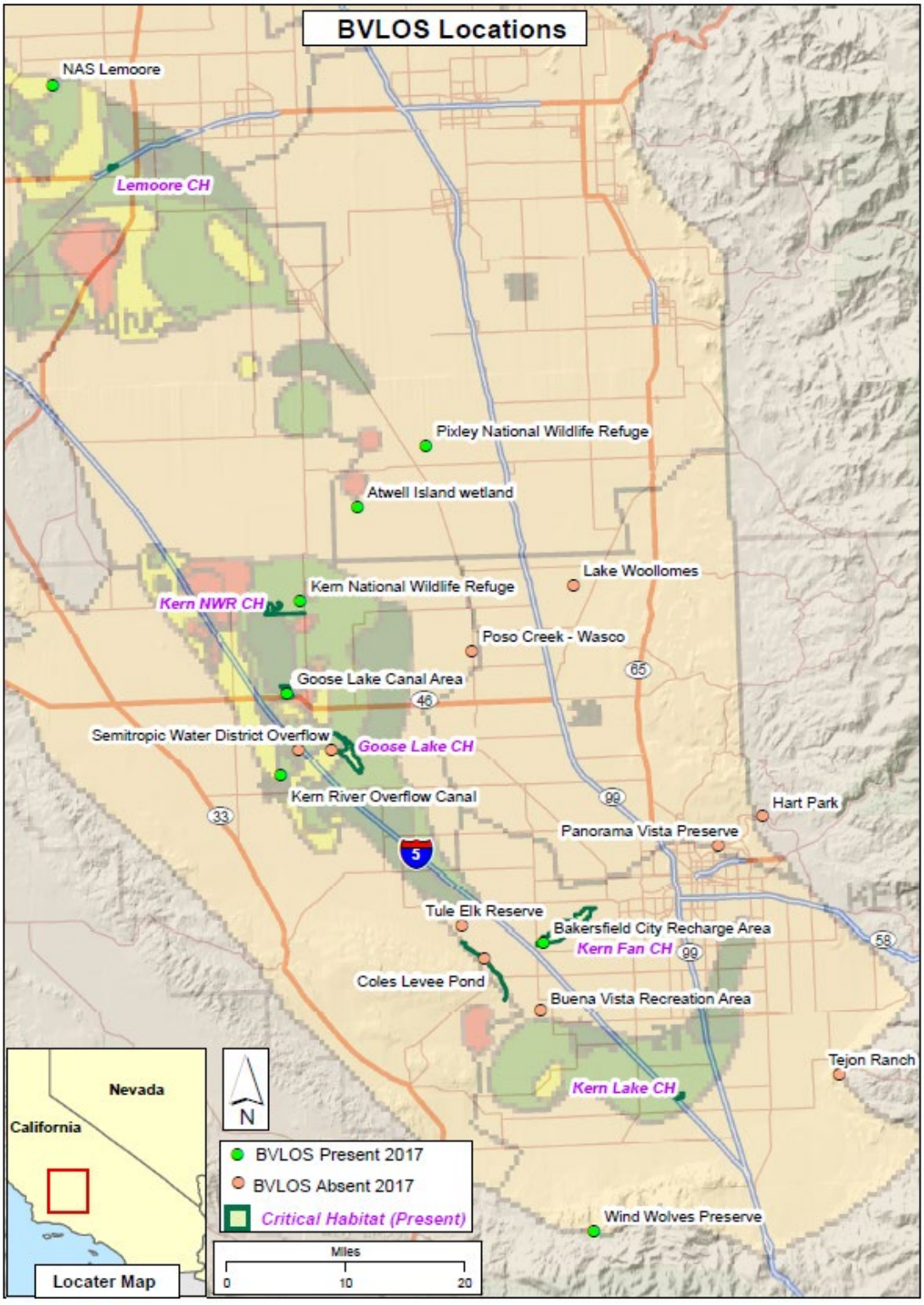


Figure 5b: Superposition of salinity levels (Figure 5a) over map of BVLOS locations (Figure 4).

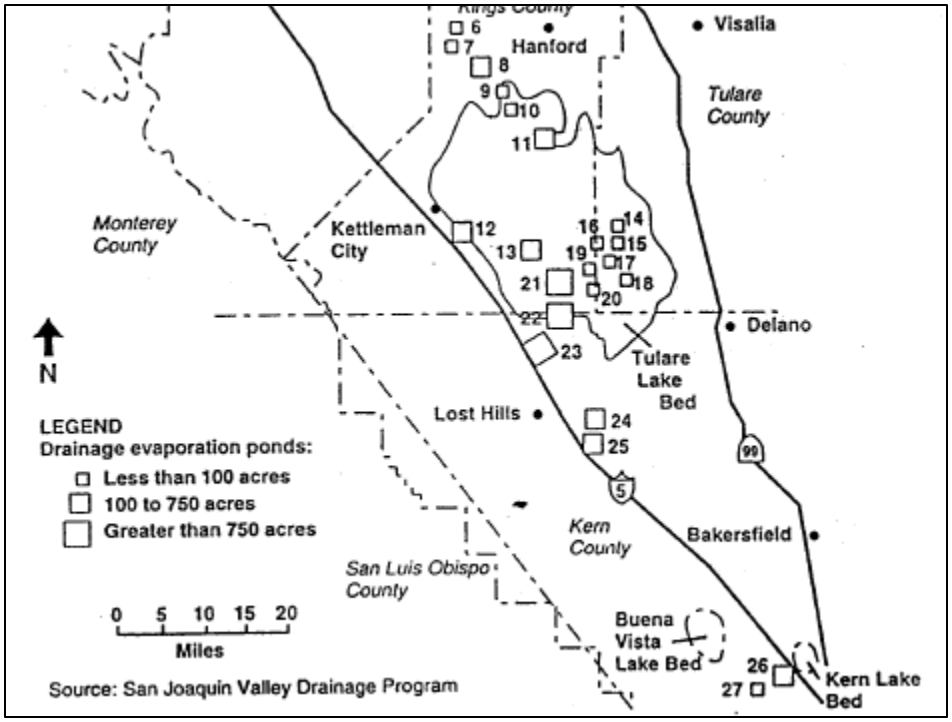


Figure 6a: Evaporation pond locations (EPTC 1999, p. 12)

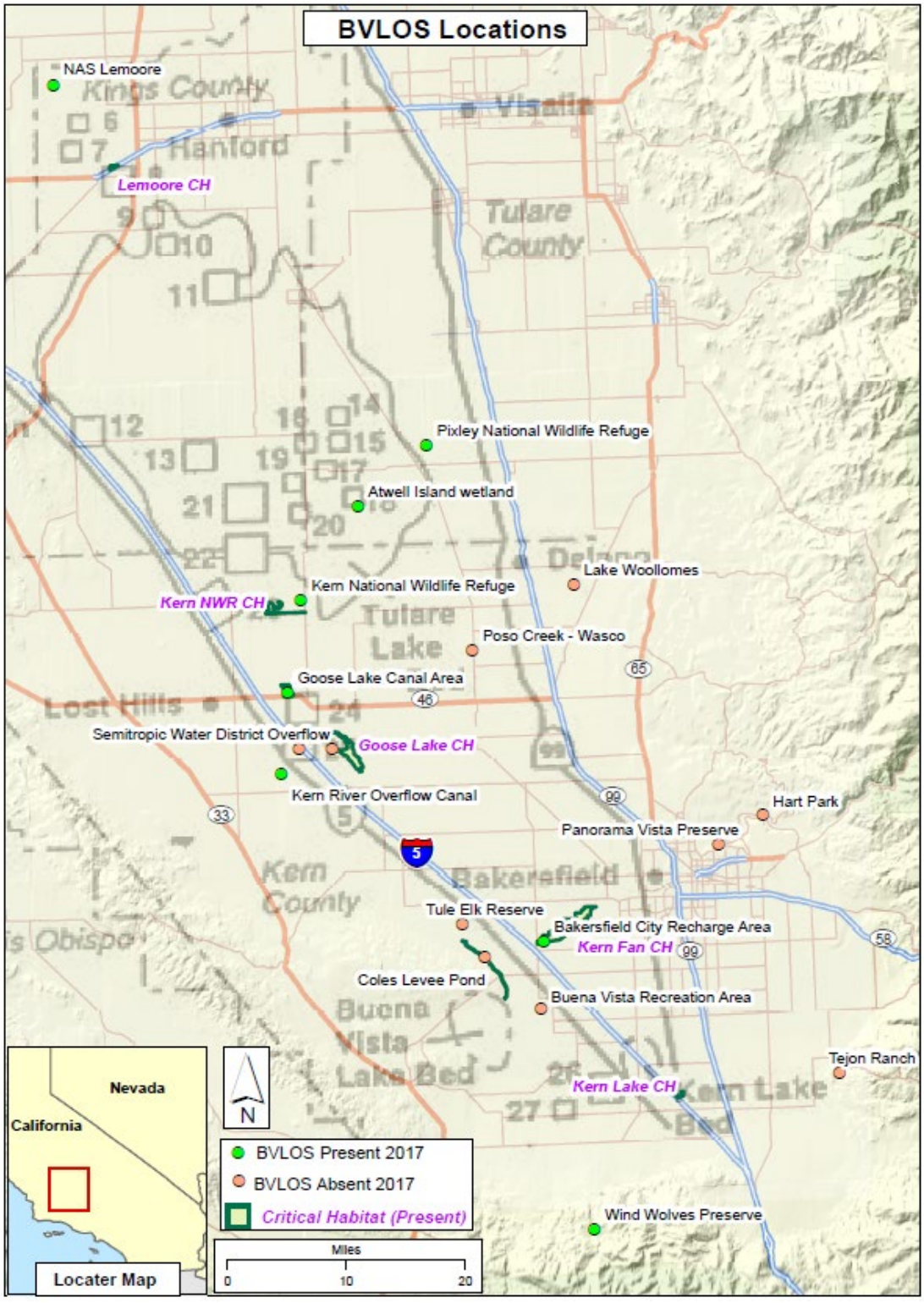


Figure 6b: Superposition of evaporation ponds (Figure 6a) over map of BVLOS locations (Figure 4).

Elevated concentrations of selenium in insects have been measured in many potential BVLOS prey species such as brine flies (Ephydridae), damselflies (Zygoptera), midges (Chironomidae), and other insects collected at 22 agricultural drainage evaporation ponds throughout the Tulare Basin, including ponds a few miles west of the Kern Lake site and along the northern border of the Kern NWR (Moore *et al*. 1989, pp. 14–28). Efforts to prevent impacts to wildlife have primarily involved monitoring of waterfowl eggs, as well as actions to make evaporation ponds from agricultural runoff less attractive to waterfowl (RWQCB 2015, p. IV-3). Such actions would be unlikely to reduce impacts to BVLOS.

Table 2, below, categorizes potential selenium levels at each occupied BVLOS location based on proximity to an evaporation pond or location primarily within an area of relatively high (yellow or above in Figure 5a) groundwater salinity:

Location	Within 1 mi of Evaporation Pond?	Groundwater Salinity > 4,000 µS/cm (yellow, orange, or red in Fig 5a)?	Total Selenium Indicators Applicable (Number of "Ys")
NAS Lemoore	N	Y	1
Lemoore Wetland Reserve	Y	N	1
Pixley NWR	N	N	0
Atwell Island	Y	N	1
Kern NWR	Y	Y	2
Poso Creek	N	N	0
Semitropic Ecological Reserve	Y	N	1
Kern River Overflow Canal at Fwy 5 & Hwy 46	N	N	0
Goose Lake	Y	N	1
Kern River Overflow Canal at Semitropic Canal Crossing	N	Y	1
Kern Fan	N	N	0
Coles Levee	N	N	0
Kern Lake	Y	N	1
Wind Wolves – Twin Fawns	N	N	0
Wind Wolves – The Willows	N	N	0

Table 2: Occupied BVLOS Locations and Areas of High Selenium Concentration (Based on Figures 5a and 6a).

6(9) Effects of Pesticides

Pesticide application data for 2016 (the most recent year available) shows heavy to moderate use of neonicotinoids in the vicinity of six of the eleven locations occupied by BVLOS, and heavy to moderate use of cholinesterase inhibitors (such as malathion) at seven locations (FWS *in litt.* 2019, pp. 1–2) (See Figure 7, below).

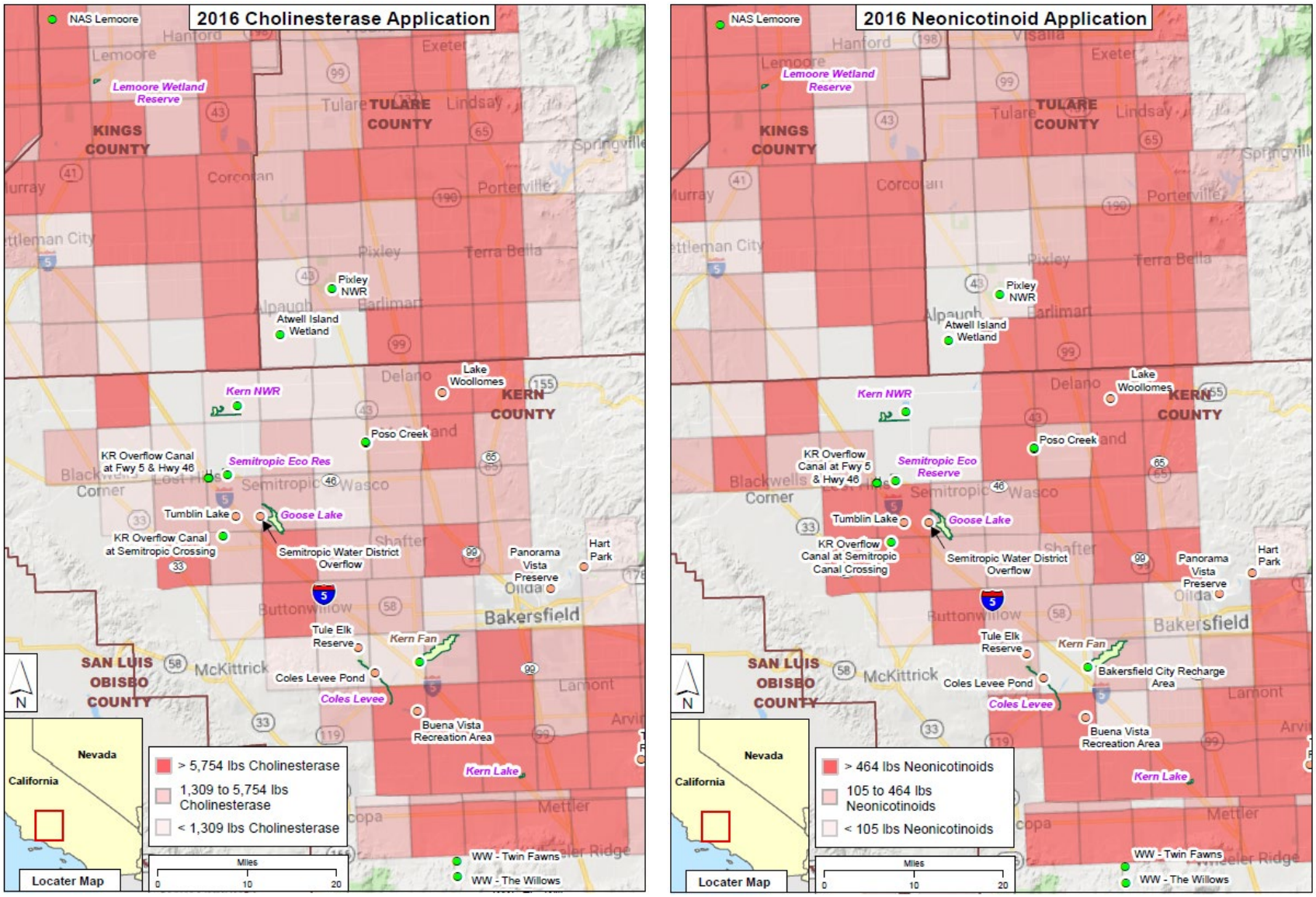


Figure 7: Application levels for two types of pesticides in 2016 (FWS *in litt.* 2019, pp. 1–2, (using data from CEHTT 2018, pp. 2–3)).

We consider the likelihood of direct or indirect pesticide effects on BVLOS to be higher in areas of high surrounding use. However, we have no direct information regarding actual amounts of pesticides moving into non-cropland ecosystems, and we are not aware of any studies directly investigating the effects of pesticides on shrews. As with selenium impacts (above), we therefore consider pesticide-related impacts to be likely but not demonstrated. In Table 5, below, where we compare potential impacts of various stressors at different population locations, we attempt to account for this uncertainty by assigning half values to effects on BVLOS resiliency from both selenium and pesticides.

Potential Direct Impacts:

> Neonicotinoid pesticides range from "practically nontoxic" to "moderately toxic" for mammals such as mice and rats (Gibbons *et al.* 2015, p. 105), but even low doses can cause reduced growth and increased likelihood of stillbirth (Gibbons *et al.* 2015, p. 110). Even at very low doses (0.21 and 2.0 mg/kg/day), such pesticides have resulted in immunotoxic effects and low sperm production. Additionally, neonicotinoids have been found to bio-accumulate (increase concentration) in earthworms (*Eisenia andrei*) (Chevillot *et al* 2017, p. 843), an important food item of ornate shrews (see section 2(2), above).
>
> Neonicotinoids are often used to treat seeds, or are applied to the roots of the crop plant, thereby helping to prevent airborne drift from spraying (Sanchez-Bayo *et al* 2016, p. 1). But these insecticides can still enter the environment using other routes, including dust generated during drilling of dressed seeds, contamination and accumulation in arable soils and soil water, runoff into waterways, and uptake of pesticides by nontarget plants via their roots or dust deposition on leaves (Bonmatin *et al.* 2015, p. 35).
>
> Malathion (a cholinesterase inhibitor) is considered only slightly toxic to mammals based on LD50 tests (which do not measure sublethal effects) (Newhart 2006, p. 16). However, a study in Ohio found that a white-footed mouse population (*Peromyscus leucopus novaboracensis*) was reduced by 45 percent in a treated area, and a chipmunk population (*Tamias striatus fisher*) was reduced 30 to 55 percent, both due to sublethal effects on survival and reproduction (Giles 1970, pp. 72–73; Newhart 2006, p. 14). Malathion is not known to bio-accumulate significantly (Faria *et al.* 2010, pp. 13, 14).

Potential Indirect Impacts:

> Windborne drift of cholinesterase inhibitors such as malathion can be lethal to non-target invertebrates at distances of up to 200 m (656 ft.) from application (Newhart 2006, p. 5). In fresh water, it is considered highly to very highly toxic to aquatic stages of non-target insects (Newhart 2006, pp. 11–12, 16). Loss of such insects could potentially affect the food supply of BVLOS.

Similarly, neonicotinoids have been associated with population declines of roughly 70% in caddisflies, mayflies and stoneflies, and have also caused larvae and nymphs of blackflies and mayflies to drift downstream into areas of lower pesticide concentration (Sanchez-Bayo *et al* 2016, pp. 6–7), thereby potentially lowering larval population numbers at occupied BVLOS locations.

Characterization of Potential Impacts by Site

In Table 3, below, we characterize pesticide condition levels in the area surrounding each occupied BVLOS site using overall scores of 0 to 6. Overall scores reflect the combination of scores from 0 to 3 for each of the two common pesticide types applied, as shown in Figure 7. Higher scores indicate better conditions for BVLOS, so areas with no application of a given pesticide were assigned a value of 3, those with light pesticide application were assigned a 2, and moderate and heavy application levels were assigned 1 and 0, respectively. Occupied sites that straddled areas with different application levels of a particular pesticide were assigned the average of the levels straddled (so a site straddling areas of moderate and heavy application (1 and 0) would be assigned a value of 0.5 for that pesticide). Descriptive categories of Low, Medium, and High were then assigned for scores of 0.0 – 2.0; 2.1 – 4.0; and 4.1 –6.0, respectively.

Location	Cholinesterase Inhibitors	Neonicotinoids	Numerical Score	Descriptive Category
NAS Lemoore	0	0	**0**	**Low**
Lemoore Wetland Reserve	0.5 (0 & 1)	0	**0.5**	**Low**
Pixley NWR	1	2	**3**	**Moderate**
Atwell Island	2	3	**5**	**High**
Kern NWR	2	3	**5**	**High**
Poso Creek	1.5 (2 & 1)	0.5 (1 & 0)	**2**	**Low**
Semitropic Ecological Reserve	2 (3 & 1)	1.5 (3 & 0)	**3.5**	**Moderate**
Kern River Overflow Canal at Fwy 5 & Hwy 46	2 (3 & 1)	1.5 (3 & 0)	**3.5**	**Moderate**
Goose Lake	1	1	**2**	**Low**
Kern River Overflow Canal at Semitropic Canal Crossing	1	0	**1**	**Low**
Kern Fan	1.5 (2 & 1)	2 (3 & 1)	**3.5**	**Moderate**
Coles Levee	1 (2, 1, & 0)	1.3 (3, 1, & 0)	**2.3**	**Moderate**
Kern Lake	0	0	**0**	**Low**
Wind Wolves –	3	3	**6**	**High**

Twin Fawns				
Wind Wolves – The Willows	3	3	**6**	**High**

Table 3: Pesticide Condition Levels in the Surrounding Area, by Site

As the table shows, sites with the highest surrounding pesticide application levels include Kern Lake, Goose Lake, Kern River Overflow, and Lemoore, while those with the lowest such levels include Wind Wolves, Kern NWR, and Atwell Island.

6(10) Effects of Inbreeding Depression and Hybridization

As discussed above in section 5(5), inbreeding depression can result from the loss of genetic diversity in small populations due to genetic drift. A recent analysis of microsatellite DNA sequences in ornate shrews from the San Joaquin Valley (including BVLOS) found that sampled populations fell into six genetically-similar groups or "clusters", three of which are not considered BVLOS (Maldonado *et al.* 2017, p. 50)[5]:

(1) Atwell Island, Coles Levee, Main Drain, Kern NWR, Kern Fan Recharge,
(2) Goose Lake, Helm, Lemoore, Wind Wolves, Sierra north,
(3) Tranquility (**not BVLOS**),
(4) Salinas (**not BVLOS**),
(5) Kern River Preserve (**not BVLOS**), and
(6) Kern Lake.

Note that shrews from the Helm population are also not considered BVLOS, despite their similarity in the genetic markers tested to BVLOS at other locations in the group (Cypher *et al.* 2017, p. 1).

Locations of the populations in these clusters are as shown in Figure 7, below.

[5]Note: the page number indicated on the document is "15" but these numbers run 1–15, then 1–4, then 1–9. Accordingly, when citing to this document we indicate the page number starting from p. 1 of Cypher *et al.* 2017, of which Maldonado *et al.* 2017 is Appendix B.

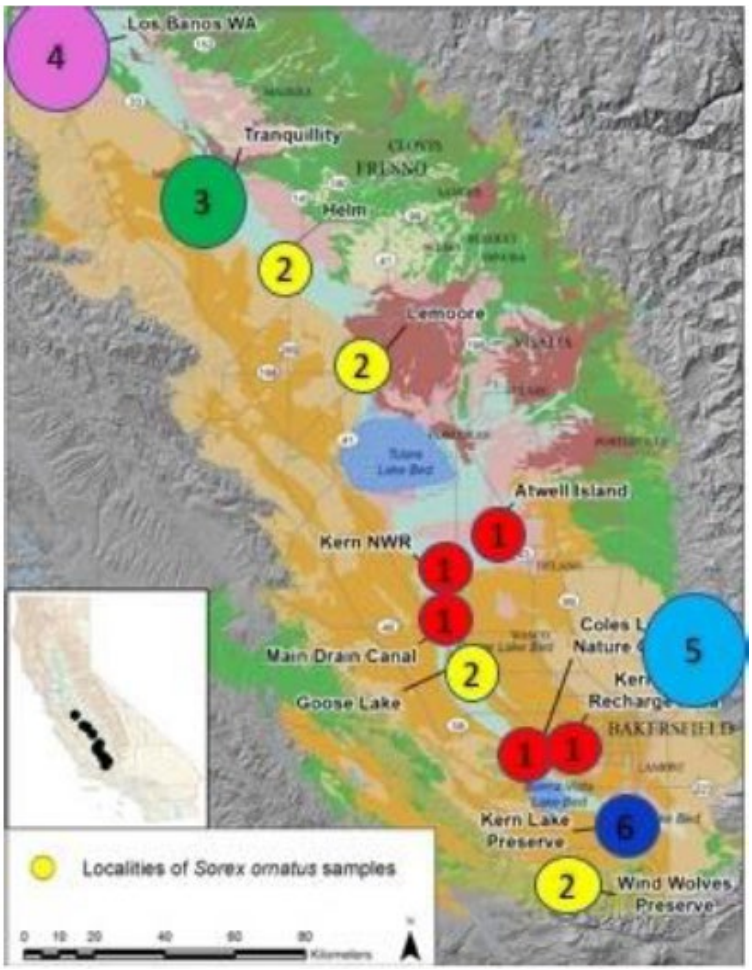


Figure 8: General locations of populations from 6 genetic clusters (indicated by color and number) (from Maldonado *et al.* 2017, p. 63). Clusters 3, 4, and 5 are not considered BVLOS. The Helm population is also not considered BVLOS, despite clustering with BVLOS populations further south. Reasons for this are unclear, but are discussed below.

Maldonado *et al.* (2017, p. 62) found that these clusters showed "moderate levels of genetic diversity," suggesting they are not currently suffering inbreeding depression. He supported this further by noting that "local populations must have remained sufficiently large to prevent the loss of genetic variation, despite opportunities for drift" (Maldonado *et al.* 2017, p. 58). Comparisons of mitochondrial DNA haplotypes also provided some support for these conclusions, as "most of the localities that we surveyed and that had sample sizes greater than n= 2 had more than one haplotype" (Maldonado *et al.* 2017, pp. 47–48). However, the report noted that habitat modification may have decreased the size of these populations in the recent past (Maldonado *et al.* 2017, p. 58). If true this could increase the chances of inbreeding depression in the future (see Future Conditions, below).

Hybridization with other subspecies, if extensive and ongoing, can potentially cause a BVLOS population to eventually become indistinguishable from the subspecies with which it is hybridizing (see Potential Stressors, above). However, if this were currently happening then the genetically-based clusters identified by Maldonado (2017, p. 50) would not follow subspecies lines. Instead, with one exception, they do. Three of the six clusters consist of BVLOS, while the other three (locations 3–5 in Figure 7 above)

consist of Southern California ornate shrews (Maldonado *et al.* 2017, p. 39). The one exception is the population at Helm, which falls into a cluster with other BVLOS populations including Lemoore, Goose Lake, and Wind Wolves, but which is not considered to be BVLOS in the overall report that includes Maldonado's 2017 genetics report as an appendix (Cypher *et al.* 2017, p. 1). The report does not make clear why shrews in Helm are not considered BVLOS, but cites to "J. Maldonado, unpubl. data." The appendix portion of the Cypher *et al.* 2017 report, which was written by Maldonado and two other authors, also mentions that a previous study, using a smaller number of representative localities (Maldonado 2006, entire), found the shrews in Helm to cluster with those in Tranquility (Maldonado *et al.* 2017, p. 59). One interpretation of the data would be that the shrews in Helm are not BVLOS, but are instead showing genetic similarities with BVLOS due to interbreeding. In that case, the results of such hybridization would be expansion of the BVLOS genetic characteristics into non-BLVOS populations, rather than the opposite. It is also possible, however, that the shrews in Helm were originally BVLOS, or that they represent a blended population of shrews arriving in the area at about the same time from both the *S. o. ornatus* and BVLOS subspecies. Additional research would be necessary to distinguish these possibilities.

Even if the shrews in Helm were originally BVLOS, however, that would not necessarily mean hybridization posed a threat to the subspecies as a whole. Hybridization is to be expected between subspecies in areas where they come into contact with each other (e.g. Allendorf *et al.* 2004, p. 1204; Haig *et al.* 2006, p. 1590), because subspecies lack the inherent isolating mechanisms that typically reduce or eliminate interbreeding between full species (Mayr 1996, pp. 264, 273). For hybridization to constitute a stressor for BLVOS, the number of hybrid areas, and extent of hybridization in those areas, would need to be both high and increasing. The available data instead show hybridization in only one area, and most areas becoming more genetically isolated than they were in the past, due to habitat conversion (Cypher *et al.* 2017, p. 1; Maldonado *et al.* 2017, p. 62). Accordingly, hybridization does not appear to constitute a current stressor for BVLOS.

6(11) Summary of Current Stressors

Based on the above analysis, the following stressors are currently acting on the BVLOS:

- Agricultural and urban development.
- Insufficient water supply.
- Changing climate (as a contributor to "insufficient water supply").
- Selenium
- Pesticides

6(12) Combined Current Effects of Multiple Stressors

Certain groups of stressors discussed above produce impacts on BVLOS that are more serious in combination. Specifically:

- Development and Insufficient Water Supply: Water for shrew habitat is now relatively scarce, largely because of historical diversions for urban and agricultural uses (Griggs *et al.* 1992, p. 111). Additional development stretches those water supplies further.
- Agricultural Development, Pesticides, and Selenium: Pesticides with the potential to affect BLVOS are applied to agricultural crops, while selenium accumulates in shallow groundwater aquifers and agricultural evaporation ponds after being imported into the Tulare Basin to water agricultural crops.

6(13) Summary – Current Resiliency

As discussed above in section 4(1), demographic factors contributing to BVLOS population resiliency include population size, connectivity, and genetic diversity. Environmental factors include the extent and type of contiguous habitat available to the population, the extent and stability of dispersal habitat connecting to other populations, and the extent and nutritional safety of the prey base. Those are in turn affected by various stressors, including agricultural and urban development, lack of water in a given year, climate change, selenium and pesticides. Figure 9, below, provides a graphical representation of how these factors interact to affect the resiliency of a given BVLOS population.

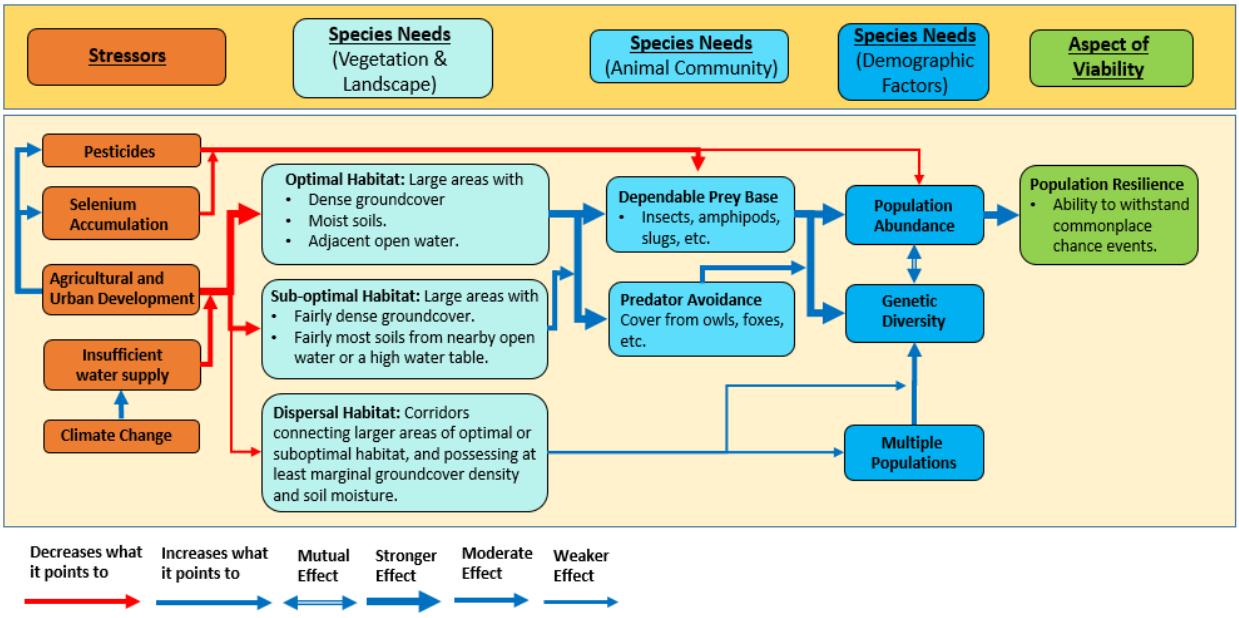


Figure 9: Factors Affecting Population Resilience

As the graphic indicates, resilience is directly affected by population abundance, which in turn is positively affected by genetic diversity, and by the vegetation and prey that the habitat supports. Genetic diversity at a given location is in turn affected by the presence of other populations, and by dispersal habitat allowing movement and genetic connectivity between them. Vegetation and prey in an area is positively affected by the amount of optimal and suboptimal habitat in that area, and those amounts are in turn

affected by development and by water supply. Climate change tends to increase the extent of areas and times of year during which habitat is affected by an insufficient water supply. Development, in addition to affecting habitat, also increases the likelihood of impacts from pesticides and selenium. Those in turn can impact the prey base, or (to a lesser extent) impact BVLOS population abundance directly.

Unfortunately, we lack direct information regarding important factors such as population abundance. Of the factors affecting viability, we have some information regarding general habitat quality at population locations, the stability of surface-water supplies, existing protections against development, and current habitat management practices. We also have information regarding which areas are more likely to be impacted by selenium concentration and by pesticide use.

Table 4, below, assigns categories (high, moderate, or low in terms of resulting quality for BVLOS) to each of the variables affecting resiliency for which we have information. Habitat quality values are taken from section 6(1); water dependability values from section 6(2); protection and management categorizations come from section 6(1); and selenium and pesticide values are from section 6(7) and 6(8), respectively.

Condition Category	Habitat Quality	Protection & Management	Water Supply Stability	Selenium	Pesticides
High	Isolated: > 112 ac total > 100 ac optimal Not Isolated: > 100 ac total > 50 ac optimal	Both habitat protection and management.	Water for wetlands is available except during bad droughts.	0 applicable selenium indicators from Table 2	Overall Score from Table 3: 0 – 2.0
Moderate	Isolated: btw 56 & 112 ac total Not Isolated: btw 50 & 100 ac optimal	Habitat protection but no management.	Water for wetlands is available most years.	1 applicable selenium indicators from Table 2	Overall Score from Table 3: 2.1 – 4.0
Low	Isolated: < 56 ac total < 50 ac optimal Not Isolated: < 45 ac total < 41 ac optimal	Neither habitat protection nor management.	Water for wetlands is highly limited except during wet years.	2 applicable selenium indicators from Table 2	Overall Score from Table 3: 4.1 – 6.0

Table 4: Condition Categories for Factors and Stressors Affecting Resiliency

By characterizing the condition of the factors affecting viability discussed above for each BVLOS population, we can estimate that population's current resiliency, as shown in

Table 5, below. Note that "High" always means beneficial to BVLOS. For the first three variables, we assigned values of 3, 2, and 1 to conditions of high, moderate, and low, respectively. We divided those values by two (so 1.5, 1, and 0.5, respectively) for Selenium and Pesticides, because impacts from those stressors are more speculative. We then totaled the numerical values of the factors and stressors to get a total current resiliency value for each site. Values for current resiliency thus run from 4 to 12. We characterized values of 9.5 through 12 as "high" resiliency, values of 6.5 through 9 as "moderate" resiliency, and values of 4 through 6 as "low" resiliency.

Location	Habitat Quality (1–3)	Protection & Mgt (1–3)	Water Stability (1–3)	Selenium Safety (0.5–1.5)	Pesticide Safety (0.5–1.5)	Current Resiliency
NAS Lemoore	Low (1)	High (3)	Moderate (2)	Moderate (1)	Low (0.5)	**Moderate (7.5)**
Lemoore Wetland Reserve	Low (1)	High (3)	High (3)	Moderate (1)	Low (0.5)	**Moderate** (8.5)
Pixley NWR	High (3)	High (3)	High (3)	High (1.5)	Moderate (1)	**High** (11.5)
Atwell Island	Moderate (2)	High (3)	High (3)	Moderate (1)	High (1.5)	**High** (10.5)
Kern NWR	High (3)	High (3)	High (3)	Low (0.5)	High (1.5)	**High** (11)
Poso Creek	Low (1)	Low (1)	Low (1)	High (1.5)	Low (0.5)	**Low (5)**
Semitropic Ecological Reserve	Low (1)	Moderate (2)	Low (1)	Moderate (1)	Moderate (1)	**Low** (6)
Kern River Overflow Canal at Fwy 5 & Hwy 46	Low (1)	Low (1)	Low (1)	High (1.5)	Moderate (1)	**Low (5.5)**
Goose Lake	Moderate (2)	Moderate (2)	Low (1)	Moderate (1)	Low (0.5)	**Moderate** (6.5)
Kern River Overflow Canal at Semitropic Canal Crossing	Low (1)	Low (1)	Low (1)	Moderate (1)	Low (0.5)	**Low** (4.5)
Kern Fan	Low (1)	Moderate (2)	Low (1)	High (1.5)	Moderate (1)	**Moderate** (6.5)
Coles Levee	Low (1)	Moderate (2)	High (3)	High (1.5)	Moderate (1)	**Moderate** (8.5)
Kern Lake	Low (1)	Low (1)	High (3)	Moderate (1)	Low (0.5)	**Moderate** (6.5)
Wind Wolves – Twin Fawns	Low (1)	Moderate (2)	High (3)	High (1.5)	High (1.5)	**Moderate** (9)
Wind Wolves – The Willows	Moderate (2)	Moderate (2)	High (3)	High (1.5)	High (1.5)	**High (10)**

Table 5: Current Resiliency Categories for Known BVLOS Populations

6(14) Current Redundancy

Since no BVLOS population is known to be particularly large, redundancy (the ability of the subspecies to withstand catastrophic events) is dependent on the existence of multiple populations. We are currently aware of 15 occupied population locations, including one (Coles Levee Ecosystem Reserve) that we assume is still occupied despite failure to find BVLOS during the most recent survey in 2017 (see Table 1 above). At the time of our last Five Year Review, in 2011, only eight occupied locations were known, whereas at the time of listing in 2002 BVLOS were only known from four locations (FWS 2011, p. 3). One area surveyed but considered unoccupied in 2011 (Pixley NWR) has been shown by recent surveys to now be occupied.

Accordingly, the current redundancy of the shrew appears significantly improved from time of listing. Unfortunately, given the apparent lack of connecting dispersal habitat between any all the populations except the two at Wind Wolves, and given the low dispersal distances documented in closely related shrews (see section 2(4), above), it is unclear how any populations could be recolonized if they were to be lost due to some catastrophe. Additional research into BVLOS dispersal capabilities and likely dispersal corridors is needed. Given the small extent of habitat at the Poso Creek site, the shrews found there may conceivably have been dispersing rather than part of a permanent population. That site is over 13 mi (21 km) from the next closest known occupied site, however, so if the shrews found there were dispersing that would imply much better dispersal capabilities than currently assumed.

6(15) Current Representation

Representation (ability to adapt to long-term changes) involves maximizing genetic diversity across the subspecies. This in turn requires preservation of populations in locations representative of the environmental variation across the range, as well as populations representative of any distinct genetic groups known to exist. For the former group, emphasis should be given to preservation of representative populations at the northern, southern, and middle portions of the range. The relatively high current resiliency values at Wind Wolves – The Willows, and Kern NWR sites thus make important contributions to representation for the middle and southern portions of the range. The most northerly representative sites, at NAS Lemoore and Lemoore Wetland Reserve, both have moderate current resiliency however. Improvements at those sites would thus particularly benefit continuing representation of the diversity of the subspecies.

With regard to preservation of representative populations in known genetic groups, the recent discovery of three population clusters with moderate genetic variation across them (Maldonado *et al.* 2017, pp. 61–63; see section 6(9), above) is informative. One cluster, consisting of Lemoore Wetland Reserve, the two Wind Wolves sites, and Goose Lake, has high resiliency at one location and moderate resiliency at the other three sites, leaving

it relatively well-positioned for preservation. Another cluster, consisting of Atwell Island, Kern NWR, The Semitropic Ecological Reserve (referred to as "Main Drain Canal" in Figure 8), Coles Levee, and the Kern Fan Recharge, includes two sites with high current resiliencies, and so is also relatively well-positioned for preservation of representative sites. The third cluster, however, has only one population (Kern Lake), and that is on private land with low protection and management. The likelihood of preserving representatives of this genetic cluster is thus lower than for the other clusters, and overall representation would increase if protection or management at the site could somehow be improved.

6(16) Overall Impacts on Current BVLOS Viability

Viability (the ability of a species to maintain populations in the wild over time) depends on the resiliency of existing populations (see Table 5, above); on the population redundancy (section 6(14) above) allowing the subspecies to recover even from large catastrophes; and on the maintenance of populations representative of the differences across the range (section 6(15), above).

Figure 10, below, illustrates how redundancy and representation are affected by the factors also affecting resiliency (compare Figure 9, above).

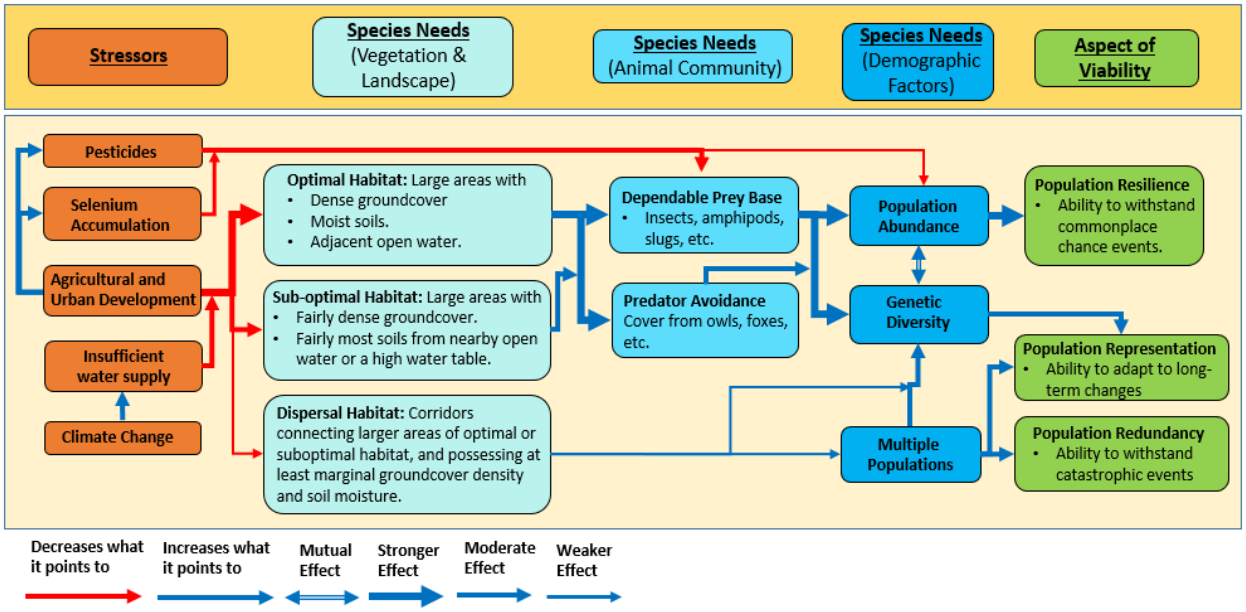


Figure 10: BVLOS Viability Model

7. FUTURE CONDITION

In this section we address the extent to which stressors on BVLOS populations may affect the viability of the subspecies over the next 50 years. We chose that timeframe because it

allows reasonable extrapolation of current trends while still considering a large number of future generations of BVLOS (roughly 50).

We first considered which current and potential stressors are likely to constitute stressors in the future. For instance, we expect all of the five current stressors (agricultural and urban development, insufficient water supply, changing climate, selenium, and pesticides) to also constitute future stressors, as all five issues are ongoing and unlikely to be solved within the time period considered.

Of the other potential stressors listed in section 5, we consider "trapping" and "inadequacy of regulatory mechanisms" unlikely to become population level stressors in the future for any population. Trapping is not currently a stressor, and with the recent demonstration of the efficacy of camera trapping (Cypher *et al.* 2017, p. iii) it is likely to become even less intrusive to individual BVLOS in the coming years. Similarly, we have no information to suggest that regulatory mechanisms will change in the future so as to not work as designed.

We also lack information to estimate future trends regarding the likelihood of impacts from disease, predation, or hybridization. Accordingly, we treat these issues as potential deleterious chance events. Resilient populations increase their chances of surviving such events, but we assume the events themselves have a relatively low but constant chance of occurring at any time during the 50 year timeframe examined.

Accordingly, we consider the following three future scenarios, under which the five current stressors are considered to also constitute future stressors, but to affect BVLOS populations to differing degrees:

7(1) Scenario 1

Under this scenario, we assume that current trends regarding the various stressors continue at essentially the same rates as before, and that protection levels remain essentially unchanged as well.

Habitat Quality: Continuing development and decreasing water availability are likely to lower habitat quality at locations where habitat protection or water stability is currently low. Habitat quality decreases by one level for each of these issues, with "very low" as the minimum category.

Water Stability: Under current trends, urban and agricultural demands on existing water supplies will continue to increase, and the likelihood and severity of droughts will also increase due to climate change. We assume the stability of water supplies will drop one level at all locations except where both current water stability and current protections are both high. Decreases below "low" condition result in "very low" and "extremely low" conditions, with numerical values of 0 and -1, respectively.

Protection and Management: We assume no changes in protection or management under this scenario.

Selenium: Groundwater selenium concentrations in the area are expected to increase by an average of 2.63 mg/l annually through at least 2030 (Howitt *et al.* 2009, p. 5-40). This translates to an increase of 12 to 15 percent in the total selenium-affected area by 2030 (as compared to 2004 levels) (Howitt *et al.* 2009, p. 3-31), and of 19.2 to 24 percent by 2070 (assuming the increase continues at the same rate). We assume increased concentration levels will affect occupied sites within two miles of an evaporation pond, or in the light green areas indicated in Figure 5b showing groundwater salinity above 2,000 µS/cm. We also assume areas that currently have groundwater salinities greater than 10,000 µS/cm (colored orange or read in Figure 5b), will increase to even higher levels, and thus deserve a separate column on the selenium indicators table, below. The maximum number of selenium indicators for Table 6 is thus 3 (very low condition) rather than 2 (low condition).

Location	**Within 2 mi of Evap-oration Pond?**	**Moderate or Higher Salinity** (Light green or higher in Fig 5a)?	**High Groundwater Salinity** (Orange or red in Fig 5a)?	**Total Selenium Indicators Applicable** (No. of Y's)	**Selenium Safety Condition for BVLOS**
NAS Lemoore	N	Y	N	1	Mod
Lemoore Wetland Reserve	Y	Y	N	2	Low
Pixley NWR	N	N	N	0	High
Atwell Island	Y	N	N	1	Mod
Kern NWR	Y	Y	Y	3	V Low
Poso Creek	N	N	N	0	High
Semitropic Ecological Reserve	Y	Y	Y	3	V Low
Kern River Overflow Canal at Fwy 5 & Hwy 46	N	Y	N	1	Mod
Goose Lake	Y	Y	N	2	Low
Kern River Overflow Canal at Semitropic Canal Crossing	Y	Y	N	2	Low
Kern Fan	N	N	N	0	High
Coles Levee	N	N	N	0	High
Kern Lake	Y	Y	N	2	Low
Wind Wolves – Twin Fawns	N	N	N	0	High
Wind Wolves – The Willows	N	N	N	0	High

Table 6: Selenium Indicators – Current Trends Scenario

Pesticides: The total number of pounds applied in Kern, Kings, and Tulare Counties has stayed essentially constant over the most recent 25 years for which we have data. In 1993 about 41 million lbs. (18.6 million kg) of all pesticide types were applied across the three counties, whereas 25 years later (2017) the total was about 44 million lbs. (20 million kg); an increase of only 0.07 percent (Tracking CA 2019, pp. 9–12). This consistency is likely due, at least in part, to the introduction of certain new insecticides and the phasing out of others. For instance, the first year for which we have data on application of neonicotinoids was 1995, and their use has been increasing ever since, while use of cholinesterase inhibitors has decreased (Tracking CA 2019, entire). Because current trends do not indicate a clear increase in pesticide use, we left that column unchanged in the Future Resiliency table (Table 7) for this scenario

Future Resiliency – Scenario 1: By applying the above assumptions for this scenario to the current resiliency of each of the known occupied sites (Table 5) we arrived at the following conditions of future resiliency:

> Note: Values for Future Resiliency run from 1.5 to 12. As for Table 5 (Current Resiliency), we characterized values of 9.5 through 12 as “high” resiliency, values of 6.5 through 9 as “moderate” resiliency, and values of 1.5 through 6 as “low” resiliency.

Location	Habitat Quality (0 to 3)	Protection & Mgt (1–3)	Water Stability (0–3)	Selenium Safety (0.0–1.5)	Pesticide Safety (0.5–1.5)	Future Resiliency
NAS Lemoore	Low (1)	High (3)	Low* (1)*	Mod (1)	Low (0.5)	**Moderate** (6.5)*
Lemoore Wetland Reserve	Low (1)	High (3)	High (3)	Low* (0.5)*	Low (0.5)	**Moderate** (8)*
Pixley NWR	High (3)	High (3)	High (3)	High (1.5)	Moderate (1)	**High** (11.5)
Atwell Island	Moderate (2)	High (3)	High (3)	Moderate (1)	High (1.5)	**High** (10.5)
Kern NWR	High (3)	High (3)	High (3)	Very Low* (0)*	High (1.5)	**High** (10.5)*
Poso Creek	Very Low* (0)*	Low (1)	Very Low* (0)*	High (1.5)	Low (0.5)	**Low** (3)*
Semitropic Ecological Reserve	Very Low* (0)*	Moderate (2)	Very Low* (0)*	Very Low* (0)*	Moderate (1)	**Low** (3)*
Kern River Overflow Canal at Fwy 5 & Hwy 46	Very Low* (0)*	Low (1)	Very Low* (0)*	Mod* (1)*	Moderate (1)	**Low** (3*
Goose Lake	Low* (1)	Moderate (2)	Very Low* (0)	Low* (0.5)*	Low (0.5)	**Low*** (4)*
Kern River Overflow Canal at Semitropic Canal Crossing	Very Low* (0)*	Low (1)	Very Low* (0)*	Low* (0.5)*	Low (0.5)	**Low** (2)*
Kern Fan	Very Low* (0)*	Moderate (2)	Very Low* (0)*	Low* (0.5)*	Moderate (1)	**Low*** (3.5)*
Coles Levee	Low (1)	Moderate (2)	Mod* (2)*	High (1.5)	Moderate (1)	**Moderate*** (7.5)*
Kern Lake	Very Low* (0)	Low (1)	Mod* (2)*	Low* (0.5)*	Low (0.5)	**Low*** (4)*
Wind Wolves – Twin Fawns	Low (1)	Moderate (2)	Mod* (2)*	High (1.5)	High (1.5)	**Moderate*** (8)*
Wind Wolves – The Willows	Moderate (2)	Moderate (2)	Mod* (2)*	High (1.5)	High (1.5)	**Moderate*** (9)*

Table 7: Future Resiliency– Scenario 1

* Asterisks indicate drops in condition quality from current levels (either numerical or at the category level).

[#] Pound signs indicate improvements in condition quality from current levels (either numerical or at the category level).
Decreases in overall resiliency category (high, moderate, or low) from current levels (Table 5) are shaded smooth gray.

Summary – Future Resiliency Under Scenario 1: Under the assumption of unabated current trends, we expect drops in the resiliency category of six occupied sites, and numerical drops within categories at an additional seven sites. Only Pixley NWR and Atwell Island would remain unaffected under this scenario.

Future Redundancy – Scenario 1: If current trends continue, overall redundancy (as indicated by the number and resiliency of populations) is likely to decrease in response to decreases in numerical resiliency values at several populations, and particularly in response to decreases in the categorical ratings of resiliency at 6 of the 15 occupied sites. This will still leave three populations with high resiliency values, however, so the shrew's likelihood of avoiding complete extinction in the foreseeable future would be reasonably good.

Future Representation – Scenario 1: The representation of the middle portion of the range is a serious concern under this scenario, since all the sites from Poso Creek to the Kern Fan would be left with low resiliency values.

The prospective drop in resiliency at Kern Lake would also constitute an important impact on representation. The shrew population at that site comprises a unique genetic cluster, which would be lost if the population were to be extirpated (Maldonado *et al.* 2017, pp. 61–63; see section 6(9), above).

7(2) Scenario 2

Under this scenario, habitat protection and management increases in most occupied areas and more stable water sources are acquired.

Habitat Quality, Water Stability, & Protection and Management: We assume that impacts on water stability from climate change and development will be minimal in areas with moderate or high levels of protection and management. We also assume that protection and management levels for occupied areas on public or preserved lands will increase to "high' if not currently at that level. This means that water stability will only decrease in privately owned locations with low levels of protection or management. We further assume that habitat quality will improve one level (to a maximum of "high") in areas where protection and management is either currently high or expected to become high under this scenario.

Selenium: We assume that selenium levels do not increase enough to change the impact levels at any occupied location.

Pesticides: We assume that pesticide impacts remain essentially unchanged.

Future Resiliency – Scenario 2: We applied the above assumptions for this scenario to the current resiliency of each of the known occupied sites (Table 5), resulting in the following conditions of future resiliency:

> Note: Values for Future Resiliency run from 3 to 12. As for Table 5 (Current Resiliency) we characterized values of 9.5 through 12 as "high" resiliency, values of 6.5 through 9 as "moderate" resiliency, and values of 3 through 6 as "low" resiliency.

Location	Habitat Quality (1–3)	Protection & Mgt (1–3)	Water Stability (1–3)	Selenium Safety (0.5–1.5)	Pesticide Safety (0.5–1.5)	Current Resiliency
NAS Lemoore	Moderate* (2)*	High (3)	Moderate (2)	Moderate (1)	Low (0.5)	**Moderate** (8.5)
Lemoore Wetland Reserve	Moderate* (2)*	High (3)	High (3)	Moderate (1)	Low (0.5)	**High#** (9.5)#
Pixley NWR	High (3)	High (3)	High (3)	High (1.5)	Moderate (1)	**High** (11.5)
Atwell Island	High* (3)*	High (3)	High (3)	Moderate (1)	High (1.5)	**High** (11.5)#
Kern NWR	High (3)	High (3)	High (3)	Low (0.5)	High (1.5)	**High** (11)
Poso Creek	Low (1)	Low (1)	Very Low* (0)*	High (1.5)	Low (0.5)	**Low** (4)*
Semitropic Ecological Reserve	Moderate* (2)*	High# (3)#	Low (1)	Moderate (1)	Moderate (1)	**Moderate#** (8)#
Kern River Overflow Canal at Fwy 5 & Hwy 46	Low (1)	Low (1)	Very Low* (0)*	High (1.5)	Moderate (1)	**Low (4.5)***
Goose Lake	Moderate (2)	Moderate (2)	Low (1)	Moderate (1)	Low (0.5)	**Moderate** (6.5)
Kern River Overflow Canal at Semitropic Canal Crossing	Low (1)	Low (1)	Very Low* (0)*	Moderate (1)	Low (0.5)	**Low** (3.5)*
Kern Fan	Moderate* (2)*	High# (3)#	Low (1)	High (1.5)	Moderate (1)	**Moderate** (8.5)#
Coles Levee	Moderate* (2)*	High# (3)#	High (3)	High (1.5)	Moderate (1)	**High#** (10.5)#
Kern Lake	Low (1)	Low (1)	Moderate* (2)*	Moderate (1)	Low (0.5)	**Low*** (5.5)*
Wind Wolves – Twin Fawns	Moderate* (2)*	High# (3)#	High (3)	High (1.5)	High (1.5)	**High#** (11)#
Wind Wolves – The Willows	High* (3)*	High# (3)#	High (3)	High (1.5)	High (1.5)	**High** (12)#

Table 8: Future Resiliency– Scenario 2

* Asterisks indicate drops in condition quality from current levels (either numerical or at the category level).

Pound signs indicate improvements in condition quality from current levels (either numerical or at the category level).

Decreases in overall resiliency category (high, moderate, or low) from current levels (Table 5) are shaded smooth gray.
Increases in overall resiliency category (high, moderate, or low) from current levels (Table 5) are shaded with a yellowed speckled pattern.

Summary – Future Resiliency Under Scenario 2: Under the relatively optimistic assumptions of this scenario, we expect the resiliency category of four occupied sites to increase; three to "high" resiliency and the third to "moderate". We also expect within-category numerical rises for three additional sites.

We also expect to see the resiliency category of the Kern Lake site to drop to low. This is projected because Kern Lake is currently at the low end of the "moderate" resiliency category (see Table 5), and it is privately owned, with "low" protection and management. We also saw decreases in numerical resiliency values at three additional privately owned sites with low protection, but these are currently in the low resiliency category already.

Future Redundancy – Scenario 2: Under optimistic assumptions, overall redundancy will tend to improve. The total number of sites with high resiliency will increase from 4 to 7, which is almost half of the known sites. The number of low-resiliency sites will remain the same, since one low site will become moderate and one moderate site will become low.

Future Representation – Scenario 2: This scenario produces sites with high resiliency in all three geographic portions of the range (northern, middle, and southern). Unfortunately, the resiliency of the Kern Lake site falls to low, so preservation of the genetic cluster represented by that site (Maldonado *et al.* 2017, pp. 61–63; see section 6(9), above) remains somewhat problematic, even given the optimistic assumptions of this scenario.

7(3) Scenario 3

Under this scenario we assume protection and management is generally ineffective at securing stable water supplies, and that development will tend to encroach on unprotected areas. We also assume higher impacts from selenium and pesticides.

Habitat Quality: Worsening trends in development and decreasing water availability cause habitat quality to lower wherever habitat protection or water stability is currently low or moderate. Habitat quality decreases by one level for each of these issues, with "very low" as the minimum category.

Protection and Management: We assume no changes in protection or management under this scenario.

Water Stability: We assume the stability of water supplies will drop one level at all locations regardless of current stability or protections.

Selenium: We assume roughly the same increases for selenium as we did in Scenario 1, but low and very low conditions for this stressor are assigned numerical values of 0 and -1 rather than 0.5 and 0. This is intended to model a situation in which selenium impacts increase more exponentially with exposure level, rather than linearly.

Pesticides: We assume that pesticide impacts reduce conditions for BVLOS by one level (potentially resulting in a "very low" level of 0) in areas that are currently in low or moderate categories. This is based on the assumption that agricultural production will intensify in those areas more so than in areas where conditions are currently at high levels.

Future Resiliency – Scenario 3: We applied the above assumptions for this scenario to the current resiliency of each of the known occupied sites (Table 5), resulting in the following pessimistic indicators of future resiliency:

> Note: Values for Future Resiliency run from 0 to 12. As for Table 5 (Current Resiliency) we characterized values of 9.5 through 12 as "high" resiliency, values of 6.5 through 9 as "moderate" resiliency, and values of 0 through 6 as "low" resiliency.

Location	Habitat Quality (0–3)	Protection & Mgt (1–3)	Water Stability (0–2)	Selenium Safety (-1 to 1.5)	Pesticide Safety (0–1.5)	Current Resiliency
NAS Lemoore	Very Low* (0)*	High (3)	Low* (1)*	Mod (1)	Very Low* (0)*	**Low*** (5)*
Lemoore Wetland Reserve	Low (1)	High (3)	Moderate* (2)*	Low* (0)*	Very Low* (0)*	**Low*** (6)*
Pixley NWR	High (3)	High (3)	Moderate* (2)*	High (1.5)	Low* (0.5)*	**High** (10)*
Atwell Island	Moderate (2)	High (3)	Moderate* (2)*	Mod (1)	High (1.5)	**High** (9.5)*
Kern NWR	High (3)	High (3)	Moderate* (2)*	V Low* (-1)*	High (1.5)	**Moderate*** (8.5)*
Poso Creek	Very Low* (0)*	Low (1)	Very Low* (0)*	High (1.5)	Very Low* (0)*	**Low (2.5)***
Semitropic Ecological Reserve	Very Low* (0)*	Moderate (2)	Very Low* (0)*	V Low* (-1)*	Low* (0.5)*	**Low** (1.5)*
Kern River Overflow Canal at Fwy 5 & Hwy 46	Very Low* (0)*	Low (1)	Very Low* (0)*	Mod* (1)*	Low* (0.5)*	**Low (2.5)***
Goose Lake	Low* (1)*	Moderate (2)	Very Low* (0)*	Low* (0)*	Very Low* (0)*	**Low*** (3)*
Kern River Overflow Canal at Semitropic Canal Crossing	Very Low* (0)*	Low (1)	Very Low* (0)	Low* (0)*	Very Low* (0)*	**Low** (1)*
Kern Fan	Very Low* (0)*	Moderate (2)	Very Low* (0)	High (1.5)	Low* (0.5)*	**Low*** (4)*
Coles Levee	Very Low* (0)*	Moderate (2)	Moderate* (2)*	High (1.5)	Low* (0.5)*	**Low*** (6)*
Kern Lake	Very Low* (0)*	Low (1)	Moderate* (2)*	Low* (0)*	Very Low* (0)*	**Low*** (3)*
Wind Wolves – Twin Fawns	Very Low* (0)*	Moderate (2)	Moderate* (2)*	High (1.5)	High (1.5)	**Moderate** (7)*
Wind Wolves – The Willows	Low* (1)*	Moderate (2)	Moderate* (2)*	High (1.5)	High (1.5)	**Moderate*** (8)*

Table 9: Future Resiliency– Scenario 3

* Asterisks indicate drops in condition quality from current levels (either numerical or at the category level).

Pound signs indicate improvements in condition quality from current levels (either numerical or at the category level).

Any changes in overall resiliency category (high, moderate, or low) from current levels are shaded for emphasis.

Summary – Future Resiliency Under Scenario 3: Under pessimistic assumptions, we expect drops in the resiliency category of 8 of the 15 total occupied sites, as well as numerical drops within categories at the remaining 7 sites. These drops result primarily from general inability to secure stable water supplies, and from relatively strong selenium and pesticide impacts at many sites.

Future Redundancy – Scenario 3: The assumptions under this scenario leave only two sites likely to maintain high resiliency (as compared to six such sites under current conditions). Furthermore, these two sites (Pixley NWR and Atwell Island) are only about 13 km (8 mi) away from each other, and so potentially capable of being seriously impacted or extirpated by the same deleterious chance event. Accordingly, overall redundancy is seriously reduced under this scenario, but not eliminated.

Future Representation – Scenario 3: Under this scenario, the most northern and most southern locations both lose their high resiliency conditions. The loss at the two sites near Lemoore is particularly important to overall resiliency because they are so distant from the next most northern site (Pixley NWR, 56 km (35 mi) away). Additionally, no central or southern sites with high resiliency remain under this scenario.

Genetic representation is also negatively affected by the decrease in resiliency at the Kern Lake site from moderate to low. This leaves the only representative of its genetic cluster at serious risk of extirpation from deleterious chance events. The second of the three genetic clusters mentioned by Maldonado (2017, pp. 61–63), consisting of the Lemoore, Goose Lake, and the Wind Wolves sites, is also left with no representative populations that maintain high resiliency levels.

8. SUMMARY OF CURRENT AND FUTURE VIABILITY

The overall viability of the BVLOS – its probability of avoiding extinction – is based on the resiliency of its populations, and on the resulting redundancy and representation established by the pattern of resiliency levels across the overall range. Although resiliency depends primarily on population size, for which information is currently lacking, we have estimated current resiliency levels at each of the 15 known occupied locations based on factors and stressors for which data are available. Those factors and stressors are: the extent of optimal habitat at the location (habitat quality); the stability and dependability of water to maintain that habitat; levels of protection and management, and relative levels of nearby selenium accumulation and pesticide use.

After using the available information to characterize the current resiliency at each site, we then used that information to make generalized conclusions regarding redundancy and representation. Overall, resiliency appears relatively high at 4 of the 15 sites, and low at 4 others. Middle, and southern geographic areas are well-represented by sites with high resiliency, but the northernmost two areas (near Lemoore) have only moderate resiliency levels. Two of the three genetically distinct population clusters are also represented by locations with high resiliency, but the third such genetic cluster is represented by a single population (Kern Lake) with only moderate resiliency. Overall, current viability thus appears fairly good, particularly in comparison to the situations at time of listing (2002) and during the 2011 5-Year Review.

We also considered how current viability might change in the future (roughly the next 50 years) under various assumptions that we grouped into scenarios. The scenarios we considered involved: (1) an extension of current trends; (2) a set of optimistic assumptions regarding future changes; and (3) a set of pessimistic assumptions regarding such changes. We estimated the resiliency of each occupied site under the assumptions of each scenario, and noted how those estimates compared to current values.

Table 10, below, summarizes the resiliency estimates we reached for each location currently and under each of the future scenarios.

Location	Current Resiliency	Future Resiliency		
		Scenario 1	Scenario 2	Scenario 3
NAS Lemoore	**Moderate** (7.5)	**Moderate** (6.5)*	**Moderate** (8.5)	**Low*** **(5)***
Lemoore Wetland Reserve	**Moderate** (8.5)	**Moderate** (8)*	**High#** (9.5)#	**Low*** (6)*
Pixley NWR	**High** (11.5)	**High** (11.5)	**High** (11.5)	**High** (10)*
Atwell Island	**High** (10.5)	**High** (10.5)	**High** (11.5)#	**High** (9.5)*
Kern NWR	**High** (11)	**High** (10.5)*	**High** (11)	**Moderate*** (8.5)*
Poso Creek	**Low** (5)	**Low** (3)*	**Low** (4)*	**Low** **(2.5)***
Semitropic Ecological Reserve	**Low** (6)	**Low** (3)*	**Moderate#** (8)#	**Low** (1.5)*
Kern River Over-flow Canal at Fwy 5 & Hwy 46	**Low** (5.5)	**Low** (3*	**Low** **(4.5)***	**Low** **(2.5)***
Goose Lake	**Moderate** (6.5)	**Low*** (4)*	**Moderate** (6.5)	**Low*** (3)*
Kern River Overflow Canal at Semitropic Canal Crossing	**Low** (4.5)	**Low** (2)*	**Low** (3.5)*	**Low** (1)*
Kern Fan	**Moderate** (6.5)	**Low*** (3.5)*	**Moderate** (8.5)#	**Low*** (4)*
Coles Levee	**Moderate** (8.5)	**Moderate** (7.5)*	**High#** (10.5)#	**Low*** (6)*
Kern Lake	**Moderate** (6.5)	**Low*** (4)*	**Low*** (5.5)*	**Low*** (3)*
Wind Wolves – Twin Fawns	**Moderate** (9)	**Moderate** (8)*	**High#** (11)#	**Moderate** (7)*
Wind Wolves – The Willows	**High** (10)	**Moderate*** (9)*	**High** (12)#	**Moderate*** (8)*

Table 10: Current and Future Resiliency Estimates

* Asterisks indicate drops in condition quality from current levels (either numerical or at the category level).

Pound signs indicate improvements in condition quality from current levels (either numerical or at the category level).

Any changes in overall resiliency category (high, moderate, or low) from current levels are shaded for emphasis.

We also considered how redundancy and representation would be affected by the resiliency patterns across the landscape under the different future scenarios. Generally, redundancy remains fairly good under all but Scenario 3. Representation decreases slightly under Scenario 1, significantly under Scenario 3, and increases under Scenario 2.

Important sites include Pixley NWR and Atwell Island, as the only locations to maintain high resiliency across all scenarios. Kern NWR is also noteworthy as the largest and best quality site, but its resiliency category was lowered to moderate under Scenario 3 due to the greater impacts from Selenium assumed under that scenario. Kern Lake is also an important site because it is the only representative of one of the three genetic clusters found by Maldonado, and because it was the only site whose resiliency category level decreased under all three future scenarios. Additional important sites include the two most northern (near Lemoore) and the two most southern (in Wind Wolves Preserve). Both groups represent extremes of the range, but the Wind Wolves sites appear comparatively more stable. The Lemoore sites fluctuate from low resiliency to high across the three future scenarios.

Overall, BLVOS viability is somewhat decreased from current levels under Scenario 1; significantly decreased under Scenario 3, and improved under Scenario 2.

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